User Guide and Model Documentation for SACSIM23

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SACOG
Sacramento Area Council of Governments

SAC SIM

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- *Mark Bradley (Bradley Research and Consulting)* and *John L. Bowman, Ph.D. (Transportation Systems and Decision Sciences)*—Worked jointly on all phases of the data preparation and the initial development of DAYSIM during 2005- 2007, and on several subsequent updates to DAYSIM used for analysis of the 2012 Metropolitan Transportation Plan (MTP) and the region's first Sustainable Community Strategy (SCS), and for the 2016 MTP/SCS.
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- *Resource Systems Group (RSG)*—Provided technical assistance to comprehensively update DAYSIM (e.g. updating the program code and improving the user interface and overall flexibility and adaptability of the program) and recently contracted to develop and implement the model capability to evaluate tolling strategies. In particular, Joel Freedman, Mark Bradley, and Albab Noor contributed significantly to this effort.

A significant amount of the content of this document is either drawn from, or based upon, technical memoranda and other written materials prepared by the above individuals and firms. Where material was directly copied, attribution is given; however, their influence and thinking are peppered throughout the document in ways impossible to specifically attribute.

SACOG staff were responsible for the organization and updating of the document. SACOG staff who contributed significantly to the document are *Bruce Griesenbeck, Kyle Shipley, Shengyi Gao, Darren Conly, Yanmei Ou.*

1 Introduction

SACOG, as the designated Metropolitan Planning Organization (MPO) for the Sacramento region, has the primary responsibility for the development and maintenance of its travel demand forecasting methods and models. These models are used by agencies like SACOG for regional-scale policy analyses of land use and transportation plans, as well as for analyses of the effects of exogenous variables, like fuel prices and demographic change (e.g. aging of the population). The travel demand model currently used by SACOG is the Sacramento Activity-Based Travel Simulation Model, or "SACSIM".

1.1 SACSIM Version

Versions of SACSIM are identified by the year the model code and data files are first utilized for a publicly released analysis. This report provides a detailed description of SACSIM23, which was developed and used for evaluation of the 2025 Metropolitan Transportation Plan/Sustainable Community Strategy (MTP/SCS), also known as the Blueprint. Table 1-1 lists the substantial changes and improvements made to SACSIM models since SACSIM19 was released

Table 1-1 SACSIM19 to SACSIM23 Comparison

Feature	Used for…	SACSIM19	SACSIM23	Change in Modeling
DAYSIM re-estimation; implement telework and TNC models	Simulation of individual's daily travel activities	Did not model teleworking (working at home but primary workplace is away from home; estimated based on year 2000 travel survey)	Re-estimated long and short term choice models using 2018 household travel survey; added telework model; activated TNC model	Model reflects more current travel behavior; better captures increase in teleworking since COVID pandemic for forecast years; captures TNC usage
Updated TAZ geographies	Spatial distribution of trip generators and attractors	1,503 zones, boundaries last updated in 2007	2,315 zones, boundaries updated in 2021. New TAZ's fully realigned to match 2020 census block geographies, city boundaries and SOIs, roadways, and natural travel barriers.	More accurate modeling and assignment
Improved ability to capture bus-only lanes	Representing effects that dedicated bus lanes have on bus speeds.	User-adjusted time factors in transit line file modify transit speeds relative to car speeds to capture bus-only lanes or other transit treatments.	User sets BUSLANE tag on highway links and in config CSV to specify where there are bus-only lanes, time(s) of day they apply, and if they remove general-purpose lanes	Better data management (tag bus only lane project IDs to specific locations on network; automatically adjust number of GP lanes based on type of bus lane); easier mapping/identification of bus-only lane locations.
Updated transit speed formula	Computing transit speeds on road links	Based transit speeds on congested vehicle speeds	Bases transit speeds on weighted average of free-flow and congested speeds	Model better reflects fact that speed difference between transit and cars is smaller in congested conditions.
Network and gateway updates in East Placer County	Modeling gateway traffic	I-80 ended at single gateway into Nevada County. No network representation in East Placer	Extends I80 to East Placer, including portions in Nevada County (outside of SACOG region); adds new gateway for SR267 and SR 89 into Tahoe Basin	More accurate representation of traffic volumes on I-80 in East Placer; captures more VMT in East Placer portion of SACOG region.
Revised gateway volume forecasting method	Predicting future-year gateway traffic volumes	Assumed linear growth in gateway traffic volumes based on changes in population	Uses gateway-specific regression formulas based regional population growth trends, historical AADT, and capturing "saturation effect"	More realistic assumptions of interregional travel based on nuances specific to each gateway.

Feature	Used for...	SACSIM19	SACSIM23	Change in Modeling
			of roadways reaching capacity.	
Revised Network Freeflow Speeds	Model Assignment	Based on speed data survey conducted in 2008	Update free flow speeds using NPMNRDS real time speed data 2017.	Reflect truer free flow traffic speeds on individual roadways. Improved free flow speed estimation for new roadways.

1.2 Version History

SACSIM23 – Current

SACSIM19 – Released in 2020 as part of the 2020 MTP/SCS

SACSIM15 – Released in 2016 as part of the 2016 MTP/SCS

SACSIM11 – Released in 2012 as part of the 2012 MTP/SCS

1.3 Public Access

The updated SACSIM modeling scripts and data files are made available for review and comment by local member agencies and the transportation consulting community in the following ways:

SACOG maintains a basic description of SACSIM on its website for the public to get a basic understanding of the model and its uses, and to connect members of the public to SACOG staff members that can provide additional information as needed: https://www.sacog.org/planning/data-resource-center/travel-demand-model/travel-model-documentation/sacsim23

SACOG has hosted model conferences in 2019 - 2022, and 2024 as an opportunity for local agency staff, consultants, and the public to learn more about the model and the latest model updates. See https://www.sacog.org/planning/data-resource-center/travel-demand-model/travel-model-user-conference

SACOG provided early releases of the SACSIM23 model and its input files to consultants who used the model to help local jurisdictions update their general plans.

With each major update to the Metropolitan Transportation Plan (MTP) or Metropolitan Transportation Improvement Plan (MTIP), SACOG prepares a shareable version of the SACSIM model with future-year scenarios reflecting the latest plan updates. The public can access these model versions by completing a Data Request Form at https://www.sacog.org/planning/data-resource-center/data-requests.

1.4 Organization of the Report

The report is organized into 11 chapters plus appendices.

1.4.1 Chapter 1 Introduction

Chapter 1 describes organization of the documentation, version history, and public access.

1.4.2 Chapter 2 Model Overview

Chapter 2 is oriented toward model users and provides information relevant to setting up and running the model such as hardware/software requirements, setting up model inputs, a review of model outputs, and troubleshooting common issues that arise when running the model.

1.4.3 Chapter 3 Model Structure

Chapter 3 describes the overall structure and flow of the SACSIM model, along with descriptions of each SACSIM submodel. The submodels include:

- *DAYSIM* is the person-day activity and travel simulator, which is the only true activity-based tour component of SACSIM. DAYSIM accounts for all travel by residents of the SACOG region for their travel within the region. The simulation is at person level, so the major outputs of DAYSIM relate to personal travel for work, school, social/recreational, and other non-work purposes. DAYSIM includes a set of *long-term* choice models at the highest level, and a larger set of short-term choice models at lower levels.

- *Airport ground access* to the Sacramento International Airport is modeled separately, at the traffic analysis zone (TAZ) level. This model is adapted from work done by the Sacramento Regional Transit District for its evaluation of the Downtown-Natomas-Airport transit corridor.

- *Commercial vehicle travel* is also modeled separately from resident travel and is modeled at the TAZ level. It includes all trips made for transportation of goods and services. This submodel was adapted from SACMET, and operates with conventional four-step trip generation, distribution, and assignment.

- *External trips* include both internal-external (trips made by region residents to points outside the region), external-internal (trips made by residents from outside the region to points within the region), and trips that pass through the region without stopping. These trips are fixed as exogenous, scenario variables. Only the portion of these trips that occur within the SACOG region are modeled.

Trips from all the submodels are aggregated to create conventional trip matrices which are assigned to the highway and transit networks. This process includes a *trip aggregator*, plus all the usual trip assignment programs.

SACSIM runs within an application shell, scripted in Cube Voyager software. DAYSIM itself is a stand-alone program written in C# and compiled to run within the SACSIM application. All trip aggregation, plus the non-DAYSIM components, are Voyager scripts.

1.4.4 Chapters 4 and 5 Land Use and Demographics

Chapters 4 and 5 cover key land use and demographic input data files required by SACSIM. Chapter 4 describes the *parcel land use file*, which is the SACSIM equivalent of a zonal data file in a conventional four-step model. In addition to descriptions of the key variables included in the file, Chapter 4 provides an overview of how the file is produced, starting from SACOG's land use model. Chapter 5 provides a description of the *representative population file*, which is a person-level representation of the region's household population. The population file is required to run activity-based tour models like SACSIM. The cumulative demographics (household size, workers, income distribution, age) of the representative population file reflect key demographic projections and forecast assumptions which underlie SACOG's travel demand forecasts. Chapter 5 provides an overview of how the population file is produced.

1.4.5 Chapters 6, 7, and 8 Transportation Networks

Chapters 6, 7, and 8 cover transportation network input files and assumptions. Chapter 6 provides a detailed description of the *highway network files* used by SACSIM. Highway networks are required for generating cost or level of service matrices (also called *skims*), which represent the level of accessibility of travel by automobile.

Chapter 7 describes SACSIM's transit network, including but not limited to attributes like routes, stop locations, service frequencies, speeds, transfer locations, access points and modes, fares, and hours of operation. Together, these transit inputs allow creation of transit skims, which represent the level of transit access between TAZs.

Chapter 8 discusses SACSIM's bike and walk network, which is a subset of its highway network. It also discusses the method by which SACSIM takes advantage of its detailed, parcel-level land use data to estimate the distances of short trips (e.g. trips that start and end within the same TAZ, or between nearby TAZs) more accurately than can be done by the SACSIM highway network on its own.

1.4.6 Chapter 9 Auto/Transit Cost and Pricing

Chapter 9 provides a SACOG-specific and California perspective on actual fuel prices and recent changes, and describes how fuel prices are represented in SACSIM. The chapter also explains how transit fares are represented in the model.

1.4.7 Chapter 10 System Equilibration

Chapter 10 describes the theoretical foundation behind and process by which SACSIM iterates in order to reach system equilibration and describes the relationships between the network assignment and DAYSIM to determine person trip travel patterns and mode choices relating to congestion.

1.4.8 Chapter 11 Model Calibration, Validation and Reasonableness Check

Chapter 11 describes the observed travel and transportation system data sources used for estimating, calibrating, validating, and reasonableness checking SACSIM along with a discussion on the quality and limitations of each source.

1.4.9 Appendix: Model Sensitivity Testing

SACOG hired an outside consultant to perform sensitivity testing, which measures how key model outputs like mode choice, VMT, etc. respond to controlled changes in model inputs like vehicle operating cost, parking and transit prices, etc., then comparing this sensitivity, or elasticity, with observed elasticities.

2 Model Overview

2.1 Key Concepts and Parameters

SACSIM is a *typical weekday* model. It represents travel demands for a typical weekday, defined as a mid-week day (Tuesday, Wednesday or Thursday) during a Spring or early Fall month (March, April, May, September or October). Mid-week days are used because Mondays and Fridays are often affected by holiday or weekend activities or events. Spring or Fall months are used because those are months when schools are normally in session, weather does not often affect peoples' activities or travel, and a lower percentage of workers are on vacation. Activities and travel in late Fall and Winter months (November through February) are strongly affected by major holidays (Thanksgiving, Christmas, New Years Day, etc.) and inclement weather. Where required, typical weekday performance measures are annualized to represent travel through the course of the year, rather than only for a typical weekday. Figure 2-1 provides a high-level overview of the SACSIM model.

The term *simulation* is used in so many ways related to transportation modeling and analysis, that its use causes confusion, even to transportation professionals. The dictionary definition of *simulation* which is applicable to SACSIM is "…the imitative representation of the functioning of one system or process by means of the functioning of another <a computer ~ of an industrial process>; examination of a problem often not subject to direct experimentation by means of a simulating device…" [1] This general definition fits SACSIM, but also fits many other four-step travel demand models. Two characteristics of *transportation simulations* which apply to SACSIM, and distinguish SACSIM from four-step travel demand models are: (1) disaggregate application; and (2) explicit treatment of time.

In truth, only one key submodel which makes up SACSIM is truly a simulation, and that is DAYSIM. DAYSIM is disaggregate in its application—its units of analysis, or agents, are people. The units of analysis for conventional four-step models are TAZs. DAYSIM applies models estimated on a household travel survey of individual people to a representative population file with one record per person, and all person-level variables in the estimation accounted for explicitly in the model. Calibration aside, the model estimated is the model applied. For conventional four-step models, many of the key variables included in the estimated model are aggregated and simplified, with true distributions of behavior represented by the averages for groups of individuals.

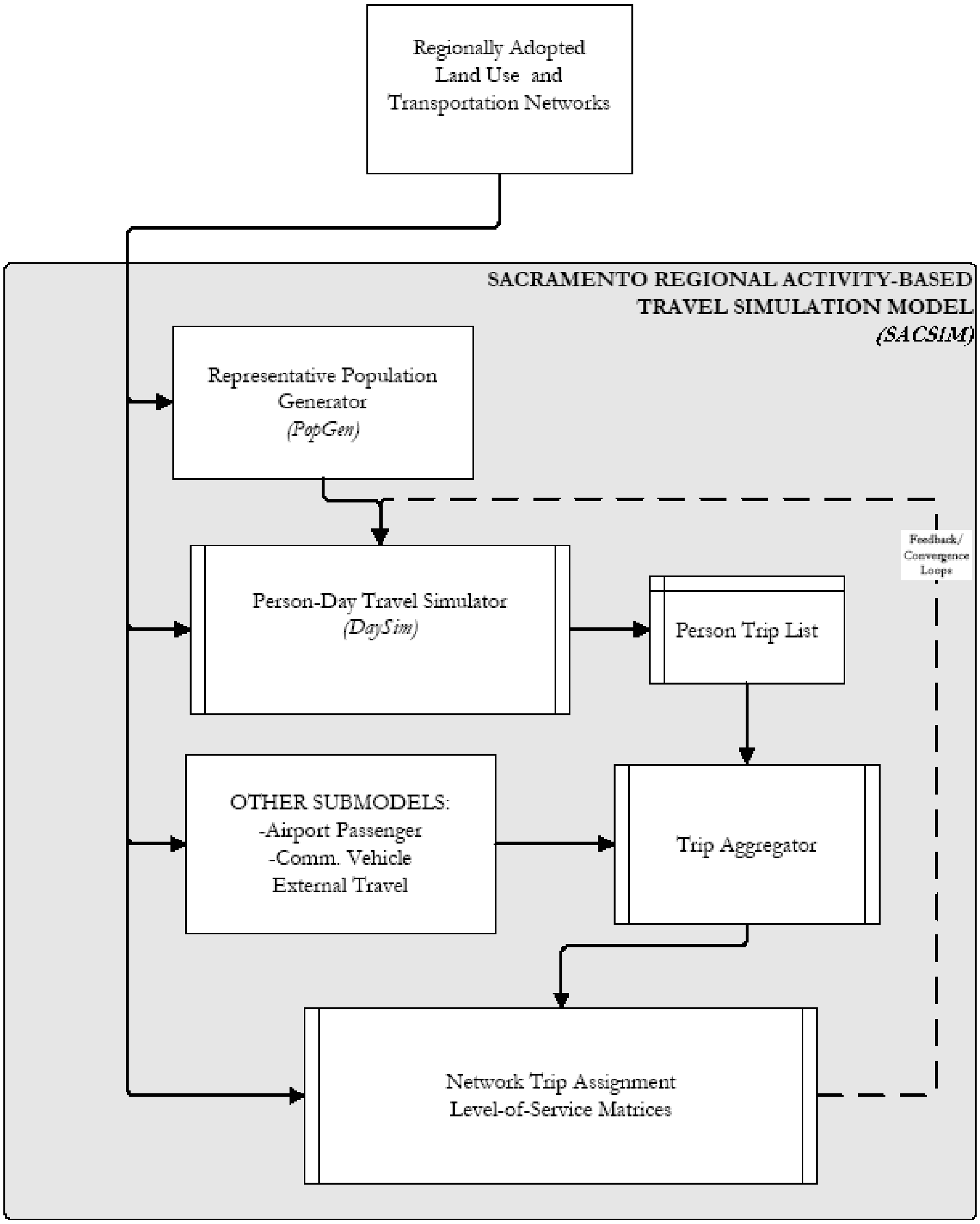
DAYSIM also explicitly treats time. Durations of activities and travel times are constrained by the length of a day, and travel choices as modeled account for time explicitly in 30 minute blocks. Most conventional four-step models actually model a complete day's travel as a number of trips, with those trips blocked into times post-hoc, using fixed time factors or aggregate "choice" models.

No other submodel within SACSIM is a true simulation. The airport passenger ground access model is a pseudo-simulation, with the model applied by enumerating the actual passenger survey database. The remaining submodels (commercial travel, external travel) are applied to TAZ's as the unit of analysis, and treat time post hoc through fixed factors.

When many transportation professionals hear transportation simulation what they think of is one of the increasingly prevalent traffic operations simulations, which show cars, or in some cases, cars, transit vehicle, and pedestrians, in animations. Some of the animations have vivid detail, e.g. three-dimensional vehicles and people, set in a world with buildings, streets, and even street fixtures and furniture shown in 3-D. SACSIM is NOT this sort of simulation. In fact, SACSIM skims and assigns trips in same old, TAZ-based, static way that is used by conventional four-step travel demand models. DAYSIM simulates the demand for travel, but the actual assignment of that demand to highway and transit networks is not simulated.

[1] Webster's Ninth New Collegiate Dictionary, Merriam-Webster, 1987.

Figure 2.1 SACSIM Model System



2.2 Hardware and Software Requirements

While SACSIM files and software are open to the public, it does require specific hardware and software to run. Table 2-1 provides minimum recommended hardware to run SACSIM.

2.2.1 Hardware

Table 2-1 Minimum Hardware Recommendations

CPU Speed	Minimum: 1.5 GHz single core Recommended: 2.0 GHz dual-core or better With Cluster: 2.0 GHz quad-core or better
Processor	Minimum: Intel Pentium 4, AMD Athlon Recommended: Intel Core i5, i7, Xeon or better; AMD Phenom II, Athlon II, FX-Series, A-Series APU or better
Memory/RAM	1 GB minimum; 4 GB or higher recommended With Cluster: 2 GB per core recommended
Hard Disk	Minimum: ATAPI IDE; 5,400 rpm Recommended: SATA 3 Gb/s or 6 Gb/s; SAS; 7,200 RPM or better; SSD
Hard Disk Space	10 GB for the application and supporting applications and data (like GIS)100+ GB for output files
Screen Resolution	Minimum: 1024 x 768 at Normal size (96dpi); 16-bit color depth Recommended: 1440 x 900 or higher at Normal size (96dpi); 32-bit color dept
Video/Graphics Adapter	Minimum: 24-bit capable graphics adapter; 64 MB video memory Recommended: 32-bit capable graphics adapter; 512 MB or more video memory
Networking Hardwar	100BT or 1000BT TCP-IP compatible Ethernet or Wireless adapter
Peripherals	DVD-ROM drive(1) available USB port, parallel port, ExpressCard slot, or PCMCIA slot for hardware dongle
Operating System	Recommended: Windows 10+
Server Configuration	
CPU Speed	2.0 GHz quad-core or higher; multiple CPUs are ideal
Processor	Recommended: Intel Xeon E3, E5, E7; AMD Opteron 42xx, 43xx, 62xx, 63xx, 83x
Memory/RAM	4 GB minimum; 16 GB or higher recommended, For Cluster: 2 GB per core recommended
Hard Disk	Recommended: SATA 3 Gb/s or 6 Gb/s; SAS; 7,200 RPM or better; SSD
Hard Disk Space	10 GB for the application and supporting applications and data (like GIS)100+ GB for output files

Source: SACOG 2025. Hardware recommendations based primarily on Bentley (formerly Citilabs) Cube Base Reference Guide Recommended workstation and server configurations for Cube Base Version 6.4.4.

2.2.2 Software

SACOG staff uses a variety of software applications to develop, run, and analyze SACSIM. The section is broken out into two primary categories. Required software is necessary to run SACSIM. Nonrequired software is additional software that SACOG staff use to develop and maintain SACSIM, however the model does not explicitly need any of these to be run.

2.2.2.1 Required Software

Operating system

Microsoft Windows (64-bit version), such as Windows 11.

Cube Software

Cube is a proprietary software package, which is produced, licensed, and marketed by Bentley Systems. Inc. Thus, to run the regional travel model, you will need to purchase the Cube software from Bentley. At the time of this writing, SACSIM23 has run on Cube version 6.5.x

Cube Voyager
Cube Voyager is the numerical engine that powers the Cube suite of software and includes its own proprietary scripting language.

Cube Cluster
Cube Cluster is also part of the Cube software package used for distributed processing, by running processes across multiple cores. Cube cluster significantly reduces model run times. If not available, Cube clustering can be turned off in SACSIM script, but model run time will significantly increase and this is not recommended.

DAYSIM
DAYSIM a travel demand microsimulation software package that works in conjunction with network modeling software packages to forecast a population's response to changes in transport infrastructure and policy. DAYSIM uses an integrated system of discrete choice models to simulate long term choices for each household, and the activity and travel choices for a 24-hour period for each household member. It uses 48 half-hour time periods across the day as the basic units of temporal resolution, and uses either individual parcels of land or block-sized microzones as the basic units of spatial resolution. DAYSIM is licensed under an open source license.

2.2.2.2 Nonrequired

Cube Base
Cube Base is the network Graphic User Interface (GUI) part of the Cube software package. While this is not technically needed to run SACSIM, it is strongly recommended and is needed to make any edits to the network variables and visualize any SACSIM model run results.

ArcGIS
ArcGIS is an ESRI platform for organizations to create, manage, share, and analyze spatial data. It consists of server components, mobile and desktop applications, and developer tools. SACOG staff uses various desktop and developer tools to develop and display SACSIM data. ESRI GIS platforms may also be used to display the modeling spatial datasets.

PopulationSim
PopulationSim is an open platform for population synthesis. More information on installation and usage can be found here (https://activitysim.github.io/populationsim/)

Python
Python is an open source interpreted, high-level, general-purpose programming language. SACOG staff use to preform general data processing and analysis tasks. It is also required for running PopulationSim

R
R is a open source language and environment for statistical computing and graphics, providing data manipulation, calculation, and graphical display.

2.3 Model Inputs

2.3.1 Scenario

Table 2-2 lists the files required for each model scenario folder.

Table 2-2 SACSIM Input File Descriptions for Scenario Folder

Folder	File Name	Type	Description
scenario_folder (can be any name)	SACSIM_Run.s (Can be any name)	Cube Voyager Script	SACSIM Cube Voyager primary script for model.
scenario_folder (can be any name)	config.sacsim.trips.xml	Trip Configuration File	User input control file for DAYSIM configurations.
scenario_folder	config.sacsim.wkscloc.xml	Work Location Configuration File	User input control file for DAYSIM configurations.
scenario_folder	tolls.csv	Toll Facility Cost Input File	User input controls for dynamic tolling during assignment.
Scenario_folder	transit_lanes.csv	Transit lane configuration	Specify types of transit lane deployments
scenario_folder	RAD_UserFee.csv	Mileage Based Fee Input File	User input for spatial adjustments for mileage based user fie.
scenario_folder	<year>_thru.dbf	Landuse/transportation	Through trips
scenario_folder	<year>_taz.dbf	Landuse/transportation	Transportation analysis zones
scenario_folder	<year>_ixxi.dbf	Landuse/transportation	Internal (i) external (e) production and attractions
scenario_folder	<year>_base.net	Landuse/transportation	Roadway network
scenario_folder	<year>_tranline.txt	Landuse/transportation	Transit line
scenario_folder	<year>_transit_links.csv	Landuse/transportation	Transit network
scenario_folder	<year>_station_links.csv	Landuse/transportation	Transit station nodes
scenario_folder	<year>_pnr.dbf	Landuse/transportation	Park-and-ride nodes
scenario_folder	<year>_raw_person.txt	Landuse/transportation	Person inputs
scenario_folder	<year>_raw_household.txt	Landuse/transportation	Household inputs
scenario_folder	<year>_raw_parcel.txt	Landuse/transportation	Parcel inputs

Source: SACOG 2025.

2.3.2 Input

Table 2-3 lists the files in the "input" folder. The "input" folder sits in the parent directory of each model run scenario folder and contains higher-level inputs.

Table 2-3 SACSIM Input File Descriptions for Input Folder

Folder	File Name	Type	Description
input	airportsurvey.dbf	Airport module input	Airport survey input for SACSIM airport module
input	Ptfactor.mustcom.txt	Transit input	Sub transit mode control file: commuter buses
input	Ptfactor.mustlrt.txt	Transit input	Sub transit mode control file: light rail
input	Ptfactor.onlyloc.txt	Transit input	Sub transit mode control file: local bus
input	Ptfactor.txt	Transit input	Transit all mode control file
input	Ptfare.txt	Transit input	Transit fares for all modes
input	Ptsystem.txt	Transit input	Transit wait curves by sum mode and operator
input	sacfftpp.txt	IXXI input	Friction Factors input by trip type
input	todfactors.txt	IXXI input	Time of day factors by trip type

Source: SACOG 2025

2.3.3 DAYSIM

Table 2-4 lists the files needed in the DAYSIM folder. The DAYSIM folder sits in the parent directory of the scenario folder and contains parameter and coefficient files related to the DAYSIM submodel.

Table 2-4 SACSIM23 Input File Descriptions for DAYSIM Folder

Folder	File Name	Type	Description
DAYSIM	sacog_roster.combinations.csv	Roster	DAYSIM Mode Roster
DAYSIM	sacsim_roster_mat.csv	Roster	DAYSIM Input Roster
DAYSIM	sacog_taz_indexes.dat	TAZ	
DAYSIM	WorkLocation_2021v3c.F12	Coefficients Files	
DAYSIM	SchoolLocation_2021v3B.F12	Coefficients Files	
DAYSIM	PayToParkAtWorkplaceCoefficients_SACOG-v1.5.F12	Coefficients Files	
DAYSIM	TransitPassOwnership_2021v3.F12	Coefficients Files	
DAYSIM	AutoOwnership_2021v3.F12	Coefficients Files	
DAYSIM	IndividualPersonDayPattern_2021v3B.F12	Coefficients Files	
DAYSIM	PersonExactNumberOfTours_2021v3.F12	Coefficients Files	
DAYSIM	WorkTourDestination_2021v3B.F12	Coefficients Files	
DAYSIM	OtherTourDestination_2021v3.F12	Coefficients Files	
DAYSIM	WorkBasedSubtourGeneration_2021v3.F12	Coefficients Files	
DAYSIM	WorkTourMode_2021v3.F12	Coefficients Files	
DAYSIM	SchoolTourMode_2021v3.F12	Coefficients Files	
DAYSIM	WorkBasedSubtourMode_2021v3.F12	Coefficients Files	
DAYSIM	EscortTourMode_2021v3.F12	Coefficients Files	
DAYSIM	OtherHomeBasedTourMode_2021v3.F12	Coefficients Files	
DAYSIM	WorkTourTime_2021v2.F12	Coefficients Files	
DAYSIM	SchoolTourTime_2021v2.F12	Coefficients Files	
DAYSIM	OtherHomeBasedTourTime_2021v2.F12	Coefficients Files	
DAYSIM	WorkBasedSubtourTime_2021v2.F12	Coefficients Files	
DAYSIM	IntermediateStopGeneration_2021v3.F12	Coefficients Files	
DAYSIM	IntermediateStopLocation_2021v2.F12	Coefficients Files	
DAYSIM	TripMode_2021v2.F12	Coefficients Files	
DAYSIM	TripTime_2021v2.F12	Coefficients Files	

Source: SACOG 2025.

2.4 Model Outputs

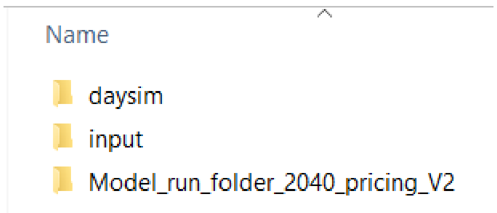
Refer to Appendix C DAYSIM Reference Guide, which contains DAYSIM data tables describing required inputs, intermediate files and outputs such as output person, households, tours and trip tables.

Other SACSIM output files include loaded Cube trip skim matrices, loaded highway network files by time period, roadway pricing costs, and Transit summaries. Further information on these outputs is in Chapter 6 Highway Networks, Chapter 7 Transit Networks, and Chapter 9 Auto Operating Costs, Pricing, and Transit Fares.

2.5 Preparing a Model Run

This section is to provide practitioners of SACSIM how to set up the SACSIM input structure to create a scenario to run. The scenario requires three subfolder directories as shown in Figure 2-2. Section 2.3 above provides names and descriptions of the required files. If multiple scenarios have the exact same input DAYSIM and input folder files, which is common for multiple scenarios using the same scenario forecast year, you can create multiple scenario folders in the same directory to call the same set of DAYSIM and input files. Each scenario will require its own SACSIM run script (.s file) and associated inputs.

Figure 2.2 SACSIM Run Folders



2.5.1 Model Run Scenario Structure

The following figures represent examples of a model file and folder structure ready to be run. For more information on files review model inputs section above and Appendix C DAYSIM Reference Guide for descriptions, requirements and file type information.

Figure 2.3 Example Scenario Input Folder Setup

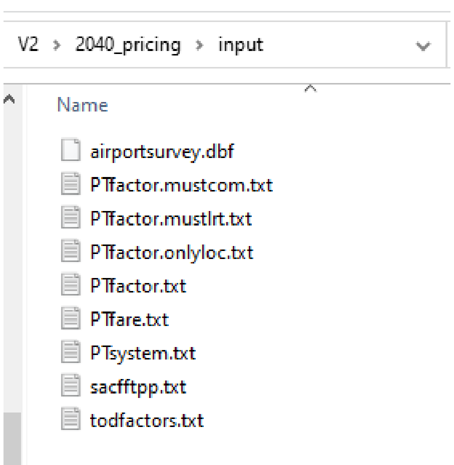


Figure 2.4 Example Scenario DAYSIM Folder Setup

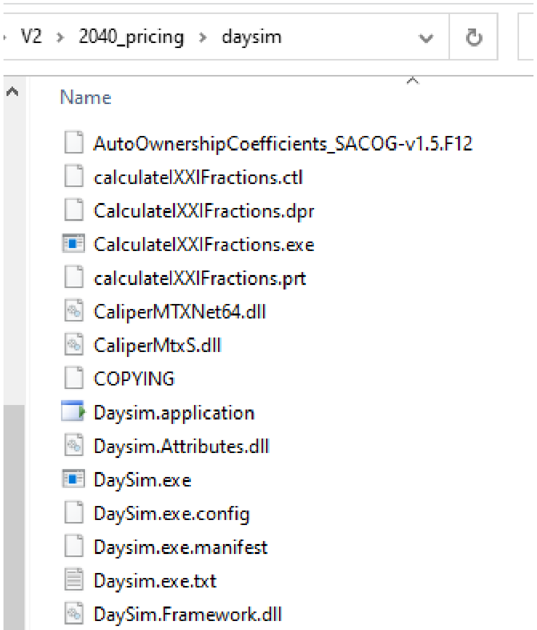
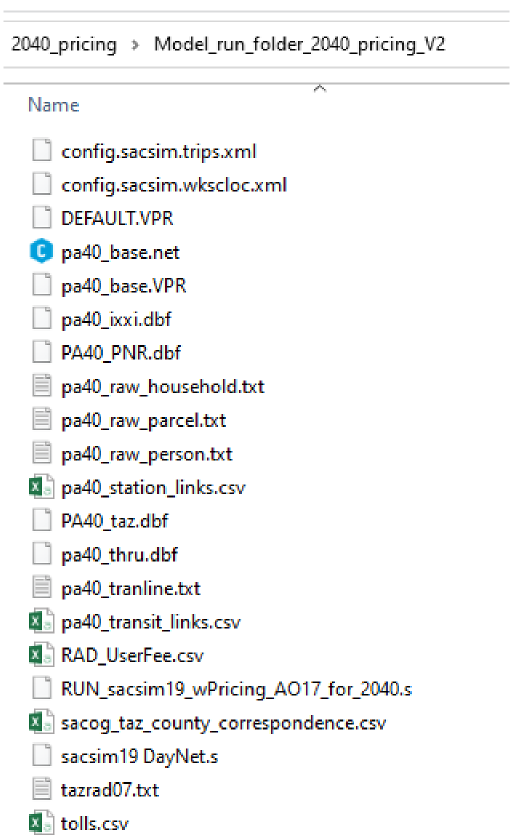


Figure 2.5 Example Scenario Run Folder Setup



2.5.2 Setup for Model Run Pricing Parameters

It's important to understand and check the following scenario files to determine if a baseline, mileage-based user fee, and/or managed or toll lane pricing scenario is setup in the input structure. Further details on costs, fees and pricing can be found in Chapter 9.

2.5.2.1 Setup Mileage Based User Fee

SACSIM run script

To incorporate pricing alternatives into SACSIM's utility cost of travel function, SACSIM breaks out auto cost, typically referred to as the "Cost of Driving" and a separate mileage-based user fee. This is a model feature that can be turned on or off by the user based on a few input parameters. Figure 2-6 illustrates variables in the SACSIM model run script to update mileage-based user fee and auto operating cost. For example, if a model run is testing a mileage-based user fee compared to today's state gas tax, the user would need to factor in the reduction by subtracting a portion of the auto cost per mile input. Therefore, if Mileage Based User fee is tuned off, variable *"userfee_per_mile"* is equal to zero. If Mileage based user fee variable turned on, "userfee_per_mile" is equal to a value greater than zero. Important Note: all auto operating costs need to be converted to year 2000 dollars for model input. Further description on SACSIM pricing implementation is in Chapter 9.

Figure 2.6 SACSIM Auto Cost and User Fee Inputs

```
;======================================================================

;Set per-mile auto operating cost here
auto_cost_per_mile = 0.1810
userfee_per_mile =   0.008
```

Spatial and Time Period Fee Adjustments

In addition to a mileage-based user fee, spatial and temporal components can be set using the RAD_Userfee.csv input file in the Scenario run folder. Table 2-5 describes the four inputs in the RAD_Userfee.csv required and an example with and without the mileage-based fee adjustments. Figure 2-7 shows an example of the RAD_Userfee.csv.

Table 2-5 Spatial and Temporal Mileage-Based Fee Adjustment

Header (Not in actual file)	RAD	Multiplicative Factor	Peak Adjustment	Off Peak Adjustment
Required input description	Regional Analysis Distract Spatial Geography where factor will apply to roadways. **Default is all RAD Zones within region.**	Factor used to multiple userfee_per_mile input. **Default is 1.**	Peak congestion rate adjustment factor applied to AM (7am-10am) and (4PM – 6PM) peak hours. **Default is 0.**	Off Peak period discount rate during non-congested times applied to Evenings (7-9), Nighttime (10-5am) and Midday. **Default is 0**
Example Spatial Adjustment **Turned On**	1	2	0.007	-0.007
Example Spatial Adjustment **Turned Off**	1	1	0	0

Source: SACOG 2025.

Figure 2.7 RAD_Userfee.csv Example

26	26	1	0.007	-0.007
27	27	2	0.007	-0.007
28	28	1	0.007	-0.007

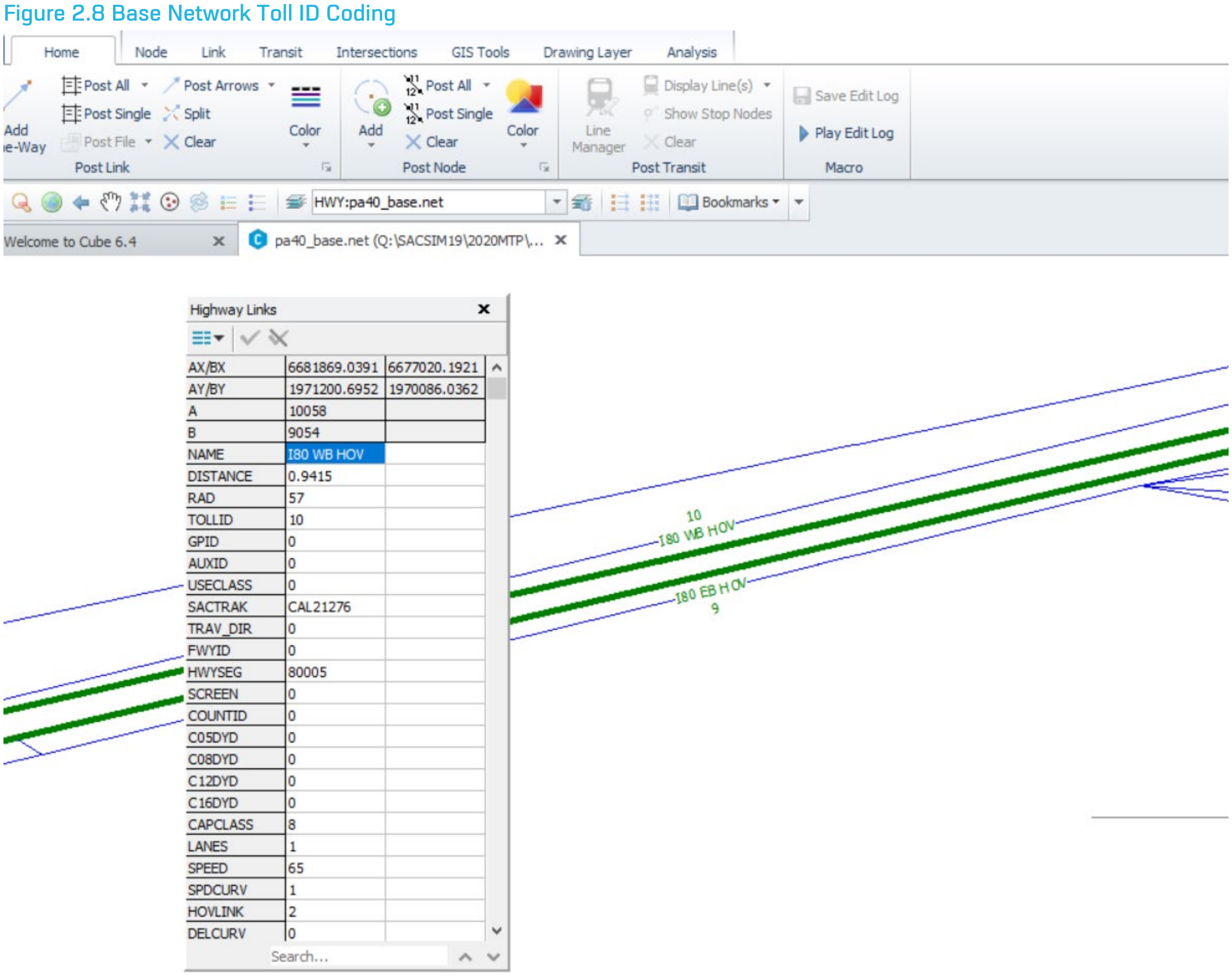
RAD_UserFee

2.5.2.2 Setup Managed Lanes Tolling

Base Scenario Model Network

A scenario's model highway network is typically named **<scenario year>_base.net.** Every priced facility must have a TOLLID number associated. For parallel general purpose and auxiliary lanes, the same ID number must be assigned to GPID (general purpose lanes) and AUXID (auxiliary lanes). This is used to determine the cost of the managed facility relative to the congestion on the parallel "free" facilities. Depending on the type of managed lane, USECLASS must also be set with a value of 0, 2, or 3 to determine the allowed vehicle type on the managed facility. Zero allows all users to drive on the facility being priced, 2 allows only vehicles with 2 or more passengers, while 3 allows only vehicles 3+ passengers. Note, USECLASS does not determine which vehicles are priced; it just determines which vehicles are allowed to use the facility. Prices are set in the Toll Input File described below. Figure 2-8 shows an example of a managed lane facility coding on the base network. In this example all vehicle types are allowed on the managed lane facility.

Figure 2.8 Base Network Toll ID Coding



AX/BX	6681869.0391	6677020.1921
AY/BY	1971200.6952	1970086.0362
A	10058	
B	9054	
NAME	I80 WB HOV	
DISTANCE	0.9415	
RAD	57	
TOLLID	10	
GPID	0	
AUXID	0	
USECLASS	0	
SACTRAK	CAL21276	
TRAV_DIR	0	
FWYID	0	
HWYSEG	80005	
SCREEN	0	
COUNTID	0	
C05DYD	0	
C08DYD	0	
C12DYD	0	
C16DYD	0	
CAPCLASS	8	
LANES	1	
SPEED	65	
SPDCURV	1	
HOVLINK	2	
DELCURV	0	

Toll Input Cost File

The TOLLID coded on the network identifies the toll segments. The costs by vehicle type then need to be associated and defined to the network toll segments. This is done in the Toll Input Cost File **tolls.csv.** Each row represents a unique TOLLID segment by time period. For every tolled segment there will be nine additional rows added to the input file (1 TOLLID X 9 SACSIM time periods). The user must specify initial, minimum, and maximum values for each row for each of the four modes:

- drive alone,
- SOV2,
- SOV3+,
- commercial vehicle.

Table 2-6 shows an example of how the Toll Input Cost File may look. If a scenario requires no toll pricing, Inputs columns 4-22 should all be set to zero. For more information, review Chapter 9 on Roadway and Mileage Based Pricing.

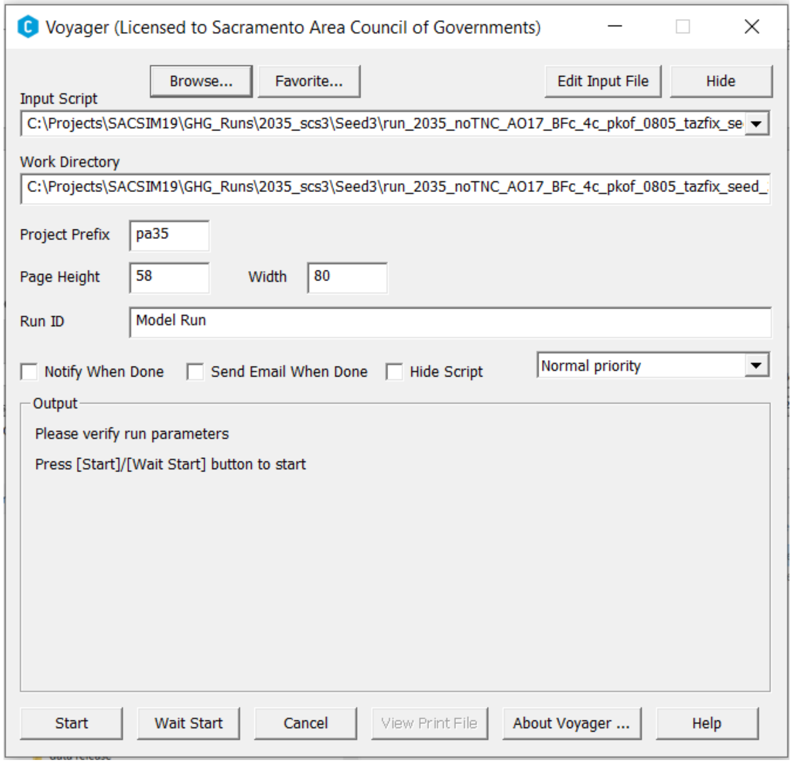
Table 2-6 Toll Cost Input Example

Fac. Index	Seg.	Per.	Fac. Type	Adjust	Toll DA	Toll S2	Toll S3	Toll CV	Min DA	Min S2	Min S3	Min CV	Max DA	Max S2	Max S3	Max CV	Reversable Lane AM	Reversable Lane PM	Shoulder lane AM	Shoulder lane PM	Take a Lane AM	Take a Lane PM
101	1	1	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
102	1	2	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
103	1	3	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
104	1	4	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
105	1	5	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
106	1	6	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
107	1	7	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
108	1	8	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
109	1	9	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0

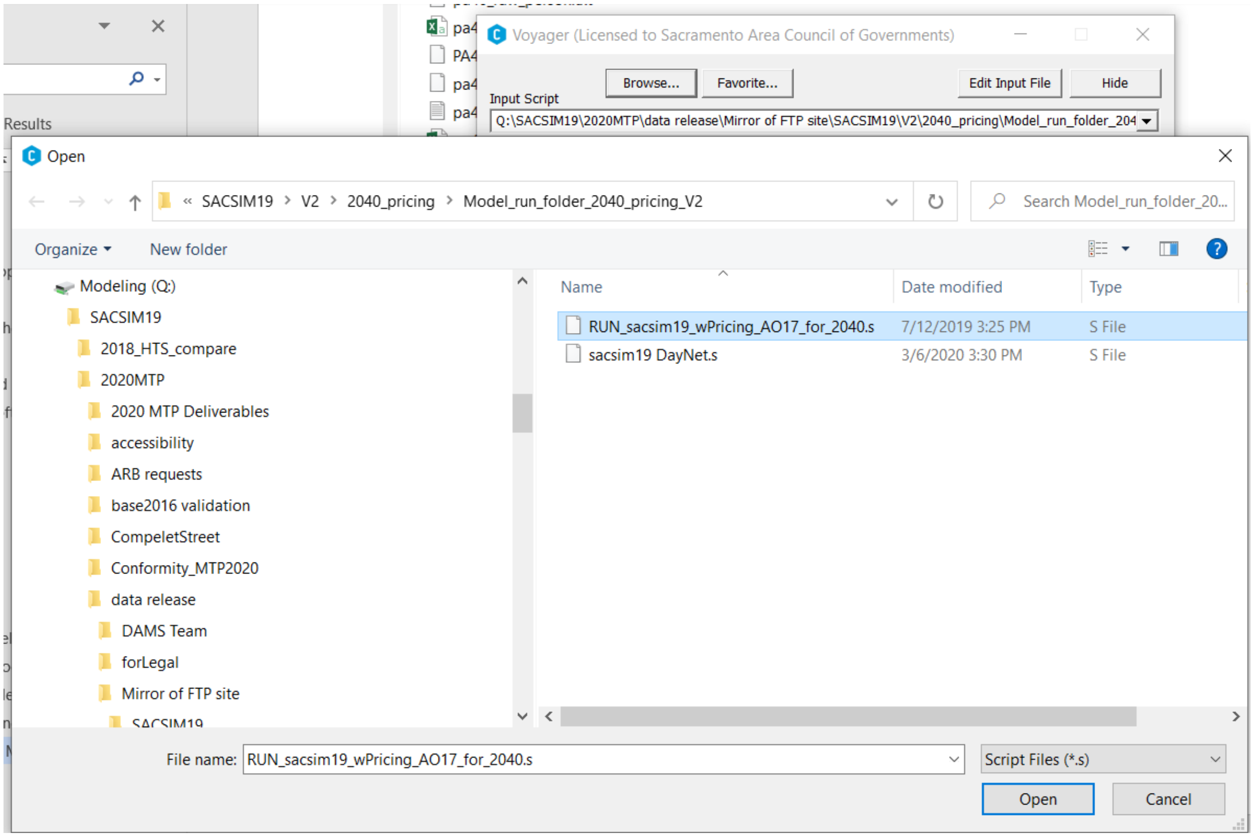
Source: SACOG 2025.

2.5.3 Start Scenario Model Run with Cube Voyager

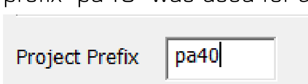
1. Open Cube Voyager Application



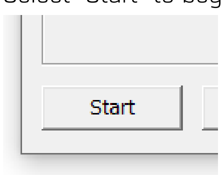
2. Select Browse and navigate the SACSIM model run script in Scenario folder created.



3. Check Prefix matches with files structure. For example, for an MTP update's modeling scenarios, the prefix "pa40" was used for all input files using Cube special "Token" inputs in naming



4. Select "Start" to begin model run.

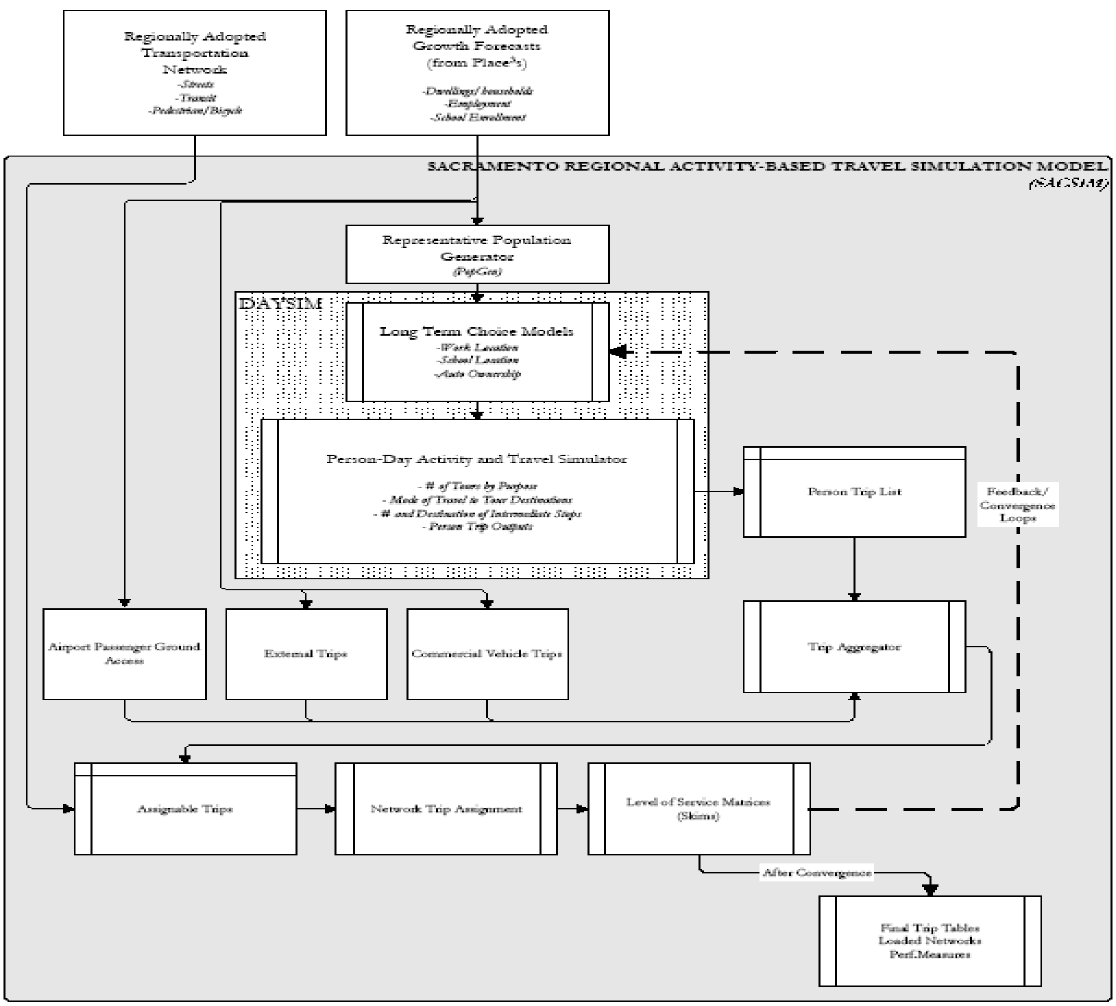


3 Model Structure

This chapter will expand upon the model concepts and parameters from Chapter 2 and describes the theory and relationships between submodels of SACSIM. The overall SACSIM model system is illustrated in Figure 3-1 below. Each submodel captures a component of travel behavior. The key submodels are:

3.1 DAYSIM – Person Day Activity-Based Tour Simulation Model
3.2 Commercial vehicle travel
3.3 External travel
3.4 Airport passenger ground access
3.5 Vehicle trip table preparation and assignment
3.6 Transit path building and assignment

Figure 3.1 SACSIM Model Structure



3.1 DAYSIM - Person Day Activity-Based Tour Simulation

DAYSIM is a regional activity-based tour (ABT) simulator for the intra-regional travel of the region's residents only. ABT models seek to represent a person's travel as it actually occurs: in a series of trips connecting activities which a traveler needs or wants to participate in during a day. DAYSIM has been re estimated based on the 2018 SACOG Household Travel Survey. Technical details of the models are provided in the Appendix A DAYSIM Users Guide for complete list of Coefficients and Appendix C DAYSIM Reference Guide for more details on latest updates.

3.1.1 DAYSIM Terminology and Concepts

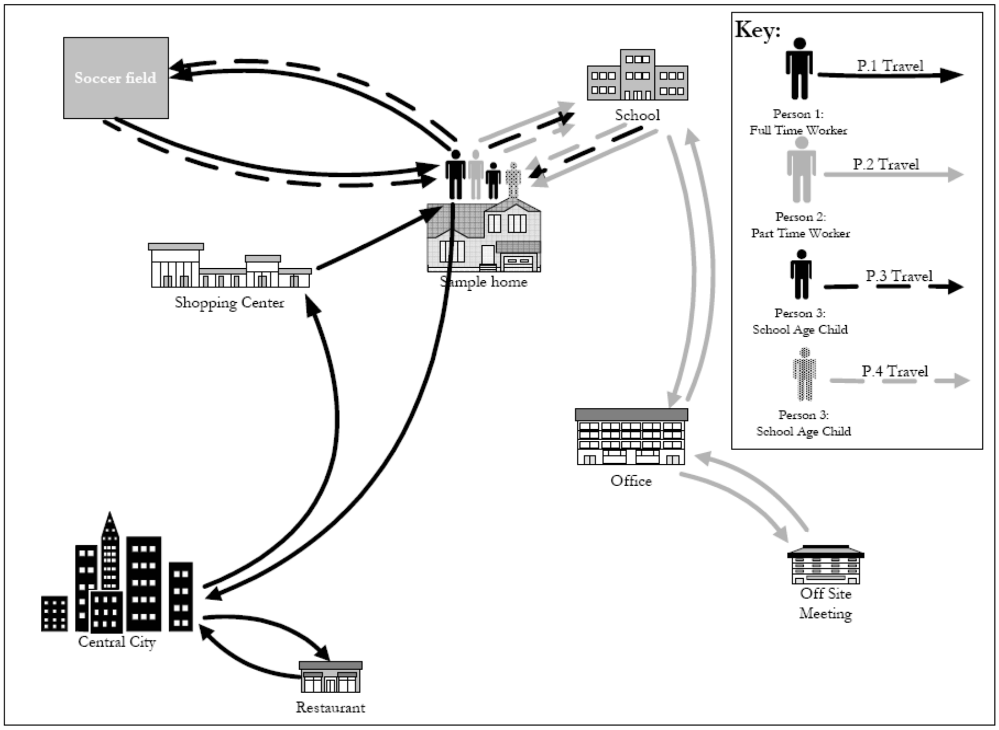
The specific definitions of *activities* and *tours* as used in this documentation are as follows:

> *Activities* are the things that people do during the course of the day, either to meet basic needs or for pleasure. The range of activities which people engage in is nearly infinite. For purposes of DAYSIM, activities are simplified into a set of seven generic categories, as follows:
>
> - Work (full time or part time)
> - School (K12, college, university, or other education)
> - Personal Business (e.g. medical appointment)
> - Shopping
> - Meal (i.e. having a meal outside of the home)
> - Social/Recreational (e.g. going to health club, visiting a friend or family member)
> - Escort (i.e. accompanying another person to an activity they are engaging in, e.g. a parent driving a child to school)
> - Home (any activity which takes place within the home)

Tours are series of trips which a person does from their home to engage in one of the above activities. A single tour is all the activities and travel one person does between leaving home and returning home. Each person in a household may engage in one or more activities during a single tour. Also, each person may make no tours (i.e. stay at home all day), or they make many tours. A tour may be very simple, consisting of as few as two trips (i.e. one trip away from home to work, for example, and a return trip home), or it may consist of many trips, with lots of intermediate stops along the way.

Figure 3-2 illustrates a typical set of activities and travel for a sample family of four. Table 3-1 provides a tally of the trips and tours for that sample family. The sample family makes a total of 19 person trips, which are grouped into eight tours. The most complicated tour is that by Person 2, who escorted two children to school, proceeded to work, and returned to pick up children on the way home. This tour included one work-based subtour, with two trips going from work to an off-site meeting, and a return trip to work. Including the subtour, Person 2 made a total of six trips in the course of the work tour. The simplest tours include four with only two trips each, by Person 1 (escort tour for Person 3 to/from soccer), two school tours made by Persons 3 and 4, and a social/recreational tour (to/from soccer) for Person 3.

Figure 3.2 Activities and Travel for a Sample Four-Person Household



Source: SACOG 2025.

Table 3-1 Trips and Tours for Sample Four-Person Household

Trip Origin/Destination	Person Trips Person 1	Person 2	Person 3	Person 4	Description
Home to Work Work to Shopping Center Shopping Center to Home	X X X				Pers. 1: ***Work Tour*** with 3 trips
Work to Restaurant Restaurant to Work	X X				Pers. 1: ***Work-Based Subtour*** with 2 trips
Home to School School to Office Office to School School to Home		X X X X	X X	X X	Pers. 2: ***Work Tour*** with 4 trips Pers. 3, 4: ***School Tours*** with 2 trips each
Office to Off Site Meeting Off Site Meeting to Office		X X			Pers. 2: ***Work-Based Subtour*** with 2 trips
Home to Soccer Field Soccer Field to Home	X X		X X		Pers. 1: ***Escort Tour*** with 2 trips Pers. 3: ***Soc/Rec Tour*** with 2 trips
Person Trips Person Tours	7 3	6 2	4 2	2 1	**Household Trips: 19** **Household Tours: 8**

Key: X = Person Trip Shaded box = Tour

Source: SACOG 2025.

DAYSIM also distinguishes long term and *short term* choices in representing activities and travel. Long term choices are those which are taken relatively infrequently, and are unlikely to change in the course of a few months or even a year. Short term choices are those which are made quite frequently, and may vary day-to-day for most people. Again, the real number and range of choices which might be *long term* or *short term* in nature for any individual or household is nearly infinite. Additionally, each household makes choices on many different timeframes, not just long or short term. DAYSIM simplifies these choices to a relatively limited number:

Long term choices:

- Household automobile availability (i.e. the number of vehicle owned and available for use by a household)
- Usual work location for each worker (i.e. the location where a worker normally reports for work, for each worker)
- Usual school location (i.e. the location where a student normally goes to school, for each student)

Short term choices:

- The number and type of tours made by each person
- The main destination of each tour
- The main mode of travel for each tour
- The arrival and departure times for each activity on each tour
- The number and purpose of intermediate stops made on each tour
- The location of each intermediate stop
- The mode of travel for each trip segment on each tour
- The arrival and departure time for each intermediate activity on each tour

DAYSIM places these choices in a hierarchy, with the highest-level choices being the long term choices, and the lowest level being the short term choices.

Other DAYSIM terms are:

> *Locations vs. destinations*—In DAYSIM, the terms location and destination both refer to parcels. Usually, in DAYSIM documentation, the term location is associated with long term choices, like usual workplace, or to intermediate stops on tours. *Destination* usually refers to the main place that a traveler chooses on any given tour. For example, the usual workplace location is the place a worker usually reports for work. However, on any given day, that worker may report to another place for their work tour destination. For most workers, the usual work location and the work tour destination on any given day are one-in-the-same.
>
> *Tour purpose*—tours are "branded" by the main activity which is engaged in during the tour. Given that multiple activities of different sorts occur during some tours, this branding requires that a hierarchy of activity purposes be established, with the tour branded by the highest-level activity engaged in on the tour. Tour purposes are keyed to the seven of the eight categories of activities defined above[2] , with the following hierarchy:

[2] "Home" activities are not used for classifying tour purpose, since every tour has a home end. Tours are classified only by the non-home activities which are engaged in by the tour-maker.

- Work
- School
- Escort
- Personal Business
- Shop
- Meal
- Social/Recreational

Tour destination—the parcel selected as the destination for the main activity on the tour. If there are two or more activities along the tour with the same, highest priority tour purpose, then the location of the activity with that purpose of the longest duration is designated as the tour destination, often referred to as the "primary" destination.

Half-tour—the trips from home to the primary destination of the tour, or the trips from the primary destination of the tour to home.

Person type—in reality, the variety of activities that any person engages in, and the degree to which any single activity typifies an individual, is highly complex and variable, with practically infinite possible classifications. DAYSIM uses many person and household characteristics to capture differences in activity and travel preferences. One useful composite variable used extensively to classify persons for purposes of estimating and applying the DAYSIM models is the person type:

- Full-time worker (more than 32 hours worked)
- Part-time worker (less than 32 hours worked)
- Non-worker, aged 65 years or older
- Other non-worker, non-student adult
- College/university student (full time student)
- Grade school student aged 16 years or older (i.e. driving age)
- Grade school student aged 5-15 years
- Child aged 0-4 years

Intermediate stop—places (parcels) on a half-tour where a person stops to engage in activity other than the activity at the main destination. Examples of intermediate stops in the sample household (Figure 3 2) are the stop at the shopping center on the way from work to home by Person 1.

Day pattern—The overall number of tours made by a person, the combination of purposes of those tours, and the purposes of intermediate stops on those tours, constitutes the *day pattern* for that person. Participation in tours and intermediate stops of the seven purposes is predicted for each person. This set of predictions is referred to as the day pattern. The exact numbers of stops on tours is predicted by lower level choice models.

Random seed and Monte Carlo selection process—Choice models predict probabilities of selecting each of several options, based on the characteristics of the person choosing and the relative attractiveness of the options available to that person. Aggregate models (not DAYSIM) utilize those probabilities by splitting the choices to all members of the applicable segment of the population according to the probabilities. E.g., if a mode choice model predicted a probability of 0.20 of using transit and 0.80 of using automobile for a particular segment with 100 persons, 20 of the persons would be assigned to transit and 80 to automobile. Person level simulations (including DAYSIM) require another process to allocate individuals to particular choices at the person level. In DAYSIM this is accomplished by assigning a random seed[3] to each possible outcome for each person. Monte Carlo selections are made based on the predicted probabilities and the random seed. For example, if a person's choice probability is 0.20 for the first of two possible outcomes in a choice situation, and their random seed for that choice is 0.20 or less, then the simulator assigns the first outcome to that choice for that person. This is the source of a unique characteristic of simulation models: random variation in result for exactly the same input files and processing, arising from differences in the random seeds from one run to the next. This issue will be revisited in the Sensitivity Testing appendix.

[3] The random seed is a real number between 0 and 1, assigned randomly to each individual in the representative population.

3.1.2 DAYSIM Structure and Flow

DAYSIM is structured as a series of hierarchical or nested choices models. The general hierarchy places the long-term models at the top of the choice hierarchy, and the short-term models at successively lower levels in the hierarchy. The detailed hierarchy and flow through the model are illustrated in Figure 3-3. Note that the general flow is down from the long-term models to the short-term models. Moving down from top to bottom, the choices from the long-term models influence or constrain choices in lower level models. 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 addition to these direct influences, utilities from lower level models flow upward to higher level models, too. Logsums of tour destination and tour mode affect other short-term models, as well as the upper level, long-term models. Some of the logsums from lower level models are aggregated for use in the long-term models, in order to reduce the computational load of using true logsums in such a complex nesting structure. The details of the process of utilizing logsums both "upward" and "downward" in the overall model structure is described in more detail in the DAYSIM Standard Technical Documentation[4], and in other published work[5,6]. Figure 3-3 provides more detail on the upward and downward flow of logsums and other variables in the location and destination models.

[4] Available at https://github.com/RSGInc/DaySim/wiki.
[5] Bowman, John L. and Bradley, Mark A., "Upward Integration of Hierarchical Activity-based models or Sensitivity to Impedance and Spatial Attributes in Activity Based Models", January 17, 2006.
[6] Bowman, John L., Bradley, Mark A., and Gibb, John, "The Sacramento Activity-based Travel Demand Model: Estimation and Validation Results", presented at the 2006 European Transport Conference, September 2006.

Figure 3.3 DAYSIM Structure and Flow

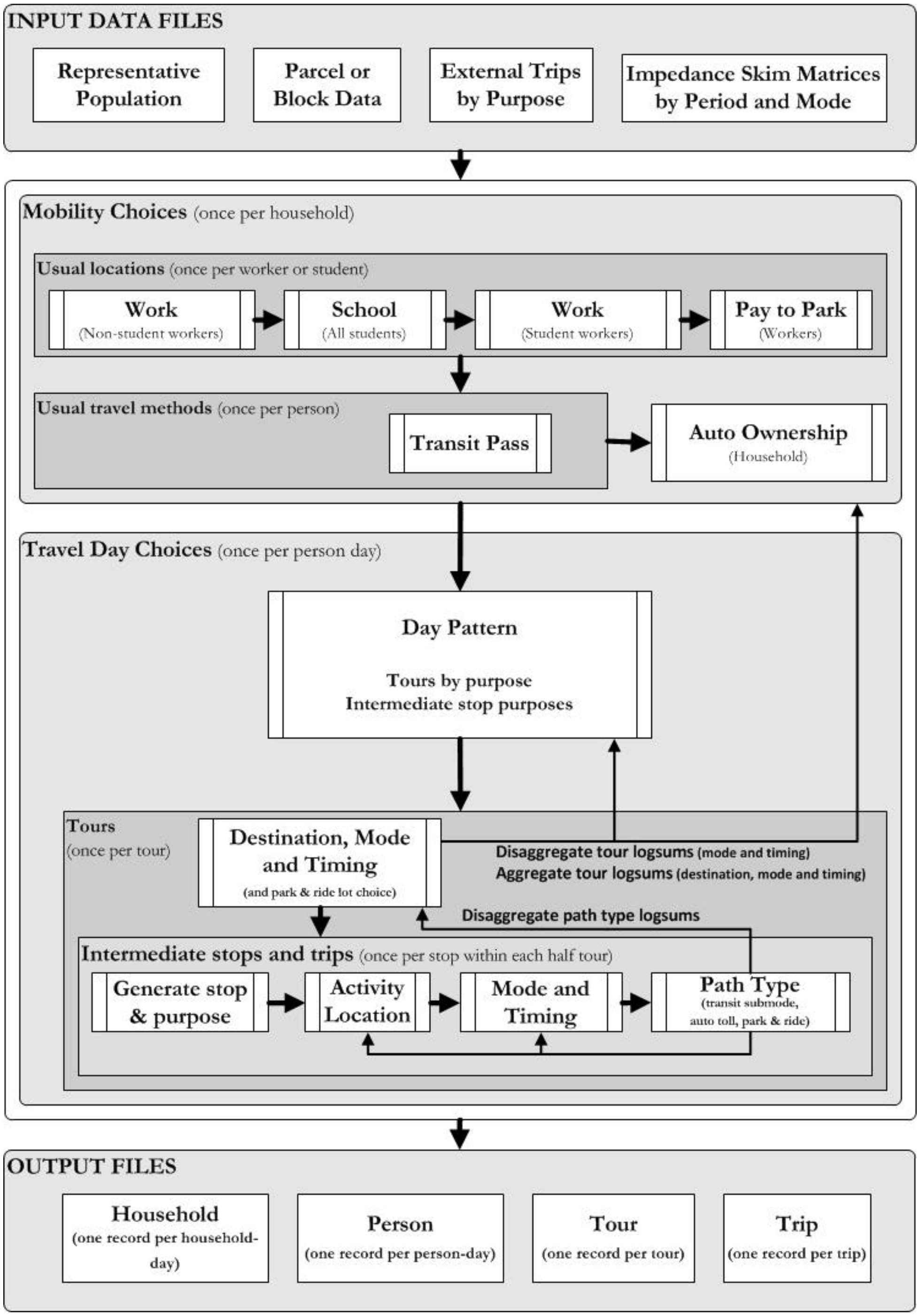


Table 3-2 Utility Function Variables in the Location Choice Models

Attributes	Models			
	Usual work location	Work tour destination	Usual school location	Non-work tour destination
Binary Choice				
Choice between...	...home vs. other	...usual vs. other	...home vs. other	n/a
Constants	By person type	By person type & tour type	By person type & HH size	
Disagg. Logsum For Usual Locations	Yes	Yes	Yes	
Conditional MNL choice among regular locations				
Disaggregate Mode Choice Logsum to Destination	Yes	Yes	Yes	Yes
Piecewise Linear Driving Distance Function	For full-time workers		For children under age 16	By Purpose Priority Pattern type
Natural Log of Driving Distance	For other then fulltime workers by person type & income	By person type & tour type	For persons age 16+ by person type	By tour type, Income, person type & time available
Distance from Usual Work Location		Yes	For not-student-aged	
Distance from Usual School Location	For student-aged	For student-aged		Yes
Aggregate Mode+Dest Logsum at Destination	By person type	By person type	By person type	By purpose
Parking and Employment Mix	For daily parking in parcel and in TAZ	for daily parking in parcel and TAZ		For hourly parking in parcel and TAZ by car availability
Ratio of "Good"-to-Total Intersections	Yes	By car availability		By car availability
Employment, Enrollment and Households by Category	By person type & income	By person type & income	By person type	By purpose (and by 'kids-in-household' for escort tours)
Zonal density	Yes	Yes	Yes	Yes
Parcel size	Yes	Yes	Yes	Yes
Person Type Categories in the Models	Full-time worker Part-time worker Not full- or part-time worker	Full-time worker Part-time worker Not full- or part-time worker	Child under 5 Child 5 to 15 Child 16+ University student Not-student-aged	Full-time worker Part-time worker Retired adult Other adult Child under 5 Child 5 to 15 Child 16+ University student

Source: SACOG 2025.

3.1.2.1 DAYSIM Choice Models Overview

Complete list of coefficients are given and annotated in the DAYSIM Users Guide. This section provides some key points for each model, starting from the "bottom" up:

Mode choice models: Mode choice models at the tour and trip levels were estimated using the logsum from the path type model for each mode as a key input. (Note: Upon first pass, this approach appears to be predicting too many long trips for walk, bike and transit, so the models will be estimated using different weights on the time component for those modes.) The use of the new parcel buffer variables also improved the land use effects on mode choice somewhat. The mode-choice models now include a TNC (paid rideshare) alternative with corresponding new variables. To represent deadheading (unoccupied repositioning), equivalent SOV (single-occupant vehicle) trips were added to the assignment; see Section 3.1.2.3.2 for details. Note that EscortTourModeModel does not include a paid-rideshare alternative and is therefore unaffected.

Time of day models: These models were also estimated (and applied) using the generalized logsums from the path type model for each time of day, rather than simply the travel time, enhancing the response to time-of-day pricing. Also, the use of time window variables and availability constraints in these models was improved to ensure that more realistic schedules are simulated.

Location choice models: The new parcel buffer variables were useful in re-estimating neighborhood effects, in combination with the size variable effects. Time window effects and availability constraints were also enhanced. Distance functions were consolidated and simplified somewhat, as recommended by the peer review panel.

Day pattern models: These include the main person-day pattern model, as well as models of work-at-home, the exact numbers of tours, work-based subtour generation, and intermediate stop generation. Notably, the "Work-At-Home" model was newly added to DaySim and was programmed as a "pre-model" to the main Person Day Pattern Model. This means that its coefficients are supplied via new entries in the properties configuration file rather than as a separate coefficient (.F12) file. This Work-At-Home model predicts whether a person works at home for a typical work day and how many hours if the person works at home. The main Person Day Pattern Model has also been updated to use these outputs and to predict whether a person makes a work tour or teleworks from home. These models were re-estimated to include enhanced accessibility logsum effects via the disaggregate and aggregate logsums. Other minor changes to the specifications were carried out as well.

Vehicle availability model: The auto ownership model was re-estimated, taking advantage of new accessibility logsum variables, but otherwise the specification was not changed.

Transit pass ownership model: This is a newly-added binary choice model predicting whether or not each person age 16+ owns a transit pass, as a function of person type, age, employment status, student status, and accessibility by transit from their home, workplace and/or school location. This model was estimated using data from the Seattle (PSRC) region, since this variable was not available in the SACOG 2000 survey data.

Pay to park at workplace model: For each worker, this model predicts whether or not the person has to pay to park at/near their workplace—i.e. that they do not receive free or totally subsidized parking. It is a binary model, mainly a function of income, employment status, and the land use and parking supply around the workplace. If the model predicts that a worker does have to pay, then the parking cost at their workplace is determined by the average daily price for paid off-street parking in the (smaller) buffer around the work parcel. Otherwise, the parking cost is set at 0 (free). This model was estimated on SACOG 2000 survey data.

3.1.2.2 Long Term Choice Models

As mentioned above, three choices are treated as long-term choice models, and are at the top level of the choice hierarchy:

- Usual work location (for workers)
- Usual school location (for students)

- Household auto availability

For persons who are both worker and student, a usual work location and a usual school location are modeled.

3.1.2.2.1 Usual Work Location Choice Model

Usual work location is the top-level model in the DAYSIM hierarchy. Except for auto ownership, logsums from lower level models influence choice; auto ownership logsum flows down to lower level models. Auto ownership is assumed to be conditioned by usual work and school locations, not the other way around. Choice sets are constrained by ratios of maximum travel times reported in the survey; alternatives which meet the time constraints are sampled for the final choice sets. In application, each choice is simulated from a sample of the available alternatives. Work-at-home utilities are determined by constants and person type.

In addition to the constraints applied to choice sets, total work location choices are constrained to TAZ-level total jobs at the work location. In application, this is accomplished by tallying the usual workplace locations to TAZ through the course of the simulation. As TAZs become "filled" they become unavailable in subsequent choices sets. This process effectively fills the equivalent of doubly constraining matrices in a gravity distribution. This accounting process is currently being replaced by a shadow price process.

Level-of-service variables are primarily home-to-work location distance, and three logsums: destination choice, mode-destination choice, and mode choice. Several parking supply and street pattern variables are included: paid, off-street parking supply (+ effect), and the "good" intersection ratio within ¼ mile (+ effect). Density variables split into two primary effects: density of service and education employment, and households (-effect); and other employment density (+ effect). Size variables enter the model at parcel level, and have similar effects by variable as density.

3.1.2.2.2 Usual School Location Choice Model

Structurally, the usual school location choice model is similar to the work location model, but with person types focused on students (K12 and college/university). Because of the strong relationship between usual school location and enrollment at the school site, and the generally shorter trip length associated with school trips, the array of land use variables is simpler compared to the work location choice model. Like work locations, alternative sampling is used in the model application.

For purposes of this model, "college/university" students are students enrolled at University of California at Davis, Sacramento State University, one of the public community colleges, or one of the private colleges or graduate schools. Students enrolled at technical or trade schools are not counted as college/university students.

3.1.2.2.3 Automobile Ownership/Availability choice model

Auto ownership here implies outright ownership, leasing, or availability of an automobile to a household for general use by other means. The submodel includes constants for ownership "choices" of no cars, one car, two cars, three cars, or four-or-more cars. Separate constants for households with one through four-plus driving age persons in the household are included. Other demographic variables relate to life cycle (e.g. presence of retired persons, school age children, or college/university students) or to household income level.

An array of accessibility and land use variables is included. Mode choice logsums to work (for workers) or to school (for students). One logsum formulation compares the mode choice logsum assuming every driver had a car, with that assuming the household owned no cars; as that difference expands (i.e. the difference between having full access to autos and no access to autos expands), the likelihood of the household owning no cars decreases. Proximity of residence to the nearest transit station or stop is included (+ for owning no cars, or for owning less than one auto per driver). The amount of accessible residential service land uses (defined as food, retail, medical, and service employment within ½ mile of the place of residence) is included (also + for owning no cars, and for owning less than one car per driver).

3.1.2.3 Short Term Choice models

Short term choice models include choices which are presumed to be more transitory in nature than usual place of work, usual school location, and auto ownership. These short term choices are: the day pattern for each person; the primary destination for each tour made; the main (but not only) mode of travel for each tour; the scheduling and timing of each activity; and subsequent choices related to the number of intermediate stops on tours, the mode of travel for each trip segment on a tour, and the timing of the trip segments. As described above, logsums from these lower level models (e.g. tour mode/destination choice, tour mode choice, etc.) are included in the upper level, long-term models. The logsums for the upper level models are also available.

3.1.2.3.1 Work at home, Day Pattern and Exact Number of Tours

Work-at-home covers whether a person works at home and, if so, for how many hours. The day pattern consists of the number of tours of different purposes a person makes during the course of a day, plus the numbers of stops made on each tour.

The day pattern submodel consists of seven parts:

- A set of binary choices of making 0 or 1+ tours, and 0 or 1+ stops on tours, for each of the seven tour purposes.
- Constants were estimated for each of seven person types, along with additional coefficients for household composition, income, auto ownership, and land use at place of residence, number of hours work-at-home, and accessibility variables.
- A set of constants for predicting multiple tour+stop purpose combinations (i.e. 1 tour purpose + 1 stop purpose, 1 tour purpose + 2 stop purposes etc.).
- A set of demographic variables and accessibility variables, which affect predictions of the exact number of tour purposes and stop purposes.
- A set of constants for various combinations of multiple tour purposes and stop purposes.

The submodel shows that personal and demographic characteristics strongly influence the number and purpose of tours.

- Work tours most likely by full time workers, less likely by part-time workers, least likely by retired adults, etc.).
- Adults aged 18 to 25 are the most likely of all adults to make a school tour.
- Adults with children of school age are most likely to make escort tours, and females are more likely than males to make escort tours.
- Persons in higher income households are more likely to make tours than those in lower income households.
- Adults who are the only adult in the household are more likely to make more non-work tours.
- Accessibility variables (logsums from lower-level models like tour mode choice, and home-work intermediate stops) generally increase the likelihood of making tours.
- Mixed use density at place of residence increases the likelihood of making shop tourTour Primary Destination Submodel

Tour destination choice occurs below the usual location choices for work and school, so for workers and students (and student-workers), the usual locations of those work and school activities are already modeled. In fact, the tour destination for the majority of these persons for work and school is the usual work or school location. The work tour destination model is structured as a nested choice, with the highest level choice being the usual work location vs. other locations, with the other locations nested. No school tour destination choice submodel was estimated, since such a high percentage of students travel to the usual school location.

For non-work/non-school tour destinations, no "usual" location has been chosen at a higher level of the submodel, so tour destination choice is more complicated. The tour destination submodel includes a set of coefficients applied to logsum variables (mode choice to destination, purpose-specific aggregate mode/destination choice at destination), and other coefficients by purpose for drive distance ranges.

An array of parking supply, street pattern, and land use variables are included in the non-work/non-school submodel:

- Combination of parking and commercial employment increase the attractiveness of parcels within a TAZ.
- Street pattern (the so-called "good intersection ratio") within one-quarter mile of a destination increases is attractiveness. The street pattern variable is computed as a proportion of the 3 or 4 leg intersections, compared to all intersections within one-quarter mile.
- A large array of density and parcel size variables by different tour purposes and density is included in the submodel. The following general patterns emerge, though:
    - Some more obvious matches between land use variables and tour purposes are captured in the submodel (e.g. higher numbers of food service employees make parcels more attractive for meal tour destinations; higher numbers of K12 enrollments make parcels more attractive for escort tour destinations; etc.).
    - Higher household density and higher numbers of households on parcels reduce the attractiveness of a parcel as a destination for most purposes.

3.1.2.3.2 Tour Main Mode Submodel

Tour main mode is the predominant mode chosen for making a given tour: the actual mode chosen for each segment of the tour is modeled as "trip mode" at a lower level. The relationship between tour main mode and trip mode for trips within a single tour for a given person has an analogous relationship as that between usual work and school location, and work and tour destination—the higher level choice is highly determinative of the lower level choice. That is, the predominant mode chosen for a tour is the most likely mode for each segment within that tour. The exceptions to this general pattern will be discussed below, in the trip mode choice section.

The tour main mode submodel is structured as a multinomial logit with the following nine mode options:

- Walk
- Bicycle
- Drive Alone
- Shared Ride (2 persons)
- Shared Ride (3-or-more persons)
- Walk-to-transit
- Drive-to-transit (work tours only)
- School Bus
- TNC

Non-mandatory trip purposes (personal business, shop, meal, social/recreational) were combined for the mode choice estimations. Submodels were estimated for the following trip purposes:

- Work tour
- School tour
- Non-mandatory tour
- Work-based subtours

For TNC mode, to account for deadheading, a Fehr & Peers study was referenced[7], which estimated that ~40% of TNC VMT is deadheading and ~60% is passenger-carrying. Accordingly, for each TNC passenger trip that generates X vehicle trips on the network, a deadhead trip of (40/60)X vehicle trips was added. Because DaySim cannot reliably predict the true origins/destinations of deadhead movements, it assigns the deadhead trip the same OD and time period as the associated passenger trip, apply the 40/60 factor, and load it as an SOV in the medium VOT bin. (In practice, some deadheading involves hurried travel to a pickup, while much of it is circulating while awaiting a request.)

3.1.2.3.3 Work Tour Mode Choice

The estimation included a set of four generic level-of-service variables (cost, in-vehicle time, wait time, and walk and bike time). Walk or bike time for drive-to-transit, walk-to-transit, walk and bike were split out from wait time, with coefficients estimated rather than fixed.

In addition to a mode constant, drive-to-transit variables included two auto-availability variables (- for no autos, - for autos less than workers), and a ratio of drive time to total in-vehicle time (the coefficient for which is useful for weighting drive access time in transit path building). Walk-to-transit had only a constant and a dummy variable, if the closest transit stop is an LRT station (+ for walk-to-transit).

Shared ride modes included variables on numbers of persons in the household, with likelihood of choosing shared ride declining steeply if the number of persons in the household is one (for 2 person shared ride), or less than three (for 3+ person shared ride). Shared ride is also more likely for households with school age children, with fewer cars than drivers, or households with a higher share of escort stops during the course of the day.

Drive alone included variables on auto availability (- for autos less than workers), income (- for household income less than $25,000), and share of escort stops during the course of the day (- for higher share).

Bike mode is more likely for males, younger travelers (- for age greater than 50 years), and for areas with good land use mix (+ for mixed use density at place of residence). Bike mode also includes a Davis constant (+).

Walk is less likely for males, and more likely in areas with good land use mix and density at place of residence.

3.1.2.3.4 School Tour Mode Choice

Three generic level-of-service variables are included in the estimation: cost and in-vehicle time (both constrained); and combined out-of-vehicle time).

School bus mode is less likely for very young students (- for age under 5 years), and for older students (- for age 18 years and older).

Walk-to-transit mode choice includes auto availability (+ for no cars, + for fewer cars than drivers). A constrained constant is included for children under 5 years. Walk-to-transit is more likely for older students (+ for age 16 or 17 years, + for age 18 or older). Walk-to-transit is also more likely in areas with good land use mix and density.=

Auto modes (shared ride and drive alone) include the same constellation of variables used in the work submodel.

[7] Balding, Melissa, Teresa Whinery, Eleanor Leshner, and Eric Womeldorff. "Estimated percent of total driving by Lyft and Uber." Fehr & Peers 22 (2019). Can be accessed at: https://cdn.mynorthwest.com/mynw/wp-content/uploads/2019/08/TNC-VMT-Findings.pdf

Bike mode is more likely for male students, and students 18 years or older. A Davis constant (+) is also included.

Walk mode is more likely in areas with good street pattern (+ for higher proportions of "good" intersections).

3.1.2.3.5 Escort Tour Mode Choice

The escort tour mode choice model is relatively simple, and relies primarily on personal and family composition constants and variables. Walk mode is more likely in areas with good street pattern.

3.1.2.3.6 Work-Based Subtour Mode Choice

Work-based subtours are the only non-home-based tours in DAYSIM. Work-based subtours begin and end at the place of work, while all other tours begin and end (albeit with other destinations and stops) at home. The mode of travel used to get to work is influential in determining the mode used for work-based subtours.

3.1.2.3.7 Non-Mandatory Tour Mode Choice

This submodel predicts tour mode choice for home-based personal business, shop, meal, and social/recreational tours. The submodel includes many of the same variables at seen in the other purposes. However, the street pattern and land use density and mix variables are more prevalent and significant in this model: the street pattern variable or mixed use density variable is included in walk-to-transit, bike, and walk modes.

Each alternative in the models is characterized by three separate dimensions: arrival time, departure time, and duration of stay. Constants are included for ten arrival time blocks, departure time blocks, and activity durations per purpose. The arrival and departure blocks differ by tour purpose; for example, work arrival blocks are the shortest for the normal, morning work start times, while the time blocks for the late morning and afternoon time blocks are longer.

Activity and travel scheduling models were estimated for four trip purposes (or aggregated purposes):

- Work activities and tours
- School activities and tours
- Non-mandatory activities and tours (i.e. personal business, shop, meal and social/recreational)
- Work-based subtours

An additional scheduling submodel was estimated for intermediate stops. For intermediate stops, the departure time is fixed for stops on the outbound half tour, so those observations only contribute to the constants for arrival time and duration, and the arrival time is fixed for stops on the return half tour, so those observations only contribute to the constants for departure time and duration.

In addition to the time block constants, the submodels included various other variables, described below.

> ***"Shift" variables by person type***—These variables effectively adjust the time block constants for arrival or duration by person type. For example, part time workers and student workers tend to start work activities later than full time workers—the shift constant for arrival time for part time workers is positive, indicating later arrivals. Negative-sign shift coefficients arrive earlier, or participate in the activity for a shorter duration, than other person types; positive-sign shift coefficient arrive later or participate longer.
>
> ***"Shift" variables by tour complexity***—Some shift variables account for complexity of tours, either by quantifying the numbers of stops for tours of different types, or the number of tours.
> *Income variables*--Lower income workers tend to work for shorter durations, and higher income workers, longer.
>
> ***Purpose specific variables***—Especially for the non-mandatory purpose submodel, arrival and duration shift variables are included to differentiate the differences in each purpose.

Time pressure/constraint variables—Several variables were used to represent the constraints imposed on scheduling by inclusion of longer activities in a daily pattern, or by overall schedule complexity (number of tours, number of stops on tours):

- Duration of the adjacent empty window before period starts
- Duration of the maximum consecutive empty window before the period starts
- Total duration of all empty windows in the day before the period starts
- Duration of the adjacent empty window after the period ends
- Duration of the maximum consecutive empty window after the period ends
- Total duration of all empty windows in the day after the period ends

Level of Service and Congestion Variables—Auto and transit travel time enters the model, along with the time spent in severe congestion. Note that for purposes of the estimation, the marginal skims for the i-j TAZ interchange was used, not any actual surveyed information about the path actually taken for the trip.

Major effects captured in the models are as follows:

Work activities and tours:

- Lower income workers tend to have shorter duration activities, and higher income workers, longer activities.
- The more work-based subtours that are part of the tour, the longer the total duration of the work activity (including the subtour).
- Making more intermediate stops to/from primary destination reduces time spent at primary activity.
- Workers with 2+ tours to schedule will tend to try to leave a large consecutive block of time rather than two or more smaller blocks.
- For both AM and PM, the tendency is to move the work activity earlier as the time in very congested conditions increases.
- School activities and tours.
- Many time pressure/constraint effects are similar to work activities and tours.

Non-mandatory activities and tours:

- Relative to personal-business activities, people tend to arrive earlier for escort activities and later for shopping, meal and social/recreation activities.
- Escort and shopping activities also tend to be much shorter in duration, while social/recreation activities are much longer.
- Escort and shopping activities are likely to last less than an hour, and shopping and meal activities are likely to last 1-2 hours.
- Shopping activities are unlikely to begin before 7 AM or end after 9 PM. Meal activities are also unlikely to end after 9 PM.
- Escort activities are relatively likely to end after 9 PM.

- Time pressure/constraint effects are similar to those found for work and school tours. The main difference is that the overall time pressure effect is stronger, but the other effects are weaker, and there is evidence that people will try to space tours more evenly in the day.
- The PM peak was found to shift both earlier and later with high congestion.

Work-based activities and tours:

- Relative to work-related activities on subtours, escort, meal and shopping activities tend to start later and be of shorter duration.
- Social/recreation activities also tend to start later, while personal business activities are also of shorter duration.
- People try to leave consecutive windows both before and after the tour, meaning a tendency to "center" the subtour during the duration of the work activity.
- Intermediate stop activities and tours
- Compared to work-related activities, stops for escort, shopping, meal, and personal business activities all tend to be of shorter duration.
- Escort, shopping, social/recreation and personal business stops also tend to be somewhat later in the day. These results are very similar to those in the work-based subtour model.

Stops will tend to be shorter when there are more tours to be scheduled in the day, and also when are there more stops to be scheduled on the half tour.

3.1.2.4 Policy-based pricing

DAYSIM models sensitivity to pricing policies base on agents evaluations of time conducted from the research as part of the SHRP 2 C04 project on model improvements to address pricing and congestion. These include:

Distributed value of time: Each tour simulated in DAYSIM has its own time/cost tradeoff, with the functions used to set the cost coefficient (c[i]) and time coefficient (t[i]) shown in Figure 3-4 below. The cost coefficient is based on an inverse power function of income and car occupancy, with the power exponents differing for work and non-work tours. The time coefficient also has different functions for work and non-work tours, and uses a log-normal distribution (see Figure 3-5) to simulate random variation around the mean.

Note that this random variation in VOT is not used in model estimation, and can also be switched off by the user for model application, in which case the mean value is assumed. Also note that this value is for auto in-vehicle time. Relative values for other types of travel time can be specified by the user as part of the DAYSIM configuration and should be set so as to be consistent with the relative values of time assumed in the generation of the network skims. Within DaySim, the SOV cost coefficient and time coefficient are set once for each tour, and the resulting values of time for all modes (based on the just-mentioned configuration parameters) are used for all models associated with that tour. The VOT associated with each simulated trip is included in the Trip output file.

Figure 3.4 Functions from SHRP 2 C04 for Tour-Specific Value of Time

Work tours

c(i) = -0.15/$ / [((income(i) / 30,000) ^ 0.6) * (occupancy(i) ^ 0.8)]

t(i) = -0.030/min * draw from a log-normal distribution, with mean 1.0 and std. deviation 0.8

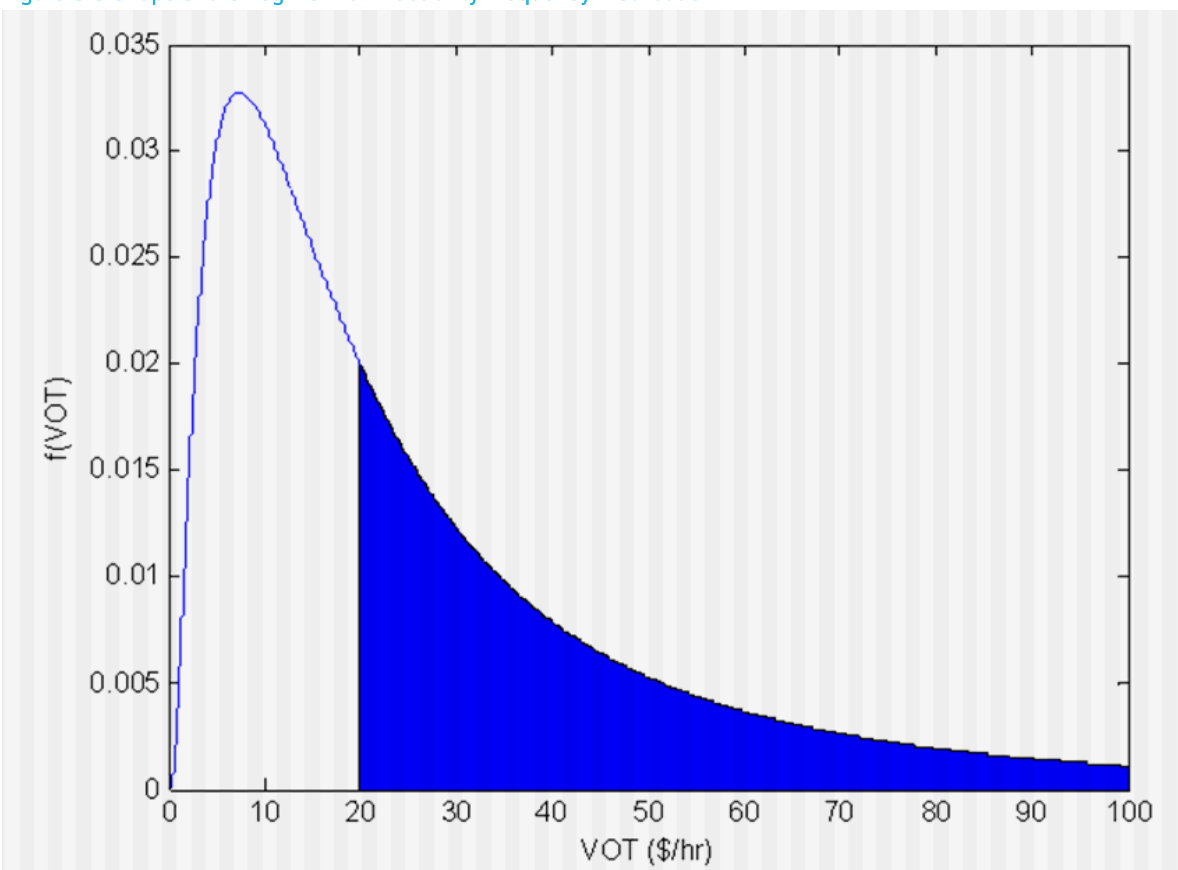
Non-work tours

c(i) = -0.15/$ / [((income(i) / 30,000) ^ 0.5) * (occupancy(i) ^ 0.7)]

t(i) = -0.015/min * draw from a log-normal distribution, with mean 1.0 and std. deviation 1.0

Source: SACOG 2025.

Figure 3.5 Shape of the Log-Normal Probability Frequency Distribution



Source: SACOG 2025.

Flexibility in using impedance matrices: DAYSIM that supports pricing analysis is a great deal of flexibility in defining and using network impedance skim matrices. This flexibility includes:

- Matrices for a given mode can be specified for different path types. This can be used for auto (i.e. the full network versus a network that excluded tolls) and for transit (i.e. the local bus network versus a light rail network)
- Matrices for any mode can be defined to be for a specific range of VOT, allowing tours with different VOT to use different matrices reflecting differences in their "best" path. In retrieving skim values, DAYSIM uses the tour's VOT to retrieve the skim value for the correct VOT range. The endpoints of the VOT ranges are set as DAYSIM configuration parameters, and should be set to correspond consistently with the VOT assumed for each VOT-specific skim.
- Matrices can be for any minute, hour or period of the day, and these periods do not need to correspond to any fixed time periods used elsewhere in DAYSIM or in supporting trip-based models. This allows a great deal of flexibility to reflect time-of-day pricing policies.
- The same input matrix can be used to reflect multiple combinations of mode, path type, time period and VOT class, providing efficiency in memory usage and I/O.

Consideration of transit fare passes and discounts: Although the transit fare values in the transit impedance skims reflect the full fare, DAYSIM does not assume that everyone pays that fare. Fare reduction is simulated in two ways:

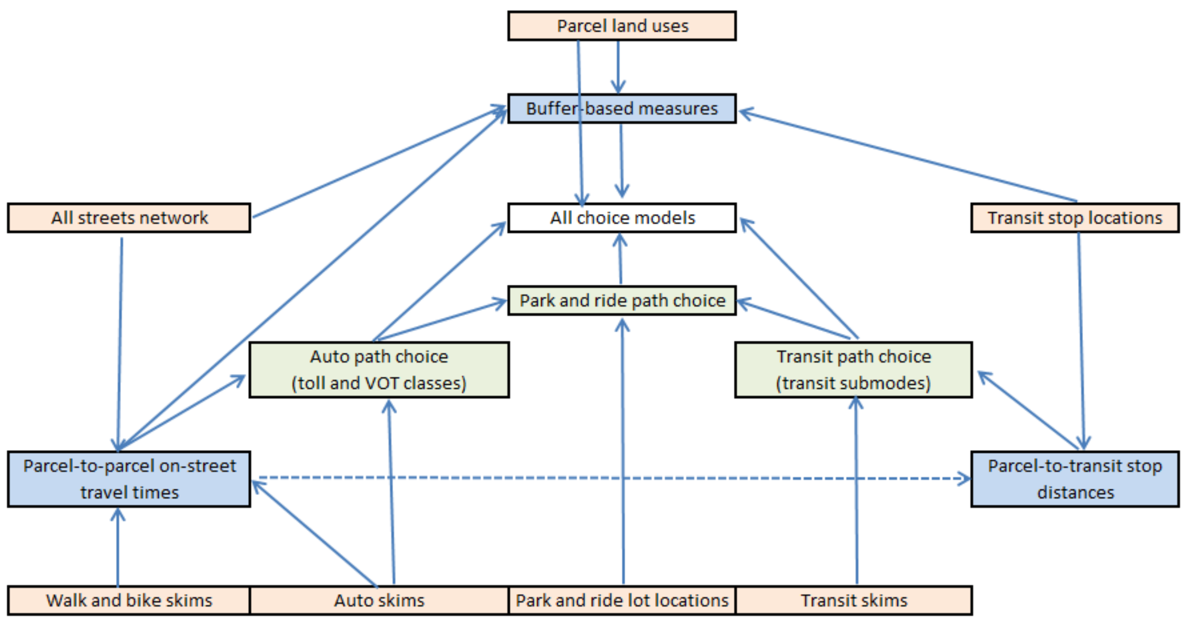
- First, transit users can receive a percentage discount based on their age and student status. This is controlled via discount factors input by the user in the DAYSIM configuration.
- DAYSIM includes a Transit Pass Ownership model. This is a binary choice model predicting whether or not each person age 16+ owns a transit pass, as a function of person type, age, employment status, student status, and accessibility by transit from their home, workplace and/or school location. The user can also vary the price and price-sensitivity for transit passes via configuration inputs. If a person is predicted to own a transit pass, then their marginal fare cost for transit is 0 (100% discount factor).

The use of path type choice models for all modes: This reflects a fundamental change to how DAYSIM uses impedance information in the choice models. Figure 3-6 illustrates how all skim information works through the path type model, which performs the following functions in a consistent way:

- For a given mode/origin parcel/destination parcel/time of day, it determines if a valid path is available via one or more path types for that mode. ("Valid" meaning that there is a network path, and that the total travel time is less than a user-defined maximum.) The path can be one-way (for trip-level models) or round trip for two different times of day (for tour-level models)
- For each possible path type, a utility is determined, using the tour-specific time and cost coefficients (VOT) as well as additional time weights provided by the user.
- If one or more path types is available, a logsum across those path types is calculated and passed back for use in higher-level models such as mode choice or time of day choice.

- The travel time, cost, and distance via a chosen path type is also generated. For most uses, this is deterministic, via the path type with the best utility, although at the trip-level where the path type is predicted for the final simulated trips, a stochastic choice can be simulated instead.

Figure 3.6 Schematic of the use of path choice models to support other DAYSIM choice models



Source: SACOG 2025.

Further technical detail on the path type models is provided in the DAYSIM Reference Guide. Some highlights for specific modes include:

- For bicycle, the user can define additive weights for distance on specific types of links, to calibrate the usage of different facility types.
- For auto, the user can define different VOT ranges for the skim matrices, and also specify the size of a constant term to be used for toll routes to calibrate/reflect resistance to using tolled facilities.
- For walk, bicycle, and auto, the parcel-based circuity factors are applied to get a more accurate estimate of distance and travel time for short trips, particularly intra-zonal trips for which the network skims provide little useful information.
- For transit, the user can define additive in-vehicle time weights, as well as path type-specific constants, in order to calibrate the usage of different types of transit services (as well as vary their attractiveness in higher level models such as mode choice). DAYSIM uses the tour's simulated value of time in modeling the choice of transit submode (path type).
- For transit, access and egress walk distance are determined based on parcel-specific walk distances to the nearest stops, and the user can change parameters related to the maximum walk distance and the characteristics of walking to direct paths versus paths that involve transfers.

- For park and ride, the model is similar to the transit model, but substituting drive access time for walk access at the home end. (Park and ride is always evaluated round trip, assuming the same lot on both halves of a tour.)
- For park and ride, DAYSIM will search across all park and ride lots and find the one that provides the best utility for the given O/D/mode/path type/times of day. Alternatively, the user can find the best park and ride lot node with other software outside of DAYSIM and provide a matrix of the best park and ride lot for each O/D pair.

A few more features of the path type models:

- Even if the user does not define different path types for a mode, the path type model will be used for the single, default path type in order to calculate the generalize time utility for that alternative. This ensures that the calculations are done consistently whether or not there are multiple path types available. For example, only the "full network" path type is currently available for the walk and bike modes, and this is why no "walk/bike path choice" is shown in Figure 3-6, even though those modes are also evaluated via the path type model. Furthermore, DAYSIM could be used to evaluate multiple path types even for those modes—an example would be to use completely separate bike skims for path types with and without Class 1 or 2 bike lines.
- As shown in Figure 3-6, the use of the path type model means that all DAYSIM models access and use the skim information consistently via path type choices and logsums. This also extends to the accessibility logsums used by the upper level DAYSIM models.
- The ability to do park and ride lot choice within DAYSIM is new, and more advantage of this will be taken in the future. For example, lot capacity constraint is not currently included. In future versions of DaySim, it will be possible to incorporate capacity constraint via a time of day-specific shadow-price mechanism.

3.1.2.5 DAYSIM Software Improvements

- The new code is written in C#, which is a standard language now used by software engineers for creating professional software. It is programmed in the Microsoft Visual C# integrated development environment (IDE), using 64-bit code.
- The new code was co-designed and created by RSG's top software engineers (Bryce Lovell and Leo Duran), and is maintained using state-of-the practice software version control (Subversion, with Tortoise SVN Windows interface) and project management tools (Redmine). Each revision of the code is reviewed to maintain professional standards of code legibility, efficiency, and manageability.
- The code is fully object-oriented, enhancing legibility and adaptability.
- The code uses multi-threading (parallel processing) wherever it is most efficient, making optimal use of hardware.
- The code uses advanced memory handling features, allowing most regional model systems to be run with less than 8 GB of RAM (depending mainly on the number of zones used for network skims)
- Most of the constants and parameters in the code are user-configurable, enhancing legibility of the code and avoiding the need for revising and re-compiling.
- The formats for the input and output files are now consistent, enhancing the capability to do partial runs.
- DAYSIM now includes a model estimation capability that produces data and control files that can be used "as is" to immediately estimate models using the ALOGIT software. DAYSIM also reads the coefficient files generated by ALOGIT as a result of model estimation. This has multiple advantages:
  - Ensures consistency between model estimation and application, avoiding a major source of potential bugs

  - Makes it very quick and efficient to re-estimate the models when new data becomes available or when minor changes are desired.
  - Ensures consistency across the different choice models and the way they are coded, making it easier for new users to understand different models.
- The new “skim roster” capability makes it possible (and fairly easy) to change many aspects of how the network skims are used (adding or subtracting submodes and path types, use of different VOT classes, changes in time period definitions, etc.) without needing to change or recompile the DAYSIM code.
- In addition to the above features, the new DAYSIM has maintained key distinctive features that were present in the old version:
  - The ability to work with parcel-level spatial alternatives. This is now configurable, also allowing inputs at the zone, or micro-zone (e.g. block) level.
  - A facility for synchronizing random seeds, reducing differences between runs/scenarios that is due solely to random simulation error.
  - Shadow pricing to maintain supply/demand consistency for choices of work and school locations.

3.2 Commercial Vehicle Travel

The commercial vehicle trip generation and distribution models maintain a standard "four-step" or "trip-based" model system approach. These models create trip matrices in two trip categories: 2 axle commercial vehicle trips, and 3+ axle commercial vehicle trips.

Commercial vehicle trip rates based on surveys of commercial vehicles in the Sacramento region [8], and surveys of commercial vehicle trip generation from the San Francisco Bay Area. Trip rates are shown in Table 3-3. Because of the relatively sparse data available for commercial vehicles, no "production/attraction" distinction is made.

Friction factors for 3-axle commercial vehicle trips were taken from the *Quick Response Freight Manual*[9]. For 2-axle trucks, 3+ commercial vehicle friction factors were derived from the Chicago Area Transportation Study factors, which compared reasonably well with the available local data. Friction factors are shown in Figure 3-7. Trip distribution was calculated using congested midday travel times, using a simple gravity model.

Because no "production/attraction" distinction is made in trip generation, all trip interchanges by time period are forced to be symmetrical in SACSIM, and time-of-travel proportions are applied as flat factors. Table 3-4 shows the time-of-travel factors used.

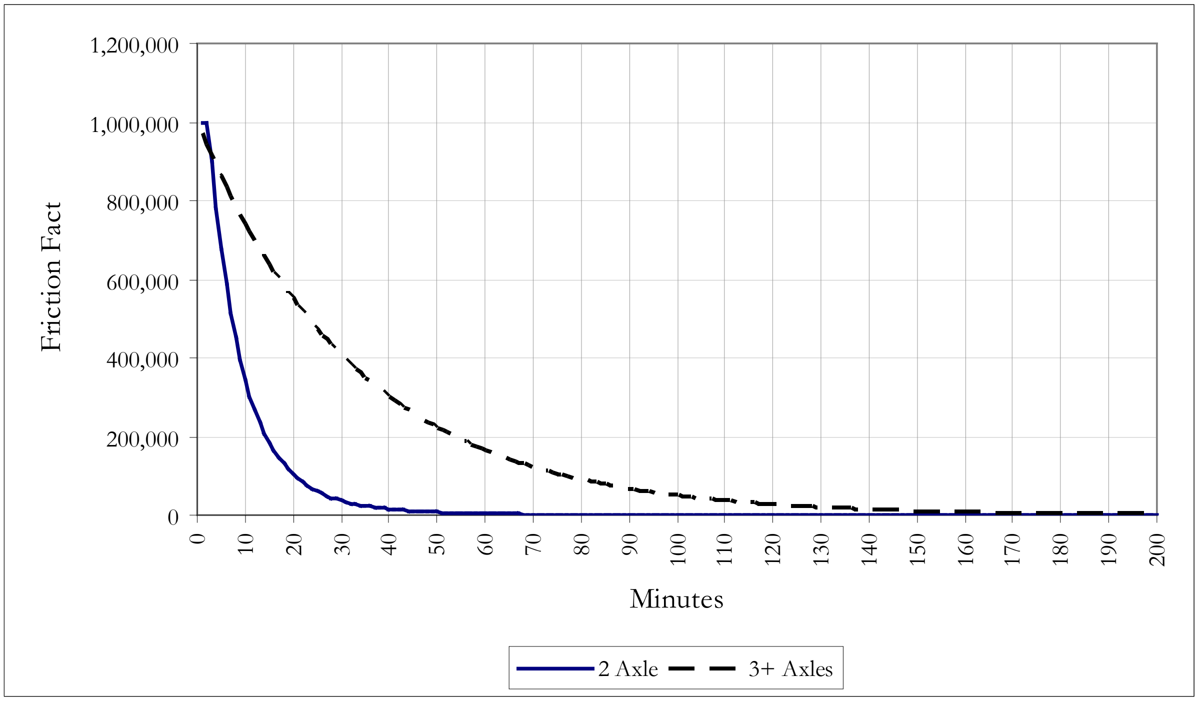
Table 3-3 Commercial Vehicle Trip Rates

Variable	2-Axles	3+ Axles
Household		
Single Family	0.28	0.003
MF 2-4	0.23	0.003
MF 5+	0.17	0.003
Employment		
Retail	0.68	0.045
Office	0.4	0.057
Medical	0.4	0.057
Education	0.4	0.057
Manufacture/Other	0.4	0.11

Source: SACOG 2025.

[8] SACOG, "Commercial Vehicle Activity Survey Report: Phase One Project Report", July 23, 1998.
[9] FHWA (by Cambridge Systematics), "Quick Response Freight Manual", September 1996.

Figure 3.7 SACSIM Commercial Vehicle Friction Factors



Source: SACOG 2025.

Table 3-4 SACSIM Commercial Vehicle Times-of-Travel

SACSIM Time Period	2 Axle	3+ Axle
AM Hour 7:00-7:59	8%	10%
AM Hour 8:00-8:59	8%	10%
AM Hour 9:00-9:59	4%	3%
Midday (10:00-14:59)	38%	30%
PM Hour (15:00-15:59)	5%	3%
PM Hour (16:00-16:59)	5%	3%
PM Hour (17:00-17:59)	5%	3%
Evening (18:00-19:59)	9%	12%
Night (20:00-6:59)	21%	27%

Source: SACOG 2025.

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*—TAZs 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.

Improvements in SACSIM23

As part of each MTP/SCS cycle, SACOG staff reevaluate interregional travel assumptions and methodology. SACSIM23 interregional travel model had two significant updates from the 2020 MTP/SCS.

First, SACSIM23 extended its primary internal roadway system out to East Placer County past previous Gateway No. 8 at Nevada/Placer County Line on I-80. This included adding 3 additional gateways and 138 additional lane miles, 34 within SACOG region in Placer County, and 104 within Nevada County and the City of Truckee that are outside the region but necessary to connect East and West Placer County roadways into the primary roadway model network of SACSIM23.

Second, SACSIM23 interregional travel forecasting internal-external (I-X) and external-internal (X-I) input volumes were reevaluated. Past I-X, X-I inputs used a linear regression to forecast plan horizon years. SACSIM23 instead takes a gateway by gateway predictive curve methodology utilizing 20 years of historic traffic counts and a 7 year moving average, DOF and/or regional population growth forecast of both SACOG region and external neighboring regions to predict future traffic volumes. The table below describes the changes between SACSIM19 and SACSIM23.

Table 3-5 Gateway Changes Between SACSIM19 and SACSIM23

Change In Model	SACSIM19	SACSIM23
East Placer County Gateways	Single Gateway at I-80/Nevada County Line	Three Gateways at I-80, SR-89 & SR-267.
East Placer County Roadways	Does not include Roadways East of Truckee in Nevada County (not in region)	Includes an additional 138 lane miles in East Placer County and 104 lane miles in Nevada County to connect East and West Placer County
Gateway Forecast Methodology	Gateway or Cluster of Gateway Linear Regression using historical traffic counts	Gateway by Gateway predictive curve using moving 7-year average historical counts and SACOG and neighboring regional population growth

Table 3-6 SACSIM Gateways

TAZ No.	SACSIM Gateway	Roadway Segment	Gateway Travel 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	SR-49 NE	NE of SR-49/ Yuba-Sierra CL	Nevada Co., via SR 49. (from Yuba Co.)
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/ CR-89 N	NE. of Truckee, PM18.276	North Tahoe Region 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	SR-88 S	S. of Omo Ranch Rd	Amador Co., via Omo Ranch Rd (from South Central El Dorado Co.
10	US-50 E	Btwn. Ice House Rd & Echo Lake, PM65.619	South Lake Tahoe Basin, via US50
11	SR-89 S	Tahoe City State Highway Maintenance Station, PM8.9	North Lake Tahoe Basin to east of region, via SR 89
12	SR-267 S	Kings Beach, North Ave.	North Lake Tahoe Basin to east of region, via SR 267
13	SR 16, 49 East	Sacramento-Amador CL, El Dorado-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. TAZ 14 is currently left blank and not used.

Source: SACOG 2025.

3.3.1 Trip Generation for I-X and X-I Travel Model

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 3-7 and Table 3-8 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 3-7 SACSIM23 Year 2020 External Gateway Demand (Workers and Home-Based Trips)

		Worker Flows		**Pers.Bus.** Trip Ends		**Shop** Trip Ends		**Soc./Rec.** Trip Ends	
Gate-way No.	Gateway Description	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	SR99N--Sutter/Butte CL	2843	2226	2124	1416	2558	1706	2558	1706
2	SR70N--Yuba/Butte CL	2326	1821	1957	1957	1211	1817	2482	1654
3	Marysville Rd--W.of SR49 Yuba/Nev CL	0	0	159	159	159	159	159	159
4	SR20NE--Yuba/Nevada CL	0	0	1865	1865	551	1285	2129	912
5	SR49NE--Placer/Nevada CL	6523	5454	3371	3371	3371	3371	3371	3371
6	I-80 NE/ CR-89 N--NE. of Truckee	1243	1039	3646	3646	7723	3310	3137	7320
7	SR174NE--Placer/Nevada CL	725	606	833	833	833	833	833	833
8	SR20NE--Placer/Nevada CL	0	0	455	455	395	395	520	780
9	Omo Ranch Rd E--N. of SR88	0	0	505	505	505	505	505	505
10	US50E--E. of Ice House Rd	1035	866	1302	1302	678	1582	1116	2604
11	SR-89 S--Tahoe City State Highway Maintenance Station	414	346	1755	1755	1755	1755	1755	1755
12	SR-267 S--Kings Beach, North Ave.	414	346	1709	1709	1709	1709	1709	1709
13	SR16+SR49E--Sacramento/Amador CL	1502	677	1158	1158	1484	1484	1444	1444
15	SR99S--Sacramento/SJ CL	7605	8856	6261	6261	8229	12344	7201	13372
16	Lincoln Rd S--Sacramento/SJ CL	761	886	266	266	266	266	266	266
17	Franklin Rd S--Sacramento/SJ CL	0	0	5	5	5	5	5	5
18	I-5 S--Sacramento/SJ CL	5324	6199	6044	4030	10785	4622	4030	6044
19	SR160S--S of SR12	1521	1771	2027	2027	2027	2027	2027	2027
20	CR95A--Yolo/Solano CL	0	0	186	186	141	329	192	192
21	CR104/Mace Blvd. SW--S.of CR32D/Mont	0	0	219	219	219	219	219	219
22	I-80 W--W. of I-505	24861	42411	12950	12950	18851	18851	17376	17376
23	SR128W--Yolo/Solano CL	0	0	307	307	491	123	421	981
24	Putah Creek Rd W--W. of Winters Rd	0	0	131	131	131	131	201	201
25	SR12SE--E. of SR160	0	0	520	966	657	1221	768	768
26	SR12SW--E. of SR160	507	866	1318	1318	1276	1276	1612	1612
27	SR16N--Yolo/Colusa CL	0	0	100	54	133	89	93	140
28	I-5N--Yolo/Colusa CL	1472	1327	4238	2825	5364	2299	2632	2632
29	SR45--Sutter/Colusa CL	0	0	148	148	160	160	110	110
30	SR20NW--Sutter/Colusa CL	30	27	1551	1551	1683	1683	1156	1156

Source: SACOG 2025.

Table 3-8 SACSIM23 Year 2020 External Gateway Demand (Commercial Vehicle Trips)

			Commercial Vehicle Trip Ends	
RAD	Gate-way No.	Gateway Description	2 Axle	3+ Axle
97	1	SR99N--Sutter/Butte CL	245	750
97	2	SR70N--Yuba/Butte CL	319	1350
97	3	Marysville Rd--W.of SR49 Yuba/Nev CL	53	0
97	4	SR20NE--Yuba/Nevada CL	397	0
97	5	SR49NE--Placer/Nevada CL	2274	300
97	6	I-80 NE/ CR-89 N--NE. of Truckee	2658	3350
97	7	SR174NE--Placer/Nevada CL	96	400
97	8	SR20NE--Placer/Nevada CL	289	300
97	9	Omo Ranch Rd E--N. of SR88	66	200
97	10	US50E--E. of Ice House Rd	471	200
97	11	SR-89 S--Tahoe City State Highway Maintenance Station	770	100
97	12	SR-267 S--Kings Beach, North Ave.	202	200
97	13	SR16+SR49E--Sacramento/Amador CL	310	450
97	15	SR99S--Sacramento/SJ CL	5868	5450
97	16	Lincoln Rd S--Sacramento/SJ CL	27	200
97	17	Franklin Rd S--Sacramento/SJ CL	27	200
97	18	I-5 S--Sacramento/SJ CL	4363	8350
97	19	SR160S--S of SR12	545	400
97	20	CR95A--Yolo/Solano CL	14	100
97	21	CR104/Mace Blvd. SW--S.of CR32D/Mont	25	200
97	22	I-80 W--W. of I-505	6140	3550
97	23	SR128W--Yolo/Solano CL	114	100
97	24	Putah Creek Rd W--W. of Winters Rd	38	200
97	25	SR12SE--E. of SR160	374	700
97	26	SR12SW--E. of SR160	445	100
97	27	SR16N--Yolo/Colusa CL	12	0
97	28	I-5N--Yolo/Colusa CL	2859	3950
97	29	SR45--Sutter/Colusa CL	23	200
97	30	SR20NW--Sutter/Colusa CL	760	200

Source: SACOG 2025

3.3.2 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.

3.3.3 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.

3.3.4 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 3-9 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

3.3.5 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.

3.3.6 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.

3.3.7 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 3-10 and Table 3-11.

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 3-11.

Table 3-10 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 2025.

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 3-11 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 2025.

Based on draft documentation provided by DKS Associates.

3.3.8 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.

3.3.9 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 3-12.

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

Table 3-12 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 2025.

[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 3-13 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 2025.

3.3.10 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 2019 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 the travel model input file.

3.3.11 External Travel Validation

To validate the X-X, I-X, and X-I input described above, the modeled base year traffic volumes on the gateway roadways were compared against the observed AADT data. The FHWA standard for traffic modeling validation was employed to assess the accuracy of the modeled volumes, which serve as indicators of the validity of the external travel inputs. The comparison revealed that all gateway modeled volumes fell within the acceptable range of errors, with an average relative error of 5%. This suggests that the base year external travel trips are valid and can serve as a reliable basis for future year projections. Validation results shown in Table 3-14.

Table 3-14 External Travel Validation

CTC Model Validation Guidelines	Thresholds	SACSIM	Threshold Acceptance
% Of Locations W/ Model < Max Deviation	>75%	100%	Yes
Correlation Coefficient	> 0.88	1.00	Yes
Rmse For Daily Traffic Assignment	<0.40	0.15	Yes
Avg. Link Error	<0.25	0.12	Yes
Validation Ratio	0.9~1.1	0.95	Yes

SACOG, April 2025

3.3.12 Future Year Forecasts

To forecast external travel for the future years, SACOG initially used regression models that consider population as predictors to forecast growth factors. For each gateway zone, regression models were trained using AADT and population data from the past 20 years. SACOG then coordinated multiple meetings with neighboring MPOs and RTPAs, including BCAG, MTC, SJCOG, NCTC and TRPA, to compare the initial forecasted volumes with the other MPOs' forecasts and discuss the methodologies used. Adjustments were made based on these comparisons and discussions to ensure consistency of external travel levels among MPOs.

The forecasting of future external travel involves two steps: **Step 1**, growth projections based on historical data and **Step 2,** coordination with corresponding neighboring MPOs.

For **Step 1**, to project the growth of external travel, an approach that utilizes the correlation between population and external trips was employed. SACOG staff noticed that the AADT data on the gateway roadways have exhibited a slowing growth rate. This aligns with the concept of saturation effects, where growth rates slow down as development approaches capacity. Upon investigation, the SACOG staff identified a significant correlation between traffic volumes on the roadways represented as gateways and two independent variables: the population of the SACOG region and the population of the corresponding neighboring MPOs. Regression models were developed for each gateway using historical population data for both the SACOG region and the neighboring MPOs, as well as AADT data for the past 20 years. These models were then used to forecast the growth rates of future traffic volumes at the gateways based on population projections from either the Department of Finance (DOF) or forecasts by the neighboring MPOs up until 2050. This approach captures the relationship between population growth and the growth rate of interregional travel levels between SACOG and the neighboring MPOs, providing a more nuanced and data-driven method compared to the assumption of linear trends used in previous MTPs.

Forecasting assuming a linear growth trend, as done in the past, is no longer applicable because a linear growth assumption will yield unrealistic traffic volumes for several gateways given the capacity limitations of the roadways. For example, for gateway zone No. 22, which represents travel to the west of the region via Interstate 80 (I-80), assuming a linear trend yields a growth rate of 28% and leads to unrealistically high traffic volumes on I-80 throughout the day. Moreover, the forecast was significantly higher than the predictions made by the neighboring MPO, MTC, leading to inconsistencies between the two regions' planning efforts.

However, when applying a growth factor obtained by fitting a curve against the population data of both MPOs, the predictions from SACOG align well with MTC's projections within an acceptable margin of error.

Step 2 of this forecasting effort involved coordination with each neighboring MPO to discuss any discrepancies in forecasted gateway travel levels. The future year X-X, I-X, and X-I trips were adjusted according to the identified differences, ensuring that the forecasts from both MPOs are within a reasonable margin of error.

3.4 Airport Passenger Ground Access Model

3.4.1 Introduction

The airport passenger ground access model is a system of models of trip generation, trip distribution, and mode choice, which forecasts auto, transit, taxi, and shuttle van travel of air travel passengers using Sacramento International Airport, as well as return trips for picked-up and dropped-off passengers. The model also includes as an exogenous input estimates of passengers traveling to the airport from origins outside the SACOG region. The model does not include travel by employees of the airport, or airport-using or airport-serving businesses, which are represented by DAYSIM and commercial vehicle models.

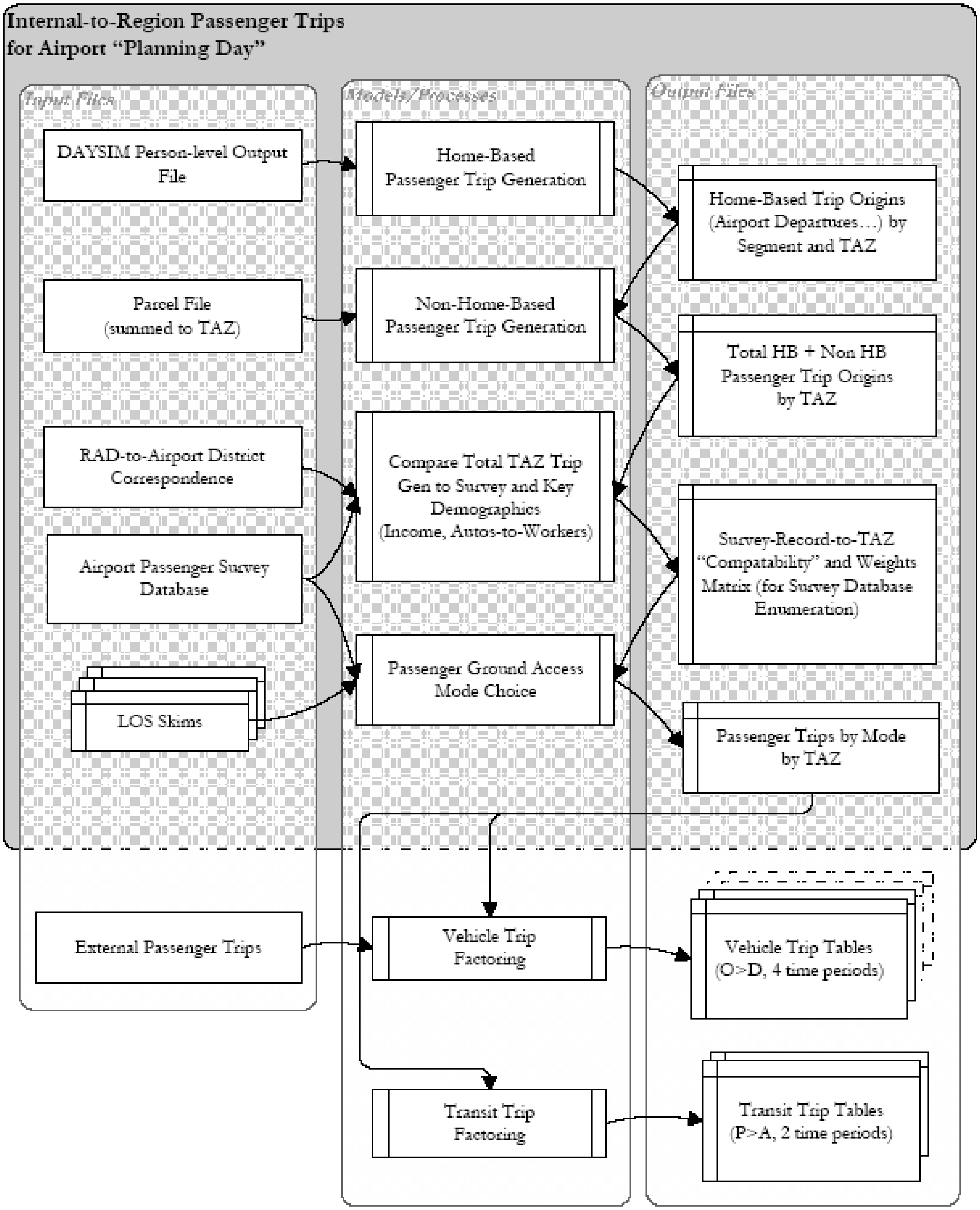
This airport trip model application consists of five main components:

- Trip generation for SACOG (internal) passengers;
- Association of generated trips to representative survey trips, for use in computing survey expansion factors for internal passengers;
- Mode choice for internal passengers;
- Direct estimate of external (i.e. outside SACOG) passengers;
- Time-of-travel and vehicle trip factoring for auto mode trips; and
- Time-of-travel and person trip factoring for transit trips.

The airport passenger ground access model is calibrated to represent activity for a "planning day" at the airport, which is defined as an average day from the peak month of passenger activity at the airport [10]. Figure 3-8 illustrates the major model components and flow.

[10] PB Aviation, "Sacramento International Airport Master Plan Study", March 8, 2001.

Figure 3.8 Airport Passenger Ground Access Model



Source: SACOG 2025, based on work by DKS Associates (2008).

3.4.2 Trip Generation for Internal Passengers

SACSIM airport internal passenger trip generation was initially built from findings from the Downtown-Natomas Airport Study, 2003 (DNA). The DNA corridor analysis did not directly use trip generation by each model zone (TAZ). Instead, it used survey observation data, with each record's weight factor "grown" proportionally to the aggregate trip generation in its RAD (Regional Analysis District, of which there are approximately 58 in the Sacramento region). This approach was modified for use in SACSIM, to allow for "on-the-fly" enumeration of the survey based on the population and employment in each TAZ.

This application uses the same trip generation factors for non-home-based trips: 0.006 per non-retail employee, except the Downtown Sacramento RAD, with 0.010 per non-retail employee.

But for home-based trips, trip generation factors are applied to household segmentations by income as shown in Table 3-13:

Table 3-15 Home-Based Airport Trip Generation based on Household Income (Enplaning Airport Passengers)

Household Income (c.2000 dollars)	Estimated Enplaning Passengers per Household
Under $15k	0.0060
$15k to 35k	0.0068
$35k to 50k	0.0133
$50k to 75k	0.0156
$75k or more	0.0269

Source: SACOG 2025.

Home-based trip generation rates apply to five household income strata as described above. These generated trips are then saved in four household categories used by the mode choice model, which can be considered a two-dimensional array of (1) whether the household income is over $50,000, and (2) whether there are as many autos available as persons in the household.

A concurrent process adjusts the survey records' expansion factors factored to match the respective grand totals of home-based and non-home-based trips. The Tripgen program is ideally suited to do this concurrently, treating each survey record's expansion factors as "attractions" flagged into either "purpose 1" or "purpose 2," respectively. Normally the "control totals" of these two purposes are determined by zonal trip generation, and naturally grow when forecasting with regional growth.

3.4.3 External Passenger Generation Rates from Population

To forecast SMF passenger demand outside the SACOG region within the SACSIM models, the full demographic detail used within the region is neither necessary nor appropriate. It would be appropriate and pragmatic to have simpler and more readily-forecast independent variables than income-stratified households and non-retail employment.

County populations were checked and found to be reasonably proportional to the preceding passenger demand estimates from detailed demographics. Non-retail employment is likewise reasonably proportional to county population. Proportionalities with respect to county population are significantly closer than to total households in county. Consequently, only one independent variable, population, is chosen for application of external airport passenger demand.

Table 3-14 shows airport passenger generation rates for external (non-SACOG) areas. Table 3-14's rates count both arrivals and departures, unlike above tables that count departures only. Table 3-14 shows passenger generation rates split into the demographic strata needed by the airport access mode choice model, obtained by dividing the generation calculated for each particular stratum, by population.

Table 3-16 Two-Way SMF External Passenger Generation Rates

Trip Category	Income	Cars per Person	2-Way Rate per Population
Home-Based	Less than $50k	As many or more	0.00090
Home-Based	Less than $50k	Fewer	0.00039
Home-Based	More than $50k	As many or more	0.00179
Home-Based	More than $50k	Fewer	0.00022
Non Home-Based			0.00095

Source: SACOG 2025. For External Areas Only

3.4.4 Enumeration of Passenger Survey Database

This model application phase calculates appropriate weights for passenger survey observations to represent a given zone's generated trips for the sake of mode choice, so that the mode choice model can be applied as a modified sample enumeration procedure. Conversely, this phase can be considered to split or spread each survey record across several zones, instead of its one observed zone. (This phase is analogous to trip distribution, although, strictly speaking, the airport trip generation described above is also trip distribution, since the trips are attracted to one zone, the airport.) The general objective is that each zone's generated trips would be represented by "compatible" survey records, that is, compatible in demographics and geography, as well as matching in being home-based or non-home-based. (This phase was not needed in the DNA Corridor Study, in which survey records "stayed in their zones" and were growth-factored for forecasting.)

This association is represented as two matrices, one for home-based and the other for non-home-based trips; rows represent actual TAZs and columns represent survey records. The cells are zero if not "compatible," and have a spread weight value otherwise. The row-sums for home-based trips must match the zonal home-based trip generation, and likewise the row-sums for non-home-based trips must match non-home-based trip generation. Column-sums are proportional to the base year expansion factor of the respective survey observation, but are scaled to the same grand total as the trip generation.

Ideally there would be several survey observations, of each demographic cross-classified category (persons by income by autos), that could be associated with each demographic category in each RAD. But there aren't enough survey cases to do this. Instead, we must combine RADs into yet larger districts just to provide home-based and non-home-based survey observations to all zones. Some cross-classified cells have few or no cases at all in the survey. Therefore, the more demographic variables of the modeled households we wish to match to representative survey records, the larger the districts must be for the computation to be possible.

For home-based trips, the present application chooses survey records for each trip in the same one of 8 regional districts, matching whether household income is less than $50,000 (a mode choice dummy variable), and whether there is a shortage of autos per person (as defined for another mode choice dummy variable). This could be conversely be thought of as spreading each survey record across all zones in the same of 8 districts, proportionally to the airport trip generation by households of the same of two income classes and two autos-per-person classes. This particular compatibility scheme is subject to change as validation and forecasting issues are considered.

For non-home-based trips, this application chooses all survey records in the same one of the 8 regional districts.

The actual mechanism to achieve these associations or spreads, subject to row and column constraints, is iterative proportional factoring. The constraint vectors are the trip generation results (home-based and non-home-based zonal demand as productions, factored survey weights as attractions). The input matrix to the home-based process is the compatible-class trip generation of the zone; the input matrix for the non-home-based process is simply a 1 if in the same of 8 districts, and a 0 otherwise. The result matrices are the number of trips generated by the *i* zone, associated with survey record number *j* (or conversely, the number of trips of survey record *j* spread to zone *i*.)

3.4.5 Ground Access Mode Choice for Internal Passengers

The mode choice model used a two-by-two segmentation of air passengers: resident vs. non-resident, and business vs. other. The model was based on highway and transit network level-of-service measures obtained from a regional travel demand model. The model is applied by enumerating (i.e. expanding) the airport survey dataset according to residential growth (for home- or residence- based trips) or non-retail employment (for non-home-based trips).

The mode choice model is taken directly from an application spreadsheet used in the DNA Corridor Study. It is multinomial logit, with these seven alternatives:

- Auto Drop-Off
- Drive-and-park at airport (for residents)
- Return rental car at airport (for visitors)
- Taxi
- Van
- Transit Walk-Access
- Transit Drive-Access
- Transit Drop-Off Access

Table 3-15 shows the coefficients of this logit model. This paper does not report the numerous details in the definitions of the variables. Demographic variables only apply to home-based trips by residents.

This model is applied to the matrix of weighted trips computed in the preceding phase, in which the *i* zone is the zone of trip generation, and the *j* zone is the survey record number. It is thus a modified form of sample enumeration, with the survey records "spread" among numerous zones, instead of kept in their original zones. The actual output result of this application is the row sums of the seven modal matrices, that is, the aggregation of them by zone, collapsing all survey records. Reports aggregating modal trips by the segment (travelers, resident business, resident leisure, visitor business, and visitor leisure) are also provided; reports aggregating by any survey data variable can be generated.

Table 3-17 Airport Ground Access Mode Choice Logit Model Coefficients

Coeff. No.	Variable	Passenger Marker Segment 1 Resident/ Business	2 Resident/ Leisure	3 Visitor/ Business	4 Visitor Leisure
Mode Constants					
1	Auto Drop-Off	0	0	0	0
2	Auto-Park(Res)/Return Rental(Vis)	0.5303	0.5303	0.106	-1.1104
3	Taxi	-1.5858	-2.1639	-0.3116	-1.8789
4	Van	-1.0737	-0.5921	-0.4271	-1.2767
5	Transit-Walk Access	0.5281	0.5281	0.705	0.705
6	Transit-Drive Access	0.1097	0.1097	-0.5949	-0.5949
7	Transit-Drop-Off Access	-0.2191	-0.2191	0.3275	0.3275
Demographic Variables					
8	Autos<Persons	-0.2494	-0.2494	0	0
12	1 Persons	-0.3995	0	0	0
13	3+ Persons	0	0.6422	0	0
14	Income<$50K	0	0.7416	0	0
Cost Variables					
15	Parking Cost	-0.0155	-0.0155	0	0
16	Van/Taxi Cost	-0.0191	-0.0003	-0.0191	-0.0003
17	Transit Cost	-0.0422	-0.0422	-0.0422	-0.0422
Travel Time/Level-of-Service Variables					
18	Main Mode Time	-0.0095	-0.0095	-0.0095	-0.0095
19	Walk and Transfer Time	-0.0518	-0.0518	-0.0518	-0.0518
20	Drive Access Time	-0.0079	-0.0079	-0.0079	-0.0079
21	Chauffer Time	-0.0055	-0.0003	-0.0055	-0.0003
22	First Transfer	0	0	0	0
23	Second+ Transfer	-0.845	-0.845	-0.845	-0.845
Airport Egress Variables					
24	Walk Egress Time	-0.0183	-0.0183	-0.0183	-0.0183
25	Walk Egress Dummy	-0.0916	-0.0916	-0.0916	-0.0916
26	Shuttle Egress Time	-0.0053	-0.0053	-0.0053	-0.0053
27	Shuttle Egress Dummy	-0.0526	-0.0526	-0.0526	-0.0526
Other Variables					
28	Scale Factor for Utility	1.865	1.865	3.0869	3.0869

Source: SACOG 2025. Using values from November 2008.
Based on technical memorandum by Bowman, John L., Bradley, Mark A., and Griesenbeck, Bruce "Sacramento RT DNA Transit Access Mode Choice Model", July 3, 2002.

3.4.6 Updated Time-of-Day Distribution of Airport Access

No surveys or counts of trips entering or exiting the airport have been available that would yield time-of-day distributions of airport passenger arrivals or departures, either at the flight gate or on the road. An alternative basis is the time of day of aircraft arrivals and departures, assuming most flights are nearly full, and different-sized aircraft are scheduled consistently across the day.

Table 3-16 presents the approximate (shifted) distribution of passenger ground travel, in the nine time periods used in the updated SACSIM model system. (Arriving and departing percentages are both normalized to 50%.)

Table 3-18 Estimated Time-of-Day Distribution of Ground Access of SMF Airport Passengers

SACSIM Time Period	Percent Departing	Percent Arriving
AM Hour 7:00-7:59	3.0%	0.3%
AM Hour 8:00-8:59	2.7%	2.0%
AM Hour 9:00-9:59	4.7%	3.0%
Midday (10:00-14:59)	15.6%	16.1%
PM Hour (15:00-15:59)	2.7%	2.7%
PM Hour (16:00-16:59)	3.0%	2.7%
PM Hour (17:00-17:59)	2.4%	3.4%
Evening (18:00-19:59)	5.1%	6.0%
Night (20:00-6:59)	10.9%	14.0%

Source: SACOG 2025.

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-A matrix is converted to a daily, both direction flow by transposing the P-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 Bentley Cube software.:

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

Transit passenger trips are assigned using Cube's public transport (PT) software, with trips in origin-to-destination format. Five demand periods are assigned:

- Period 1, spanning from start of service 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 end of service

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. SACSIM vehicle traffic assignment is broken into nine time periods for simplicity, performance, and establish unit-hour period durations for the entire day. Table 3-19 describes the start and end times for each highway assignment period.

Table 3-19 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	11

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, three value-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 directionality conversion from production-attraction format to origin-destination (O-D) format[11], nor conversion 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 VOT 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 of the SACSIM19 documentation[12].

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-D format, without explicit reference to the location of the transition the between transit and auto. The (O-D) person trips were split and converted to Production-to-Attraction (P-A) format, then split into the five transit service periods.

A simple park-and-ride (also including kiss-and-ride) lot choice model in SACSIM 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-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.

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[11] "Production-attraction" refers to the number of trips that start and end in a single zone, while "origin-destination" more specifically refers to the number and direction of trips between each pair of zones in the model.
[12] SACSIM19 Documentation Appendix B: RSG Travel Demand Model Toll Enhancement Technical Memorandum, September 2018.

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-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 SACSIM system-equilibrium solution.

This application is a simultaneous multi-class assignment. 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+)

Controls for the equilibrium assignment are set to an 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. 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 3-20 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 2025.

3.5.3.1 Congestion Delay Functions

3.5.3.1.1 Conical Delay

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

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

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:

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

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 TC=+/- 1.5 when VC=1.0
- 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 3-21 Congestion Factor Variables and Values

	Variable					
	A	B	E	L	M	N
Class of Roadway	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

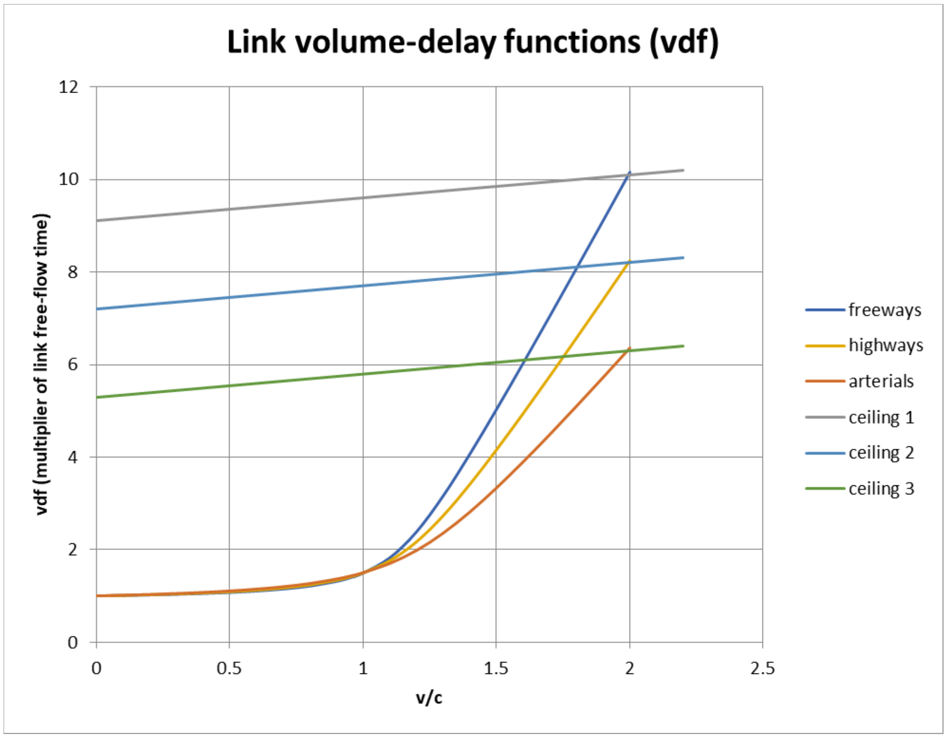
Source: SACOG 2025.

Table 3-22 Range of Congestion Factor Calculations

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 2025.

Figure 3.9 SACSIM Link volume delay function



Source: SACOG 2025.

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

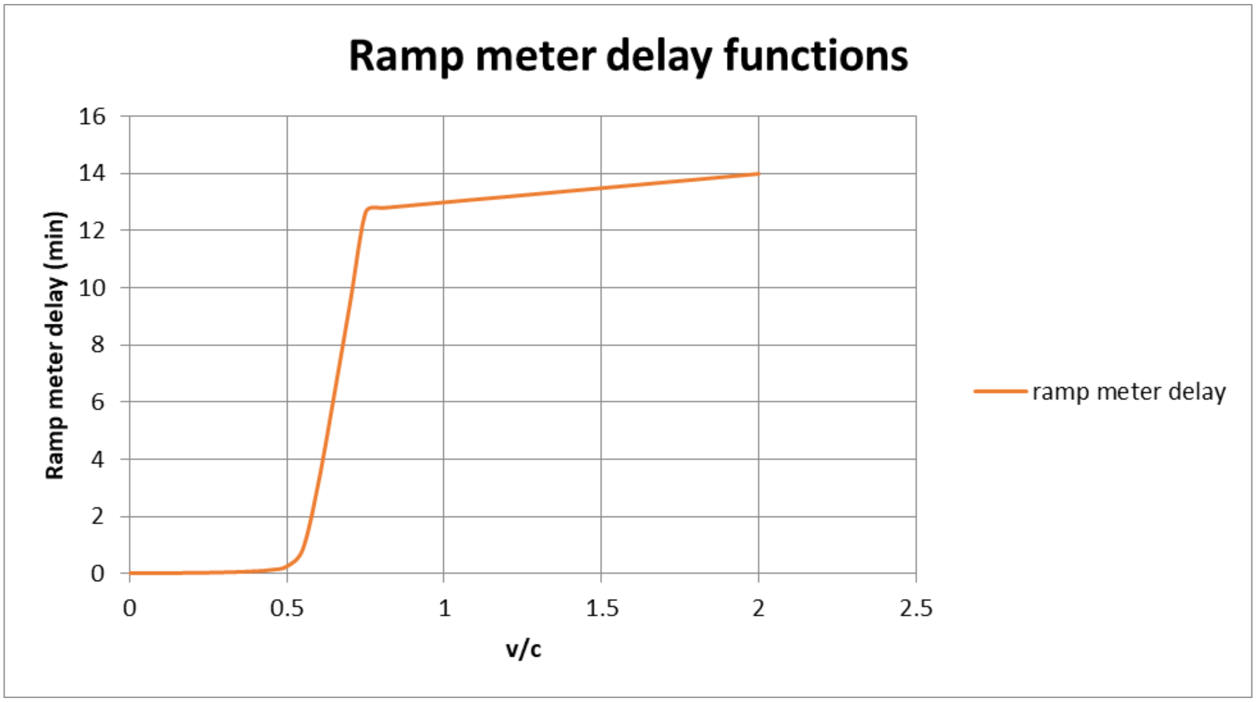
In the highway network, DELCURV identifies on-ramp links that restrict or "meter" flow entering a freeway at certain times of the day using special traffic signal systems at the on-ramp. Values of this code are:

- 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 ad 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

Some metered on-ramps have special lanes for high-occupancy vehicles allowing them to bypass potential congestion in the general-purpose onramp lanes. These lanes are not controlled or otherwise delayed by the ramp-meter signal. The model network representation of these lanes consists of pairs of links parallel to the metered on-ramp link. 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)

3.5.3.5 HOV Lane Violators and Exemptions

In the real world, some percentage of HOV lane capacity is consumed by SOVs that are either disobeying the HOV restrictions or have an exemption that allows them to use the HOV lane as an SOV, such as some electric vehicle models. However, SACSIM does not account for such users and assumes all HOV lane vehicles contain the specified minimum number of occupants.

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 11:00PM)

Additionally, transit path-building and assignment is done in an origin-to-destination, direction format. SACSIM 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 highway traffic assignment, outside of Cube’s public transport (PT) program.

3.6.2 Transit Background Network

The 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. As described in Chapter 7, this also captures the presence of bus-only lanes that allow transit vehicles to bypass congested traffic.
- 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 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. Transit fare types area shown in Table 3-22.

Table 3-23 SACSIM 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 2025.

Table 3-24 SACSIM Transit Operators

Operator ID	Description
1	Sacramento Regional Transit*
2	Yolo County Transportation District (Yolobus)
3	Roseville Transit
4	Yuba-Sutter Transit
5	El Dorado Transit
6	Placer County Transit
7	Auburn Transit
8	Sacramento State Hornet shuttle
9	UC Davis Unitrans
10	Amtrak Capitol Corridor
11	South County Transit
12	Reserved for future operator

Source: SACOG 2025.
*Sacramento Regional Transit includes routes formerly under Folsom Stage Line and Elk Grove E-Tran

The PT factors file declares:

- Parameters for path building
  - Maximums on numbers of boardings per trip, 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, plus the presence of bus-only lanes when and where applicable. 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 are specified from an operator-to-operator matrix (ptfare.txt). 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. For example, 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.

3.6.6 Skimming

SACSIM creates the following skim components for transit: walk time to/from first and last stop and any walking between stops for transfers, wait time at first stop, in-vehicle travel time, transfer wait time, and fare. Notably, DAYSIM replaces the SACSIM-skimmed walk-to-transit time with parcel-specific distances to transit specified in the parcel table, specifically the dist_bus and dist_lrt fields. These distances are computed for each parcel using the buffering process described in section 4.6.

Importantly, different TAZ-TAZ transit skims are created for key transit submodes:

- All transit modes
- “Must use rail”
- “Only use local bus”
- “Must use commuter bus and/or commuter rail”
- “Must use light rail”

DAYSIM’s path type model uses these separate skims to determine which transit submode a traveler will use on their trip. Specifically, whether a traveler will take local bus only, include a commuter bus or heavy rail for some or all of their trip, or use light rail for some or all of their trip. In addition to tagging a submode to each trip, the path type model allows the user to configure constants to capture qualitative differences between the submodes. E.g., applying a discount to the in-vehicle time cost for commuter buses to capture a more ”pleasant” ride. These submode-specific discount factors can be configured in DAYSIM configuration files (see Appendix C DAYSIM Reference Guide for details).

3.6.7 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 SACSIM, DAYSIM uses five discrete period skims, but outputs trips in continuous time, therefore it is not always certain by which skim period SACSIM created a transit trip prior to settling the person’s full itinerary. Additionally, DAYSIM’s roster table does specify a transit skim for the 11pm-5am period. 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 into the night-time (8pm-end of service) period,
- 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.

3.6.8 Drive Access to Transit

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.

3.6.9 Park-and-Ride Lot Assignment

Park-and-ride assignment simulates filling of parking lots over time, making each lot that fills up unavailable to later trips. 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.

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*:

$GC(auto)_{ik}$ = {W_a*Auto $Time_{ik}$ + W_t*($TermTime_i$ + $TermTime_k$) + W_{da}*($AutoDist_{ik}$ * C_d + $ParkCost_k$ /2)*F_{mt}} / 1.28 persons per vehicle

Where:

- GC(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)
- W_a = Weight factor for auto time
- W_t = Weight factor for terminal travel time
- W_{da} = Weight factor for auto distance
- C_d = per-mile cost for auto travel
- F_{mt} = Factor to convert monetary cost to equivalent time cost. As of this writing, this factor was 0.0558 (i.e., multiply the dollar cost component of the trip by 0.558 to convert to a number of minutes).

$GC(transit)_{kj}$= InVehTime + W_{wt}*WalkTime + W_{iw}*InitWaitTime + W_{xw}*TransfTime + (2*Fare*F_{mt})

Where:

- W_{wt} = weight factor for walk-to-transit time
- W_{iw} = weight factor for time spent waiting for first transit vehicle
- W_{xw} = weight factor for time spent waiting for subsequent transit vehicles at transfer points

Costs are in year 2000 cents, consistent with SACSIM inputs. 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 exact locations of the parking lots. However, presently they are in ordinary TAZs, 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+ cannot 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.

4 Land Use Data

4.1 Land Use for SACSIM Introduction

For its transportation planning functions as a Metropolitan Planning Organization, SACOG's jurisdiction covers part of all of the six county Sacramento region. This area includes Sacramento, Sutter, Yolo and Yuba counties in their entirety, and the portions of Placer and El Dorado counties below the Sierra Nevada ridge line. The extreme eastern portion of Solano County falls in the Sacramento air basin for some emissions, but is within the jurisdiction of the Metropolitan Transportation Commission for federal transportation planning purposes; for this reason the Commission provides emissions estimates to SACOG for air quality regulatory purposes.

This chapter presents the process for assembling SACSIM parcel-point data files. This discussion focuses mostly on building the SACSIM file from land use datasets and other data sources. The land use dataset is the primary data source for households and jobs on each parcel. School employment and enrollments, street pattern, off-street parking supply and cost, and transit proximity come from various other data sources, described below. It is helpful to have clear definitions of some terms and processes:

4.1.1 Terminology

- ***Parcels*** are pieces of land with area, shape, and location defined by assessor's maps and records. In general, this definition applies to SACSIM, with a couple of caveats:
  - SACSIM parcellation was initially created on best assessors records available to SACOG . Every four years during the MTP/SCS, this parcel data is updated with most recent data from available sources.
  - Large parcels with significant growth from the base year to the planning horizon year (2050) were manually split down to "false" or "pseudo" parcels, which have no bearing to assessor's records.
- *A* ***Parcel-point*** is a dimensionless point located roughly at the geographic center of a parcel, and used to represent the location of that parcel for SACSIM. The points have unique identifiers which allow for parcel data (e.g. dwellings or jobs estimates from land use model) to be matched or aggregated to the parcel-points.
- ***Base year inventories*** are datasets of land use features which are not directly represented in land use model, and maintained as separate datasets. Generally, these are GIS point files, which are matched or aggregated to parcels (and later, parcel-points) based on their location.
- ***Base-to-future changes*** are land use or transportation system changes which are flagged by comparing a future year scenario file (typically, a land use parcel data file) with a comparable base year file. Changes are flagged based on change in use (place type), or a change in the intensity of development (dwellings and jobs), comparing the future year scenario to the base year data at parcel level.
- ***Base-plus-future-change*** *datasets* are assembled by using the base year data for parcels with little or no change, and a future year estimate of use if a change has been flagged. This basic approach for creating future year datasets is used for SACSIM school enrollment, school employment, street pattern, transit station or stop, and off-street parking facility uses.

4.2 Land Use Data Files

The land use model provides the land use input data file for use in creating the SACSIM parcel-point data file. Estimates of dwelling units and employment by sector are developed at parcel level in land use model. SACSIM utilizes geographic information system (GIS) outputs from Land use modeling and augments the dwelling and employment estimates with other information, which is described in greater detail below. There are several key concepts and terms which are useful in understanding the capabilities of land use model:

- *Landuse Type* is the fundamental description of the existing or future land use of a parcel. This roughly corresponds to general plan land use types commonly used by jurisdictions for describing land use policy; however, Land use model allows for more standardized land use types to be utilized across the region. Along with other variables described below, dwelling unit and employment rates per acre are associated with place types, and are utilized as one component of an estimate of the quantity of dwellings or jobs on a parcel.
- *Percent developed or percent covered* is the percentage of a parcel which is developed per the coded place type.
- *Gross-to-net acreage percentage* is the percentage of the parcel area which could be developed, net of setbacks, sidewalks, streets, and other dedications.
- *Constraints* are geographic (e.g. slope) or policy (e.g. flood zone) variables which generally reduce the development potential of a particular parcel.
- *Redevelopment potential* is coded to parcels through various fields in Land use model, to represent the likelihood of a given existing, developed parcel changing its use (place type) or development intensity.

Using all these available concepts and data layers, land use modeling generates estimates or yields of dwellings and jobs for each parcel Base year (2020) inventory, estimates are gathered by control totals at the census block level and paired with parcel database inventory to determine the land use with number of dwelling units. Employment categories also collected at the census block level or smallest geography available, are then proportionally distributed or “painted” onto the parcel level into sub-employment categories based on the land use types.

Future scenarios are developed by changing place type, coverage, constraints or redevelopment potential at parcel level, and re-estimating the yields of dwelling and jobs for each parcel. The MTP/SCS must address state and federal requirements Table 4-1 illustrates all the regulatory, policy, and market based factors considered in considering the MTP/SCS land use forecasts.

Table 4-1 Land Use Forecast Consideration Factors

Draft February 2018

Factors Considered in Updating the MTP/SCS Land Use Forecast

	Regulatory/Policy and Market Factors	Description of projects assumed to have the highest likelihood to build within 20 years	Middle range of conditions	Description of projects assumed to have the lowest likelihood to build within 20 years
REGULATORY	Local Entitlements	Specific Plan approved, Annexation complete (if required), Tentative Map(s) in process	Range of conditions includes: projects that are approved but still need annexation; projects approved but no tentative maps submitted; projects approved but have unsettled lawsuit; projects currently in process; projects in pre-application	No current entitlement activity; identified by general plan or SOI as future growth area
REGULATORY	State/Federal Entitlements	Approved	Range of conditions includes: projects that are not yet approved but in process; projects participating in an HCP or NCCP; projects with no significant resource issues	Significant, unresolved resource issues
POLICY	Air Quality	In SCS with lower VMT than average for Developing Communities	Range of conditions includes: projects that are in the SCS with average VMT; projects in the SCS with higher than average VMT; projects not in the SCS with lower than average VMT; projects not in the SCS with average VMT	Not in SCS with above average VMT for Developing Communites
POLICY	Regional Plans and Policies	Consistent with 2012 MTP/SCS and Blueprint	Range of conditions includes: projects in MTP/SCS and partially consistent with Blueprint; projects in MTP/SCS and not consistent with Blueprint; projects consistent with Blueprint and not MTP/SCS; projects partially consistent with Blueprint and not in MTP/SCS	Not consistent with 2012 MTP/SCS or Blueprint
MARKET	Proximity to Job Centers	Close proximity to a regional jobs center	Range of conditions includes: projects partially within 4 miles of a regional job center; projects within 4 miles of a secondary job center; partially within 4 miles of a secondary job center	Significant distance from any job center(s)
MARKET	Housing Mix	Mix of housing types including mostly small-lot and attached	Range of conditions includes: projects that have a mix of housing types including small-lot and attached housing at varying amounts; projects that are primarily large-lot residential because they are in more rural areas	All large-lot single-family where higher densities could be supported (i.e more urban or suburban locations)
MARKET	Market Area Saturation	Historically high market demand and limited number of approved or pending projects in market area	Range of conditions includes: projects in areas with high market demand and high number of approved or pending projects in market area; projects in areas with average market demand and a high number of approved or pending projects in market area; projects in area with lower market demand and a high number of approved or pending projects in market area, but have a unique factor that could significantly change the market demand for the area	Historically low market demand and a high number of approved or pending projects in market area
MARKET	Adjacency	Adjacent to existing urban development or has significant borders with a city boundary or areas designated for future urban development	Range of conditions includes: projects that are adjacent to existing development at varying rates	Less than 10% adjacent with existing urban development,a city boundary or areas designated for future urban development
MARKET	Developer Activity	Very active, single ownership or experienced ownership partnerships, multiple completed projects in region	Range of conditions includes: very active to active, single or multiple ownerships with no development history; single or mulitple ownerships with varying levels of activity and some projects completed in the region; single or mulitple ownerships with varying levels of activity and no history of completed projects in or outside the region	Not active, single or multiple ownership, no completed projects in the region
MARKET	Transportation Infrastructure	No major or regional infrastructure needed or infrastructure is fully funded	Range of conditions includes: projects that have some infrastructure, but need more; projects that can build some before significant infrastructure investment is needed; projects that need significant infrastructure and have funding	Significant infrastructure needed and not funded or not yet defined
MARKET	Other Infrastructure (sewer, water, flood control, etc)	No major or regional infrastructure needed of infrastructure is fully funded	Range of conditions includes: projects that have some infrastructure, but need more; projects that can build some before significant infrastructure investment is needed; projects that need significant infrastructure and have funding	Significant infrastructure needed and not funded or not yet defined

Source: SACOG 2025

4.3 Traffic Analysis Zones (TAZs)

Traffic Analysis Zones, or TAZs, are "…geographic areas dividing the planning region into relatively similar areas of land use and land activity. [TAZs] represent the origins and destinations of travel activity within the region… every household, place of employment, shopping center, and other activity… are first aggregated into zones and then further simplified into a single node called a centroid [placed at the geographic center of the TAZ]." [13]

Prior to SACSIM23, SACSIM's TAZ file had not been updated since 2007 and thus no longer captured significant changes in population, land use, and the transportation system that have taken place since then. As part of SACSIM23 development, SACOG built a new TAZ layer from scratch, using 2020 census block group geographies as a starting point, then refining the geographies using the following criteria:

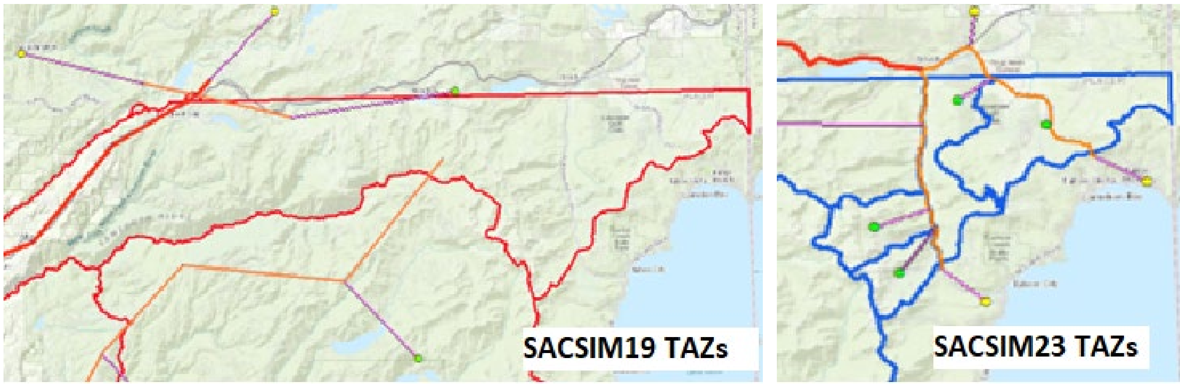
- TAZs must not be larger than census block groups nor cross block group boundaries.
- TAZs must not cross freeways, expressways or major arterials, with strong consideration for natural boundaries as well such as creeks and rivers.
- TAZs should, where possible, follow city boundaries and consider city sphere of influence (planned future annexations
- TAZ splits should be considered for areas with 2050 land use growth
- Generally, TAZs should cover at least 40 acres, except:
- In areas with especially dense clusters of jobs and/or residents.
- Meeting the 40-acre minimum would require crossing a major barrier
- TAZs must be geographically smaller than 122,000 acres
- Base year TAZ population must be less than 4,000; current regional plan horizon TAZ population must be less than 5,000.
- Federally recognized tribal lands were placed into their own TAZs.

The SACSIM23 TAZ update increased the number of TAZs from 1,503 in SACSIM19 to 2,315 for SACSIM23, an increase of +54%. This greater granularity results in TAZs better meeting the above-listed criteria and in turn resulting in more realistic trip assignment and model results.

SACSIM23's TAZ update also added more detail to the highway network and TAZ geographies in the Eastern Placer County. Specifically, SACSIM19 had I-80's eastern gateway at the point where it crosses into Nevada County, and had a single TAZ to capture a large area including Truckee. SACSIM23 splits this TAZ into several smaller TAZs, with Truckee getting a separate TAZ. It also extends I-80 east and adds SR-267 from I-80 until a new gateway into the Tahoe Basin. This update enables more accurately capturing travel within the portion of East Placer that is in the SACOG region. Figure 4-1 below visualizes the change in East Placer between SACSIM19 and SACSIM23, and more details on the resulting gateway changes are in Section 3.3.

[13] Martin and McGuckin. 1998. Travel Estimation Techniques for Urban Planning. NCHRP Report 365.

Figure 4.1 TAZ Updates in Eastern Placer County



4.4 SACSIM Parcel-Point Structure and Variables

The SACSIM parcel file is the key land use input for the SACSIM model. Each record in this file represents an individual parcel. The only spatial information contained in the file is the X and Y coordinates of a point (preferably the centroid) within the parcel. Table 4-5 presents the variable names and descriptions included in the initial parcel point file. While the majority of the parcel data is built in GIS, the SACSIM input is written to an ASCII delimited (tab, space or comma as delimiter specified in the DAYSIM configuration files) text file format. Additional buffering information will be added to the Parcel-Point file for the SACSIM final input format described later in this chapter. Below are further descriptions of the parcel-point initial variables.

4.5 Parcel Variables

The parcel point file is used as the DAYSIM "microzone" file containing the parcel id, geographic coordinates, and land use variables including land use type, number of households, employee total and sub employee categories, public off street parking spaces and pricing. The sections that follow provide a brief description of the parcel variables and Table 4-3 lists out the field names as they appear in the parcel file.

4.5.1 Parcel Identification

The PARCELID filed is required as the unique identity for every individual parcel This must be a unique, ascending, positive integer identification number. PARCELID is required to associate back to the trip and household tables DAYSIM table outputs. SACSIM only used Parcel's with households, employment, students, and/or parking. All other areas such as forests or vacant parcels are not included. For this reason, PACELID may have gaps provided in ascending order to remove these parcels from the complete SACOG regional parcel land use file.

4.5.2 Coordinates

The XCOORD_P and YCOORD_P fields store the X and Y State plane coordinates of each parcel's location. The location is a point within the parcel area and closest to the centroid as possible. The precision of the coordinates is to the nearest foot and therefore these fields store the data as Long Integers.

4.5.3 Area

The SQFT_P field stores the area of the parcel in square feet. This is usually calculated from the geometric area of the parcel polygon feature. Some parcels may have a geometry that could be corrupt which could result in zero square feet.

4.5.4 Traffic Analysis Zone

The TAZ_P field is used to link the DAYSIM "Zone" data to the "Microzone" data. SACSIM links ~2300 Traffic Analysis Zones (TAZ) to ~800,000 parcels. TAZs are later used for SACSIM trip aggregation and assignment.

4.5.5 Households

Households on each parcel are estimated by occupancy rate and the number of dwelling units (DU's) from land use dataset. Occupancy rate is sourced from ACS sample data and adjusted by regional control of the number of households. More information on households is in chapter 5, Representative Population Data.

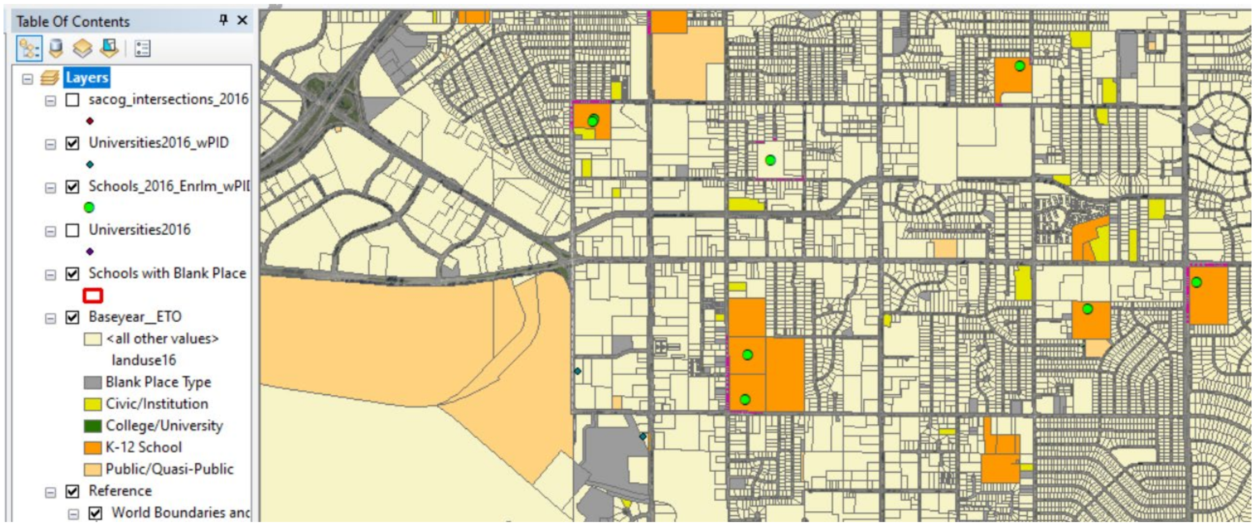
4.5.6 K-12 Student Enrollment

The STUGRD field contains the number of elementary and middle school students who attend school on the parcel. The STUHGH field stores the number of students who attend high school on the parcel. SACOG collected student enrollment data for the base year inventory (2020), and forecasts future enrollment based on land use forecasting data. Populating student enrollment fields involves constructing a shapefile or table of existing or forecasted school locations with enrollment numbers and moving these numbers.

4.5.7 College and University Student Enrollment

The STUUNI field stores the number of students on parcels that are part of major universities and community colleges. As with K-12 enrollment, university enrollment inventory involves constructing a shapefile or table of existing and projected university/college locations with student enrollment. Figure 4-1 illustrates an example of K-12 and University enrollment inventory spatially associated to corresponding parcel land use types.

Figure 4.2 K-12 and University Student Inventory Collection for Parcel File Development



Universities with a student body largely in person are counted in full. Universities or colleges with enrollment but have a larger amount of online classes and are not likely to travel daily to campuses to attend courses are weighted by reducing the overall student enrollment. Full or primarily online programs with student enrollment that do not travel to campus are not included in STUUNI number of students.

4.5.8 Employment

Employment variables are:

- Education (empedu);
- Food service (empfoo);
- Government (empgov);
- Industrial (empind);
- Medical (empmed);
- Office (empofc);
- Retail (empret);
- Service (empsvc);
- Other (empoth); and
- Total employment (emptot).

SACSIM employment types are based on land use model employment types, which in turn are based on a simplified scheme of industrial sector categories. That is, they are based on the industrial sector which describes the use on a given parcel, and not the classification of the job in occupational terms (e.g. laborer, clerical, administrative, technical, professional, managerial, etc.). Table 4-2 shows SACSIM defined employment categories based on the North American Industry Classification System (NAICS) codes. These definitions were applied and used by SACOG in establishing its land use scenario analysis system.

4.5.9 Parking

Parking is included in SACSIM for off-street, paid parking only. The number of daily spaces (PARKDY_P), hourly spaces (PARKHR_P), daily parking cost (PPRICDYP), and hourly parking cost (PPRICHRP) variables are included. Base year parking inventory was gathered by using parking inventory data from previous iterations of SACSIM, aerial imagery, and ParkMe spaces and prices. Currently, the supply variables are not distinguished; i.e. for paid off-street facilities, all spaces are assumed to be available for either hourly or daily use, and the supply variables are equal.

Table 4-2 SACSIM Unbuffered Parcel File Variables

Header label	Valid values	Description, comments
parcelid	1 – 9999999	The parcel ID number. Values must be unique positive integers, in ascending order. (Gaps are allowed, but not efficient for memory.)
xcoord_p	1-999999999	The x coordinate of the parcel centroid, in integer length units (typically SPF).
ycoord_p	1-999999999	The y coordinate of the parcel centroid, in integer length units (typically SPF).
sqft_p	0-999999999	The area of the parcel, in thousands of square length units (typically sqf, does not need to be an integer)
taz_p	1-9999999	The zone that the parcel is in. Must be a valid zone_id in the “zone” file
lutype_p	0-9999999	A land use type value. This variable currently has no mandatory use in the DAYSIM code, so is available for region-specific usage.
hh_p	Real >=0	The number of households residing on a parcel.
stugrd_p	Real >=0	The number of grade school (K-8) students enrolled in schools on a parcel
stuhgh_p	Real >=0	The number of high school (9-12) students enrolled in schools on a parcel. If this is not available separately, then set to 0 & put the number of K-12 students in stugrd_p
stuuni_p	Real >=0	The number of university/college students enrolled in schools on a parcel.
empedu_p	Real >=0	The number of educational employees working on a parcel
empfoo_p	Real >=0	The number of food service employees working on a parcel
empgov_p	Real >=0	The number of government employees working on a parcel
empind_p	Real >=0	The number of industrial employees working on a parcel
empmed_p	Real >=0	The number of medical employees working on a parcel
empofc_p	Real >=0	The number of (other) office employees working on a parcel
empret_p	Real >=0	The number of retail employees working on a parcel
empsvc_p	Real >=0	The number of (other) service employees working on a parcel
empoth_p	Real >=0	The number of other sector employees working on a parcel. Typically contains construction, agriculture, mining.
emptot_p	Real >=0	The total number of employees working on a parcel. Should equal the sum of the 9 previous fields.
parkdy_p	Real >=0	The number of paid public off-street parking spaces on a parcel with per day pricing. (May overlap with parkhr_p if have both types of pricing.)
parkhr_p	Real >=0	The number of paid public off-street parking spaces on a parcel with per hour pricing. (May overlap with parkdy_p if have both types of pricing.)
ppricdyp	Real >=0	The average price of public off-street parking spaces on a parcel with per day pricing. (In cents per day)
pprichrp	Real >=0	The average price of public off-street parking spaces on a parcel with per hour pricing. (In cents per hour)

Source: SACOG 2025. Downloaded from RSG *DAYSIM Input Data File Documentation* GitHub RSGInc/DAYSIM

4.6 SACSIM Land Use Spatial Association

4.6.1 Circuity Buffer Introduction

The Parcel-Point DAYSIM file not only includes the parcel level variables described above, but also requires relative distance information to calculate attractiveness between land use data. Previous versions of SACSIM utilized a Euclidean distance parcel point to parcel point approach which is common in buffering analysis. SACSIM23 parcel point files uses a hybrid approach between shortest orthogonal path, and node to node path distances call "circuity-based measures for each parcel". This method creates a "circuity surface" using 24 radially distributed points to represent the path distances from a walkable streets network based on XY coordinates; 8 directions at 3 distinct distance bands (0.5 mile, 1 mile and 1.5 mile) and the parcel-point location. Each point is then mapped to the closest network node. For a parcel, a circuity factor or ratio is calculated based on the shortest path distance and straight line distance for all 24 radial points. To measure the distance from a parcel to another parcel, the distance is interpolated based on the circuity factors surrounding the destination parcel. Figure 4-2 illustrates the circuity path distance calculation conceptually. Figure 4-3 shows how the decay function adjusts the radial point distances per parcel. Figure 4-4 compares the relationship of parcels distance to employment centers using the "Circuity buffering" process compared to a Euclidean distance.

Figure 4.3 Parcel Circuity Ratio Diagram

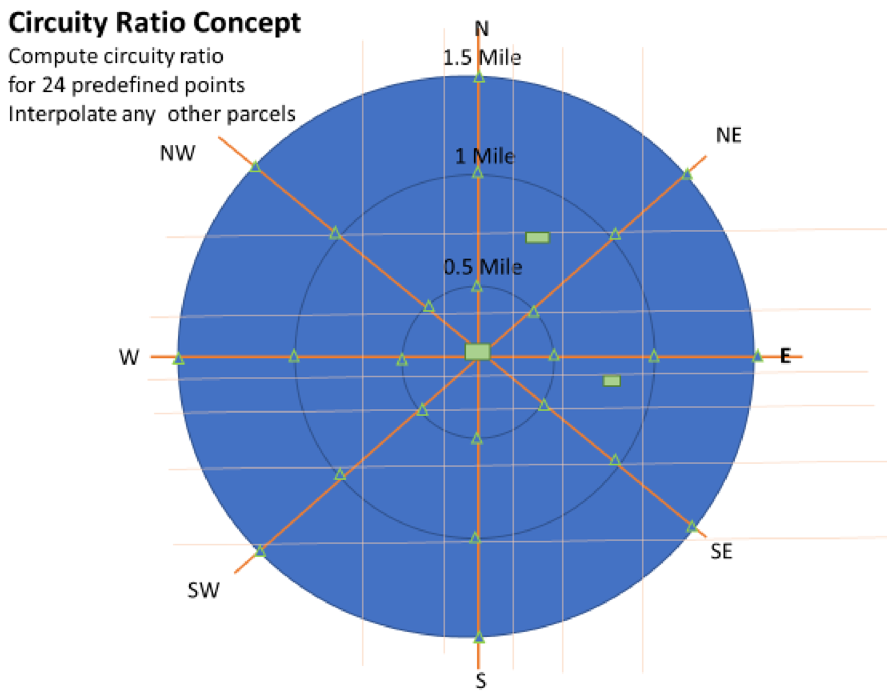
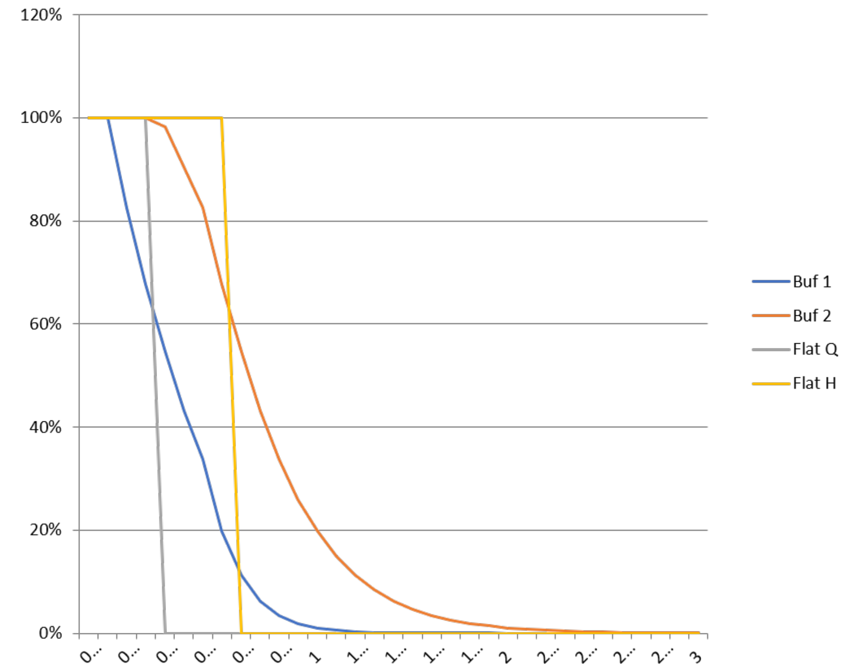


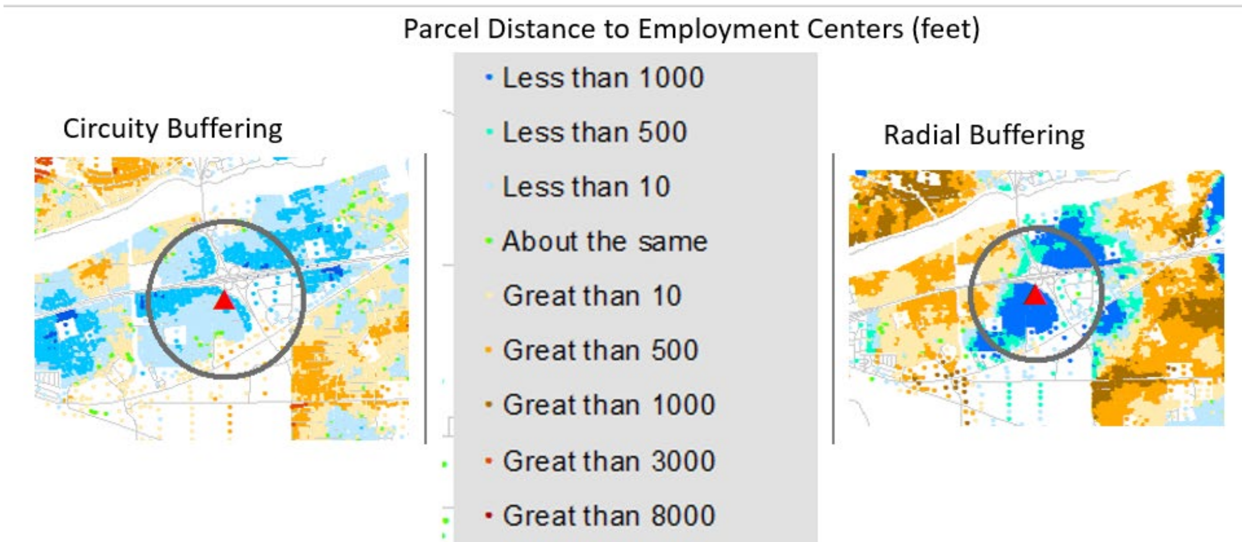
Figure 4.4 Decay Function Compared to Flat Buffering Relationship

Mile	Feet	Buf 1	Buf 2	Flat Q	Flat H
0.1	528	100%	100%	100%	100%
0.125	660	100%	100%	100%	100%
0.2	1056	83%	100%	100%	100%
0.25	1320	68%	100%	100%	100%
0.3	1584	55%	98%	100%	100%
0.35	1848	43%	90%	100%	100%
0.4	2112	34%	83%	0%	100%
0.5	2640	20%	68%	0%	100%
0.6	3168	11%	55%	0%	100%
0.7	3696	6%	43%	0%	100%
0.8	4224	3%	34%	0%	0%
0.9	4752	2%	26%	0%	0%
1	5280	1%	20%	0%	0%
1.1	5808	1%	15%	0%	0%
1.2	6336	0%	11%	0%	0%
1.3	6864	0%	8%	0%	0%
1.4	7392	0%	6%	0%	0%
1.5	7920	0%	5%	0%	0%
1.6	8448	0%	3%	0%	0%
1.7	8976	0%	3%	0%	0%
1.8	9504	0%	2%	0%	0%
1.9	10032	0%	1%	0%	0%
2	10560	0%	1%	0%	0%
2.1	11088	0%	1%	0%	0%
2.2	11616	0%	1%	0%	0%
2.3	12144	0%	0%	0%	0%
2.4	12672	0%	0%	0%	0%
2.5	13200	0%	0%	0%	0%
2.6	13728	0%	0%	0%	0%
2.7	14256	0%	0%	0%	0%
2.8	14784	0%	0%	0%	0%
2.9	15312	0%	0%	0%	0%
3	15840	0%	0%	0%	0%



Source: SACOG 2025.

Figure 4.5 Circuity vs Radial Buffering Comparison



Source: SACOG 2025.

4.6.2 Files Required for Circuity Buffer Process

Circuity Factor File: a parcel list with circuity factors or ratios of 24 points described above.

Parcel Base: a parcel list with all variables is specified in Table 4-5.

Intersections: A list of intersections, with node ID, XY coordinates, and number of links terminating at the node. (This can be the same file as the node list used above, but it should contain all intersections, regardless of whether or not it is a nearest node to any parcel, and it contains the extra information on number of links ending at the node.)

Transit stops: A list of transit stops, with stop ID, XY coordinates, and the type of transit serving the stop. SACSIM23 currently uses local bus and LRT stops are used for parcel to parcel buffering.

Open space areas: A list of parks, sports fields and other public recreational areas, with an ID and the size, in square feet. If this file is not provided, the buffered variables for open space will be 0.

4.6.3 Development of Circuity Buffering Inputs

This section describes the process of how to create the necessary input variables to calculate the parcel circuity buffering process.

4.6.3.1 Circuity Factor File Creation

Parcel and network information are read in and 24 fictitious points around the parcel are created (from the X and Y coordinates of the parcels). The 24 points correspond to 8 directions (East, Northeast, North, Northwest, West, Southwest, South, and Southeast) and 3 distance bands (0.5, 1.0, and 1.5 miles) around each parcel. Each of the 25 points (including the parcel itself) is then mapped to its closest node on the network. The process and tools needed are described in Appendix F, Circuity Surface Data Preparation Memo.

Regional circuity factor regional averages by base year land use type inventories were used to forecast scenario parcels in new development areas.

Further process, description and tools needed are described in Appendix F Circuity Surface Data Preparation Memo.

Intersection File Process

Each parcel record in the SACSIM table must have information about the surrounding walkable street network pattern. This information is stored in the following fields: NODES1Q, NODES1H, NODES3Q, NODES3H, NODES4Q and NODES4H. NODES1 indicates the number of nearby cul-de-sacs and dead-ends. NODES3 indicates the number of nearby "T" or three-way intersections and NODES4 indicates the number of nearby 4-way (or more) intersections. These fields affect the walkability of the street network surrounding a parcel.

4.6.3.1.1 Street Intersection Base Layer

To populate the node fields, spatial buffer operations must be performed against a layer of street intersections. Generally, this layer can be created from a street centerline layer use a line to point style node_builder script. These street intersections do not include nodes along freeways and other facilities that are closed-off to pedestrians.

The node_builder script will identify the number of links attached to the nodes (valence) so that they can be separated into 1-link, 3-link and 4+-link layers.

Figure 4.6 Street Intersection (NODE) Layer

Source: SACOG 2025.

Figure 4.7 Node Typology

Source: SACOG 2025.

4.6.3.1.2 Intersections for Future Streets

Street centerline data do not exist for future development areas. SACOG implemented an estimation of 1-link, 3-link and 4+-link nodes per acre based on the place type of a future-development area. These estimations were applied to a grid of synthetic nodes of fixed area, and nodes/acre values to them. For example, for a newly developed greenfield area typical rates of 1-link, 3-link and 4+-link intersections were applied to each grid point, based on the development type. These node densities are listed below in Table 4-4 for each place type.

Table 4-3 Node Density by Place Type

Place Type	1-Leg Intersections per acre	3-Leg Intersections per acre	4-Leg Intersections per acre
1. Rural Residential	0.026	0.020	0.039
2. Very Low Density Residential	0.026	0.065	0.052
3. Low Density Residential	0.065	0.260	0.104
4. Medium Density Residential	0.130	0.390	0.260
5. Medium-High Density Residential	0.130	0.390	0.260
6. High Density Residential	0.013	0.390	0.455
7. Urban Residential	0.013	0.390	0.455
8. High-Intensity Office	0.013	0.390	0.455
9. Moderate-Intensity Office	0.130	0.195	0.390
10. Community/Neighborhood Retail	0.000	0.104	0.039
11. Regional Retail	0.013	0.104	0.013
12. Light Industrial - Office	0.013	0.104	0.013
13. Light Industrial	0.013	0.104	0.013
14. Heavy Industrial	0.013	0.104	0.013
15. Public/Quasi-Public	0.013	0.026	0.013
16. Community/Neighborhood Commercial/Office	0.000	0.104	0.039
17. Regional Commercial/Office	0.013	0.104	0.013
18. Mixed Use Employment Focus	0.130	0.390	0.260
19. Mixed Use Residential Focus	0.130	0.390	0.260
24. Low Density Mixed Residential	0.065	0.260	0.104
25. Medium Density Mixed Residential	0.130	0.390	0.260
26. High Density Mixed Residential	0.013	0.390	0.455
27. Low Density Mixed Use Center or Corridor	0.065	0.260	0.130
28. Medium Density Mixed Use Center or Corridor	0.130	0.325	0.195
29. High Density Mixed Use Center or Corridor	0.013	0.325	0.390
31. Suburban Center/Corridor	0.065	0.260	0.130
40. Sac CBD High Intensity Mixed Use Office	0.020	0.260	0.590
45. Intense Urban Residential	0.100	0.260	0.260
47. Agricultural Residential	0.020	0.010	0.050
47. Medical Facility	0.010	0.070	0.010
48. Airport	0.010	0.010	0.010
50. K-12 Schools	0.010	0.030	0.010
51. Colleges and Universities	0.050	0.070	0.130
52. Civic/Institution	0.100	0.260	0.130

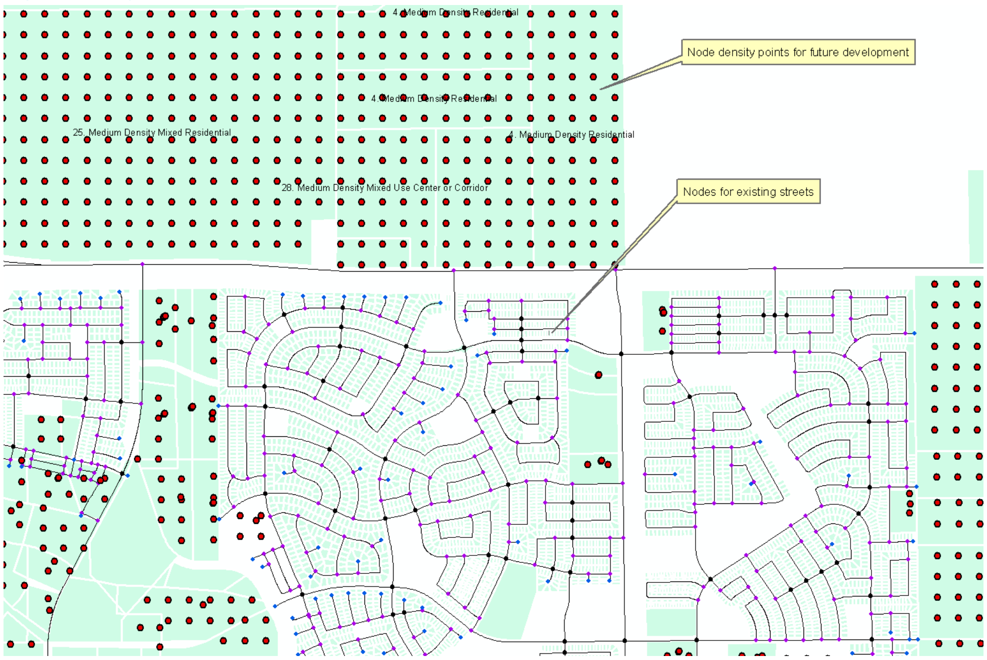
Source: SACOG 2025.

The first step in determining where to generate the grids of synthetic nodes is to identify those areas where future greenfield development will occur. Figure 4-7 shows a portion of the region where development exists with streets and areas slated for future development. In these areas of future development are synthetic nodes to represent a street pattern based on development type.

Once node rates have been set, the synthetic nodes may be combined with real nodes so that the node proximity variables (NODES1Q, NODES1H, NODES3Q, NODES3H, NODES4Q and NODES4H) can be computed. An example is shown below of combining the node sets to create a point layer of 1-link nodes.

A final forecasting step takes into consideration new development areas within SACOG designated Complete Street project areas. Within 500 feet of the complete street identified segments, a 20 percent increase in unit value was added to 3- or 4-way intersections and a 20 percent decrease for one-way (cul-de-sac) intersections. These factors are applied as a factor to better represent complete street design infrastructure and safety characteristics.

Figure 4.8 Synthetic Nodes for Future Development Street Pattern

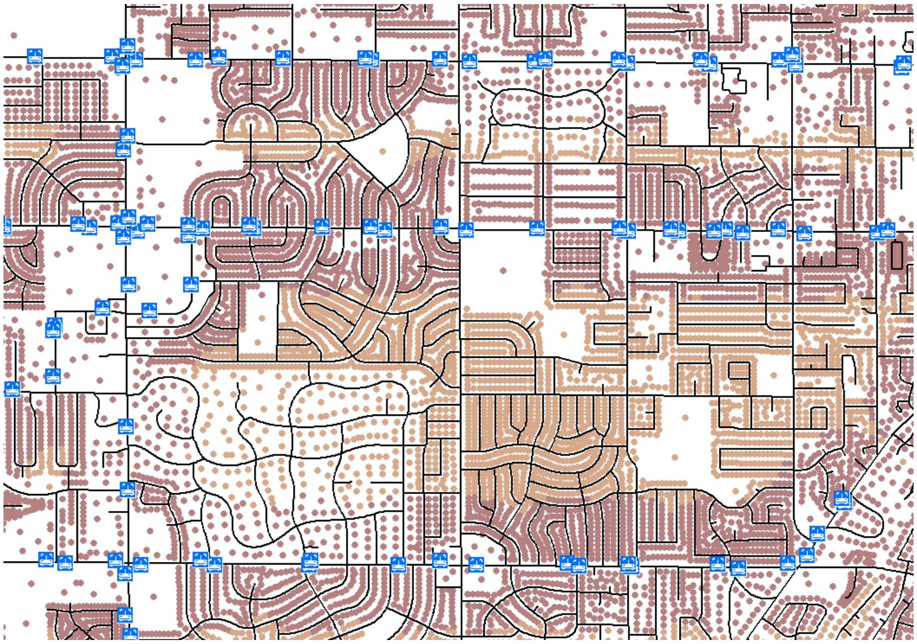


Source: SACOG 2025.

4.6.3.2 Transit Stops File Process

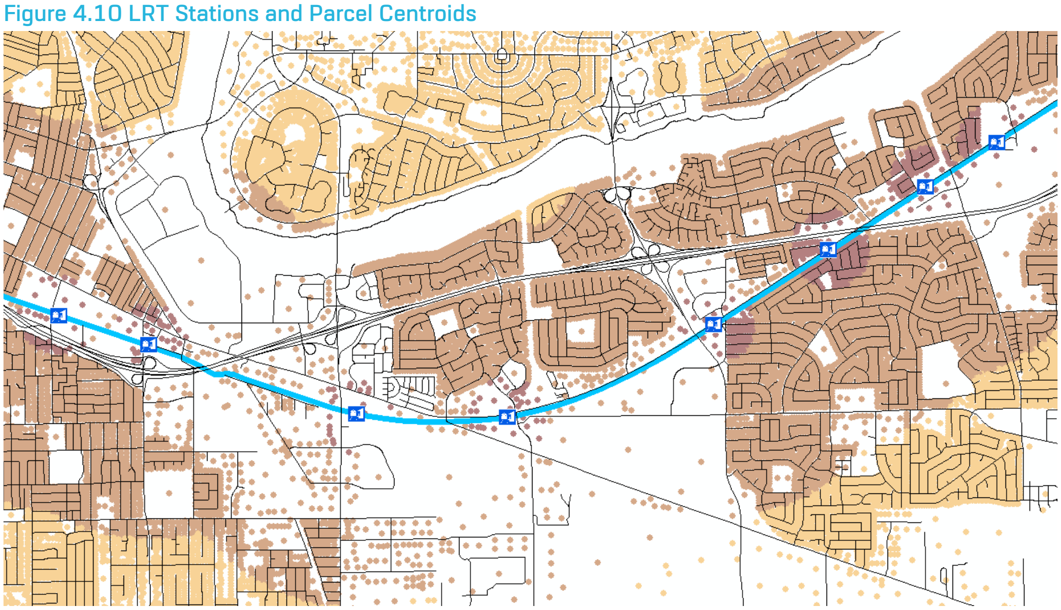
Transit proximity is represented at parcel level as the distance to the nearest transit station or stop. Two variables are computed for each parcel: the distance to the nearest LRT (or more generally, rail) station (DIST_LRT), and distance to the nearest bus (or more generally, rubber-tired) stop. The distance is computed as the straight-line distance from the parcel point and the nearest station or stop. Figure 4-8 and Figure 4-9 show the relationship between Bus and Light Rail Stops to parcel-points.

Figure 4.9 Bus Stops and Parcel Centroids



Source: SACOG 2025.

Figure 4.10 LRT Stations and Parcel Centroids



Source: SACOG 2025.

4.6.3.3 Open Space File Process

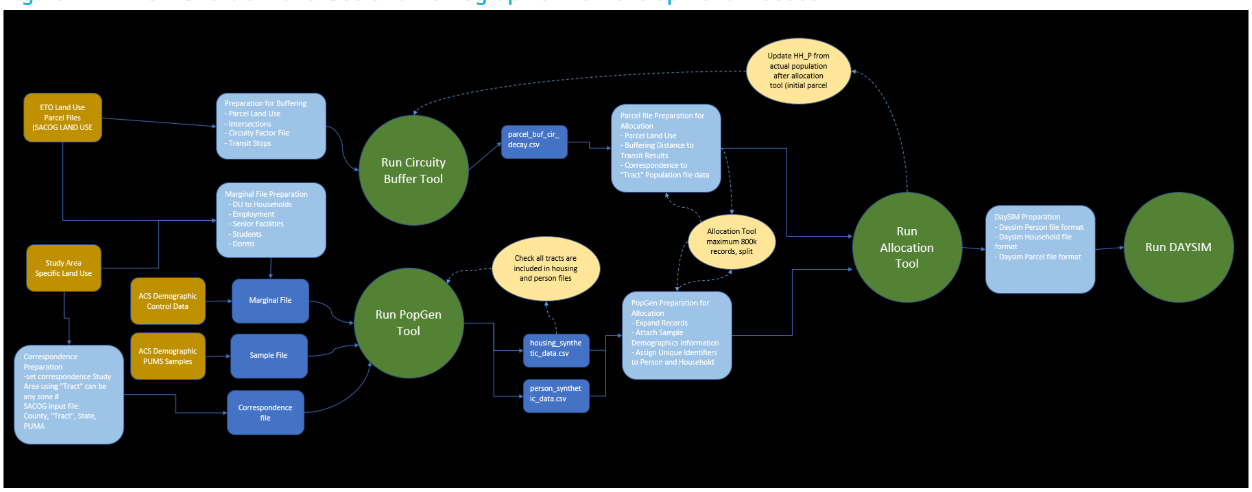
Open space file includes open space areas with public recreation access. This includes parks and sporting fields. Large open spaces with restricted access were removed from file. Open spaces are represented by a centroid location and area.

4.7 SACSIM Parcel Land Use User Guide

4.7.1 Introduction

SACSIM requires detailed parcel, household, and population data inputs to run DAYSIM at a parcel zone level. Preparing these files is not part of SACSIM itself, but a necessary preparatory step to create and format the inputs needed to model a scenario. These three files are interdependent; they require specific relationship identification fields to link between data such as parcel point locations, household and person characteristics. Steps below layout how to create the initial parcel file, spatial land use attributes, and tools to join parcel, household, and population files together. Chapter 5 describes how to create the household and population files and will need to be used concurrently to develop the three inputs. Figure 4-10 illustrates the flow and sometimes iterative nature used to prepare the preprocessing land use, demographic, and population files used to build the SACSIM ***<scenario>_raw_parcel.txt***, ***<scenario>_raw_household.txt***, ***<scenario>_raw_person.txt*** required inputs.

Figure 4.11 Flow Chart of Land Use and Demographic File Development Process



4.7.2 Step 1: Create Scenario Parcel Base File

Create Parcel file containing all parcel variables described in Section 4.5 above and formatted in Table 4-3. Since XY coordinates, TAZ relationships, and parcel area are required, starting with a GIS boundary field is helpful.

Households and Employment totals must be defined for each SACSIM scenario. Households on each parcel are estimated by occupancy rate and the number of dwelling units (DU's) from land use dataset. Dwelling units are developed as part of our 2025 Blueprint. Then occupancy rate is sourced from ACS sample data and adjusted by regional control to determine the initial estimate of number of households per parcel. Employment totals and sub totals are also forecasted as part of the MTP/SCS process.

For project-level analysis, more disaggregated land use information may be readily available and should be formatted into the SACSIM parcel categories and formatting.

K-12 and University parcels will need to be identified with the number of students enrolled. This data is then assigned a corresponding PARCELID based on land use and proximity and combined into the scenario parcel file. See section Parcel Variables K-12 Student Enrollment on details for enrollment inventory and forecasting.

Parking inventory and pricing is joined to the parcel similar to student enrollment by assigning a corresponding PARCELID based on land use and proximity. SACSIM23 cost functions operates using 2000 dollars. Daily and hourly parking price data must be converted to 2000 dollars using an appropriate Consumer Price Index (CPI) conversion rate. SACOG uses the Western Regional CPI. See section Parcel Variables Parking on details for enrollment inventory and forecasting.

4.7.3 Step 2: Prepare Inputs for Parcel Buffering

Once the base scenario parcel file is created. The following Circuity Buffering process inputs must be prepared:

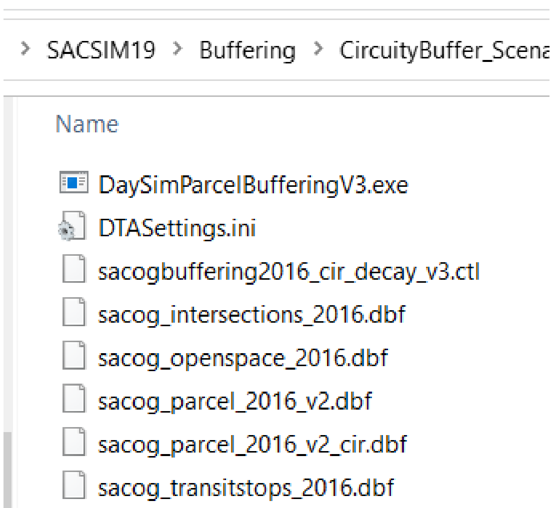
- Intersections
- Transit Stops
- Open Space
- Circuity Points

Descriptions and formatting for these files can be found under Section 4.6.3.

4.7.4 Step 3: Run Circuity Buffering Tool

1. Set up scenario folder with buffering executable **DaySimParcelBufferingV3.exe**, control file **sacogbuffering_.ctl**, and parcel buffering inputs.

Figure 4.12 Circuity Buffer Tool Input Folder Example



2. Set up control file inputs.
    a. Output file name and directory, this will be the be the parcel input for DAYSIM.
    b. Parcel Buffering inputs and file types created in step 1.
    c. Buffering Parameters
        i. Logistic decay parameters:
            1. Limited 3 miles
            2. Buffer Band 1 Distance 0.125 miles
            3. Buffer Band 2: Distance 0.25 miles
            4. Offsets 0.5 miles

Figure 4.13 Circuity Buffering Tool Configuration File Example

sacogbuffering2016_cir_decay_v3.ctl

```
RUNLAB sacog 2008 decay buffering with circuity adjustment
PRNTFN sacog_2016_decay_and_circ.prn                         print file name

OUTDIR .\                                            output directory pathname
OUTFNM parcel_16_buf_cir_decay_may19.txt                     output parcel buffer file name (file type always ascii)
OUTDLM 3                                             outfile file delimiter (1=space, 2=tab, 3=comma)
INPDIR .\                                            input directory pathname
PARCFT 1                                             input parcel file type (1=dbf, 2=ascii - space or tab delimited)
PARCFN sacog_parcel_2016_v2.dbf                       input parcel base data file name
INTSFT 1                                             input intersection file type (0=none, 1=dbf, 2=ascii - space or tab delimited)
INTSFN sacog_intersections_2016.dbf                  input intersection data file name
TRSTFT 1                                             input transit stop file type (0=none, 1=dbf, 2=ascii - space or tab delimited)
TRSTFN sacog_transitstops_2016.dbf                   input transit stop data file name
OPSPFT 1                                             input open space file type (0=none, 1=dbf, 2=ascii - space or tab delimited)
OPSPFN sacog_openspace_2016.dbf                      input open space data file name
CIRCFT 1                                             input circuity file type (0=none, 1=dbf, 2=ascii - space or tab delimited)
CIRCFN sacog_parcel_2016_v2_cir.dbf               input circuity data file name
CIRCDF 0                                             >0 if circuity data file is for different set of points

DLIMIT 15840.0          orthogonal distance limit (feet) above which parcels are not considered for buffering

BTYPE1 2                type for buffer 1 (1 = flat, 2 = logistic decay, 3 = exponential decay)
BDIST1 660.0            buffer 1 inflection distance (feet) - used in different way depending on buffer type
BOFFS1 2640.0           buffer1 offset distance (feet) (used for logistic decay type)
DECAY1 0.76             buffer 1 decay slope parameter (used for logistic decay type)

BTYPE2 2                type for buffer 2 (1 = flat, 2 = logistic decay, 3 = exponential decay)
BDIST2 1320.0           buffer 2 inflecton distance (feet) - used in different way depending on buffer type
BOFFS2 2640.0           buffer2 offset distance (feet) (used for logistic decay type)
DECAY2 0.76             buffer 2 decay slope parameter (used for logistic decay type)
```

3. Run executable from Command Prompt.
   a. Point to directory example: *cd Q:\SACSIM19\Buffering\Circuity\circuity_buffer_2016*
   b. Run executable with control file: **DaySimParcelBufferingV3.exe sacogbuffering_.ctl**

Figure 4.14 Run Circuity Buffer From Command Prompt

Command Prompt

```
Microsoft Windows [Version 10.0.18363.720]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Windows\system32>Q:

Q:\>cd Q:\SACSIM19\2020MTP\data release\Mirror of FTP site\SACSIM19\Buffering\CircuityBuffer_Scenarios\CircuityBuffer_Sc
enarios\circuity_buffer_2016

Q:\SACSIM19\2020MTP\data release\Mirror of FTP site\SACSIM19\Buffering\CircuityBuffer_Scenarios\CircuityBuffer_Scenarios
\circuity_buffer_2016>DaySimParcelBufferingV3.exe sacogbuffering2016_cir_decay_v3.ctl
```

   c. Confirm Buffer scripts begins running through zones.

Figure 4.15 Run Circuity Buffer From Command Prompt 2

```
Command Prompt - DaySimParcelBufferingV3.exe  sacogbuffering2016_cir_decay_v3.ctl
BOFFS2 2640.0           buffer2 offset distance (feet) (used for logistic decay type)
DECAY2 0.76             buffer 2 decay slope parameter (used for logistic decay type)
Opened DBase file .\sacog_parcel_2016_v2.dbf for input
dBase file last updated: 6/5/119
File has 24 data fields  and 751364 records of 403 bytes
Field 1: PARCELID   N10.0
Field 2: X_COORD   N10.0
Field 3: Y_COORD   N10.0
Field 4: AREA_SQF   N10.0
Field 5: TAZ   N10.0
Field 6: LUSECODE   N10.0
Field 7: HH_P   F19.11
Field 8: STUGRD_P   F19.11
Field 9: STUHGH_P   F19.11
Field 10: STUUNI_P   F19.11
Field 11: EMPEDU_P   F19.11
Field 12: EMPFOO_P   F19.11
Field 13: EMPGOV_P   F19.11
Field 14: EMPIND_P   F19.11
Field 15: EMPMED_P   F19.11
Field 16: EMPOFC_P   F19.11
Field 17: EMPRET_P   F19.11
Field 18: EMPSVC_P   F19.11
Field 19: EMPOTH_P   F19.11
Field 20: EMPTOT_P   F19.11
Field 21: PARKDY_P   F19.11
Field 22: PARKHR_P   F19.11
Field 23: PPRICDYP   F19.11
Field 24: PPRICHRP   F19.11
   10000    20000    30000    40000    50000    60000    70000
```

d. Buffer Complete

4.7.5 Step 4: Prepare Population file for Allocation

See Chapter 5 for more detailed instructions on preparing the household and population files.

4.7.6 Step 5: Prepare Parcel Buffer Outputs for Allocation Process

Once the synthetic population and households have been developed (Step 4) and the parcel buffering is complete. The parcel file must be prepared for the population and households to be associated back with the parcel file. SACOG uses an executable allocation process developed by RSG to perform this process. This includes assigning the correct number of dorm students, and senior facilities to the proper TAZ.

To prepare the parcel file for the allocation process, the land use parcel input must be combined with the circuity buffering project outputs.

Distance fields must also be updated. The Circuity file produces 999 distance placeholders for far away distance that must be replaced with -1. All other distance formats must be converted by multiplying the distance 100 and converting to an integer.

The household count field (hh_p) from the circuity script must also be multiplied by 100 and converted to a whole integer.

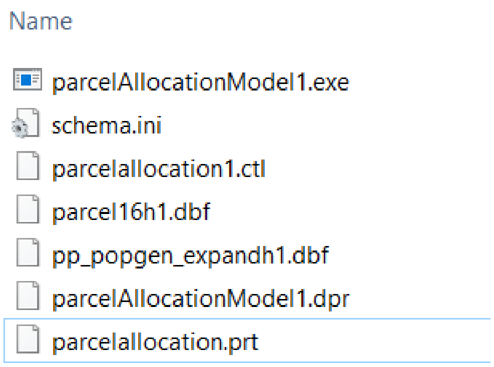
Since senior facilities household demographics characteristics are controlled to only parcels where senior living facilities exists, senior facilities are added to a separate category and treated the same way Dorm students are for the Allocation process. For that purpose, PseudoTAZs are created that separate out dorms and senior facilities from the rest of the parcels in their TAZ. The PseudoTAZ value is used instead of TRACT for controlling totals.

The Allocation tool requires parcel unique identifier to be sorted in ascending order and must not be greater than 200,000 records. For this reason, we split the parcel and population files into six parts and run the allocation tool for each split.

4.7.7 Step 6: Run Allocation Tool

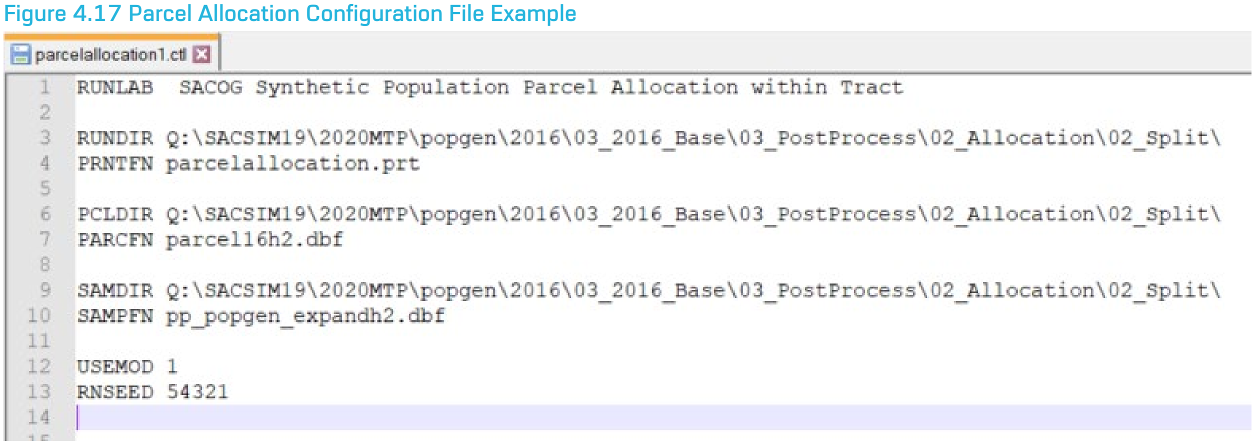
1. Once both Population (Step 4) and parcel file (Step 5) have been prepared for allocation tool, scenario folder set is required with Allocation executable parcelAllocationModel1.exe, control file parcelallocation1.ctl, print file, dpr, and parcel and population inputs as shown in Figure 4-17.

Figure 4.16 Allocation Inputs



2. Set up control file inputs and directory paths.
   a. Print file (*parcelallocation.prt*)
   b. Parcel file
   c. Population file

Figure 4.17 Parcel Allocation Configuration File Example



parcelallocation1.ctl

```
RUNLAB  SACOG Synthetic Population Parcel Allocation within Tract

RUNDIR Q:\SACSIM19\2020MTP\popgen\2016\03_2016_Base\03_PostProcess\02_Allocation\02_Split\
PRNTFN parcelallocation.prt

PCLDIR Q:\SACSIM19\2020MTP\popgen\2016\03_2016_Base\03_PostProcess\02_Allocation\02_Split\
PARCFN parcel16h2.dbf

SAMDIR Q:\SACSIM19\2020MTP\popgen\2016\03_2016_Base\03_PostProcess\02_Allocation\02_Split\
SAMPFN pp_popgen_expandh2.dbf

USEMOD 1
RNSEED 54321
```

3. Run executable **parcelAllocationModel1.exe** from Command Prompt.
   a. Point to directory example: *cd Q:\SACSIM19\2020MTP\popgen\\01_2016_Base\03_PostProcess\02_Allocation\01_Split*
   b. Run executable with control file: **parcelAllocationModel1.exe parcelallocation1.ctl**

4. Check for Parcel Allocation Errors in print file.
   a. During allocation process, print statements keep track of parcel allocated to zones. This step may break if number of populations per zone or group quarter per zone between the parcel and population files do not match.

Figure 4.18 Review Allocation Print File for Errors

parcelallocation.prt

```


Reading sample households ....  Percent completed ...
0...10...20...30...40...50...60...70...80...90...100
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
Finished at  5/7/2019 10:20:11 AM
1244673 records read from pp_popgen_expandh2.dbf

SEQ TRACT NPCLS NDORM NDREC NHHLDS NHHREC  D/PCL  SLACK    Before Adjustment
  1 30602  2195    24    24   2446   2446  0.000      0
  2 30603  1077     0     0   1163   1163  0.000      0
  3 30601  1786     0     0   1921   1921  0.000      0
  4 31900    31     0     0     31     31  0.000      0
  5 30901  1041     0     0   1161   1161  0.000      0
  6 31302  1276     0     0   1828   1828  0.000      0
  7 31000  1673     0     0   2453   2453  0.000      0
  8 31100  1665     0     0   2221   2221  0.000      0
  9 31301  1101     1     1   1258   1258  0.000      0
 10 30801  1282     1     1   1341   1341  0.000      0
 11 30701  1945     0     0   2170   2170  0.000      0
 12 31406  1899     0     0   1971   1971  0.000      0
 13 30902  1543     1     1   1577   1577  0.000      0
 14 31405   845     0     0    876    876  0.000      0
 15 31200  1656    96    96   1934   1934  0.000      0
```

5. Review Allocation tool run is complete, review result outputs and summary in print statement.

Figure 4.19 Review Allocation Print Summary Example

parcelallocation.prt

```

Reading sample households ....  Percent completed ...
0...10...20...30...40...50...60...70...80...90...100
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
Finished at  5/7/2019 10:20:58 AM
1244673 records read from pp_popgen_expandh2.dbf

        High  Mod.High   Mod.Low       Low  Very Low Urban/Mix Segment
        5896     17530     14066     32081     18584       611 Income   0- 20
        3963     14757     13295     38500     22513       433 Income  20 -40
        1940      9412      9990     36297     20447       199 Income  40 -60
        1991     10567     11264     42943     28619       189 Income  60-100
        1050      5602      7329     35976     26829       122 Income  > 100
        8299     40727     41163    151906     95238       847 2+ pers hhld
        6541     17141     14781     33891     21754       707 1 pers hhld
       11900     50091     45636    162076    106288      1299 Family hhld
        2940      7777     10308     23721     10704       255 Non-family hhd
       12616     47096     42670    130012     85465      1281 No school kids
        2224     10772     13274     55785     31527       273 1+ school kids
        9722     43285     45055    161074     99112       895 Not all senior
        5118     14583     10889     24723     17880       659 All seniors
       14488     56237     55225    182678    114205      1507 Not single prt
         352      1631       719      3119      2787        47 Single parent

```

4.7.8 Step 7: Rerun buffering analysis

The initial buffer tool was calculated based off estimated households (ACS occupancy rates * dwelling units). Because of this, after the representative population and household allocation have been completed, the circuity buffer tool should be rerun to make sure all households proximity to transit are accurate. Important: If split for allocation, both results must be merged back using PARCELID before running Circuity Buffering and Step 8.

4.7.9 Step 8: Format Parcel File for DAYSIM

Rename and format results of final circuity buffering results into DAYSIM parcel input format: ASCII delimited, with header. The delimiter can be specified in the configuration file. Table 4-5 lists the order and description of all required fields.

Table 4-4 Parcel Input File Fields for SACSIM23

Field	Description
parcelid	The parcel ID number
xcoord_p	The X coordinate (SPF) of the parcel centroid
ycoord_p	The Y coordinate (SPF) of the parcel centroid
sqft_p	The square footage area of the parcel
taz_p	The zone_ID associated with the parcel
lutype_p	The land use type code (housing density class)
hh_p	The number of households residing on the parcel
stugrd_p	The number of grade school (K-8) students enrolled at the parcel
stuhgh_p	The number of high school students enrolled at the parcel
stuuni_p	The number of college students enrolled at the parcel
empedu_p	The number of educational employees working at the parcel
empfoo_p	The number of food service employees working at the parcel
empgov_p	The number of government employees working at the parcel
empind_p	The number of industrial employees working at the parcel
empmed_p	The number of medical employees working at the parcel
empofc_p	The number of (other) office employees working at the parcel
empret_p	The number of retail employees working at the parcel
empsvc_p	The number of (other) service employees working at the parcel
empoth_p	The number of other sector employees working at the parcel (typically agriculture, mining - not used for SACOG)
emptot_p	The total number of employees working at the parcel (equals the sum of the previous 9 values)
parkdy_p	The number of paid off street parking spaces on the parcel with per day pricing
parkhr_p	The number of paid off street parking spaces on the parcel with per hour pricing
ppricdyp	The average price per day for paid off street parking spaces on the parcel
pprichrp	The average price per hour for paid off street parking spaces on the parcel
hh_1	The number of households residing in Buffer 1
stugrd_1	The number of grade school (K-8) students enrolled in Buffer 1
stuhgh_1	The number of high school students enrolled in Buffer 1
stuuni_1	The number of college students enrolled in Buffer 1
empedu_1	The number of educational employees working in Buffer 1
empfoo_1	The number of food service employees working in Buffer 1
empgov_1	The number of government employees working in Buffer 1
empind_1	The number of industrial employees working in Buffer 1
empmed_1	The number of medical employees working in Buffer 1
empofc_1	The number of (other) office employees working in Buffer 1
empret_1	The number of retail employees working in Buffer 1
empsvc_1	The number of (other) service employees working in Buffer 1
empoth_1	The number of other sector employees working in Buffer 1 (typically agriculture, mining - not used for SACOG)
emptot_1	The total number of employees working in Buffer 1 (equals the sum of the previous 9 values)
parkdy_1	The number of paid off street parking spaces in Buffer 1 with per day pricing
parkhr_1	The number of paid off street parking spaces in Buffer 1 with per hour pricing
ppricdy1	The average price per day for paid off street parking spaces in Buffer 1
pprichr1	The average price per hour for paid off street parking spaces in Buffer 1
nodes1_1	The number of 1-node intersections (dead-ends, cul-de-sacs) in Buffer 1
nodes3_1	The number of 3-node intersections (T junctions) in Buffer 1
nodes4_1	The number of 4+ node intersections in Buffer 1
tstops_1	The number of transit stops (of all types) in Buffer 1
nparks_1	The number of publicly accessible open space areas in Buffer 1
aparks_1	The average area (sq feet) of publicly accessible open space areas in Buffer 1
hh_2	The number of households residing in Buffer 2
stugrd_2	The number of grade school (K-8) students enrolled in Buffer 2
stuhgh_2	The number of high school students enrolled in Buffer 2

Field	Description
stuuni_2	The number of college students enrolled in Buffer 2
empedu_2	The number of educational employees working in Buffer 2
empfoo_2	The number of food service employees working in Buffer 2
empgov_2	The number of government employees working in Buffer 2
empind_2	The number of industrial employees working in Buffer 2
empmed_2	The number of medical employees working in Buffer 2
empofc_2	The number of (other) office employees working in Buffer 2
empret_2	The number of retail employees working in Buffer 2
empsvc_2	The number of (other) service employees working in Buffer 2
empoth_2	The number of other sector employees working in Buffer 2 (typically agriculture, mining - not used for SACOG)
emptot_2	The total number of employees working in Buffer 2 (equals the sum of the previous 9 values)
parkdy_2	The number of paid off street parking spaces in Buffer 2 with per day pricing
parkhr_2	The number of paid off street parking spaces in Buffer 2 with per hour pricing
ppricdy2	The average price per day for paid off street parking spaces in Buffer 2
pprichr2	The average price per hour for paid off street parking spaces in Buffer 2
nodes1_2	The number of 1-node intersections (dead-ends, cul-de-sacs) in Buffer 2
nodes3_2	The number of 3-node intersections (T junctions) in Buffer 2
nodes4_2	The number of 4+ node intersections in Buffer 2
tstops_2	The number of transit stops (of all types) in Buffer 2
nparks_2	The number of publicly accessible open space areas in Buffer 2
aparks_2	The average area (sq feet) of publicly accessible open space areas in Buffer 2
dist_lbus	The distance (miles) to the nearest local bus stop (999 if beyond 3 miles)
dist_ebus	The distance (miles) to the nearest premium bus stop (999 if beyond 3 miles)
dist_crt	The distance (miles) to the nearest commuter rail stop/station (999 if beyond 3 miles)
dist_fry	The distance (miles) to the nearest passenger ferry terminal (999 if beyond 3 miles)
dist_lrt	The distance (miles) to the nearest light rail stop/station (999 if beyond 3 miles)
dist_park	The distance (miles) to the edge of the nearest publicly accessible open space area (999 if beyond 3 miles)
Circ_E1	The short-distance circuity factor for direction E, distance 0.5 miles
Circ_E2	The short-distance circuity factor for direction E, distance 1.0 miles
Circ_E3	The short-distance circuity factor for direction E, distance 1.5 miles
Circ_NE1	The short-distance circuity factor for direction NE, distance 0.5 miles
Circ_NE2	The short-distance circuity factor for direction NE, distance 1.0 miles
Circ_NE3	The short-distance circuity factor for direction NE, distance 1.5 miles
Circ_N1	The short-distance circuity factor for direction N, distance 0.5 miles
Circ_N2	The short-distance circuity factor for direction N, distance 1.0 miles
Circ_N3	The short-distance circuity factor for direction N, distance 1.5 miles
Circ_NW1	The short-distance circuity factor for direction NW, distance 0.5 miles
Circ_NW2	The short-distance circuity factor for direction NW, distance 1.0 miles
Circ_NW3	The short-distance circuity factor for direction NW, distance 1.5 miles
Circ_W1	The short-distance circuity factor for direction W, distance 0.5 miles
Circ_W2	The short-distance circuity factor for direction W, distance 1.0 miles
Circ_W3	The short-distance circuity factor for direction W, distance 1.5 miles
Circ_SW1	The short-distance circuity factor for direction SW, distance 0.5 miles
Circ_SW2	The short-distance circuity factor for direction SW, distance 1.0 miles
Circ_SW3	The short-distance circuity factor for direction SW, distance 1.5 miles
Circ_S1	The short-distance circuity factor for direction S, distance 0.5 miles
Circ_S2	The short-distance circuity factor for direction S, distance 1.0 miles
Circ_S3	The short-distance circuity factor for direction S, distance 1.5 miles
Circ_SE1	The short-distance circuity factor for direction SE, distance 0.5 miles
Circ_SE2	The short-distance circuity factor for direction SE, distance 1.0 miles
Circ_SE3	The short-distance circuity factor for direction SE, distance 1.5 miles

5 Representative Population Data

The SACSIM model requires a detailed population file with representation of key demographics, such as household size, income and age of the population. SACOG uses the following process to generate the representative population file. The key software used in the process is known as "PopulationSim". The program generates synthetic populations whereby both household-level and person-level characteristics of interest can be matched. This chapter describes the various aspects involved in the process of generating the representative population for transportation demand forecasting.

5.1 Land Use Scenarios

Parcel-based dwelling units maintained in the land use scenario model is the base for generating representative population. Land use scenarios include "yield" estimates of a range of land use variables at parcel level. Two variables are used directly in SACSIM: dwelling units and jobs by sector. The yield estimates are based on the "place type" (generalized land use) of the parcel, the parcel area, and several physical, environmental, or policy constraints. Yield estimates are calibrated to match small area inventories of dwellings and jobs for the base year. Yield estimates are made for future year growth based on the future year place type and development status of each parcel in the future year scenario, and constraints expected to be in place at each parcel in the future year.

5.2 Household/Population Demographics

Travel demand forecasting models like SACSIM have always relied heavily on representations of key demographic characteristics in the population input file used for modeling. The following variables and categories are used for the household and person controls in the current process:

- Household and person numbers are based on the 2020 Census, housing inventory and occupancy rates.
- Household size (5 categories: 1, 2, 3, 4, and 5-or-more persons per household)
- Household Income in 2020 dollars (5 categories: less-than-$35,000, $35,000 to $60,000, $60,000 to $100,000, $100,000 to $150,000, and $150,000-or-more). These values are converted to 2000 dollars after sampling.
- Age of householder, or head-of-household (3 categories: <35 years; 35 to 64 years; and 65-or-more years)
- Workers per household (4 categories: 0, 1, 2 and 3-or-more workers per household).
- The number of university student "households" clustered near to colleges or universities are controlled.
- Person Ethnicity: (5 categories: 1. White Non-Hispanic, 2. Black Non-Hispanic, 3. Hispanic, and 4. Asian, 5. Pacific Islander, or Other; including people who identify with two ethnic groups and Native Americans and Pacific Islanders. Note person ethnicity does not impact travel in the model, but helps make the synthetic population better represent the region's residents.
- Person Age: There are five categories of age controls: 0-4, 5-14, 15-35, 35-63, 64-74, and 75-plus.
- The number of dorms as well as the number of senior "households" at senior living facilities and 55+ communities. Dorm students and people living in senior facilities and 55+ communities are accounted for as Group Quarter population throughout the development of the representative population process. They are still included in general household and population summaries. Person-level controls on age are also included.
- Senior facilities and dorms characteristics are controlled separately. The characteristics of future 55+ communities are also controlled to match state regulations for their residents.

These variables are controlled at different geographic levels further detailed in section 5.4.

5.3 Base Year Household/Population Demographics

The base year for SACSIM23 is 2020. The 2020 Census is used to control the region-wide household and population totals. The ACS data, 5-year sample 2016-2020, provides a demographic portrait of the region's population characteristic splits. Additionally, the housing inventory maintained by SACOG provides details on household number and location. The ACS Public Use Microdata Sample (PUMS) data provides the characteristics of a sample of the region's residents. Based on the data obtained from these sources, SACOG uses a software tool PopulationSim to develop a representative, or synthetic, population to use to model travel within the region using SACSIM. The process is explained in further detail in Section 5.4.

The following tables present different characteristics of the synthesized representative base year population at the county level. Further details on how this data validates compared to ACS data can be found in Section 11.

Table 5-1. Synthetic Household Size Distribution

SACSIM23 Representative Population Data

County	1 person	2 persons	3 persons	4 persons	5+ persons
El Dorado*	21%	42%	14%	13%	9%
Placer*	23%	37%	15%	15%	10%
Sacramento	25%	31%	16%	15%	12%
Sutter	22%	30%	18%	16%	14%
Yolo	22%	32%	18%	17%	11%
Yuba	24%	28%	17%	16%	15%
Total	24%	33%	16%	15%	12%

Table 5-2. Number of Synthetic Household Workers Distribution

SACSIM23 Representative Population Data

County	0 workers	1 worker	2 workers	3+ workers
El Dorado*	34%	34%	26%	6%
Placer*	29%	33%	31%	7%
Sacramento	25%	38%	29%	8%
Sutter	28%	36%	28%	9%
Yolo	26%	34%	32%	8%
Yuba	28%	40%	26%	6%
Total	27%	36%	29%	8%

Table 5-3. Synthetic Household Income Distribution

SACSIM23 Representative Population Data

County	< $35k	$35k - $60k	$60k - $100k	$100k - $150k	$150k+
El Dorado*	18%	15%	21%	19%	26%
Placer*	17%	14%	21%	19%	28%
Sacramento	24%	19%	23%	18%	17%
Sutter	26%	21%	24%	16%	13%
Yolo	25%	15%	21%	17%	22%
Yuba	29%	20%	23%	18%	10%
Total	23%	17%	22%	18%	19%

Table 5-4. Synthetic Householder Age Distribution

SACSIM23 Representative Population Data

County	< 35 years	35 - 64 years	>= 65 years
El Dorado*	9%	56%	35%
Placer*	12%	56%	32%
Sacramento	21%	56%	23%
Sutter	20%	54%	26%
Yolo	25%	52%	22%
Yuba	23%	55%	22%
Total	19%	56%	25%

*exclude Tahoe basin

5.4 Future Year Household/Population Demographics

SACOG relies on the Center for Continuing Study of the California Economy (CCSCE) to prepare the long range, region-level projections of population, housing and jobs. These projections were adopted by the SACOG Board of Directors, for use in development and analysis of the MTP/SCS scenarios. The Board-adopted region-level projections serve as control totals and guidance for development of spatially detailed, small area projections.

When establishing marginal controls for future years, a new process is implemented. For the residential areas already developed in 2020 base year, demographics from the 5-year 2016-2020 ACS data are applied. Then, the regional demographic projections from CCSCE are factored in, to forecast total population and household numbers. For the future developing residential areas, average demographics by community type, generalized place type and county from base year 2020 are used. Further age and ethnicity projections are applied region-wide based on the data provided by the California Department of Finance's Demographic Projections Unit's projections. Also, an income control is added to ensure the region-wide average income remains constant due to the absence of income forecasts.

Table 5-5 Description of Generalized Place Types

Place Type #	Description	Examples of Place Types from Land use Model
1	High density	High density attached residential/Very high density attached residential
2	Medium-High density	Medium-High density attached/detached residential
3	Medium density	Medium density attached/detached residential, mobile home
4	Low density	Low density detached residential
5	Very low density	Farm home/Rural residential/Very low density detached residential
6	Mixed/Urban	Residential/Retail Mixed Use Low/High, Urban Attached Residential

Source: SACOG 2025.

5.4.1 Representative Population Generation Process

A representative population file includes one data record per person in the base year or future year to be analyzed. This section describes the steps SACOG uses to generate a representative population.

1. Prepare Input files for PopulationSim

As described above, SACOG uses a population synthesis software called PopulationSim, which requires three sets of input files:

Marginal control files for the control variables, micro-samples collected by the Census Bureau, and geographic corresponding file describing relationships among levels of geographic areas. *Marginal control files* are prepared at different geographic levels. To prepare household marginal control files, dwelling units from land use model are aggregated to the PseudoTAZ (TAZ plus distinctions for dorms, seniors and 55+ communities) level and are converted to households by applying adjusted occupancy rates based on ACS 5-year sample data at census block group level. These households are aggregated to the block group and tract level and split by predefined categories of control variables. The person control totals are estimated using the number of households by household size controls. Then, the person control tables are aggregated to the block group level and split by the person level control variables (age and ethnicity). This process is done separately for dorms, senior facilities, and 55+ communities.

Sample Files are used to create this micro-sample file for PopulationSim. Public Use Micro-sample (PUMS) files from Census are modified by recoding control variables to the defined categories. 2016-2020 5-year PUMS survey was used and cleaned. Certain households are identified as clustered university student households if they are one- or two- person households in which all members are students.

Correspondence file is used to connect the different geographies in the marginal and sample files.

Additional information on preparing these files is provided upon request from the SACOG Modeling Team.

2. Run PopulationSim

Using the prepared inputs, PopulationSim samples households that fit specified requirements. Refer to PopulationSim documentation for detailed steps (https://activitysim.github.io/populationsim/index.html).

PopulationSim SACOG Input File Descriptions The following table shows the different marginal control variables and at what geographic level.

Table 5-6. PopulationSim Marginal File Field Descriptions

Variable	Description	Control Geography
pbase	Number of persons	PseudoTAZ
hhbase	Number of Households	PseudoTAZ
hh_size_1	Household Size 1	Block Group
hh_size_2	Household Size 2	Block Group
hh_size_3	Household Size 3	Block Group
hh_size_4	Household Size 4	Block Group
hh_size_5_plus	Household Size 5+	Block Group
hh_age_0_35	Householder Age 0-34	Block Group
hh_age_35_64	Householder Age 35-64	Block Group
hh_age_65_plus	Householder Age 65+	Block Group
hh_income_0_35	Household Income $0-$35,000	Block Group
hh_income_35_60	Household Income $35,000-$60,000	Block Group
hh_income_60_100	Household Income $60,000-$100,000	Block Group
hh_income_100_150	Household Income $100,00-$150,000	Block Group
hh_income_150_plus	Household Income $150,000+	Block Group
hh_workers_0	0 Household Workers	Tract
hh_workers_1	1 Household Workers	Tract
hh_workers_2	2 Household Workers	Tract
hh_workers_3_plus	3+ Household Workers	Tract
univ_cluster_regular	Not a University Cluster	Tract
univ_cluster_student	University Cluster	Tract
ethn_white_non_hispanic	Person Ethnicity White Non-Hispanic	Block Group
ethn_black_non_hispanic	Person Ethnicity Black Non-Hispanic	Block Group
ethn_hispanic	Person Ethnicity Hispanic	Block Group
ethn_asian	Person Ethnicity Asian	Block Group
ethn_other	Person Ethnicity Other	Block Group
age_0_4_p	Person Age 0-4	Block Group
age_5_15_p	Person Age 5-15	Block Group
age_15_34_p	Person Age 16-34	Block Group
age_35_64_p	Person Age 35-64	Block Group
age_65_74_p	Person Age 65-75	Block Group
age_75_plus_p	Person Age 75+	Block Group

Source: SACOG 2025. Note: All income values are in year 2020 dollars in the marginal table.

3. Post-process PopulationSim Outputs

The outputs of PopulationSim include PUMS variables. They are postprocessed using a script to match SACSIM requirements. Some variables like ethnicity are categorical while others are numerical like income. Also, since SACSIM23 uses 2000 dollars, the income of sampled individuals is converted from 2020 dollars.

4. Allocate Household/population to Parcels

Finally, a separate, customized program is used to allocate the representative population households to parcels within PseudoTAZs considering characteristics of the parcel such as land use type, distance to transit, distance to schools etc. See Chapter 4 for more information on how to set up and run the household and population to parcel allocation process.

6 Highway Networks

The travel model uses coded representations of the Sacramento region's highway network, which provides the basis of estimating zone-to-zone travel times and costs for the trip distribution and mode choice models and for trip routing in the vehicle assignments. The highway network serves not only as the basis of highway travel times and traffic assignments, but also as the basis of bus running times and zonal walk- and drive-access for transit travel time and assignment. This section provides an overview of the coding of the highway network.

6.1 Opening and Editing the Highway Network

SACSIM's highway network is a Cube NET file. To open and edit the file, use Cube Base modeling software.

Table 6-1 lists the network variables used in the SACSIM highway base network. Most link attributes are intuitive and modelers can use Table 6-1 as a reference for coding updates to the highway network. However, the conventions for coding the CAPCLASS values are more nuanced and we recommend users refer to section 6.3 below on Capacity Class.

Table 6-1 SACSIM Highway Network Variables

Property (SACSIM variable name)	Convention
SPEED (Free Flow Speed)	"Free-flow" speed, or average speed with no congestion.
DISTANCE	Link distance (miles).
CAPCLASS	Capacity Class. Points to a lookup table of capacity values, in vehicles per hour per lane.
TOLLID	ID for links comprising one tolled facility in one direction.
GPID	ID corresponding to the general-purpose links that run parallel to a tolled facility. The toll for the links with the TOLLID are based on congestion on links whose GPID is the same as the TOLLID.
AUXID	ID corresponding to auxiliary lanes that run parallel to a tolled facility. Must be same value as GPID.
USECLASS	0 = General-purpose (GP) lane 2 = Restricted to vehicles with 2+ occupants 3 = Restricted to vehicles with 3+ occupants
LANES	Number of through-lanes in the link's direction
BUSLANE	0 = No dedicated bus lane 1 = All-day bus-only lane created from repurposed GP lane 2 = Bus-only lane during peak periods; GP lane off-peak 3 = Bus-only lane built as new lane (no GP lanes taken) See Chapter 7 for more details on bus-only lane coding.
SPDCURV (Speed-flow Curve)	1 = Freeway 2 = Two-Lane Transitional Roadway 3 = Urban/Suburban Arterial
DELCURV (Ramp Meter Indicator)[1]	0 = Not Metered 1 = AM 3 hours only 2 = PM 3 hours only 3 = AM and PM periods (6 hours) 4 = AM, Midday, and PM periods (12 hours) 5 = Metered 24 hours
HOVLINK (Access Codes for Path Building and Assignment)	0 = All trips permitted 1 = Walk and bicycle trips only 2 = HOV-only facility in freeway[1] 3 = HOV-only bypass lane at metered on-ramp
BIKE (Type of bicycle route or facility present on link)	0 = No bike lane 1 = Class 1 bike route 2 = Class 2 bike route 3 = Class 3 bike route 8 = Surface street over- or under- crossing of a freeway, with ramps present, and NO bike lane 9 = Same as type 8, but WITH Class 2 bike lane

Notes: 1 – HOVs, or high-occupancy vehicles are vehicles with two or more occupants.

6.2 Tolling Attributes

Table 6-1 provides a quick description of the link attributes used to code tolled facilities into the highway network. For a more comprehensive review of how to use SACSIM's tolling capabilities, refer to Chapter 9 Auto Operating Costs, Pricing and Transit Fares.

6.3 Capacity Class

The capacity class, or CAPCLASS, attribute determines the capacity of a link in the model network. Capacity classes should not be treated as black-or-white categories. While the definitions of some categories are relatively clear (e.g. "freeway"), most roadways are not "textbook" examples and exhibit some, but not all, characteristics of a specific capacity class. Users must exercise professional judgment to classify a specific existing roadway, based on its observed characteristics, or future roadway, based on the best planning information available. Note that SACSIM capacity classes have no intentional relation to Federal Aid functional classifications.

The definitions below should provide background for the categories used in SACSIM, and guidance to modelers who are using SACSIM networks. Following the definitions is Table 6-3, summarizing basic operating characteristics for each capacity class.

6.3.1 Freeways

A ***freeway*** is a restricted access roadway facility, with all access mediated by ramps. Freeways are intended primarily for longer trips, including: through trips to a region; longer inter-regional trips which begin or end outside the region; and longer regional trips, such as commute trips. There are several "sub-classes" within the general capacity classification:

- General-purpose lanes allow access to any vehicle at any time of day, regardless of occupancy within the vehicle.
- Auxiliary lanes are freeway lanes which connect from an on-ramp to the next downstream off-ramp. They serve as extensions of the subject on-ramp and off-ramp, providing more distance to complete merges and weaves entering or leaving the freeway between the subject ramps. Additionally, auxiliary lanes provide lanes for shorter, ramp-to-ramp trips to use.

  Auxiliary lanes are further split into two types:

  - Lanes of one-mile-or-greater length, which are coded to full freeway capacity, but with a slightly slower free-flow speed than CAPCLASS=1 freeway lanes.
  - Lanes of less-than-one-mile length, which are coded to 1500 vplph, and with free-flow speed 5 mph less than the "through" lanes to capture operational impedance of frequent merging and weaving.

High-occupancy vehicle lanes, or HOV facilities, are typically lanes on freeways that require vehicles to have a minimum number of occupants in order to access them. The USECLASS value, detailed above in Table 6-1, determines the minimum number of occupants required to enter a given HOV facility.

6.3.2 Expressways

An ***expressway*** is a multi-lane surface street with widely spaced signals (one-half mile or greater) and high level of access control. Driveways to or from fronting properties are limited (e.g. by connecting to a frontage road or side street, or consolidated with other properties). Expressways have continuous median barriers between traffic signals, and turning lanes at intersections are heavily channelized. Traffic signal cycle lengths are generally greater than 120 seconds or more during peak periods.

A ***high capacity river crossing*** is a special category for Watt Avenue, Sunrise Boulevard and Hazel Avenue crossings of the American River. These streets have higher than normal capacity for a "surface" or non-freeway street. Although this capacity class could be used for future proposed crossings, it is currently only used to represent streets which, through a combination of design features, operational strategies, and unique driver characteristics or behaviors, are observed to operate at super-normal flows.

6.3.3 Other Urban/Suburban Surface Streets

A ***major arterial*** is a multi-lane surface street with less widely spaced signals and moderate level of driveway access control. Traffic signals are generally spaced at about one-half mile, with turning movements heavily channelized. Medians barriers are present, but breaks between traffic signals (i.e. to a mid-block driveway or un-signalized cross street) may exist. Most driveway access to major arterial streets is for larger commercial uses (shopping centers, office buildings, etc.). Traffic signal cycles are usually about 120 seconds during peak periods.

A ***minor arterial*** is a two-to-four lane surface street with traffic signals spaced at one-quarter to one-half mile intervals. Median barriers may or may not be present. If present, breaks in the median for driveways or un-signalized side streets are more frequent. In some cases, no median barrier is present, and a continuous turn-lane or median stripe is present. Driveway access to the roadway is more frequent. Most driveway access is for commercial uses, but some residential uses may have driveway access. Traffic signal cycles, where applicable, are generally less than 120 seconds. If an intersection is un-signalized, however, generally only the side street is controlled.

A ***collector*** is most often a two-lane roadway but can be up to four lanes. In many ways, collectors are similar to minor arterial, but have even less control of driveway access and potentially more closely spaced intersections. Collectors generally do not have median barriers.

6.3.4 Ramps

A ***ramp*** is a roadway facility which connects to or from the freeway system. There are several sub-classes within the general capacity classification:

- A standard ramp connects from the surface street system to the freeway system. No distinction is made between diagonal and loop ramps of this type. However, there are several types of standard ramp:
  - Metered ramps signalize access from the ramp to the freeway system during peak hours.
  - HOV bypass ramps allow vehicles with two-or-more occupants to bypass a ramp meter.
- High capacity connector ramps connect from one freeway to another.
- Low capacity ramps connect from surface street to freeway, but because of unique features such as slope, curvature, etc. they have lower capacity than normal ramps. An example of a low capacity ramp is the South River Road on-ramp to eastbound US-50 in West Sacramento.

6.3.5 Rural Roadways

A ***rural highway*** is a two-lane surface street in a rural area, generally controlled only on side streets, and with relatively high design speeds. Examples of rural highways are State Highway 65 north of the City of Lincoln and State Highway 70 north of Marysville

A ***rural arterial*** is similar to a rural highway, but with more stop signs and lower design speeds.

6.3.6 Special Highway Links

Centroid connectors are abstract links in the travel demand model, intended to represent local street access to the collector-and-above roadway network.

Exclusive bike or walk links are special links added to the highway networks, but only accessible for non-motorized (i.e. bike/walk) path building. In most cases, bike or walk links have a one-to-one correspondence with an actual physical facility (e.g. the Guy West Bridge from Campus Commons to Sacramento State University, or one of the several pedestrian bridge overcrossings of freeways). However, in some instances, bike or walk links are intended to represent a combination of bike/walk routes or generalized bike or walk connectivity between two areas. Exclusive bike links are coded as "Class 1" facilities.

Bike lanes on roadways are coded with a special "bike"' identifier. The coding is used for Class 2 or Class 3 lanes on roadways. Chapter 8 on the bike and walk networks provides details on how the bike route coding is used in path building and skimming for the bicycle mode. _Bike_and_Walk

Park-and-ride connectors are abstract links which provide connections from the highway network to park-and-ride lot nodes, which are only used in the transit network. These connector links must be present for paths to the park-and-ride lot to be built in the transit skimming process. Park-and-ride connectors also work to connect drop-off, or "kiss-and-ride" locations to the highway network.

HOV connectors are abstract links which mediate access between the mixed flow and HOV lane links on a freeway segment.

Transit-only links represent links serving transit that operates fully separated from car traffic, notably light rail and regional rail (and potentially fully-separated busways). Their A-B nodes correspond to the links specified in the transit_links.csv described in the Transit Networks chapter.

Disabled links are links in the master network which are not active in the scenario being modeled.

Table 6-2 Capacity and Free-Flow Speed

CAPACITY CLASS		CAPACITY	FREE FLOW SPEED				
#	Description	(vplph)	Median	Average	Std.Dev.	Min	Max
1	Freeway (Mixed Flow)	2000	63	61	4	40	70
8	Freeway Lane (Pk Period HOV)	2000	60	51	13	20	63
51	Freeway (Auxiliary >= 1 mile)	2000	58	58	1	55	58
56	Freeway (Auxiliary <1 mile)	1500	58	55	3	50	58
12	High Capacity River Crossing	1500	42.5	43	3	40	45
2	Expressway	1000	50	49	6	35	55
3	Major Arterial	850	40	37	7	15	55
4	Minor Arterial	800	35	33	9	5	50
5	Collector	700	25	29	7	10	50
6	Freeway Ramp	1500	20	21	4	20	55
26	Low Capacity Ramp	500	20	18	4	10	20
16	High Capacity Ramp/Connector	2000	45	42	10	20	63
6	Ramp	1500	20	21	4	20	55
22	Rural Highway	1000	55	51	5	35	55
24	Rural Arterial	750	40	40	6	20	55
7	Walk/Bike	n/a	3	3	0	3	3
9	Connector (Mixed Flow-HOV)	1500	63	63	0	63	63
61	Transit-only linke	n/a	0	0	0	0	0
62	Connector (PNR-Roadway)	n/a	20	20	0	20	20
63	Centroid Connector (TAZ to roadway)	n/a	20	20	0	20	20
99	Disabled	n/a	0	0	0	0	0

Source: SACOG 2025.

7 Transit Networks

The transit network represents major fixed-route transit services. On-street transit services like buses are represented as lines overlaid on the highway network. Separate transit-only links are coded for light rail transit lines, which generally operate on exclusive right-of-way. The SACSIM model can represent the impacts of increased road congestion on bus travel times as well as time savings for buses traveling in managed lanes or bus-only lanes.

7.1 Working with the Transit Network

7.1.1 Fixed-Route Regular Bus Services

1. Open the transit line file (tranline.txt) in Cube to edit fixed-route, normal bus service attributes:
    - Line geometry (which streets bus routes use)
    - Line attributes, discussed below
2. Use the Cube interface to add new lines or delete lines.

7.1.2 Rail Transit Services

1. Edit the geometry (i.e., where the rail line goes):
    a. Open the transit.txt line file in Cube
    b. Add nodes to the SACSIM highway network at each stop location and significant vertex (e.g. where the line makes a significant turn).
    c. Update the CSVs of rail links and station links in Excel.
2. Update the node list and other transit line attributes in Cube.

7.1.3 Bus Rapid Transit (BRT)

There is no established, single way to represent bus rapid transit (BRT) in SACSIM, but below are some general guidelines to follow depending on the level of BRT you intend to represent.

Fully separated busways
For BRT that acts more like rail, with total separation from mixed-flow vehicular traffic, it may be best to code as a rail transit service.

On-street bus-only lanes
To capture the effects of on-street bus-only lanes (e.g. center-running or curb-running), you will need to set the BUSLANE value on the highway network to reflect the appropriate type of bus-only lane operation. Specifically:

Table 7-1 BUSLANE Value Key

BUSLANE value	Operational Characteristics
0	No bus lane
1	Convert existing GP lane to all-day bus-only lane
2	Convert existing GP lane to bus-only lane during AM and PM peak periods
3	All-day bus-only lane that is separate from

Note that you may update the transit_lanes.csv value if you want a bus lane operational policy that differs from those above (e.g., for peak-hour bus-on-shoulder, you may add a new value that "adds a lane" during peak periods). The table below describes each field in transit_lanes.csv (fields are in order but headers are not present in the actual CSV):

Table 7-2 Field Descriptions for transit_lanes.csv

Field	Description
ftype_period	unique ID combining facility type + time period
factype	ID for type of bus-only lane
period	SACSIM hwy network time period
trn_lane_cnt	total bus-only lanes
gp_lanes_taken	number of general-purpose lanes removed/repurposes as bus lanes

By default, if a bus lane is active on a link, then the base speed of the link (before applying the transit time factor) is weighted 85% toward the link's free-flow car speed and 15% toward the congested speed. You may want to adjust these weights to capture context-specific variation (e.g., if you expect lots of interruption from turning private vehicles using the lane, you may want to increase the weight for congested speed). They are configurable in the main model run script in the transit background network phase.

Other operational improvements
To capture improvements other than dedicated lanes that improve transit operations (e.g. off-board fare payment, queue-jump lanes, signal priority, etc.), you may adjust the time factor attribute to have the bus speed be closer to that of non-transit vehicular traffic. E.g., in the main documentation, a time factor of 1.78 has often been used as a rule-of-thumb for urban bus routes that have such operational improvements.

7.1.4 Park-and-Ride Lots

To edit or update park-and-ride facilities in SACSIM, refer to the section on Park-and-Rides.

7.1.5 Coding Future or Forecasted Transit Service

How you code in future transit service into the model network entails essentially the same procedures and file types as coding in or editing existing transit service, described above. However, *what* you code in (e.g., where you put future service, how frequent you make it, what times of day it runs, which stops have park-and-ride facilities, etc.) depends on the application or scenario you are modeling transit for. Some examples include:

- Modeling future services explicitly planned by a transit agency, such as a planned rail line extension, service reorganization, or new bus route.
- Aligning future transit service with expected population in job growth, even if it is not based on explicit transit agency plans, which rarely forecast transit service more than five years out. SACOG's 2020 MTP-SCS applied this approach in developing its future-year transit services, providing new service or increased service levels to areas in which it forecasted significant job or population grown.

7.2 Transit Lines

The major fixed route transit services in the SACOG region are explicitly represented in the transit networks as "lines", or series of stops served by a transit vehicle at a specified service frequency. Table 7-1 provides a listing of the operators included. Each line operating on a fixed (or largely fixed) route, and with a published schedule, is coded into the SACSIM transit networks.

7.2.1 Transit Service Periods

SACSIM fixed-route transit considers five different service periods:

- Period 1, spanning from the start of service 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 the end of service

By breaking up transit service into these periods, SACSIM aims to accurately represent how transit service varies throughout the day, e.g.:

- Transit availability and frequency differences throughout the day
- How transit is affected by changes in highway traffic congestion throughout the day

7.2.2 Transit Line Attributes

Table 7-2 provides a listing of the key variables coded for each transit line.

- The NAME of the line.
    - For lines existing in the base year, the first 4 characters refer to the operator name:
        - AMTR – Amtrak Capitol Corridor service
        - AUBT – Auburn Transit
        - CSUS – California State University Sacramento Hornet Shuttle
        - ELDO – El Dorado Transit
        - PLAC – Placer County Transit
        - RSVL – Roseville Transit
        - SCTL – South County Link (serving south Sacramento County)
        - SRTD – Sacramento Regional Transit District
        - UTRN - Unitrans
        - YOLO – Yolo County Transportation District (Yolobus)
        - YUSU – Yuba-Sutter Transit
    - The next characters up until the underscore (_) refer to the line number
    - The A/B indicator after the underscore refers to the direction
        - Example: SRTD1_A = Sacramento Regional Transit route 1, direction A
        - Not all routes are split out by direction
- TIMEFACs are factors applied multiplicatively to the time on the transit supply link (for transit only links like LRT or BRT) or the congested time from the highway network for the appropriate service period (for lines operating in mixed traffic on the road network) to factor in stops and dwell time into overall transit travel times. Table 7-3 shows the typical transit time factors used in SACSIM.

- ONEWAY is an indicator for a one-way direction route. An example of a true one-way route is one of the many commuter buses into Downtown Sacramento, which operate inbound-only in the morning, and outbound-only in the afternoon. ONEWAY is also used on many two-way routes that are broken out into two separate, one-way routes to account for routing or scheduling differences between the two directions.
- CIRCULAR is an indicator of routes operating as a loop, with the last station or stop on one trip being the first station or stop on the next trip. Riders of CIRCULAR routes do not incur any wait time penalty if their trip takes them through the route's last/first stop.
- OPERATOR identifies which transit agency operates the line.
- FARESYSTEM indicates which fare policy within the PT Fare file (ptfare.txt) applies to the line.
- MODE is an indicator of the transit "submode" for each line. Submodes include: rail; commuter bus; and all other bus.
    - Note - links added to the lines through the Cube PT "autogenerate" functions (MODE =12, 13) are used for controlling access to and from stations or stops
- COLOR indicates more general service types, listed below. Important to note is that COLOR value does not in any way affect a line's attractiveness, travel speed, etc. It is primarily used to visually denote different service types when mapping transit lines, or for getting ridership or other tallies grouped by service type.
    - *1 = Light Rail*. Lines are generally longer, linear, run in their own dedicated right of way, and outside of downtown centers usually have stops spaced more than 0.5 miles apart.
    - *3 = Commuter Bus*. These bus services usually serve only during the AM and PM peak periods and serve major employment centers such as downtown Sacramento and UC Davis. These services generally have several stops at the "home end" where users live and at the "work end" where users work, with few if any stops in between.
    - *4 = Bus Rapid Transit (low)*. As discussed under Working with the Transit Network, bus rapid transit, or BRT, usually has routes that are similar to fixed-route local buses, but with varying levels enhancements like dedicated lanes, queue-jump lanes, off-board fare payment, etc. to improve operations and provide an experience closer to rail service.
    - *5 = Fixed Route Local Bus*. Local fixed-route buses typically travel longer, linear routes that cross large parts of the operator's service area. Stops are generally less than 0.25mi apart.
    - *6 = Regional/Commuter (Heavy) Rail* includes service such as Amtrak's Capitol Corridor service to the Bay Area. Regional rail has generally infrequent service, but has higher speeds and long distances (10+ miles) between stops.
    - *7 = Neighborhood shuttle.* Like a local fixed-route bus but serves a smaller area and is more likely to be a circular or loop-shaped route rather than a longer linear route. Most of UC Davis's Unitrans routes are considered neighborhood shuttles.
    - *8 = Streetcar.* Like light rail, but generally has more frequent stops and serves a smaller area.

  As with capacity class designations for the highway network, some of the distinctions between service type COLORs are not black-or-white. Examples are: so-called "hybrid" streetcar systems that operate more like light rail; or certain types of lower end bus rapid transit (BRT) that operate more like a normal fixed-route local bus. The model user must use his/her professional judgement in such situations to decide which COLOR to assign a specific line.
- HEADWAY[#] is the average headway, or time spacing between scheduled buses or trains, in minutes. The # in parentheses indicates the service period. HEADWAY is computed as follows:
    - Total minutes in service period / Total trips made by the route in service period

  - E.g. if the service period is AM peak, the total minutes is 240. For a route with 4 trips during this period, that route's AM peak headway is 240/4 = 60 minute headway between arrivals.
- HEADWAY values of 0 denote times during which there is no service. E.g., if the HEADWAY for midday is 0, it means that route makes no trips during the midday period.

Table 7-3 SACSIM Transit Operators

Operator ID	Description
1	Sacramento Regional Transit*
2	Yolo County Transportation District (Yolobus)
3	Roseville Transit
4	Yuba-Sutter Transit
5	El Dorado Transit
6	Placer County Transit
7	Auburn Transit
8	Sacramento State Hornet shuttle
9	UC Davis Unitrans
10	Amtrak Capitol Corridor
11	South County Transit
12	Reserved for future operator

Source: SACOG 2025.

Table 7-4 Transit FARESYSTEM Key

Faresystem ID	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 2025

7.2.3 Demand-Responsive Transit Services

Dial-a-ride, paratransit, private transit operations, and individual bus routes that operate within a travel analysis zone (TAZ) or that operate very infrequently were not included in the transit network. Such routes are excluded in standard transit modeling practice for several reasons. They cannot be modeled reliably using macro-level measures. Additionally, these services usually carry very small volumes, and are not addressed explicitly in regional planning or corridor studies.

SACSIM currently excludes "microtransit" services, such as Sacramento Regional Transit's SmaRT Ride and West Sacramento's Via shuttle, which essentially provide on-demand transit service within a defined area and to select light rail stations. Future versions of SACSIM may incorporate microtransit services if they rise as a significant transit mode.

7.3 Transit Access Coding and Network Additions

Transit access coding refers to the use of links explicitly coded in the highway network, links manually added to the highway network in order to provide access to transit stations or stops, and links which are "auto-generated" by Cube to provide access to transit stations or stops, and to provide transfers from one line to another line. These three sets of links, in combination, are included in a "transit background network" which is subsequently used in transit path-building, skimming and assignment.

7.3.1 Links Explicitly Coded in Highway Network

Transit access links include all highway links, except for freeway mainline and freeway ramp links. Walk paths from traffic analysis zones to the first-boarding transit station or stop include centroid connectors, all surface streets, and explicitly coded pedestrian/bike-only links. Additionally, walk paths can include "contra-flow" direction on one-way surface streets.

7.3.2 Transit Access Links Manually Added to Highway Network

One major subset of these links are links representing exclusive transit links. The biggest categories of these links are rail lines, such as the Sacramento Regional Transit light rail lines, or the portions of the Capital Corridor train service within the SACOG region. However, in the future these links could include bus-only roadway segments. These links are not actually "access links", but are alignments for transit lines to operate on. These links are included in the "transit_links.csv" file.

A second subset of these links are access links which connect between the highway network and the rail stations in the above-described rail transit links. These links allow for paths to be built from the highway network to stations or stops on exclusive guideway transit links, and for transfers between transit lines operating on exclusive guideways, and transit lines operating in mixed traffic. These links are included in the "station_links.csv" file. Importantly, links listed in the station_links.csv file must also be coded in the highway NET file with CAPCLASS=61, as described earlier in chapter 6.

A third subset of these links connect from park-and-ride lots to the nearest traffic analysis zone. The drive portion of park-and-ride transit trips are skimmed and assigned in the vehicle assignment process, and the transit portion of these trips are assigned from the park-and-ride lot node to the final destination, via the transit access links and transit lines. The connection between the park-and-ride lot TAZ, through the park-and-ride lot node and to the transit station, is built through links included in the "pnr.dbf" file.

7.3.3 Auto-Generated Transit Access Links

Links for two access modes are generated through Cube PT path-building software. One mode is walk access and egress links, which consolidate the more complicated paths built on the actual network components described above into single links connecting from TAZ to a range transit stations or stops (coded as MODE = 13). Another mode is transfer links which connect between one or more transit lines, and other transit lines, where the lines do not have stations or stops in common (MODE =12). Examples include: rail-to-bus station connections; and rail-to-rail station connections, if the rail lines do not share a common station.

7.4 Transit Travel Speeds and Stop Times

7.4.1 On-Street Transit Travel Speeds

On-street transit speeds (mostly applicable to buses) are generally computed for each link via the following steps:

1. Obtain the link's auto speed, inclusive of congestion
2. Update the link speed to be a weighted average of the congested speed and free-flow speed:
    a. By default, weight 65% to congested speed, 35% to free-flow speed
    b. If a bus-only lane is active, weight 85% to free-flow speed and 15% to congested speed to capture ability of buses in bus-only lanes to bypass congestion.
3. Compute updated link travel time based on updated speed[14].
4. Apply the appropriate time factor to the link travel time. Time factors help account for dwell time at stops and the lower maneuverability of transit vehicles compared to private autos. Portions of the highway network are not detailed enough to explicitly represent each bus stop, so the time factor gives a reasonable estimate unbiased by the relative fineness or coarseness of the highway network. Table 7-3 provides the typical time factors for a variety of typical operating contexts.

Table 7-5 Highway to Bus Transit Time Factors

Service Type	Time Factor
Urban Fixed Route (most RT bus routes)	2.01
Urban Fixed Route w/in Sac. CBD	2.25
Urban BRT w/ Signal Priority	1.78
Rural Fixed Route	1.62
Commuter Bus (Freeway Segments)	1.18

Source: SACOG 2025.

7.4.2 Off-Street (Dedicated Right-of-Way) Transit Speeds

Off-street transit refers to transit that has no interaction with private vehicles. It is mostly rail modes in SACSIM, but could potentially be used to represent bus service on a fully-separated busway. Off-street speeds are specified in the transit_links.csv file and assumed to be fixed and not influenced by traffic congestion. Travel times are influenced by the characteristics of the track they operate on, vehicle performance, and station spacing. For existing service, off-street transit speeds are based on transit schedules. Speeds for future service are estimated by finding existing segments that best approximate the characteristics of the new service and copying those segments' speeds.

[14] Weighting transit link speed partly toward free-flow speed, combined with applying time factors, helps capture the fact that stopping, dwell time, etc. are less of a speed disadvantage at higher levels of congestion. I.e., the effective speed difference between transit vehicles and private autos is less under congested conditions.

7.5 Park-and-Ride Locations

Park-and-ride (PNR) locations with transit service are included in the transit network. Where they are coded in the network, they enable transit trips in which the traveler drives to the PNR, parks in it, then transfers to its corresponding transit stop to continue his/her journey. SACSIM does not include PNR locations that are not served by transit. Table 7-5 lists the attributes for the PNR DBF table.

Table 7-6 Park-and-Ride Table Fields

Field	Description
PNR_NODE	Node ID from highway network representing PNR location
STA_NODE	Node ID of the bus or rail stop served by the PNR lot
ZONE	Node ID of the TAZ centroid tagged to the PNR lot
PNRCAP	Number of parking spaces (enter zero if KNR)
PRKCOST	Daily parking cost, in cents
DESC_	Location description. Include station name and indicate if KNR or PNR
X/Y	Latitude/longitude

Source: SACOG 2025.

7.5.1 Transit Drop-Off Locations (KNR)

Transit drop-off zones, also knows as "kiss-and-ride", or KNR locations, enable trips in which a traveler rides as a passenger in a private auto and gets dropped off at a transit stop. KNR locations are coded using the same process as PNRs and are stored in the same "pnr.dbf" table, but do not have any parking capacity (e.g., number of spaces is set to zero).

7.5.2 Adding PNR or KNR locations

To code in a park-and-ride or kiss-and-ride location:

1. Add a node to the SACSIM highway network at the PNR location.
2. Include it in the "pnr.dbf" table of PNR nodes and attributes.
3. Include it in the station_links CSV.
4. Ensure it is connected to the rest of the highway network with a link of CAPCLASS 62.

8 Bike and Walk Networks

8.1 Coding Bike Facilities into the Highway Network

8.1.1 Off-Street Bicycle-Pedestrian Facilities

Off-street bike paths are separate links in the model network that prohibit motor vehicles, coded with a CAPCLASS value of 7 and BIKE value of 1. Normally, the free-flow SPEED value for these off-street bike-walk links is 3mph. Use these links to represent any off-street bike and pedestrian paths, bridges, etc.

8.1.2 On-Street Bicycle Facilities

On-street bicycle facilities (i.e., on a street where motor vehicles can operate) are represented by the BIKE value in the highway network. The values for each on-street bicycle facility type are listed below. A link's bicycle facility type influences the perceived cost of bicycling on that link, as described below in the section on Building Bike and Walk Skims.

BIKE values in the highway network correspond to the following facility types:

- 0 = bikes are allowed, but no signage or other special infrastructure exists for cyclists.
- 1 = off-street bike-ped path. Motorized vehicles are not allowed on these links. Only off-street bike facilities should have a BIKE value of 1.
- 2 = Class 2 on-street painted bike lane.
- 3 = Class 3 on-street bike route, usually indicated by "bike route" signs and/or shared-lane markings, known as "sharrows".
- = Class 2 painted bike lane, but on the arterial overpass or underpass of a freeway interchange. These are coded separately from BIKE values of 2 to capture the higher levels of stress associated with cycling through freeway interchanges.
- = The arterial overpass or underpass of a freeway interchange. These are coded separately from BIKE values of 0 to capture the higher levels of stress associated with cycling through freeway interchanges.

8.2 Building Bike and Walk Skims

8.2.1 Building Bike and Walk Paths for Skims

Separate TAZ-to-TAZ distance skims are prepared for walk modes, which include the following features:

- Bike and walk links described above.
- All surface streets.
- Reverse direction on one-way streets is allowed.
- Ramps and freeways are excluded from walking and biking network.

8.2.2 Effect of Bike Facility Type

Research has shown that bicyclists have unique route preferences and aversions, based on route characteristics such as presence or absence of a bike lane and traffic volumes [15, 16]. SACSIM attempts to model these preferences, based on the type of bicycle facility coded and the motor vehicle volume on the link. The adjustment to distance is scaled to reflect the level of preference (indicated by an adjustment factor < 1.0—effectively "shortening" the perceived distance on the link) or aversion (indicated by an adjustment factor >1.0—effectively "lengthening" the perceived distance on the link). Table 8-1 summarizes how these preferences are represented in SACSIM. In general, the assumptions are:

- Bicyclists prefer exclusive, Class 1 bicycle facilities where available and will travel extra distance to use them. The distance adjustment factor sets this preference at 16 percent—i.e. a cyclist might travel 16 percent further in order to use Class 1 bicycle facility, compared to a shared roadway.
- If exclusive, Class 1 facilities are not available, bicyclists prefer roadways with lower vehicle volumes. The aversive effect of higher volumes increases with increasing volumes. For example, roadways with about 12,000 daily vehicles are perceived as being 13 percent longer than a low volume roadway, but a roadway with 60,000 or more vehicle is perceived as being 150 percent longer. Looked at the other way, a bicyclist might travel 150 percent extra distance in order to avoid a high volume roadway with no bike lane.
- If a Class 2 bike lane is provided, the aversive effect of higher vehicle volumes on a roadway is reduced. For example, while a bicyclist might travel 150 percent extra distance to avoid a roadway with 60,000 vehicles and NO bicycle lane, they might travel 100 percent extra distance to avoid the same roadway WITH a Class 2 bike lane.
- Bicyclists avoid routes which take them through freeway interchanges, and will travel significant extra distance to avoid these facilities. This factor was not explicitly researched in any study used by SACOG for establishing this process for path-building—it was generated by SACOG staff based on anecdotal evidence, and application of well researched factors like slope.

Bicycle TAZ-to-TAZ skims are then built from the adjusted distance. In all cases, the true distance is skimmed, but the paths are built using the adjusted distance. Five different skim values are skimmed. The

[15] Broach, Joseph, et al, "Bicycle Route Choice Model Developed Using Revealed Preference GPS Data", Portland State University, November 2010.
[16] Charlton, et al, "Bicycle Route Choice Data Collection using GPS-Enabled Smartphones", San Francisco Transportation Authority, 2010.

first value is the end-to-end distance—each of the four subsequent values area portions of the total end-to-end distance:

- The total TAZ-to-TAZ true distance;
- The distance on Class 1 bicycle paths;
- The distance on Class 2 bicycle lanes;
- The distance on BIKE="8" links; and
- The distance on BIKE="9" links.

Table 8-1 Distance Adjustment Factors for Skimming Bicycle Facilities

	"BIKE" Link Coding‡					
Daily Vehicle Volume†	0	1	2	3	8	9
< 2,000	1.00	0.84	0.90	1.00	1.10	1.00
6,000	1.00	n/a	0.90	1.00	1.10	1.00
12,000	1.13	n/a	0.95	1.07	1.35	1.18
30,000	1.87	n/a	1.28	1.51	2.74	2.14
60,000+	2.50	n/a	1.50	2.00	4.00	3.00

Source: SACOG 2025.

Note: Distance adjustment factors used to scale actual link distance in SACSIM networks—e.g. "0.84" translates to a 16 percent reduction (shortening) of link distance; "1.50" translates to a 50 percent increase of link distance.

Daily vehicle volume is total (i.e. both directions for 2-way roads) and is drawn from the highway assignment results for each iteration of SACSIM. Distance adjustment factors are computed from volumes—shown on this table are a few key points.

"BIKE" codes are described in detail in Chapter 3. "0"= no bike facility; "1" = Class 1 (exclusive bicycle lane); "2" = Class 2; "3" = Class 3; "8" = surface street at freeway interchange with NO bicycle lane; "9" = same as "8" but with Class 2 lane.

8.3 Estimating Bike and Walk Trip Distances

The ideal way to measure parcel-to-parcel distance would be a street-centerline GIS file rather than a stick-and-ball TAZ-based highway network to find "true" proximity of one parcel to another rather than one TAZ to another. However, this is impractical for a working travel demand model for two reasons. First, finding actual parcel-to-parcel paths using a GIS file would be prohibitive in terms of computation time. Second, in many cases specific street patterns for future land uses are not known in the present, and some treatment of street access to future developments would need to be created.

As a workaround, SACSIM computes a "hybrid" distance that considers both orthogonal and TAZ-to-TAZ distance between parcels. For parcels which are closer together, the parcel-to-parcel distance is weighted heavily; for parcels which are more distant, the TAZ-to-TAZ distance skim is weighted heavily. With this combined approach, unique measures of parcel-to-parcel distance are computed, which reflect the "true" proximity to a greater degree than do TAZ-to-TAZ skims along. The sections below describe this method in more detail.

8.3.1 Intrazonal Distance Computation

Intrazonal parcel-to-parcel bike and walk distance is computed as follows:

$$D_H = FD_S + (1 - F) * D_P$$

Where:

$$F = Min(1, \frac{D_S}{T_D})$$

And:

- D_H = Hybrid parcel-to-parcel distance
- F = "Fractional" weight toward using TAZ-TAZ skim distance versus parcel-to-parcel distance
- D_S = TAZ-to-TAZ network skim distance
- D_P = Parcel-to-parcel distance, based on the circuity factors in the parcel table. See Chapter 4 for more details on circuity factors.
- T_D = Threshold distance (miles) at which weight starts applying to the skim distance rather than parcel distance. This value depends on the outermost distance for which parcel-level circuity factors are calculated. It is set in the DAYSIM configuration file.

8.3.2 Interzonal Distance Computation

If parcels are in different zones and more than a minimum distance apart (as of this writing, that distance is three miles, based on the parcel file providing circuity factors for parcels up to 1.5 miles away), then the TAZ-to-TAZ network skim distance is used as the distance between the parcels. If they are less than this distance apart, then the method used to compute the intrazonal distance below is used.

9 Auto Operating Costs, Pricing and Transit Fares

9.1 Auto Operating Costs

SACSIM uses consumer full "out-of-pocket" auto operating costs as a key concept and input for driving mode choice and usage. Cost include gasoline, maintenance and tires, and federal and state taxes; computed on a per mile basis (Table 9-1). Gasoline costs are the largest share of per-mile out-of-pocket operating costs for most vehicles.

Table 9-1 SACSIM Auto Operating Costs

SACSIM Variables		2020	2035	2050
Auto Operating Cost	Vehicle Operating Costs. ($/mile Yr. 2022 $)†	$0.241	$0.266	0.269
	State Fuel Tax or Milage Fee Price ($/mile)	$0.021	$0.028	$0.028
Milage Base User Fee	SACOG Milage Fee Price ($/mile)	$0.00	$0.027	$0.027

Source: SACOG 2025.

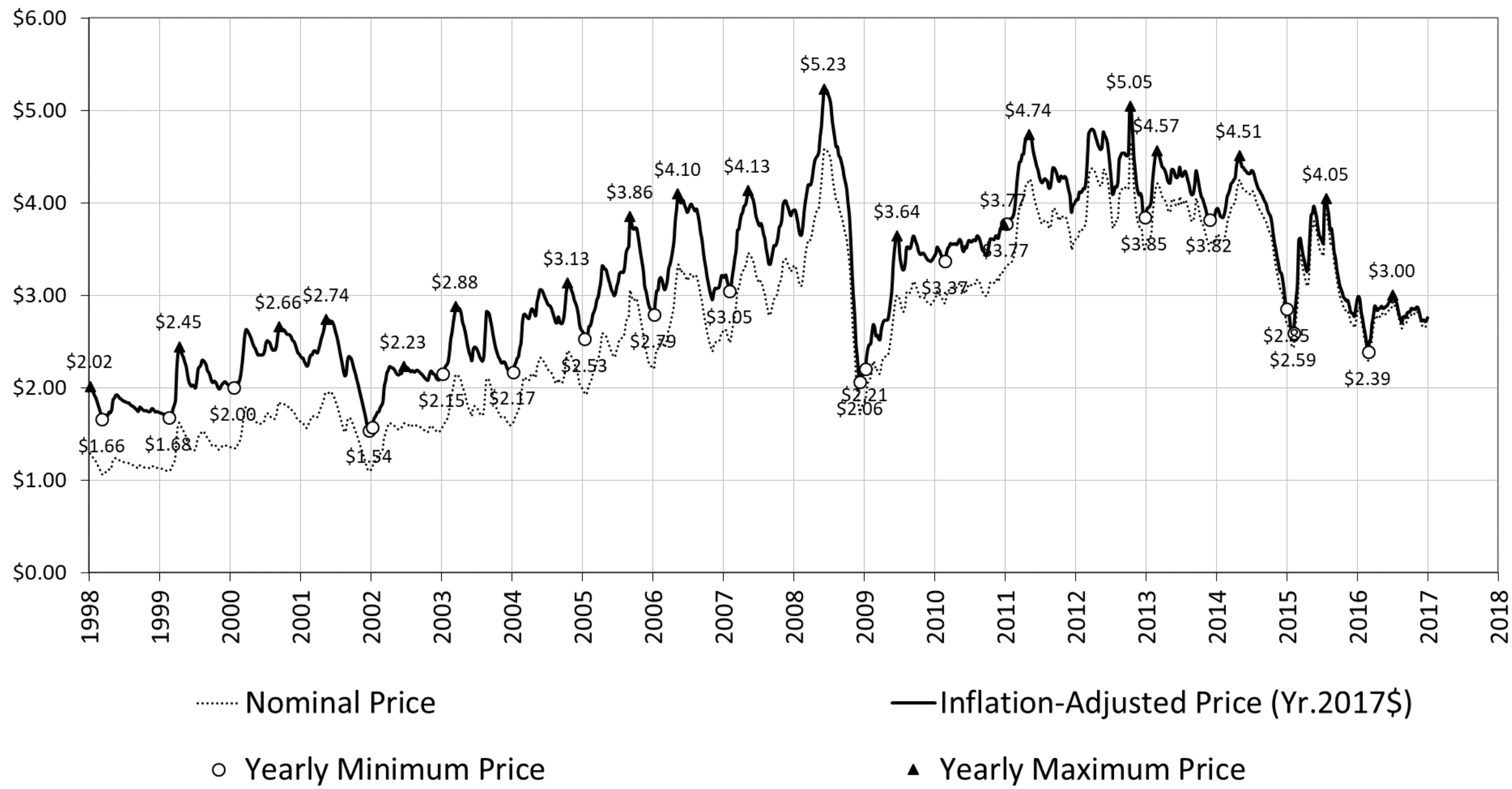
†Based on California Energy Commission spot prices ‡Inflation adjustments based on Bureau of Labor Statistics CPI.† From EMFAC2023 passenger car vehicle fleet miles per gallon. From CSAA "Your Cost of Driving" reports. Values reported in 2022 dollars, model variables must be entered into SACSIM as 2000 dollars.

For future the approach used:

- recent federal Energy Information Administration "Low" and "High" forecasts of gasoline prices;
- average passenger vehicle fleet MPG forecasts using the EMFAC emissions model;
- non-fuel costs projected based on AAA "Your Cost of Driving" data; and
- update the CA/US price differential using most recent data.

SACSIM and other MPO Travel Demand models have shifted to average cost per mile as standard practice. Use of average variable cost per mile have been shown to be more predictive of trip-making behavior than average "full" costs (which include vehicle ownership costs like finance charges, depreciation, insurance, etc.). The behavioral theory underpinning this is that for most households, vehicle ownership is a necessity, and choices of use of a vehicle (number of trips, length of trip, etc.) do not factor in auto ownership costs.

Figure 9.1 California Gasoline Prices, 1998 to 2017



Source: SACOG 2025.

Based on gasoline price data from the California Energy Commission, with inflation adjustments calculated using the Western States Urban consumer price index.

9.2 Facility and Mileage Based Pricing

One of the major changes from SACSIM15 to SACSIM19 was the implementation of facility and user fee-based pricing. In order to integrate pricing, major SACSIM overhauls include:

- DAYSIM calibration
- DAYSIM distribution of value-of-time (VOT)
- VOT bins during highway assignment
- Network Skimming
- Dynamic tolling adjustment algorithm during highway assignment
- Reconfiguration of Path loading by mode
- New Mileage Based User Fee spatial and temporal inputs
- New priced roadway network identification attributes and cost inputs
- Model equilibrium, population sampling, and global iterations

This section will not discuss calibration or model structure details for all topics above and instead focuses on SACSIM23's user fee or roadway pricing functionality. For model structure adjustments, see Chapter 3 on Model Structure and Chapter 12 on Calibration and Validation.

9.2.1 Facility Pricing

To incorporate effects of roadway pricing, travel choice components must be considered such as trip generation, distribution, time-of-day, congestion, mode choice, and routing. The concept is based off the *Strategic Highway Research program C04: Improving Our Understand of How Highway Congestion and Pricing Affect Travel Demand, 2012*. Consistent with the SHRP2 C04 report, SACSIM23 implements the utility-based function in Equation 9-1 to model the effects of pricing and congestion to travel.

Equation 9-1 Utility-based function to model the effects of pricing on travel[17]

$$U = \Delta + a_1 Time \times (1 + a_2 Dist + a_3 Dist^2) + b\left[Cost/\left(Inc^e \times Occ^f\right)\right] + c\,STD/Dist \qquad (1)$$

Where:

Δ	=	Alternative-specific "bias" constant for priced facilities
a_1	=	Travel time coefficient, estimated as a random parameter to capture unobserved user heterogeneity
$Time$	=	Average travel time
a_2, a_3	=	Coefficients reflecting the impact of travel distance on perception of travel time
$Dist$	=	Average travel distance
b	=	Coefficient on travel cost
$Cost$	=	Cost of travel including tolls, parking, and auto operating costs
Inc	=	Household income of traveler
e	=	Coefficient reflecting the impact of income on the perception of cost
Occ	=	Occupancy of vehicle
f	=	Coefficient reflecting the impact of auto occupancy on the perception of cost
c	=	Coefficient reflecting the impact of travel time (un-)reliability
STD	=	Day-to-day standard deviation

SACSIM23 does not implement all congestion pricing recommendations from the SHRP C04, but builds off the key concepts for functionality of SACSIM's existing modules and structure. SACSIM does incorporate congestion as its primary proxy for reliability, a difficult input for Demand modeling, with time factors that range from 10.05 to 1.80 based on traffic conditions. Table 9-2 compares key concepts from SHRP C04 pricing recommendations and how they are implemented into SACSIM23.

Table 9-2 SACSIM23 Implementation of SHRP C04 Concepts

ID	Recommendations	Built into SACSIM23
1	Random coefficient on travel time to reflect unobserved user, such as a truncated lognormal distribution curve constrained as negative ensuring logical negative utility with respect to travel time.	Adjusted distributed travel time sensitivities based from a lognormal distribution with standard deviation of 0.85. Higher standard deviation shifting majority trips to lower initial VOT bin.
2	Travel time sensitivity should be a function of distance with short distances and longer distance decreasing sensitivity factors to travel time.	Not implemented due to contradictory findings from other studies.
3	Scaling travel cost coefficient by a function of household income and auto occupancy.	Already built into previous versions of SACSIM
4	Utility function include standard deviation of travel time, scaled by distance as a measure of reliability. Suggest congestion a proxy for reliability with time factors that range from 1.05 to 1.80 traffic conditions.	Cost of delays built in with time factors from 1.05 to 1.80 during highway assignment.

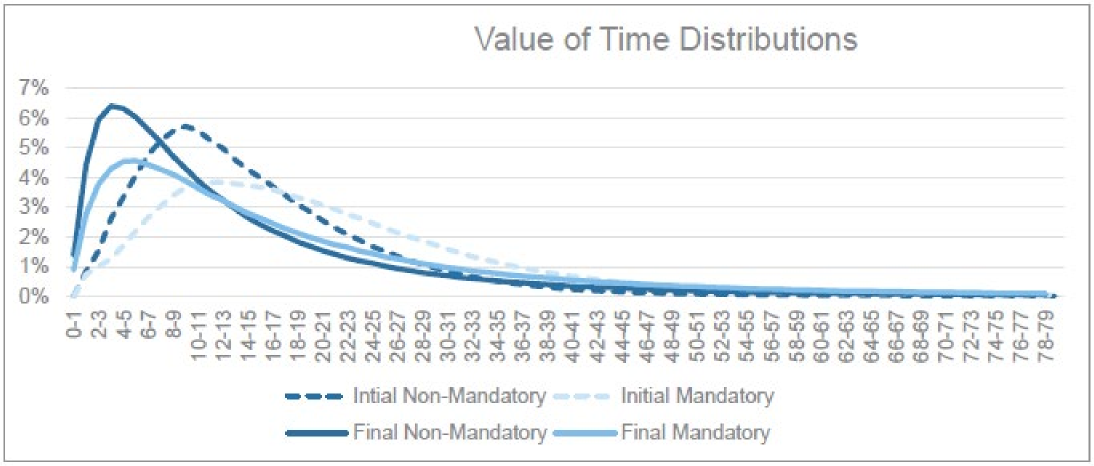
Source: SACOG 2025

9.2.1.1 Valuation of Time

Per RSG Travel demand Model Toll Enhancements[17], SACSIM uses distributed travel time sensitivities that are drawn from a lognormal distribution whose shape is controlled by the user. In the initial model, the values-of-time (VOT) for mandatory and non-mandatory SACSIM trips were drawn from log normal distributions with standard deviations equal to 0.24 and 0.15 respectively. Comparison of the resulting distributions of value-of-time with that of other regions collected by RSG indicated the need for increasing the standard deviation for SACSIM trips. Several trials were run with different values of standard deviation and compared against the other regions' distributions. A standard deviation of 0.85 was selected for both mandatory and non-mandatory trips in the current version. Figure 9-2 shows the initial and final value-of-time distributions for trips by tour type (mandatory versus non-mandatory). As shown in the plot, the new distributions use a higher standard deviation and therefore shift trips to the left (more trips with lower value-of-time than the initial distributions). These plots more closely match the results of several Stated Preference surveys conducted by RSG over the past several years1.

[17] RSG Travel Demand Model Toll Enhancements Technical Memorandum for SACOG, September 20, 2018

Figure 9.2 Initial Versus Final Value of Time Distributions



9.2.1.2 Auto Value-of-Time Bins

Per RSG's toll modeling enhancements memo[17], the initial model setup used one value-of-time to determine path choice for all trips in the model. In the new model setup, three VOT bins were created for highway skimming and assignment. The bins were created using 33rd, 66th and 90th percentile values of the values-of-time for all trips. The corresponding dollar amount of the percentiles were $7.25, $16.85 and $38.80 respectively. These bins were used to group all trips into three VOT classes; low (1), medium (2) and high (3). The resulting cube script skims time, distance, and toll cost for three occupancy groups (drive alone, shared ride-2 and shared ride 3+) and 9 time periods for each of the three VOT classes. The total number of skim matrices thus produced is 243. A generalized cost function, shown below in Equation 9-2, was used to find the shortest path that considers both time and cost.

Equation 9-2 Generalized cost roadway utilization function with VOT and toll pricing[17]

$\text{cost} = \text{time} + (\text{AOC} + \text{toll}) * \text{VOT}_i$

Where:

- cost is the generalized cost on the link in minutes
- time is the congested time on the link returned by the volume-delay function
- AOC is the auto operating cost on the link, in dollars
- VOT_i is the value-of-time on the link, in minutes per dollar.
- The VOTs used for the three classes are:
  - Low VOT bin: 60/7.25 = 8.28 min/$
  - Medium VOT bin: 60/16.85 = 3.56 min/$
  - High VOT bin: 60/38.80 = 1.55 min/$

9.2.1.3 Dynamic Roadway Pricing Loop

The toll optimization algorithm was incorporated to allow dynamic roadway pricing in SACSIM19. In order to maximize travel time savings from a priced facility, the priced facility volume must continue to flow. Therefore, the price must increase or decrease based on demand to maintain the facility at an optimal level of service. The toll optimization algorithm does this at link level by comparing the travel time savings of a toll segment to the adjacent "free" or general-purpose lane. The toll price is then calculated by multiplying the time savings by the average value-of-time the highway assignment takes place. This toll value is then applied to the vehicle pathloading impedance function represented as part of the cost as describe above in Equation 9-2 to determine the demand and person who will use the priced facility. If the V/C ratio of any link in a defined toll segment exceed the optimal level of service, currently set to 0.8, or LOS D, the toll increase reducing the attractiveness, by increase the value in the impedance function. Ideally, this process continues until the facility has converged to an optimal price based on demand. In practice, this process of running the optimization loop is rather time consuming and is set to beak each toll loop when the maximum toll changes (new toll - previous toll) for any segment is less than $0.05 or 5 toll optimization loops have been run.

9.2.1.3.1 Sequential Steps of Toll Optimization Algorithm:

1. Start the toll optimization loop.
2. Read initial tolls for each segment from the tolls.csv file.
3. Calculate the travel time on the toll segments and the corresponding gp segments.
4. Calculate the time savings in the toll segment (tollseg_time – gpseg_time)
5. Multiply the time savings by the average VOT to get the current toll.
6. If the v/c ratio in any link of the toll segment is greater than 0.8, multiply the current toll by 2 (or any other factor).
7. Calculate new toll by taking an average of the previous toll and the current toll.
8. Apportion the segment toll to each link in the segment.
9. If the maximum change in tolls from the previous step is less than 50 cents, break the loop.

9.2.2 Mileage Based User Fee

A mileage-based fee, known as a pay-as-you-go, or PAYGO fee, is included in SACSIM's path building utilization cost function. The fee is defined as:

- Combination of state and federal fuel tax per mile traveled, based on the inflation-adjusted cost of fuel taxes on a per mile basis; or
- PAYGO or mileage-based fees assumed to replace part or all of the fuel taxes in future scenarios

Within the Cube script used to run SACSIM, a user would set the "direct" costs of fuel, maintenance and tires on a per-mile basis for the "AOC" variable described below, and the fuel tax or PAYGO fee per mile for the "mileagefee" variable as described below.

This allows SACSIM functionalities described above for travel time sensitivity distribution curves and three VOT bins for highway skimming to also be sensitive to a dynamic mileage-based fees. The fee can also vary by defined geography and time periods to represent potential fee increases based on congestion around denser land use areas or peak commute travel times. Similarly, allow fee reductions for non-congestion areas, due to off peak travel times or locations requiring longer mandatory trips to job and service areas such as rural and agricultural areas.

The generalized cost function described in Equation 9-2 for shortest path during skimming and assignment is now updated to consider not only time, costs outlined above but also, mileage-based user fees. Equation 9-3 and Equation 9-4 show the mileage-based fee integration into the cost equation.

Equation 9-3 Generalized Cost Function with Mileage Based User Fee (Equation 2 update)

cost = time + (AOC + toll + ***mileagefee***) * VOT_i

Where:

- cost is the generalized cost on the link in minutes
- mileagefee is the mileage-based fee applied on the link, in dollars

Equation 9-4 Mileage Based User Fee

mileagefee = (imilagefee * spatialfactor) + congestionfee + feediscount

Where:

- imilagefee is the initial mileage-based fee applied on the link, in 2000 dollars (typically as a fraction of cents)
- spatialfactor is a multiplicative factor spatial adjustment by regional analysis zone (RAD) applied on the link level, in 2000 dollars, for "flat fee" spatial factor is set to one.
- congestionfee is a mileage-based fee increase applied on the link based on time period, in 2000 dollars, for "flat fee" congestionfee is set to zero.
- feediscount is a mileage-based fee decrease (negative value) applied on the link based on time period, in 2000 dollars, for "flat fee" feediscount is set to zero.

9.3 Auto Operating Costs and Pricing User Guide Setup

9.3.1 Auto Operating Cost User Guide Setup

9.3.1.1 Step 1: Determine AOC for scenario year

Auto Operating Cost must be determined as a SACSIM23 user input. See section Auto Operating Costs section above on how to compute AOC based on scenario year.

9.3.1.2 Step 2: Set AOC in SACSIM23 Script (.s) file

Open SACSIM23 model run script to update the auto cost input variable ***auto_cost_per_mile*** as shown in Figure 9-3.

Figure 9.3 SACSIM Auto Cost and User Fee Inputs

```
;==========================================================================

;Set per-mile auto operating cost here
auto_cost_per_mile = 0.162
userfee_per_mile =   0.014
```

9.3.2 Mileage Based User Fee User Guide Setup

9.3.2.1 Step 1: Determine Scenario Mileage Based User Fee

Determine mileage-based user fee for scenario. User must convert mileage-based fees back to 2000 dollars for SACSIM23 use.

9.3.2.2 Step 2: Set User fee in SACSIM23 (.s) file

Open SACSIM23 model run script to update the initial mileage-based user fee input variable ***userfee_per_mile***. If not user fee is desired for the scenario, ***userfee_per_mile*** should be set to 0.00. For a flat user fee per mile, ***userfee_per_mile*** is the only input required. If time period or spatial adjustments are need additional inputs are required. Regardless, it is important to review other user fee inputs to confirm they are set on or off properly.

9.3.2.3 Step 3: Spatial and Time Period Fee Adjustments

Spatial and temporal components can be set using the ***RAD_Userfee.csv*** input file in the Scenario run folder. Table 9-3 describes the four inputs in the ***RAD_Userfee.csv*** required and an example with and without the mileage based fee adjustments. Figure 9-4 shows an example of the ***RAD_Userfee.csv***.

Table 9-3 Spatial and Temporal Mileage-Based Fee Adjustment

Header (Not in actual file)	RAD	Multiplicative Factor	Peak Adjustment	Off Peak Adjustment
Required input description	Regional Analysis Distract Spatial Geography where factor will apply to roadways. **Default is all RAD Zones within region.**	Factor used to multiple userfee_per_mile input. **Default is 1.**	Peak congestion rate adjustment factor applied to AM (7am-10am) and (4PM – 6PM) peak hours. **Default is 0.**	Off Peak period discount rate during non-congested times applied to Evenings (7-9), Nighttime (10-5am) and Midday. **Default is 0**
Example Spatial Adjustment **Turned On**	1	2	0.007	-0.007
Example Spatial Adjustment **Turned Off**	1	1	0	0

Figure 9.4 RAD_Userfee.csv Example

26	26	1	0.007	-0.007
27	27	2	0.007	-0.007
28	28	1	0.007	-0.007

RAD_UserFee

9.3.3 Facility Pricing User Guide Setup

SACSIM23 requires two facility pricing inputs:

- Network Segment Identification
- Toll Input Cost
- Model Run Script *(only for adjusting all-lane toll facility)*

9.3.3.1 Step 1: Network Segment Identification

Open the base network, typically named **<scenario year>_base.net.** Every priced facility must have a TOLLID number associated. For parallel general purpose and auxiliary lanes. The same ID number must be assigned to GPID (general purpose lanes) and AUXID (auxiliary lanes). This is used to determine the cost of the managed facility relative to the congestion on the parallel "free" facilities. Depending on the type of managed lane, USECLASS must also be set with a value of 0, 2, or 3 to determine the allowed vehicle type on the managed facility. Zero allows all users to drive on the facility being priced. Note, USECLASS does not determine which vehicles are priced, the prices are set in the Toll Input File described below. Two refers to vehicle occupancy of 2+ and 3 allows vehicle with 3 or more passengers only to enter the facility. Figure 9-5Figure 2-8 shows an example of a managed lane facility coding on the base network. In this example all vehicle types are allowed on the managed lane facility. For more information on other network attributes that may influence the network toll segment see chapter 4 on Highway Network.

9.3.3.1.1 Define Network Toll Segment

Defining toll segment distance and extents is an important input to determine the cost and utilization of the priced facility. Each toll segment has multiple links, but only one TOLLID identifier, one GPID identifier, and one AUXID identifier (if auxiliary lane exists along segment). Travel time savings is taken as the total toll segment time minus the total general-purpose segment time, and if any V/C ratio link is greater than the level of service threshold, cost increases. Taking into consideration distance, number of lanes, interchanges, ramps, and speeds is important for a priced facility to work properly. Figure 9-6 shows an example where the number of lanes and demand of the highway facility changed for different toll segments were defined before and after the ramps.

Figure 9.5 Base Network Toll ID Coding

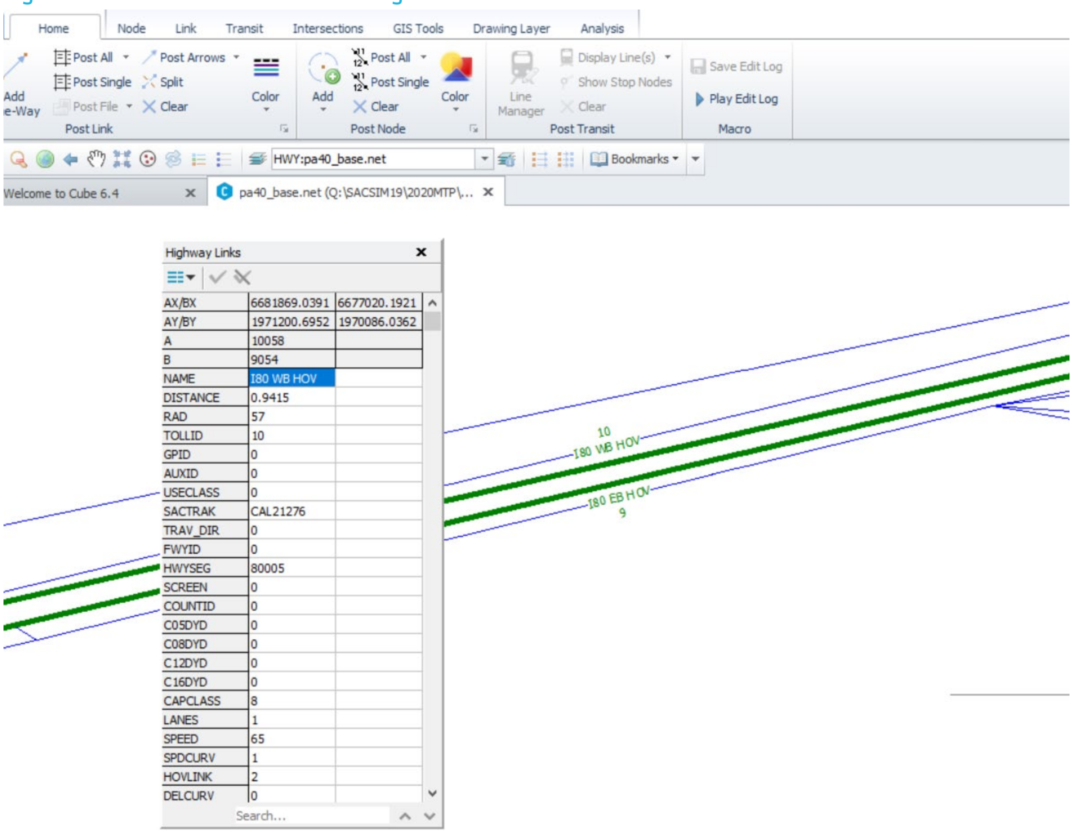
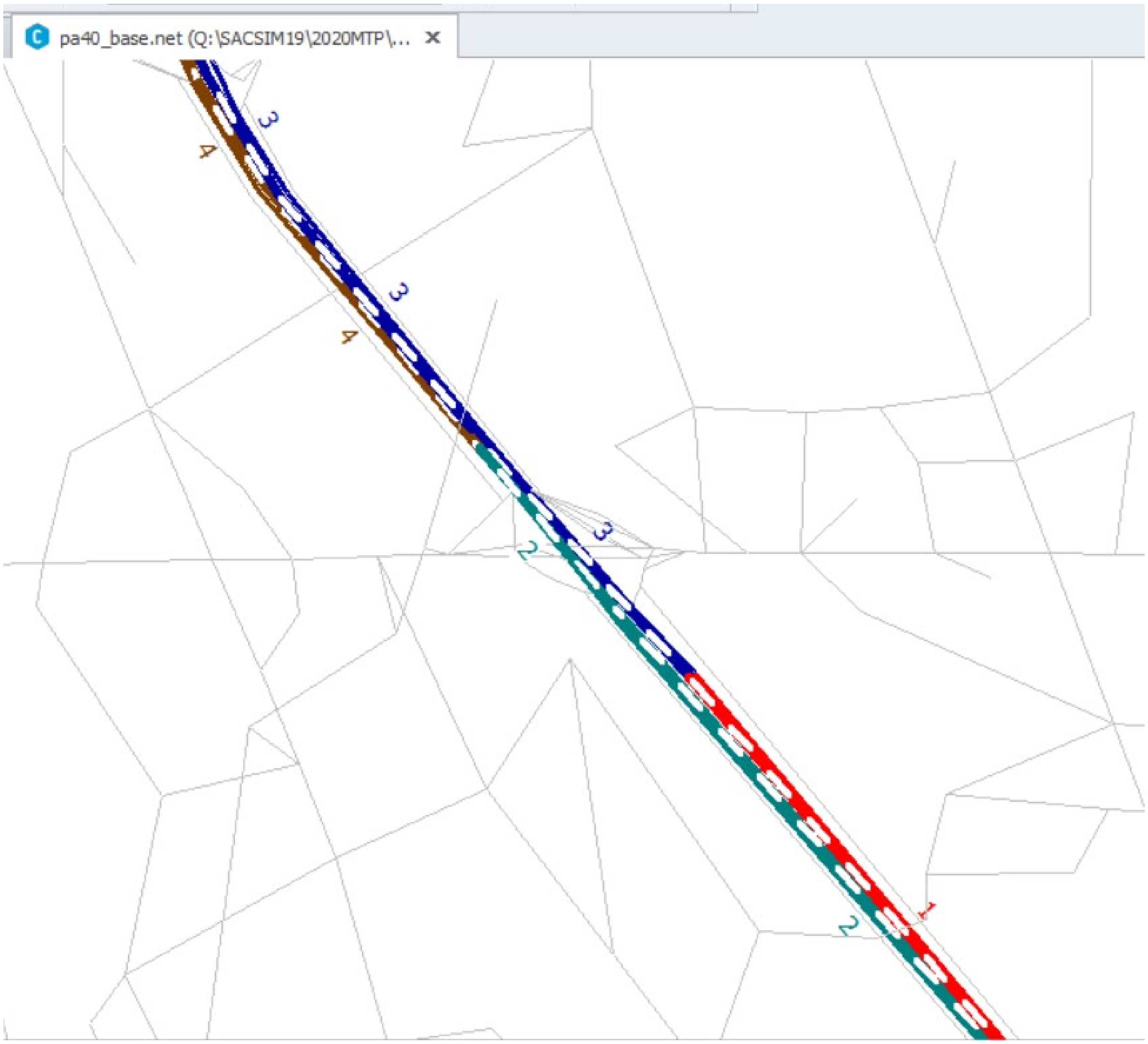


Figure 9.6 Multiple Toll Segments Identified on Network



9.3.3.1.2 Define Network General Purpose and Auxiliary Segment

Since the travel time from the general-purpose lane is needed to compare savings to the priced facility, the general purpose segment length must be the same distance as the priced facility distance. If these distances are too far off this will affect the travel time savings function. For this reason, if the total general-purpose distances less or greater than 0.25 miles different from the priced facility, SACSIM will immediately error out. These lengths can be checked in the tollseg_length.csv file created during SACSIM initial setup. Auxiliary lanes are not used in the pricing optimization algorithm and therefore do not require and maximum or minimum lengths. Auxiliary lanes need to be coded to ensure the vehicles do not skip the facility all together and allow the total volume across all lanes to be accounted for.

9.3.3.1.3 Define Network Segments for All-Lane Toll Facility

To define an all-lane toll facility. The TOLLID must be identified for all lanes, including what may have been previously coded as general-purpose lanes or auxiliary lanes. Additionally, the model run script input variable ***AllLaneToll*** must be set from 0 (default) to 1, as shown in Figure 9-7. Since the toll optimization loop is based off the travel time savings from the parallel free option, the dynamic pricing is not available for all toll facilities, instead users will have to specify the cost of the toll as an input in the toll cost file ***toll.csv***.

Figure 9.7 SACSIM23 All-lane Toll Facility Input

```
; this block of code calculates the total length of each toll segments, which will later be used to apportion tolls to each link
    AllLaneToll = 0 ;1 True, 0 False. Turn true if all lane toll facilities exist.
    run pgm = hwynet  MSG='step 0 Calculate toll segment length'
```

9.3.3.2 Step 2: Toll Cost File

The TOLLID coded on the network identifies the toll segments. The costs by vehicle types then need to be associated and defined to the network toll segments. This is done in the Toll Input Cost File *tolls.csv*. Each row represents a unique TOLLID segment by time period. For every tolled there will be nine additional rows added to the input file (1 tollid X 9 SACSIM time periods). Table 9-4 describes the columns required for the toll cost file. Table 9-5 Toll Cost Input Example shows an example of the Toll Input Cost File with one toll segment. The actual csv file does not have column headers and must be written in the same order as Table 9-4.

Table 9-4 Toll Cost Inputs

Input Order	Columns	Description	Value Type
1	Facility Index	unique ID for a link during a time period: toll_gp_id*100 + period	Unique Integer >100 (based on Segment Number and period)
2	Segment #	corresponds to TOLLID, GPID, and AUXID in model network	Unique Integer
3	period	SACSIM time period	1-9
4	adjustment	1/0 indicating if toll optimization algorithm is applied	Binary (0-1)
5	toll_da	starting toll value for drive-alone	2000 dollar
6	toll_s2	starting toll value for HOV2	2000 dollar
7	toll_s3	starting toll value for HOV3	2000 dollar
8	toll_cv	starting toll value for commercial vehicles	2000 dollar
9	mintoll_da	minimum toll value for drive-alone	2000 dollar
10	mintoll_s2	minimum toll value for HOV2	2000 dollar
11	mintoll_s3	minimum toll value for HOV3	2000 dollar
12	mintoll_cv	minimum toll value for commercial vehicles	2000 dollar
13	maxtoll_da	maximum toll value for drive-alone	2000 dollar
14	maxtoll_s2	maximum toll value for HOV2	2000 dollar
15	maxtoll_s3	maximum toll value for HOV3	2000 dollar
16	maxtoll_cv	maximum toll value for commercial vehicles	2000 dollar
17	Reversable Lane AM	add managed lane(s), remove opposite flow general purpose lane, during AM peak period (7-10am), general purpose removal should be on different toll segment ID.	positive integer to add managed lane(s), negative integer to remove general purpose lane(s)
18	Reversable Lane PM	add managed lane(s), remove opposite flow general purpose lane, during PM peak period (3-6pm), general purpose removal should be on different toll segment ID.	positive integer to add managed lane(s), negative integer to remove general purpose lane(s)
19	Shoulder lane AM	add managed lane(s) during AM peak period (7-10am), assumption is shoulder space is converted to a managed or general purpose along the facility adding width for an additional managed lane.	positive integer to add managed lane(s)
20	Shoulder lane PM	add managed lane(s), during PM peak period (3-6pm)	positive integer to add managed lane(s)
21	Take a Lane AM	add managed lane(s), remove adjacent general-purpose lane, during AM peak period (7-10am)	positive integer to add managed lane(s), (will subtract value from general purpose lane(s))
22	Take a Lane PM	add managed lane(s), remove adjacent general-purpose lane, during PM peak period (3-6pm)	positive integer to add managed lane(s), (will subtract value from general purpose lane(s))

Table 9-5 Toll Cost Input Example

Fac. Index	Seg.	Per.	Fac. Type	Adjust	Toll DA	Toll S2	Toll S3	Toll CV	Min DA	Min S2	Min S3	Min CV	Max DA	Max S2	Max S3	Max CV	Reversable Lane AM	Reversable Lane PM	Shoulder lane AM	Shoulder lane PM	Take a Lane AM	Take a Lane PM
101	1	1	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
102	1	2	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
103	1	3	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
104	1	4	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
105	1	5	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
106	1	6	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
107	1	7	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
108	1	8	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0
109	1	9	2	1	1	0	0	2	0.1	0	0	0.2	30	0	0	30	0	0	0	0	0	0

Referring to the Input Order Column of Table 9-4:

Inputs 1-3 are used to tie the network toll links identified to the cost per time period. Input 1 should be calculated by input 2 * 100 + input 3. If additional time periods or toll segments are added, these rows will need to be expanded on in the same format for every new toll segment added to the network.

If a scenario requires no toll pricing, Inputs 4-22 should all be set to zero.

Input 4 adjustment if the toll optimization algorithm is turned on or off. This must be turned on to use the dynamic pricing. There are a few reasons to turn off:

- User want toll prices fixed, may have already determined the optimal cost or running post processing assignments.
- All toll lane scenario or facility is being applied
- For testing purpose, user wants to reduce model run time.

Inputs 5-8 are user specified initial toll prices by four mode vehicle classifications. These values are put into model as part of the initial cost function and then adjusted during the toll optimization loop. If a fixed or all lane toll scenario is being ran, the initial inputs will also be the final cost. Based on default settings, the toll optimization loop is set to run a maximum of five iterations. If toll price curve results seem too high or too low based on no osculation occurring or not enough convergence in price, it is recommended to start the next run with a higher or lower initial toll to help convergence to occur within the 5 iterations.

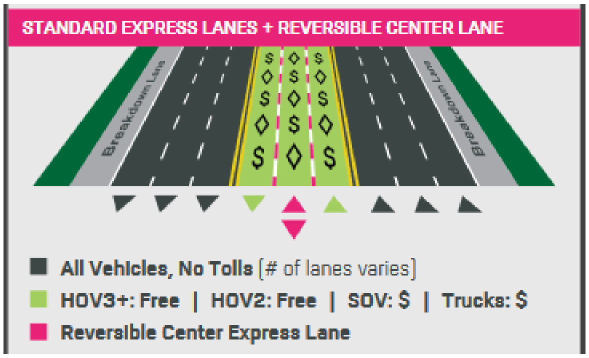
- DA = drive alone or single occupancy vehicle
- S2 = Shared Occupancy Vehicle with two persons (SOV2)
- S3+ = Shared Occupancy Vehicle with three or more persons (SOV3+)
- CV = Commercial Vehicles, currently defined as SACSIM category CV 2 axle, 3+ axle CVs are not allowed access to managed lanes. This can be adjusted in the model run script.

Inputs 9-16 are user specified toll prices constraints. Inputs 9-12 are the minimum by set price by mode. Input 13-16 are the maximum price by mode. For example, if a minimum toll price was set to $1.00 and a maximum to $10.00, the final price must be at or between these upper and lower bounded constraints regardless of demand, or lack thereof, along the facility. Since the toll optimization loop sets the price based on the vehicle demand, the more constraints added the less likely the algorithm can find the optimal price to set.

Inputs 17-22 are user specified lane configuration adjustments on both the general purpose or "free" lanes and the managed lanes or "priced" lanes.

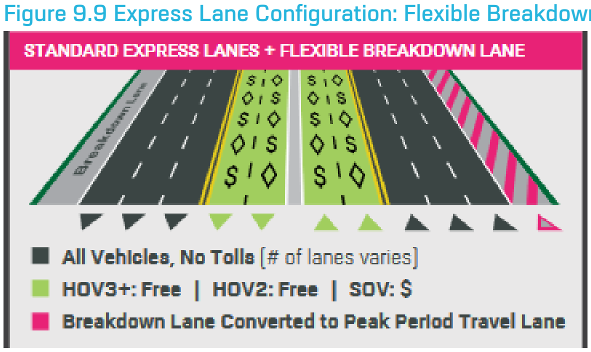
Inputs 17 and 18 add reversable lanes to the priced facility to the peak period: 17: 3 AM peak hours 7-8, 8-9, 8-10 am, 18: 3 PM peak hour 3-4,4-5,5-6 pm. If positive value is entered to a toll segment, a priced lane(s) will be added. If a negative value is added a general-purpose lane(s) will be added. Using this logic, to maintain the number of lanes defined in the scenario base network file, a negative value should always be assigned to the parallel opposite direction toll segment ID. If no negative number is specified, an additional lane is added to the network. Figure 9-8 shows an example of a reversable lane as an additional middle lane that can reverse directions based on the peak period traffic flow directional demand of travel.

Figure 9.8 Express Lane Configuration: Reversible Center Lane



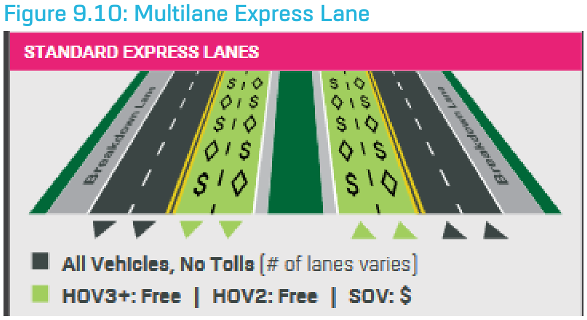
Inputs 19 and 20 add a managed lane(s) during AM peak period (7-10am) and PM peak periods (3-6pm) respectively. SACSIM23 assumption is shoulder space is converted to a managed or general purpose along the facility adding width for an additional managed lane. Since SACSIM23 assignment is a "stick and ball" network, land configuration curvature and geometry is not accounted for at the demand level software. Nor is type of pricing facility implementation infrastructure design. Microsimulation or CAD software's may be used to determine if adding a shoulder lane scenario is realistic based on a roadway geometry. SACSIM23 simple provides the capability to add or remove the lane during assignment. Figure 9-9 shows an example of a shoulder or breakdown lane converted into an additional lane during peak periods.

Figure 9.9 Express Lane Configuration: Flexible Breakdown Lane



Inputs 21 and 22 add an additional managed during AM peak period (7-10am) and PM peak periods (3-6pm) respectively by removing a general-purpose lane during the defined time period. This allows scenarios with multilane express lanes during times of high demand to manage congestion, and "free" or general-purpose lanes during lower demand. An facility example of could be a highway with high morning peak congestion into downtown in the mornings, however, during the PM the traffic may be more evenly dispersed throughout the duration of the afternoon evening and not require as many managed lanes available. Figure 9-10 shows an example of a multi-lane express lane configuration where a "Take A Lane" may be applied.

Figure 9.10: Multilane Express Lane



9.4 Transit Fares

Zone-to-zone transit fares are required as inputs to the mode choice model, reflecting boarding fares, transfer discounts, and (where applicable) zonal fares along the transit paths.

9.4.1 Transit Pass and Discount Models

By default, SACSIM assumes a potential transit user will pay the single-ride adult cash fare for each transit trip and pay the price, if applicable, for any transfers. However, significant shares of transit users either use a transit pass or receive a significantly discounted fare.

DAYSIM's transit pass model predicts whether a person would own a transit pass based on his/her age, type, access to transit from his/her home, employment status, and student status. If a person owns a transit pass, then the fare cost of taking a trip by transit is zero. Model users can adjust the coefficients for predicting transit pass ownership or turn the pass ownership model off if desired.

DAYSIM also predicts whether a person will pay a discounted fare, as well as how much that discount is, by applying a percentage discount to the adult cash fare based on the person's age (e.g. for a senior/child discount) and student status (e.g. students ride for free or pay a discounted fare).

Both fare discounts and the transit pass model are configurable in the DAYSIM configuration file, though there is a separate coefficient file for adjusting the transit pass model coefficients.

9.4.2 Limits of Transit Fare Estimation

While SACSIM captures the bulk of transit fare types, it cannot capture all of them. Examples of fare types not estimated by SACSIM include day passes and week passes that, respectively, allow unlimited boardings during a 24-hour day or 7-day week. Also, even within the discount factors applied above, SACSIM does not capture the full variation of discounts that apply across different operators, e.g., while one operator allows students to ride for free, another operator may just give them a discounted fare. Ideally, SACSIM would capture all fare policies and variations, but doing so would add considerable complexity to the model while only marginally improving model accuracy.

9.4.3 SACOG Transit Operator Base Fares and Transfer Policies

Table 9-6 lists the undiscounted adult cash fares for operators included in SACSIM. Boardings and transfer fares are defined for each group of transit services.

Note that although fares in Table 9-6 are stated in year 2020 dollars, for the model fare input table, "ptfare.txt", all fares are converted to year 2000 dollars. This is consistent with other dollar cost model inputs such as auto operating cost.

Table 9-6 Year 2020 Transit Fares (Single-Ride Adult Fare, in 2020 Dollars)

Fare Group	Transit Service	2020 Adult Cash Fare, in 2020 Dollars	Discount(s)	Monthly Passes
1,2	RT LRT & Bus (includes Folsom and Elk Grove services)	$2.50	Seniors, youth	Yes
3	Yolobus Express	$3.25	Seniors, youth	Yes
4	Yolobus Local / Intercity	$2.00	Seniors, youth	Yes
5	Roseville Commuter	$3.25	Seniors, youth	Yes
6	Roseville Local	$1.50	Seniors, youth	Yes
7	Yuba-Sutter Commuter	$4.50	Seniors, youth	Yes
8	Yuba-Sutter Local	$1.00	Seniors, youth	Yes
9	El Dorado Transit Commuter	$5.00	Seniors, youth	Yes
10	El Dorado Transit Local	$1.50	Seniors, youth	Yes
11	Placer County Transit Commuter	$4.25-$5.75	Seniors, youth	Yes
12	Placer County Transit Local	$1.25	Seniors, youth	Yes
13	Unitrans	$1.25	Seniors, college students	Yes
14	Heavy Rail	Varies	Seniors	Yes
15	South County Link (Galt)	$3.25	Seniors, youth	Yes
18	Future operator, shuttle service	$1.00	Seniors, youth	Yes
19	Future operator, streetcar service	$1.00	Seniors, youth	Yes

Source: SACOG 2025. Excludes fare systems 16 and 17, which in in previous SACSIM versions corresponded to Folsom and Elk Grove services, which were annexed by Regional Transit

10 Model System Equilibration

10.1 Background and Concepts

SACSIM design has a cyclical relationship between network performance and trips: DAYSIM and the auxiliary trip models use network performance measures to model person-trips, which are then loaded to the network, determining congestion and network performance for the next iteration. The model system is in equilibrium when the network performance used as input to DAYSIM and the other trip models matches the network performance resulting from assignment of the resulting trips. Network performance for this purpose is times, distances, and costs measured zone-to-zone along the least-time paths (or more specifically, the paths of least generalized cost).

The theory of system equilibrium was developed based on trip-based models [18]. A wide range of trip-based models have a fixed point solution for all zone-to-zone and link flows, which can be solved with proper algorithms. These have been rare in practice until the 1990s, which saw development of many convergent model systems.

Almost all convergent trip-based models, at some stage in an iteration process, use the method of convex combinations. This is to update the current best solution of flows (zone-to-zone matrices and/or link volumes) with a weighted average of the previous best solution of those flows ($\mathbf{x}_{i-1}$), and an alternative set of flows calculated by the new iteration shown in Equation 10-1. The first iteration normally uses network performance skim matrices based on free-flow link times.) When flows are combined in this manner, the result meets the same conservation-of-flow constraints as the iteration matrices.

Equation 10-1 SACSIM Iteration

($\mathbf{y}_i$): $\mathbf{x}_i = (1-\lambda)\mathbf{x}_{i-1} + \lambda \mathbf{y}_i$

Where the step size λ must satisfy $0 < \lambda \leq 1$. In the first iteration, there is no $\mathbf{x}_{i-1}$, so λ must be 1.

[18] Evans, Suzanne P. "Derivation and Analysis of Some Models for Combining Trip Distribution and Assignment", *Transportation Research*, Vol. 10, pp. 37-57 (1976).

Several trip-based model systems are defined so that the step size can be chosen at each iteration to optimize an objective function, or approach the solution to a variational inequality. But most models in practice do not satisfy those models' specific requirements, so the step size must be predetermined. The classic reliable workhorse is the Method of Successive Averages (MSA). This reliably converges for a wide range of models for which there is no determination of an iteration's optimal λ. This method chooses $\lambda = 1/i$, so that, in effect, after any iteration *n*, the solution approximation is the average of all the iteration-result vectors computed so far: $\mathbf{x}_i = \frac{\mathbf{y}_1 + \mathbf{y}_2 + \ldots + \mathbf{y}_i}{i}$. Some trip-based models converge reliably and more efficiently with a fixed step size [19], though care must be taken in the choice of that step size, which depends on the problem.

Equilibrium theory of trip-based models has unfortunately not been extended into activity-based models directly. In these, zone-to-zone flows are only an indirect result of more complex behavior models which cannot be reduced to the terms of the established equilibrium trip-based models. Activity models also have excessively vast choice sets to be able to split travel among all alternatives in proportion to their probability. Consequently, most, such as DAYSIM, are applied as Monte Carlo processes, randomly generating one outcome (household trip diary) per unit of analysis (household or person), and then aggregating the trips as zone-to-zone flows. Thus, the equilibration procedure employed by trip-based models can be applied by activity based model.

The equilibration procedure in SACSIM employs equilibrium assignment iteration loops (a-iterations) nested within iterations between the demand and assignment models (da-iterations).

Assignment is run for nine time periods, and each one employs multi-class equilibrium assignment, with classes composed of SOV, HOVs not using median HOV lanes, and HOVs using them. A convex combinations algorithm is used, with the step size α determined automatically by the Cube Voyager software, and closure criteria determined by the user: maximum number of iterations (N_i), and relative gap as defined by CUBE VOYAGER (g_i). Iterations stop when one of the closure criteria is satisfied.

There are several points in the model stream where it is possible to apply convex combinations as a "blending" of trips and/or volumes. The following are prevalent in the literature for convergent models:

(1) "Pre-assignment blending" - Blend the trip demand matrices from the system-iteration's demand model, with the previous system-iteration's blended trips, into a weighted average [20]. Then assign these new blended trips in equilibrium.

(2) "Post-assignment blending" - assign the new iteration trips alone in equilibrium, then blend those volumes with the previous system-iteration's blended link volumes [21].

(3) Assign each iteration's trips in an all-or-nothing assignment on the same paths used to derive the skims [22]. Most modeling software, and the several whole-matrix processes in SACSIM (and most trip-based models) conspire against the practicality of such an approach. Consequently, the Evans model and numerous generalizations [23] are rarely used in practice.

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[19] Boyce, D., Ralevic-Dekic, B., and Bar-Gera, H., "Convergence of Traffic Assignments: How Much is Enough?" *Journal of Transportation Engineering,* 130:1(49), American Society of Civil Engineers, 2004.

[20] Boyce, David, et.al., "Introducing 'Feedback' into Four-Step Travel Forecasting Procedure vs. Equilibrium Solution of Combined Model", Transportation Research Record No. 1443, Transportation Research Board, Washington, D.C, 1994, pp. 65-74.

[21] Boyce, David, et.al. (1994), ibid.

[22] Evans (1976) ibid.

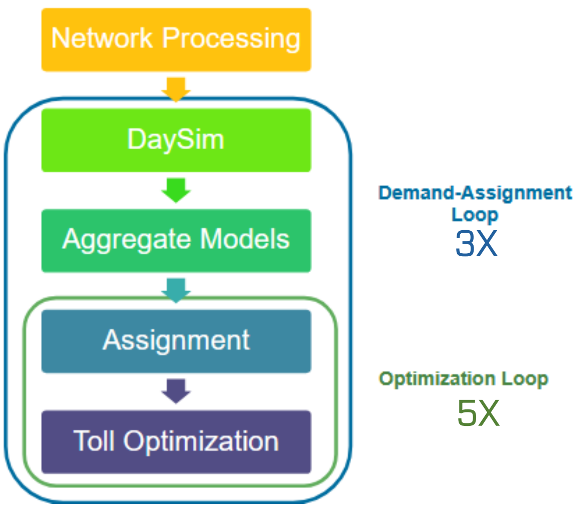
[23] Miller, Harvey J., "Towards Consistent Travel Demand Estimation in Transportation Planning: A Guide to the Theory and Practice of Equilibrium Travel Demand Modeling", U.S. Department of Transportation, Bureau of Transportation Statistics, June 27, 2001.

10.2 SACSIM Equilibrium Solution Procedure with Pricing Scenarios

As described in Chapters 3 and 9, SACSIM generates separate skims for three different value-of-time, or VOT, classes to better capture the effects of roadway pricing through facility tolling and/or per-mile user fees. This affects a traveler's choices based on their VOT class as well as road use choice when pricing is applied.

Pricing optimization in SACSIM is implemented after the initial assignment converges and forms an internal feedback loop of up to five toll iterations around each completed assignment. Therefore, including toll optimization takes a much longer time to converge. In the full global model iterations, SACSIM run three iterations with 100% sampling rates of households and persons for each iteration.

Figure 10.1 SACSIM Loop Structure



11 Model Calibration and Validation

11.1 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 SACSIM23.

11.1.1 American Community Survey

Five-year ACS data (2016-2020) from the Census Bureau was used as the source of demographic controls for the development of the base year 2020 representative population file for SACSIM23. In addition to the demographic profiles, ACS data reports commute statistics such as mode of commute.

11.1.2 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 SACSIM23. HTSs are also used to calibrate key submodels to ensure that they are reasonable representations of observed travel behavior.

The 2018 SACOG HTS 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 on SACOG's website[24].

DAYSIM was fully re-estimated for SACSIM23 using 2018 household travel survey (HTS) and no longer incorporates year 2000 HTS data. More details on DAYSIM re-estimation using the 2018 HTS are available on the SACSIM23 documentation page[25].

11.1.3 Sacramento Regional Transit Airport Passenger Survey

In January and February 2002, a contractor for Sacramento Regional Transit surveyed air passengers at the Sacramento International Airport[26]. 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

[24] 2018 Household Travel Survey - https://www.sacog.org/planning/data-resource-center/travel-demand-model/travel-model-documentation-225

[25] SACSIM23 documentation https://www.sacog.org/planning/data-resource-center/travel-demand-model/travel-model-documentation/sacsim23

[26] Parsons Brinckerhof 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.

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.

11.1.4 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). Although somewhat dated, we used their transfer rates to help validate SACSIM's transit assignment.

11.1.5 Transit Boarding Counts

Year 2020 pre-COVID weekday passenger boardings by line were assembled for use in validation of the transit assignment.

11.1.6 Traffic Counts

Traffic counts are used for validation and reasonableness checking of the SACSIM highway vehicle assignments for the MTP/SCS base scenario year pre-pandemic 2020. Historical count data for 2008, 2012, and 2016 from past model generations are also used for reasonableness checking. Year 2020 is the base year for SACSIM23 and for analysis of the 2025 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.

In general, counts were used which were:

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

For SACSIM23, the data window is the closest pre-pandemic span: September–October 2019 and January–February 2020. In some cases, counts were utilized by SACOG which did not meet these 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.

In addition to validating daily volumes, we compared time-period traffic counts against Caltrans PeMS data aggregated to the same SACSIM time periods. These comparisons serve as a reference for adjusting DAYSIM's time-of-day patterns. Validation was done using pre-pandemic 2020 data.

Peak-hour counts were not used in the SACSIM validation. 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 11-1 provides a tabulation of the traffic counts assembled by county of the count location by year.

Table 11-1 Traffic Counts Collected by Year

	YEAR			
Functional Class	**2008**	**2012**	**2016**	**2020**
Freeway/HOV	241	191	371	440
Arterial/Expressway/Rural Highway	702	481	1,065	430
Other Surface Streets & Ramps	820	368	760	1,486
Total	1,763	1,040	2,196	2,356

Source: SACOG 2025.

11.1.7 Vehicle Miles Traveled

Estimates of VMT were extracted from the annual Highway Performance Monitory System data from the California Public Road Data (CPRD)[27] report, and adjusted for comparison to SACSIM's VMT estimates. Adjustments to 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 SACSIM23 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. Instead 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 3 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.

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 85 percent and 90 percent for El Dorado and Placer Counties, respectively.

[27] California Department of Transportation, *California Public Road Data*, published annually, https://dot.ca.gov/programs/research-innovation-system-information/highway-performance-monitoring-system

11.1.8 Other Data Sources

For reasonableness checks and manual free-flow speed adjustments, SACOG used FHWA's National Performance Management Research Dataset (NPMRDS), which provides observed vehicle speeds collected from mobile devices and in-vehicle probes.

SACOG used the NPMRDS to adjust free-flow speeds on freeways and major arterials in the SACSIM23 network wherever observed data are available. For links without NPMRDS data, we imputed free-flow speed based on the link's functional class and surrounding land use types (e.g., rural, suburban, rural, etc.).

To compute free-flow speeds from NPMRDS data, SACOG used the 2017 average direction-specific passenger-vehicle speeds recorded between 10:00 PM and 4:00 AM for each roadway segment. For reasonableness checks, mid-week (Tuesday–Thursday) averages by time of day and direction were calculated for March, April, May, and October of that year.

11.2 Model Calibration

11.2.1 DAYSIM Model Calibration

As described in Chapter 3, DAYSIM is the core of SACSIM and consists of two modules: long-term and short-term choices. Both modules consist of a series of nested choice models. In operation, given the households' residence, DAYSIM runs the long-term module first and simulates people's long-term choices such as usual work and school locations, and auto ownership, and then runs the 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.

All DAYSIM choice models were re-estimated using the 2020 parcel level land use data, skim data and SACOG's 2018 household travel survey data. More details on the DAYSIM update are provided in a 2022 update memorandum [28], available on the SACSIM23 documentation page[25].

In addition to standard calibrations—such as work-location and mode-choice adjustments—we refined the time-of-day calibration using newly developed time-period volume and congested-speed validations as references. The time-of-day model models travelers' choices of departure times and trip durations for purposes such as work, school, and recreation. We use time-of-day volume validation as our primary benchmark, then adjust model coefficients to bring simulated volumes into better alignment with observed counts. For example, if the model overestimates morning-peak volumes but underestimates midday traffic, we recalibrate to shift departures away from the peak hour and toward the afternoon. Congested-speed data provide a secondary reference for similar fine-tuning.

For post-pandemic mode-choice parameters related to work-from-home, SACOG 2018 household travel survey data and ACS data were utilized to calibrate the base-year work from home rate, and U.S. Survey of Working Arrangements and Attitudes (SWAA) data were used to adjust the work-at-home rate and telework mode share in future years.

[28] The calibration effort described in the 2022 update memorandum used 2016 land use data because 2020 land use data were not yet available, but SACOG staff re-calibrated again using 2020 land use data once it was available.

Table 11-2 DAYSIM Choice Model Coefficients

	1. WorkLocation - WorkLocation_2021v3c.F12		
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
9	Beta000009	workAwayFromHomeFlag * IsPartTimeWorkerFlag * LN(1 + one-way drive dist (10s of mi))	Distance sensitivity of part-time workers' usual-work-place
10	Beta000010	workAwayFromHomeFlag * IsNotFullOrPartTimeWorkerFlag * LN(1 + one-way drive dist (10s of mi))	Distance sensitivity of student workers' usual-work-place
41	Beta00041	workAtHomeFlag	% of workers working at home

	2. SchoolLocation - SchoolLocation_2021v3B.F12		
Item#	Name	Description	Ratio variable Description
14	Beta000014	schoolAwayFromHomeFlag * IsUniversityStudentFlag * LN(1 + one-way drive dist (10s of mi))	Distance sensitivity of university students' usual-school-place
50	Beta000050	schoolAtHomeFlag	% of school-at-home students

	3. WorkTourMode - WorkTourMode_2021v3.F12		
Item#	Name	Description	Ratio variable Description
10	dt-const	Drive to transit constant	Drive to transit tours
11	dt-nocars	Drive to transit constant for households with no cars	Drive to transit tours for households with no cars
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
41	sr-nocars	Shared drive constant for households with no car	Shared drive tours of households with no car
50	da-const	Drive alone constant	Drive alone tours
53	da-carsltw	Drive alone constant for households with fewer cars than workers	Drive alone tours of households with fewer cars than workers
60	bi-const	Bike mode constant	Bike tours
70	wk-const	Walk mode constant	Walk tours
77	wk-nocars	Walk mode constant for households with no car	Walk tours of households with no car
80	tnc-const	TNC mode constant	TNC tours

	4. WorkBasedSubTourMode - WorkBasedSubtourMode_2021v3.F12		
Item#	Name	Description	Ratio variable Description
70	wk-const	walk constant	Walk to work subtours

	5. Work tour time - WorkTourTime_2021v2.F12		
Item#	Name	Description	Ratio variable Description
11	arr3-5	Arrive 3-6 am Constant	Arrive 3-6 am Tours
12	arr=6	Arrive 6-7 am Constant	Arrive 6-7 am Tours
13	arr=7	Arrive 7-8 am Constant	Arrive 7-8 am Tours
15	arr=9	Arrive 8-9 am Constant	Arrive 8-9 am Tours
16	arr10-12	Arrive 10 am-1 pm Constant	Arrive 10 am-1 pm Tours
17	arr13-15	Arrive 1-4 pm Constant	Arrive 1-4 pm Tours
18	arr16-18	Arrive 4-7 pm Constant	Arrive 4-7 pm Tours
19	arr19-21	Arrive 7-10 pm Constant	Arrive 7-10 pm Tours
20	arr22-26	Arrive 10 pm-3 am Constant	Arrive 10 pm-3 am Tours
21	dep3-6	Depart 3-7 am Constant	Depart 3-7 am Tours
22	dep7-9	Depart 7-10 am Constant	Depart 7-10 am Tours
23	dep10-12	Depart 10 am-1 pm Constant	Depart 10 am-1 pm Tours
24	dep13-14	Depart 1-3 pm Constant	Depart 1-3 pm Tours
26	dep=17	Depart 5-6 pm Constant	Depart 5-6 pm Tours
27	dep=18	Depart 6-7 pm Constant	Depart 6-7 pm Tours
28	dep19-20	Depart 7-9 pm Constant	Depart 7-9 pm Tours
29	dep21-23	Depart 9-12 pm Constant	Depart 9-12 pm Tours
30	dep24-26	Depart 12-3 am Constant	Depart 12-3 am Tours
31	dur0-2	Duration 0-3 hrs Constant	Duration 0-3 hrs Tours
32	dur3-4	Duration 3-5 hrs Constant	Duration 3-5 hrs Tours
33	dur5-6	Duration 5-7 hrs Constant	Duration 5-7 hrs Tours
34	dur7-8	Duration 7-9 hrs Constant	Duration 7-9 hrs Tours
36	dur10	Duration 9-10 hrs Constant	Duration 9-10 hrs Tours
37	dur=11	Duration 11-12 hrs Constant	Duration 11-12 hrs Tours
38	dur12-13	Duration 12-14 hrs Constant	Duration 12-14 hrs Tours
39	dur14-17	Duration 14-18 hrs	Duration 14-18 hrs Tours
40	dur18-23	Duration 18-24 hrs	Duration 18-24 hrs Tours

	6. Work based subtour time - WorkBasedSubtourTime_2021v2.F12		
Item#	Name	Description	Ratio variable Description
11	arr3-5	Arrive 3-6 am Constant	Arrive 3-6 am Subtours
13	arr=7	Arrive 7-8 am Constant	Arrive 7-8 am Subtours
15	arr=9	Arrive 8-9 am Constant	Arrive 8-9 am Subtours
16	arr10-12	Arrive 10 am-1 pm Constant	Arrive 10 am-1 pm Subtours
17	arr13-15	Arrive 1-4 pm Constant	Arrive 1-4 pm Subtours
18	arr16-18	Arrive 4-7 pm Constant	Arrive 4-7 pm Subtours
19	arr19-21	Arrive 7-10 pm Constant	Arrive 7-10 pm Subtours
21	dep3-6	Depart 3-7 am Constant	Depart 3-7 am Subtours
22	dep7-9	Depart 7-10 am Constant	Depart 7-10 am Subtours
23	dep10-12	Depart 10 am-1 pm Constant	Depart 10 am-1 pm Subtours
24	dep13-14	Depart 1-3 pm Constant	Depart 1-3 pm Subtours
26	dep=17	Depart 5-6 pm Constant	Depart 5-6 pm Subtours
27	dep=18	Depart 6-7 pm Constant	Depart 6-7 pm Subtours
28	dep19-20	Depart 7-9 pm Constant	Depart 7-9 pm Subtours
29	dep21-23	Depart 9-12 pm Constant	Depart 9-12 pm Subtours
31	dur0-0	Duration 0-1 hrs Constant	Duration 0-1 hrs Subtours
32	dur1-1	Duration 1-2 hrs Constant	Duration 1-2 hrs Subtours
34	dur3-4	Duration 3-5 hrs Constant	Duration 3-5 hrs Subtours
37	dur9-11	Duration 9-12 hrs Constant	Duration 9-12 hrs Subtours

	7. School tour time - SchoolTourTime_2021v2.F12		
Item#	Name	Description	Ratio variable Description
12	arr=6	Arrive 6-7 am Constant	Arrive 6-7 am Tours
13	arr=7	Arrive 7-8 am Constant	Arrive 7-8 am Tours
15	arr=9	Arrive 8-9 am Constant	Arrive 8-9 am Tours
16	arr10-12	Arrive 10 am-1 pm Constant	Arrive 10 am-1 pm Tours
17	arr13-15	Arrive 1-4 pm Constant	Arrive 1-4 pm Tours
18	arr16-18	Arrive 4-7 pm Constant	Arrive 4-7 pm Tours
19	arr19-21	Arrive 7-10 pm Constant	Arrive 7-10 pm Tours
22	dep7-9	Depart 7-10 am Constant	Depart 7-10 am Tours
23	dep10-12	Depart 10 am-1 pm Constant	Depart 10 am-1 pm Tours
24	dep13-14	Depart 1-3 pm Constant	Depart 1-3 pm Tours
26	dep=17	Depart 5-6 pm Constant	Depart 5-6 pm Tours
27	dep=18	Depart 6-7 pm Constant	Depart 6-7 pm Tours
28	dep19-20	Depart 7-9 pm Constant	Depart 7-9 pm Tours
29	dep21-23	Depart 9-12 pm Constant	Depart 9-12 pm Tours
31	dur0-2	Duration 0-3 hrs Constant	Duration 0-3 hrs Tours
32	dur3-4	Duration 3-5 hrs Constant	Duration 3-5 hrs Tours
33	dur5-6	Duration 5-7 hrs Constant	Duration 5-7 hrs Tours
34	dur7-8	Duration 7-9 hrs Constant	Duration 7-9 hrs Tours
36	dur10	Duration 10-11 hrs Constant	Duration 10-11 hrs Tours
37	dur11	Duration 11-12 hrs Constant	Duration 11-12 hrs Tours
38	dur12-13	Duration 12-14 hrs Constant	Duration 12-14 hrs Tours

	8. Other home-based tour destination - OtherTourDestination_2021v3.F12		
Item#	Name	Description	Ratio variable Description
27	Beta000027	personalBusinessFlag * distanceFromOrigin4	% of personal-business tours with destination within 1 mile.
28	Beta000028	personalBusinessFlag * distanceFromOrigin8	% of personal-business tours with destination within 1-3.5 miles
29	Beta000029	personalBusinessFlag * distanceFromOrigin9	% of personal-business tours with destination within 3.5-10 miles
30	Beta000030	personalBusinessFlag * distanceFromOrigin3	% of personal business tours with destination beyond 10 miles.
37	Beta000037	shoppingPurposeFlag * distanceFromOrigin4	% of shopping tours with destination within 1 mile.
38	Beta000038	shoppingPurposeFlag * distanceFromOrigin8	% of shopping tours with destination within 1-3.5 miles
39	Beta000039	shoppingPurposeFlag * distanceFromOrigin9	% of shopping tours with destination within 3.5-10 miles
40	Beta000040	shoppingPurposeFlag * distanceFromOrigin3	% of shopping tours with destination beyond 10 miles.
44	Beta000044	mealPurposeFlag * distanceFromOrigin4	% of meal tours with destination within 1 mile.
45	Beta000045	mealPurposeFlag * distanceFromOrigin8	% of meal tours with destination within 1-3.5 miles
46	Beta000046	mealPurposeFlag * distanceFromOrigin9	% of meal tours with destination within 3.5-10 miles
47	Beta000047	mealPurposeFlag * distanceFromOrigin3	% of meal tours with destination beyond 10 miles.
50	Beta000050	socialRecreationPurposeFlag * distanceFromOrigin4	% of social/rec tours with destination within 1 mile.
51	Beta000051	socialRecreationPurposeFlag * distanceFromOrigin8	% of social/rec tours with destination within 1-3.5 miles
52	Beta000052	socialRecreationPurposeFlag * distanceFromOrigin9	% of social/rec tours with destination within 3.5-10 miles
53	Beta000053	socialRecreationPurposeFlag * distanceFromOrigin3	% of social/rec tours with destination beyond 10 miles.

Source: SACOG 2025

11.3 Model Validation and Reasonableness Check

11.3.1 DAYSIM Reasonableness Check and Validation

As mentioned in model calibration section, DAYSIM submodels were estimated using 2018 household travel survey data based on 2016 land use and travel conditions. Selected DAYSIM submodels and variables were calibrated based on 2020 land use and demographic data and ACS 2014-2019 5-year data. The work-location and mode-choice models were further calibrated using the 2018 household travel survey and ACS data.

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

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

11.3.1.1 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 workplace based on the worker's demographic characteristics and job availability in the region. Table 11-3 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 12-1 shows the number of commute trips by travel distances. Compared to the 2018 survey, DAYSIM's average commute distance is slightly higher overall, with much of this difference due to DAYSIM predicting a higher share of long commute distances (greater than ~5 miles).

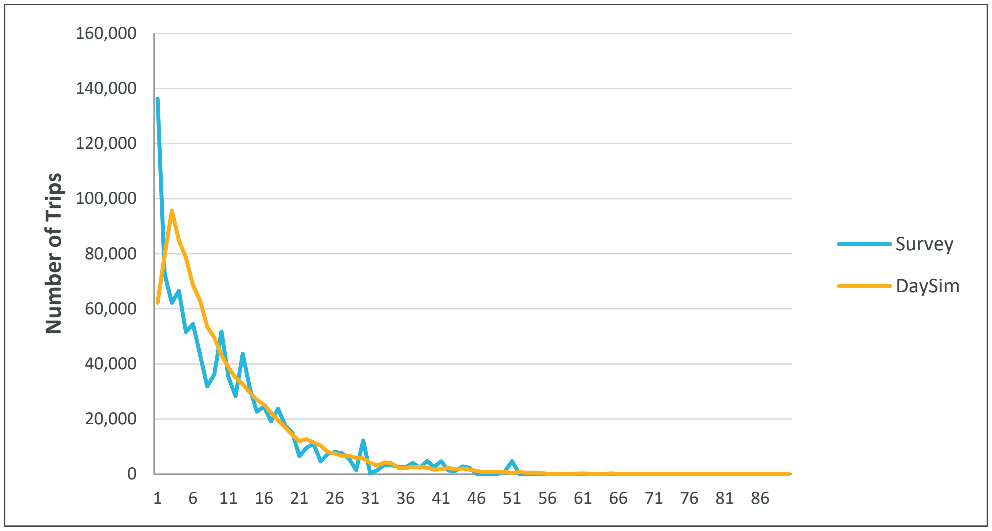
The total work location choices are constrained to TAZ-level total jobs by a shadow price process. Figure 12-2 demonstrates a good fit between the number of jobs in each TAZ and how many workers' usual work locations are in that TAZ.

Table 11-3 Average Commute Distance by Auto (2020 DAYSIM vs 2018 HTS)

Worker Type	Survey	DaySim	Ratio (DAYSIM/Survey)
Full Time	10.97	11.22	1.02
Part Time	6.82	6.86	1.01
Others	8.17	8.02	0.98
All	9.86	10.08	1.02

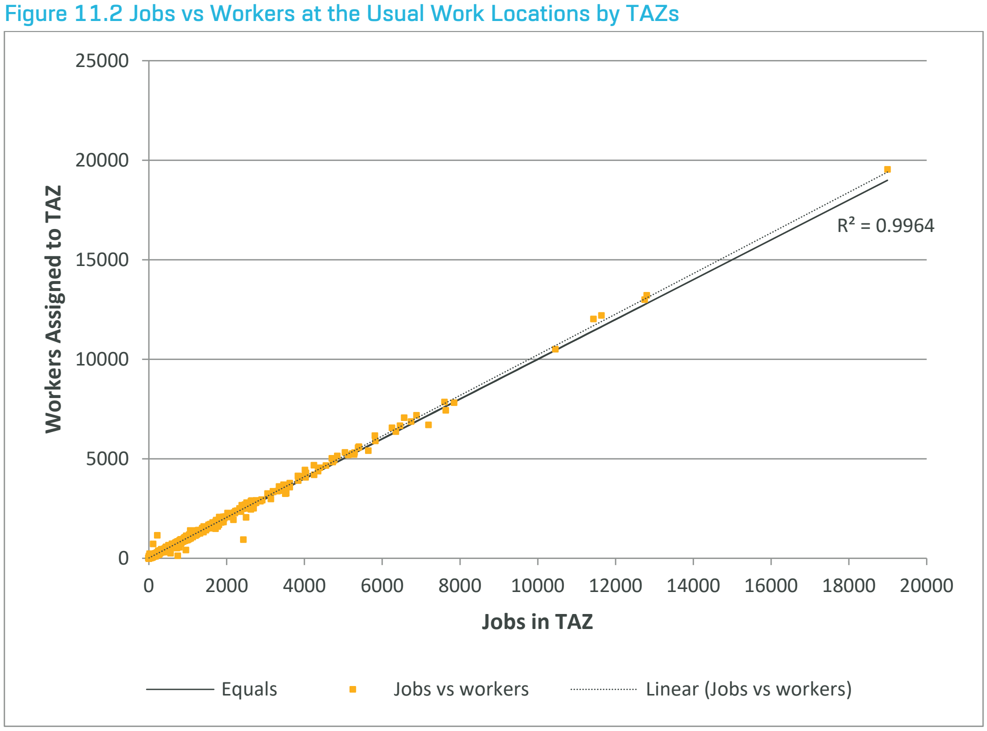
Source: SACOG 2025

Figure 11.1 Commute Distance Frequency – All Workers



Source: SACOG 2025

Figure 11.2 Jobs vs Workers at the Usual Work Locations by TAZs



Source: SACOG 2025

11.3.1.2 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 11-4 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 11-4 Auto Ownership Validation

2016 ACS[29]	Number of Vehicles					
HH # of Potential Drivers	*0*	*1*	*2*	*3*	*4+*	*Total*
1	6%	20%	3%	1%	0%	30%
2	1%	8%	30%	6%	2%	47%
3	0%	2%	4%	6%	2%	13%
4+	0%	3%	2%	1%	5%	10%
Total	8%	32%	39%	14%	8%	100%
DAYSIM	*Number of Vehicles*					
HH # of Potential Drivers	*0*	*1*	*2*	*3*	*4+*	*Total*
1	5%	18%	3%	1%	0%	28%
2	1%	8%	30%	6%	2%	46%
3	0%	2%	4%	6%	2%	14%
4+	0%	3%	2%	2%	6%	12%
Total	7%	31%	39%	14%	10%	100%
Ratio (DAYSIM Vs 2018 HTS)	*Number of Vehicles*					
HH # of Potential Drivers	*0*	*1*	*2*	*3*	*4+*	*Total*
1	0.9	0.9	1.0	0.9	0.2	0.9
2	0.8	1.0	1.0	1.0	0.9	1.0
3	0.5	1.1	1.0	1.0	1.1	1.0
4+	1.1	0.9	1.1	1.3	1.4	1.2
Total	0.9	1.0	1.0	1.0	1.2	1.0

Source: SACOG 2025

11.3.1.3 Telework and Work From Home

Because pre-pandemic 2020 is the SACSIM23 base year, SACOG calibrated the base-year work-from-home (WFH) rate using SACOG's household travel survey and ACS data. WFH comprises (1) home-based workers or workers with no fixed job location and (2) teleworkers—workers with an out-of-home workplace who work from home for all or part of a day before traveling to the office or to meetings. Table 11-5 reports the observed (data) and modeled WFH rates for the base year and for the future year.

Table 11-5 Work From Home Rates Validation

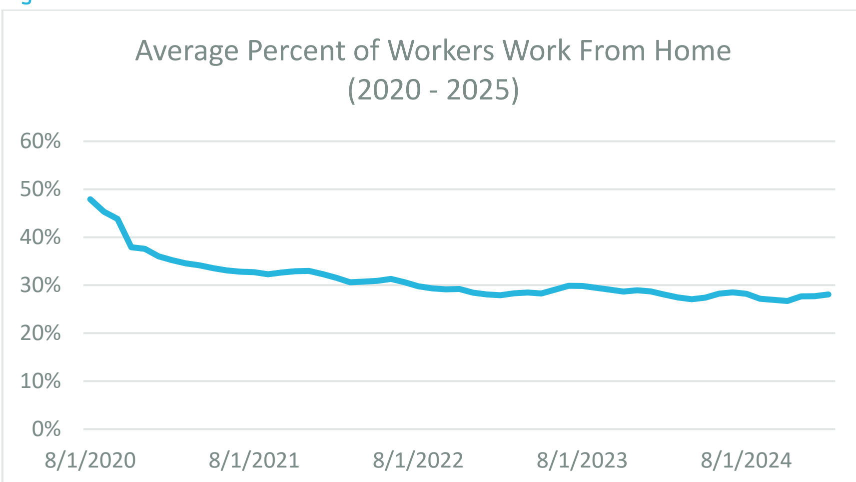
	2020 (PRE-PANDEMIC)			2035
Type	Data	SACSIM	Validation Ratio	SACSIM
Home-based workers	3.7% (Average of 2019 ACS PUMS: 2.7% and 2018 HTS: 4.6%)	3.6%	0.99	3.5%
Teleworkers	5.8% (2018 HTS)	5.7%	0.98	23.6%
Total Work from home	9.4%	9.3%	0.99	27.1%

[29] Table compares 2020 base year model scenario results against observed 2016 ACS data. DAYSIM was calibrated using a 2016 scenario year against 2016 ACS data because at the time of calibration (2022) we did not yet have a 2020 base year model scenario available.

As Table 11-5 shows, the modeled WFH rates align with observed data. For the base year (pre-pandemic 2020), we calibrated the home-based worker rate using the average of the 2019 ACS PUMS estimate and the 2018 SACOG household travel survey, and set the telework rate from the 2018 HTS, since ACS does not precisely reflect telework on a typical workday. ACS measures work-from-home via the journey-to-work item ("How did this person usually get to work last week?"), where respondents select a single usual mode, including 'Worked from home', based on the mode used for most of the distance. It does not capture number of WFH days or partial-day telework, so it can understate hybrid telework on a typical workday.

For future years, we used the SWAA to capture post-pandemic behavior. SWAA data indicate that WFH stabilized at roughly 28% by 2024 (Figure 11-3). To reflect California's July 2025 telework policy (requiring most state employees to work on-site at least four days per week), we conservatively set the total future-year WFH rate to 27%. We then decompose WFH into home-based workers and teleworkers. Given ACS data showed a slight decline in home-based workers (2.7% in 2019 to 2.4% in 2022), we assumed 3.5% for future year modeling. Given a total WFH rate of 27%, the implied telework share is 23.5% (= 27% − 3.5%).

Figure 11.3 SWAA Work From Home Rates 2020-2025



11.3.1.4 Mode share

Table 11-6 through Table 11-9 compare 2020 modeled mode split against the observed mode split from the 2018 Household Travel Survey (HTS). Generally, tour mode split validates better than trip mode split because DAYSIM is calibrated based on matching modeled to observed tour splits. Validation is also closer when considering all trip purposes than when comparing specifically for commute trips and tours, which is expected since model accuracy declines as you look at a more granular level.

Table 11-6 Mode Split Validation, 2020 Model Results vs. 2018 Household Travel Survey – All Trips

	2018 Household Travel Survey	2020 Travel Model	Ratio
Walk	8.6%	9.1%	1.1
Bike	2.1%	2.5%	1.2
Drive Alone	41.4%	42.6%	1.0
Shared Drive 2	23.3%	22.7%	1.0
Shared Drive 3+	22.5%	21.7%	1.0
Transit	1.3%	1.1%	0.8
Other	0.6%	0.6%	1.0

Source: SACOG 2025

Table 11-7 Mode Split Validation, 2020 Model Results vs. 2018 Household Travel Survey – All Tours

	2018 Household Travel Survey	2020 Travel Model	Ratio
Walk	6.8%	6.8%	1.0
Bike	2.2%	2.0%	0.9
Drive Alone	35.9%	37.6%	1.0
Shared Drive 2	23.7%	23.0%	1.0
Shared Drive 3+	28.5%	28.0%	1.0
Transit	1.9%	1.5%	0.8
Other	1.1%	1.1%	1.0

Source: SACOG 2025

Table 11-8 Mode Split Validation, 2020 Model Results vs. 2018 Household Travel Survey – Commute Trips

	2018 Household Travel Survey	2020 Travel Model	Ratio
Walk	5.2%	5.3%	1.0
Bike	1.8%	2.3%	1.3
Drive Alone	71.4%	70.9%	1.0
Shared Drive 2	12.7%	11.1%	0.9
Shared Drive 3+	6.9%	9.0%	1.3
Transit	1.4%	0.7%	0.5

Source: SACOG 2025

Table 11-9 Mode Split Validation, 2020 Model Results vs. 2018 Household Travel Survey – Commute Tours

	2018 Household Travel Survey	2020 Travel Model	Ratio
Walk	1.4%	1.3%	0.9
Bike	2.1%	2.3%	1.1
Drive Alone	65.0%	65.0%	1.0
Shared Drive 2	15.2%	15.1%	1.0
Shared Drive 3+	13.6%	13.8%	1.0
Transit	1.2%	1.0%	0.8

Source: SACOG 2025

11.3.1.5 Trip length

Table compares the average trip distance by mode, for all trip types, from the 2020 travel model and 2018 household travel survey. Table 11-11 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. Most notably: 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 a blend of higher-level streets and parcel-based factors described in Chapter 8. This disproportionately affects non-motorized trips, which are more likely to use minor streets in the model and be shorter trips.

Modeled transit trip distances were shorter than transit trips recorded in the survey. This is likely because the model reports transit trip distances 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. Importantly, this discrepancy does not affect transit mode choice, which is based on travel time rather than distance.

Given the above weaknesses of the model to accurately represent transit, walk, and bike travel distances, we are not surprised by the lower 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 11-10 Average Trip Distance by Mode (All Trips) – SACSIM vs. 2018 Household Travel Survey

	2018 Household Travel Survey	2020 Travel Model	Validation Ratio
Walk	0.7	1.5	2.0
Bike	2.3	3.8	1.7
Drive Alone	7.9	6.9	0.9
Shared Drive 2	6.6	5.9	0.9
Shared Drive 3+	5.9	5.9	1.0
Transit	8.7	5.3	0.6
Other	10.0	4.9	0.5
All Modes	6.5	5.9	0.9

Source: SACOG 2025

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

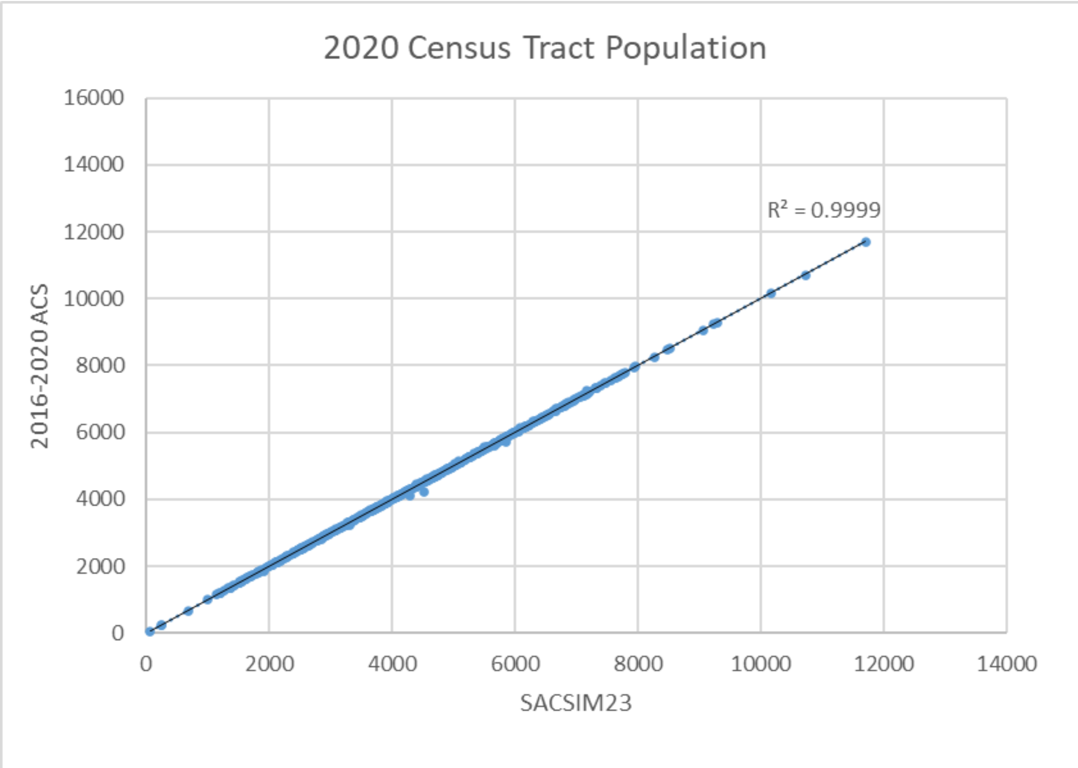
	2018 Household Travel Survey	2020 Travel Model	Validation Ratio
Walk	0.9	1.6	1.9
Bike	3.6	4.5	1.3
Drive Alone	10.6	8.5	0.8
Shared Drive 2	9.0	8.0	0.9
Shared Drive 3+	9.3	8.2	0.9
Transit	12.7	7.2	0.6
All Modes	9.7	7.9	0.8

Source: SACOG 2025

11.3.2 Demographic Reasonableness Check

ACS 2020 5-year sample data are used to establish demographic controls at Census tract level and are then used to generate the representative population file. Figure 12-3 compares ACS 2020 5-year sample household population to the SACSIM23 2020 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 2020 5-year sample data tract population using the 2020 SACSIM23 population as an independent variable is above 0.99.

Figure 11.4 Comparison of 2020 Population



Source: SACOG 2025

Table 11-12 through Table 11-15 provide comparisons between ACS 2020 5-year sample data and SACSIM23 2020 Population control household variables. These tables also show a high degree of consistency for all variables at county level.

Table 11-12 Year 2020 Household Size Distribution by County

SACSIM23 Representative Population Data					
County	1 person	2 persons	3 persons	4 persons	5+ persons
El Dorado*	21%	42%	14%	13%	9%
Placer*	23%	37%	15%	15%	10%
Sacramento	25%	31%	16%	15%	12%
Sutter	22%	30%	18%	16%	14%
Yolo	22%	32%	18%	17%	11%
Yuba	24%	28%	17%	16%	15%
Total	24%	33%	16%	15%	12%
2016-2020 ACS-Based Control Distributions					
County	1 person	2 persons	3 persons	4 persons	5+ persons
El Dorado*	21%	42%	14%	13%	9%
Placer*	23%	37%	15%	15%	10%
Sacramento	25%	31%	16%	15%	12%
Sutter	22%	30%	18%	16%	14%
Yolo	22%	32%	18%	17%	11%
Yuba	24%	28%	17%	16%	15%
Total	24%	33%	16%	15%	12%
Validation Ratio SACSIM23 to ACS					
County	1 person	2 persons	3 persons	4 persons	5+ persons
El Dorado*	1.000	1.000	1.000	1.001	1.000
Placer*	1.000	1.000	1.000	1.000	1.000
Sacramento	1.000	1.000	1.000	1.000	1.000
Sutter	1.000	1.000	1.000	1.000	1.000
Yolo	1.000	1.000	1.000	1.000	0.999
Yuba	1.000	1.000	1.000	0.999	1.001
Total	1.000	1.000	1.000	1.000	1.000

Source: SACOG, 2025, based on American Community Survey 2020 5-year Sample data.

*Partial county—Tahoe Basin excluded.

Table 11-13 Comparison of Distribution of Workers in Household by County

SACSIM23 Representative Population Data				
County	0 workers	1 worker	2 workers	3+ workers
El Dorado*	34%	34%	26%	6%
Placer*	29%	33%	31%	7%
Sacramento	25%	38%	29%	8%
Sutter	28%	36%	28%	9%
Yolo	26%	34%	32%	8%
Yuba	28%	40%	26%	6%
Total	27%	36%	29%	8%
2016-2020 ACS-Based Control Distributions				
County	0 workers	1 worker	2 workers	3+ workers
El Dorado*	34%	34%	26%	6%
Placer*	29%	33%	31%	7%
Sacramento	25%	38%	29%	8%
Sutter	28%	36%	28%	9%
Yolo	26%	34%	32%	8%
Yuba	28%	40%	26%	6%
Total	27%	36%	29%	8%
Validation Ratio SACSIM23 to ACS				
County	0 workers	1 worker	2 workers	3+ workers
El Dorado*	1.000	1.000	1.000	1.000
Placer*	1.000	1.000	1.000	1.000
Sacramento	1.000	1.000	1.000	1.001
Sutter	1.001	1.001	0.998	0.999
Yolo	1.000	0.999	1.001	1.000
Yuba	1.000	1.000	0.999	1.000
Total	1.000	1.000	1.000	1.000

Source: SACOG, 2025, based on American Community Survey 2020 5-year Sample data.

*Partial county—Tahoe Basin excluded.

Table 11-14 Comparison of Household Income Distribution by County

SACSIM23 Representative Population Data					
County	< $35k	$35k - $60k	$60k - $100k	$100k - $150k	$150k+
El Dorado*	18%	15%	21%	19%	26%
Placer*	17%	14%	21%	19%	28%
Sacramento	24%	19%	23%	18%	17%
Sutter	26%	21%	24%	16%	13%
Yolo	25%	15%	21%	17%	22%
Yuba	29%	20%	23%	18%	10%
Total	23%	17%	22%	18%	19%

2016-2020 ACS-Based Control Distributions					
County	< $35k	$35k - $60k	$60k - $100k	$100k - $150k	$150k+
El Dorado*	18%	15%	21%	19%	26%
Placer*	17%	14%	21%	19%	28%
Sacramento	24%	19%	23%	18%	17%
Sutter	26%	21%	24%	16%	13%
Yolo	25%	15%	21%	17%	22%
Yuba	29%	20%	23%	18%	10%
Total	23%	17%	22%	18%	19%

Validation Ratio SACSIM23 to ACS					
County	< $35k	$35k - $60k	$60k - $100k	$100k - $150k	$150k+
El Dorado*	1.000	1.000	1.000	1.000	1.000
Placer*	1.000	1.000	1.000	1.000	1.000
Sacramento	1.000	1.000	1.001	0.999	0.999
Sutter	0.999	1.002	1.001	0.998	1.000
Yolo	0.997	1.001	0.996	1.005	1.003
Yuba	1.001	0.999	1.000	1.000	1.000
Total	1.000	1.000	1.000	1.000	1.000

Source: SACOG, 2025, based on American Community Survey 2020 5-year Sample data.

*Partial county—Tahoe Basin excluded.

Table 11-15 Comparison of Householder's Age Distribution

SACSIM23 Representative Population Data			
County	< 35 years	35 - 64 years	>= 65 years
El Dorado*	9%	56%	35%
Placer*	12%	56%	32%
Sacramento	21%	56%	23%
Sutter	20%	54%	26%
Yolo	25%	52%	22%
Yuba	23%	55%	22%
Total	19%	56%	25%

2016-2020 ACS-Based Control Distributions			
County	< 35 years	35 - 64 years	>= 65 years
El Dorado*	9%	56%	35%
Placer*	12%	56%	32%
Sacramento	21%	56%	23%
Sutter	20%	54%	26%
Yolo	25%	52%	22%
Yuba	23%	55%	22%
Total	19%	56%	25%

Validation Ratio SACSIM23 to ACS			
County	< 35 years	35 - 64 years	>= 65 years
El Dorado*	1.001	1.000	1.000
Placer*	1.000	1.000	1.000
Sacramento	1.000	1.000	1.000
Sutter	0.999	1.000	1.001
Yolo	0.998	0.999	1.003
Yuba	1.000	1.000	1.000
Total	1.000	1.000	1.000

Source: SACOG, 2025, based on American Community Survey 2020 5-year Sample data.

*Partial county—Tahoe Basin excluded.

11.3.3 Highway Assignment Validation

11.3.3.1 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 2020. "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, excluding minor collectors and residential streets.

Table compares 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 differences 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.

Table 11-16 Model Network Route- and Lane-Mile Validation

Roadway Class	Model	HPMS	Ratio
Route Mileage †			
Freeway/Interstate*	325	320	0.98
Surface Street**	3,773	3,756	1.00
Subtotal	4,098	4,076	1.00
Lane Mileage ‡			
Freeway/Interstate*	1,959	2,051	1.05
Surface Street**	9,304	9,042	0.97
Subtotal	11,267	11,453	1.02

Source: SACOG 2025, Caltrans, 2020

Based on HPMS data reported in Caltrans' 2020 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 "applesto-apples" comparison is not possible.

11.3.3.2 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. Traffic assignment procedures do affect the amount of VMT, but 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 SACSIM23.

Validation of estimates of VMT by travel demand models to estimates of observed VMT gathered through the Highway Performance Monitoring System is required by federal statute for agencies like SACOG which implement air quality conformity analysis [30]. This requirement has been more generally applied for validation of travel demand models used for other purposes. For example, validation to HPMS is identified as a key recommended validation task in the FHWA guidance on validation of travel demand models [31].

Table 11-17 reports the comparison of SACSIM estimates of VMT to HPMS-sourced estimates. At region level, SACSIM estimates line up very closely with HPMS-sourced estimates, with less than three percent difference.

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

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

Table 11-17 Comparison of Daily Vehicle Miles Traveled Estimates: HPMS and SACSIM23

	2019	Pre-pandemic 2020
County	HPMS	SACSIM
El Dorado[32]	4,324	4,041
Placer[32]	9,986	10,431
Sacramento	36,391	35,335
Sutter	2,830	2,472
Yolo	6,551	6,331
Yuba	2,080	1,899
Region	62,162	60,509
Population	2,486	2,540
VMT per Capita	25.0	23.8

Source: SACOG 2025

*VMT Totals and Populations are in 1000s.

Table 11-18 Comparison of Daily Vehicle Miles Traveled Ratios: HPMS and SACSIM23

HPMS to SACSIM Validation Ratio	
County	**2019 (HPMS) vs Pre-pandemic 2020 (SACSIM)**
El Dorado[32]	0.93
Placer[32]	1.04
Sacramento	0.97
Sutter	0.87
Yolo	0.97
Yuba	0.92
Region	0.97

Source: SACOG 2025

[32] Only the portions of Placer and El Dorado County outside the Tahoe Basin are reported. SACOG staff adjusted the full-county data reported in CPRD reports.

11.3.3.3 Validation of Highway Link Assignment

Late 2019 and pre-pandemic months of 2020 are the primary period of highway assignment validation for SACSIM23. 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 11-19 shows how SACSIM23 2020 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.

Table 11-19 SACSIM23 and CTC Guidelines on Highway Assignment Validation

Validation Measures	Threshold	2020
% of Locations w/ Model < Max Deviation	>75%	83%
Correlation Coefficient	>0.88	0.97
RMSE for Daily Traffic Assignment	<0.40	0.36

While the regional guidelines serve an important role for model validation, they are only a partial indication of model performance. Highway 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 11-20 provides a comparison of forecasted 2020 model volumes to traffic counts by facility type. The table includes comparisons of average weekday volumes.

SACSIM23 shows 2020 performing well for freeways and major arterials roadway classifications. SACSIM23 does not perform as well for ramps and expressways, which may be due to a small number of samples collected from these facility types. Similarly, collector and rural highway roads did not validate as well, though this may be due to lower volumes on these roads, so smaller errors can appear proportionally larger.

Table 11-20 SACSIM23 Highway Volume Validation By Roadway Functional Class for Pre-pandemic 2020

Functional Class	No. of Counts	Sum of Counts	Sum of Model (if Counted)	Ratio	Avg. Link Error	RMSE
Daily Volumes						
Freeway	440	21547338	21415485	0.99	24%	0.20
Expressway	2	49728	69432	1.40	40%	0.40
Major Arterial	411	5863470	6084932	1.04	23%	0.32
Minor Arterial	494	4293171	4008294	0.93	36%	0.51
Collector	493	1498593	1338554	0.89	53%	0.76
Ramp	77	565096.7	550333	0.97	38%	0.57
Rural Hwy	17	92988	112836	1.21	29%	0.34
Rural Art./Coll	422	1285810	1311197	1.02	33%	0.46
Total	2356	35196194	34891063	0.99	22%	0.36

Source: SACOG 2025.

Figure 11-5 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.

The Figure 11-6 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 11.5 Pre-pandemic 2020 Weekday Modeled to Observed Volume

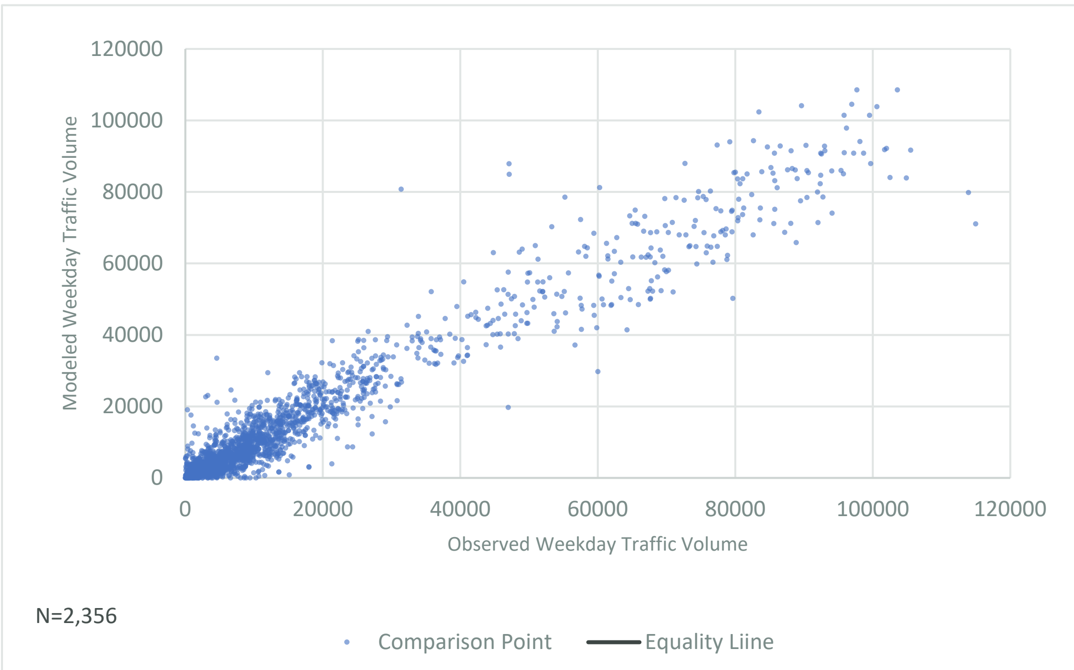
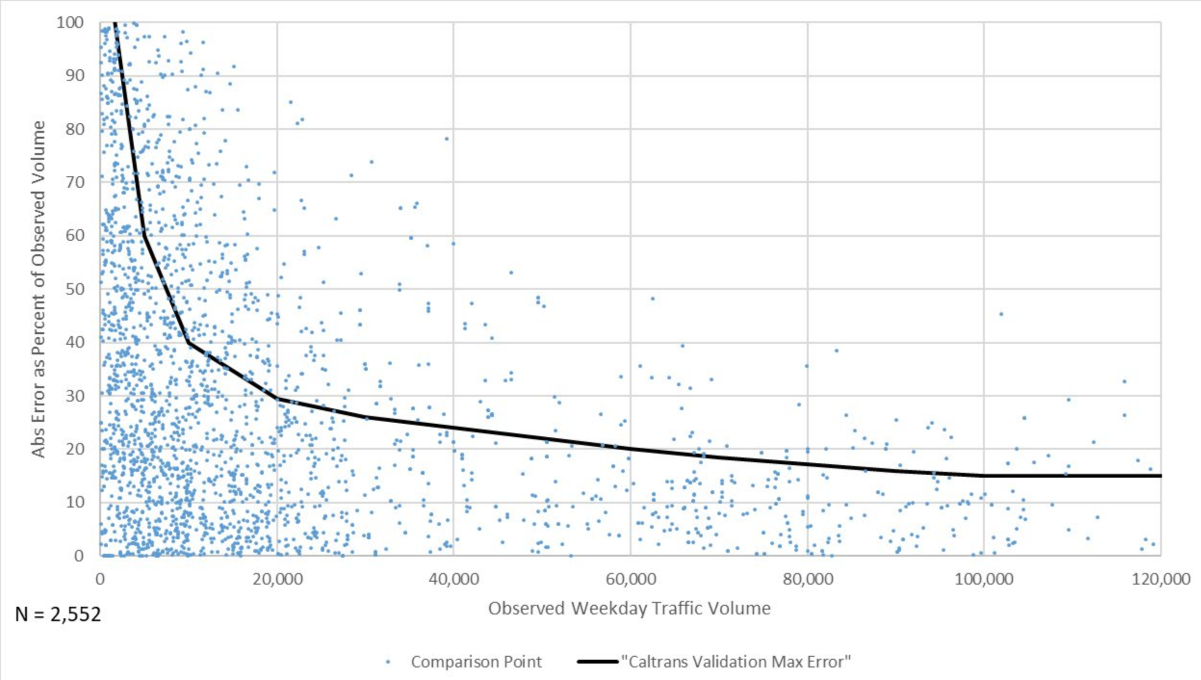


Figure 11.6 Year 2020 Pre-pandemic Weekday Volumes and Maximum Desirable Error



11.3.3.4 Gateways Assignment Validation and Reasonableness Check

As described in Chapter 3, SACSIM 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 11-21 shows the gateway SACSIM traffic volumes compared to counts using the CTC guidelines. The gateways meet all validation acceptance criteria including 100 percent of the locations within the acceptable range of deviation between traffic volume to observed count.

Table 11-21 SACSIM23 Gateways Assignment Validation

Validation Measures	Threshold	2020
% of Locations w/ Model < Max Deviation	>75%	100%
Correlation Coefficient	> 0.88	1.00
RMSE for Daily Traffic Assignment	<0.40	0.15

Source: SACOG 2025

11.3.4 Transit Network and Assignment Validation

11.3.4.1 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 11-7 provides a comparison of observed data and model estimates of weekday VSH for each route operating in the SACOG region for the period of late 2019 through pre-COVID 2020. Overall "fit" between model estimates and observed data is good, with an r-squared correlation between observed and modeled VSH of about 0.96. However, SACSIM's VSH predictions are somewhat lower than observed VSH, with a beta between modeled and observed VSH of 0.91.

Table 11-23 summarizes 2020 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 ratio of 0.96. VSH estimates for local buses are very close to operator-reported VSH (ratio of 0.97), while light rail estimated VSH is slightly lower than operator-report VSH (ratio of 0.94). VSH estimates for express buses are, on average, high, with a beta of 1.23.

Discrepancies between modeled and observed VSH are because 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 using stop-specific dwell times, 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.

VSH discrepancies are also in part due to needing to estimate a single "end of service" time for the night period. In reality, service ends at different times for different routes, with the last run of the day on local routes being anywhere from 8pm until after midnight. But for SACSIM, both for trip assignment and VSH computation, we assume all lines that have any service during the night time period stop running at 11pm.

Figure 11.7 Year 2020 Transit Line Vehicle Service Hours: Model Estimates and Observed Data

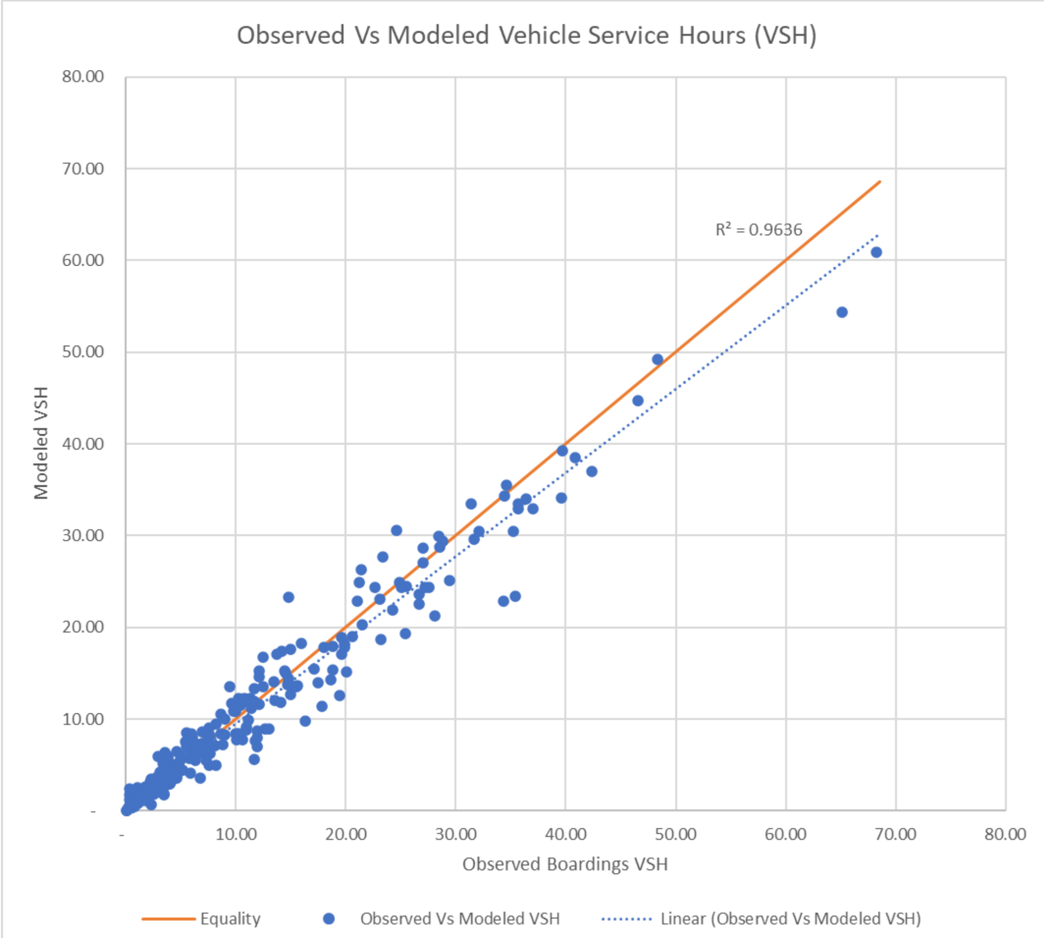


Table 11-22 Line-Level Transit Network Comparison: Model Estimates and Observed Data

	Regression Statistics (β * Model VSH= Actual VSH)	
Variable	R-Squared	Beta
2020 Vehicle Service Hours ‡	0.96	0.91

Source: SACOG 2025, 2019-2020 GTFS

Table 11-23 Year 2020 Transit Vehicle Service Hours by Type of Service: Model Estimates and Observed Data

	Weekday Vehicle Service Hours		
Service Type	Observed	Modeled	Validation Ratio
Light Rail	257	241	0.94
Fixed Route Bus	2,472	2,361	0.96
Express Bus	282	280	0.99
All Service Types	2,883	3,011	0.96

Source: SACOG 2025, 2019-2020 operator boarding data. Validation does not show all modeled transit, only where observed data was available.

11.3.4.2 Transit Assignment Validation

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

1. Generate and distribute transit trips using DAYSIM.
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 11-24 summarizes transit assignment validation results by transit mode, while Figure plots observed versus modeled boardings at the line level. SACSIM's estimate of boardings exceeded observed boardings by about 27% for local bus routes, 18% for LRT routes, and 20% across all transit modes, the latter of which is at the outer limit of California Transportation Commission's validation threshold of +/- 20% for transit boardings[33].

It's notable that while SACSIM overpredicts boardings for light rail and local bus modes, it underpredicts boardings for express/commuter bus modes by about 36% (a ratio of 0.64).

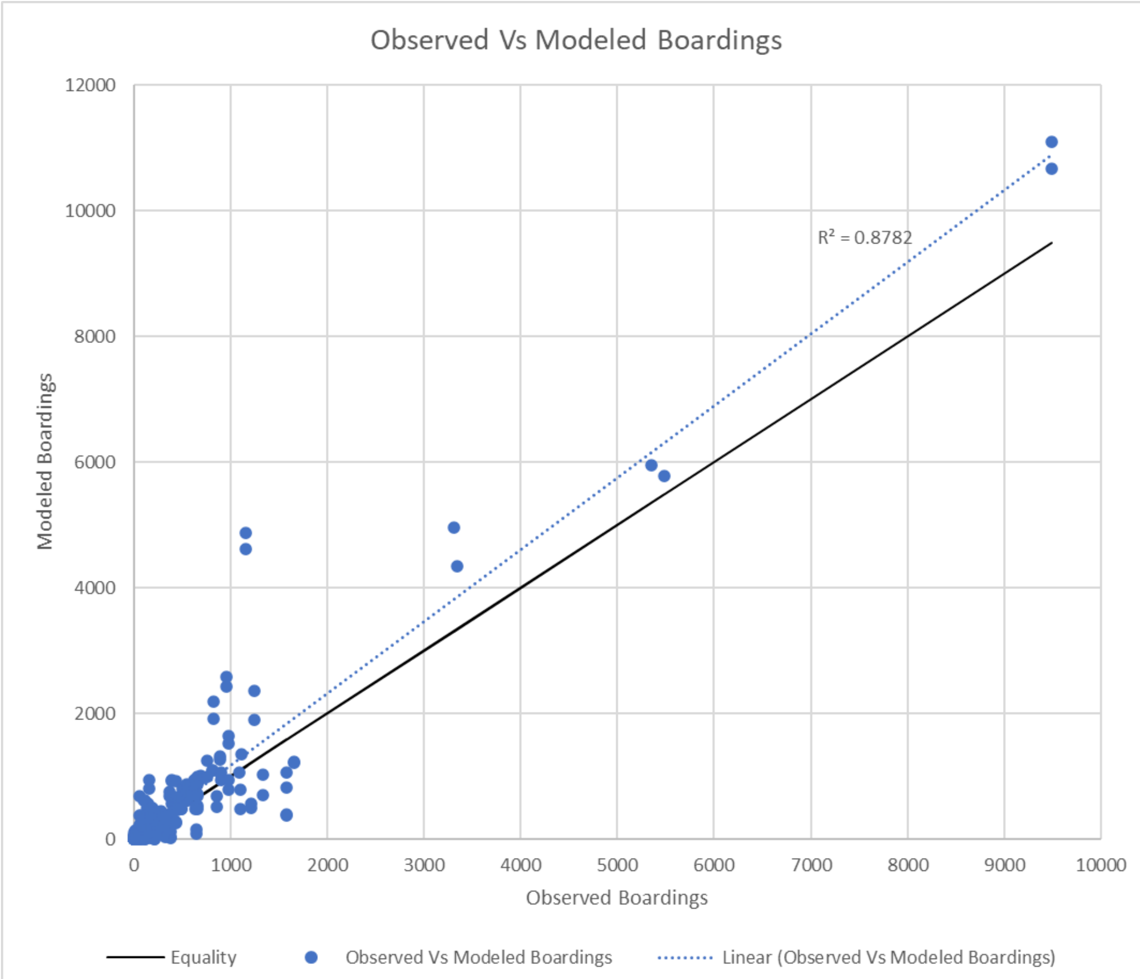
Table 11-24 Weekday Transit Passenger Boardings by Service Type: Comparison of Model to Counts

	Weekday Boardings			Boardings per Trip	
Service Type	Observed	Modeled	Ratio	Modeled Transit Trips	Boardings per Trip
Light Rail	37,016	43,571	1.18	40,486	1.08
Express Bus	6,659	4,237	0.64	4,192	1.01
Local Bus	74,993	95,090	1.27	55,235	1.72
All Service Types	118,668	142,897	1.20	99,913	1.43

Source: SACOG 2025

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

Figure 11.8 Line-Level Transit Boarding Validation



Although at the edge of CTC's transit assignment validation threshold, SACSIM's boarding estimate is not of significant concern because, as described above, SACSIM is calibrated to match regional overall transit tour share rather than match boardings at the line level. However, users should be aware of the poorer calibration if using SACSIM to estimate line-level boardings.

An alternative way to determine how reasonably SACSIM assigns transit trips is to compare SACSIM's transfer rate (boardings per trip) to an observed transfer rate. Table 11-25 suggests at first that observed transfer rates from the 2013 Connect Card Survey (1.78) are much higher than those predicted by SACSIM (1.44). However, 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 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 1.44 boardings per trip is reasonable.

Table 11-25 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
All Systems	*33%*	*58%*	*7%*	*2%*	*0%*	*1.78*
SACSIM	*N/A*					*1.44*

Source: SACOG 2025

Appendices

Appendix A. SACSIM23 Sensitivity Report

Appendix B. 2022 DAYSIM Update and Re-Estimation Memorandum

Appendix C. DAYSIM Reference Guide

Note – The DAYSIM Reference Guide is a Microsoft Excel (XLSX) spreadsheet.

SENSITIVITY ANALYSIS FOR THE SACSIM23 TRAVEL DEMAND MODEL

FINAL REPORT

AUGUST 2023

PREPARED FOR:

SACRAMENTO AREA COUNCIL OF GOVERNMENTS

Prepared by DKS Associates

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DOCUMENT DESCRIPTION

CLIENT	SACRAMENTO AREA COUNCIL OF GOVERNMENTS
DKS Project / Proposal Number	P22300-001
Project / Proposal Name	SACOG TO1 SACSIM23 Sensitivity Analysis
Document Name	Sensitivity Analysis for the SACSIM23 Travel Demand Model
Date Document Issued	August 22, 2023

EXECUTIVE SUMMARY

This is an analysis of the draft update of the tour-based regional travel demand model "SACSIM23" provided and maintained by the Sacramento Area Council of Governments (SACOG), to measure its responsive sensitivities to changes in highway speeds, capacities, costs, and policies, changes in transit service frequency, lines, costs, and accessibility, and its relationships between travel and land-use factors such as residential density, proximity to transit, regional accessibility, and street pattern. The direction and magnitude of the model's response to these various changes upon hypothetical scenarios is compared to empirical findings in published literature, including but not limited to studies of different regions before and after significant changes of infrastructure, services, or policies.

This analysis consists of three parts:

(1) cross-sectional, analyzing correlations between travel and factors of land-use (built environment) and accessibility from place to place within the base run.

(2) experimental testing of full runs of SACSIM23 with one independent variable per scenario changed systematically,

(3) examining random variation due to the random sampling method of application of the tour-based model within SACSIM23.

Besides the model's calibration to observation-based statistics such as traffic counts, transit boardings, and vehicle-miles traveled (VMT), the model's sensitivities underlie its suitability in comparing alternative future regional planning scenarios.

This analysis finds the SACSIM23 travel demand is appropriately responsive in representing the population's response in travel behavior choices, including activity locations, tour and trip formation and timing, modes and paths of travel, to the variety of alternative input factors tested. It is thereby suitable for evaluation and comparison of a wide range of land use, highway, and transit scenarios and policies throughout the Sacramento region.

INTRODUCTION

Within its responsibilities as the Metropolitan Planning Organization (MPO) for the greater Sacramento region, the Sacramento Area Council of Governments (SACOG) leads the continued development of the SACSIM travel demand forecasting model of the region. SACOG uses this model for region-wide analyses of travel under alternative transportation and land use plans, plus the influences of such factors as demographic changes and fuel prices.

Comparing alternative plans relies on the model's response to differences, even small differences, between factors known or expected to influence travel demand. That is why federal and state laws require a range of sensitivity analyses for their model. SACOG performed a sensitivity analysis for the 2019 version of SACSIM (SACSIM19), as documented in a portion of *User Guide and Model Documentation for SACSIM19* (*1*).

Since that analysis, Resource Systems Group Inc. (RSG) and SACOG have revised the choice models and their parameters within the SACSIM implementation of the Daysim tour-based travel demand model, using a new household travel survey conducted by SACOG and RSG in 2018 for the Sacramento Regional Transportation Study (*2*). Furthermore, the Daysim application software has been evolving in response to RSG's work for numerous MPOs and research, so implementation details have also changed.

Another change of the draft SACSIM23 model application relative to SACSIM19 is that it introduces a new zone (TAZ) system with 2274 zones, with detail added to the highway and transit networks to accommodate the finer spatial resolution and the new centroids. (SACSIM19 had 1503 zones for this same coverage area.) Daysim works at two levels of spatial resolution, one being the network TAZ system, the other being pseudo-parcels (most corresponding to real parcels) used particularly in modeling short-distance travel. SACSIM23's parcels are of comparable spatial resolution to those in SACSIM19.

SACOG also incorporated link free-flow speed data from "big data" sources, replacing most of the speeds in SACSIM19 which evolved over years of calibration efforts and accumulated analyst judgements but lacking consistent or "ground-truth" sources.

These cumulative changes from SACSIM19 to the current draft SACSIM23 indicate that model sensitivities may have also changed, warranting a new sensitivity analysis.

SACOG retained DKS Associates to perform this sensitivity analysis of a draft version of SACSIM23 of the new base year 2020 "normal" conditions, prior to responses to the COVID-19 pandemic beginning mid-March 2020. This analysis is similar to SACOG's own analysis of SACSIM19, with some additions and adjustments.

As with the SACSIM19 analysis, this analysis of draft SACSIM23 consists of three parts:

(1) cross-sectional, analyzing correlations between travel and factors of land-use (built environment) and accessibility from place to place within the base run.

(2) experimental testing of full runs of SACSIM23 with one independent variable per scenario changed systematically,

(3) examining random variation from different sampled Daysim outcomes.

The tables compiled herein are arranged similar to topics in Appendix B in the California Air Resources Board's Sustainable Communities Strategies document (*3*).

This sensitivity analysis focuses on selected dependent variables of particular relevance to SACOG's responsibilities regarding regional air quality and greenhouse gas emissions and transportation system performance, addressed through vehicle-miles of travel, vehicle-miles under congested traffic conditions, public transit usage, and walk and bike travel, all at regional and district geographic resolution.

CROSS-SECTIONAL TESTING OF LAND USE/TRANSPORTATION FACTORS

This section examines how simulated travel by residents in draft SACSIM23 varies with their home-location land-use/transportation factors, these being characteristics of their built environment, and local and regional accessibility. These relations are compared to findings compiled from empirical studies of travel behavior in relation to similar environment and accessibility variables.

These relations have for the dependent variable each modeled person's modeled travel summarized into vehicle-miles (VMT), transit trips, and walk trips. A multivariate regression analysis relates these each to the independent variables consisting of demographic variables of household size, household income, and whether the person is either employed, a non-working student, over 65 in age, or other, plus the examined set of land use/transportation factors.

The examined land use/transportation factors are as follows:

Buffer Variables are weighted sums of parcel land use quantities using "Buffer 2", one of two buffer sums used in SACSIM19 and the draft SACSIM23 models. For Buffer 2, the weight is a decay function of distance starting at 100% (fully counted) for parcels within ¼ mile of the parcel, approximately 68% counted for those ½ mile away, and tapering down to zero (uncounted) near 2 miles away (*1*). SACOG calculated and furnished the buffer-sums of each parcel attribute for all parcels, as part of the inputs for the draft SACSIM23 model. According to the documentation for the buffering method, the distance used between any two parcels was the straight-line distance multiplied by the given parcel's circuity factor for the second parcel's direction and distance range from the first. (Circuity factors for parcels were also prepared by SACOG and furnished in the parcel data for model input.)

Mix of Use is based on the Mix Index identified by Hossack (*4*). If we define

function $R(x, y) = \frac{\min(x,y)}{\max(x,y)}$, and given

parcel attributes HH=households, Emp=total employment, $K12$=K-12 school enrollment, Ret=retail employment, and Svc=service employment,

parcel attribute subscript b for the buffer sum of that attribute for any given parcel p, and

parcel attribute subscript t for the regional total of all parcels,

then a parcel's $MixIndex_p = 0.1R\left(\frac{HH_b}{HH_t}, \frac{Emp_b}{Emp_t}\right) + 0.3R\left(\frac{HH_b}{HH_t}, \frac{K12_b}{K12_t}\right) + 0.3R\left(\frac{HH_b}{HH_t}, \frac{Ret_b}{Ret_t}\right) + 0.3R\left(\frac{HH_b}{HH_t}, \frac{Svc_b}{Svc_t}\right)$. Its values range between 0 and 1. The maximum of 1 is achieved if and where the buffer sums of households, employment, school enrollment, retail, and service employment, are all in the same proportion as their regional totals, and the minimum of 0 where the buffer has only one of those land uses alone.

As originally defined by Hossack, each buffer sum is the unweighted sum for all parcels within one-half mile, which was the larger of two buffer distances used in the then-current SACSIM. This analysis uses the weighted "Buffer 2" sum now used in SACSIM19 and SACSIM23.

Comparisons to results in literature must be cautious that measures of land use mix in literature vary, some defined from entropy formulations and/or different buffers, but most are similarly defined in (or scalable to) a 0 to 1 range.

Street pattern/urban design concerns street connectivity, with small-block grids offering efficient walk paths to numerous destinations within walking distance, versus long cul-de-sacs offering few walkable paths or destinations. This measures not the amount of potential destinations themselves (represented by mix and density), but rather, efficient walk paths available to them. Consistent with many quantitative analyses, this is taken as the buffer-count of 3- and 4-way intersections, in which small-block grids tend to count higher than layouts with many cul-de-sacs.

Residential density and **employment density** are the buffer-sums around each residence location, of nearby households and employment, respectively.

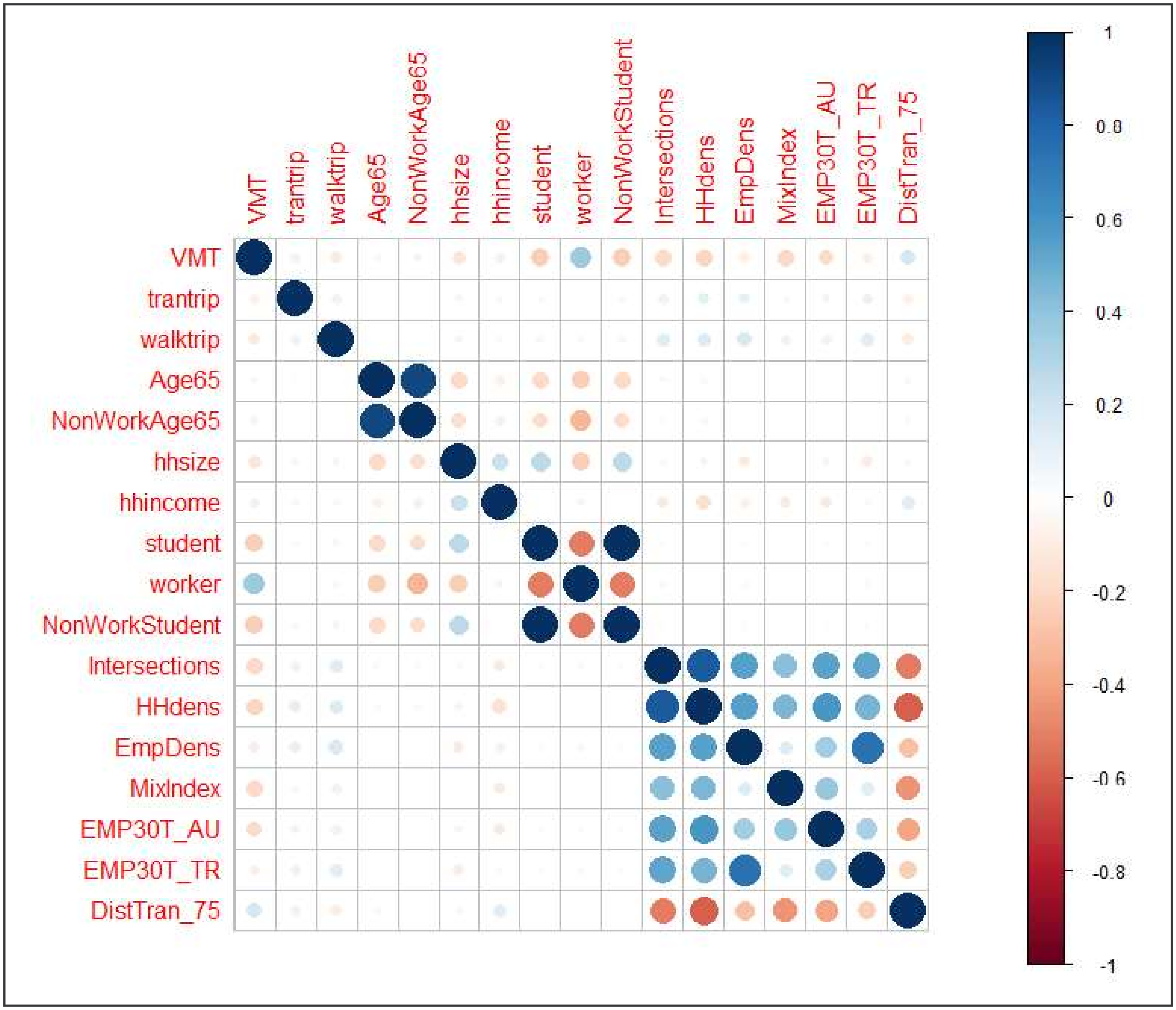
Employment density around the residence is a residence-centric representation or aspect of local jobs-housing balance, in the sense of there being jobs and services close to the home and reachable by a walk or a short drive.

Regional accessibility quantifies opportunities reachable within an average commute. Regional accessibilities by auto, and by transit, are each defined as the number of jobs within 30 minutes by the respective mode (including walking and waiting times for transit).

Proximity to Transit is here defined as min(0, Distance to transit stop - 0.75), basically specifying a continuous piecewise-linear relation with distance to the transit stop that (a) increases with distance up to the threshold of 0.75 miles, and (b) increases no more thereafter. Published empirical relations show irrelevance of further distance, particularly Cervero (*5*). The households with long distance to transit, and expectably little transit use, don't exert a dampening effect here as they would with an open-ended or censored distance. SACOG calculated and furnished the distance to transit for each parcel, also as part of the draft SACSIM23 model.

As indicated in the SACSIM19 Sensitivity Report (*1*), interactions among the land use-transportation factors are difficult to control, many are highly correlated, and the combined effect of many factors can be less or greater than the individual effects of each factor. Unexpected relations, and differences of elasticities between single and all-variables estimates, appear to be a consequence of strong correlations between many of the land-use variables. Figure 1 diagrams the correlations among variables on a color scale. It shows, for example, development density tends to correlate with street intersection density, greater mix of proximate land uses, regional accessibility, and close transit service (less distance to transit).

FIGURE 1 – CORRELATION OF REGRESSION VARIABLES



Multivariate regression analysis is identified with either one land use/transportation factor at a time, or all of them, each controlling for the demographic variables. SACSIM being disaggregate, individual modeled persons are the "observations" of each regression.

The mean-point elasticity is reported as $e_{kl} = \lim_{\Delta x \to 0} \frac{\Delta y_k}{\bar{y}_k} \frac{\bar{x}_l}{\Delta x_l} = \frac{\partial y_k}{\partial x_l} \frac{\bar{x}_l}{\bar{y}_k} = \beta_{kl} \frac{\bar{x}_l}{\bar{y}_k}$,

where $\beta_{kl} = \frac{\partial y_k}{\partial x_l}$ is an estimated regression coefficient from a regression model $y_k = \beta_{k0} + \sum_l \beta_{kl} x_l$, and

$\bar{x}_l$ and $\bar{y}_k$ are the means of the respective independent and dependent variables.

Table 1 shows the elasticities of travel from the land use/transportation factors, resulting from regressions that included, or controlled for, demographic variables. "Buffer 2" refers to the buffer variables defined above.

The comparison values from literature were primarily compiled by SACOG for their SACSIM19 sensitivity analysis, citing the works in (*4, 5, 6, 7, 8*).

TABLE 1 – LAND USE/TRANSPORTATION ELASTICITY COMPARISON

Factor	Variable	Elasticities, Literature	Elasticities, SACSIM23 All variables	Elasticities, SACSIM23 Single variables
VMT per person				
Street Pattern	3- & 4-way Intersections in Buffer 2	-0.12 [*-0.03 to -0.19*]	-0.08	-0.36
Residential Density	Households in Buffer 2	-0.04 [*-0.04 to -0.19*]	-0.12	-0.38
Regional Auto Accessibility	Jobs w/in 30 Minute Drive	-0.20 [*-0.13 to -0.25*]	-0.12	-0.33
Regional Transit Accessibility	Jobs w/in 30 Minute Transit Trip*	-0.05	0.01	-0.04
Proximity to Transit	min(DistTranStop - 0.75, 0)	-0.05	-0.05	-0.25
Mix of Use	SACOG Mix Index (0-1 scale)**	-0.09 [*-0.02 to -0.11*]	-0.25	-0.46
Local Destination Accessibility	Jobs in Buffer 2	n/a	-0.01	-0.06
Transit Trips per person				
Street Pattern	3- & 4-way Intersections in Buffer 2*	0.23	-1.27	0.79
Residential Density	Households in Buffer 2**	0.39	1.65	1.25
Regional Auto Accessibility	Jobs w/in 30 Minute Drive	n/a	0.09	0.75
Regional Transit Accessibility	Jobs w/in 30 Minute Transit Trip	n/a	0.05	0.19
Proximity to Transit	min(DistTranStop - 0.75, 0)	0.29	0.24	0.72
Mix of Use	SACOG Mix Index (0-1 scale)*	0.12	-0.18	0.52
Local Destination Accessibility	Jobs in Buffer 2	n/a	0.18	0.32
Walk Trips per person				
Street Pattern	3- & 4-way Intersections in Buffer 2*	0.39	-0.02	0.45
Residential Density	Households in Buffer 2**	0.07	0.29	0.49
Regional Auto Accessibility	Jobs w/in 30 Minute Drive*	n/a	-0.11	0.23
Regional Transit Accessibility	Jobs w/in 30 Minute Transit Trip	n/a	0.01	0.08
Proximity to Transit	min(DistTranStop - 0.75, 0)	0.15	0.07	0.29
Mix of Use	SACOG Mix Index (0-1 scale)	0.15	0.10	0.33
Local Destination Accessibility	Jobs in Buffer 2	0.15	0.08	0.13

Footnotes: * Model had a weaker or opposite response compared to the literature range or expected direction. ** Model's response range is overall stronger than literature range.

VMT responded to all of the tested land use variables in the same direction and general magnitude of the literature values, except that the weak positive of regional transit accessibility in the all-variables test is opposite of expectation (but has no literature values for comparison). Taking each variable's single-variable and all-variables elasticities as a modeled range, these ranges bracket or intersect with those of the literature, except for the model's stronger response to mixed land use. Most of the modeled ranges were stronger than the literature ranges, and single-variable elasticities stronger than with all variables.

Transit trips per person responded to single variables in the expected direction and more strongly than the literature estimates, but most elasticities were quite diminished with all variables together. With all variables, distance to transit held up a strong relationship while related variables that may support or correlate to short distance to transit weakened or reversed. The causal link between land use mix and transit use by the residents is less clear than that of mix to walk trips: mixed use gives opportunities reachable by walking that forego use of transit.

Walk trips per person also responded to single variables in expected directions and more strongly than literature estimates, while with all variables, all elasticities weakened and a few reversed.

Figures 2 through 5 present a cross-classification analysis, illustrating relationships and trends between demographic factors, land use factors, and VMT per capita.

FIGURE 2 – MODELED VMT PER CAPITA BY INCOME AND JOB ACCESSIBILITY BY CAR

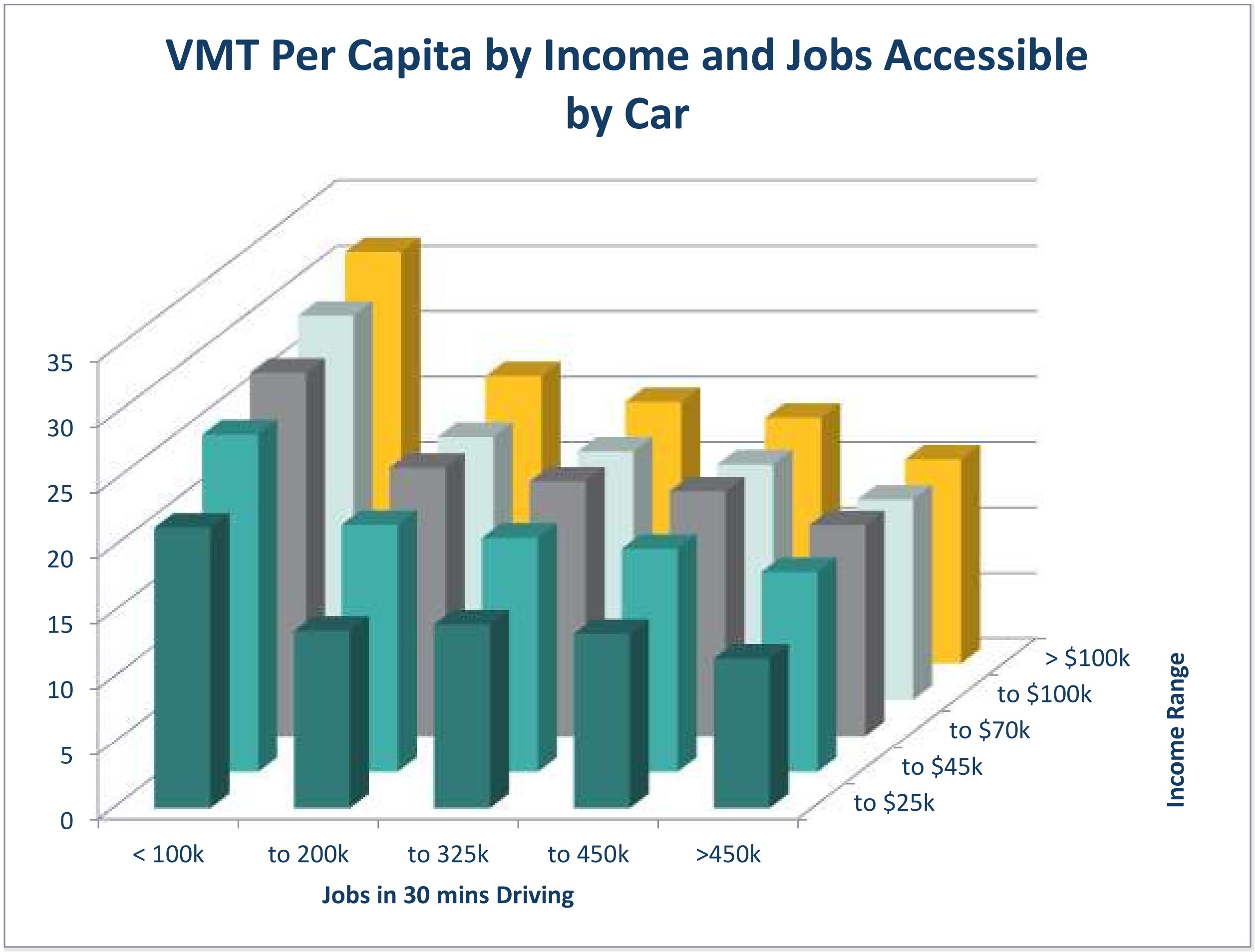


Figure 2 agrees with the regression analysis of Table 1, of lesser VMT by residents having more jobs within a half-hour drive (and less of the regional jobs farther away) when controlling for household income, while also showing increasing VMT with income when controlling for regional accessibility.

FIGURE 3 – MODELED VMT PER CAPITA BY INCOME AND JOB ACCESSIBILITY BY TRANSIT

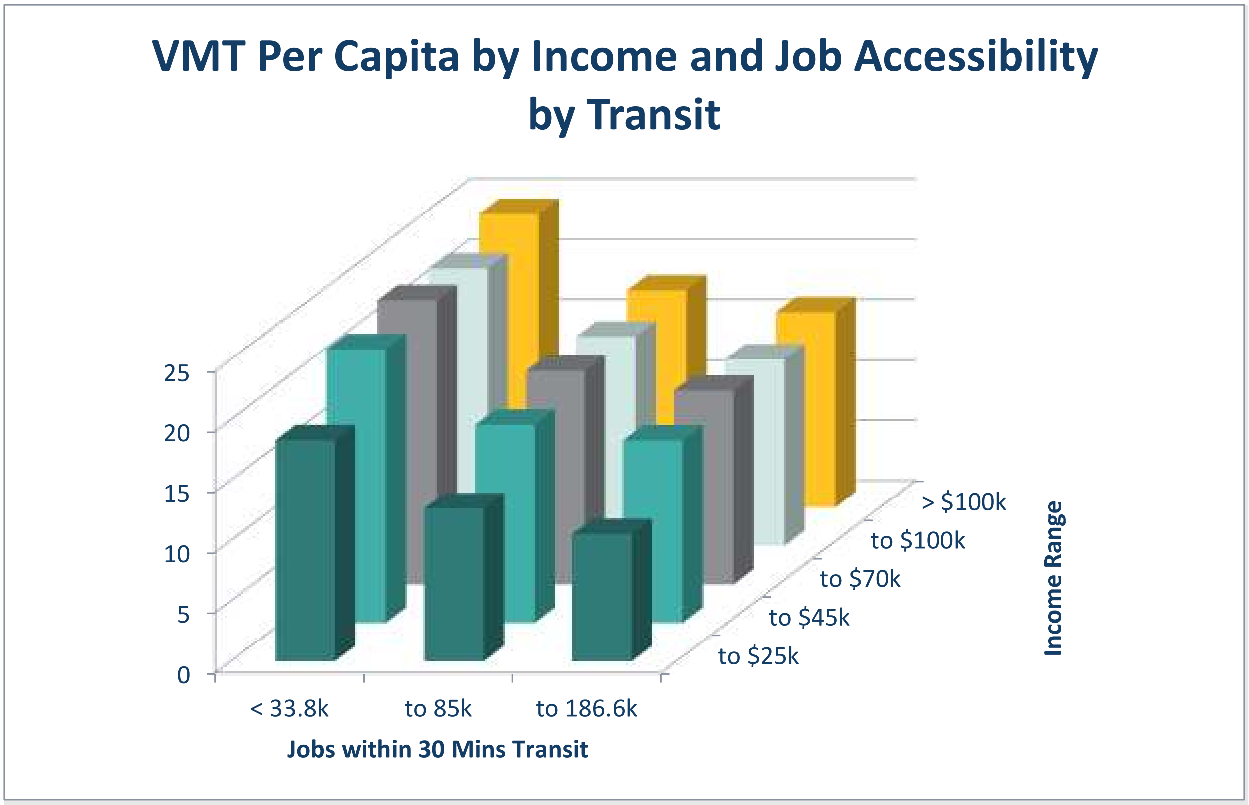


Figure 3 shows in each income group, modeled VMT per capita is less where more jobs (and their co-located activities) are accessible by transit. This confirms, despite a weak regression result in Table 1, that the travel choice models in SACSIM23 result in a negative relation between regional transit accessibility and automobile travel.

FIGURE 4 – MODELED VMT PER CAPITA BY INCOME AND PERSON TYPE

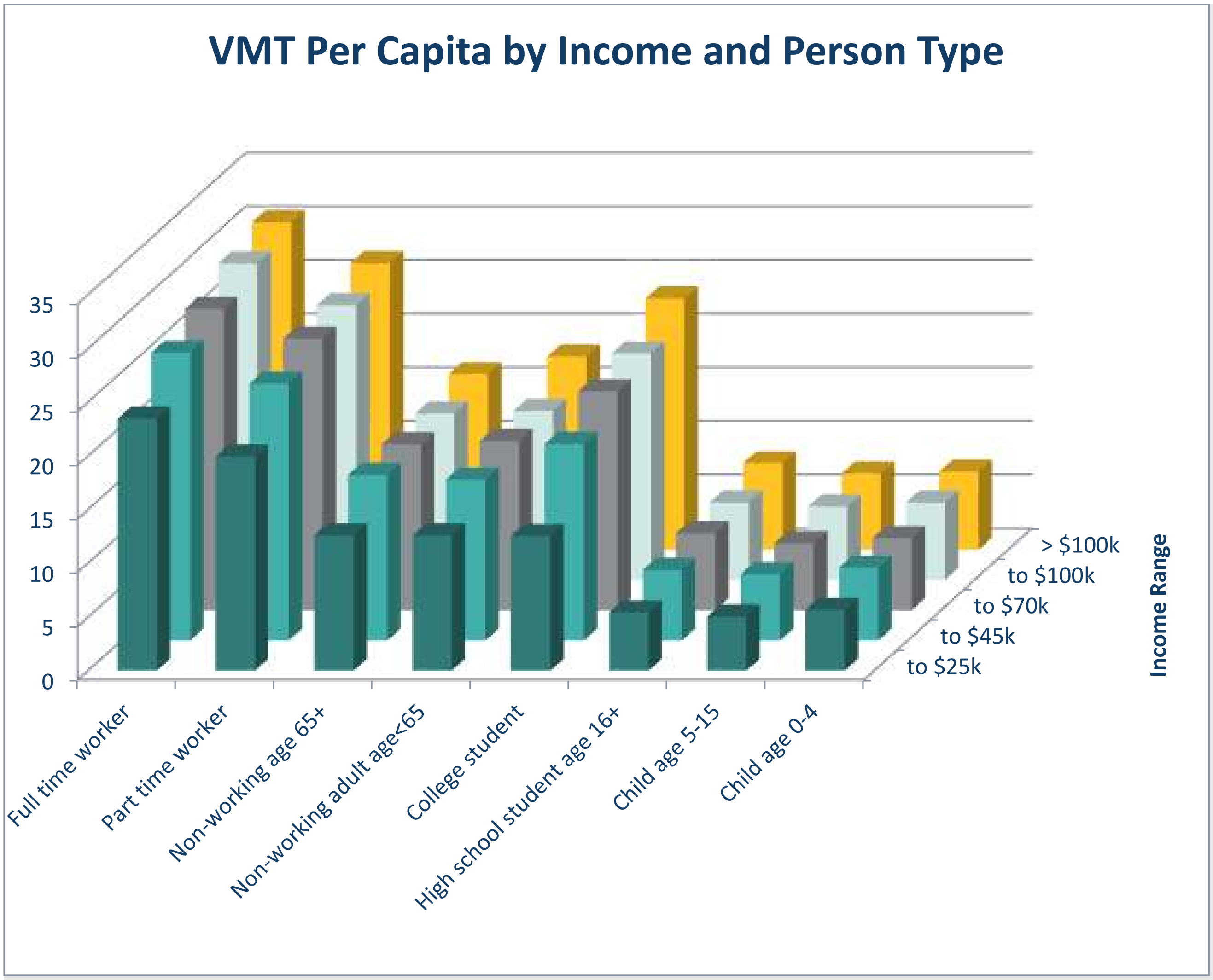


Figure 4 shows VMT per capita in a cross-classification detail with combinations of person demographics and household income. For all person demographics, increasing income shows increasing VMT, while person characteristics show reasonable comparisons among each other for all income groups. Individual person type, as well as the combinations of persons in the household, along with household income, are independent variables used by several of the activity and travel choice models built into SACSIM23.

FIGURE 5 – MODELED VMT PER CAPITA BY INCOME AND STREET INTERSECTION DENSITY NEAR RESIDENCE

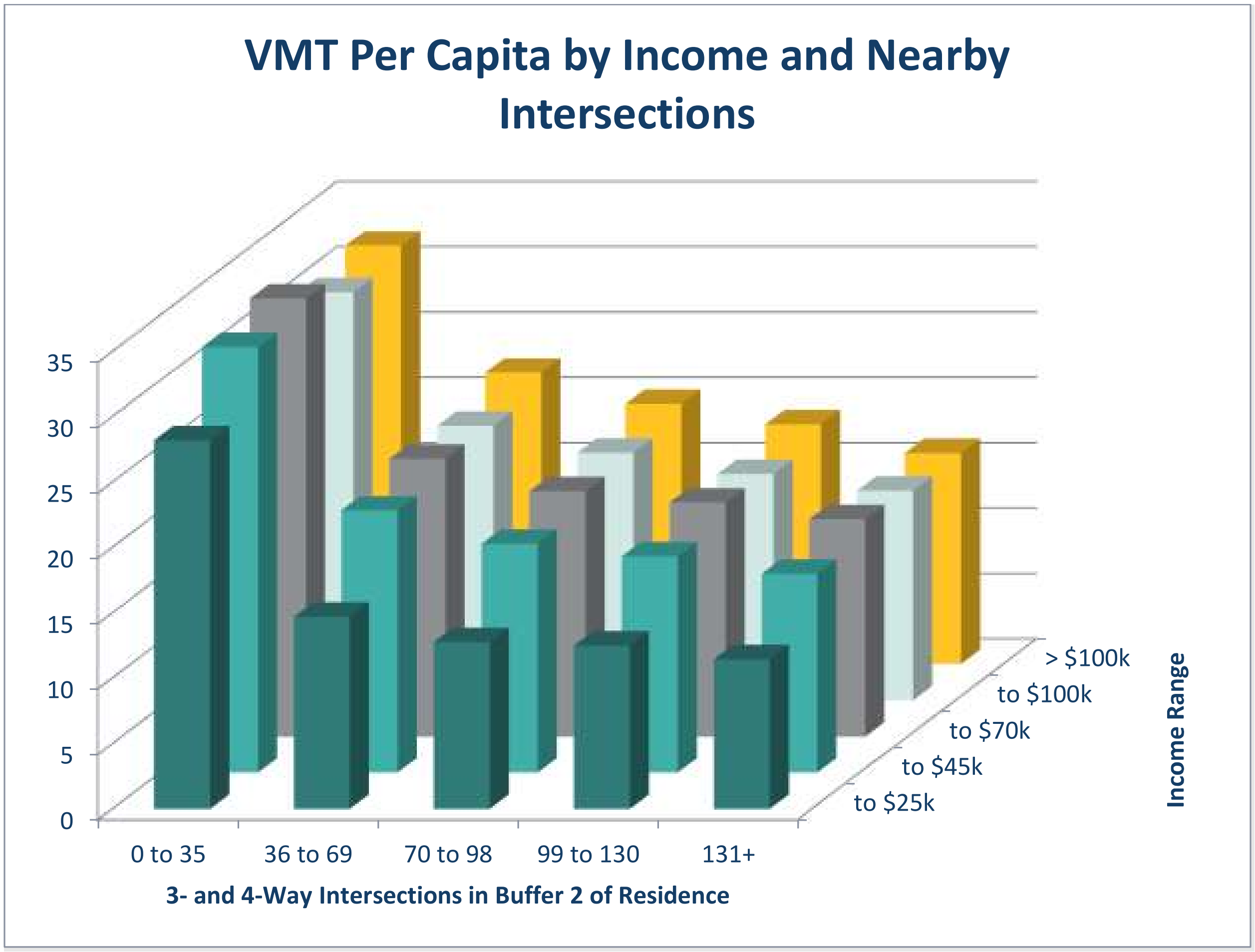


Figure 5 shows modeled VMT per capita in relation to the number of nearby 3- and 4-way intersections, where larger numbers are indicative of more walking paths from the home. The declining VMT trend agrees with the negative regression result in Table 1.

In the SACSIM models, travel arises from person and household decisions to pursue and schedule activities, due to their accessibilities by mode and time to those activities. The regression and cross-classification analyses show in SACSIM23 strong reasonable relationships between inputs of built environment, local accessibility, regional accessibility, summarized as land use/transportation factors, and its outputs summarized of auto, transit, and walk travel, while controlling for demographics.

EXPERIMENTAL TESTING

For the experimental testing, numerous runs of the draft SACSIM23 model are performed, with one input factor is systematically varied from the base case, holding all other factors constant. Variations in key outputs are then compared in relation to the varied input factors. The regional output, or dependent, variables of focus in this analysis are average weekday totals for:

- Total person-trips
- Vehicle trips
- Vehicle-miles of travel (VMT) on the network
- Congested vehicle-miles of travel (CVMT), when and where demand exceeds capacity
- Transit person-trips ("linked")
- Walk and bike person-trips

Input factors, or independent variables, cover alternatives in transit infrastructure, local and regional pricing, exogenous variables, teleworking propensity, and highway infrastructure:

- Transit headways
- Transit lines (adding or removing)
- Transit accessibility
- Freeway HOV and managed-lane policy
- Auto operating costs
- Transit fares
- Off-street parking price
- Household income
- Teleworking availability and propensity
- Highway capacity
- Highway base (free-flow) speeds

No representation is made that any of the experimental scenarios are probable, feasible, or recommended.

Comparable sensitivities in published literature are often expressed as *elasticities*. When calculated from two points, the *arc elasticity* is $\frac{\text{percent change of output measure}}{\text{percent change of input factor}}$. Most arc elasticities in this section are calculated using percent changes relative to the base model.

TRANSIT INFRASTRUCTURE

The sensitivities of SACSIM23 to changes in the amount of transit infrastructure, or network transit service, are here examined distinctly for transit service frequencies (specified as headways), and additions or removals of transit lines. The general expectation for any model, and real-world situation, is an increase in ridership with an increase in network service, either by frequency or by provision of lines on new routes.

For both, the amount of transit infrastructure used as the elasticity denominator is total regional *revenue hours* per weekday, which is calculated from the coded transit network as

$$\boldsymbol{revenue\ hours} = \sum_{periods}\left(\boldsymbol{duration} \cdot \sum_{lines}\frac{\boldsymbol{run\ time}}{\boldsymbol{headway}}\right).$$

As a practical simplification of actual scheduling, SACSIM23 designates transit service in five periods of the day (AM, mid-day, PM, evening, and night, with durations respectively 4, 6, 3, 2, and 9 hours). Each line has a run time to traverse its route through the network, and a headway, the average time interval between runs. (The headway and run time for a line can vary from one period to another.)

Transit Frequencies

Table 3 summarizes regional response to changes in transit frequencies, if all are either halved or doubled (or the headways respectively doubled or halved). The main result is transit use showing an elasticity of 0.28 to 0.60 with respect to frequency, equivalent to -0.30 to -0.57 with respect to headways. These elasticities are a matter of interpretation: a halving of headway is a 50% change, while a doubling of frequency is a 100% change. Either interpretation brackets an average empirical elasticity of 0.5 (to frequency, or -0.5 to headway) (*9*).

TABLE 3 – SENSITIVITY TO TRANSIT FREQUENCY

Regional Revenue-Hours	2,172	4,342	8,681	**End-to-End**
% Change of Frequencies from base	*-50.00%*	*0.00%*	*100.00%*	**Changes** *150.00%*
Response Variable				
Person Trips	9,424,479	9,427,263	9,431,789	n/a
Change from Base	-2,784	n/a	4,526	7,310
% Change from Base	*-0.03%*	n/a	*0.05%*	*0.08%*
Computed Elasticity	*~0.00*	n/a	*~0.00*	*~0.00*
Vehicle Trips	5,864,487	5,849,174	5,836,971	n/a
Change from Base	15,312	n/a	-12,203	-27,515
% Change from Base	*0.26%*	n/a	*-0.21%*	*-0.47%*
Computed Elasticity	*~0.00*	n/a	*~0.00*	*~0.00*
VMT (network)	63,915,498	63,828,536	63,758,951	n/a
Change from Base	86,962	n/a	-69,585	-156,547
% Change from Base	*0.14%*	n/a	*-0.11%*	*-0.25%*
Computed Elasticity	*~0.00*	n/a	*~0.00*	*~0.00*
CVMT (network)	5,479,803	5,561,505	5,381,310	n/a
Change from Base	9,682	n/a	-88,811	-98,493
% Change from Base	*-0.18%*	n/a	*-1.62%*	*-1.80%*
Computed Elasticity	*~0.00*	n/a	*-0.02*	*-0.01*
Transit Person Trips	67,385	96,011	123,203	n/a
Change from Base	-28,626	n/a	27,191	55,817
% Change from Base	*-29.82%*	n/a	*28.32%*	*58.14%*
Computed Elasticity	*0.60*	n/a	*0.28*	*0.39*
Bike+Walk Person Trips	1,112,849	1,107,487	1,102,699	n/a
Change from Base	5,362	n/a	-4,788	-10,150
% Change from Base	*0.48%*	n/a	*-0.43%*	*-0.92%*
Computed Elasticity	*-0.01*	n/a	*~0.00*	*-0.01*

Transit Lines

Table 4 analyzes sensitivity to the removal or addition of transit lines. Scenarios:

1) Remove bus lines RSVLA, SRTD23, and SRTD68.
2) Remove Folsom SRT (SRTD507), a short run of light rail between Rancho Cordova and Downtown Sacramento which parallels a long run to/from Folsom on the same tracks.
3) Add transit lines ZF_QP02 (Roseville), ZF_QS29 (Arden), ZF_QS50 (Stockton Blvd) only. These are among the highest ridership of the lines added in scenario (4) below. (This was prepared following scenario (4) below.)
4) Add the transit lines that had been added as future lines in SACOG's draft 2035 transit network. There were 94 directional lines thus added.

Scenario 1 removed lines which, in the base, carried 6,790 boardings per day upon 255 revenue-hours per day. Regional boardings decreased by 1,160, consistent that a portion of those riders could have found useful alternate routes.

Scenario 2 removed a light rail run carrying 10,608 boardings per day upon 79 revenue-hours per day. Regional boardings decreased 5,968, also consistent with the availability of alternate light rail runs as well as alternate routes. While Scenario 2 removed fewer revenue-hours of transit service compared to Scenario 1, it disrupted many more passengers, resulting in a greater decrease in regional transit person-trips than Scenario 1.

For light rail alone, Scenario 2 decreased revenue-hours by 21%, and ridership by 28%, representing an elasticity of +0.73. This agrees closely with a meta-analysis of several empirical studies (*10, 11*). The elasticities in Table 3 combine bus and light rail for transit service, with bus carrying around an eighth as many passengers per revenue-hour as light rail.

Scenario 3 added 1,855 transit trips, and the added lines themselves carried 6,712 boardings, evidencing a diversion of many of their passengers from other lines. Of the bus service change scenarios (1, 3, and 4), this showed the largest elasticity of +0.27, likely due to these lines being selected from the most popular of the large set of lines in Scenario 4. This elasticity is lower than the average reported in (*10*), but "no single transit elasticity value applies in all situations" (*12*).

Scenario 4 added 6,186 transit trips, with the added lines carrying 25,834 boardings, also evidencing diversion of some of their passengers from other lines. This scenario achieved the least elasticity to transit service. Its relative weakness is reasonable, due to adding a "long list" of prospective future lines, some in presently undeveloped areas, and not likely optimized for maximum efficiency in their design.

TABLE 4 – SENSITIVITY TO TRANSIT LINES

	1: Remove 3 bus lines	2: Remove LRT express	Base	3: Add 3 bus lines	4: Add 94 bus lines	
Regional Revenue-Hours	4,087	4,264	4,342	4,650	6,677	**End-to-End**
Change from Base	-255.36	-78.28	0	307.92	2334.5	**Changes**
% Change from Base	*-5.88%*	*-1.80%*	*0.00%*	*7.09%*	*53.76%*	*59.64%*
Response Variable						
Person Trips	9,429,790	9,423,917	9,427,263	9,428,862	9,427,422	n/a
Change from Base	2,527	-3,346	n/a	1,599	159	-2,368
% Change from Base	*0.03%*	*-0.04%*	n/a	*0.02%*	*0.00%*	*-0.03%*
Computed Elasticity	*-0.01*	*0.02*	n/a	*~0.00*	*~0.00*	*~0.00*
Vehicle Trips	5,852,220	5,849,862	5,849,174	5,847,384	5,845,127	n/a
Change from Base	3,046	688	n/a	-1,791	-4,047	-7,093
% Change from Base	*0.05%*	*0.01%*	n/a	*-0.03%*	*-0.07%*	*-0.12%*
Computed Elasticity	*~0.00*	*~0.00*	n/a	*~0.00*	*~0.00*	*~0.00*
VMT (network)	63,833,579	63,834,533	63,828,536	63,818,693	63,803,940	n/a
Change from Base	5,043	5,997	n/a	-9,843	-24,596	-29,639
% Change from Base	*0.01%*	*0.01%*	n/a	*-0.02%*	*-0.04%*	*-0.05%*
Computed Elasticity	*~0.00*	*~0.00*	n/a	*~0.00*	*~0.00*	*~0.00*
CVMT (network)	5,395,601	5,400,500	5,470,121	5,424,154	5,379,834	n/a
Change from Base	-74,520	-69,621	n/a	-45,967	-90,287	-15,767
% Change from Base	*-1.36%*	*-1.27%*	n/a	*-0.84%*	*-1.65%*	*-0.28%*
Computed Elasticity	*0.23*	*0.70*	n/a	*-0.12*	*-0.03*	*~0.00*
Transit Person Trips	94,851	90,043	96,011	97,866	102,197	n/a
Change from Base	-1,160	-5,968	n/a	1,855	6,186	7,346
% Change from Base	*-1.21%*	*-6.22%*	n/a	*1.93%*	*6.44%*	*7.65%*
Computed Elasticity	*0.21*	*3.45*	n/a	*0.27*	*0.12*	*0.13*
Bike+Walk Person Trips	1,107,489	1,108,281	1,107,487	1,108,493	1,106,279	n/a
Change from Base	2	794	n/a	1,006	-1,208	-1,210
% Change from Base	*0.00%*	*0.07%*	n/a	*0.09%*	*-0.11%*	*-0.11%*
Computed Elasticity	*~0.00*	*-0.04*	n/a	*0.01*	*~0.00*	*~0.00*

LOCAL/REGIONAL PRICING

Managed Freeway Lane Policy

Table 5 summarizes results of changing existing HOV lanes on I-80 and SR 99 to alternative policies. These existing HOV lanes are one concurrent-flow left-side lane in each direction, allowing direct lane changes into and out of these lanes anywhere. During the AM and PM commute periods, they are open free to vehicles with 2 or more occupants and closed to single-occupant vehicles; during other times, they are open free to all. The alternative policies are, for the commute periods:

- HOT (high occupancy tolled), free for 2 or more occupants, variably tolled for single-occupant, the toll of segments chosen to get a v/c ratio near 0.82 on the respective segment if possible.
- Express, open and tolled for all vehicles, the toll similarly chosen for v/c near 0.82.
- HOV 3+, open only to vehicles with 3 or more occupants, no toll.
- Deleted – closed all day with no replacement.
- Open free – opened to all vehicles, with no toll.

TABLE 5 – SENSITIVITY TO MANAGED-LANE POLICY
HOV LANE AVAILIBILITY AND/OR VARIABLE PRICING

Policy	HOV 2+ (Base)	HOT (SOV tolled)	Express (All tolled)	HOV 3+	Delete	Open Free
% Change from Base		*(not defined)*				
Response Variable						
Person Trips	9,427,263	9,427,930	9,428,958	9,425,521	9,424,938	9,426,721
Change from Base	n/a	667	1,695	-1,742	-2,325	-542
% Change from Base	n/a	*0.01%*	*0.02%*	*-0.02%*	*-0.02%*	*-0.01%*
Vehicle Trips	5,849,174	5,849,555	5,849,566	5,847,168	5,849,298	5,853,036
Change from Base	n/a	381	391	-2,006	124	3,862
% Change from Base	n/a	*0.01%*	*0.01%*	*-0.03%*	*0.00%*	*0.07%*
VMT (network)	63,828,536	63,841,092	63,773,038	63,725,111	63,331,714	63,899,928
Change from Base	n/a	12,556	-55,499	-103,425	-496,822	71,392
% Change from Base	n/a	*0.02%*	*-0.09%*	*-0.16%*	*-0.78%*	*0.11%*
CVMT (network)	5,470,121	5,290,556	5,433,128	5,595,529	6,103,627	5,383,523
Change from Base	n/a	-179,564	-36,993	125,408	633,506	-86,598
% Change from Base	n/a	*-3.28%*	*-0.68%*	*2.29%*	*11.58%*	*-1.58%*
Transit Person Trips	96,011	96,152	96,002	95,776	95,799	96,098
Change from Base	n/a	141	-9	-235	-212	87
% Change from Base	n/a	*0.15%*	*-0.01%*	*-0.24%*	*-0.22%*	*0.09%*
Bike+Walk Person Trips	1,107,487	1,107,462	1,108,965	1,107,309	1,110,868	1,106,553
Change from Base	n/a	-25	1,478	-178	3,381	-934
% Change from Base	n/a	*0.00%*	*0.13%*	*-0.02%*	*0.31%*	*-0.08%*

The road supply provided by these alternatives cannot be summarized by any single variable with a percent change, so elasticities are not defined.

Expected responses are slightly positive for person trips and vehicle trips with the more permissive policies, and negative for the more restrictive policies. Most of these results agree with this expectation, but the differences are close to the random noise levels.

VMT responded strongly in the expected same direction as permissivity, while CVMT usually responded discernably in the opposite direction, consistent with capacity increase and congestion relief. Transit responses were small and within noise, while the more-discernable walk and bike travel responses were expectably contrary to VMT changes.

Auto Operating Cost

Table 6 shows the model response to global changes in auto operating cost. This is not isolated to any one cost contributor such as fuel prices, fuel economy, or mileage-based fees, but encompasses all such per-mile costs. (In SACSIM models, costs are expressed in year 2000 US currency.)

TABLE 6 – SENSITIVITY TO AUTO OPERATING COST
ALL INCOMES

Auto Operating Cost (cents per mile)	8	14	16	21	32	**End-to-End**
Change from Base	-8	-2	0	5	16	**Changes**
% Change from Base	*-50.00%*	*-12.50%*	*0.00%*	*31.25%*	*100.00%*	*150.00%*
Response Variable						
Person Trips	9,542,879	9,454,381	9,427,263	9,374,546	9,283,232	n/a
Change from Base	115,616	27,118	n/a	-52,717	-144,031	-259,647
% Change from Base	*1.23%*	*0.29%*	n/a	*-0.56%*	*-1.53%*	*-2.75%*
Computed Elasticity	*-0.02*	*-0.02*	n/a	*-0.02*	*-0.02*	*-0.02*
Vehicle Trips	5,991,496	5,883,080	5,849,174	5,776,009	5,637,626	n/a
Change from Base	142,322	33,906	n/a	-73,165	-211,548	-353,870
% Change from Base	*2.43%*	*0.58%*	n/a	*-1.25%*	*-3.62%*	*-6.05%*
Computed Elasticity	*-0.05*	*-0.05*	n/a	*-0.040*	*-0.04*	*-0.040*
VMT (network)	67,245,840	64,588,564	63,828,536	62,103,867	58,913,321	n/a
Change from Base	3,417,304	760,028	n/a	-1,724,669	-4,915,215	-8,332,519
% Change from Base	*5.35%*	*1.19%*	n/a	*-2.70%*	*-7.70%*	*-13.05%*
Computed Elasticity	*-0.11*	*-0.010*	n/a	*-0.09*	*-0.08*	*-0.09*
CVMT (network)	6,994,879	5,782,974	5,470,121	4,913,721	3,705,572	n/a
Change from Base	1,524,758	312,854	n/a	-556,400	-1,764,548	-3,289,306
% Change from Base	*27.87%*	*5.72%*	n/a	*-10.17%*	*-32.26%*	*-60.13%*
Computed Elasticity	*-0.56*	*-0.46*	n/a	*-0.32*	*-0.32*	*-0.40*
Transit Person Trips	92,316	95,190	96,011	98,642	104,765	n/a
Change from Base	-3,695	-821	n/a	2,631	8,754	12,449
% Change from Base	*-3.85%*	*-0.86%*	n/a	*2.74%*	*9.12%*	*12.97%*
Computed Elasticity	*0.08*	*0.07*	n/a	*0.09*	*0.09*	*0.09*
Bike+Walk Person Trips	1,069,248	1,097,891	1,107,487	1,133,108	1,187,307	n/a
Change from Base	-38,239	-9,596	n/a	25,621	79,820	118,059
% Change from Base	*-3.45%*	*-0.87%*	n/a	*2.31%*	*7.21%*	*10.66%*
Computed Elasticity	*0.07*	*0.07*	n/a	*0.07*	*0.07*	*0.07*

Table 7 compares the modeled end-to-end elasticities to literature estimates, compiled by SACOG (*1*) and Litman (*13*). These estimates are in the range (and may be among the same sources) of the SACOG compilation before accounting for the “rebound” effect identified by Small & Van Dender (*14*) of people adapting by getting more fuel-efficient vehicles, and changing other trip-making behavior.

TABLE 7 – LITERATURE COMPARISON, SENSITIVITY TO AUTO OPERATING COST

Result	Literature	Value or Range	Model
Person trips	Small negative	Small negative	-0.02
Vehicle trips	SACOG compilation (*1*) Litman (*13*)	Small negative -0.19	-0.04
VMT	SACOG compilation (*1*) Litman (*13*)	-0.03 to -0.38 -0.29 to -0.33	-0.08
CVMT	SACOG compilation (*1*)	Negative, stronger than for VMT	-0.39
Transit trips	SACOG compilation (*1*) Litman (*13*)	+0.05 to +0.16 +0.13 to +0.4	0.09
Walk+bike trips	SACOG compilation (*1*) Litman (*13*)	less than +0.13 0.13	0.07

Transit Fare

Table 8 shows the model's response to proportional decreases or increases to all transit fares. (As with other costs, SACSIM fares are expressed in year 2000 US currency.)

TABLE 8 – SENSITIVITY TO TRANSIT FARE
ALL INCOMES

Average Transit Fare	$0.62	$1.12	$1.24	$1.37	$1.87	**End-to-End**
Change from Base						**Changes**
% Change from Base	*-50.00%*	*-10.00%*	*0.00%*	*10.00%*	*50.00%*	*100.00%*
Response Variable						
Person Trips	9,429,546	9,427,931	9,427,263	9,427,500	9,429,079	n/a
Change from Base	2,283	668	n/a	237	1,816	-467
% Change from Base	*0.02%*	*0.01%*	n/a	*0.00%*	*0.02%*	*0.00%*
Computed Elasticity	*~0.00*	*~0.00*	n/a	*~0.00*	*~0.00*	*~0.00*
Vehicle Trips	5,844,399	5,848,770	5,849,174	5,850,031	5,856,257	n/a
Change from Base	-4,776	-405	n/a	856	7,083	11,858
% Change from Base	*-0.08%*	*-0.01%*	n/a	*0.01%*	*0.12%*	*0.20%*
Computed Elasticity	*~0.00*	*~0.00*	n/a	*~0.00*	*~0.00*	*~0.00*
VMT (network)	63,767,104	63,829,612	63,828,536	63,817,051	63,844,655	n/a
Change from Base	-61,432	1,076	n/a	-11,485	16,119	77,551
% Change from Base	*-0.10%*	*0.00%*	n/a	*-0.02%*	*0.03%*	*0.12%*
Computed Elasticity	*~0.00*	*~0.00*	n/a	*~0.00*	*~0.00*	*~0.00*
CVMT (network)	5,532,392	5,380,780	5,470,121	5,449,970	5,568,048	n/a
Change from Base	62,271	-89,341	n/a	-20,150	97,927	35,656
% Change from Base	*1.14%*	*-1.63%*	n/a	*-0.37%*	*1.79%*	*0.65%*
Computed Elasticity	*-0.02*	*0.16*	n/a	*-0.04*	*0.04*	*0.01*
Transit Person Trips	109,480	98,906	96,011	94,346	85,879	n/a
Change from Base	13,469	2,895	n/a	-1,665	-10,132	-23,601
% Change from Base	*14.03%*	*3.02%*	n/a	*-1.73%*	*-10.55%*	*-24.58%*
Computed Elasticity	*-0.28*	*-0.30*	n/a	*-0.17*	*-0.21*	*-0.25*
Bike+Walk Person Trips	1,103,823	1,105,343	1,107,487	1,107,621	1,111,028	n/a
Change from Base	-3,664	-2,144	n/a	134	3,541	7,205
% Change from Base	*-0.33%*	*-0.19%*	n/a	*0.01%*	*0.32%*	*0.65%*
Computed Elasticity	*0.01*	*0.02*	n/a	*~0.00*	*0.01*	*0.01*

The model's response to changes in transit fare is most expectably prominent in the transit trips, with most of the change being shifts of trips to or from other modes. All but the weakest modeled transit use elasticities are in the range of the several studies compiled in (*13*), ranging from 0.22 to 0.60 (long-term, less for short-term). Table 9A distinguishes the response of transit trips by household income range, and Table 9B summarizes their end-to-end elasticities.

TABLE 9A – SENSITIVITY TO TRANSIT FARE
BY HOUSEHOLD INCOME CATEGORIES

Average Transit Fare	$0.62	$1.12	$1.24	$1.37	$1.87	**End-to-End Changes**
Change from Base						
% Change from Base	*-50.00%*	*-10.00%*	*0.00%*	*10.00%*	*50.00%*	*100.00%*
Response Variable: Transit Person Trips						
Income Under $12,500	32,517	28,780	27,479	27,116	23,863	n/a
Change from Base	5,038	1,301	n/a	-363	-3,616	-8,654
% Change from Base	*18.33%*	*4.73%*	n/a	*-1.32%*	*-13.16%*	*-31.49%*
Computed Elasticity	*-0.37*	*-0.47*	n/a	*-0.13*	*-0.26*	*-0.31*
Income $12,500 to $24,999	16,986	14,720	14,274	13,983	12,270	n/a
Change from Base	2,712	446	n/a	-291	-2,004	-4,716
% Change from Base	*19.00%*	*3.12%*	n/a	*-2.04%*	*-14.04%*	*-33.04%*
Computed Elasticity	*-0.38*	*-0.31*	n/a	*-0.20*	*-0.28*	*-0.33*
Income $25,000 to $49,999	22,853	20,658	20,216	19,695	17,949	n/a
Change from Base	2,637	442	n/a	-521	-2,267	-4,904
% Change from Base	*13.04%*	*2.19%*	n/a	*-2.58%*	*-11.21%*	*-24.26%*
Computed Elasticity	*-0.26*	*-0.22*	n/a	*-0.26*	*-0.22*	*-0.24*
Income $50,000 to $79,999	16,501	15,131	15,095	14,522	13,697	n/a
Change from Base	1,406	36	n/a	-573	-1,398	-2,804
% Change from Base	*9.31%*	*0.24%*	n/a	*-3.80%*	*-9.26%*	*-18.58%*
Computed Elasticity	*-0.19*	*-0.02*	n/a	*-0.38*	*-0.19*	*-0.19*
Income $80,000 or more	20,623	19,617	18,947	19,030	18,100	n/a
Change from Base	1,676	670	n/a	83	-847	-2,523
% Change from Base	*8.85%*	*3.54%*	n/a	*0.44%*	*-4.47%*	*-13.32%*
Computed Elasticity	*-0.18*	*-0.35*	n/a	*0.04*	*-0.09*	*-0.13*

TABLE 9B – SENSITIVITY TO TRANSIT FARE
BY HOUSEHOLD INCOME CATEGORIES

End-to-End Summary of Elasticities					
Income Range:	< $12.5k	$12.5 to $25k	$25k to $50k	$50k to $80k	> $80k
Response Variable					
Transit Person Trips					
Computed Elasticity	-0.31	-0.33	-0.24	-0.19	-0.13

The prominent relationship is the direct one – between transit fare and transit ridership. The decreasing magnitude of elasticity with increasing income reflects utility theory in that a given fare change takes (or gives) a larger portion of income from lower-income persons than higher-income, and hence are more sensitive to costs. Gillen (*15*) (in (*13*)) reported comparable magnitudes but a contrary pattern, of -0.19 for those earning under $5k, and -0.28 for those earning over $15k.

This difference of sensitivity pattern may correspond to the model representing relatively more transit “choice” riders, versus “captive” riders, than the Gillen study.

Parking Cost

Response of SACSIM23 to parking is evaluated for the entire region in Tables 10A and 10B, for all trips attracted to downtown Sacramento in Tables 11A and 11B, and finally for workers in downtown Sacramento in Tables 12A and 12B.

TABLE 10A – SENSITIVITY TO PARKING COST
ENTIRE REGION

Median Day Park Price	$5.45	$9.81	$10.90	$11.99	$16.35	**End-to-End Changes**
% Change from Base	*-50.00%*	*-10.00%*	*0.00%*	*10.00%*	*50.00%*	*100.00%*
Response Variable						
Person Trips	9,437,294	9,430,920	9,427,263	9,425,673	9,422,535	n/a
Change from Base	10,031	3,657	n/a	-1,590	-4,728	-14,759
% Change from Base	*0.11%*	*0.04%*	n/a	*-0.02%*	*-0.05%*	*-0.16%*
Computed Elasticity	*~0.00*	*~0.00*	n/a	*~0.00*	*~0.00*	*-~0.00*
Vehicle Trips	5,900,540	5,859,736	5,849,174	5,840,022	5,809,252	n/a
Change from Base	51,366	10,562	n/a	-9,152	-39,923	-91,289
% Change from Base	*0.88%*	*0.18%*	n/a	*-0.16%*	*-0.68%*	*-1.56%*
Computed Elasticity	*-0.02*	*-0.02*	n/a	*-0.02*	*-0.01*	*-0.02*
VMT (network)	63,979,405	63,857,672	63,828,536	63,793,875	63,696,595	n/a
Change from Base	150,869	29,136	n/a	-34,662**	-131,941	-282,810
% Change from Base	*0.24%*	*0.05%*	n/a	*-0.05%*	*-0.21%*	*-0.44%*
Computed Elasticity	*~0.00*	*~0.00*	n/a	*-0.01*	*~0.00*	*~0.00*
CVMT (network)	5,450,371	5,472,472	5,470,121	5,514,794	5,393,845	n/a
Change from Base	-19,750	-2,352	n/a	44,673	-76,276	-56,526
% Change from Base	*-0.36%*	*-0.04%*	n/a	*0.82%*	*-1.39%*	*-1.03%*
Computed Elasticity	*0.01*	*~0.00*	n/a	*0.08*	*0.03*	*-0.01*
Transit Person Trips	91,362	95,628	96,011	96,775	100,263	n/a
Change from Base	-4,649	-383	n/a	764	4,252	8,901
% Change from Base	*-4.84%*	*-0.40%*	n/a	*0.80%*	*4.43%*	*9.27%*
Computed Elasticity	*0.10*	*0.04*	n/a	*0.08*	*0.09*	*0.09*
Bike+Walk Person Trips	1,072,878	1,101,966	1,107,487	1,113,596	1,136,958	n/a
Change from Base	-34,609	-5,521	n/a	6,109	29,471	64,080
% Change from Base	*-3.13%*	*-0.50%*	n/a	*0.55%*	*2.66%*	*5.79%*
Computed Elasticity	*0.06*	*0.05*	n/a	*0.06*	*0.05*	*0.06*

Table 10B summarizes the end-to-end elasticities from Table 10A with comparison to a compilation of empirically estimated values.

TABLE 10B – SENSITIVITY TO PARKING COST COMPARISON (ENTIRE REGION)

Result	Literature	Value or Range	Model
Person trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	small negative	~0.00
Vehicle trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	-0.08 to -0.4	-0.02
VMT	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	less magnitude than -0.04	~0.00
CVMT	SACOG compilation (*1*)	n/a	-0.01
Transit trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	+0.02 but up to +0.29	0.09
Walk+bike trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	+0.03 to +0.05	0.06

Most auto trip destinations in the greater Sacramento region have free parking, changes of parking prices only affects a small portion of such trips.

Since the main area in the Sacramento region with parking costs is Downtown Sacramento, Tables 11A and 12A show the model's response for trips beginning or ending in SACOG's Regional Analysis District (RAD) 1, covering the greater downtown area, and thus, mostly the affected activities and trips. Each of these tables is accompanied by a Table 11B and 12B summarizing with comparison to empirical literature. Tables 11A and B include all trips for out-of-home activities in this area, while Tables 12A and B include only those for work in this area.

TABLE 11A – SENSITIVITY TO PARKING COST

DOWNTOWN SACRAMENTO

Median Day Park Price	$7.90	$14.22	$15.80	$17.38	$23.70	**End-to-End Changes**
% Change from Base	*-50.00%*	*-10.00%*	*0.00%*	*10.00%*	*50.00%*	*100.00%*
Response Variable						
Person Trips (work or other)	835,950	827,552	825,074	823,502	824,666	n/a
Change from Base	10,876	2,478	n/a	-1,572	-408	-11,284
% Change from Base	*1.32%*	*0.30%*	n/a	*-0.19%*	*-0.05%*	*-1.37%*
Computed Elasticity	*-0.03*	*-0.03*	n/a	*-0.02*	*~0.00*	*-0.01*
Vehicle Trips (work or other)	458,863	426,597	419,931	414,351	398,293	n/a
Change from Base	38,932	6,666	n/a	-5,580	-21,639	-60,571
% Change from Base	*9.27%*	*1.59%*	n/a	*-1.33%*	*-5.15%*	*-14.42%*
Computed Elasticity	*-0.18*	*-0.16*	n/a	*-0.13*	*-0.10*	*-0.14*
VMT (work or other)	3,342,877	3,261,309	3,238,748	3,217,190	3,173,774	n/a
Change from Base	104,129	22,561	n/a	-21,558	-64,973	-169,102
% Change from Base	*3.22%*	*0.70%*	n/a	*-0.67%*	*-2.01%*	*-5.22%*
Computed Elasticity	*-0.06*	*-0.07*	n/a	*-0.07*	*-0.04*	*-0.05*
CVMT (work or other)	538,722	525,291	521,165	510,530	515,474	n/a
Change from Base	17,556	4,126	n/a	-10,635	-5,692	-23,248
% Change from Base	*3.37%*	*0.79%*	n/a	*-2.04%*	*-1.09%*	*-4.46%*
Computed Elasticity	*-0.07*	*-0.08*	n/a	*-0.20*	*-0.02*	*-0.04*
Transit Trips (work or other)	29,898	31,999	31,990	31,871	33,966	n/a
Change from Base	-2,092	9	n/a	-119	1,976	4,068
% Change from Base	*-6.54%*	*0.03%*	n/a	*-0.37%*	*6.18%*	*12.72%*
Computed Elasticity	*0.13*	*~0.00*	n/a	*-0.04*	*0.12*	*0.13*
Bike+Walk Trips (work or other)	217,869	241,402	246,138	250,153	266,741	n/a
Change from Base	-28,269	-4,736	n/a	4,015	20,603	48,872
% Change from Base	*-11.49%*	*-1.92%*	n/a	*1.63%*	*8.37%*	*19.86%*
Computed Elasticity	*0.23*	*0.19*	n/a	*0.16*	*0.17*	*0.20*

TABLE 11B – SENSITIVITY TO PARKING COST COMPARISON
DOWNTOWNS

Result	Literature	Value or Range	Model
Person trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	small negative	-0.014
Vehicle trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	-0.05 to -0.3	-0.144
	Hensher & King 2001 (in (*14*), portions of CBDs, Australia	-0.541 to -0.015	
VMT	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	-0.04 to -0.07	-0.052
CVMT	SACOG compilation (*1*)	small negative	-0.045
Transit trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	+.01 to +0.3	0.127
Walk+bike trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	+0.03	0.199

Tables 11A and 11B show stronger elasticities of all modes of travel where directly affected by parking price, compared to regional travel. Modeled elasticities show a general agreement with most observed ranges reported. In the exception, walk and bike, the model responds comparably to the other modes, while the literature value is probably not comparable due to being lower than the regional elasticity value. (The compilation (*1*) indicates this observed value is from a 1999 survey of several European cities.)

TABLE 12A – SENSITIVITY TO PARKING COST
DOWNTOWN SACRAMENTO WORK TRIPS

Median Day Park Price	$7.90	$14.22	$15.80	$17.38	$23.70	**End-to-End Changes**
% Change from Base	*-50.00%*	*-10.00%*	*0.00%*	*10.00%*	*50.00%*	*100.00%*
Response Variable						
Person Trips (work)	310,146	306,824	306,770	306,012	307,266	n/a
Change from Base	3,376	54	n/a	-758	496	-2,880
% Change from Base	*1.10%*	*0.02%*	n/a	*-0.25%*	*0.16%*	*-0.94%*
Computed Elasticity	*-0.02*	*~0.00*	n/a	*-0.02*	*~0.00*	*-0.01*
Vehicle Trips (work)	193,306	180,817	178,534	176,358	170,938	n/a
Change from Base	14,772	2,284	n/a	-2,176	-7,596	-22,367
% Change from Base	*8.27%*	*1.28%*	n/a	*-1.22%*	*-4.25%*	*-12.53%*
Computed Elasticity	*-0.16*	*-0.13*	n/a	*-0.12*	*-0.08*	*-0.12*
VMT (work)	1,779,617	1,738,293	1,730,595	1,725,106	1,701,940	n/a
Change from Base	49,022	7,698	n/a	-5,488	-28,655	-77,677
% Change from Base	*2.83%*	*0.44%*	n/a	*-0.32%*	*-1.66%*	*-4.49%*
Computed Elasticity	*-0.06*	*-0.04*	n/a	*-0.03*	*-0.03*	*-0.04*
CVMT (work)	367,600	357,419	355,862	350,812	351,905	n/a
Change from Base	11,738	1,557	n/a	-5,050	-3,957	-15,695
% Change from Base	*3.30%*	*0.44%*	n/a	*-1.42%*	*-1.11%*	*-4.41%*
Computed Elasticity	*-0.07*	*-0.04*	n/a	*-0.14%*	*-0.02*	*-0.04*
Transit Trips (work)	15,537	16,238	16,313	16,514	17,321	n/a
Change from Base	-776	-75	n/a	201	1,008	1,784
% Change from Base	*-4.76%*	*-0.46%*	n/a	*1.23%*	*6.18%*	*10.94%*
Computed Elasticity	*0.10*	*0.05*	n/a	*0.12*	*0.12*	*0.11*
Bike+Walk Trips (work)	83,023	91,589	93,869	95,023	100,854	n/a
Change from Base	-10,846	-2,280	n/a	1,154	6,985	17,831
% Change from Base	*-11.55%*	*-2.43%*	n/a	*1.23%*	*7.44%*	*19.00%*
Computed Elasticity	*0.23*	*0.24*	n/a	*0.12*	*0.15*	*0.19*

TABLE 12B – SENSITIVITY TO PARKING COST COMPARISON
DOWNTOWN WORK TRIPS

Result	Literature	Value or Range	Model
Person trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	small negative	-0.009
Vehicle trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	-0.05 to -0.3	-0.125
VMT	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	-0.04 to -0.07	-0.045
CVMT	SACOG compilation (*1*)	small negative	-0.044
Transit trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	+.01 to +0.3	0.109
Walk+bike trips	SACOG compilation (*1*) ((*9*), (*18*), (*19*), (*20*))	+0.03	0.19

The overall elasticities of downtown work trips are moderately smaller than those of all downtown-attracted trips (including work). Non-work trips have been found more price-sensitive than work trips ((*9*), p. 45) since non-work trips have easier options to stay less time or go somewhere else.

NEW MOBILITY

New Mobility represents emerging technologies affecting travel and mobility, some with the potential to reduce VMT and greenhouse gas emissions. The strategies outlined in (*3*) primarily involve off-model variables such as promoting electric vehicles and charging infrastructure, ride-hailing, and carpooling, plus intelligent transportation systems and transportation systems management programs.

Transit Access

While not explicitly outlined in the SCS, another method is to improve "first-mile" and "last-mile" access to transit, through a variety of strategies such as bicycle conveyance, bicycle or scooter loaning, on-demand shuttle service, and/or route-deviation. In lieu of modeling any such methods directly and explicitly, sensitivity tests model these in a generalized, implicit approach by varying walk speed to/from transit, either regionally or in specified areas.

Table 13 below summarizes sensitivity to transit accessibility scenarios. These are:

1) access and egress walk speed *1.5,
2) access and egress walk speed *2,
3) access and egress walk speed *1.5 only in central Downtown Sacramento,
4) walk speed *1.5 only in Rancho Cordova within 2 miles of light rail.

No particular input variable can be identified as having a particular percentage change, so no elasticity can be identified. However, the sign and relative magnitudes of percentage change can be compared: as defined, Scenario # 2 benefits transit more than #1; #3 less than #1 but still better than base, and #4 probably less than #3 but still better than base.

Accessibility alternatives 1 and 2 have discernable effects upon mode choice in the expected directions, to transit from all the other modes. The regional effects of alternatives 3 and 4 are not discernable between single model runs. The effects at the RADs of the improvements (Downtown RAD 1 and Rancho Cordova RAD 16 respectively) show as distinct increases of transit trips, though not always the largest increase among RADs.

TABLE 13 – SENSITIVITY TO TRANSIT ACCESSIBILITY

	Base	#1	#2	#3	#4
Change from Base					
% Change from Base					
Response Variable					
Person Trips	9,427,263	9,430,417	9,433,196	9,428,198	9,427,604
Change from Base	n/a	3,154	5,933	935	341
% Change from Base	n/a	*0.03%*	*0.06%*	*0.01%*	*0.00%*
Vehicle Trips	5,849,174	5,842,817	5,837,937	5,850,257	5,849,806
Change from Base	n/a	-6,357	-11,237	1,083	632
% Change from Base	n/a	*-0.11%*	*-0.19%*	*0.02%*	*0.01%*
VMT (network)	63,828,536	63,779,986	63,753,458	63,808,057	63,837,794
Change from Base	n/a	-48,550	-75,078	-20,479	9,258
% Change from Base	n/a	*-0.08%*	*-0.12%*	*-0.03%*	*0.01%*
CVMT (network)	5,470,121	5,523,284	5,374,541	5,549,959	5,550,647
Change from Base	n/a	53,163	-95,580	79,839	80,526
% Change from Base	n/a	*-0.97%*	*-1.75%*	*1.46%*	*1.47%*
Transit Person Trips	96,011	109,783	121,080	96,394	95,912
Change from Base	n/a	13,772	25,069	383	-99
% Change from Base	n/a	*14.34%*	*26.11%*	*0.40%*	*-0.10%*
Bike+Walk Person Trips	1,107,487	1,104,812	1,103,651	1,105,866	1,108,134
Change from Base	n/a	-2,675	-3,836	-1,621	647
% Change from Base	n/a	*-0.24%*	*-0.35%*	*-0.15%*	*0.06%*

Table 14 focuses on the transit trips in the affected RADs by the local accessibility scenarios. The global scenarios (#1 and #2) affect these RADs more strongly, since both ends of all their transit trips are affected. The local scenarios (#3 and #4) respectively improve RADs 1 and 16. Each shows discernable increase of transit trips in the affected RADs.

TABLE 14 – LOCAL SENSITIVITY TO TRANSIT ACCESSIBILITY

	Base	#1	#2	#3	#4
RAD 1 (Downtown) Transit Person Trip-Ends	36,752	40,756	43,327	37,485	36,500
Change from Base	n/a	4,004	6,575	733*	-252
% Change from Base	n/a	*10.9%*	*17.9%*	*2.0%*	*-0.7%*
RAD 16 (Rancho Cordova) Transit Person Trip-Ends	6,569	7,437	8,392	6,449	7,124
Change from Base	n/a	868	1823	-120	555
% Change from Base	n/a	*13.2%*	*27.8%*	*-1.8%*	*8.4%*

Teleworking

A new alternative to mobility itself is "teleworking," workers using telecommunications technologies to perform some or all of their work at home as employees for establishments located elsewhere, doing work that had customarily been done on site, especially offices.

Within the SACSIM23 implementation of Daysim is a nested logit model of the choice of usual work location. The inner-level choice is for the nominal location of employment within the region, and the outer-level choice is binary, whether to work at home, or at the nominal location. For the base condition model, this model was calibrated (*2*) using the 2018 Household Travel Survey and the 2019 American Community Survey – recently enough for work-at-home technologies to be widely available, but before COVID-19 prompted mass adoption of this manner of work.

The SACSIM23 work-at-home model includes a user-specifiable alternative-specific constant for work at home, originally calibrated to match the regional share of work-at-home. This can be calibrated or re-calibrated iteratively: given a prior model run that achieved a certain share different from the observed share, the typical-practice adjustment is $c_{adj} = c_{prior} + \ln \frac{observed\ share}{prior\ model\ share}$. The model rerun with this adjustment does not generally achieve the target share immediately, but approaches it closer with each iteration of rerun and readjustment.

The alternative-specific constant represents, in a generalized manner, unobserved attributes of the alternatives (*21, 22*), here both work-at-home and contrary attributes of work-on-location including but not limited to employer policies, the practical pros and cons of remote work to the employers and employees, the growth of technologies enabling work at home, cultural pressures and norms, macroeconomics and externalities, plus laws and public policy. All of these were shocked by the COVID-19 pandemic and the societal response into both transient and long-term changes toward more working at home than before, indicating that teleworking patterns may have changed and may continue to differ from pre-COVID observations (*23*). The alternative-specific constant in the logit model context applies such shifts in the most generalized, even-handed manner with a minimum of assumptions.

Sensitivity testing was made by directly modifying the alternative-specific constant; telework shares are a result, not an input. If a new regional share is observed or stipulated, the respective alternative-specific constant can be approximated by interpolation or curve-fitting from the findings of these tests, and further adjusted iteratively if necessary.

Table 15 reports SACSIM23 model's response to changes in the work-at-home alternative-specific constant, including its resulting shares of work-at-home. (These shares are further qualified as those who worked on the simulated day only at home, making no work-related tours, among persons who work for an employer elsewhere. Persons who work in a home-based business are not counted in either the numerator or the denominator of these shares.)

TABLE 15 – SENSITIVITY TO GENERALIZED TELEWORKING AVAILABILITY
AS AN ADDITIVE UTILITY OF THE CHOICE TO TELEWORK

NOTE: ELASTICITIES ARE WITH RESPECT TO THE NUMBER OF PERSONS WORKING AT HOME

Alternative-Specific Constant	-1	-0.5	0	0.5	1	1.998	End-to-End
Response Variable							**Changes**
Primary Response Variable: Persons working at home	11,531	18,610	29,788	46,868	72,168	154,579	n/a
Change	-18,257	-11,178	n/a	17,080	42,380	124,791	143,048
Worker share	*1.03%*	*1.66%*	2.66%	*4.18%*	*6.44%*	*13.80%*	*12.77%*
% Change	*-61.29%*	*-37.53%*	n/a	*57.34%*	*142.27%*	*418.93%*	*480.22%*
Consequential Response Variables							
Person Trips	9,443,295	9,436,201	9,427,263	9,410,722	9,388,224	9,315,106	n/a
Change	16,032	8,938	n/a	-16,541	-39,039	-112,157	-128,189
% Change	*0.17%*	*0.09%*	n/a	*-0.18%*	*-0.41%*	*-1.19%*	*-1.36%*
Elasticity	*0.00*	*0.00*	n/a	*0.00*	*0.00*	*0.00*	*0.00*
Vehicle Trips	5,865,182	5,858,769	5,849,174	5,830,907	5,809,840	5,732,355	n/a
Change	16,008	9,595	n/a	-18,267	-39,335	-116,820	-132,827
% Change	*0.27%*	*0.16%*	n/a	*-0.31%*	*-0.67%*	*-2.00%*	*-2.27%*
Elasticity	*0.00*	*0.00*	n/a	*-0.01*	*0.00*	*0.00*	*0.00*
VMT (network)	63,987,835	63,928,250	63,828,536	63,684,702	63,468,073	62,796,533	n/a
Change	159,299	99,714	n/a	-143,834	-360,463	-1,032,003	-1,191,302
% Change	*0.25%*	*0.16%*	n/a	*-0.23%*	*-0.56%*	*-1.62%*	*-1.87%*
Elasticity	*0.00*	*0.00*	n/a	*0.00*	*0.00*	*0.00*	*0.00*
CVMT (network)	5,489,976	5,454,604	5,470,121	5,340,532	5,313,669	5,009,313	n/a
Change	19,855	-15,516	n/a	-129,588	-156,452	-460,808	-480,663
% Change	*0.36%*	*-0.28%*	n/a	*-2.37%*	*-2.86%*	*-8.42%*	*-8.79%*
Elasticity	*-0.01*	*0.01*	n/a	*-0.04*	*-0.02*	*-0.02*	*-0.02*
Transit Person Trips	96,122	96,359	96,011	96,280	95,270	94,419	n/a
Change	111	348	n/a	269	-741	-1,592	-1,703
% Change	*0.12%*	*0.36%*	n/a	*0.28%*	*-0.77%*	*-1.66%*	*-1.77%*
Elasticity	*0.00*	*0.00*	n/a	*0.00*	*0.00*	*0.00*	*0.00*
Bike+Walk Person Trips	1,109,792	1,109,379	1,107,487	1,106,644	1,101,679	1,089,615	n/a
Change	2,305	1,892	n/a	-843	-5,808	-17,872	-20,177
% Change	*0.21%*	*0.17%*	n/a	*-0.08%*	*-0.52%*	*-1.61%*	*-1.82%*
Elasticity	*0.00*	*0.00*	n/a	*0.00*	*0.00*	*0.00*	*0.00*

The model responded to increased working-at-home with consistently less travel by all modes, aside from some of the smallest deviations within possible random variation. This is a reasonable result. Modeled VMT reduced by 8.3 vehicle-miles per day per telecommute-day (i.e. end-to-end 1,191,302 VMT/ 143,048 telecommuters). This is a more modest result than the works cited in (*24*) ranging from 43 to 79 household VMT reduction due to a household member telecommuting.

This synopsis notes that such amounts may be the upper range of effects, and some studies cited therein have found long-term complementary travel effects of commute travel being replaced by other personal travel.

Table 16 compares person-trips by location of work, for the low telework, base, and high telework scenarios, for geographic areas aggregated from RADs approximating the named areas. The largest decreases were at most of the rural areas and outlying cities, and most cities decreased less than their respective nearby suburbs and rural area.

TABLE 16 – WORK PERSON-TRIPS BY LOCATION OF WORK

		Person trips to/from work			
County	**Area**	**Low Telework**	**Base**	**High Telework**	**End-to-end % difference**
Sacramento	Downtown	312,226	306,770	283,690	-9.3%
Sacramento	Sacramento city	464,658	459,492	421,482	-9.4%
Sacramento	Rural	22,138	21,404	19,362	-13.0%
Sacramento	Suburbs	650,658	644,768	587,360	-9.8%
Sutter	All	67,726	67,084	60,774	-10.4%
Yuba	All	43,176	42,710	38,944	-9.9%
Yolo	Davis	67,858	67,728	61,068	-10.0%
Yolo	W Sac	75,720	75,366	67,888	-10.4%
Yolo	Woodland	52,982	52,360	48,566	-8.4%
Yolo	Other	0	0	0	n/a
Placer	Auburn	52,456	51,500	47,352	-9.9%
Placer	Granite Bay	9,336	9,174	8,332	-10.9%
Placer	Loomis	12,800	12,914	11,500	-10.1%
Placer	Rural	8,426	8,558	7,558	-10.1%
Placer	Roseville+Rocklin+Lincoln	244,240	240,636	220,728	-9.8%
El Dorado	Rural	3,554	3,538	3,280	-7.7%
El Dorado	Suburbs	47,466	46,804	42,522	-10.6%
El Dorado	Placerville	42,008	41,238	38,328	-8.9%

Table 17 similarly compares vehicle trips by location of work, for the low telework, base, and high telework scenarios, for geographic areas aggregated from RADs approximating the named areas. Most changed nearly in proportion to the person trips in Table 16.

TABLE 17 – WORK VEHICLE-TRIPS BY LOCATION OF WORK

		Vehicle trips to/from work			
County	Area	Low Telework	Base	High Telework	End-to-end % difference
Sacramento	Downtown	181,184	178,534	166,448	-8.3%
Sacramento	Sacramento city	383,873	379,161	349,366	-9.1%
Sacramento	Rural	19,260	18,658	16,896	-12.7%
Sacramento	Suburbs	556,107	551,901	504,013	-9.4%
Sutter	All	56,529	56,140	50,844	-10.1%
Yuba	All	37,196	36,878	33,519	-10.0%
Yolo	Davis	53,700	53,638	48,409	-9.9%
Yolo	W Sac	63,204	62,786	56,873	-10.1%
Yolo	Woodland	43,724	43,302	40,385	-7.7%
Yolo	Other	0	0	0	n/a
Placer	Auburn	45,868	44,904	41,474	-9.8%
Placer	Granite Bay	8,322	8,260	7,486	-10.1%
Placer	Loomis	11,362	11,390	10,155	-10.6%
Placer	Rural	7,212	7,277	6,439	-10.6%
Placer	Roseville+Rocklin+Lincoln	211,326	208,189	191,563	-9.5%
El Dorado	Rural	3,185	3,216	2,996	-5.9%
El Dorado	Suburbs	42,058	41,502	37,903	-10.0%
El Dorado	Placerville	36,763	36,014	33,553	-8.9%

Table 18 compares telework shares of workers by household income for the low-, base, and high-telework scenarios. Telework shares, by this model, are fairly close to equal across household income ranges. The work-at-home model's independent variables include household attributes (income categories, the presence of children and non-workers in the household, vehicle availability) plus distinct coefficients for eight employment categories. Thereby the model explicitly accounts for employment industries, some more easily accommodating work-at-home than others. However, the model output does not attach the workplace industry to each worker, so a summary comparison by workplace industry is not available.

TABLE 18 TELEWORK OF WORKERS BY HOUSEHOLD INCOME

		Modeled % of workers teleworked		
Household Income	Workers	Low Telework	Base	High Telework
<$25k	150,454	1.1%	2.7%	14.3%
$25k to $45k	219,635	1.0%	2.5%	13.1%
$45k to $70k	278,037	1.0%	2.5%	13.3%
$70k to $100k	205,855	1.1%	2.7%	14.0%
>$100k	266,193	1.1%	2.9%	14.5%

Connected and Autonomous Vehicles

Growing technologies of connected and autonomous vehicles are anticipated to change vehicle interactions, and thus highway operations and performance, effectively changing capacities and/or speeds. Motivated by such potentialities (but with no representation of what is likely or feasible), Table 19 shows the model's sensitivity to combinations of proportionally changed arterial and/or freeway capacities. Since the number of lane-miles is not being changed, elasticities are shown with respect to aggregate capacity, the sum of lane-miles times their respective hourly capacities per lane.

Examples of literature estimating changes of highway performance from technology include references (*25*) through (*29*).

TABLE 19 – SENSITIVITY TO ROADWAY CAPACITY
ADDING OR REDUCING CAPACITY REGIONALLY BY FACILITY TYPE

Arterial Capacities	-10%	Base	0	10%	10%
Freeway Capacities	0		10%	10%	30%
Total capacity-miles (lane-miles * capacity/lane/hr), all except zone connectors					
	11,545,670	11,837,938	12,231,076	12,523,343	13,309,619
% Change from Base	*-2.47%*	*0.00%*	*3.32%*	*5.79%*	*12.43%*
Response Variable					
Person Trips	9,420,234	9,427,263	9,429,081	9,432,694	9,438,110
Change from Base	-7,029	n/a	1,818	5,431	10,847
% Change from Base	*-0.07%*	n/a	*0.02%*	*0.06%*	*0.12%*
Computed Elasticity	*0.03*	n/a	*~0.00*	*0.01*	*0.01*
Vehicle Trips	5,840,224	5,849,174	5,854,671	5,859,284	5,867,925
Change from Base	-8,951	n/a	5,497	10,110	18,751
% Change from Base	*-0.15%*	n/a	*0.09%*	*0.17%*	*0.32%*
Computed Elasticity	*0.06*	n/a	*0.03*	*0.03*	*0.03*
VMT (network)	63,603,944	63,828,536	64,425,130	64,574,534	65,473,742
Change from Base	-224,592	n/a	596,594	745,998	1,645,206
% Change from Base	*-0.35%*	n/a	*0.93%*	*1.17%*	*2.58%*
Computed Elasticity	*0.14*	n/a	*0.28*	*0.20*	*0.21*
CVMT (network)	5,812,013	5,470,121	4,734,542	4,423,524	3,136,794
Change from Base	341,893	n/a	-735,579	-1,046,597	-2,424,711
% Change from Base	*6.25%*	n/a	*-13.45%*	*-19.13%*	*-42.66%*
Computed Elasticity	*-2.53*	n/a	*-4.05*	*-3.30*	*-3.43*
Transit Person Trips	95,633	96,011	96,340	96,042	96,006
Change from Base	-378	n/a	329	31	-5
% Change from Base	*-0.39%*	n/a	*0.34%*	*0.03%*	*-0.01%*
Computed Elasticity	*0.16*	n/a	*0.10*	*0.01*	*~0.00*
Bike+Walk Person Trips	1,113,281	1,107,487	1,105,299	1,100,504	1,097,169
Change from Base	5,794	n/a	-2,188	-6,983	-10,318
% Change from Base	*0.52%*	n/a	*-0.20%*	*-0.63%*	*-0.93%*
Computed Elasticity	*-0.21*	n/a	*-0.06*	*-0.11*	*-0.07*
Ave. Vehicle Speed (mph)	33.73	34.08	34.53	34.82	35.49
Change from Base	-0.35	n/a	0.45	0.74	1.41
% Change from Base	-1.02%	n/a	1.32%	2.17%	4.15%
Computed Elasticity	0.41	n/a	0.40	0.37	0.33
Elast: VMT to Speed	0.34	n/a	0.71	0.54	0.62

Table 20 similarly shows the model's response to changes in the free-flow speed of freeways and/or arterials. (Any link's free-flow speed is its given maximum effective speed, accounting for minimal traffic control delays; traffic flows in relation to its capacity reduce this speed in the model.)

TABLE 20 – SENSITIVITY TO ROADWAY BASE (FREE-FLOW) SPEED
INCREASING OR REDUCING SPEED REGIONALLY BY FACILITY TYPE

Arterial Speeds	Base	SACSIM19	-10%	0	10%	10%
Freeway Speeds		SACSIM19	0	10%	10%	20%
Capacity-miles-weighted average speed	37.52	41.71	36.23	38.25	39.42	40.09
% Change from Base		*11.17%*	*-3.44%*	*1.95%*	*5.07%*	*6.86%*
Response Variable						
Person Trips	9,427,263	9,459,361	9,413,783	9,429,218	9,439,147	9,437,646
Change from Base	n/a	32,098	-13,480	1,955	11,884	10,383
% Change from Base	n/a	*0.34%*	*-0.14%*	*0.02%*	*0.13%*	*0.11%*
Computed Elasticity	n/a	*0.03*	*0.04*	*~0.00*	*0.02*	*0.02*
Vehicle Trips	5,849,174	5,904,586	5,828,027	5,855,033	5,873,816	5,874,022
Change from Base	n/a	55,412	-21,147	5,859	24,642	24,847
% Change from Base	n/a	*0.95%*	*-0.36%*	*0.10%*	*0.42%*	*0.42%*
Computed Elasticity	n/a	*0.08*	*0.11*	*0.05*	*0.08*	*0.06*
VMT (network)	63,828,536	64,506,721	63,144,783	65,205,153	65,810,138	67,041,617
Change from Base	n/a	678,185	-683,753	1,376,617	1,981,602	3,213,081
% Change from Base	n/a	*1.06%*	*-1.07%*	*2.16%*	*3.10%*	*5.03%*
Computed Elasticity	n/a	*0.10*	*0.31*	*1.11*	*0.61*	*0.73*
CVMT (network)	5,470,121	4,945,151	5,328,575	6,677,612	6,815,512	8,026,536
Change from Base	n/a	-524,970	-141,545	1,207,492	1,345,391	2,556,416
% Change from Base	n/a	*-9.60%*	*-2.59%*	*22.07%*	*24.60%*	*46.73%*
Computed Elasticity	n/a	*-0.86*	*0.75*	*11.32*	*4.85*	*6.81*
Transit Person Trips	96,011	100,157	94,337	96,187	96,918	96,878
Change from Base	n/a	4,146	-1,674	176	907	867
% Change from Base	n/a	*4.32%*	*-1.74%*	*0.18%*	*0.94%*	*0.90%*
Computed Elasticity	n/a	*0.36*	*0.51*	*0.09*	*0.18*	*0.13*
Bike+Walk Person Trips	1,107,487	1,061,723	1,126,294	1,100,137	1,083,415	1,079,556
Change from Base	n/a	-45,764	18,807	-7,350	-24,072	-27,931
% Change from Base	n/a	*-4.13%*	*1.70%*	*-0.66%*	*-2.17%*	*-2.52%*
Computed Elasticity	n/a	*-0.37*	*-0.49*	*-0.34*	*-0.43*	*-0.37*

With respect to link free-flow base speeds averaged by weight of capacity-miles, person trips and vehicle trips show small positive elasticity as is reasonably expected, and walk+bike trips show negative elasticity, as reasonably expected.

Elasticities of VMT to free-flow speeds varied widely but were expectedly positive, with average 0.57, also in the vicinity of the estimate (0.42) by Cervero (*30*). Incremental increases in freeway speeds (holding arterials constant) show proportionally more response, and thus higher elasticities with respect to capacity-weighted average speed, compared to incremental increases of arterial speeds (holding freeways constant).

Transit trips show consistent moderate-to-strong positive elasticity. This is unexpected, because roadway speeds affect bus travel times about equally to auto travel times on the same roads. Largely explaining this is the model's means of estimating bus travel times. Bus routes are specified as sequences of nodes on the highway network, but at the network's spatial resolution, these do not generally correspond one-for-one with individual real bus stops. In lieu of dwell times per stop, the model's bus travel times are estimated as the auto travel time on the underlying link, multiplied by a "time factor". This is a calibrated factor to bring modeled bus run times into agreement, at least on average, with scheduled run times. Most frequent-stop local busses have a time factor near 2, while many limited-stop express lines have a factor near 1.6. While this exaggerates the transit model's sensitivity to free-flow speed, it is rare that alternative scenarios for a road project differ by free-flow speed alone or as the main factor.

SACSIM23 applies approximately two thirds of congestion delay of road links upon the bus network, to correct for this exaggerated sensitivity. Consequently, bus travel times are lengthened by underlying highway congestion delays slightly more than those delays themselves.

EXOGENOUS VARIABLES

SACSIM23 was tested for sensitivity to exogenous input factors of household income, auto operating cost, and demographic mix. Sensitivity to auto operating cost was already analyzed above as a representation of regional pricing. Demographic mix was reviewed in the cross-classification (cross-sectional) analysis above in conjunction with land use factors, most particularly Figure 4.

Household Income

Table 21 summarizes the response of the model to a proportional decrease or increase of each input household's income.

TABLE 21 – SENSITIVITY TO HOUSEHOLD INCOME

Median Household Income	$22,696	$40,852	$45,391	$49,930	$68,087	**End-to-End Changes**
% Change from Base	*-50.00%*	*-10.00%*	*0.00%*	*10.00%*	*50.00%*	*100.00%*
Response Variable						
Person Trips	9,194,635	9,393,862	9,427,263	9,448,517	9,520,574	n/a
Change from Base	-232,628	-33,401	n/a	21,254	93,311	325,939
% Change from Base	*-2.47%*	*-0.35%*	n/a	*0.23%*	*0.99%*	*3.46%*
Computed Elasticity	*0.05*	*0.04*	n/a	*0.02*	*0.02*	*0.03*
Vehicle Trips	5,614,612	5,813,871	5,849,174	5,874,655	5,956,409	n/a
Change from Base	-234,562	-35,304	n/a	25,481	107,235	341,797
% Change from Base	*-4.01%*	*-0.60%*	n/a	*0.44%*	*1.83%*	*5.84%*
Computed Elasticity	*0.08*	*0.06*	n/a	*0.04*	*0.04*	*0.06*
VMT (network)	61,411,009	63,472,979	63,828,536	64,108,618	65,010,922	n/a
Change from Base	-2,417,527	-355,557	n/a	280,082	1,182,386	3,599,914
% Change from Base	*-3.79%*	*-0.56%*	n/a	*0.44%*	*1.85%*	*5.64%*
Computed Elasticity	*0.08*	*0.06*	n/a	*0.04*	*0.04*	*0.06*
CVMT (network)	4,595,651	5,289,078	5,470,121	5,536,764	6,038,061	n/a
Change from Base	-874,469	-181,042	n/a	66,643	567,940	1,442,410
% Change from Base	*-15.99%*	*-3.31%*	n/a	*1.22%*	*10.38%*	*26.37%*
Computed Elasticity	*0.32*	*0.33*	n/a	*0.12*	*0.21*	*0.26*
Transit Person Trips	110,596	98,316	96,011	94,422	89,101	n/a
Change from Base	14,585	2,305	n/a	-1,589	-6,910	-21,495
% Change from Base	*15.19%*	*2.40%*	n/a	*-1.66%*	*-7.20%*	*-22.39%*
Computed Elasticity	*-0.30*	*-0.24*	n/a	*-0.17*	*-0.14*	*-0.22*
Bike+Walk Person Trips	1,162,480	1,116,391	1,107,487	1,100,668	1,076,512	n/a
Change from Base	54,993	8,904	n/a	-6,819	-30,975	-85,968
% Change from Base	*4.97%*	*0.80%*	n/a	*-0.62%*	*-2.80%*	*-7.76%*
Computed Elasticity	*-0.10*	*-0.08*	n/a	*-0.06*	*-0.06*	*-0.08*

Table 22 summarizes the end-to-end elasticities and compares them to empirical literature findings.

TABLE 22 – SENSITIVITY TO HOUSEHOLD INCOME COMPARISON

Result	Literature	Value or Range	Model
Person trips	SACOG compilation (*1*) ((*31*), (*32*))	small positive	0.03
Vehicle trips	SACOG compilation (*1*) ((*31*), (*32*))	higher than person trips	0.06
VMT	SACOG compilation (*1*) ((*31*), (*32*))	+0.05 to +0.18	0.06
CVMT	n/a	n/a	0.26
Transit trips	SACOG compilation (*1*) ((*31*), (*32*)) Holmgren 2007 (*33*) (in (*9*), short-run	-0.26 to -0.36 -0.62	-0.22
Walk+bike trips	SACOG compilation (*1*) ((*31*), (*32*))	small negative	-0.08

SENSITIVITY TESTS OF OTHER FACTORS

An additional set of experimental sensitivity runs of the SACSIM23 model examined its response to specific highway capacities, by either adding or removing lanes to particular roads, as summarized on Tables 23A and 23B. (This supplements the above analysis with global capacity changes summarized on Table 19.)

The locations for test widenings are:

- Sunrise Blvd, Roseville to Rancho Cordova, a congested urban arterial
- Watt Ave, Rosemont to North Highlands, a congested urban arterial
- El Camino Ave, Natomas to Carmichael, a mostly uncongested urban arterial
- SR 51 (Capital City Freeway), a severely congested urban freeway
- SR 65, north of Lincoln to junction with SR 99/70, a rural highway with moderate congestion
- SR 99/70, Sacramento to south side of Marysville, an uncongested rural highway/freeway
- Broadway-Franklin-Stockton Blvd reduction, a removal of one lane per direction on these urban arterials
- Blue Oaks Blvd, a short, moderately congested section in Roseville.

TABLE 23A – SENSITIVITY TO ROADWAY CAPACITY
ADDING ONE LANE EACH DIRECTION AT SPECIFIED LOCATIONS

Location	Base	Sunrise Bl.	Watt Av.	El Camino Ave	SR 51
Network Lane-Miles	16,734	16,753	16,756	16,756	16,751
Change from Base		19	21	22	17
% Change from Base		*0.11%*	*0.13%*	*0.13%*	*0.10%*
Response Variable					
Person Trips	9,427,263	9,428,085	9,426,919	9,427,938	9,429,014
Change from Base	n/a	822	-344	675	1,751
% Change from Base	n/a	*0.01%*	*0.00%*	*0.01%*	*0.02%*
Computed Elasticity	n/a	*-0.08*	*-0.03*	*0.06*	*0.18*
Vehicle Trips	5,849,174	5,852,587	5,851,484	5,850,684	5,852,002
Change from Base	n/a	3,413	2,310	1,510	2,828
% Change from Base	n/a	*0.06%*	*0.04%*	*0.03%*	*0.05%*
Computed Elasticity	n/a	*0.52*	*0.31*	*0.20*	*0.48*
VMT (network)	63,828,536	63,889,972	63,878,198	63,841,878	64,007,051
Change from Base	n/a	61,436	49,662	13,342	178,515
% Change from Base	n/a	*0.10%*	*0.08%*	*0.02%*	*0.28%*
Computed Elasticity	n/a	*0.85*	*0.61*	*0.16*	*2.75*
CVMT (network)	5,470,121	5,468,260	5,329,029	5,590,228	5,334,149
Change from Base	n/a	-1,861	-141,091	120,108	-135,971
% Change from Base	n/a	*-0.03%*	*-2.58%*	*2.20%*	*2.49%*
Computed Elasticity	n/a	*-0.30*	*-20.08*	*2.22*	*-3.30*
Transit Person Trips	96,011	94,968	95,843	96,288	95,689
Change from Base	n/a	-1,043	-168	277	-322
% Change from Base	n/a	*-1.09%*	*-0.17%*	*0.29%*	*-0.34%*
Computed Elasticity	n/a	*-9.61*	*-1.36*	*2.23*	*-3.30*
Bike+Walk Person Trips	1,107,487	1,105,046	1,105,166	1,107,320	1,106,196
Change from Base	n/a	-2,441	-2,321	-167	-1,291
% Change from Base	n/a	*-0.22%*	*-0.21%*	*-0.02%*	*-0.12%*
Computed Elasticity	n/a	*-2.0*	*-1.6*	*-0.12*	*-1.15*
Ave. Vehicle Speed (mph)	34.08	34.14	34.13	34.09	34.20
Change from Base	n/a	0.06	0.05	0.01	0.12
% Change from Base	n/a	*0.19%*	*0.16%*	*0.04%*	*0.35%*
Computed Elasticity	n/a	*1.65*	*1.23*	*0.33*	*3.48*
Elasticity: VMT to Speed		0.51	0.49	0.48	0.79

TABLE 23B – SENSITIVITY TO ROADWAY CAPACITY

ADDING OR REDUCING ONE LANE EACH DIRECTION AT SPECIFIED LOCATIONS

Location	SR 65 (N of Lincoln)	SR 70,99 (S. Sutter Co.)	Broadway-Franklin reduction	Blue Oaks Bl.
Network Lane-Miles	16,753	16,802	16,721	16,738
Change from Base	19	68	-13	4
% Change from Base	*0.11%*	*0.40%*	*-0.08%*	*0.02%*
Response Variable				
Person Trips	9,426,900	9,426,164	9,427,323	9,425,882
Change from Base	-363	-1,099	60	-1,381
% Change from Base	*0.00%*	*-0.01%*	*0.00%*	*-0.01%*
Computed Elasticity	*-0.03*	*-0.03*	*-0.01*	*-0.67*
Vehicle Trips	5,848,234	5,847,559	5,850,366	5,849,023
Change from Base	-940	-1,616	1,192	-151
% Change from Base	*-0.02%*	*-0.03%*	*0.02%*	*0.00%*
Computed Elasticity	*-0.14*	*-0.07*	*-0.26*	*-0.12*
VMT (network)	63,867,173	63,876,955	63,836,674	63,831,047
Change from Base	38,637	48,419	8,138	2,511
% Change from Base	*0.06%*	*0.08%*	*0.01%*	*0.00%*
Computed Elasticity	*0.53*	*0.19*	*-0.16*	*0.18*
CVMT (network)	5,412,318	5,521,624	5,430,839	5,531,585
Change from Base	-57,803	51,504	-39,282	61,464
% Change from Base	*-1.06%*	*0.94%*	*-0.72%*	*1.12%*
Computed Elasticity	*-9.24*	*2.33*	*9.07*	*51.4*
Transit Person Trips	95,847	96,091	95,716	95,826
Change from Base	-164	80	-295	-185
% Change from Base	*-0.17%*	*0.08%*	*-0.31%*	*-0.19%*
Computed Elasticity	*-1.49*	*0.21*	*3.88*	*-8.82*
Bike+Walk Person Trips	1,109,112	1,108,362	1,106,960	1,107,515
Change from Base	1,625	875	-527	28
% Change from Base	*0.15%*	*0.08%*	*-0.05%*	*0.00%*
Computed Elasticity	*1.28*	*0.20*	*0.60*	*0.12*
Ave. Vehicle Speed (mph)	34.10	34.12	34.07	34.09
Change from Base	0.02	0.04	-0.01	0.01
% Change from Base	*0.07%*	*0.13%*	*-0.02%*	*0.03%*
Computed Elasticity	*0.58*	*0.31*	*0.20*	*1.43*
Elasticity: VMT to Speed	0.91	0.60	-0.81	0.13

A body of empirical research literature has established that relieving congestion through roadway capacity expansion leads to additional vehicle travel, commonly identified as "induced traffic" (*34-38*). Elasticities of 0.1 to 1.1 have been reported for VMT with respect to aggregate roadway capacity in lane-miles. The National Center for Sustainable Transportation (NCST) Calculator (*39*) applies elasticities of 0.75 to 1.0 for VMT to capacity expansion in California.

A simplistic reading of the evidence for induced traffic suggests that roadway lanes themselves attract people to drive on them, and more lanes attract people to drive more. Relatively few such studies have attempted to unravel the causality. Cervero (*30, 40*), examined simultaneity bias (that road capacity expansions follow VMT growth, as well as VMT growth following capacity expansion), speed as the mediating variable, and land development changes. It is works like these that helped promote better travel demand models that we now have, since many models at that time had fixed trip generation, fixed time-of-day splits (or no time-of-day splits), and some still had fixed mode choice or no feedback of congested travel times to the demand models.

In SACSIM23, as in nearly all travel demand models, travel is derived from persons and their households satisfying their needs or preferences for income, food, goods, services, and social and recreational activities at places outside of their homes where these are available. No such model represents any direct demand or attraction of people to roadway lanes, and there is no reason to suspect this exists (aside from tourism on scenic highways). Route, mode, scheduling, and activity-location choices depend largely on travel times, which include traffic delays and congestion at specific facilities, which in turn depend on their capacities. The building of roadway lanes does not directly satisfy or add to peoples' underlying needs, but rather, depending on changes of congested speeds, can change their choices of where and how to satisfy them. SACSIM23 accounts fully for congested traffic delay with feedback applied to achieve a reasonable consistency between travel times input to the demand models, and those resulting from traffic assignment.

The choices affected by travel times in SACSIM23, and thus, the range of peoples' adaptations to changes of travel times, include personal day pattern (including whether to work at home, which activities to pursue, whether to travel to them in separate tours or chained into fewer tours, or to forgo an activity), location of mandatory and discretionary activities and the lengths of trips to reach them, time of day for activities and travel, modes of travel (now including use of Transportation Network Companies), as well as auto and transit paths. This range of adaptations distinguishes modern models such as SACSIM23 from older models with fixed rates for many of these behaviors, and fewer adaptations in response.

In addition to daily choices of travel, SACSIM23 includes long-term choices of auto ownership and work and school location. Home location choice is implicit in the work location model – that is, this model could be "inverted" into an equivalent model of home location choice, so it makes little to no difference to the model's estimation or application that some people change residence location given their job location, and others their job given their residence location. Consequently, changing home and/or job location is among the adaptations represented in SACSIM23. (One household's change of location is balanced by another similar household taking its place.)

Land use – both residential and employment, are given as inputs for SACSIM23. The remaining component of "induced demand" identified in Cervero *(30, 40*), is more correctly identified as "induced growth," that is, the distribution and timing of land development and/or demographic changes. SACSIM23 estimates travel given land use at a point in time; separate land use models estimate development locations as a process over years of time. (But as Cervero indicated, sometimes highways are planned in anticipation of growth, and some growth is planned and development entitlements secured in anticipation of highway expansions.)

A variety of locations throughout the Sacramento region were chosen for widening or reduction tests. But unlike the before-and-after studies of induced demand from widenings that were actually built (resulting from processes and behaviors of planning, prioritizing, and funding), some of the test locations are arbitrary, uncongested, and unlikely to be widened foreseeably, while some others are chronically congested and difficult and costly to widen.

Differences between regional person trips, vehicle trips, transit trips, and walk & bike trips among the test cases were small as may be reasonably expected, and overly affected by random noise to infer elasticities.

VMT responded in the same direction as capacity for all cases except possibly one, which was a reduction of arterials (Broadway, Franklin Blvd, and Stockton Blvd) having several parallel arterial and freeway route alternatives. The particular experiment yielded a slightly more VMT with narrower roads, but the VMT was well within random variation. In this case the alternative routes include parallel freeways, offering comparable travel times by way of longer distances at faster speeds. All other scenarios responded positively in VMT with respect to capacity. The widening with the highest modeled elasticity was SR 51, a severely congested freeway in Sacramento.

Cervero (*30*) distinguished the two parts of the elasticity of VMT to capacity, that is, speed to capacity (around 0.24), and VMT to speed (around 0.42). At the test roadways, speed to capacity was consistently positive, small for less-congested locations and much larger for highly-congested locations. This is consistent with the link time functions applied in the network performance and traffic assignment component of SACSIM having positive second-derivatives with respect to volume, consistent with traffic flow theory. (*41*) The elasticity of VMT to speed averaged 0.44, close to Cervero's estimate.

Table 24 summarizes the elasticities of VMT to lane-miles or aggregate capacity from Tables 20A, 20B, plus Table 16. Also shown are the components of this elasticity, speed to capacity and VMT to speed. Higher elasticities are associated with higher congestion. Greater congestion means more opportunity for speed increase from widening, consistent with traffic flow theory, and thus, higher speed to capacity elasticities at congested locations. Elasticities of VMT to speed show less variation among the scenarios. That the model responded differently and appropriately to the different capacity changes, in response to the particular congestion and travel and route choice situations, is a strength of demand models like SACSIM23.

TABLE 24– MODELED VMT ELASTICITIES BY COMPONENT

Location of Capacity Increase (facility type, congestion level)	**Elasticity, VMT to lane-miles**	**Component: Speed to Capacity**	**Component: VMT to Speed**
Sunrise Blvd (arterial, severe)	0.85	1.65	0.51
Watt Ave (arterial, moderate)	0.61	1.23	0.49
El Camino Ave (arterial, uncongested)	0.16	0.33	0.48
SR 51 (freeway, severe)	2.75	3.48	0.79
SR 65 N of Lincoln (highway, moderate)	0.53	0.58	0.91
SR 70,99 in S. Sutter Co. (freeway, uncongested)	0.19	0.31	0.60
Broadway-Franklin "road diet" (arterial, moderate)	-0.16*	0.20*	-0.81*
Blue Oaks Blvd, Roseville (arterial, moderate)	0.18*	1.43	0.13
Arterials -10%	0.14†	0.41†	0.34
Freeways +10%	0.28†	0.40†	0.71
Arterials and Freeway +10%	0.20†	0.37†	0.54
Arterials +10%, Freeways +30%	0.21†	0.33†	0.62

*Changes of VMT and vehicle trips may be insignificant relative to random sample variability.

† Elasticities with respect to aggregate capacity in lane-miles times capacity per hour per lane.

RANDOM VARIATION OF THE MODEL

Like most tour-based models, SACSIM23 model results have random variation or “noise” due to random choice sampling in its Daysim tour-based model, compounded by the precision limitations of its iterative computations such as equilibrium traffic network assignment. Therefore, differences between scenarios should be interpreted in light of random variation, and differences between small selections or aggregations may need to be averaged from multiple runs before and after.

Daysim simulates a one-day activity pattern and the resulting trips by each individual person (*1*). One set of persons is input to all of the model scenarios in this analysis. (This set is not particular persons, but is a synthesis devised to be statistically similar to US Census estimates from the American Community Survey, published in various aggregate forms to preserve anonymity.) Persons are grouped in households, and households are placed in small areal units called “parcels,” which were derived from actual parcels. The synthesis of persons is itself an outcome of random sampling, but the same synthetic population is used in all SACSIM23 experimental and cross-sectional tests in this report. Thereby population uncertainty does not contribute to the reported model variability.

As a practical solution for the vast number of personal activity and trip possibilities, Daysim randomly draws a single outcome for each activity and travel choice by each person, with probabilities determined by its various choice models, many of which are applied conditionally on the single outcome of other choices. The random draw is the outcome of a Monte-Carlo procedure using a random number generator. The random number generator is a deterministic algorithm designed to generate a series of numbers that are practically random statistically (e.g. uniform distribution, no self-correlations). Daysim has among its input specifications a *seed*, a number that initiates the random sequence of a run, applied so that with any particular seed, (1) Daysim exactly reproduces its results from any run, on any computer, with identical inputs, and (2) the smaller the magnitude of changes to the inputs, the more persons reproduce their travel choice results. However, when applied with a different random seed, but otherwise identical inputs, Daysim draws independently different random outcomes for each person’s day of travel. The random outcomes from any given seed are independent of the outcomes from any other seed, aside from being drawn from the same probability distributions. No Daysim results are correlated with the seed itself or otherwise biased in relation to the seed.

This random application means that when comparing the results of any two SACSIM models with different inputs, some of the difference is random, not all is systematic due to the change of the inputs. But with re-use of the random seed between scenarios, differences between scenarios are minimized, and may be less than random variation itself (*42*).

Tables 25A through 25D summarize the resulting trips from Daysim from ten independent complete runs of the draft SACSIM23 model system with all the same inputs except the random seed, for combinations of activity, mode, and location.

TABLE 25A - VARIATION OF TRIP-ENDS AMONG TEN MODEL RUNS

LOCATION: REGION

Activity	Quantity	Average	Standard Deviation	Max % Difference from Average	
				Low	High
Home	Person trip-ends	6,284,033	1,486	-0.04%	0.04%
	Vehicle trip-ends	3,844,750	1,310	-0.04%	0.06%
	Transit trip-ends	60,498	338	-0.91%	0.76%
	Walk+Bike trip-ends	673,281	768	-0.24%	0.14%
Work	Person trip-ends	2,159,525	2,399	-0.16%	0.14%
	Vehicle trip-ends	1,748,707	2,082	-0.19%	0.18%
	Transit trip-ends	26,219	221	-1.37%	1.38%
	Walk+Bike trip-ends	258,457	556	-0.27%	0.43%
Other	Person trip-ends	10,411,521	2,830	-0.06%	0.04%
	Vehicle trip-ends	6,107,379	3,905	-0.14%	0.10%
	Transit trip-ends	106,603	649	-1.18%	0.72%
	Walk+Bike trip-ends	1,281,892	1,937	-0.27%	0.19%

TABLE 25B - VARIATION OF TRIP-ENDS AMONG TEN MODEL RUNS

LOCATION: LARGEST-POPULATION RAD 19 (SOUTH SACRAMENTO)

Activity	Quantity	Average	Standard Deviation	Max % Difference from Average	
				Low	High
Home	Person trip-ends	475,906	1,055	-0.33%	0.30%
	Vehicle trip-ends	267,911	579	-0.39%	0.33%
	Transit trip-ends	5,847	105	-3.20%	2.33%
	Walk+Bike trip-ends	54,841	387	-1.02%	0.88%
Work	Person trip-ends	98,551	557	-0.92%	0.86%
	Vehicle trip-ends	82,908	554	-1.05%	1.14%
	Transit trip-ends	552	22	-4.73%	7.23%
	Walk+Bike trip-ends	8,790	158	-2.21%	3.91%
Other	Person trip-ends	774,317	1,574	-0.39%	0.27%
	Vehicle trip-ends	441,318	846	-0.26%	0.31%
	Transit trip-ends	7,137	148	-2.68%	2.81%
	Walk+Bike trip-ends	87,016	656	-1.08%	0.86%

TABLE 25C - VARIATION OF TRIP-ENDS AMONG TEN MODEL RUNS

LOCATION: MEDIAN-POPULATION RAD 77 (LOOMIS)

Activity	Quantity	Average	Standard Deviation	Max % Difference from Average	
				Low	High
Home	Person trip-ends	45,301	259	-1.42%	0.53%
	Vehicle trip-ends	30,185	198	-1.34%	0.75%
	Transit trip-ends	85	11	-24.88%	19.72%
	Walk+Bike trip-ends	2,394	71	-3.58%	4.69%
Work	Person trip-ends	12,801	279	-3.63%	3.48%
	Vehicle trip-ends	11,339	268	-3.76%	4.16%
	Transit trip-ends	32	6	-25.23%	40.19%
	Walk+Bike trip-ends	725	28	-4.72%	6.73%
Other	Person trip-ends	51,337	439	-1.17%	0.95%
	Vehicle trip-ends	31,937	269	-1.20%	1.29%
	Transit trip-ends	439	26	-12.57%	7.01%
	Walk+Bike trip-ends	4,038	123	-5.58%	3.53%

TABLE 25D - VARIATION OF TRIP-ENDS AMONG TEN MODEL RUNS

SELECTION: SMALLEST-POPULATION RAD 4 (UNINCORPORATED NORTH NATOMAS)

Activity	Quantity	Average	Standard Deviation	Max % Difference from Average	
				Low	High
Home	Person trip-ends	817	27	-3.8%	6.4%
	Vehicle trip-ends	545	19	-4.7%	4.7%
	Transit trip-ends	0	0	n/a	n/a
	Walk+Bike trip-ends	14	5	-50.7%	54.9%
Work	Person trip-ends	9,406	265	-2.5%	6.3%
	Vehicle trip-ends	8,592	243	-2.7%	6.4%
	Transit trip-ends	16	6	-38.3%	85.2%
	Walk+Bike trip-ends	219	17	-9.7%	15.4%
Other	Person trip-ends	2,909	58	-4.3%	2.2%
	Vehicle trip-ends	2,021	44	-4.3%	3.0%
	Transit trip-ends	7	3	-38.5%	69.2%
	Walk+Bike trip-ends	169	14	-11.6%	13.9%

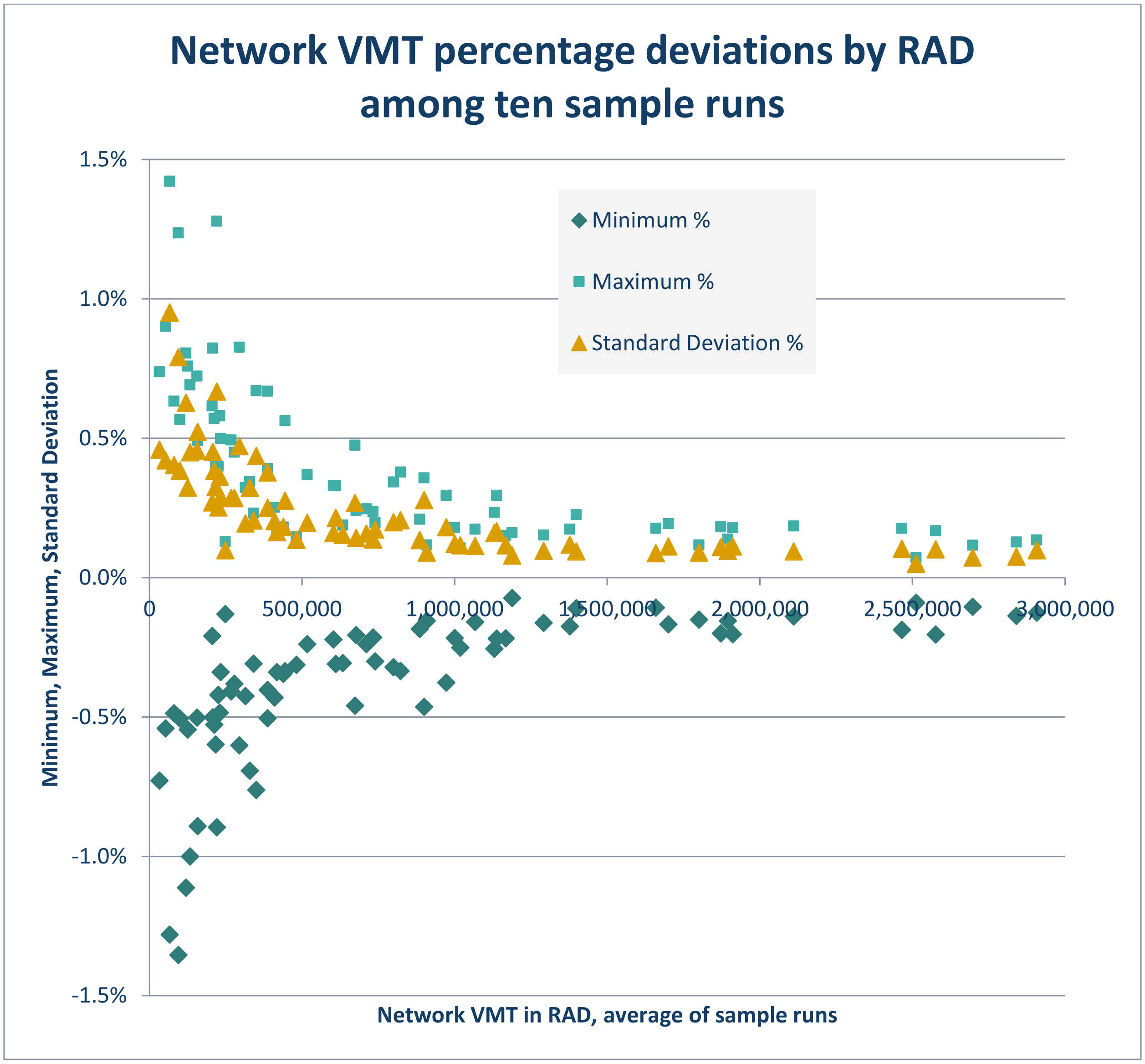
Table 26 summarizes variation of the regional total quantities that are compared by scenario in the Experimental Sensitivity Analysis section of this document (above).

TABLE 26 - REGIONAL TOTALS VARIATION AMONG TEN MODEL RUNS

Quantity	Average	Standard Deviation	Max % Difference from Average	
			Low	High
Person trips	9,427,539	1,679	-0.03%	0.03%
Vehicle trips	5,850,418	2,801	-0.08%	0.09%
Transit trips	96,660	540	-0.92%	0.76%
Walk+Bike trips	1,106,814	1,441	-0.24%	0.13%
VMT	63,820,815	28,922	-0.06%	0.09%
CVMT	5,482,456	57,739	-1.44%	1.44%

Figure 6 plots percentage variation among the ten model runs of the VMT loaded on the links in each RAD against their respective average VMT. It shows both the extrema and standard deviations tending to diminish in percentage with larger average VMT.

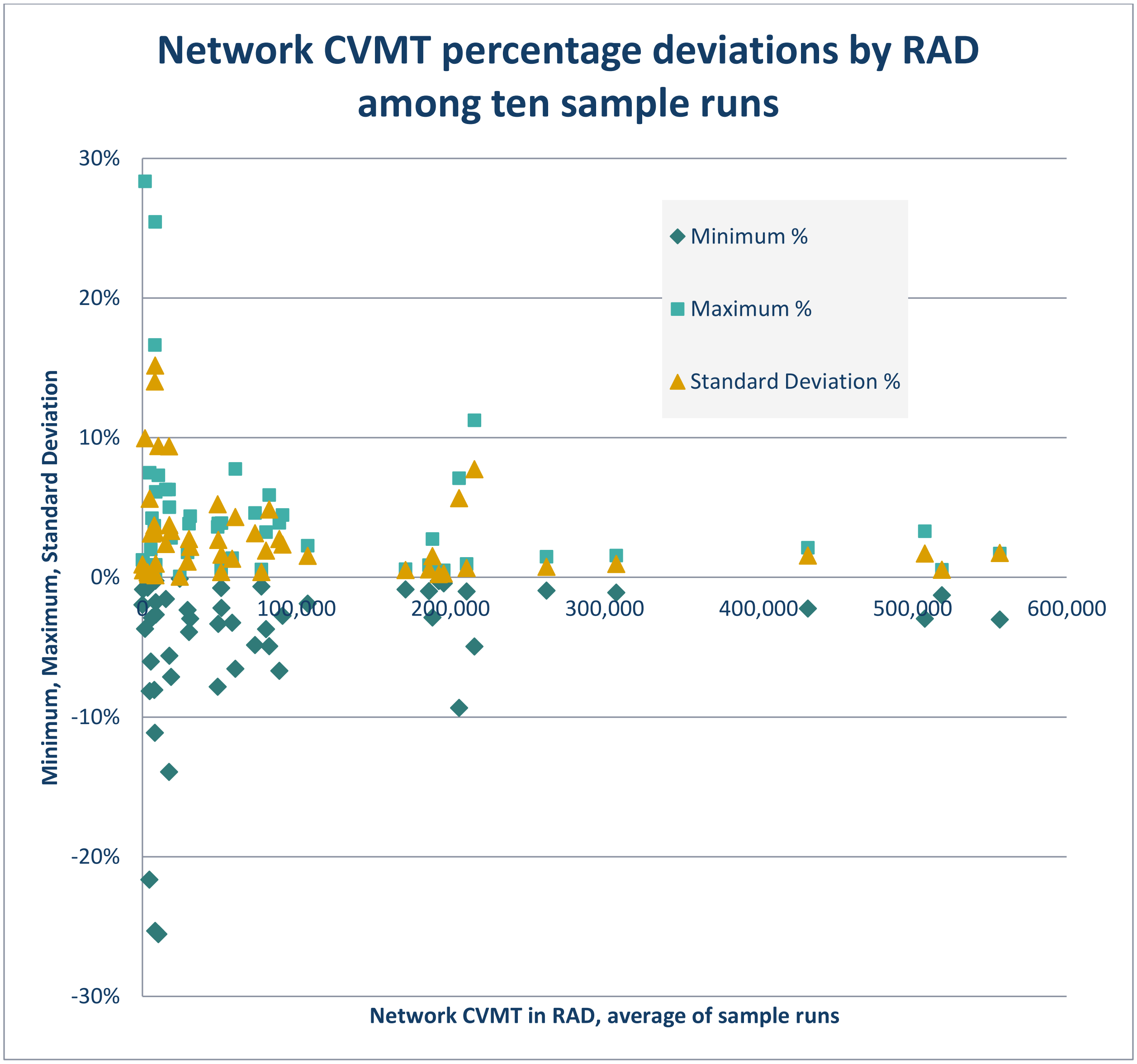
FIGURE 6



Congested vehicle miles traveled (CVMT), that is, vehicle-miles on links when their demand exceeds capacity (v/c > 1), is a network performance measure of interest not only for level-of-service, but also for air pollutant emissions including greenhouse gasses. The traffic assignment model imposes limitations on the precision of this particular measure, by the all-or-nothing inclusion or exclusion of particular links not only between models being compared, but between iterations of assignment. A small change of a link's volume can add or remove its entire VMT to or from CVMT, even if its emissions change little. During assignment, link volumes change somewhat randomly and in fluctuation from iteration to iteration; assignment normally stops when this fluctuation level is diminished, but practical traffic assignments cannot narrow down the fluctuation anywhere near computer machine numerical precision, nor with any favoritism or consistency for which links are included or excluded.

Figure 7 plots the same relation for CVMT as in Figure 6 did for total VMT, showing wider overall variation among the ten experimental runs than total VMT, with percentage deviation likewise tending to diminish with larger averages.

FIGURE 7



Note: Three RADs have deviations exceeding the chart's range. Their average CVMTs are each less than 4,600.

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