Sacramento Activity-Based Travel Simulation Model (SACSIM07):

MODEL REFERENCE REPORT

--REVIEW DRAFT--

Sacramento Area Council of Governments

with assistance from

DKS Associates

Bradley Research and Consulting

Transportation Systems and Decision Sciences

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Sacramento Area
Council of
Governments

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- *Mark Bradley (Bradley Reseach and Consulting)* and *John L. Bowman, Ph.D. (Transportation Systems and Decision Sciences)*--Worked jointly in Phase 1 of the SACSIM development, assisted in preparation and development of the estimation datasets, performed all the estimations, and programmed DAYSIM. Additionally, both Mark and John were available for an interminable series of questions, requests and entreaties during the calibration, validation and testing of the overall model system.
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A significant amount of the content of this document is either drawn directly 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 is peppered throughout the document in ways impossible to specifically attribute.

SACOG staff was responsible for the organization of the document, and were the sole authors of Chapters 1 through 7. For all the remaining chapters, SACOG staff worked with technical memoranda written by the individuals acknowledged above. All of the calibration, validation and reasonableness checking sections of Chapters 8 and 9 were the work of SACOG staff. The sensitivity testing reported in Chapter 11 is also the work of SACOG staff. SACOG staff who contributed significantly to the document are:

- *Gordon Garry, Director Research and Analysis*—Overall editorial assistance for entire document.
- *Bruce Griesenbeck, Principal Transportation Analyst*—Primary author or editor of the document.
- *Steve Hossack, Senior Research Analyst*—Contributor to Chapter 1 on the parcel file.
- *Raju Penmetsa, Assistant Research Analyst*—Contributor to Chapter 11.
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SACOG

Introduction and Overview

SACOG, as the designated Metropolitan Planning Organization (MPO) for the Sacramento region, has the primary responsibility for the development and maintenance of travel demand forecasting methods and models for the region. These models are used by SACOG for regional-scale policy analyses of land use and transportation plans, as well as for analyses of the effects of exongenous variables, like fuel prices and demographic change (e.g. aging of the population). Until recently, the only travel demand forecasting model maintained and used by SACOG was the Sacramento Regional Travel Demand Model (or SACMET), which is a traditional, zone-aggregated, "four-step", trip model[1]. During its landmark "Blueprint" transportation/land use study, SACOG identified significant limitations of SACMET in fully capturing the value of detailed land use scenarios. These limitations, combined with the general progression and evolution of regional travel demand models away from four-step models and towards activity-based models, motivated SACOG to embark in Year 2005 on the development of an activity-based tour travel simulation model using parcel, rather than zone-aggregate, land use data. The model, now complete and in use for regional transporation and land use analyses, is called the Sacramento Activity-Based Travel Simulation Model (or SACSIM). This report provides a detailed description of SACSIM, and is intended to serve as a reference document for external users of SACSIM.

Organization of the Report

The report is organized into eleven chapters. Chapters 1 and 2 cover key land use and demographic input data files required by SACSIM. Chapter 1 provides a description of 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 1 provides an overview of how the file is produced, starting from iPlace3s[2], which SACOG's land use scenario software and database. Chapter 2 provides a description of the *representative population file*, which is literally a person-level representation of the region's household population. Representative population files are generated at individual level, and are 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 underly SACOG's travel demand forecasts. Chapter 2 also provides an overview of how the file is produced.

Chapters 3, 4, and 5 cover transportation input files and assumptions. Chapters 3 and provide a detailed descriptions of the *highway network files* and *transit network files* used by SACSIM. Highway networks are required for generating level-of-service matrices (also called *skims*), which represent the level of accessibility of travel by automobile. Transit networks are also required for

[1] SACOG, "Sacramento Regional Travel Demand Model Verion 2007 (SACMET07): Model Update Report", August 2008.
[2] iPlace3s was developed by the California Energy Commission.

generating LOS matrices. By their nature, transit networks are more complicated than are highway networks. First, more characteristics need to be represented in transit networks, like stop locations, service frequencies, transfer locations, access points (e.g. park-and-ride lots), and hours of operation need to be coded. Second access to transit (i.e. how a traveler gets from his or her place of residence to the first transit line and stop boarded) is more difficult to characterize in computer models, and additional network features and coding are required to capture the options which can be used to access transit. Finally, transfers and fare policies vary within operators by type of passenger, and vary across operators, too, based on what inter-agency agreements on transfers are in place.

In part because SACSIM was intended to allow for more complete evaluation of detailed land use plans, the model is based on parcel or point level land use data. This level of detail allows for much more accurate representation of proximity of people and land uses than is possible with a zone-aggregated model, especially for short trips. Short trips also tend to be the most likely trips to be made by bike, walk or other non-motorized modes. So, the process for representing proximity of land uses for shorter trips was modified to take advantage of the detailed land use input files. In addition, walk or bike links were added to highway networks, and a non-motorized travel network is generated from the highway network. All of these changes in treatment of bike and walk trip networks are described in Chapter 5.

Recent increases in fuel prices have initiated a heart-felt re-evaluation around the country of fuel price as it affects travel costs and behavior in travel demand models. Chapter 6 provides a local and California perspective on actual fuel prices and recent changes, and describes how fuel prices are represented in SACSIM. The chapter also provides background on the representation of transist fares in the model.

Chapter 7 provides an accounting of the observed travel and transportation system data sources which were used for estimation, calibration, validation and reasonable-ness checking of SACSIM. It is not typical to provide an entire chapter simply presenting the data sources; however, because of the importance of model validation and reasonable-ness checking, it was determined that a discussion of the sources which are used for these evaluations, as well as a frank appraisal of the quality and limitations of each source, was merited.

Chapter 8 provides a detailed description of each submodel which makes up SACSIM, as well as the overall structure and flow of the model in its operation. Figure 1 provides a very simplified flow chart for the model, and identifies each major submodel.

- *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.

- *Air passenger ground access* to the Sacramento International Airport is modeled separately, at 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 at TAZ level, and includes all trips made for transporation 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 through trips. These trips are fixed as exogenous, scenario variables. Only the portion of these trips which occur within the SACOG region are actually modeled.

- Trips from all the submodels are aggregated and factored 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 Citilabs® TP-Plus software. DAYSIM itself is a stand-alone program written in Pascal, and compiled to run within the SACSIM application. All trip aggregation, plus the non-DAYSIM components, are TP-Plus scripts.

Chapter 9 descibes the process for taking all the trip-level outputs of the submodels described in Chapter 8, creating trip tables, and assigning them to highway and transit networks.

Chapter 10 provides and accounting of a key feature of the model: system equilibration. The chapter describes the "recipe" by which SACSIM iterates in order to achieve results which are stable, if not optimal or unique. By "stable", it is meant that the LOS matrices have stabilized, and the "incoming" LOS matrices for the final iteration are similar to the "outgoing" matrices from the final iteration.

Chapter 11 presents the results of a number of sensitivity tests applied to SACSIM. The tests are rigorous, accounting for the "random" variation which occurs in simulation models, and testing for factors like fuel price, transit fare, income, land use density, and proximity to transit.

It should be noted that there is no chapter on "Validation Results". This omission was intentional. Validation results and reasonable-ness checks are reported at the end of each section or chapter, as appropriate.

Basic Parameters of SACSIM

SACSIM is a *typical weekday* model. It represents travel demands for a typical weekday. A typical weekday is 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 by 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.

Also, it bears some explanation of what sort of *simulation* SACSIM actually is. 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…"[3] 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 TAZ's. 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,

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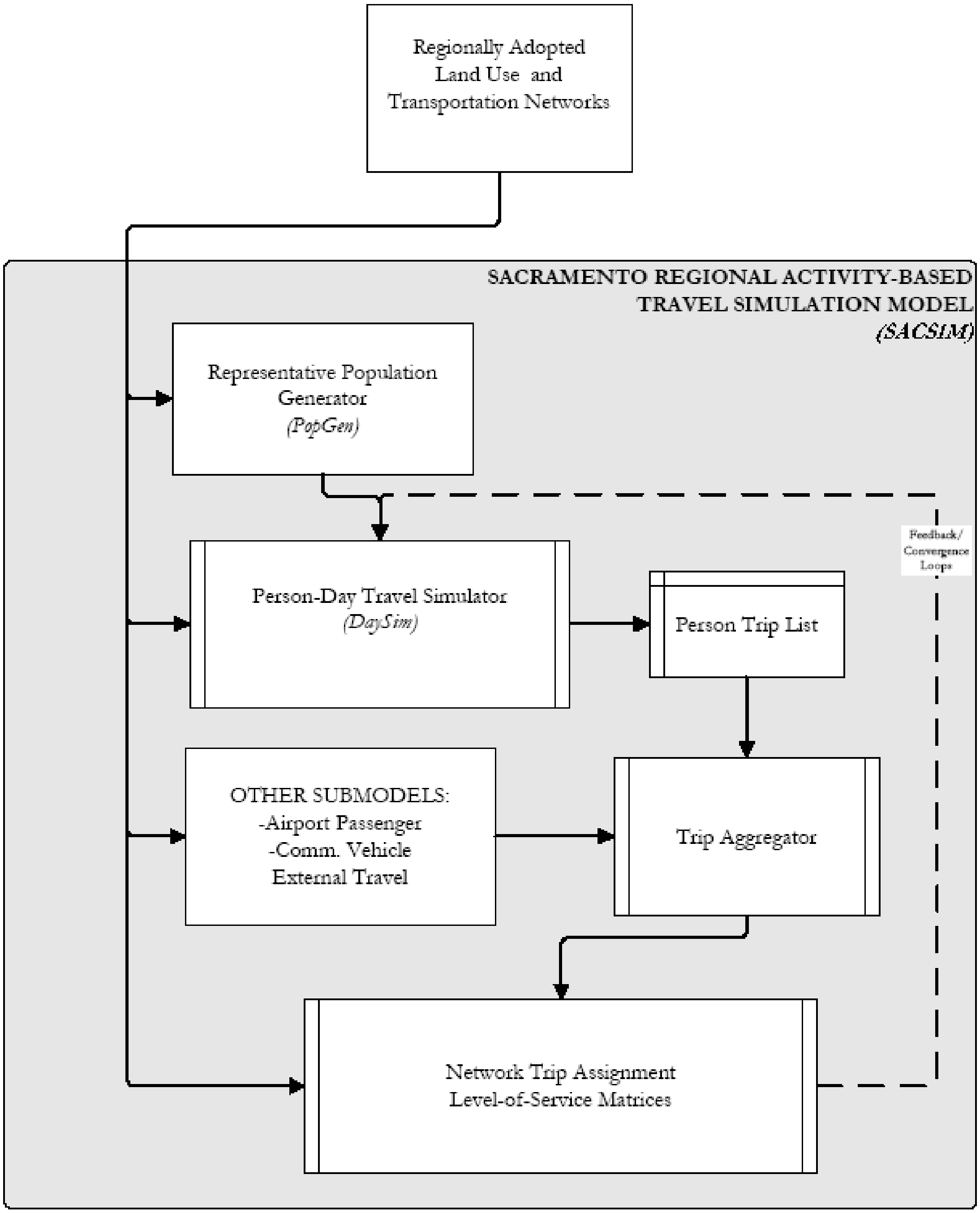
[3] <u>Webster's Ninth New Collegiate Dictionary</u>, Merriam-Webster, 1987.

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.

Ironically, while SACSIM, through its DAYSIM submodel, truly simulates at least a large portion of the demand for travel, and then assigns that demand to networks using static, aggregate tools, virtually all of the traffic operations simulations estimate travel demand through static, aggregate travel demand models, then simulate the assignment of that demand onto highway and transit networks. No model application known to the authors puts together a simulation of travel demand with a simulation of the assignment of that demand to networks.

Figure 0-1. SACSIM Model System



Source: SACOG, November 2008.

1—Parcel-Point Land Use Data

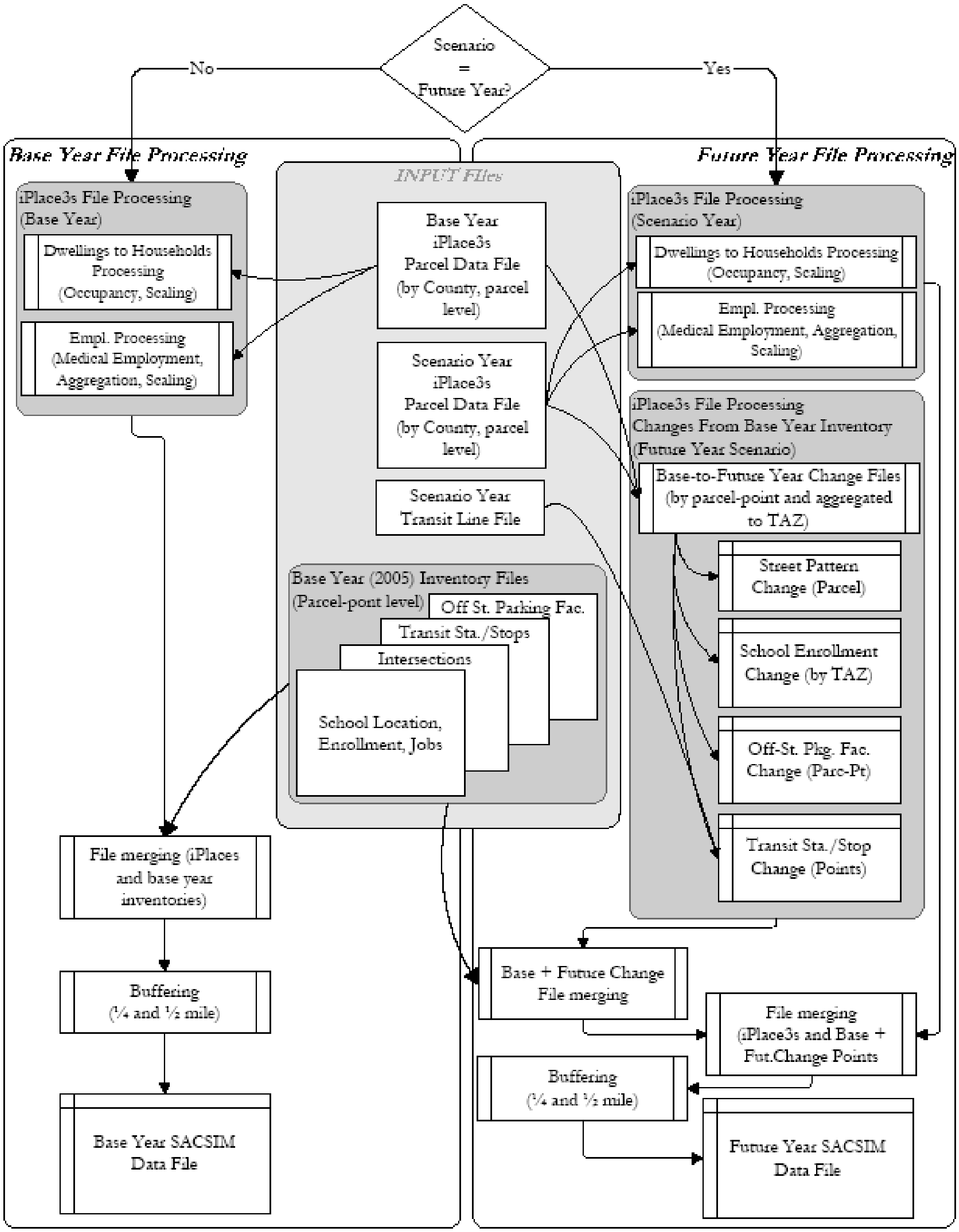
For its transportation planning functions as a Metropolitan Planning Organization, SACOG's jurisdiction covers part of all of the six county Sacramento region. This area includes Sacramento, Sutter, Yolo and Yuba counties in their entirety, and the portions of Placer and El Dorado counties below the Sierra Nevada ridge line. The extreme eastern portion of 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 iPLACE3S datasets and other data sources. iPlace3s is the primary data source for households and jobs on each parcel. School employment and enrollments, street pattern, off-street parking suppy 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:

- *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 parcelization is based on the best assessors records available to SACOG in electronic form in Year 2004. Subdivisions of parcels since 2004 are not included in the SACSIM parcelization.
    - Large parcels with significant growth from the base year to the planning horizon year (2035) 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. iPlace3s dwellings or jobs estimates) to be matched or aggregated to the parcel-points.
- *Base year inventories* are datasets of land use features which are not directly represented in iPlace3s, 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, an iPlace3s 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.

Figure 1-1 illustrates the basic process for assembling a base year or future year SACSIM dataset.

Figure 1-1. SACSIM Parcel-Point Data File Creation



Source: SACOG, November 2008.

iPlace3s Data Files

iPlace3s is a sophisticated land use scenario planning and analysis tool, which was developed by the California Energy Commission. iPlace3s is an open source, web-accessed system, which allows for multiple users, and also allows for use of iPlace3s in public workshop settings. SACOG has utilized iPlace3s scenario planning functionality in developing the Sacramento Region Blueprint Land Use/Transportation Study, which resulted in adoption of a long range, Year 2050 preferred land use scenario for the region. Since that time, SACOG has worked with the CEC, other iPlace3s users, and EcoInteractive, Inc. to adapt iPlace3s for use in developing and maintaining SACOG's Board-adopted land use projections for use in developing and evaluating the regions long-range transportation plan.

iPlace3s 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 within iPlace3s, and output to a GIS shapefile. SACSIM utilizes the shapefile outputs from iPlace3s, and augments the dwelling and employment estimates with other information, which is described in greater detail below. There are several key terms which are useful in understanding the capabilities of iPlace3s:

- *Place Type* (OPTYPE) is the fundamental description of the existing or future land use of a parcel. Place type roughly corresponds to general plan land use types commonly used by jurisdictions for describing land use policy; however, iPlace3s 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* (OPCTDEV) is the percentage of a parcel which is developed per the coded place type.
- *Gross-to-net acreage percentage* (OPCTACRE) 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. floodzone) variables which generally reduce the development potential of a particular parcel.
- *Redevelopment potential* is coded to parcels through various fields in iPlace3s, to represent the likelihood of a given existing, developed parcel changing its use (place type) or development intensity.

Using all of these available variables and data layers, iPlace3s generates estimates or yields of dwellings and jobs for each parcel. For the iPlace3s base year (2005), these estimates are calibrated to match the best available observed data at the smallest geography available. 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.

SACSIM Parcel-Point File Structure

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 1-1 presents the variables include in the file. While the final table is written to dBASE IV (*.dbf) format; ArcSDE on MS SQL Server (MSSQL) is used during the data assembly and processing[4].

Table 1-1. SACSIM Parcel File Variables

Label	Definition	Data Type	Comments	Needed for SACSIM?
PARCELID	Parcel ID number	Long Int.	This must have unique values.	Yes
X_COORD	X coordinate – state plane feet	Long Int.	These coordinates are of a parcel's centroid (forced inside of parcel polygon)	Yes
Y_COORD	Y coordinate – state plane feet			
AREA_SQF	Area of parcel – square feet	Long Int.		Yes
TAZ	TAZ number	Long Int.		Yes
HOUSES*	Households – (x 100)	Long Int.		Yes
STUDK12*	K-12 Enrollment- (x 100)	Long Int.	Enrollment at school on parcel	Yes
STUDUNI*	Students University–(x 100)	Long Int.	Enrollment at school on parcel	Yes
NODES1*	1 link nodes	Long Int.	1 link nodes are typically cul-de-sacs and dead-ends	Yes
NODES3*	3 link nodes	Long Int.		Yes
NODES4*	4+ link nodes	Long Int.	4 link nodes are typically 4-way intersections or more	Yes
DIST_LRT	Distance to nearest LRT stop (miles x 100 -1 if none)	Long Int.		Yes
DIST_BUS	Distance to nearest bus stop (miles x 100, -1 if none)	Long Int.		Yes
PARKDY_*	Daily paid parking spaces	Long Int.		Yes
PPRICDY*	Avg price daily parking- (cents)	Long Int.		Yes
PARKHR_*	Hourly paid parking spaces	Long Int.		Yes
PPRICHR*	Avg price hourly parking- (cents)	Long Int.		Yes
EMPEDU_*	Education jobs – (x 100)	Long Int.		Yes
EMPFOOD *	Food service jobs – (x 100)	Long Int.		Yes
EMPGOV_*	Government jobs – (x 100)	Long Int.		Yes
EMPOFC_*	Office jobs – (x 100)	Long Int.		Yes
EMPOTH_*	Other jobs – (x 100)	Long Int.		Yes
EMPRET_*	Retail jobs – (x 100)	Long Int.		Yes
EMPSVC_*	Service jobs – (x 100)	Long Int.		Yes
EMPMED_*	Medical jobs – (x 100)	Long Int.		Yes
EMPIND_*	Industrial jobs – (x 100)	Long Int.		Yes
EMPTOT_*	Total jobs – (x 100)	Long Int.		Yes
PIDSTR	Text-based unique identifier (<county	String	This must have unique	No

[4] The program code for executing this is reported in a working paper available from SACOG on request.

Label	Definition	Data Type	Comments	Needed for SACSIM?
	id> + <PLCSHPID>)		values.	
TRANPROX	Transit proximity code	Long Int.		No
STRTPATT	Street pattern code	Long Int.		No
TOTDEN	Total density code	Long Int.		No
GRID_ID	Grid index number for buffer processing	Long Int.		No
ACTION	Identifier to indicate if record will be written to the final table	Long Int.		No
MIXINDEX	Land use diversity measure.	Long Int.		No

Source: SACOG, November 2008.
"*" at the end of a variable name indicates that three variable forms are included in the file: the "P" form = the quantity on the instant parcel; the "Q" form = the quantity within ¼ mile radius of the instant parcel; and the "H" form = the quantity within ½ mile of the instant parcel. The "Q" and "H" forms are referred to as "buffered" values.

Variable Definitions and Formats

As mentioned above, many SACSIM variables are represented in three forms: parcel values, which represent the quantity or type of use on a specific parcel; or buffered values, which represent the quantity or type of use within one-quarter or one-half miles of a parcel. The naming convention is for parcel-value variable names to end with letter "P", one-quarter-mile buffer variable names to end in letter "Q", and one-half-mile buffer variable names to end in letter "H". In the discussion below, variable names referenced with names ending in and asterisk (*) are variables which have both parcel and buffer values, and the asterisk stands in for "P", "Q", and "H".

Variable names without asterisks take on only one value, determined by the quantity or type of use on the parcel.

X_COORD and Y_COORD

The X_COORD and Y_COORD fields store the X and Y State plane coordinates of each parcel's location. The location is actually 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 Int.s.

AREA_SQF

The AREA_SQF 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. For these anomalies, the area can just be manually calculated to a reasonable value (i.e. 1000 sq-ft).

PIDSTR Field

The PIDSTR field stores a unique alphanumeric value that is useful for relating the records of the SACSIM table back to the original source files. For right now, the original source files are iPLACE3S downloads.

The format is as follows PIDSTR = "<*county prefix code*>-" PLCSHPID using the following county prefix codes: El Dorardo = "ELD"; Placer = "PLA"; Sacramento = "SAC"; Sutter = "SUT"; Yolo = "YOL"; and Yuba = "YUB". For example, if PLCSHPID is 1278 and it is in Sacramento County then the PIDSTR will be "SAC-1278". There may be situations where sub areas that will be separate from the county source files. In that case, indicate the county prefix code with a number attached to it. For example, a sub area in Placer County will have a county prefix code of "PLA2".

Households (HOUSESP*)

Households on each parcel are estimated from the number of dwelling units (DU's) estimated to be on the parcel in the iPlace3s dataset. iPlace3s estimates the number of dwelling units according to the

K-12 Student Enrollment (STUDK12*)

The STUDK12P field stores the number of students on parcels that have elementary, middle and high schools. These enrollment numbers do not come from iPLACE3S but from our inventory of schools as well as projected school locations.

Populating STUDK12P involves constructing a shapefile or table of existing and projected school locations with enrollment numbers and moving these numbers to the STUDK12P field in the SACSIM table. What is critical is that each record in the dataset represents a single parcel and that it is related to the parcels in the SACSIM table via PIDSTR.

College and University Student Enrollment (STUDUNI*)

The STUDUNIP field stores the number of students on parcels that are part of major universities and community colleges. As with K-12 enrollment, university enrollment does not come from iPLACE3S but from inventory and projected locations.

Populating STUDUNIP involves constructing a shapefile or table of existing and projected university/college locations with enrollment numbers and moving these numbers to the STUDUNIP field in the SACSIM table. What is critical is that each record in the dataset represents a single parcel and that it is related to the parcels in the SACSIM table via PIDSTR.

Street Pattern (NODES1*, NODES3*, and NODES4*)

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. I

Street Intersection 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 the 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.

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 for each place type.

Figure 1-2. Street Intersection (NODE) Layer

Source: SACOG, November 2008.

Figure 1-3. Node Typology

Source: SACOG, November 2008.

Table 1-2. Node Density by Place type

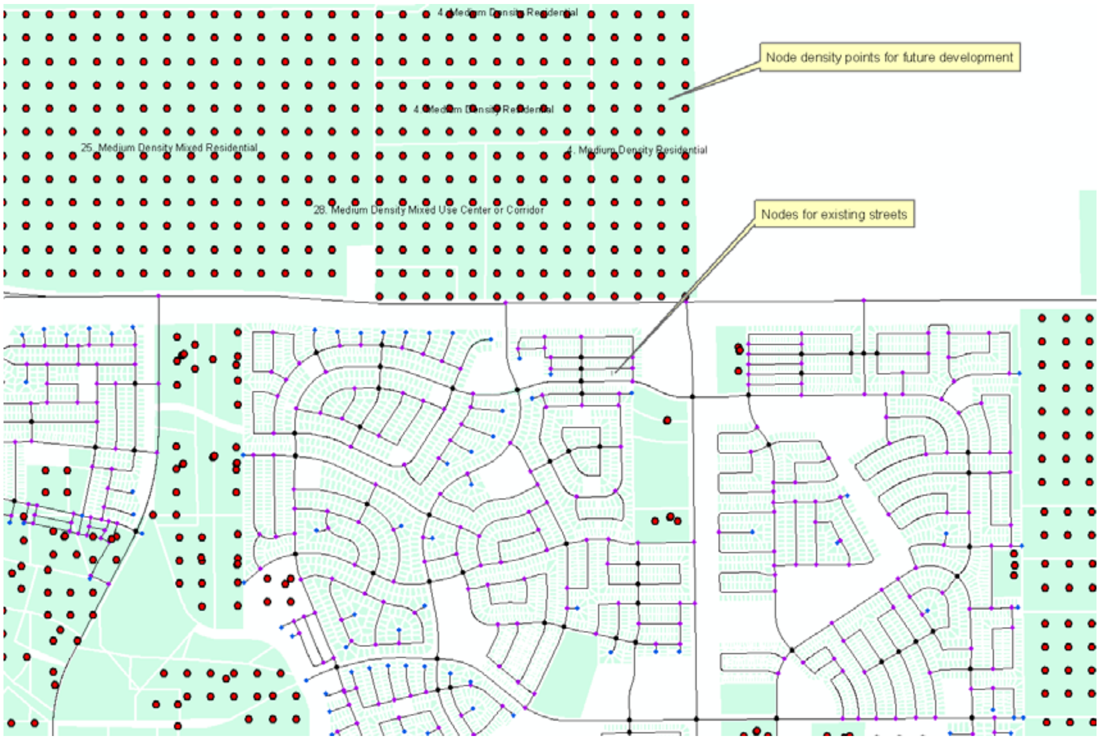
Place type	1-Link Intersections per acre	3-Link Intersections per acre	3-Link Intersections per acre
1. Rural Residential	0.01519	0.02503	0.00707
2. Very Low Density Residential	0.01519	0.02503	0.00707
3. Low Density Residential	0.09786	0.16279	0.03149
4. Medium Density Residential	0.13402	0.26355	0.08176
5. Medium-High Density Residential	0.03113	0.26849	0.10475
6. High Density Residential	0.01920	0.10301	0.37885
7. Urban Residential	0.01920	0.10301	0.37885
9. Moderate-Intensity Office	0.00007	0.00019	0.00008
10. Community/Neighborhood Retail	0.00051	0.00124	0.00016
11. Regional Retail	0.00018	0.00031	0.00019
12. Light Industrial – Office	0.00007	0.00019	0.00008
13. Light Industrial	0.00004	0.00009	0.00004
14. Heavy Industrial	0.00004	0.00009	0.00004
15. Public/Quasi-Public	0.00051	0.00124	0.00016
16. Community/Neighborhood Commercial/Office	0.00051	0.00124	0.00016
16a. Community/Neighborhood Commercial/Office – Modified	0.00051	0.00124	0.00016
17. Regional Commercial/Office	0.00007	0.00019	0.00008
18. Mixed Use Employment Focus	0.03113	0.26849	0.10475

Place type	1-Link Intersections per acre	3-Link Intersections per acre	3-Link Intersections per acre
19. Mixed Use Residential Focus	0.03113	0.26849	0.10475
24. Low Density Mixed Residential	0.09786	0.16279	0.03149
25. Medium Density Mixed Residential	0.13402	0.26355	0.08176
24C. Low Density Mixed Residential	0.09786	0.16279	0.03149
25C. Medium Density Mixed Residential C	0.13402	0.26355	0.08176
26. High Density Mixed Residential	0.01920	0.10301	0.37885
27. Low Density Mixed Use Center or Corridor	0.00051	0.00124	0.00016
28. Medium Density Mixed Use Center or Corridor	0.09786	0.16279	0.03149
29. High Density Mixed Use Center or Corridor	0.13402	0.26355	0.08176
30. NEW MIXED USE CENTER OR CORRIDOR	0.09786	0.16279	0.03149
31. Suburban Center/Corridor	0.00051	0.00124	0.00016
32. Minor (Outer) Urban Center/Corridor	0.09786	0.16279	0.03149
36. Urban Reserve	0.09786	0.16279	0.03149
47. Agricultural Residential	0.01519	0.02503	0.00707
50. K-12 Schools	0.09786	0.16279	0.03149
H. Public/Quasi-Public*	0.00051	0.00124	0.00016
O. Low Density Mixed-Use Center/Corridor*	0.00051	0.00124	0.00016
P. Medium Density Mixed Use Center/Corridor*	0.09786	0.16279	0.03149
Q. High-Density Mixed Use Center/Corridor*	0.03113	0.26849	0.10475
R. Employment Focus Mixed Use Center/Corridor*	0.03113	0.26849	0.10475
Woodbury	0.09786	0.16279	0.03149
Isleton greenfields	0.01519	0.02503	0.00707
UCD Village	0.03113	0.26849	0.10475
spring valley south	0.03113	0.26849	0.10475
51. University/College	0.03113	0.26849	0.10475
8. High-Intensity Office	0.01921	0.10301	0.37886
34. New Area SF	0.09786	0.16279	0.03149
47. Medical Facility	0.00007	0.00019	0.00008
Source: SACOG, November 2008.			

The first step in determining where to generate the grids of synthetic nodes is to identify those areas where future greenfield development will occur. The figure below 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.

Figure 1-4. Synthetic Nodes for Future Development Street Pattern



Source: SACOG, November 2008.

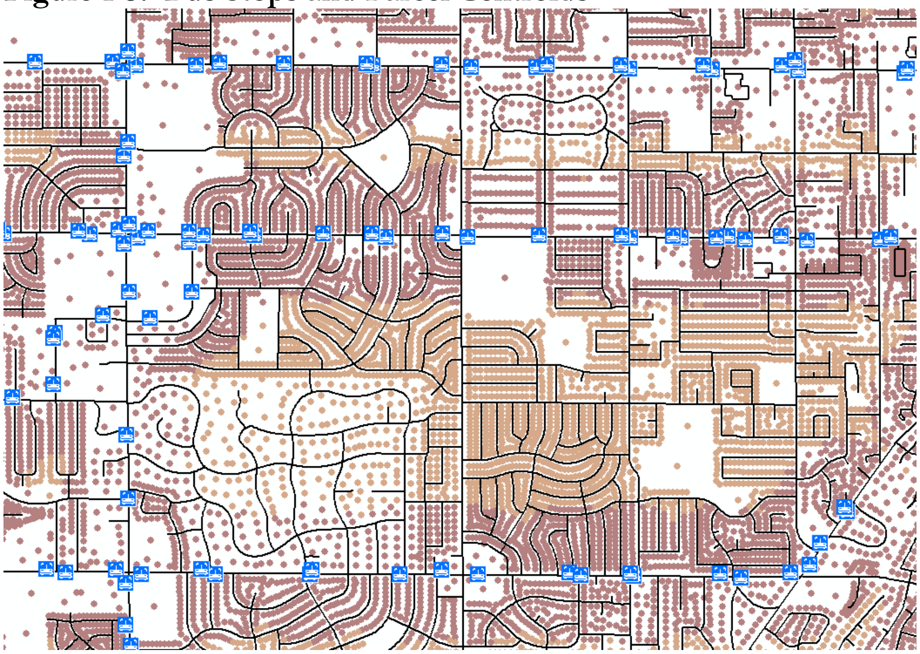
Transit Proximity Variables (DIST_LRT, DIST_BUS)

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.

Parking Supply and Cost Variables

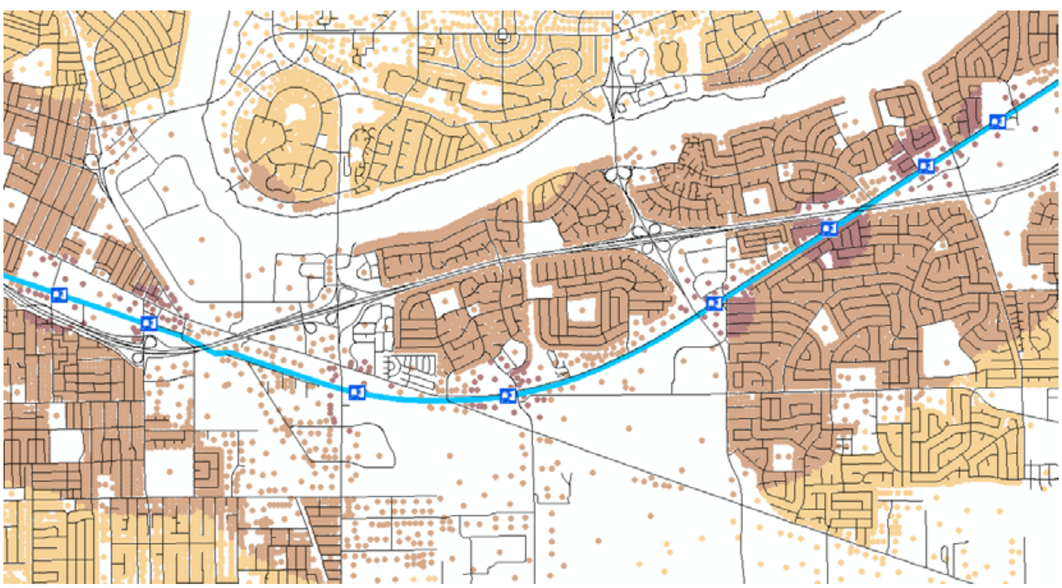
Only one sort of parking is included in SACSIM: off-street, paid parking. Both supply and cost variables are included.

Figure 1-5. Bus Stops and Parcel Centroids



Source: SACOG, November 2008.

Figure 1-6. LRT Stations and Parcel Centroids



Source: SACOG, November 2008.

Supply variables include the number of off-street, paid parking spaces on a parcel, split into spaces available hourly (PARKHR*) and daily spaces (PARKDY*). 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.

The hourly (PPRICHR*) and daily (PPRICDY*) posted rates charged at facilities are included in the file.

Employment Data

Employment variables are:

- Education (EMPEDU_*);
- Food service (EMPFOOD*);
- Government (EMPGOV_*);
- Office (EMPOFC_*);
- Other (EMPOTH_*);
- Retail (EMPRET_*);
- Service (EMPSVC_*);
- Medical (EMPMED_*);
- Industrial (EMPIND_*); and
- Total employment (EMPTOT_*).

SACSIM employment definitions are sector based; 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.). The sector definitions are based on IMPLAN[5] industrial sector definitions (see Table 1-3). These definitions were applied and used by SACOG in establishing its iPlace3s land use scenario analysis system. Future iterations of iPlace3s, as well as SACOG's employment inventories, will be based on the North American Industrial Classification System (NAICS). Rough, 2-digit NAICS codes for the SACSIM employment categories are provided in the table; however, as NAICS is fully implemented in SACOG's employment inventory and iPlace3s employment sector definitions, 3-, 4-, and 5- digit NAICS codes will be used to refine the sector definitions.

Processing of Medical Employment

Medical employment is defined differently between iPlace3s and SACSIM. Medical employment is generated in iPlace3s by one place type: Medical Facility, which is defined as hospitals and major medical centers, with 400 or more employees. SACSIM requires a more expansive definition of medical employment, which includes both hospitals/major medical centers, plus medical employment in smaller offices, clinics, etc. Most of this medical sector employment is dispursed and mixed in office and business park areas, with higher concentrations located around hospitals and major medical centers. In order to resolve this inconsistency in definition, a portion of the employment in office and service areas is "converted" to medical; additionally, the portion of the total employment which is so converted varies directly with proximity to hospitals/major medical centers. That is, the closer an office- or service- employment generating use is to a hospital/major medical center, the greater the proportion of total employment which is likely to be medical.

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[5] "IMPLAN" is a trademarked name for an economic impact modeling system, developed by Minnesota IMPLAN Group (MIG), Inc. As part of the modeling system, MIG, Inc. developed a set of codes for industrial sectors.

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Table 1-3. SACSIM Employment Sector Categories and Definitions

SACSIM Employment Category	Description	IMPLAN 2001 Codes	NAICS 2007 2-Digit Codes
Education (K12)	Elementary, Middle, Junior High, and High Schools	461	61
Education (University/ College)	Community College, State University, Univeristy of California	462	61
Food	Food Services and Drinking Places	481	72
Government	Non-Utility and Non-Eduction City, County and State Offices and Enterprises	499, 504	92
Office	FIRE, Business Services, Membership and Non-Profit Orgs., Professional Services	41-45,423-431, 437-455, 457-460, 463, 475, 485, 491-493	52-55
Other	Military, Unclassified	505 + many other residual categories	81
Retail	Retail Trade	401-412	44,45
Services	Automotive & Transportation, Amusement, Personal Services	391-398, 432-436, 456, 469-472, 476-478, 482, 483,	48, 71, 81
Medical	Health Services	464-468	62
Industrial	Agriculture/Mining, Construction, Manufacturing, Comm./Utilities, Wholesale Trade	1-41, 46-400, 495-498	11,21-23, 31-33, 42
Source: SACOG, November 2008.			

Figure 1-7 below shows clusters of parcels that represent major medical centers. The center cluster is Mercy General Hospital with 1,595 employees combined from seven parcels. SACOG research showed that other, small office and clinic medical employment clustered around hospitals and major medical centers (Figure 1-7).

Figure 1-7. Hospital/Major Medical Center Employment

A simple model of proportions was hand fitted to predict the proportion of the total office and service employment would be medical, based on three factors: straightline distance from parcel to the nearest hospital or major medical center; size of the nearest hospital/major medical center; and dummy variables for areas with high intensity office development, or multiple clusters of hospitals. The model is applied at parcel level, but was fitted to observed data aggregated to regional analysis district. The model is presented in Table 1-4, along with goodness of fit measure (a simple regression of predicted vs. observed medical employment by regional analysis district.

Buffering/Proximity Calculations

Of the twenty-eight SACSIM variables on the parcel file, twenty require buffered formulations as well as parcel values. The buffered values are computed as straight-line radius distance from the parcel centroid, based on the X and Y coordinate values of the surrounding parcels. This operation is executed in PYTHON, and not as a GIS application.

Table 1-4. Medical Employment Split Model

Final Model: P (Medical / Office + Service Empl) = Scale x ParcDistFac x Dummy	**Coefficient**
Scale (Size of the Hospital/Major Medical Center: (Emp[H/MC] / 2000)^0.2	
if Scale > 1.2	1.20
if Scale = 0.85 to 1.2	1.00
if Scale <0.85	0.85
Parcel Dist. From H/MC	
0.00 to 0.49 mi	0.65
0.50 to 1.49 mi	0.28
1.50 to 1.99 mi	0.12
>2.00 mi	0.08
Dummy Variables (multiplier)	
Parcel in CBD	0.02
Parcel in Midtown	0.33
Parcel in East Sac	0.50
Goodness of Fit	
Adj R-squared	0.93
Source: SACOG, November 2008.	

Reasonable-ness of Dwelling Unit, Household and Employment Estimates

No independent data source exists which allows for validation of small area estimates of dwellings or employment. Table 1-5 provides comparison of regionwide totals of households, jobs, and K12 school enrollments from SACSIM against other independent data sources. SACSIM model data is within two percent of regionwide totals. Retail jobs per household are reasonable (0.23).

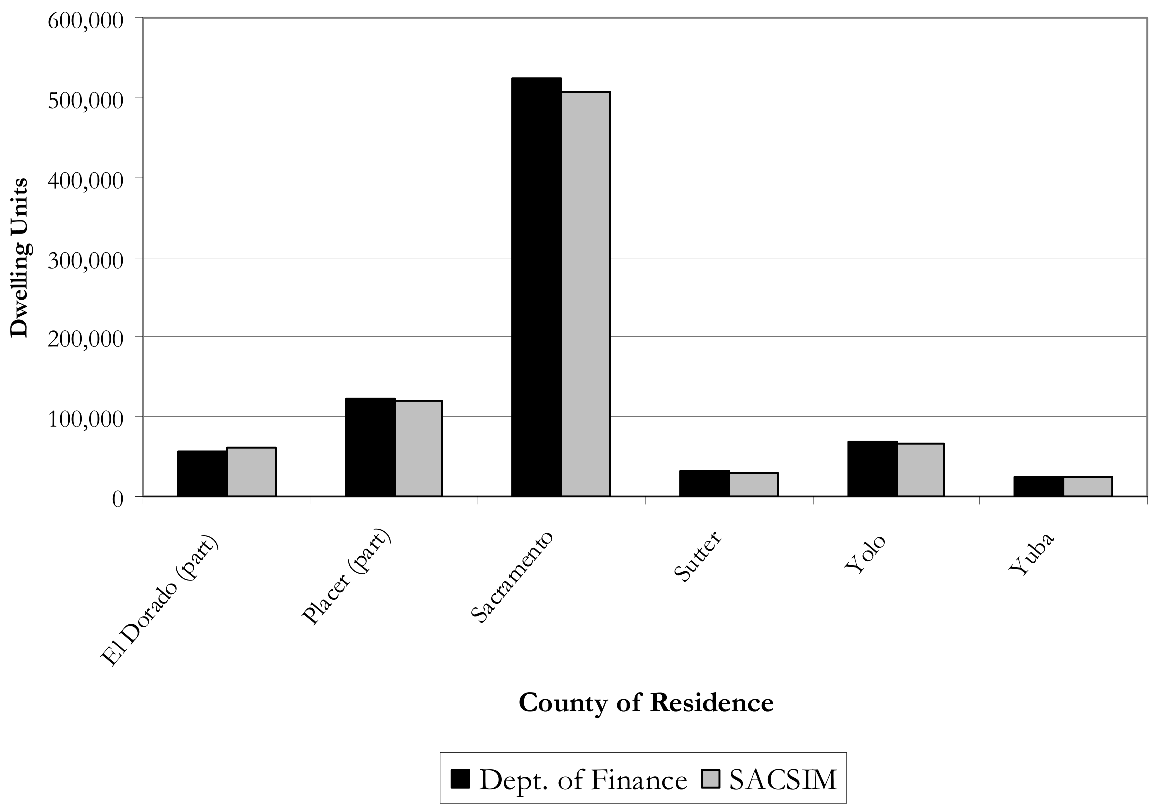
Figure 1-8 provides comparisons of dwelling units by county. SACSIM model data matches county totals closely.

Table 1-5. Year 2005 SACOG Region Parcel Data

Variable	Observed	SACSIM	Validation Ratio
Households[1]	787,000	768,082	0.98
Total Jobs[2]	1,016,000	1,000,887	0.99
Retail Jobs		230,877	n/a
K12 Enrollments[3]	384,000	391,995	1.02
Retail Jobs / HH	n/a	0.23	n/a
K12 Enr / HH	0.49	0.51	1.05

Source: SACOG, November 2008.
[1] California Department of Finance Projections.
[2] Levy, Stephen, California Center for Continuing Study of the California Economy.
[3] California Department of Education, Educational Demographics Office (CBEDS, assign05 8/18/06, pubschls 8/4/06, sfib0506 8/22/06)

Figure 1-8. Year 2005 Dwelling Units by County



Source: SACOG, November 2008.

2--Representative Population Data

By policy, SACOG projections include detailed population demographics for variables like household size, age and income. Additionally, SACOG has developed a new, person-level travel demand micro-simulation model called SACSIM, which was utilized for the 2008 Metropolitan Transportation Plan. SACSIM requires detailed demographics in a "representative population" (a.k.a. "synthetic population") dataset for forecasting transportation demand. Historically, there has been no process to ensure that these key variables are directly represented in future year projections. This chapter describes the process for directly representing demographic variables in the Board-adopted regional growth forecasts in small-area datasets used for forecasting transportation demand.

Regional Population Projections

SACOG has relied on outside researchers and consultants to prepare long range, region-level projections of population, housing, and jobs. The most recent of these region-level projections was prepared by the Center for the Continuing Study of the California Economy[6]. These projections were adopted by the SACOG Board[7], for use in development and analysis of the recently-adopted MTP. Although vital to providing a economic and demographic projection of the future for the region as a whole, the region-level projections can not be used directly in preparing transportation demand forecasts. Transportation forecasts require demographic data to be subtotaled for small areas within the region. The Board-adopted region-level projections serve as control totals and guidance for development of spatially detailed, small area projections.

iPlace^{3}s Parcel-Based Land Use Scenarios

Working within the region-level control totals, SACOG staff works iteratively with the Planners' Committee to prepare jurisdiction-level growth allocations. SACOG staff allocations are prepared based on existing inventories of residential and employment developable acreage by jurisdiction, an accounting of land use policy actions currently under way (e.g. general plan amendments, specific plans, spheres of influence, etc.), and an accounting of future anticipated land use policy changes (e.g. future annexations, etc.). Current inventories and land use policies for undeveloped areas are maintained in SACOG iPlace3s land use scenario analysis software. SACOG iPlace3s is maintained at parcel level[8], and is available for outside review at that level; however, the primary Planners' Committee review and comment is provided at jurisdiction level, and specific/community plan areas within jurisdictions. Once consensus is reached at the

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6 Levy, Stephen, "Projections of Employment, Population, Households and Household Income in the SACOG Region for 2000 – 2050", prepared by Center for Continuing Study of the California Economy for SACOG, August 23, 2005.
7 SACOG Board meeting, September 2005.
8 SACOG iPlace3s parcels are based on the 2004 parcel boundaries. Some large parcels with future growth expected were split down to "pseudo-parcels" to better represent future planned land use patterns and mix of use.

Planners' Committee, the jurisdiction level land use allocations, the allocations are taken to the SACOG Board for review and adoption[9].

iPlace3s land use scenarios include "yield" estimates of a range of land use variables at parcel level. Two variables are used directly in the travel demand models: total households; and jobs by sector. The yield estimates are based on the "place type" (generalized land use) of the parcel, the parcel area, and a number of physical, environmental, or policy constraints which apply to a given parcel. Yield estimates are calibrated to match small area inventories of dwellings and jobs for the forecasting 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 scenario, and constraints expected to be in place at each parcel in the future year.

Developing Small Area Demographics for Travel Models

The remainder of this memorandum focuses on the development of detailed demographics for small areas within the SACOG region for use in travel demand forecasting. iPlace3s itself does not currently have capability to generate detailed population demographics. iPlace3s estimates of households are post-processed to apply demographic details. The starting assumption in the post-processing is that *dwelling unit type* is the most powerful variable for "tagging" detailed demographics to households. The strong correlation between dwelling type, demographics and travel behavior was documented in prior memoranda[10]. Table 2-1 provides key points of comparison from prior work.

Table 2-1. Household Demographic Characteristics by Dwelling Type

Dwelling Type	Households #	Households %	Pers/ HH	Wkr/ HH	% Zero Wkr	% Zero Auto	% < $15,000 HH Income
One Unit Det.	460,946	66.4%	2.78	1.30	22.2%	3.6%	9.0%
One Unit Att.	41,146	5.9%	2.43	1.10	26.8%	6.3%	14.4%
Mobile Homes	28,281	4.1%	2.01	0.78	44.8%	10.3%	23.4%
Combined	530,373	76.4%	2.71	1.25	23.8%	4.2%	10.2%
2 to 4 Units	47,365	6.8%	2.36	0.99	30.5%	15.1%	23.1%
5 or More Units	116,318	16.8%	2.01	0.91	33.3%	19.9%	26.8%
All	694,056	100.0%	2.57	1.18	25.9%	7.6%	13.9%

Source: SACOG, based on 2000 Census Transportation Planning Package data.

The Year 2000 Census Transportation Planning Package data files were used to establish persons-by-workers-by-income-by-dwelling-type proportions files by regional analysis district.

[9] For the 2008 MTP, the final SACOG Board adoption of jurisdiction-level growth allocations took place at the May 2007 meeting.
[10] Griesenbeck, Bruce, "Data Needs for Travel Models and Approaches to Forecasting Household Structure", memorandum to Gordon Garry, et al, SACOG, December 16, 2005.

Prior memoranda also document this process[11]. Three proportions files were created: one for households in single family dwellings; one for households in dwelling structures with 2-to-4 units; and one for households in dwelling structures with 5-or-more units. Each proportion file expresses the proportion of households which fall into a 65-cell persons-by-workers-by-income-class (P-W-I) scheme. The proportions files are used to compute the number of households in each TAZ which fall into each of the 65 cells in the cross-classification. Obviously, the proportions vary significantly by dwelling type; they also vary by geography at regional analysis district level.

SACMET Cross-Classified Households (HHMV) File

iPlace3s parcel-level estimates of total dwelling units are split into households by type in the first of three post-processing steps. iPlace3s total dwelling units are split into dwellings by type by applying lookup tables by place type. For higher-residential-density place types, the lookup tables split higher shares to multi-family dwelling; for lower density place types, the lookup tables split higher shares to single-family dwellings; and so on.

In a second post-processing step, the households by dwelling type are then split into the P-W-I "cells" using the above referenced CTPP demographic split files. The cross classification scheme includes 65 cells, with each cell representing a unique P-W-I combination. The classification scheme include: 4 household size categories (1, 2, 3, and 4+ persons per household); 4 workers-per-household categories (0, 1, 2 and 3+ workers); and 5 income categories (<$10,000; $10,000-19,999; $20,000-34,999; $35,000-49,999; $50,000-74,999; $75,000+). So, for example: Cell 1 includes households with 1 person, zero workers, and income class 1; Cell 2 includes households with 1 person, zero workers, and income class 2; and so on to Cell 65, with households with 4+ persons, 3+ workers, and income class 5.

In a third post-processing step, the three cross-classified files (single family, multi-family 2-4 units, and multi-family 5+ units) are added together by the 65 cells to get an "all households" total.

If the file is a future year forecast, the income distribution is adjusted to reflect the increasing real household incomes projected by CCSCE[12]. If the file is for the forecasting base year (2005), no adjustment to household income is made, and the distribution of income reflects that present in the Year 2000 Census.

Figure 2-1 illustrates how the proportions files are applied to iPlace3s-generated estimates of dwellings and households to create the cross-classified households files (the so-called HHMV

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[11] Griesenbeck, Bruce, "2000 Census CTPP—Results of Iterative Proportional Factoring of Selected Cross-Tabulations", memorandum to Gordon Garry, et al, SACOG, December 21, 2005, plus two subsequent follow-up memoranda.
[12] Levy, Stephen, "Projections of Employment, Population, Households and Household Income in the SACOG Region for 2000 – 2050", pp. 19-22.

files) for SACMET. The SACMET HHMV file becomes the basis for generation of the SACSIM representative population.

SACSIM Representative Populations

SACSIM is based on a more detailed representative population file, rather than the more aggregate cross-classified household file required by SACMET. A representative population is defined as: A datafile representing a regional population, with each person represented by one record in the datafile. The file is created by randomly drawing from a bank of Public Use Micro-Sample households, and enumerating the persons in the households based on the PUMS characteristics. The generation of the representative population file is controlled by: 1) geography (TAZ-level); household size distribution; workers-per-household distribution; income class distribution; and age of the householder. By "control", it is meant that the representative population matched pre-set, simultaneous distributions of the control variables at TAZ level.

Representative population files are required for mirco-simulation travel demand models, because each persons travel activities are represented. Micro-simulation travel demand models, like SACSIM, have the added advantage of requiring minimal calibration to account for aggregation which is required for TAZ/aggregate models; in micro-simulation travel demand models, discrete choice models are applied at person level, which is consistent with the level of estimation of the models.

The SACMET HHMV files for a given scenario are the basis for the control file for generating the SACSIM representative population. If the scenario is a future year, the age of the householder distribution is adjusted to reflect the CCSCE projected aging of the population[13]. Currently, the age distribution is treated as binary, with households classified as headed by persons aged less-than-55-years, or greater-than-or-equal-to-55-years. The distribution is applied at PUMA[14] level. The splits in the binary age distribution in the Year 2000 PUMS files by PUMA are adjusted to reflect aging of the population over time. This effectively doubles the number of cells in the control file, from 65 (the SACMET P-W-I scheme) to 130 (with two age categories in each P-W-I cell). The SACSIM demographic control file is generated from this 130-cell file. For each TAZ, the control file specifies the number of households which should be included in each cell in the representative population.

The SACSIM population synthesizer reads the demographic control file and the SACSIM parcel data file. The only field read from the parcel file is the number of households per parcel TAZ of each parcel. A separate file includes a correspondence of TAZ's to PUMA's; PUMA is needed to allow the random draws to be made from the PUMS databank. The population synthesizer executes random draws from the PUMS databank to fill up each cell in each TAZ to match the control file for that TAZ and cell. Within each TAZ, the allocation of households to parcels is

[13] Ibid, pp. 25-26.
[14] Public Use Micro-sample Area. This is the greography included in the PUMS files.

determined by the number of households in the parcel file. The allocation of households to parcel within each TAZ is random.

The resulting population file matches very closely the control file demographics. However, the file includes several added variables which are attached to the PUMS records: an exact number of persons-per-household, instead of the simpler 4-category scheme in the control file; exact numbers of workers-per-household, instead of the simpler 4-category scheme; exact household income, instead of the simpler 5-category scheme; exact age of each person in the household; worker status of each person (full-time worker, part-time worker, or non-worker); and student status of each person (K-12 student, college/university student, or non-student). These added variables are extremely important in predicting travel behavior, and are included in the various discrete choice models which make up SACSIM. Although not controlled explicitly in the synthesis process, basic reasonable-ness checks are performed on the regional totals of each added variables.

The basic steps to produce the SACSIM representative population files are illustrated in Figure 2-2.

Special Treatment of "Clustered" University Student Households

Not illustrated in Figure 2 is an additional step, to account for the clustering of university student households in on-campus dormitories, and in off-campus dwellings in close proximity to universities. This step is currently only performed for Sacramento State; similar treatment of clustered university student households at UC Davis is in development.

For Sacramento State, a portion of the enrolled students live in on-campus dormitories, or in dwellings immediately north of the campus across the Guy West Bridge, or immediately east of the Campus along La Riviera. Explicitly representing these concentrations of students is important for travel demand modeling, because these students are highly likely to walk, bike or take campus shuttles to school, rather than drive and pay for parking.

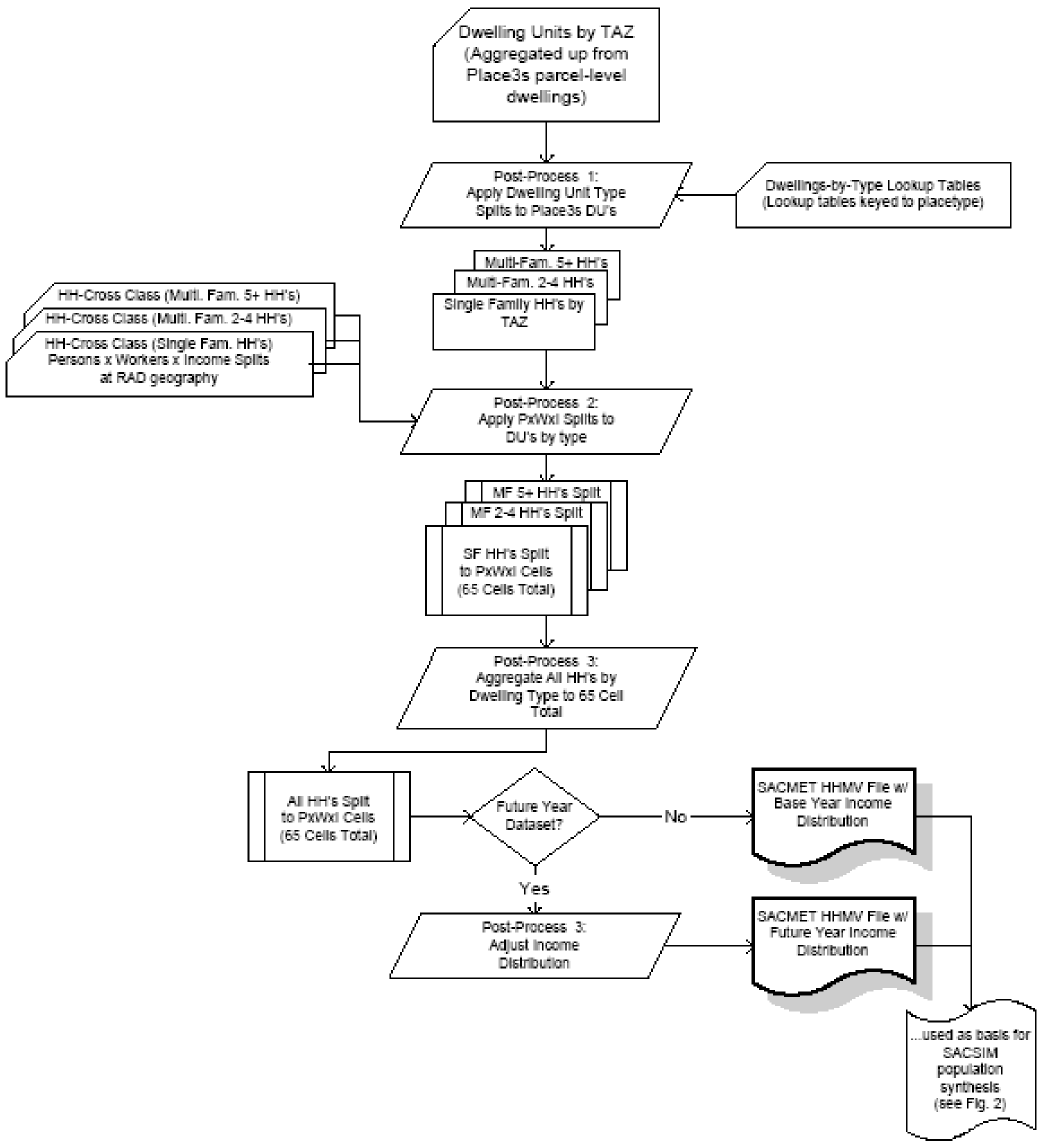
The clustering of university students in these areas was estimated by using frequencies of enrolled students residence zip codes provided by Sacramento State. A separate population synthesis was prepared for these students.

The synthesis process was identical to that for the general population, as illustrated in Figure 2. However, the key input files were different, as follows:

- The demographic control file was developed directly from PUMS data, filtered to include only households of one or two persons, with all persons in the household university students, and residing in the PUMA which includes Sacramento State.
- The PUMS databank was similarly screened to include only households of one or two university students, residing in the Sacramento State PUMA.
- The parcel file was modified to include only on-campus dormitory units, and a clustering of units in the two areas north and east of the campus.

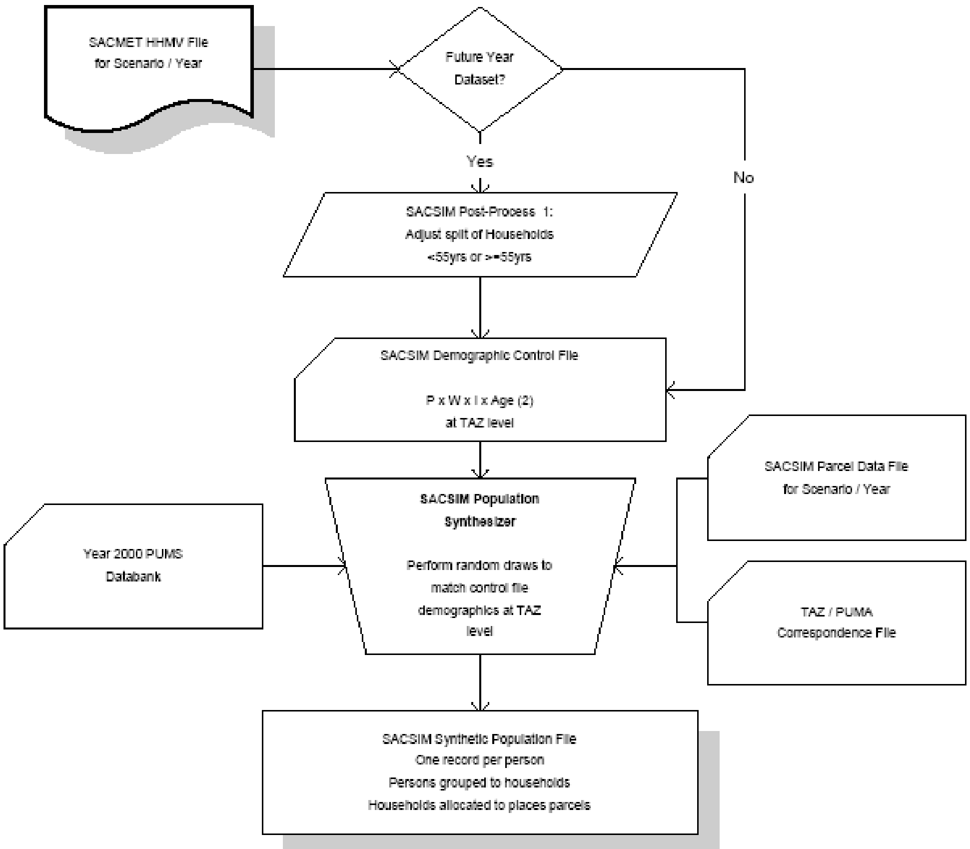
The resulting clustered university student population was added to the general population file.

Figure 2-1. Processing of SACMET Cross-Classified Household File



Source: SACOG, November 2008.

Figure 2-2. Processing of SACSIM Representative Population File



Source: SACOG, November 2008.

Reasonable-ness of Representative Population File

The only data source which can be used for comprehensive validation of the population file is the 2000 Census. This is not a wholly independent validation comparison, since the Census was used to develop the control file for generating the representative population file, though. This comparison is more a quality control check, to ensure that the drawing of the population was correctly controlled to the Census.

Tables 2-2 through 2-5 provide tabulations of household size, workers per household, household income, and persons of drivers age per household distributions, comparing the SACSIM representative population to the Census CTPP data for Year 2000. In general, county totals for each distribution are within five percent of the Census for each variable. One exception is for Yuba County, where some distribution cells deviate from the Census by over ten percent in some cases (e.g. income, workers per household, and driver age persons per household). Yuba County is the smallest of the counties, and has a very limited distribution of dwelling unit types for some areas, which leads to some lumpiness in the population synthesis process. Also, Yuba and Sutter Counties are combined into one PUMA, and the Sutter County demographics overwhelm the Yuba County demographics due to the higher population in Sutter County.

Figures 2-3 through 2-6 illustrate comparisons the SACSIM representative population to the Census for the same demographic variables and distributions by regional analysis district. The RAD-level comparisons confirm that even at smaller, sub-county geography the representative population file closely matches the Census.

Table 2-2. Year 2000 Household Size Distribution (SACSIM vs. Census)

County	Persons Per Household				
	1	2	3	4+	Total
Census					
El Dorado	8,400	17,786	7,233	12,100	45,519
Placer	18,416	32,047	14,542	23,680	88,685
Sacramento	121,682	142,359	72,000	117,782	453,823
Sutter	5,634	8,323	4,425	8,705	27,088
Yolo	13,953	18,624	10,028	16,740	59,345
Yuba	4,517	6,440	3,399	6,197	20,553
Total	172,603	225,578	111,628	185,204	695,013
SACSIM Representative Population					
El Dorado	8,299	17,759	7,416	12,045	45,519
Placer	18,623	32,052	14,720	23,290	88,685
Sacramento	121,869	142,576	72,351	117,024	453,820
Sutter	5,849	8,509	4,413	8,317	27,088
Yolo	14,177	18,570	10,027	16,571	59,345
Yuba	4,540	6,578	3,188	6,247	20,553
Total	173,357	226,044	112,115	183,494	695,010
SACSIM % Difference from Census					
El Dorado	-1.2%	-0.1%	2.5%	-0.5%	0.0%
Placer	1.1%	0.0%	1.2%	-1.6%	0.0%
Sacramento	0.2%	0.2%	0.5%	-0.6%	0.0%
Sutter	3.8%	2.2%	-0.3%	-4.5%	0.0%
Yolo	1.6%	-0.3%	0.0%	-1.0%	0.0%
Yuba	0.5%	2.1%	-6.2%	0.8%	0.0%
Total	0.4%	0.2%	0.4%	-0.9%	0.0%
Source: SACOG, November 2008.					

Table 2-3. Year 2000 Workers Per Household (SACSIM vs. Census)

County	Workers Per Household				
	0	1	2	3+	Total
Census					
El Dorado	12,228	15,947	14,433	2,912	45,519
Placer	22,189	31,614	29,088	5,795	88,685
Sacramento	116,909	177,802	133,238	25,873	453,823
Sutter	8,002	9,861	7,709	1,516	27,088
Yolo	14,710	21,830	18,555	4,250	59,345
Yuba	6,597	7,908	4,954	1,094	20,553
Total	180,635	264,962	207,977	41,440	695,013
SACSIM Representative Population					
El Dorado	11,992	16,113	14,512	2,902	45,519
Placer	22,358	31,648	29,032	5,647	88,685
Sacramento	116,246	178,469	133,406	25,699	453,820
Sutter	8,185	10,089	7,335	1,479	27,088
Yolo	14,550	21,835	18,648	4,312	59,345
Yuba	6,150	7,462	5,777	1,164	20,553
Total	179,481	265,616	208,710	41,203	695,010
SACSIM % Difference from Census					
El Dorado	-1.9%	1.0%	0.5%	-0.3%	0.0%
Placer	0.8%	0.1%	-0.2%	-2.6%	0.0%
Sacramento	-0.6%	0.4%	0.1%	-0.7%	0.0%
Sutter	2.3%	2.3%	-4.8%	-2.4%	0.0%
Yolo	-1.1%	0.0%	0.5%	1.5%	0.0%
Yuba	-6.8%	-5.6%	16.6%	6.4%	0.0%
Total	-0.6%	0.2%	0.4%	-0.6%	0.0%

Source: SACOG, November 2008.

Table 2-4. Year 2000 Income Distribution (SACSIM vs. Census)

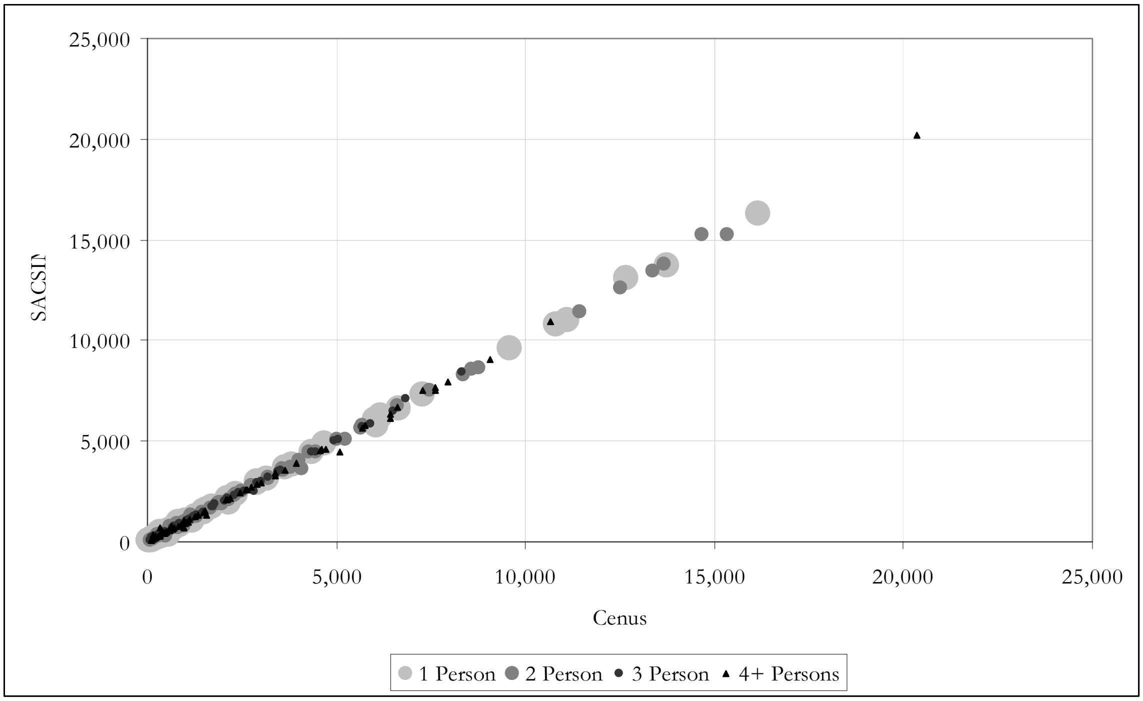
County	Household Income			
	<$50k	$50k-$75k	>$75k	Total
Census				
El Dorado	20,026	10,006	15,487	45,519
Placer	37,292	19,623	31,770	88,685
Sacramento	255,484	92,868	105,470	453,823
Sutter	16,859	5,186	5,044	27,088
Yolo	35,044	10,495	13,806	59,345
Yuba	15,534	2,928	2,091	20,553
Total	380,239	141,105	173,669	695,013
SACSIM Representative Population				
El Dorado	19,985	10,071	15,463	45,519
Placer	37,737	19,763	31,185	88,685
Sacramento	257,300	93,300	103,220	453,820
Sutter	17,311	4,947	4,830	27,088
Yolo	34,609	10,562	14,174	59,345
Yuba	13,287	3,798	3,468	20,553
Total	380,229	142,441	172,340	695,010
SACSIM % Difference from Census				
El Dorado	-0.2%	0.7%	-0.2%	0.0%
Placer	1.2%	0.7%	-1.8%	0.0%
Sacramento	0.7%	0.5%	-2.1%	0.0%
Sutter	2.7%	-4.6%	-4.2%	0.0%
Yolo	-1.2%	0.6%	2.7%	0.0%
Yuba	-14.5%	29.7%	65.8%	0.0%
Total	0.0%	0.9%	-0.8%	0.0%

Source: SACOG, November 2008.

Table 2-5. Year 2000 Driving Ager Persons Per Household (SACSIM vs. Census)

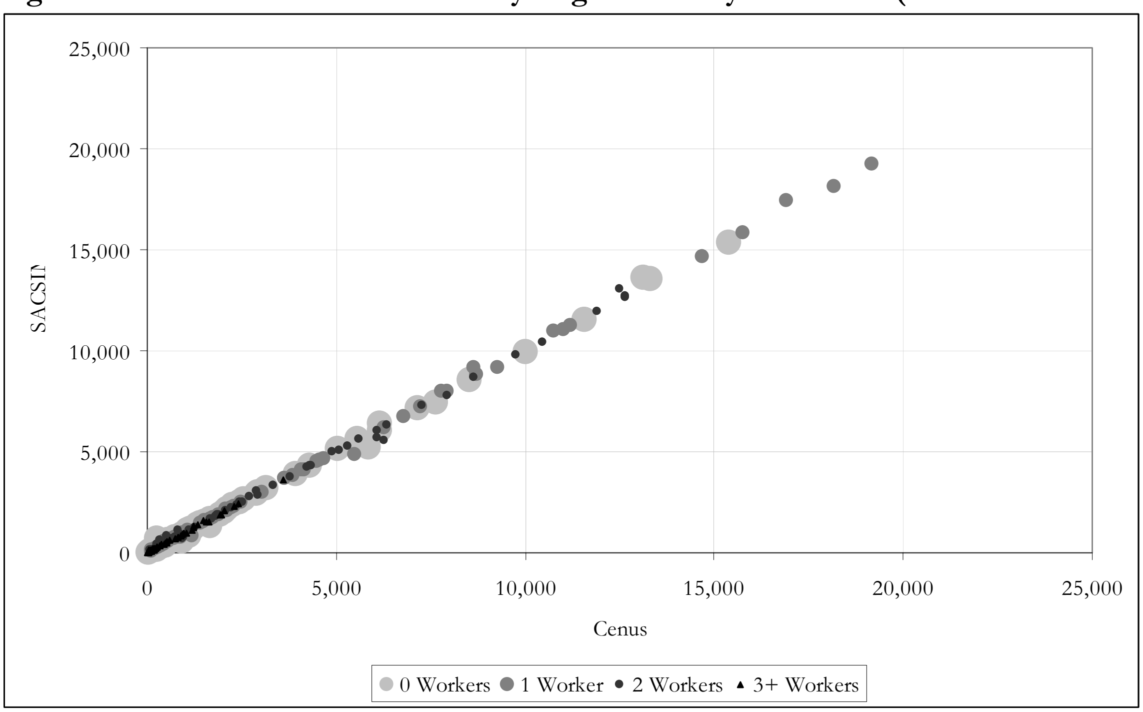
County	Persons Age 16+ Years				
	1	2	3	4+	Total
Census					
El Dorado	9,977	27,273	5,965	2,304	45,519
Placer	21,991	51,103	11,015	4,576	88,685
Sacramento	145,988	222,353	56,880	28,602	453,823
Sutter	6,897	14,134	3,814	2,243	27,088
Yolo	16,522	30,054	8,098	4,670	59,345
Yuba	5,646	10,496	2,768	1,644	20,553
Total	207,022	355,412	88,541	44,039	695,013
SACSIM Representative Population					
El Dorado	9,890	27,506	5,880	2,243	45,519
Placer	22,117	51,141	11,152	4,275	88,685
Sacramento	148,305	222,302	54,641	28,572	453,820
Sutter	7,149	14,359	3,508	2,072	27,088
Yolo	16,856	29,747	7,825	4,917	59,345
Yuba	5,501	10,905	2,524	1,623	20,553
Total	209,818	355,960	85,530	43,702	695,010
SACSIM % Difference from Census					
El Dorado	-0.9%	0.9%	-1.4%	-2.6%	0.0%
Placer	0.6%	0.1%	1.2%	-6.6%	0.0%
Sacramento	1.6%	0.0%	-3.9%	-0.1%	0.0%
Sutter	3.7%	1.6%	-8.0%	-7.6%	0.0%
Yolo	2.0%	-1.0%	-3.4%	5.3%	0.0%
Yuba	-2.6%	3.9%	-8.8%	-1.3%	0.0%
Total	1.4%	0.2%	-3.4%	-0.8%	0.0%
Source: SACOG, November 2008.					

Figure 2-3. Household Size by Regional Analysis District (SACSIM vs. Census)



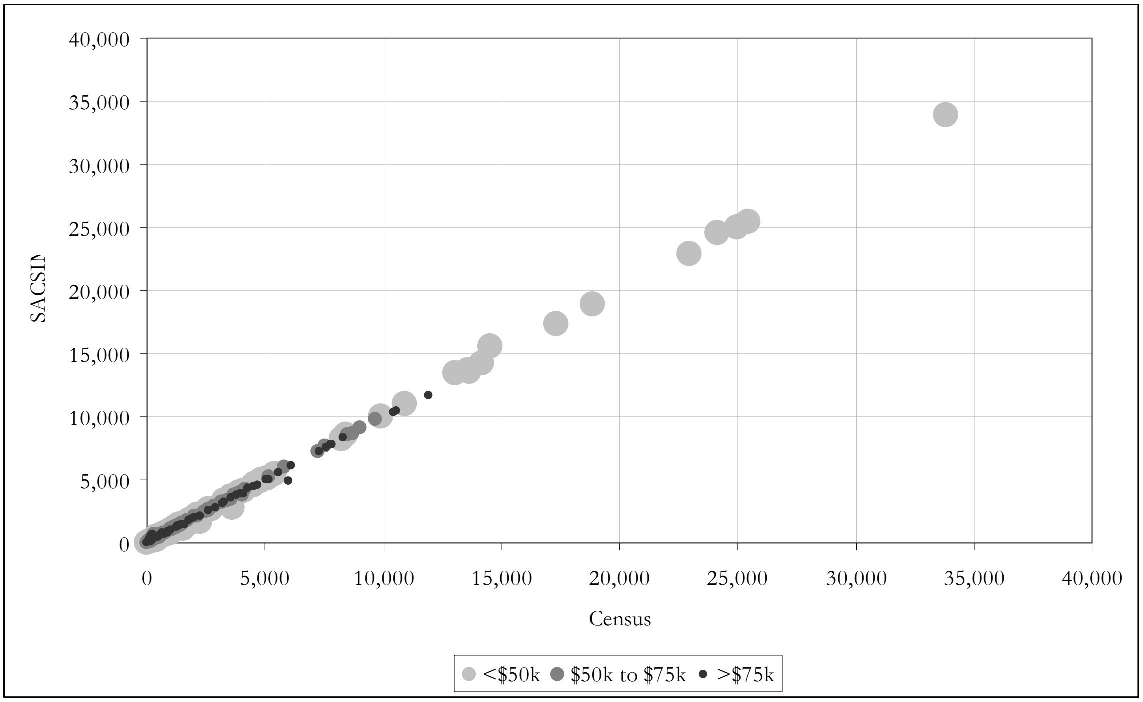
Source: SACOG, November 2008.

Figure 2-4. Workers Per Household by Regional Analysis District (SACSIM v. Census)



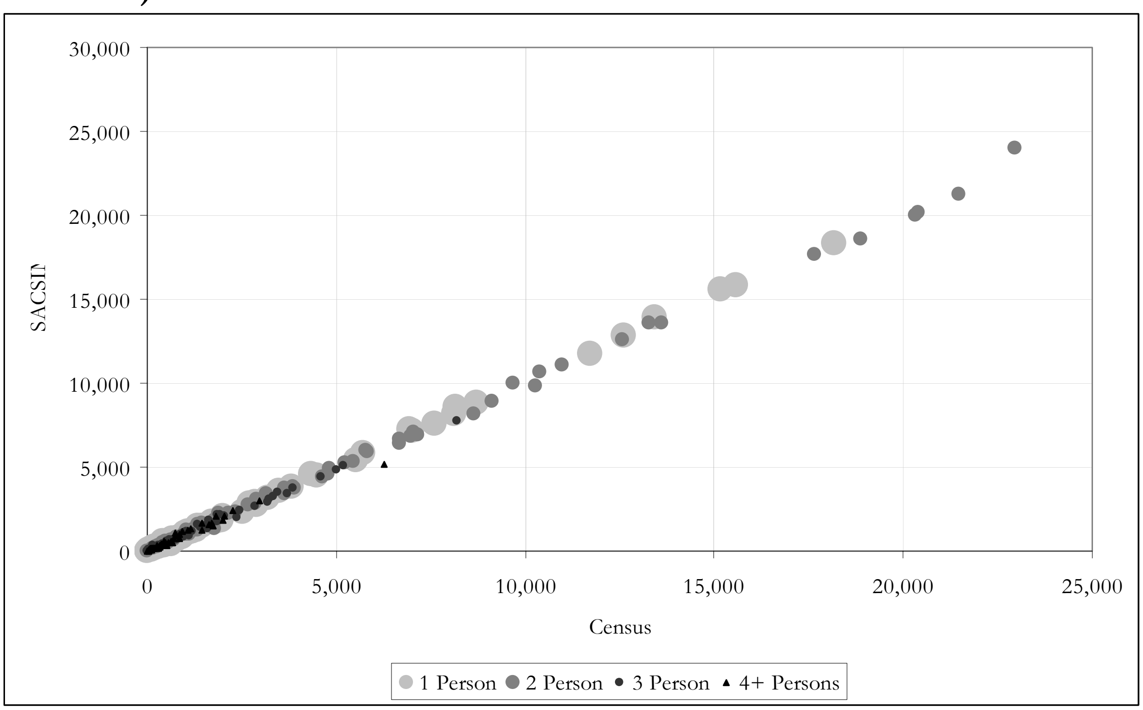
Source: SACOG, November 2008.

Figure 2-5. Household Income by Regional Analysis District (SACSIM vs. Census)



Source: SACOG, November 2008.

Figure 2-6. Driving Age Persons Per Houshold by Regional Analysis District (SACSIM vs. Census)



Source: SACOG, November 2008.

3--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. Appendix A provides a coding guide for model users.

Table 3-1 lists the variables coded to each highway link in the network. Links are directional; and two-way links are actually two distinct directional links. Most of the items are fairly conventional, but a few merit additional discussion. In prior versions of SACSIM, area type was coded into link capacity class, which used the 10's digit (e.g. capacity class "54" is area type "5" and link class "4"). This convention was abandonded with SACSIM07.

Table 3-1. Highway Network Variables

Property (SACSIM variable name)	**Convention**
TSVA (Free Flow Speed)	"Free-flow" speed, or average travel speed with no congestion.
DISTANCE	Link distance (miles).
CAPCLASS (Capacity Class Code)	Points to a lookup table of capacities. Values, in vehicles per hour per lane:
LANES	Number of through-lanes in the link's direction
SPDCURV (Speed-flow Curve Selector)	1 = Freeway 2 = Two-Lane Transitional Roadway 3 = Urban/Suburban Arterial
DELCURV (Ramp Meter Indicator)	0 = Not Metered 1 = Metered in the AM peak period 2 = Metered in the PM peak period
HOVLINK (Access Codes for Path Building and Assignment)	0 = All trips permitted 1 = Walk and bicycle trips only 2 = HOV-only facility in freeway 3 = HOV-only bypass lane at metered on-ramp
Note: HOVs are vehicles with two or more occupants.	

Capacity Class

Capacity classes should not be treated as black-or-white categories. 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. Some urban surface streets could arguably be classifyied in more than one way. Judgment is used to classify a specific existing roadway (based on its observed characteristics) or future roadway (based on the best planning information available). Note that capacity class for SACSIM purposes bears no intentional relation to Federal Aid functional classifications. The definitions below should provide background for the categories used in SACSIM, and guideance to modelers who are using SACSIM networks.

Freeways

A ***freeway*** is restricted access roadway facility, with all access to/from the facility 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; longer regional trips, such as commute trips. There are several "sub-classes" within the general capacity classification:

- Mixed flow facilities allow access to any vehicle at any time of day, regardless of occupancy within the vehicle.
- High occupancy vehicle (HOV) facilities allow vehicles with two-or-more passengers during peak commute periods, and allow any vehicle during other times.
- Auxiliary lanes are freeway lanes which connect from an on-ramp to the next downstream off-ramp. In other words, freeway auxiliary lanes are physically added at an on-ramp, and dropped at the next downstream off-ramp. Auxiliary lanes operationally serve as extensions of the subject on-ramp and off-ramp, and provide 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 free-flow speed 5 mph less than the "through" 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.

Expressways

An ***expressway*** is a multi-lane surface street w/ widely spaced signals (one-half mile or greater) and high level of driveway access control. Driveways to or from fronting properties are limited (e.g. by connecting to a frontage road or sidestreet, 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 Boulevar and Hazel Avenue crossings of the American River. All of 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 behaviours, are observed to operate at super-normal flows.

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 unsignalized cross street) may be allowed. 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 unsignalized sidestreets 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 unsignalized, however, generally only the sidestreet is controlled.

A ***collector*** 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. The majority of Collectors generally do not have median barriers.

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 very low capacity. An example of a low capacity ramp is the South River Road on-ramp to eastbound US-50 in West Sacramento.

Rural Roadways

A ***rural highway*** is a two-lane surface street in a rural area, generally controlled only on sidestreets, and with relatively high design speeds. Examples of rural highways are State Highway 65 north of the City of Lincoln, State Highway 99 north of Riego Road.

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

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.

Bike/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/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/walk links are intended to represent a combination of bike/walk routes or generalized bike/walk connectivity between two areas.

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 actually be built in the transit skimming process.

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

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

Hourly capacity in vehicles-per-lane-per-hour (vplph) are coded via a lookup table in the TP+ assignment scripts. Free-flow speeds are hard-coded to links, rather than a lookup table. Free flow speeds are coded based on local knowledge and judgment, and vary within specific capacity classes.

Other Highway Network Characteristics

Table 3-2 provides the vplph and ranges of speeds for each capacity class. As an additional reference point, Table 3-3 provides observed Year 2005 weekday traffic volumes *per direction* by capacity class.

Validation and Reasonable-ness Checking of Highway Networks

Because of the level of detail and the lack of available sources for independent checks of the highway network, true validation and reasonable-ness checks of the highway network as a whole are not possible. However, the freeway system coding was rigorously checked against "Freeway Lane Configuration Diagrams and Trafffic Monitoring Stations: Sacramento Metropolitan Area", published annually by Caltrans District 3. Other major surface streets were spot checked against aerial photos or field checked.

Table 3-2. 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	61.1	4.0	40	70
8	Freeway Lane (Pk Period HOV)	2000	63	63.0	0.0	63	63
51	Freeway (Auxiliary >= 1 mile)	2000	58	58.0	0.0	58	58
56	Freeway (Auxiliarn <1 mile)	1500	58	56.0	3.3	50	58
12	High Capacity River Crossing	1500	45	45.0	0.0	45	45
2	Expressway	1000	55	52.1	5.0	40	55
3	Major Arterial	850	40	37.2	6.6	15	50
4	Minor Arterial	800	35	32.8	8.6	10	50
5	Collector	700	25	29.2	7.0	10	50
6	Freeway Ramp	1500	20	21.2	4.5	20	55
	Ramp (Metered AM)	1500	20	21.1	5.0	20	55
	Ramp (Metered PM)	1500	20	20.0	0.0	20	20
26	Low Capacity Ramp	500	20	18.3	4.1	10	20
16	High Capacity Ramp/Connector	2000	45	41.7	9.9	20	63
6	Ramp (HOV Bypass)	1500	40	39.2	4.3	25	45
22	Rural Highway	1000	55	52.3	4.7	35	55
24	Rural Arterial	750	40	40.3	5.8	20	55
7	Walk/Bike	n/a	3	3.0	0.0	3	3
9	Connector (Mixed Flow-HOV)	1500	63	63.0	0.0	63	63
62	Connector (PNR-Roadway)	n/a	20	20.0	0.0	20	20
63	Centroid Connector (TAZ-Roadway)	n/a	20	20.0	0.0	20	20
99	Disabled	n/a	0	0.0	0.0	0	0

Table 3-3. 2005 Weekday Traffic Volumes

Capacity Class		Observed Daily Volumes (Directional)				
#	Description	Median	Average	Std.Dev.	Min	Max
1	Freeway (Mixed Flow)	45,515	51,598	33,094	3,225	135,348
12	High Capacity River Crossing	44,641	40,933	10,118	27,205	51,011
2	Expressway	26,825	27,916	11,755	15,696	53,650
3	Major Arterial	15,308	16,148	7,397	2,076	42,642
4	Minor Arterial	10,316	10,432	5,154	678	25,783
5	Collector	4,453	5,464	4,560	248	20,546
6	Freeway Ramp	2,755	3,959	4,200	30	18,400
	Ramp (Metered AM)	8,710	9,733	4,570	4,550	22,470
	Ramp (Metered PM)	8,500	8,500	500	8,000	9,000
22	Rural Highway	3,888	4,560	3,510	509	10,700
24	Rural Arterial	3,008	3,955	3,338	148	13,244

4--Transit Networks

The transit network is a computerized representation of the major transit systems in the SACOG area. In the SACSIM model (which uses the TP+ "TRNBLD" software), the transit network is essentially an overlay on the road network. It is specified primarily by designation of bus transit lines on the road 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 and can also represent time savings for buses traveling in HOV lanes. Appendix B provides a coding guide for model users.

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 4-1 provides a listing of the operators included. Each line operated on a fixed (or largely fixed) route, and with a published schedule, is coded into the SACSIM07 transit networks.

Table 4-2 provides a listing of the key variables coded for each transit line.

- The NAME of the line for most lines is a 4-space, alpha-numeric code. The first character of the NAME indicates the operator, as follows:
  - "L" = Regional Transit light rail lines
  - Any number = Regional Transit fixed route bus
  - "G" = Elk Grove Transit
  - "E" = El Dorado Transit
  - "R" = Roseville Transit
  - "Y" = Yolobus
  - "U" = Unitrans
  - "S" =Yuba/Sutter Transit
  - "C" = CSUS shuttle
- The second through fourth characters of the NAME are user defined identifiers for that line. For routes which operate two-ways (i.e. inbound and outbound), but for which the line is coded as two, one-way lines, the fifth character of the NAME is coded as "A" (for one direction of travel) and "B" for the other.
- TIMEFAC is a factor applied multipicatively to the time on the transit supply link (for transit only links) or the congested time from the highway network (for lines operating in traffic) to estimate the transit travel time, with stops.
  - Most urban fixed route buses operating in traffic are coded with TIMEFAC = 2.01.
  - Most rural or suburban fixed route buses operating in traffic are coded with TIMEFAC = 1.62.
  - Most commuter buses operating in freeway traffic are coded with TIMEFAC=1.18.

- 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 to identify two-way routes, which are coded as two oneway routes due to differences in routing from one direction to the other.
- MODE is an indicator of both operator(s) and fare groups. Fares are coded by "transfer" (i.e. a monetary cost charged to "transfer" from one MODE to another. The groupings of the operators by fare groups is generalized to reduce the number of fares coded to ten.
- COLOR is an indicator or more general service types, as follows. Note that, as with capacity class designations for the highway network, some of the distinctions between service types are not black-or-white. Examples are: so-called "hybrid" streetcar systems aere increasingly looking like light rail; there is some overlap potential between a lower end bus rapid transit (BRT) service, and a fixed route local bus:
  - 1 = Light Rail
  - 2 = Streetcar
  - 3 = Commuter Bus
  - 4 = Bus Rapid Transit (low)
  - 5 = Fixed Route Local Bus
  - 6 = Regional/Commuter (Heavy) Rail
  - 7 = Neighborhood shuttle
- FREQ(#) is actually the average headway, or time spacing between scheduled buses or trains, in minutes. The # in parentheses indicates the service period. SACSIM uses only two service periods: peak (combining both AM and PM peak service periods) and midday. Both service periods are weekday. FREQ is computed as follows:
  - $\sum$ minutes in service period / $\sum$ schedules in service period
  - E.g. if the service period is peak, the sum of minutes is 360. For a route with 4 schedules in the AM and 4 in the PM, the total number of peak schedules is 8. 360 / 8 = 45 minutes.
  - Maximum FREQ is 180 (i.e. a line with only one schedule in 360 minutes would be coded as 180.
  - FREQ(3) is used to indicate a "disabled" or unused line in the file. If FREQ(3)=99, the line is disabled, and FREQ(1) and FREQ(2) must be 0; if FREQ(3)=0, the line is active, and FREQ(1) or FREQ(2) must be greater than 0.

The above-referenced characteristics of fixed route transit lines are coded into a Citilabs® TRNBLD format transit line file.

Dial-a-ride, paratransit and private transit operations and individual bus routes that operate within a single study zone or that operate very infrequently were not included in the transit network. Such routes are excluded in standard transit modeling practice for a number of 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.

"Regional Rail" is included as a transit operator/fare group. Regional reail is defined as relatively low frequency, commuter-oriented, heavy rail, operated within the SACOG region. Because of the uniqueness of this type of service, the ability to forecast regional rail ridership using SACSIM is very limited.

Table 4-1. SACSIM Transit Operators

Operator/Fare Group Number	Description
1	RT Light Rail
2	RT Fixed Route Local, E-Tran Fixed Route Local
3	Yolobus commuter lines
4	Yolobus regular lines
5	Roseville Commuter Bus, El Dorado Commuter Bus, Yuba/Sutter Commuter Bus
6	Regional Rail (i.e. intercity rail, within the SACOG region)
7	Neighborhood Shuttles
8	Folsom Local Bus
9	Roseville Fixed Route Local, Placer County Fixed Route Local, El Dorado Fixed Route Local, Yuba/Sutter Fixed Route Local
10	CSUS & UCDMC shuttle, UNITRANS

Table 4-2. Transit Line File Variables

Variable	Description
NAME	Name of Line
TIMEFAC	Highway to transit running time factor
ONEWAY	Oneway line
MODE	Transit Fare Group and Mode
COLOR	Service type
FREQ[1]	Peak Service Period Headway (minutes)
FREQ[2]	Midday Service Period Headway (minutes)
FREQ[3]	Disable variable

Transit Access Coding

In addition to the characteristics of transit lines, SACSIM transit networks require the following information:

- Additional nodes for transit lines which do not travel on the road network
- Park-and-ride lots and connecting park-and-ride lot access links
- Walk access links from TAZ's to the shortest-path transit stop

- "Funnel" links which collect park-and-ride and walk access links from various origins, and consolidate volumes going to LRT stations.
- Additional links for transit lines which do not travel on the road network
- Transfer connecting links, to allow for transfers to/from transit lines which do not share common stations (e.g. transfers from LRT to bus, or from bus to LRT).
- Timed transfer points ("pulse nodes")

A more complex coding procedure is used for rail transit stations and other transit lines which are not on the road network (Figure 4-1). The more complex procedure is used for several reasons.
First, it is necessary to define additional connections between the road network and the transit line to allow drive access and bus transfers. Second, it allows for separate tracking of station access by walking, driving or bus transfers, which assists with station design and environmental evaluation. Finally, it allows for consideration of drive access constraints, such as full parking lots or parking fees.

In this procedure, each rail station is defined by up to three nodes:

- The rail station itself, where the rail transit line stops.
- A walk access node, where zones within walking distance of the station are connected.
- A park-and-ride lot node, where zones which are in the market area for driving to the station are connected.

After defining these nodes, some or all of the following connector links are defined:

- Park-and-ride lot connector link or links between the road network and the park-and-ride nodes, to define where automobiles can gain access to the parking lots (mode 16).
- One park-and-ride funnel link between the park-and-ride node and the rail station (mode 15).
- Walk access link or links between the roadway node nearest the LRT station and an intermediate walk access node (mode 17).
- One walk access funnel link between the walk access node and the LRT station (mode 14).
- Transfer links between the LRT station node and any nearby bus line stops. These are required to allow for LRT-to-bus and bus-to-LRT transfers (mode 12)

All of the above-referenced additional network features are coded into a Citilabs® TRNBLD format transit supply link file. In addition to the above-referenced features, Citilabs® TRNBLD software generates two additional transit access links:

- TAZ to nearest transit stop walk access connectors (mode 13).
- TAZ to park-and-ride lot connectors (mode 11).
- Mode 13 links are software-generated, but the process is controlled to a certain degree with user-specified terms in skimming and assignment scripts. The links are generated from the TAZ to the first transit stop on the shortest path from the origin TAZ to the

final destination. In terms of travel time and distance, the links take on the characteristics of the series of roadway links which create the path to the first transit stop.

- Mode 11 links are also software-generated, and also controlled to a certain degree with user-specified terms. Links are generated from a hard-coded list of TAZ's served by a specific park-and-ride lot. A separate file is required which corresponds each park-and-ride lot with the TAZ nearest the transit station or stop which it serves. This correspondence file is used to generate an adjunct vehicle trip table of vehicle trips from their origin TAZ to the TAZ nearest the transit station, and vice versa for return trips, to be included in the highway vehicle trip assignment.

Figure 4-1. Transit Access Coding

Once all of the various additional nodes and connector links are defined, the actual transit lines can be input into the network.

Transit Travel Speeds and Stop Times

Travel speeds of buses operating in mixed flow are determined by means of a time factor relating bus speed (including stops) to auto speed. Time factors were determined separately for peak and off peak local bus service by comparing the scheduled transit travel times with the model's respective highway travel times.

For buses, delays from stopping, deceleration, and acceleration are implicitly represented in the time factors discussed in the preceding section. 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 4-3. 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 (Freewy Segments)	1.18

For most of the LRT system, light rail vehicles operate on exclusive right-of-way, with pre-emption of traffic signals at crossings of surface streets. For this reason, travel times are less subject to road conditions, and more stable and predictable. LRT travel times are influenced by the characteristics of the track they operate on, performance of the LRV's, and the spacing of stations. Table 4-4 provides the performance characteristics of LRVs used for estimation of travel times. Although for base year (in this case, Year 2005) it is not necessary to have a method of estimation of LRV travel times, since they can be observed directly, for future lines an estimation method is required.

Table 4-4. Light Rail Vehicle Operating Assumptions

Variable	Performance
Acceleration Rate	2.5 mph/sec
Deceleration Rate	-2.5 mph/sec
Maximum Running Speed	55 mph
Station Dwell Time	0.5 minutes

Table 4-5. LRV Calibration Factors

Calib Blocks	Factor
Watt-I-80 to ADP	1.0
ADP to Alkali Flt,Rich/Railyds	0.5
Alkali Flt to 16th	0.3
16th to 29th	0.6
29th to 65th	0.9
65th to MM	0.9
MM to Hazel	1.0
Hazel to Folsom,Mv-MorrCrk	0.95
16th to WH	0.5
WH to Meadowview	0.7

Park-and-Ride Locations

Park-and-ride locations that have commute period transit service were coded into the transit network. Table 4-6 provides a listing of park-and-ride lots explicitly included in the 2005 baseyear model network. Park-and-ride lots without transit service, of which there are many, are not included.

Table 4-6. Year 2005 Park-and-Ride Lots

Description	Number of Spaces	Transit Service
Watt/I-80 LRT /1/	1578	Blue Line LRT; RT fixed route (1,9,10,15,19,26,80.84,93,100-107)
Marconi LRT	416	Blue Line LRT; RT fixed route (17,18,25,86,87)
Swanston LRT	311	Blue Line LRT
Arden DP LRT	45	Blue Line LRT; RT fixed route (13-16,19,20,22,23,25,88)
47th Ave LRT	423	Blue Line LRT; RT fixed route (63)
Florin LRT	1076	Blue Line LRT; RT fixed route (54,65,81)
Meadowview LRT	690	Blue Line LRT; RT fixed route (4,5,47,56,63,64)
Power Inn LRT	299	Gold Line LRT; RT fixed route (8,61,83)
Watt/Manlove LRT	498	Gold Line LRT; RT fixed route (72,80,84,220,237,239,255,261)
Butterfield LRT	406	Gold Line LRT; RT fixed route (28)
Mather Mills LRT	235	Gold Line LRT; RT fixed route (21,28,72-75)
Sunrise LRT	487	Gold Line LRT; RT fixed route (73,74,91)
Hazel LRT	432	Gold Line LRT
Iron Point LRT	216	Gold Line LRT, Folsom Transit
Glenn LRT	165	Gold Line LRT, Folsom Transit
Historic Folsom LRT	102	Gold Line LRT, Folsom Transit
Florin Mall Bus	Unknown	???
B'ville/Calv Bus	Unknown	E-Tran
Bville Rd Bus	Unknown	E-Tran
EGB/B'ville Bus	Unknown	E-Tran
EGB/E.Stock Bus	Unknown	E-Tran
Grantline/E.Stockton Bus	Unknown	E-Tran
Laguna Bus	Unknown	E-Tran
Sheldon/E.Stockton Bus	Unknown	E-Tran
Calvine/Power Inn	Unknown	E-Tran
Ponderosa Bus	Unknown	El Dorado Transit Commuter
Placerville Mosquito Road	Unknown	El Dorado Transit Commuter
Rodeo Road Bus	unknown	El Dorado Transit Commuter
El Dorado Fairgrounds Bus	unknown	El Dorado Transit Commuter
El Dorado Hills Bus	unknown	El Dorado Transit Commuter
Cambridge Road Bus	unknown	El Dorado Transit Commuter

Description	Number of Spaces	Transit Service
Roseville Amtrak	unknown	Amtrak, Roseville Transit Commuter
Clipper Gap Bus	unknown	Placer County Transit Commuter
Horseshoe Bar Bus	unknown	Placer County Transit Commuter
Ophir/Taylor Bus	unknown	Placer County Transit Commuter
Auburn Multi-Modal	unknown	Placer County Transit Commuter
Galleria Bus	unknown	Roseville Transit Commuter
Mahanny Park Bus	unknown	Roseville Transit Commuter
Maidu Center Bus	unknown	Roseville Transit Commuter
Saugstad Park Bus	unknown	Roseville Transit Commuter
Taylor/80 Bus	unknown	Roseville Transit Commuter, Placer County Transit Commuter
Davis Mace Blvd. Bus	unknown	Yolobus
W.Capitol/Enterprise	unknown	Yolobus
Woodland Kmart Bus	unknown	Yolobus
Source: SACOG, November 2008, based on maps and schedules from each operator.		

Validation and Reasonable-ness Checking of Transit Networks

As with highway networks, direct, independent checks of transit model networks against actual networks are very difficult to perform. Two generic checks of transit networks were performed: schedule running times, and system total revenue hours and miles of service for the major transit operator (Sacramento Regional Transit District).

Table 4-7 presents LRT travel times from the 2005 schedule book versus those computed for use in SACSIM07 using the factors and method described above. Cumulative run times for both lines match exactly, and station-to-station times are all within one minute.

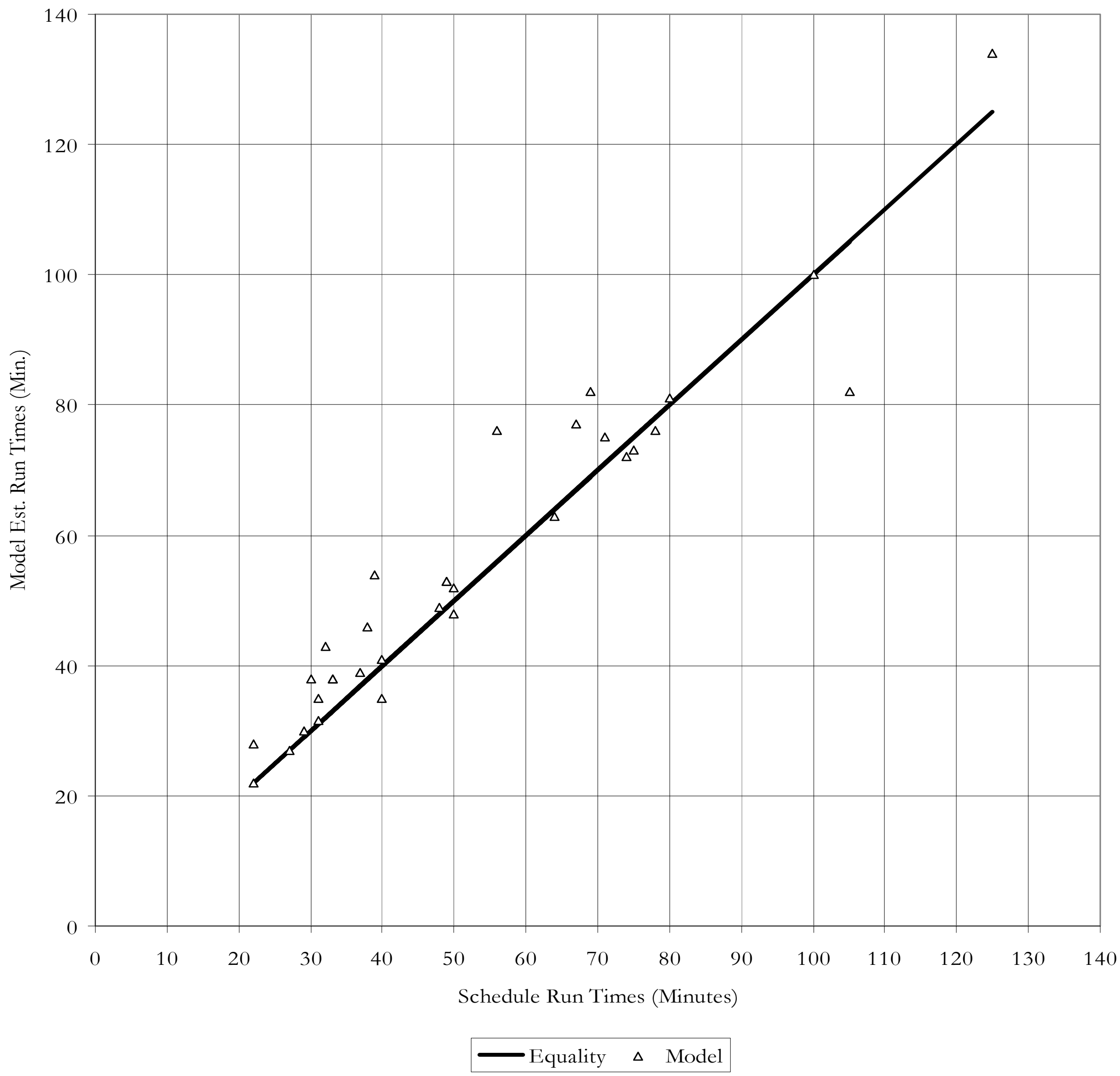
Figure 4-2 illustrates end-to-end run times for thirty selected routes for Year 2005. The selected routes included about twenty of the highest volume routes, and ten commuter express bus routes. The R-squared for a model-to-schedule-book-time regression was 0.95, and the beta for the regression was 0.95.

Table 4-8 provides a tabulation of Year 2005 weekday revenue miles and revenue hours of transit service for LRT and fixed route bus service for Sacramento Regional Transit District.

Table 4-7. Year 2005 LRT Travel Times (Including Dwell Time)

Station-to-Station Pairs			Time (Minutes)	
From	To	Distance (Miles)	**Sched.**	**Calc'd**
Blue Line (Watt-I-80 to Meadowview)				
Watt-I/80	Watt-I/80 West	0.64		
Watt-I/80 West	Roseville Road	0.60		
Roseville Road	Marconi	1.58	5	6
Marconi	Swanston	1.29		
Swanston	Royal Oaks	0.63		
Royal Oaks	Del Paso	0.49	11	11
Del Paso	Globe	0.56		
Globe	Alkalai Flats	1.76	18	18
Alkalai Flats	12th/I	0.32		
12th/I	Cathedral	0.24		
Cathedral	St.Rose of Lima	0.29	24	23
St.Rose of Lima	7th/8th Capitol	0.18		
7th/8th Capitol	8th/O	0.21	27	27
8th/O	Archives Plaza	0.23		
Archives Plaza	13th	0.31		
13th	16th	0.24	32	32
16th	Broadway	0.88		
Broadway	Wayne Hultgren	0.53		
Wayne Hultgren	City College	0.71	39	39
City College	Fruitridge	1.17	41	41
Fruitridge	47th	0.95		
47th	Florin	1.01	46	46
Florin	Meadowview	1.03	48	48
Gold Line (16th Street to Folsom Only)				
16th	23rd	0.54		
23rd	29th	0.54	4	4
29th	39th	0.80		
39th	48th	0.49		
48th	59th	0.74		
59th	65th	0.49	10	10
65th	Power Inn	1.13		
Power Inn	College Greens	0.80		
College Greens	Watt/Manlove	1.19	16	17
Watt/Manlove	Starfire	0.77		
Starfire	Tiber	0.86		
Tiber	Butterfield	0.19		
Butterfield	Mather Field/Mills	2.20	24	25
Mather Field/Mills	Zinfandel	1.31		
Zinfandel	Cordova Town Center	0.24		
Cordova Town Center	Sunrise	1.23		
Sunrise	Mineshaft (fut)	1.24	35	33
Mineshaft (fut)	Hazel	2.14		
Hazel	Iron Point	1.76		
Iron Point	Glenn	1.22		
Glenn	Historic Folsom	1.22	42	42
Source: SACOG, November 2008.				

Figure 4-2. Transit Line Times



Source: SACOG November 2008, based on published schedules.

Table 4-8. Comparison of Vehicle Service Hours for Selected Operators

Operator/Service Type	Revenue Hours of Service			Revenue Miles of Service		
	SAC-MET07	RT Actual[1]	Model/ Actual	SAC-MET07	RT Actual[1]	Model/ Actual
SRTD / LRT (trains)	235	238	0.99	4,636	4,106	1.13
SRTD / LRT (LRV's)	610	650	0.94	12,054	11,308	1.07
SRTD / Fixed Route Bus	2,436	2,502	0.97	29,174	27,213	1.07
Total LRT+FR Bus	3,281	3,390	0.97	45,864	42,627	1.08

Source: SACOG, April 2008.
[1] Provided by SRTD from 2005 National Transit Database submittals.

5--Bike and Walk Networks

Special bike and walk links coded into the highway network were described in Chapter 3. These links are coded to allow for more accurate skims across features like parks, etc., where biking or walking is allowed, but where no motorized access is allowed. TAZ-to-TAZ distance skims are prepared for non-motorized modes, which include the following features:

- Bike and walk links are included in path building
- All surfaces streets are included in path building
- Reverse direction on one-way streets are allowed
- Ramps and freeways are excluded

DAYSIM starts from parcel level land use inputs, and all location and destination choice models predict choices at parcel level, too. However, highway and transit networks are TAZ-based. Because of this inconsistency in spatial detail between the land use inputs and DAYSIM locations/destinations, and the highway and transit networks, an algorithm was developed to merge parcel-to-parcel distance estimates, and TAZ-to-TAZ estimates of the same. For more detail on this process, see Chapter 5 (Bike and Walk Networks). The algorithm used is:

- TRAVDIST = NWFRAC * SKIMDtaz + (1-NWFRAC)*ORTHDparcel
- Where:
    - TRAVDIST = the travel distance between to parcels, adjusted
    - SKIMDtaz = TAZ-to-TAZ distance skim
    - NWFRAC = a proportion ranging from 0 to 1, computed as:
        - Min (1, SKIMDtaz / 6)
        - ORTHDparcel = the orthogonal (x+y component) distance between the parcels

Starting with parcel/points in SACSIM provides an opportunity to replace the centroid/skim representation of proximity with something more detailed and more directly based on the actual land use pattern. In theory, the best approach would be to use 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.

SACSIM computes two measures of proximity at parcel level. One is a parcel-to-parcel orthogonal distance (the sum of the "X" and "Y" coordinate distance separating two parcels). The second is a conventional TAZ-to-TAZ distance skim, comparable to skims for four-step, TAZ-based models. Based on orthogonal distance estimate, the two measures of proximity are formulaically combined. For parcels which are closer, the parcel-to-parcel distance is weighted heavily; for parcels which are very distant, the TAZ-to-TAZ distance skim is weighted heavily. By using 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 alone.

Figures 5-1 and 5-2 illustrate the results of a validation of SACSIM parcel/point level estimates of travel distance, and a comparable TAZ-level estimate, both compared to actual travel distances measured from parcel-to-parcel using a street centerline GIS. The figures illustrate how estimates of short (< 1.0 miles) travel distances are estimated. SACSIM is a fairly accurate, unbiased estimate of actual travel distances. The TAZ-level estimates of short distances include a mix of intra-zonal trips, for which "one-half-nearest-neighbor" distances are substituted, neighboring TAZ trips, for which TAZ-to-TAZ skims are used. As shown in Figure 5-1, this combination estimates tends to be too high for short trips, and too low for longer trips. This bias is inherent in TAZ-to-TAZ skims for distance estimation.

Table 5-1 provides statistics for model estimated distances regressed on actual distances. The adjusted R-squared statistics for SACSIM are 0.89 or higher, and the regression beta's are lower than the SACMET for all two of three types of trips (short and intrazonal), and comparable for medium trips. (Note: a recent change in treatment of SACSIM distance estimation for intrazonal trips should eliminate the bias in the estimation).

Table 5-1. Comparison of Model Travel Distances Estimates

	Regression Statistics (β * Model Dist = Actual Dist)[1]			
	SACMET		SACSIM	
Trip Length	Adj R-Sq	Beta	Adj R-Sq	Beta
Trips < 1.0 miles	0.71	0.72	0.93	1.07
Trips 1.0 to 5.0 miles	0.93	1.06	0.98	1.09
Intrazonal Trips	0.55	1.88	0.89	1.59

Source: SACOG, July 2008.
[1] Model estimated drive distance regressed against actual drive distance for a sample of about 100 actual point-to-point trips from the Year 2000 Household Travel Survey.

Figure 5-1. SACSIM (Point-to-Point) Measures of Travel Distance for Short Trips

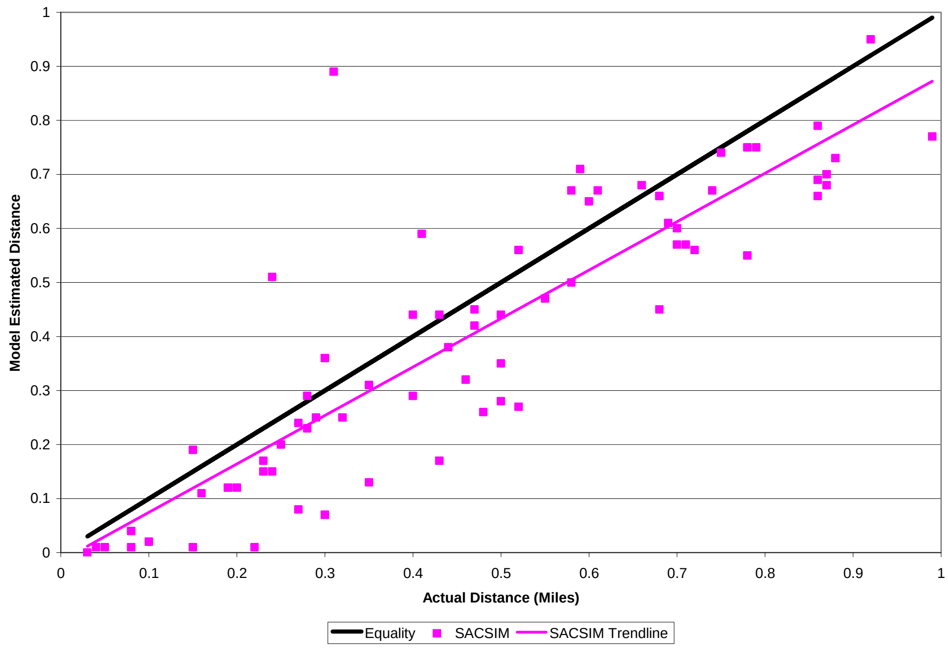
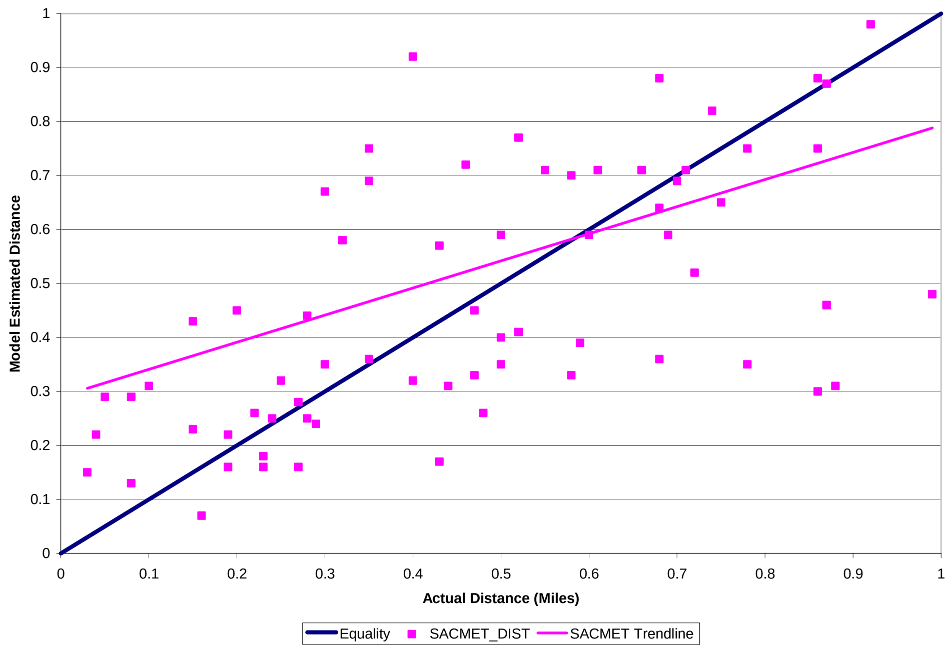


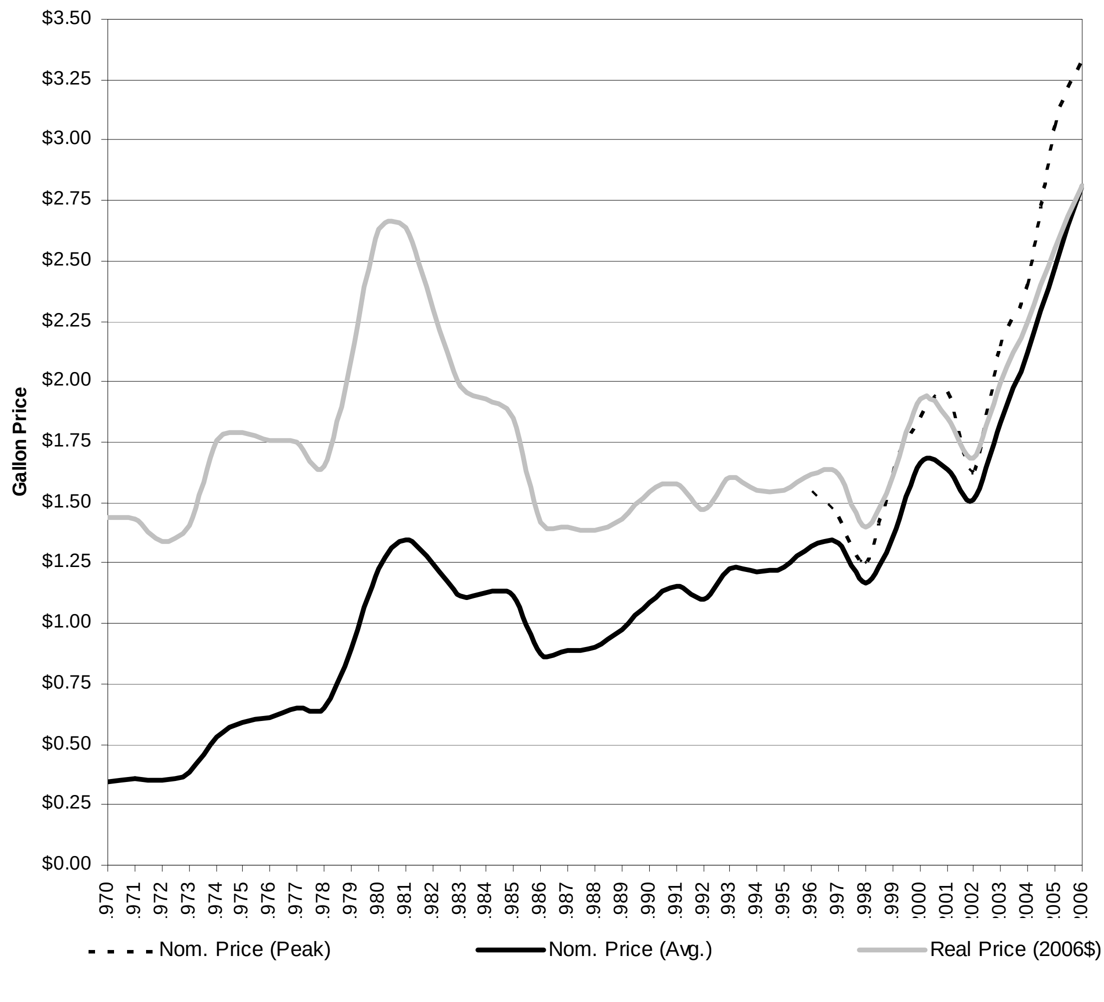
Figure 5-2. SACMET (TAZ-to-TAZ) Measures of Travel Distance for Short Trips



6--Auto Operating Costs and Transit Fares

SACSIM was estimated assuming that "out-of-pocket" auto operating costs were most influential in determining automobile usage. These costs include fuel, maintenance, and tire costs averaged per mile for a "typical" driver. The Bureau of Transportation Statistics reports that these costs were 5 cents per mile in 1990. These costs have increased in real terms to nearly 10 cents per mile (in 1990 cents) in 2005. Fuel costs are the most significant share of operating costs. Fuel costs were relatively stable through the 1990's, and have increased markedly in recent years (Figure 6-1).

Figure 6-1. Average Annual California Gasoline Prices, 1970-2006



Source: SACOG, April 2008, based on data from the California Energy Commission and the Bureau of Labor Statistics.

Figure 6-2. Monthly California Gasoline Prices, Nominal Dollars, 2002 to 2008

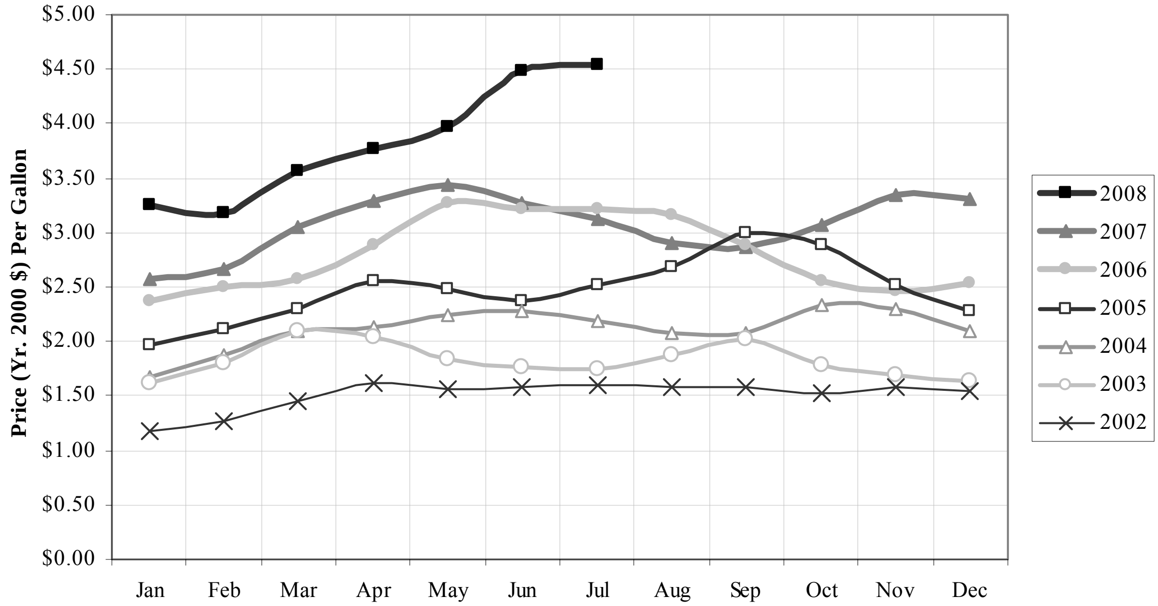


Figure 6-3. Monthly California Gasoline Prices, Inflation Adjusted Dollars, 2002 to 2008

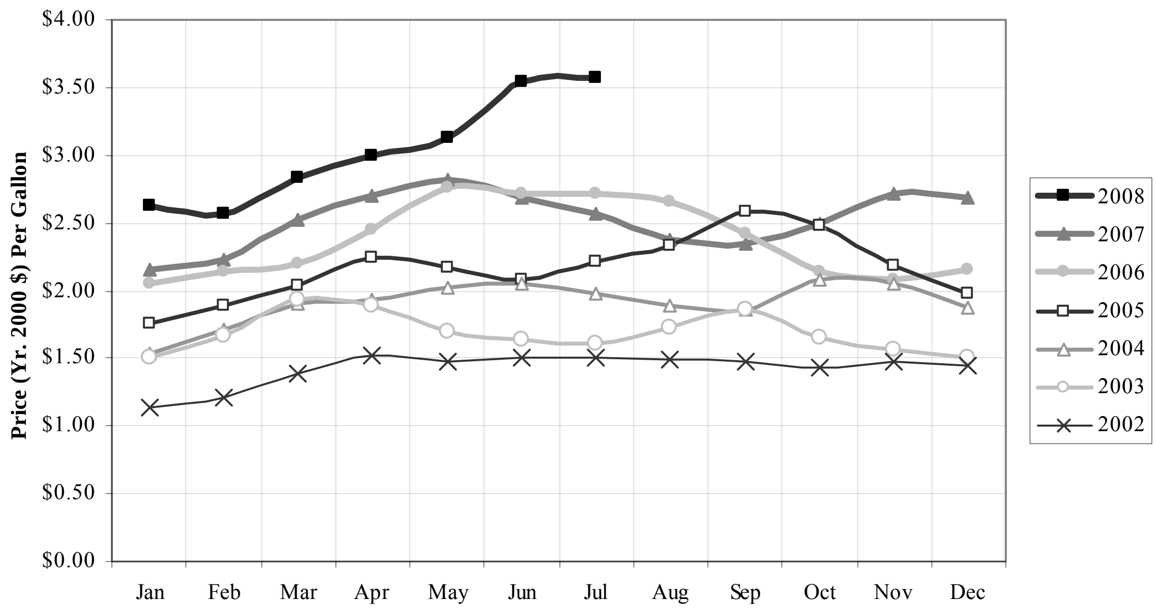


Table 6-1. Calculation of Auto Operating Costs

Variable	Year 2000	Year 2005
Fuel Price Per Gal. (Nominal) /1/	$1.66	$2.47
Fuel Price Per Gal. (Yr.'00 $) /2/	$1.66	$2.17
Avg. Auto Miles / Gal	22	22
Gas Cost Per Mile (Yr. '00 $)	$0.08	$0.10
Tire+Maint Cost Per Mile (Yr. '00 $)	$0.04	$0.05
Total Auto Ops Cost Per Mile (Yr. '00 $)	$0.12	$0.15

Source: SACOG, November 2008.
/1/ Based on California Energy Commission
/2/ Inflation adjustments based on Bureau of Labor Statistics Consumer Price Index data.

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. Boardings and transfer fares are defined for each group of transit services; transit services with similar fares were grouped together.

Table 6-2 lists the ranges of nominal fares for operators included in SACSIM. Table 6-3 provides a calculation of average passenger fare used in SACSIM.

Table 6-2. Year 2005 Transit Fares

Mode /Fare Group	Transit Service	Boarding Fare 2005 $	Transfers, Notes
1	RT LRT	Basic OW: $1.75 Monthly: $80.00	$0.25 transfer to other RT
2	RT Bus	Basic OW: $1.75 Monthly: $80.00	$0.25 transfer to other RT
3	Yolobus Express	Basic OW: $2.00 Monthly: $80	Free transfer to other Yolobus $0.25 transfer to RT
4	Yolobus Local / Intercity	Basic OW: $1.50 Monthly: $60	Free transfer to other Yolobus $0.25 transfer to RT
5	Roseville, El Dorado, and Yuba-Sutter commuter lines	Basic:$2.50 to $4.00 Monthly:$100-$144	Discount transfer to RT available from some operators
8	Folsom stage lines (local and RT Metro connection)	2.00	
9	Placer County Transit, El Dorado Transit, and Yuba-Sutter local fixed route lines	Basic: $1.00-$2.00 Monthly:$30 - $40	
10	CSUS, UCDMC, UNITRANS	Free	Student/staff shuttles

Table 6-3. Year 2000 and 2005 Average Transit Fares Calculations Used for SACSIM

Fare Group	Operator	Service Type	Nominal Fares: One-Way Basic 2000	Nominal Fares: One-Way Basic 2005	Nominal Fares: Monthly / 50 2000	Nominal Fares: Monthly / 50 2005	Real Fares (in '00 $)[1] 2000[2]	Real Fares (in '00 $)[1] 2005[2]	Subsidy Rate[3]	Real Fares (in '00 $) 2000	Real Fares (in '00 $) 2005
1,2	SRTD	All	1.50	1.75	1.00	1.45	1.35	1.43	20%	1.08	1.15
3	Yolobus	Express	1.50	2.00	1.30	1.60	1.44	1.62	20%	1.15	1.30
4	Yolobus	Local Fixed Rte	1.00	1.50	1.10	1.20	1.03	1.22	20%	0.82	0.97
5	Roseville Transit	Commuter	2.50	3.25	1.00	1.80	2.05	2.43	20%	1.64	1.94
5	Yuba Sutter Transit	Commuter		3.00		2.00		2.33	20%		1.86
8	El Dorado Transit	Commuter	2.50	4.00		2.88	2.50	3.16	20%	2.00	2.53
8	Placer County Transit	Commuter		4.00		2.50		3.06	20%		2.45
9	Placer County Transit	Local Fixed Rte	1.50	2.00		0.68	1.50	1.38	20%	1.20	1.11
9	Roseville Transit	Local Fixed Rte	1.00	1.30	0.36	0.00	0.81	1.12	20%	0.65	0.90
9	Yuba Sutter Transit	Local Fixed Rte		1.00		0.60		0.76	20%		0.61
9	El Dorado Transit	Local Fixed Rte	1.10	1.10		0.66	1.10	0.84	20%	0.88	0.67
10	Unitrans	Local Fixed Rte	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10	Hornet	Local Fixed Rte	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Source: SACOG, November 2008. Based on available published operator fares.
[1] Adjusted to Year 2000 dollars using Western States urban area CPI.
[2] Calculated as 0.65*basic one-way fare + 0.35*monthly/50—a weighted average of walk-up and monthly pass fares.
[3] Assumed adjustment to reflect total effect of subsidized travelers, and estimate average out-of-pocket fare.

7--Observed Travel Data

Observed travel data is used for model development (estimation and calibration of statistical submodels) and for reasonable-ness 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 SACSIM07.

SACOG 2000 Household Travel Survey

The original estimation of the SACMET model's major components (auto ownership, trip generation, trip distribution, mode choice and time of day) described in the following sections used SACOG's 1991 Household Travel Survey. New estimation of some components (e.g. trip generation) were made using the 2000 Household Travel Survey. A systematic re-calibration of all of the submodels was also made using the 2000 survey.

The 2000 survey included Sacramento, Sutter, Yolo, and Yuba Counties, and the western portions of El Dorado and Placer Counties. The survey had two purposes: to provide data for research and planning purposes, and to help update the regional travel demand model. SACOG documented the initial findings from the travel survey and provided an extensive set of tabulations of the survey data, in a July 2001 report: "Pre-Census Travel Behavior Report: Analysis of the 2000 SACOG Household Travel Survey". Since that time, the detailed Year 2000 Census tabulations have been made available. Using these more recently-released Census data, the household travel survey was re-expanded to adjust for more bias in the survey sample. Also, the 2001 report considered the pre-2005 SACMET geography, which excluded Yuba and Sutter Counties north of the Bear River.

Tables 7-1 through 7-5 provide a series of basic demographic and travel variables, matching the expanded and raw household survey tabulations to observed tabulations from the Year 2000 Census. The new survey expansion factors were calculated using the following steps: 1) expansion factors for basic demographics (numbers of households by county and the following other demographic dimensions: household size; number of workers; income class; age of head-of-household) were computed using iterative proportional factoring; 2) IPF expansion factors were adjusted post-hoc for two non-demographic variables: mode of travel for commuters and overall activity level (number of trips and VMT). The new expansion factors reduced overall error in simultaneously matching the key Year 2000 Census demographics by one third over the pre-Census expansion factors.

Table 7-1. Households by Area Type

Area Type	Survey Sample Households	Observed Households (2000 Census)	Sample Rate	Expanded Survey	Effective Survey Expansion
Rural	599	143,722	240	136,765	228
ExUrban	887	218,631	246	223,550	252
Suburban	950	145,168	153	158,176	167
Urban	1505	186,750	124	178,091	118
Total	3941	694,270	176	696,581	177

Source: SACOG, May 2007.

Table 7-2. Households by County

County of Residence	Survey Sample Households	Observed Households (2000 Census)	Sample Rate	Expanded Survey	Effective Survey Expansion
El Dorado (part)	161	45,519	283	45,405	282
Placer (part)	360	88,685	246	90,136	250
Sacramento	2,947	453,823	154	453,942	154
Sutter	90	27,088	301	26,610	296
Yolo	321	59,345	185	63,036	196
Yuba	62	20,553	332	17,452	281
	3,941	695,013	176	696,581	177

Source: SACOG, May 2007.

Table 7-3. Household Size Distribution

Number of Persons in HH	Survey Sample Households	Observed Households (2000 Census)	Sample Rate	Expanded Survey	Effective Survey Expansion
1	1,008	172,603	171	157,829	157
2	1,693	225,578	133	253,205	150
3	580	111,628	192	109,104	188
4+	660	185,204	281	176,443	267
Total	3,941	695,013	176	696,581	177

Source: SACOG, May 2007.

Table 7-4. Number of Workers

Number of Workers Per HH	Survey Sample Households	Observed Households (2000 Census)	Sample Rate	Expanded Survey	Effective Survey Expansion
0	1,201	180,635	150	168,868	141
1	1,272	264,962	208	273,702	215
2	1,228	207,977	169	219,856	179
3+	240	32,490	135	34,155	142
Total	3,941	686,064	174	696,581	177
Source: SACOG, May 2007.					

Table 7-5. Income Class

Income Category	Survey Sample Households	Observed Households (2000 Census)	Sample Rate	Expanded Survey	Effective Survey Expansion
<$10,000	233	56,594	243	41,887	180
$10-14.999k	203	39,789	196	34,974	172
$15-29.999k	737	125,863	171	119,571	162
$30-39.999k	405	83,603	206	85,601	211
$40-49.999k	576	74,401	129	74,830	130
$50-59.999k	449	63,651	142	68,631	153
$60-74.999k	389	77,597	199	82,743	213
$75-99.999k	348	79,489	228	86,038	247
>$100,000	603	91,233	151	102,307	170
All	3,941	692,220	176	696,582	177
Source: SACOG, May 2007.					

Sacramento Regional Transit 2002 Airport Passenger Survey

In January and February 2002, a contractor for Sacramento Regional Transit surveyed air passengers at the Sacramento International Airport[15]. 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.

[15] 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 sample included 777 departing passengers, which were pre-screened to include passengers traveling to the arport 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. Table 7-6 includes a comparison of key passenger variables. 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.

Table 7-6. Comparison of 2002 and 1999 Passenger Intercept Surveys

Variable	1999 Survey[1]		2002 Survey	
	%	#	%	#
Ground Access Trip Origin (County)				
Sacramento	78%	6,000	78%	592
Placer	16%	1,200	16%	124
El Dorado	6%	480	6%	43
Total	100%	7,680	100%	759
Home vs. Non-Home Origin				
Private Home	64%	4,915	66%	513
Business	19%	1,459	16%	126
Hotel	15%	1,152	15%	119
Other	2%	154	2%	19
Total	100%	7,680	100%	777
Trip Purpose				
Business	52%	3,994	51%	394
Visit	28%	2,150	31%	238
Vacation	13%	998	14%	112
Other	7%	538	4%	33
Total	100%	7,680	100%	777

Source: SACOG, November 2008.
[1] 1999 Sacramento International Airport Passenger Intercept Surveys, reported in technical materials in the Downtown-Natomas-Airport Draft Environmental Impact Report.

The survey included both revealed and stated preference elements. The first questions related to the mode of travel actually taken to the airport on that day. Because very little transit service was present at the time of the survey, a set of stated-preference questions were asked related to transit service. A third set of questions elicited demographic information on the passenger. Table 7-7 provides a summary tabulation of the survey results broken down by passenger market segment. The segments are defined by a two-by-two matrix of purpose (business or other) and residence status (resident or visitor).

Table 7-7. Sacramento International Airport Air Passenger Survey Summary

Passenger Market Segment		**Segment Travel/Demographic Characteristics**								
Passenger Type	Trip Purpose	# in Sample	Checked Luggage?	Avg. Party Size	% Female	Frequent Air Passenger From Sacto?[1]	Regular Transit User?[2]	Avg. # of Autos in HH	% of Trips From D'town Sacto	Home/ Resid. Based Trip?[3]
Resident	Business	191	59%	1.28	39%	51%	14%	2.30	8%	82%
	Other	206	71%	1.83	61%	18%	15%	2.32	8%	90%
Visitor	Business	194	56%	1.54	36%	19%	8%	n/a	30%	15%
	Other	186	72%	1.44	59%	8%	12%	n/a	9%	76%
Total Sample		**777**	**64%**	**1.53**	**49%**	**24%**	**12%**	**2.32**	**14%**	**66%**

Source: DKS Associates, based on passenger intercept survey conducted January, February 2002.
[1] Defined as reporting 10 or more trips from the Sacramento International Airport in the last 12 months.
[2] Defined as reporting "regular" or "fairly often" use of transit in Sacramento or elsewhere.
[3] If the passenger's trip to airport started from home (for a resident) or the home of a friend or relative (for a visitor), trip to airport

On-Board Transit Surveys

SACOG and the Sacramento Regional Transit District conducted a region-wide survey of passengers on-board regularly scheduled transit lines in the spring of 1994. In 1999, a second survey was completed, but only included the SRTD lines, and sampled more at a lower rate than the 1994 survey (1-in-9 sampling, compared to 1-in-5 for the 1994 survey). In fall of 2005, a new regional on-board transit survey was completed., with full participation of all operators of fixed route services in the survey design and execution The sampling was approximately 1-in-8 linked trips. In general, because of advanaces in data collection technology, the more collaborative approach used in developing the survey, and the fact that the survey was contracted out to a specialist firm rather than launched with temporary employees hired, trained and managed by SACOG, the quality data in the survey is higher in the 2005 survey than in either of the prior surveys. However, the analysis and use of the 2005 survey has only "scratched the surface" as far as calibration and validation of SACMET.

Table 7-8 shows a comparison of the 1999 to the 1994 survey on trips by purpose. Exact comparisons are not possible, because "College" was not included as a separate trip purpose in the 1999 survey. Informally accounting for this difference in survey, though, the mix of passengers from the 1999 survey generally matched that of the 1994 survey.

Table 7-9 shows comparable statistics (transit trips by purpose) for the 2005 survey. A few striking differences from the 1994 and 1995 surveys are apparent. First, the number and percentage of transit trips by university students is much higher (20 percent in 2005, compared to only 9 percent in 1994). Second, home-to-work commute trips accounted for far less of the total trips (35 percent in 2005, compared to 43 to 46 percent in 1994 and 1999 respectively).

Table 7-10 shows the number of boardings per linked trip for the 2005 survey, broken down by different operators and service types. The systemwide average boardings per linked trip was 1.44. Figure 7-1 illustrates the relationship between boardings, unlinked trip segments, and linked trips. "Boardings" refer to passengers entering a transit vehicle in the course of their travel. "Linked trips" refer to the entire journey from a trip origin to a destination, to engage in some sort of activity (e.g. work, as shown in Figure 7-1). "Unlinked trip segments" are all of the discrete pieces of a trip made on transit, including the walk access (e.g. walking from home to the first transit stop), transit trip segments (e.g. riding a bus to LRT, taking LRT to a second bus, riding the second bus to the last transit stop), and the final walk egress trip segment. In the example shown in Figure 7-1, one linked trip (i.e. the entire journey from home to work) requires five trip segments (not counting the walk from bus to LRT, or from LRT to bus), and generates three transit boardings. Additionally, "transfers" refer to all transit boardings after the initial boarding in the course of making a linked trip. Again referring to the example, the linked trip generated three boardings, two of which (the second and third boardings) were also transfers.

Table 7-11 provides a tabulation of linked trips by the numbers of boardings (and transfers) they generate. Two-thirds of all transit trips are direct (i.e. one boarding and no transfers); 22 percent generate two boardings (and one transfer) each; 11 percent generate three boardings (and two transfers) each.

Table 7-8. Year 1994 and 1999 Transit Trips by Purpose

Trip Purpose	1994 Survey #	1994 Survey %	1999 Survey[1] #	1999 Survey[1] %
Home-Work	22,426	43%	27,795	46%
Home-Shop	4,772	9%	3,528	6%
Home-School	6,345	12%	9,791	16%
Home-Other	7,570	14%	9,411	16%
Work-Other	4,903	9%	4,452	7%
Other-Other	2,844	5%	5,240	9%
Home-College	3,488	7%	n/a	0%
All Trips	52,348	100%	60,217	100%

Source: DKS Associates, 2001.
[1]For Sacramento Regional Transit District passengers only.
No other systems surveyed in 1999.

Table 7-9. Year 2005 Transit Trips by Purpose

Trip Purpose	Raw Survey[1] #	Raw Survey[1] %	Expanded Survey[1] #	Expanded Survey[1] %
Home-Based Work	4,784	37%	34,097	35%
Home-Based Univ (student)	2,781	21%	19,673	20%
Home-Based Shop	896	7%	6,760	7%
Home-Based Other	2,062	16%	15,579	16%
Work-Other	768	6%	8,445	9%
Other-Other	964	7%	7,960	8%
Home-Based K12School (student)	758	6%	5,269	5%
Airport passenger	42	0%	226	0%
Totals	13,055	100%	98,009	100%

Source: SACOG, April 2008, based on 2005 On Board Transit Survey.
[1]For 400 survey records (3,276 expanded) trip purpose was missing or mis-coded.

Table 7-10. Year 2005 Transfer Rates by Service Type

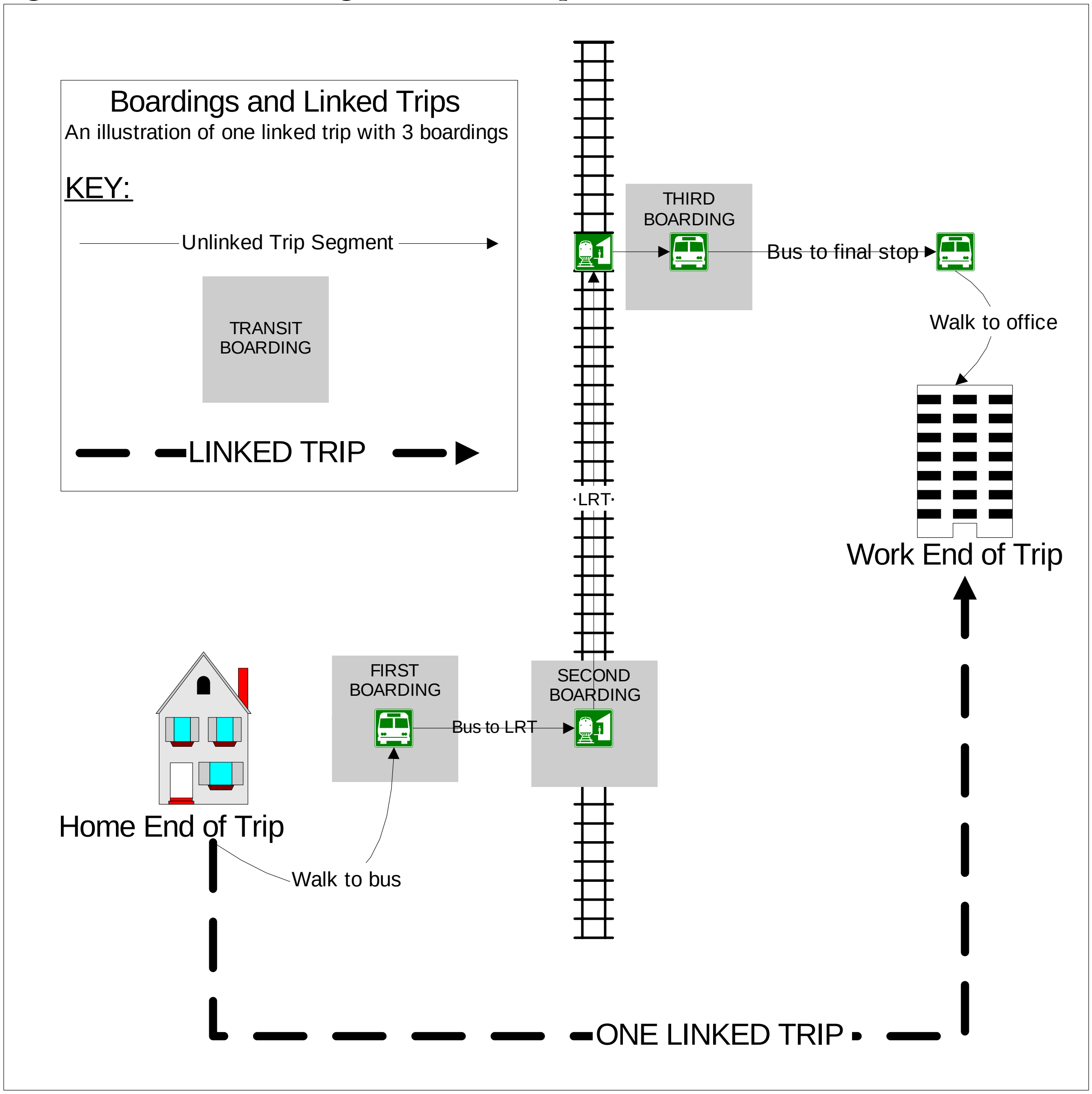
Operator	Service Type	Boardings	Linked Trips	Boarding Per Linked Trip
RT	Light Rail	52,563	37,461	1.40
RT	Fixed Route Bus	64,282	39,842	1.61
RT	Downtown Commute	244	221	1.11
RT	LRT Feeder Bus	595	339	1.75
Yolobus	Fixed Route Bus	3,197	2,262	1.41
Yolobus	Downtown Commute	755	677	1.12
Roseville Transit	Fixed Route Bus	1,023	650	1.57
Roseville Transit	Downtown Commute	336	314	1.07
E-Tran	Fixed Route Bus	1,540	1,059	1.45
E-Tran	Downtown Commute	1,204	1,010	1.19
Yuba-Sutter Transit	Fixed Route Bus	2,134	1,454	1.47
Yuba-Sutter Transit	Downtown Commute	410	377	1.09
Placer County Transit	LRT Feeder Bus	361	209	1.73
Placer County Transit	Other Bus	487	374	1.30
El Dorado Transit	Downtown Commute	533	506	1.05
El Dorado Transit	Other Bus	369	259	1.42
Unitrans	Fixed Route Bus	15,490	13,905	1.11
Folsom Transit	Other Bus	152	106	1.43
Lincoln Transit	Other Bus	80	64	1.26
South County Transit	All Bus	281	196	1.44
Region Total		146,035	101,284	1.44

Table 7-11. Year 2005 Trips by Number of Boardings on Trips

Linked Trips with…	N of Trips	% of Trips
…One Boarding (i.e. No Trasnsfers)	67,673	66.8%
…Two Boardings (i.e. One Transfer)	22,472	22.2%
…Three-or-More Boardings (i.e. Two-or-more Transfers)	11,139	11.0%
Total Trips	101,284	100.0%

Source: SACOG, April 2008, based on 2005 On Board Transit Survey.

Figure 7-1. Transit Boardings and Linked Trips



The survey forms with complete information were expanded to represent the average weekday boardings for each transit route. The expansion applied to the boardings by time of day and geographic area. Four periods were used to describe the time of day, the AM travel period from 5 AM to 9 AM, the midday travel period from 9 AM to 3:30 PM, the PM travel period from 3:30 PM to 6 PM, and the night period from 6 PM to 8 PM. These time periods were chosen because each has different travel characteristics.

The on-board survey data were used to revalidate the mode choice and transit assignment portions of the SACMET travel model to 1999/2000 conditions. In order to utilize the survey data for travel model development, the origin/destination based trip records were converted into production/attraction form.

Traffic Counts

Traffic counts are used for validation and reasonable-ness checking of the SACSIM highway vehicle assignments. SACOG does not perform its own traffic counts, but assembles appropriate traffic counts performed by others. There were three sources for the Year 2005 traffic counts:

- Data from permanent electronic count stations on the State Highway system, which were provided to SACOG in raw form, and reduced by SACOG staff.
- Processed counts provided by local agency staff in various forms, but generally as paper counts.
- 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 met the following criteria:

- Counts were daily volumes broken down by direction of travel, or daily volumes broken down by direction of travel and hour.
- Counts were taken in Spring months (March, April, or May) or early Autumn months (September or October) of calendar year 2005.
- Counts were taken during the mid-week weekdays (Tuesday, Wednesday or Thursday).

In some cases, counts were utilized by SACOG which did not meet these two criteria. The most common exceptions were non-directional daily counts, which were split 50/50 to get to direction of tavel, 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 2005 weekday volumes.

Where counts had hourly breakdowns of vehicle volumes by direction, time period by direction counts were also utilized, for the following time periods:

- AM peak period (three hours, from 7:00-9:59 AM)
- Midday period (five hours, from 10:00 AM to 2:59 PM)
- PM peak period (three hours, from 3:00 to 5:59 PM)
- Late evening/early morning period (13 hours, from 6:00 PM to 6:59 AM)

All counts assembled by SACOG were reduced the the above referenced time periods, and entered into SACOG's master highway network for use in model validation and reasonable-ness checking.

No peak hour counts were processed or utilized for SACSIM. The reasons for this have to do with the limitiations of static or aggregate assignment of vehicle trips onto a regional network the size and extent of SACSIM.

Table 7-12 provides a tabulation of the traffic counts assembled.

Table 7-12. Year 2005 Traffic Counts

County	AM Period	Midday	PM Period	Late Eve/Early AM	Daily
El Dorado	12	12	12	12	12
Placer	91	91	91	91	95
Sacramento	503	504	504	504	838
Sutter	45	45	45	45	53
Yolo	109	109	109	109	191
Yuba	16	16	16	16	18
Total	776	777	777	777	1,207

Source: SACOG, April 2008.

Sacramento Area
Council of
Governments

8--SACSIM Submodels

The overall SACSIM model system is illustrated in Figure 8-1 below. This overall system can be viewed as a set of ***submodels***, with each submodel capturing a component of travel behaviour. The key submodels are:

- Day-pattern activity simulator (DAYSIM)
- Commercial vehicle trips submodel
- External trips submodel
- Airport passenger ground access submodel
- Trip aggregation submodel
- Trip assignment submodel

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. Around the country, ABT models are increasingly used as replacements for more conventional, four-step trip models. 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 the course of a day.

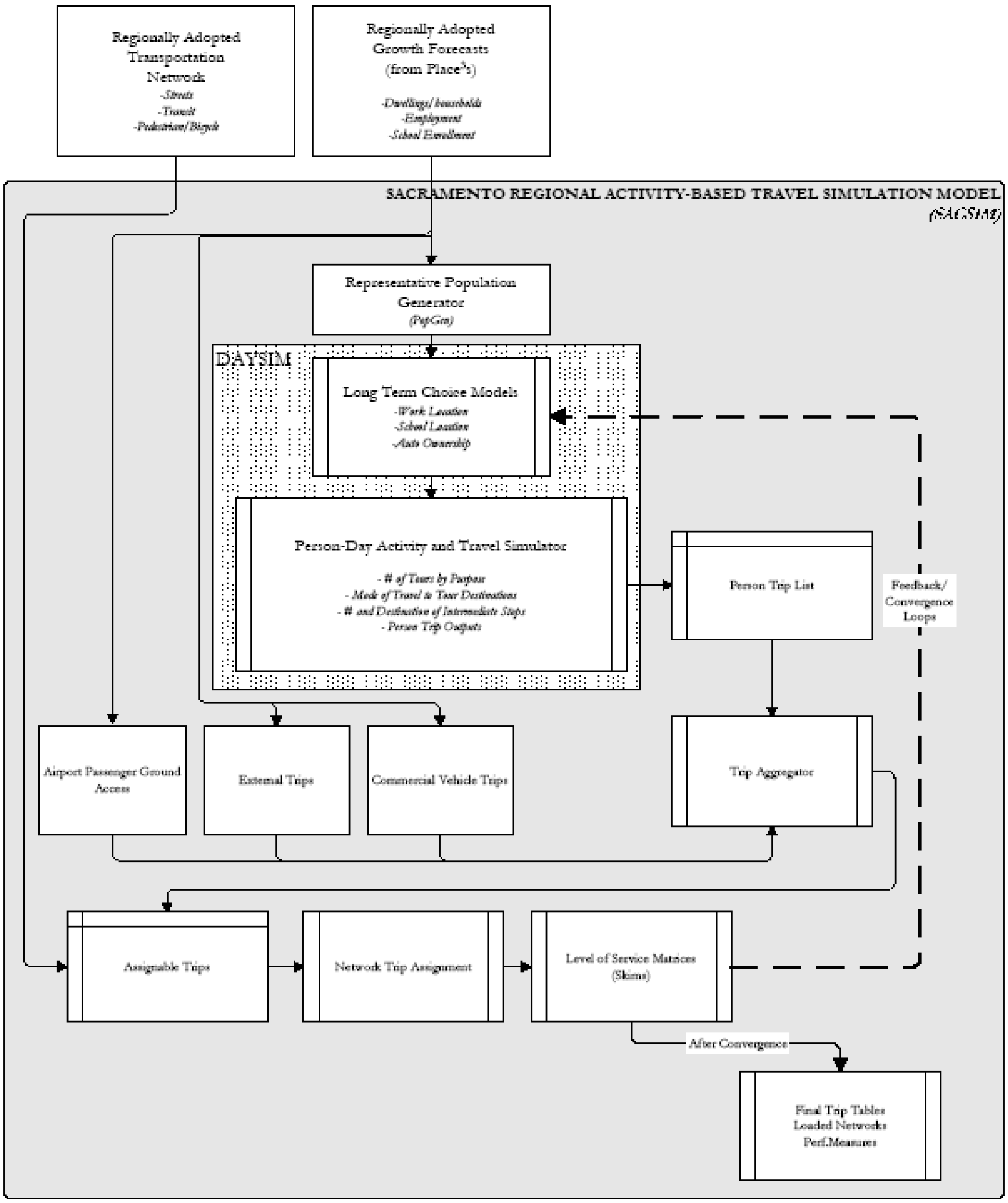
DAYSIM Terminolgy and Concepts

The specific definitions of *activities* and *tours* should be clearly established before detailing the model:

- *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 in order to engage in one of the above activities. A single tour is all of 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 in the course of 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 8-1. Sacramento Regional Activity-Based Travel Simulation Model Flowchart



Source: SACOG, November 2008.

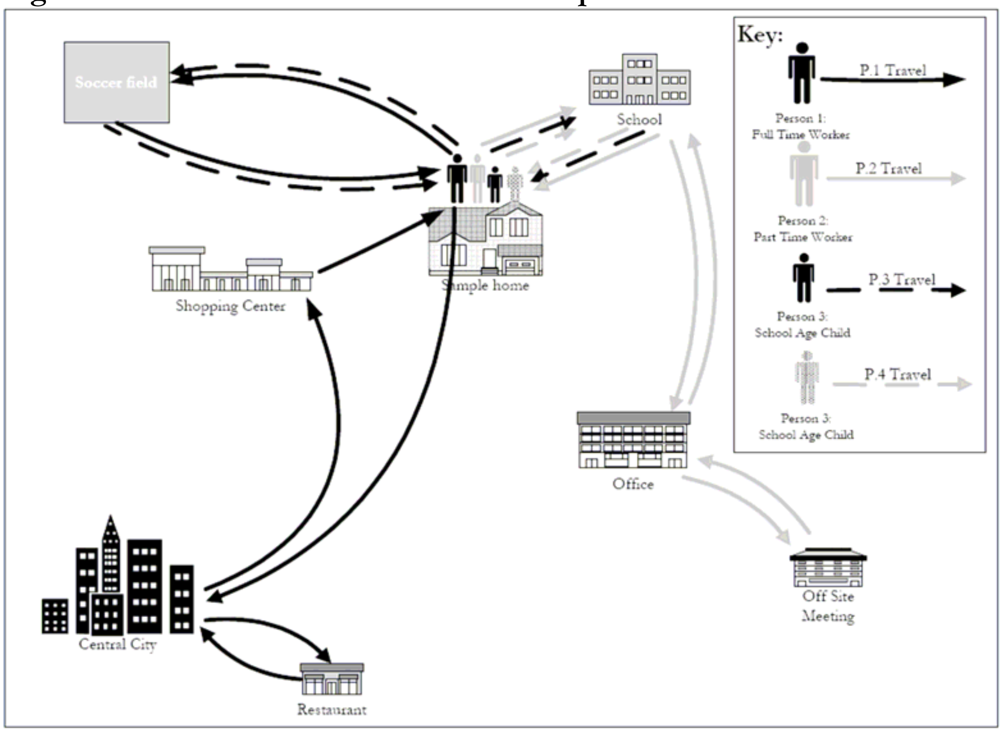
Figure 8-2 illustrates a typical set of activities and travel for a sample family of four. Table 8-1 provides a tally of the trips and tours for that sample family. The sample family makes a total of 19 person trips, which are grouped into eight tours. The most complicated tour is that by Person 2, who escorted two children to school, proceeded to work, and returned to pick up children on the way home. This tour included one work-based sub-tour, with two trips going from work to an off-site meeting, and a return trip to work. Including the sub-tour, 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.

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, in reality the 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.

Figure 8-2. Activities and Travel for a Sample Four-Person Household



Source: SACOG, November 2008.

Table 8-1. 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, November 2008.

Other DAYSIM terms are:

- *Locations vs. destinations*— In DAYSIM, the terms *location* and *destimation* 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 the vast majority of 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[16], with the following hierarchy:
    - 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)

[16] "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.

  - 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 8-2) 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[17] 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 Chapter 11 of this report.

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 is illustrated in Figure 8-3. 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:

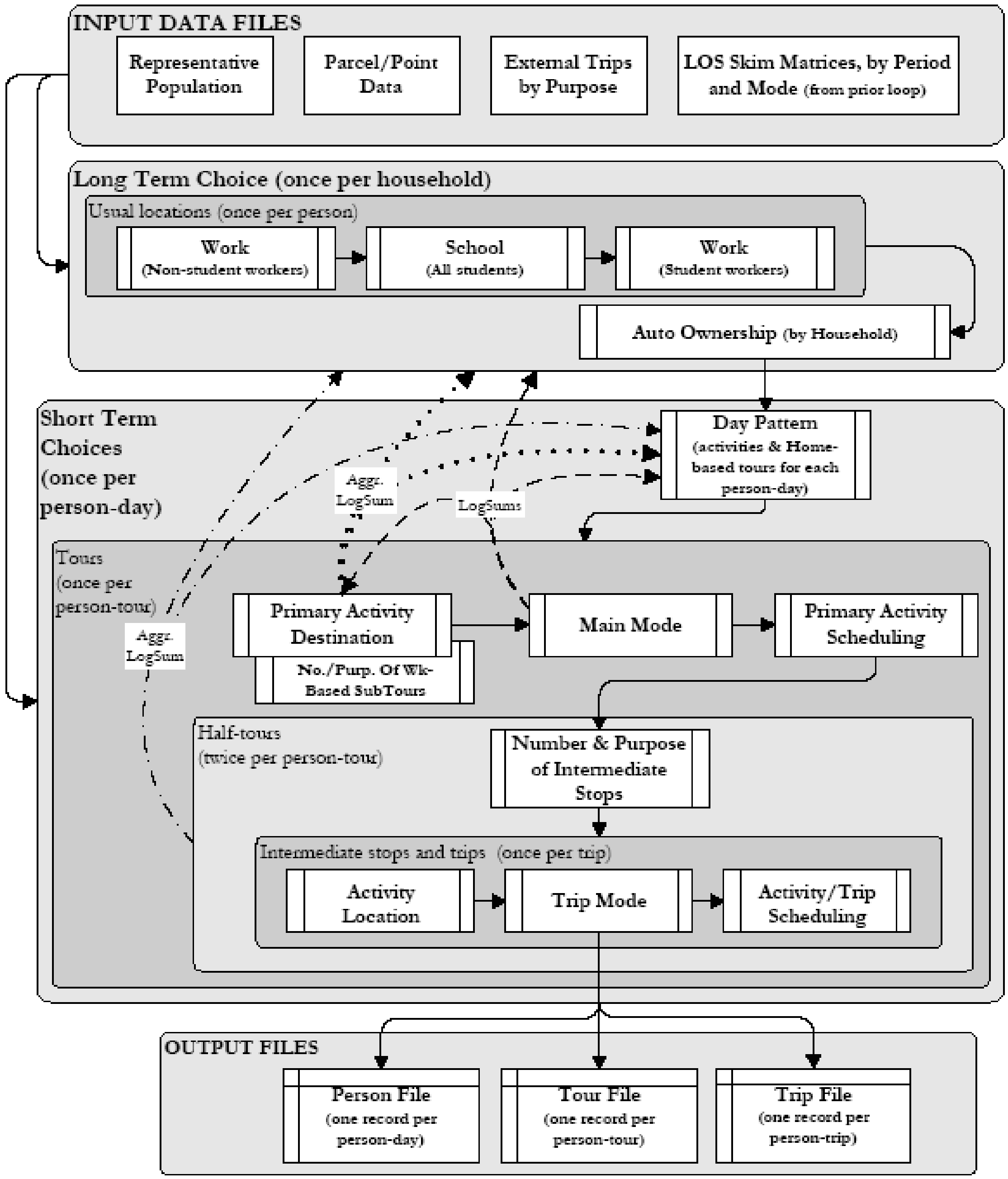
[17] The random seed is a real number between 0 and 1, assigned randomly to each individual in the representative population.

- 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 technical memoranda[18].

[18] Technical memoranda for DAYSIM development are available at http://www.jbowman.net/.

Figure 8-3. DAYSIM Hierarchy and Flow



Source: SACOG, November 2008.

Table 8-2. 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, Septermber 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 8: Usual Location and Tour Destination Models", October 28, 2005.

technical memoranda [19], and in other published work[20,21]. Table 8-2 provides more detail on the upward and downward flow of logsums and other variables in the location and destination models.

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.

An addidional long term choice model is included in DAYSIM:

- Usual workplace (for students)

This section details the structure, estimation results, calibration and validation of these models.

Usual Work Location Submodel

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.

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[19] Ibid., http://www.jbowman.net/

[20] Bowman, John L. and Bradley, Mark A., "Upward Integration of Hierarchical Activity-based models or Sensitivity to Impedence and Spatial Attributes in Activity Based Models", January 17, 2006, available at http://www.jbowman.net/.

[21] 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, available at http://www.jbowman.net/.

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.

Table 8-3 provides detailed specification of the model and estimation results.

Submodel Calibration and Application

The model was calibrated against the Census distance distributions by worker type (full and part time). Constants for work-at-home adjusted to match Census reported work-at-home percentages. Table 8-4 presents the calibrated values for key constants and coefficients.

Figures 8-4 and 8-5 presents a model vs. Census comparison of driving distance from home-to-usual-place-of-work. Table 8-5 provides a comparison of key points of comparison. Calibration of work-at-home percentages to match census percentages failed; a combination of work-at-home constants and distance coefficients was used to match the combined total of work-at-home plus work within the same TAZ.

Figure 8-6 illustrates a comparison of the SACSIM home-to-usual-work-location flows to RAD-to-RAD Census worker flows. As will all comparisons of model-to-observed flows for geographic areas this small, many flows are over- or under- predicted. Table 8-5 reports results of a SACSIM-to-Census regression of RAD-to-RAD flows: the adjusted R-squared for this regression is 0.95, and the regression beta is 1.06, indicating a slight overprediction bias.

Table 8-3. Usual Work Location Submodel Estimation Results

Coeff. No.	Variable Description	Person Type	HH Inc (annual)	Est.	Std. error	T-stat
1	Sampling adjustment factor for estimation			1.000		
192	Home location	Constant		-6.2272	7.225	-0.2
193	Home location	PT worker		7.0933	3.569	2.0
194	Home location	child or univ. stud.		-11.5700	5.508	-2.1
195	Home location	Female		-2.7963	1.369	-2.0
LogSum and Accessibility Variables						
998	Dest choice LogSum (in home vs other choice)			0.1496	0.065	2.3
2	Mode choice LogSum	FT worker		1.0000		
4	Mode choice LogSum	PT worker		1.0000		
5	Mode choice LogSum	not FT/PT worker		1.0000		
18	OW drive dist--0-3.5 mi (mi. x 10)	FT worker		-4.0525	0.332	-12.2
27	OW drive dist--3.5-10 mi (mi. x 10)	FT worker		-0.1416	0.114	-1.2
28	OW drive dist—10+ mi (mi. x 10)	FT worker		-0.5787	0.040	-14.3
20	Ln (1 + OW drive dist (mi. x 10))	PT worker		-2.8608	0.195	-14.7
21	Ln (1 + OW drive dist (mi. x 10))	not FT/PT worker		-3.3753	0.329	-10.3
22	Ln (1 + OW drive dist (mi. x 10))		<$15K	-0.3740	0.289	-1.3
23	Ln (1 + OW drive dist (mi. x 10))		$50-75K	0.3497	0.114	3.1
24	Ln (1 + OW drive dist (mi. x 10))		$75-100K	0.4282	0.152	2.8
29	Ln (1 + OW drive dist (mi. x 10))	Female		-0.4861	0.104	-4.7
35	Ln (1 + OW drive dist from school (mi. x 10))	child or univ. stud.		-1.7998	0.335	-5.4
37	Aggr. mode-dest LogSum at dest	FT worker		0.1081	0.035	3.1
38	Aggr. mode-dest LogSum at dest	PT worker		0.0362	0.092	0.4
39	Aggr. mode-dest LogSum at dest	not FT/PT worker		0.0657	0.133	0.5
Parking Supply and Street Pattern Variables						
52	Mix of daily parking & empl. in parcel: ln(1+prkg*empl/(prkg+empl))			0.1989	0.023	8.8
54	Mix of daily parking & (empl+stud) in TAZ: ln(1+prkgDens*(emplDens+studDens)/ (prkgDens+emplDens+studDens)), (Dens in units/Msqft)			0.1231	0.011	10.9
56	Street connectivity: (# 3 & 4 link nodes)/(# 1,3,4-link nodes) within a qtr mile			0.7375	0.121	6.1
Land Use Density and Mix Variables						
69	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	FT worker	<$50K	-0.0525	0.019	-2.7
70	Dens of households in TAZ (ln[1+HH*100/Msqft])	"	<$50K	-0.0782	0.012	-6.4
71	Dens of educ empl in TAZ (ln[1+empl*100/Msqft])	"	>$50K	-0.0270	0.009	-3.1
72	Dens of gov empl in TAZ (ln[1+empl*100/Msqft])	"	>$50K	0.0268	0.008	3.6
73	Dens of office empl in TAZ (ln[1+empl*100/Msqft])	"	>$50K	0.1275	0.023	5.6
74	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	"	>$50K	-0.0861	0.023	-3.7
75	Dens of households in TAZ	"	>$50K	-0.0711	0.009	-7.8

Coeff. No.	Variable Description	Person Type	HH Inc (annual)	Est.	Std. error	T-stat
	(ln[1+HH*100/Msqft])					
83	Dens of office empl in TAZ (ln[1+empl*100/Msqft])	PT worker	>$50K	0.1243	0.072	1.7
84	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	PT worker	>$50K	-0.1452	0.075	-1.9
90	Dens of households in TAZ (ln[1+HH*100/Msqft])	not FT/PT worker	reported	-0.0990	0.028	-3.6
91	Dens of educ empl in TAZ (ln[1+empl*100/Msqft])		unreported	0.0124	0.025	0.5
92	Dens of gov empl in TAZ (ln[1+empl*100/Msqft])		unreported	0.0024	0.019	0.1
93	Dens of office empl in TAZ (ln[1+empl*100/Msqft])		unreported	0.1711	0.059	2.9
94	Dens of service empl in TAZ (ln[1+empl*100/Msqft])		unreported	-0.1163	0.062	-1.9
95	Dens of households in TAZ (ln[1+HH*100/Msqft])		unreported	-0.0564	0.025	-2.2
Size Variables						
999	Size function scale			0.4963	0.012	43.0
101	Service empl. in parcel	FT worker	<$50K	-0.9521	0.316	-3.0
102	Education empl. in parcel	"	<$50K	-1.0527	0.408	-2.6
103	Restaurant empl. in parcel	"	<$50K	-1.5551	0.427	-3.6
104	Gov't empl. in parcel	"	<$50K	0.0000		
105	Office empl. in parcel	"	<$50K	-0.8820	0.311	-2.8
106	Other empl. in parcel	"	<$50K	-1.5311	0.670	-2.3
107	Retail empl. in parcel	"	<$50K	-1.1755	0.349	-3.4
108	Medical empl. in parcel	"	<$50K	-0.3607	0.380	-1.0
109	Industrial empl. in parcel	"	<$50K	-1.2685	0.320	-4.0
111	# Households in parcel	"	<$50K	-10.9767	0.607	-18.1
114	Service empl. in parcel	"	>$50K	-1.2946	0.232	-5.6
115	Education empl. in parcel	"	>$50K	-0.3744	0.251	-1.5
116	Restaurant empl. in parcel	"	>$50K	-2.7613	0.341	-8.1
117	Gov't empl. in parcel	"	>$50K	0.0000		
118	Office empl. in parcel	"	>$50K	-0.9407	0.218	-4.3
119	Other empl. in parcel	"	>$50K	-0.6419	0.342	-1.9
120	Retail empl. in parcel	"	>$50K	-2.1009	0.280	-7.5
121	Medical empl. in parcel	"	>$50K	-0.8232	0.267	-3.1
122	Industrial empl. in parcel	"	>$50K	-2.0504	0.253	-8.1
124	# Households in parcel	"	>$50K	-11.5899	0.536	-21.6
125	University enrollment in parcel	"	>$50K	-3.3305	1.396	-2.4
127	Service empl. in parcel	PT worker	<$50K	-0.3965	0.650	-0.6
128	Education empl. in parcel	"	<$50K	0.0000		
129	Restaurant empl. in parcel	"	<$50K	-0.9330	0.870	-1.1
130	Gov't empl. in parcel	"	<$50K	-0.7620	1.021	-0.7
131	Office empl. in parcel	"	<$50K	-0.3803	0.629	-0.6
132	Other empl. in parcel	"	<$50K	-1.8330	1.976	-0.9
133	Retail empl. in parcel	"	<$50K	-0.7966	0.745	-1.1
134	Medical empl. in parcel	"	<$50K	-2.6180	1.362	-1.9
135	Industrial empl. in parcel	"	<$50K	-1.7761	0.749	-2.4
137	# Households in parcel	"	<$50K	-11.1622	1.202	-9.3
140	Service empl. in parcel	"	>$50K	-1.0957	0.778	-1.4

Coeff. No.	Variable Description	Person Type	HH Inc (annual)	Est.	Std. error	T-stat
141	Education empl. in parcel	"	>$50K	0.5177	0.932	0.6
142	Restaurant empl. in parcel	"	>$50K	-2.2181	1.131	-2.0
143	Gov't empl. in parcel	"	>$50K	0.1927	0.938	0.2
144	Office empl. in parcel	"	>$50K	-0.1419	0.707	-0.2
145	Other empl. in parcel	"	>$50K	-1.0089	1.423	-0.7
146	Retail empl. in parcel	"	>$50K	-0.8157	0.802	-1.0
147	Medical empl. in parcel	"	>$50K	0.1336	0.825	0.2
148	Industrial empl. in parcel	"	>$50K	-2.1698	0.854	-2.5
150	# Households in parcel	"	>$50K	-12.7760	1.617	-7.9
152	K-12 enrollment in parcel	"	>$50K	0.0000		
153	Service empl. in parcel	not FT/PT worker	reported	-1.8385	0.590	-3.1
154	Education empl. in parcel	"	reported	-1.9346	0.781	-2.5
155	Restaurant empl. in parcel	"	reported	0.0000		
156	Gov't empl. in parcel	"	reported	-0.8038	0.833	-1.0
157	Office empl. in parcel	"	reported	-0.1983	0.490	-0.4
158	Other empl. in parcel	"	reported	-1.4767	1.185	-1.2
159	Retail empl. in parcel	"	reported	-0.8931	0.590	-1.5
160	Medical empl. in parcel	"	reported	-2.5169	1.000	-2.5
161	Industrial empl. in parcel	"	reported	-3.2164	0.745	-4.3
163	# Households in parcel	"	reported	-11.1020	0.984	-11.3
164	University enrollment in parcel	"	reported	-1.4594	2.157	-0.7
175	Total empl. in parcel		unreported	-0.3911	1.448	-0.3
176	# Households in parcel		unreported	-9.5848	1.636	-5.9
177	University enrollment in parcel		unreported	0.0000		
178	K-12 enrollment in parcel		unreported	-1.4187	1.668	-0.9

Summary Satistics:

Number observed choices	3,362
Number of estimated parameters	88
Log Lkelihood w Coeffs=0	-17,723.0
Final Log likelihood	-15,470.9
Rho squared	0.127
Adjusted rho squared	0.122

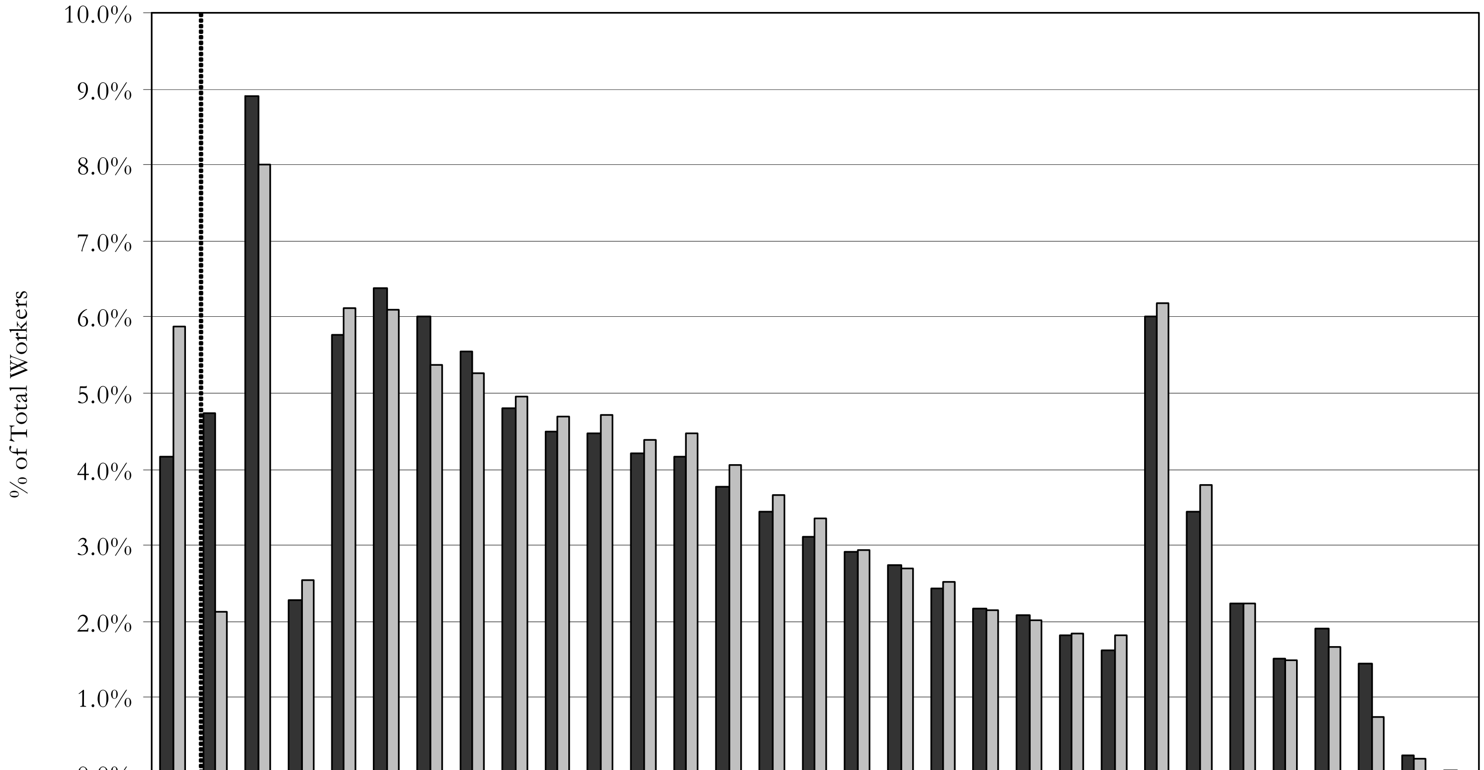
Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 8: Usual Location and Tour Destination Models", October 28, 2005.

Table 8-4. Usual Work Location Submodel Calibrated Coefficients

Coeff. No.	Variable Description	Person Type	Coefficients	
			Estimated Coeff.	Calibrated Coeff.
192	Home location	Constant	-6.2272	-8.9253
193	Home location	PT worker	7.0933	4.0933
18	One-way drive dist--0-3.5 mi (10s of mi)	FT worker	-4.0525	-3.3625
20	Nat log (1 + one-way drive dist (10s of mi))	PT worker	-2.8608	-2.8608

Source: SACOG, November 2008.

Figure 8-4. Distince Distribution, Place of Residence and Place of Work (Percentages)



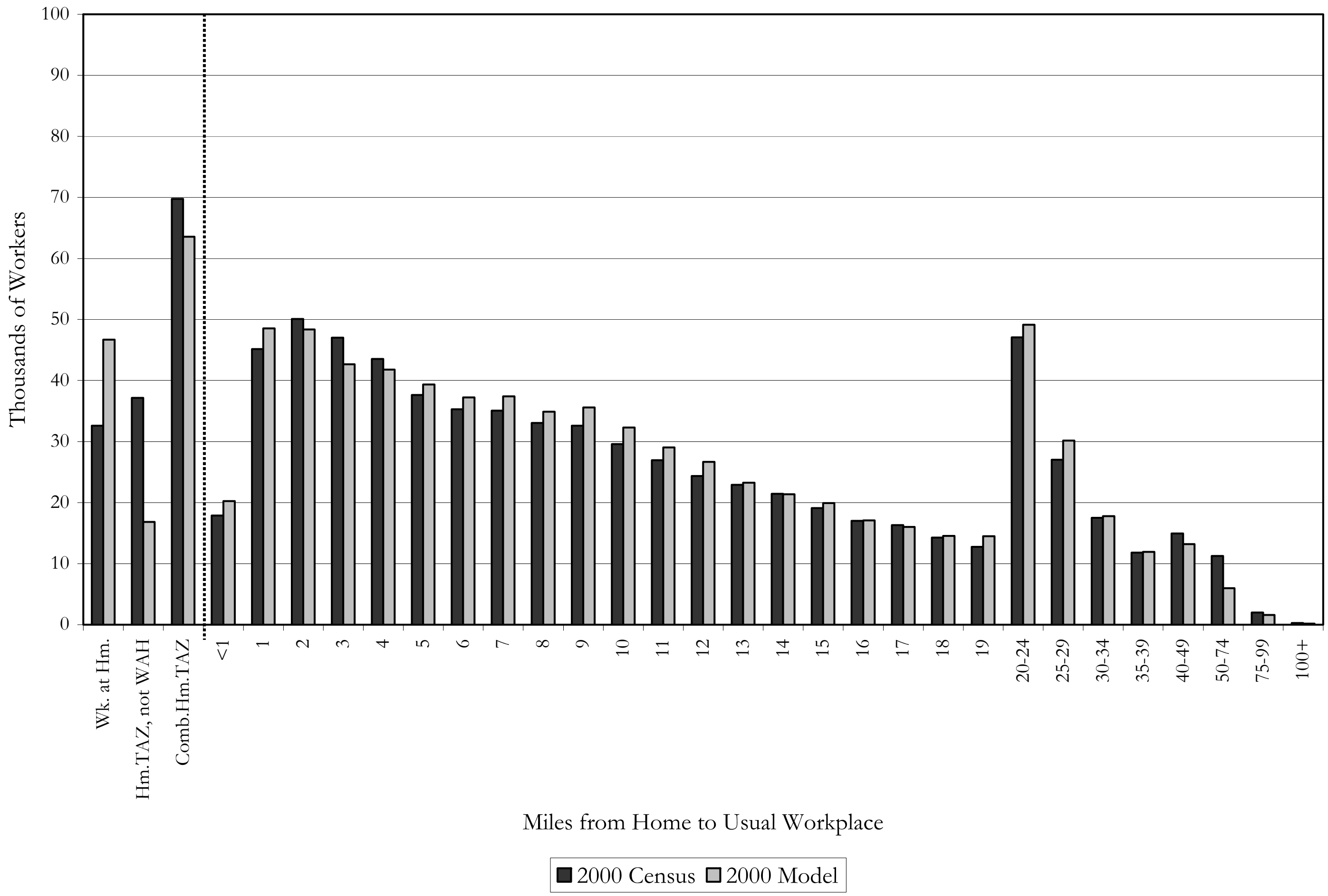
	Wk. at Hm.	Hm.TAZ, not	Comb.Hm. TAZ	<1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20-24	25-29	30-34	35-39	40-49	50-74	75-99	100+
2000 Census	4.2%	4.7%	8.9%	2.3%	5.8%	6.4%	6.0%	5.6%	4.8%	4.5%	4.5%	4.2%	4.2%	3.8%	3.4%	3.1%	2.9%	2.7%	2.4%	2.2%	2.1%	1.8%	1.6%	6.0%	3.4%	2.2%	1.5%	1.9%	1.4%	0.3%	0.0%
2000 Model	5.9%	2.1%	8.0%	2.5%	6.1%	6.1%	5.4%	5.3%	5.0%	4.7%	4.7%	4.4%	4.5%	4.1%	3.7%	3.4%	2.9%	2.7%	2.5%	2.1%	2.0%	1.8%	1.8%	6.2%	3.8%	2.2%	1.5%	1.7%	0.8%	0.2%	0.0%

Miles from Home to Usual Workplace

2000 Census 2000 Model

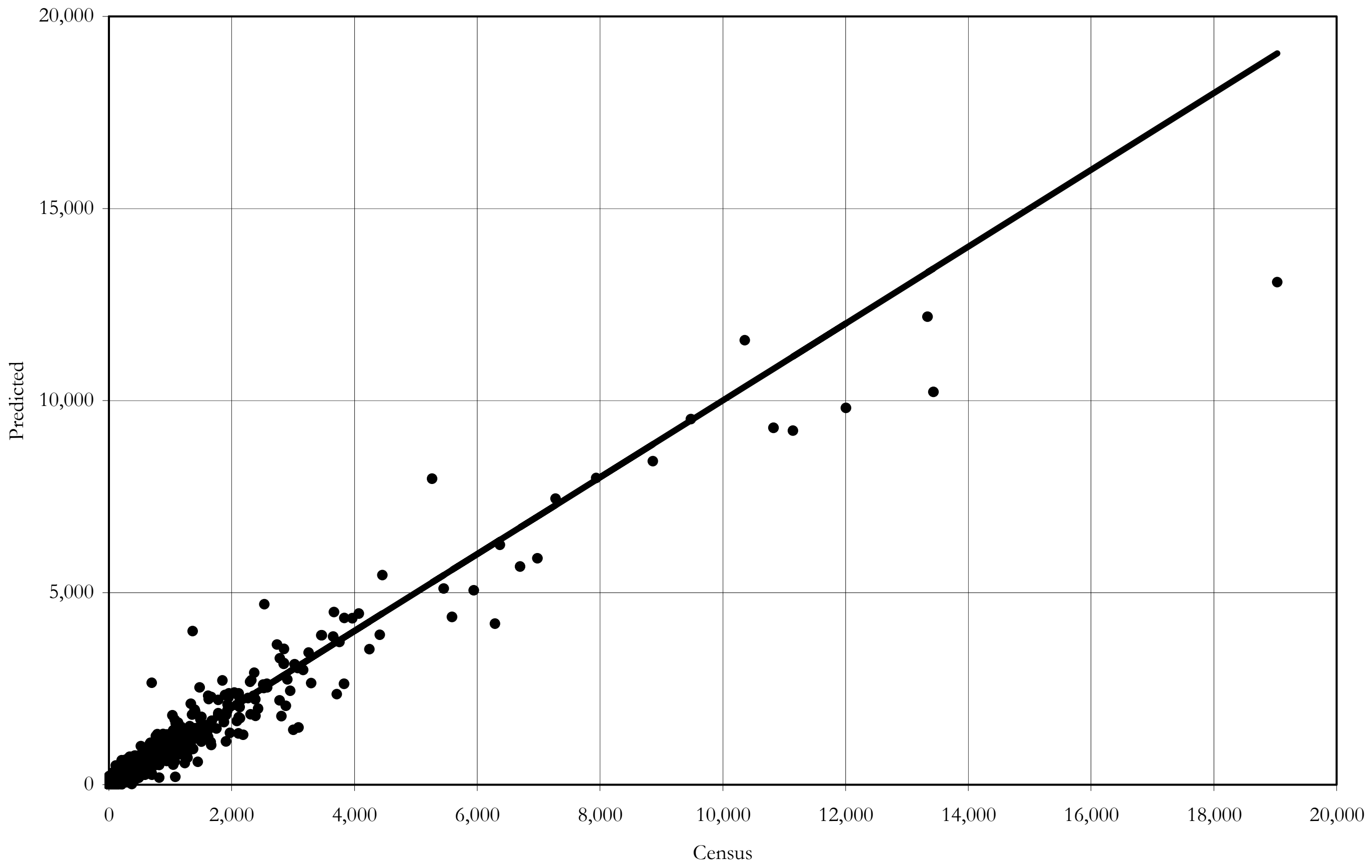
Source: November 2008.

Figure 8-5. Distince Distribution, Place of Residence and Place of Work (Worker Flows)



Source: SACOG, November 2008.

Figure 8-6. Home to Work Flows by Regional Analysis District



Source: SACOG, November 2008.

Table 8-5. Comparison of Key Points

Variable	Census	Model
Average Home-to-Work Distance (One-Way Miles)	11.8	11.5
Median Home-to-Work Distance (One-Way Miles)	8	8
95th %-tile Distance (One Way Miles)	35	33
Work-at-Home Percentage	4.2%	5.9%
Work within TAZ	4.7%	2.1%
Combined W-a-H + Home TAZ	8.9%	8.0%
Model Predicting Census RAD-to-RAD Flow	Adj. R-sq = 0.95 Beta = 1.06	
Source: SACOG, November 2008.		

Usual School Location Submodel

Structurally, the usual school location submodel 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 submodel. 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.

Table 8-6 provides detailed tabulations of model variables and coefficients. The model was applied as estimated, without any calibration.

Figures 8-7 through 8-9 present home-to-usual-school distance distributions for all students, K12 students, and college/university students, respectively, compared to the 2000 SACOG household survey. SACSIM distance distributions for all students and K12 students match survey results fairly closely; university student distance distributions do not match very closely. Table 8-7 illustrates the extent of the mismatch for university students: average model distance is 1.2 miles longer than the household survey; median distance is 2 miles longer (6 compared to 4).

University student residence location is not fully controlled in the SACSIM representative population. Around Sacramento State University, a cluster of university student residents are manually placed in the population; this manual correction has not been executed for University of California at Davis. The data to do the manual correction has been acquired, but the correction has not be implemented. Once the clustering of student residences around UC Davis is implemented, the usual school location model will be re-calibrated and validated against the household survey.

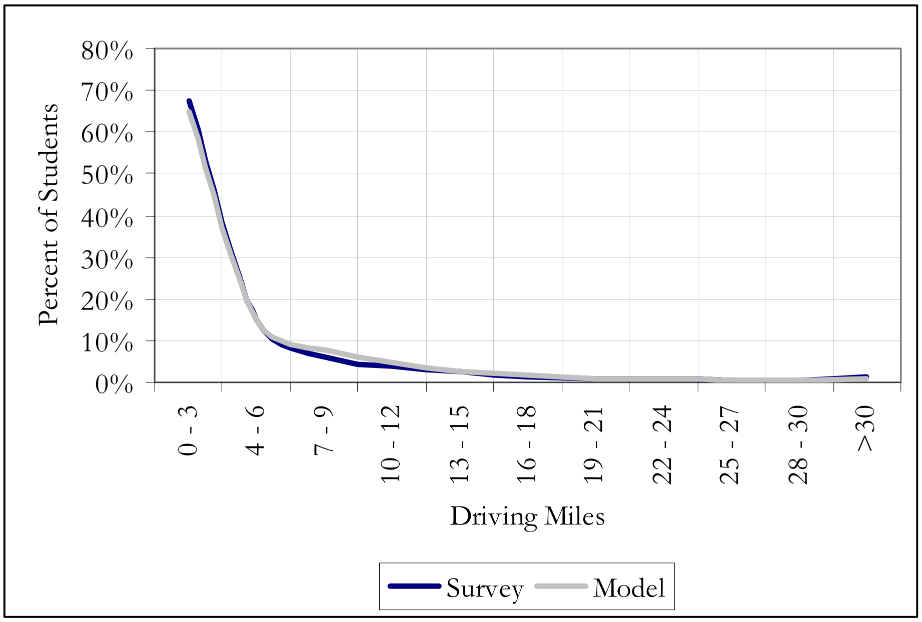
Table 8-6. Usual School Location Submodel Estimation Results

Coeff. No.	Variable Description	Person Type	Est.	Std. error	T-stat
1	Sampling adjustment factor for estimation		1.0000		
95	Home location	Constant	-80.5728	65.388	-1.2
96	Home location	adult not univ. stud.	22.4107	11.362	2.0
102	Home location	HH size	7.3239	5.451	1.3
LogSum and Accessibility Variables					
998	Dest choice LogSum (in home vs other choice)		0.0675	0.047	1.4
2	Mode choice LogSum	child age <5	1.0000		
3	Mode choice LogSum	child age 5-15	1.0000		
4	Mode choice LogSum	driving age stud.	1.0000		
5	Mode choice LogSum	univ. Stud.	1.0000		
6	Mode choice LogSum	adult not univ. stud.	1.0000		
7	OW drive dist--0-1 mi (mi. x 10)	child age <5	-22.7384	5.052	-4.5
8	OW drive dist--1-5 mi (mi. x 10)	child age <5	-4.1532	0.795	-5.2
9	OW drive dist--5+ mi (mi. x 10)	child age <5	-1.6212	0.249	-6.5
10	OW drive dist--0-1 mi (mi. x 10)	child age 5-15	-16.2979	1.577	-10.3
11	OW drive dist--1-5 mi (mi. x 10)	child age 5-15	-8.0099	0.307	-26.1
12	OW drive dist--5+ mi (mi. x 10)	child age 5-15	-2.2769	0.154	-14.8
13	Ln (1 + OW drive dist (mi. x 10))	driving age stud.	-6.1357	0.299	-20.5
14	Ln (1 + OW drive dist (mi. x 10))	univ. stud.	-2.9403	0.188	-15.6
15	Ln (1 + OW drive dist (mi. x 10))	adult not univ. stud.	-1.7008	0.235	-7.2
16	Ln (1 + OW drive dist from work (mi. x 10))	adult not univ. stud.	-1.4594	0.254	-5.8
17	Aggr. mode-dest LogSum at dest	child age <5	0.2850	0.159	1.8
18	Aggr. mode-dest LogSum at dest	child age 5-15	0.1009	0.085	1.2
19	Aggr. mode-dest LogSum at dest	driving age stud.	0.1085	0.161	0.7
20	Aggr. mode-dest LogSum at dest	univ. stud.	1.3147	0.115	11.4
21	Aggr. mode-dest LogSum at dest	adult not univ. stud.	1.0434	0.127	8.2
Land Use Density and Mix Variables					
53	Dens of educ empl in TAZ (ln[1+empl*100/Msqft])	child age 5-15	0.0884	0.019	4.7
56	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	child age 5-15	-0.0952	0.025	-3.8
71	Dens of educ empl in TAZ (ln[1+empl*100/Msqft])	driving age stud.	0.0895	0.033	2.7
91	Dens of gov empl in TAZ (ln[1+empl*100/Msqft])	adult or univ. stud.	0.0628	0.015	4.2
92	Dens of office empl in TAZ (ln[1+empl*100/Msqft])	adult or univ. stud.	0.0793	0.038	2.1
93	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	adult or univ. stud.	-0.2318	0.040	-5.8
94	Dens of households in TAZ (ln[1+HH*100/Msqft])	adult or univ. stud.	-0.1620	0.016	-9.8
Size Variables					
999	Size function scale		0.2395	0.004	62.1
22	Education empl. in parcel	child age <5	-6.4212	2.178	-2.9
28	Service empl. in parcel	child age <5	-8.0189	1.212	-6.6
32	# Households in parcel	child age <5	-18.3839	0.997	-18.4
34	K-12 enrollment in parcel	child age <5	0.0000		
40	Education empl. in parcel	child age 5-15	-9.0152	0.740	-12.2

Coeff. No.	Variable Description	Person Type	Est.	Std. error	T-stat
46	Service empl. in parcel	child age 5-15	-22.4509	1.546	-14.5
50	# Households in parcel	child age 5-15	-23.4589	0.553	-42.4
52	K-12 enrollment in parcel	child age 5-15	0.0000		
58	Education empl. in parcel	driving age stud.	-8.5263	1.391	-6.1
64	Service empl. in parcel	driving age stud.	-18.6746	1.854	-10.1
68	# Households in parcel	driving age stud.	-21.0771	0.695	-30.3
70	K-12 enrollment in parcel	driving age stud.	0.0000		
76	Education empl. in parcel	adult or univ. stud.	-5.9870	0.469	-12.8
85	Total empl. in parcel	adult or univ. stud.	-24.9657	0.742	-33.6
87	University enrollment in parcel	adult or univ. stud.	0.0000		
	Summary statistics				
	Number observed choices		2,109		
	Number of estimated parameters		38		
	Log likelihood w coeffs=0		-9,131.7		
	Final Log likelihood		-6,915.2		
	Rho squared		0.243		
	Adjusted rho squared		0.239		

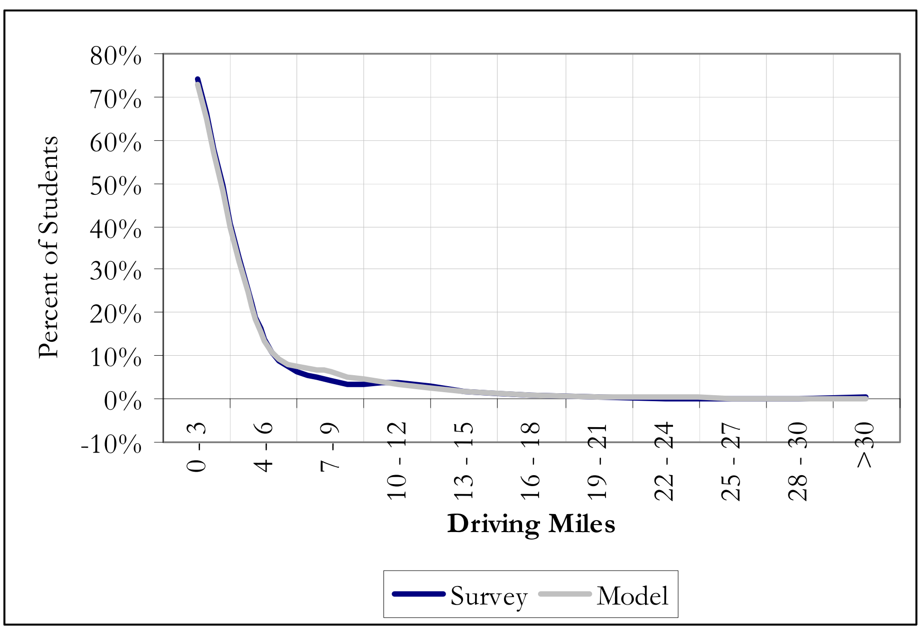
Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 8: Usual Location and Tour Destination Models", October 28, 2005.

Figure 8-7. Distance Distribution, All Students
Home to Usual School Location



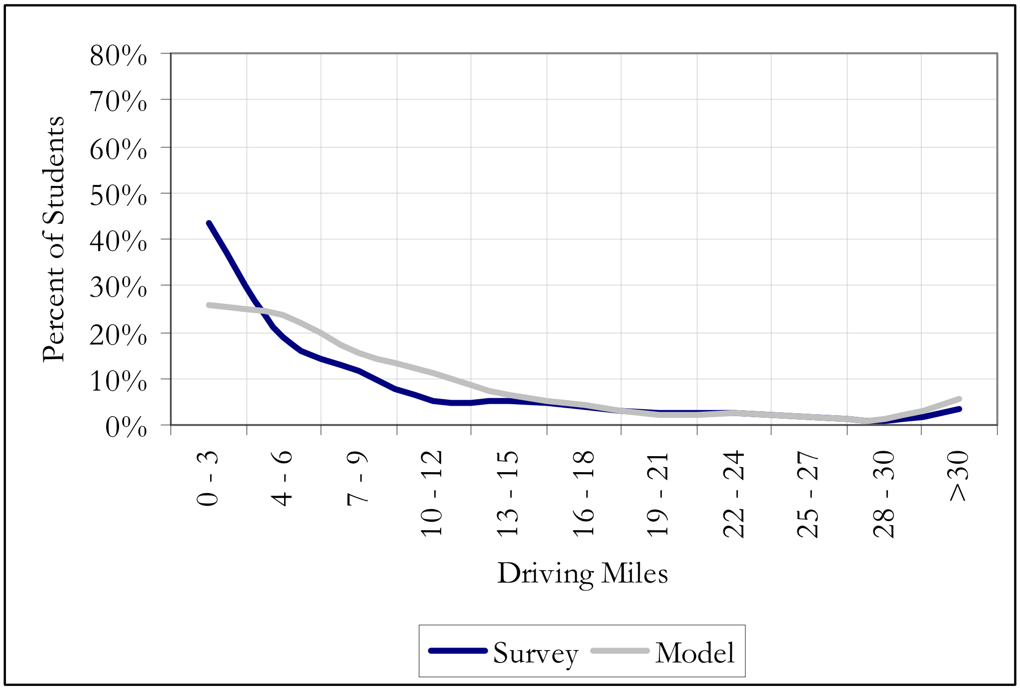
Source: SACOG, November 2008.
Survey data from SACOG 2000 Household Travel Survey.

Figure 8-8. Distance Distribution, K12 Students
Home to Usual School Location



Source: SACOG, November 2008.
Survey data from SACOG 2000 Household Travel Survey.

Figure 8-9. Distance Distribution, College/University Students Home to Usual School Location



Source: SACOG, November 2008.
Survey data from SACOG 2000 Household Travel Survey.

Table 8-7. Home-to-Usual School Distance Distribution

Student Type	HH Survey	Model
Average Distance (One-Way Miles)		
College/University	7.8	9.0
Driving Age K12 Student	4.2	3.9
K12 Student, Age 5-15 Yrs.	3.1	3.1
All Students	4.3	4.2
Median Distance (One-Way Miles)		
College/University	4	6
Driving Age K12 Student	2	2
K12 Student, Age 5-15 Yrs.	1	1
All Students	2	2

Source: SACOG, November 2008.
Based on SACOG 2000 Household Travel Survey.

Automobile Ownership/Availability Submodel

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).

Table 8-8 provides details on all the variables included, as well as overall estimation results.

Submodel Calibration and Application

Calibration was set to predict auto ownership distribution at RAD level, using the Census as the point of comparison. Initial calibration focused on adjustment of the array of constants for different auto ownership levels by number of drivers in household. However, this calibration failed to predict relatively high rates of no-auto households in several rural RAD's in the region. For example, the Linda and Olivehurst RAD's in Yuba County, which are very low density, rural residential in character, both had over 10 percent no-auto households in the Census. Also, the extent of no-auto households in the Downtown Sacramento RAD (32 percent) was not predicted. For this reason, a set of calibration coefficients were introduced to the model, and adjusted to match the observed percentages of no-auto households. Table 8-9 provides details on the final calibrated model coefficients. The model was re-estimated with some of the introduced calibration coefficients, which is reflected in this table.

Table 8-10 compares regionwide totals of the number-of-autos-owned distribution for the Census and the calibrated model. Figures 8-10 and 8-11 illustrate a comparison of RAD-level estimates of average number of autos per household for the lowest and highest 25 RAD's. Figures 8-12 and 8-13 provide similar illustrations for the percentage of no-auto households by RAD.

Table 8-8. Auto Ownership/Availability Submodel Estimation Results

Coef. No.	Variable Description	No car Coeff	No car T stat	1 car Coeff	1 car T stat	2 cars Coeff	2 cars T stat	3 cars Coeff	3 cars T stat	4+ cars Coeff	4+ cars T stat
Alternative Specific Constants											
1	1 driver in HH	-5.819	-5.6			-1.575	-10.1	-2.676	-12.9	-4.031	-10.4
2	2 drivers in HH	-6.830	-6.5	-1.772	-9.3			-1.375	-11.8	-2.100	-9.3
3	3 drivers in HH	-6.680	-5.7	-1.486	-5.3	-0.280	-1.3			-0.477	-1.9
4	4+ drivers in HH	-8.086	-5.3	-1.997	-4.6	-1.024	-3.0	-0.969	-2.8		
Demographic Variables											
5	Cars per driver--nonfamily households	-0.469	-1.8	-0.469	-1.8	-0.469	-1.8	-0.469	-1.8	-0.469	-1.8
6	Dummy--at least as many cars as workers	0.578	4.9	0.578	4.9	0.578	4.9	0.578	4.9	0.578	4.9
7	Part-time workers per driver							-0.325	-1.2	-0.382	-0.9
8	Retired adults per driver			0.281	2.4			-0.338	-2.1	-0.560	-2.2
9	University students per driver			0.795	3.0			0.682	2.1		
10	Driving age children per driver	2.281	1.9	1.234	2.1			-0.742	-1.4	-2.830	-3.8
11	Home-based workers + students per driver	1.000	2.7	0.570	3.2					-0.211	-0.8
12	Children under 5 per driver	-0.630	-0.9					-0.475	-1.6	-1.717	-2.8
13	Dummy—HH income < $15K per year	2.217	8.7	0.547	3.0			-0.609	-1.9	-1.218	-2.2
14	Dummy--HH income $50-75K per year	-1.419	-3.5	-1.138	-9.0			0.178	1.4	0.198	1.1
15	Dummy—HH income > $75K per year	-1.600		-1.231	-6.6			0.310	2.2	0.435	2.2
16	Dummy--HH income not reported	-0.081	-0.2	-0.577	-3.6			0.168	0.9	-0.371	-1.2

Accessibility and Land Use Variables

Coef. No.	Variable Description	No car Coeff	No car T stat	Cars < drivers Coeff	Cars < drivers T stat
17	Accessibility: Diff. btwn. logsums with full HH car availability and no HH car availability (M/C logsum to wk—FT workers)	-0.242	-3.3	-0.068	-3.1
18	M/C logsum to work—Other workers	-0.279	-1.9	-0.077	-2.0
19	M/C logsum to school—Driving age students			-0.094	-1.9
20	Driver's non-work mode/dest logsum	-0.250	-1.7		
21	Amount (mi) by which distance to nearest transit stop is less than ½ mile (capped at .25)	11.141	2.6	1.126	1.5
22	Amount (mi) by which distance to nearest transit stop is less than ¼ mile	5.244	3.3	1.338	1.7
23	Avg daily parking price ($) w/in 1/2 mi. of home	0.104	3.5	0.051	1.2
24	Log of comm'l empl. (food, retail, serevice, medical) w/in 1/2 mi. of home	0.210	3.8	0.138	5.0

Summary statistics	
Number observed choices	3942
Number of estimated parameters	64
Log likelihood w coeffs=0	-6344
Final Log likelihood	-3884
Rho squared	0.388
Adjusted rho squared	0.378

Coef. No.	Variable Description	No car		1 car		2 cars		3 cars		4+ cars	
		Coeff	T stat	Coeff	T stat	Coeff	T stat	Coeff	T stat	Coeff	T stat

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 9: Household Auto Availability Model", July 31, 2006.

Table 8-9. Auto Ownership Submodel: Calibrated or Final Model Coefficients

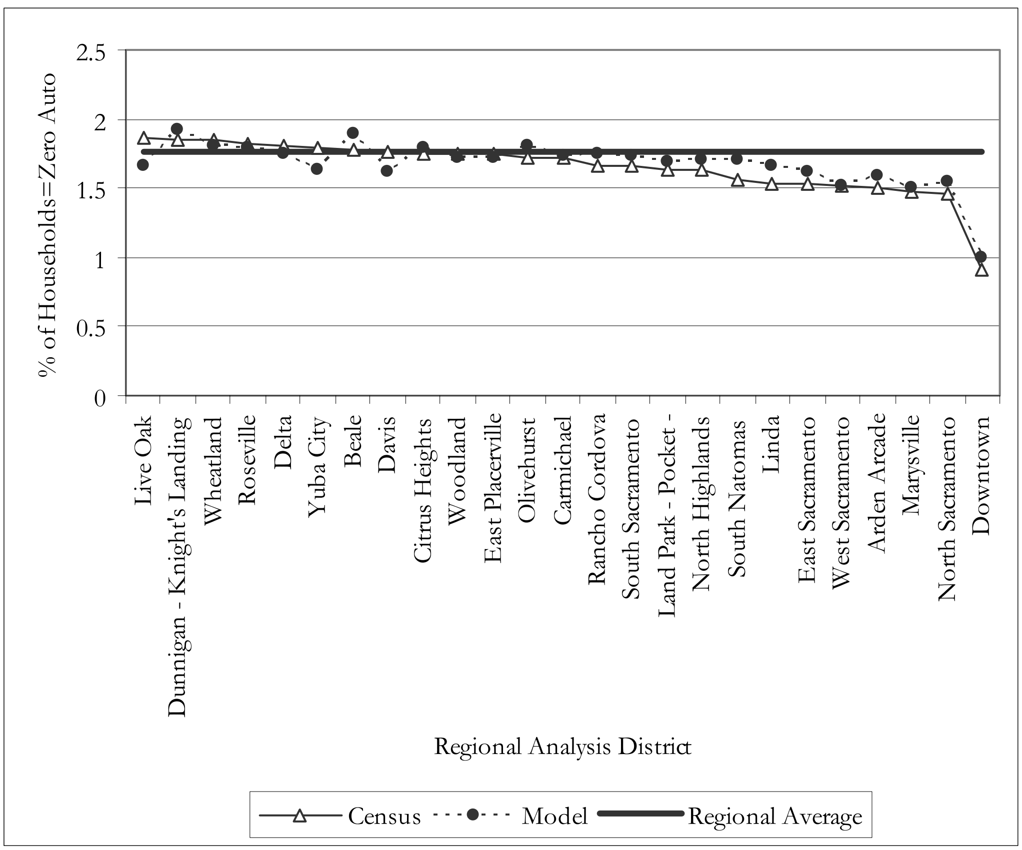
Coeff. No.	Variable Description	No car Estim.	No car Calib	1 car Estim.	1 car Calib	2 cars Estim.	2 cars Calib	3 cars Estim.	3 cars Calib	4+ cars Estim.	4+ cars Calib
Alternative Specific Constants											
1	1 driver in HH	-5.819	-5.294			-1.575	-1.466	-2.676	-2.802	-4.031	-3.425
2	2 drivers in HH	-6.830	-5.000	-1.772	-1.361			-1.375	-1.302	-2.100	-2.386
3	3 drivers in HH	-6.680	-4.063	-1.486	-0.777					-0.477	-0.854
4	4+ drivers in HH	-8.086	-3.810	-1.997	-0.946	-1.024	-0.490	-0.969	-0.569		
Accessibility and Land Use Variables											
17	Accessibility: Difference between logsums with full HH car availability and no HH car availability	-0.242	-0.266								
18	--Mode choice logsum to work—other workers	-0.279	-0.307								
20	--Driver's non-work mode-dest logsum	-0.250	-0.275								
21	Amount (mi) by which distance to nearest transit stop is less than ½ mile (capped at .25)	11.141	10.027								
22	Amount (mi) by which distance to nearest transit stop is less than ¼ mile	5.244	4.720								
23	Avg daily parking price ($) within 1/2 mile of home	0.104	0.094								
24	Natural log of commercial employment (food, retail, serevice, medical) within 1/2 mi of home	0.210	0.189								
Calibration Coefficients											
25	Rural Factor * Coeff 17 (0 Cars)	n/a	0.024								
26	Rural Factor * Coeff 18 (0 Cars)	n/a	0.028								
27	Rural Factor * Coeff 20 (0 Cars)	n/a	0.025								
28	Rural Factor * Coeff 22 (0 Cars)	n/a	0.524								
29	Rural Factor * Coeff 21 (0 Cars)	n/a	1.114								
30	Rural Factor * Coeff 24 (0 Cars)	n/a	0.010								
31	Rural Factor * ASC (0 Cars)	n/a	-1.138								
32	CBD Factor * ASC (0 Cars)	n/a	-0.051								

Source: SACOG, November 2008.
Based on work performed by Bowman, John L. and Bradley, Mark A. after Tech. Memo 9 completed.

Table 8-10. Autos Per Household, DAYSIM Compared to Census

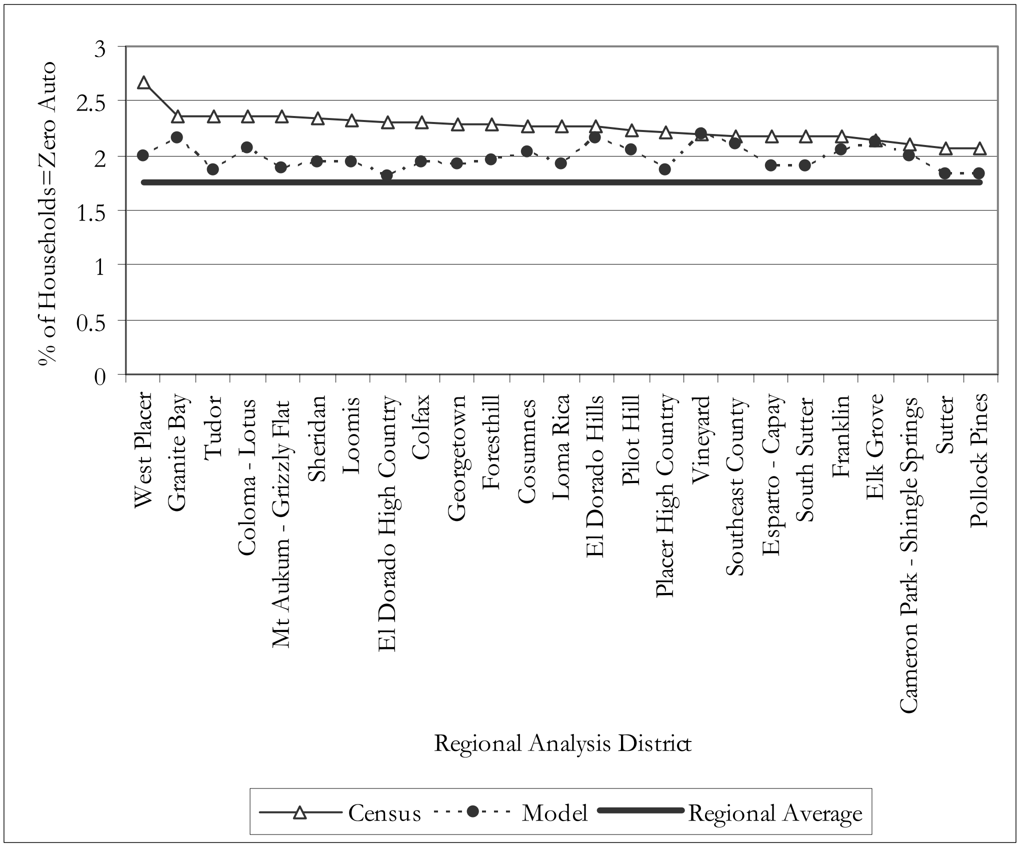
Variable	Census	Model
Total Households	695,013	695,010
Zero-Auto HH's	53,471	53,319
1-Auto HH's	239,309	240,967
2-Auto HH's	276,266	274,992
3-Auto HH's	92,093	91,618
4-or-more Auto HH's	33,875	34,114
% Zero Auto	7.7%	7.7%
% 1-Auto	34.4%	34.7%
% 2-Auto	39.7%	39.6%
% 3-Auto	13.3%	13.2%
% 4+ Auto	4.9%	4.9%
Source: SACOG, November 2008. Based on Year 2000 Census data.		

Figure 8-10. Autos Per Household by Regional Analysis District SACSIM Compared to Census for Lowest 25 Districts



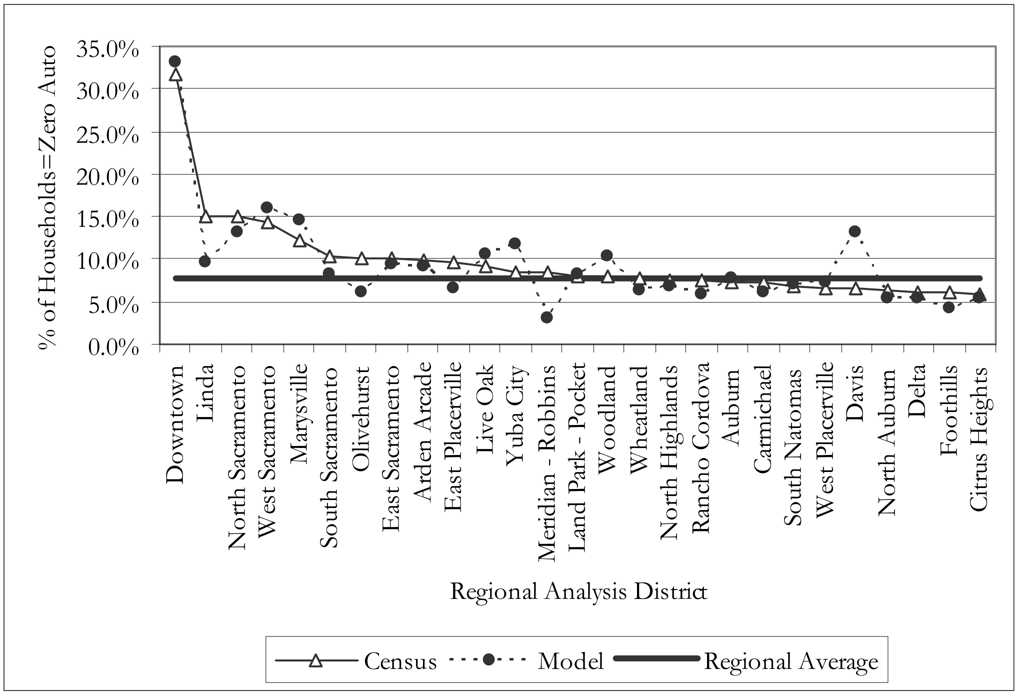
Source: SACOG, November 2008.

Figure 8-11. Autos Per Household by Regional Analysis District SACSIM Compared to Census for Highest 25 Districts



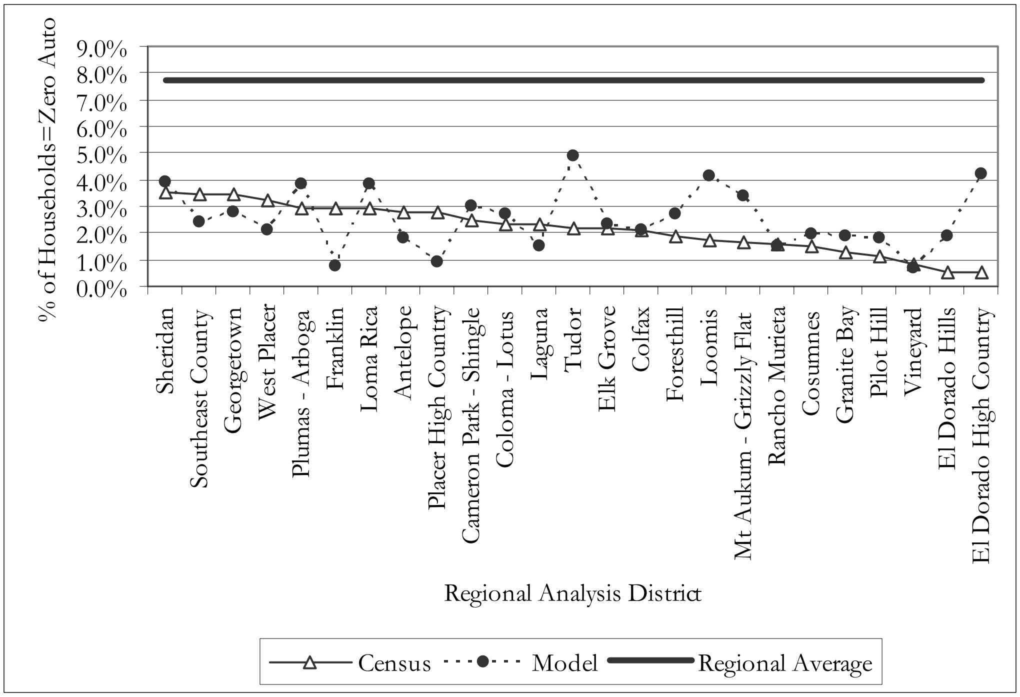
Source: SACOG, November 2008.

Figure 8-12. Zero-Auto Households by Regional Analysis District SACSIM Compared to Census for Highest 25 Districts



Source: SACOG, November 2008.

Figure 8-13. Zero-Auto Households by Regional Analysis District SACSIM Compared to Census for Lowest 25 Districts



Source: SACOG, November 2008.

Short Term Submodels

Short term submodels 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.

Day Pattern and Exact Number of Tours Submodels

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, and accessibility variables (see Table 8-12).
- 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.—see Table 8-13).
- A set of demographic variables and accessibility variables, which affect predictions of the exact number of tour purposes and stop purposes (see Table 8-14).
- A set of constants for various combinations of multiple tour purposes and stop purposes (see Table 8-15).

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 tours.

Overall estimation results are for the submodel is shown below:

Table 8-11. Day Pattern Submodel Estimation Results

Observations	8,755
Final log likelihood	33,234.3
Rho-squared(0)	0.503
Rho-squared(constants)	0.136
Source: SACOG, November 2008. Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 6: Day Pattern Activity Generation Models", July 31, 2006.	

Another submodel predicts the exact number of tours by purpose, and is shown in Table 8-16. The person type, demographic, and family composition variables are less influential in predicting exact number of tours, and the accessibility variables (logums for 2 or 3 tours) are more influential than in the higher level pattern models; in general, the higher number of tours per person (2 or 3+) are much more likely in areas with higher accessibility as measured by logsums.

Submodel Calibration and Application

The calibration approach used for these models is focused on the adjustment of the person type constants for the 0 or 1+ tours and stops constants for the tour and stop frequency (Table 8-18), and the 2 and 3+ tours constants for the exact number of tours models (Table 8-19). Initially, the adjustments were computed to match the weighted household travel survey. However, subsequent validation of traffic volumes and vehicle miles traveled indicated that the overall amount of personal travel was likely underestimated in the household travel survey. Presuming that this underestimation had to do with survey bias, which reduced the chances of very active households from being recruited and surviving in the household survey, a second wave of calibration was done, with the household survey adjusted to include more active (i.e. fewer 0-tour, and more 1, 2 and 3+ tour) persons and households. Tables 8-20 through 8-22 provide comparisons of tour frequency for various person types and tour types. Both the initially-weighted and adjusted household travel survey statistics are provided in the tables.

Table 8-12. Day Pattern Choice Estimation Results (Part 1 of 4)
Basic Submodel Coefficients

Coeff. No.	Variable Description	Work (X=1)		School (X=2)		Escort (X=3)		Per.Bus. (X=4)		Shop (X=5)		Meal (X=6)		Soc+Rec (X=7)	
		Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat
Basic Tour & Stop Constants															
X00	Constant-Tour	0.513	3.2	-4.256	-20.4	-4.077	-16.2	-2.575	-18.4	-2.998	-20.9	-3.671	-20.8	-2.39	-24.1
X01	Constant-Stop	1.19	1.9	-4.623	-6.8	-1.354	-3.3	-0.165	-0.5	-0.486	-1.4	-0.648	-1.8	-0.473	-1.5
Person Type															
X02	Part-time worker	-0.784	-7.1	-1.448	-2.0					0.242	2.2	-0.260	-2.0		
X03	Retired	-5.769	-23.0	-3.364	-3.3	-0.497	-3.9	0.520	5.2	0.306	3.3				
X04	Other non-worker	-4.465	-26.6	-0.385	-1.1			0.252	2.4	0.426	4.2				
X05	University student	-2.305	-14.7	1.903	9.6										
X06	Student age 16+	-3.136	-13.5	3.897	16.7			-0.379	-1.9	-0.563	-2.7	-0.514	-2.2		
X07	Student age 5-15	-20		4.309	20.7			-0.541	-3.7	-0.667	-4.6	-0.914	-5.0	0.323	3.0
X08	Child age 0-4	-20		1.896	8.1	0.864	5.5	-0.506	-3.1			-0.206	-1.1	0.528	3.9
Adult Age Group															
X21	Age 18-25			0.849	4.5	-0.702	-4.8	-0.425	-3.5	-0.318	-2.7				
X22	Age 26-35			0.378	1.6	-0.277	-2.4	-0.282	-2.6	-0.261	-2.5				
X23	Age 51-65			-0.950	-3.3	-0.254	-2.7	0.150	2.0	0.114	1.6			-0.266	-3.5
Adult Gender/ Age of Children															
X19	Male / age 0-4					0.495	2.9			-0.387	-2.3				
X20	Male / age 5-15					1.206	10.6	-0.444	-4.0			-0.493	-3.8	-0.512	-4.0
X16	Female / none	0.163	2.1							0.185	3.1	-0.131	-1.8		
X17	Female / age 0-4	-0.241	-1.5	-1.124	-2.8	1.350	9.0	-0.389	-2.5						
X18	Female / age 5-15					1.803	17.6	-0.276	-2.6			-0.679	-5.2	-0.530	-4.5
Household Composition															
X13	Only adult in HH					0.345	2.9	0.112	1.4	0.298	3.7			0.112	1.2
X14	Only worker in HH					-0.484	-4.4								
X15	Non-family , 2+ Pers											0.158	0.9		
Household Iincome															
X09	Income $0-25K	-0.244	-2.1	0.440	3.1	-0.277	-2.6	-0.131	-1.6	-0.189	-2.3	-0.171	-1.7	-0.489	-5.3
X10	Income $25-45K	-0.131	-1.3	0.449	3.5	-0.168	-2.0					-0.121	-1.4	-0.250	-3.2
X11	Income over $75K	0.131	1.6					0.166	2.8	0.109	1.8			0.061	0.9
Other															

Coeff. No.	Variable Description	Work (X=1)		School (X=2)		Escort (X=3)		Per.Bus. (X=4)		Shop (X=5)		Meal (X=6)		Soc+Rec (X=7)	
		Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat
X12	Cars per adult in HH	0.473	2.9					0.472	4.0	0.578	4.7	0.421	2.8	0.134	1.4
X24	Work at home	-2.54	-16.5											-0.604	-3.3
X25	Hm. MU dens.									0.156	2.1				
X26	Hm. Intersect. Dens.														
X27	Hm.-wk./sch. Access.	0.198	3.6	1.40	18.0										
X27	Hm. Agg. Access.					0.043	1.8								
X28	Hm.-wk. stop access.			0.112	4.2	0.011	1.1	0.012	1.4			0.013	1.4		

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 6: Day Pattern Activity Generation Models", July 31, 2006.

Table 8-13. Day Pattern Choice Estimation Results (Part 2 of 4)
Additional Constants

Coeff. No.	Additional Constants (C[NT,NS])	Coeff	T-stat
1311	1 tour purpose + 1 stop purpose	-2.145	-6.9
1312	1 tour purpose + 2 stop purposes	-3.313	-6.1
1313	1 tour purpose + 3+stop purposes	-3.649	-5.1
1321	2 tour purposes + 1 stop purpose	-1.965	-6.2
1322	2 tour purposes + 2 stop purposes	-3.018	-5.5
1323	2 tour purposes + 3 stop purposes	-3.393	-4.7
1331	3 tour purposes + 1 stop purpose	-1.66	-4.6
1332	3 tour purposes + 2 stop purposes	-2.809	-4.7

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 6: Day Pattern Activity Generation Models", July 31, 2006.

Table 8-14. Day Pattern Choice Estimation Results (Part 3 of 4)
Tour Purpose and Stop Frequency Specific Variables

Coeff. No.	Variable Description	LN(Tour purposes) X=8 Coeff	X=8 T-stat	LN(Stop purposes) X=9 Coeff (X=9)	X=9 T-stat
Person Type					
X02	Part-time worker	1.081	7.4		
X03	Retired	0.503	3.2		
X04	Other non-worker	0.596	3.8	0.228	1.8
X05	University student	0.709	3.6		
X06	Student age 16+	1.106	4.6	1.058	4.2
X07	Student age 5-15	0.547	2.7	0.678	3.6
X08	Child age 0-4				
Adult age group					
X21	Age 18-25	0.480	3.1		
X22	Age 26-35				
X23	Age 51-65	-0.077	-0.7		
Adult Gender/ Age of Chidren					
X19	Male / age 0-4	-0.340	-1.5		
X20	Male / age 5-15	0.703	4.5		
X16	Female / none	-0.216	-2.3		
X17	Female / age 0-4	-0.784	-3.8		
X18	Female / age 5-15	0.802	5.4		
Household composition					
X13	Only adult in HH				
X14	Only worker in HH				
X15	Non-family 2+person HH				
Household income					
X09	Income $0-25K				
X10	Income $25-45K				
X11	Income over $75K				
Other					

Coeff. No.	Variable Description	LN(Tour purposes)	X=8	LN(Stop purposes)	X=9
		Coeff	T-stat	Coeff (X=9)	T-stat
X12	Cars per adult in HH				
X24	Work at home	1.011	5.1	0.499	2.6
X25	Home mixed use density		*		
X26	Home intersection density	0.002	2.1		
X27	Home-work/school accessibiiity				
X27	Home aggregate accessibility	0.044	2.5		
X28	Home-work stop accessibility				

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 6: Day Pattern Activity Generation Models", July 31, 2006.

Table 8-15. Day Pattern Choice Estimation Results (Part 4 of 4)
Tour / Stop Combination Variables

Coeff. No.	Variable Description	Tour+Tour Y=11		Stop+Stop Y=12		Tour+Stop Y=10	
		Coeff	T-stat	Coeff	T-stat	Coeff	T-stat
Y11	Work + Work					-1.469	-2.7
Y12	Work + School	-1.454	-6.8			0.2223	0.4
Y13	Work + Escort	-0.7426	-5.1	-1.028	-5.4	0.5514	4.2
Y14	Work + Per.Bus	-1.22	-9.6	-0.2313	-1.5	-0.1685	-1.4
Y15	Work + Shop	-1.025	-8.2	-0.3903	-2.4	0.04718	0.4
Y16	Work + Meal	-0.2655	-1.8	-0.3467	-2.1	0.1761	1.3
Y17	Work + Soc/Rec	-0.4903	-4.0	-0.8318	-3.9		
Y21	School + Work					-0.4215	-0.9
Y22	School + School					2.625	4.7
Y23	School + Escort	-1.01	-5.3	-0.8321	-2.7	0.5689	4.0
Y24	School + Per.Bus	-0.9665	-5.9	-0.3223	-1.1	-0.3841	-2.7
Y25	School + Shop	-0.8558	-5.1	-1.203	-3.3	-0.3848	-2.6
Y26	School + Meal	-0.4355	-2.0	-0.0102	0.0	-0.4487	-2.6
Y27	School + Soc/Rec	-0.5298	-3.6	-0.05269	-0.2		
Y33	Escort + Escort					2.312	8.9
Y34	Escort + Per.Bus	0.5593	4.2	-0.5243	-4.1	-0.1566	-1.2
Y35	Escort + Shop	0.33	2.4	-0.5016	-3.9	-0.3028	-2.3
Y36	Escort + Meal	-0.04151	-0.2	-0.1916	-1.4	-0.1474	-1.0
Y37	Escort + Soc/Rec	0.4668	3.3	-0.2277	-1.6		
Y43	Per.Bus + Escort					0.3288	2.9
Y44	Per Bus + Per Bus					0.9089	5.6
Y45	Per Bus + Shop	-0.2195	-1.9	-0.03368	-0.3	0.254	2.5
Y46	Per Bus + Meal	0.3488	2.3	-0.3466	-2.8	0.4017	3.5
Y47	Per Bus + Soc/Rec	-0.01914	-0.2	-0.4352	-3.3		
Y53	Shop + Escort					0.179	1.5
Y54	Shop + Per Bus					0.3853	3.8
Y55	Shop + Shop					1.392	8.5
Y56	Shop + Meal	-0.116	-0.7	-0.3225	-2.6	0.06504	0.5
Y57	Shop + Soc/Rec	0.00233	0.0	-0.4836	-3.6		
Y63	Meal + Escort					0.4539	2.9
Y64	Meal + Per Bus					-0.2992	-2.0
Y65	Meal + Shop					-0.1665	-1.1
Y66	Meal + Meal					0.36	1.7
Y73	Soc/Rec + Escort					0.09108	0.8
Y74	Soc/Rec + Per Bus					-0.182	-1.7
Y75	Soc/Rec + Shop					-0.04755	-0.4
Y76	Soc/Rec + Meal					0.4006	3.5

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 6: Day Pattern Activity Generation Models", July 31, 2006.

Table 8-16. Exact Number of Tours by Purpose Estimation Results

Coeff. No.	Variables	Work (P=1)		School (P=2)		Escort (P=3)		Per.Bus. (P=4)		Shop (P=5)		Meal (P=6)		Soc./Rec. (P=7)	
		Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat
Person Type															
P01	Full-time worker	0.371	1.8							0.564	2.2	-10	*		
P02	Part-time worker			-10	*							-10	*		
P03	Retired			-10	*										
P04	Other non-worker					0.828	3.3								
P05	University student			0.94	2.7							-10	*		
P06	Student age 16+			0.479	1.3			0.719	1.2			-10	*		
P07	Student age 5-15							-0.934	-1.6	-0.640	-0.8	-10	*		
P08	Child age 0-4			-10	*							-10	*	-10	*
Adult age group															
P21	Age 18-25	-0.483	-1.6			-1.102	-1.6							0.769	1.8
P22	Age 26-35	-0.415	-1.9			-0.610	-1.9			-1.661	-2.2			0.622	1.1
P23	Age 51-65					-0.429	-1.6							0.779	2.7
Adult gender/ chidren															
P19	Male / age 0-4														
P20	Male / age 5-15					0.646	2.1			1.105	2.8				
P16	Female / none	-0.302	-1.9					0.314	2.1						
P17	Female / age 0-4	-0.512	-1.2					0.537	1.3					-0.891	-0.8
P18	Female / age 5-15					0.872	3.6			0.544	1.7			-1.006	-1.3
Household composition															
P13	Only adult in HH							0.360	1.8	0.540	2.3	-1.428	-1.7	0.7188	2.2
P14	Only worker in HH														
P15	Non-fam. 2+ pers. In HH					-5	*								
Household income															
P09	Income 0-25K	0.863	3.4	0.967	3.2	0.822	3.0	-0.494	-2.3			1.651	2.8		
P10	Income 25-45K					0.444	1.8								
P11	Income over 75K									0.354	1.5				
Other															
P12	Cars /adult in HH			0.702	1.4										
P24	Work at home	1.036	3.0			0.925	2.8			0.494	1.3				

Coeff. No.	Variables	Work (P=1) Coeff	Work (P=1) T-stat	School (P=2) Coeff	School (P=2) T-stat	Escort (P=3) Coeff	Escort (P=3) T-stat	Per.Bus. (P=4) Coeff	Per.Bus. (P=4) T-stat	Shop (P=5) Coeff	Shop (P=5) T-stat	Meal (P=6) Coeff	Meal (P=6) T-stat	Soc./Rec. (P=7) Coeff	Soc./Rec. (P=7) T-stat
Accessibility Variables															
P27	LogSum- 2 tours	1.66	10.4	0.391	1.5	0.148	2.1	0.035	0.6	0.501	3.9				
P29	LogSum- 3 tours	2.917	4.5	1.185	1.7	0.212	2.0	0.058	0.4	0.952	1.9				
Other tours in day															
P31	Work tours (#)					-0.420	-2.1	-0.758	-3.7	-2.44	-5.2	-10	*	-1.465	-3.4
P32	School tours (#)**	-0.654	-1.2			-1.675	-3.3	-1.104	-2.1			-10	*		
P33	Escort tours (#)**	0.632	2.5					-0.266	-1.6			-10	*	0.648	2.3
P34	Per.bus tours (#)									-0.215	-1.1				
P35	Shop tours (0/1+)							-0.574	-2.9						
Other stops in day															
P41	Work stops (0.1+)	0.646	3.5												
P42	School stops (0.1+)			0.715	1.4										
P43	Escort stops (0.1+)									0.722	2.7				
P44	Per.bus stops (0.1+)	0.549	3.5					0.742	5.1	0.310	1.5				
P45	Shop stops (0.1+)									0.351	1.7				
P46	Meal stops (0.1+)	-0.354	-1.7											0.5485	1.8
P47	Soc/rec stops (0.1+)									0.328	1.2			0.4922	1.6
Constants (C)															
P52	2 Tours	-3.264	-14.1	-4.515	-8.1	-2.802	-4.0	-2.165	-2.9	-7.469	-6.1	-2.416	-6.9	-3.034	-13.9
P53	3+ Tours	-6.72	-12.8	-7.928	-6.8	-4.704	-4.6	-4.379	-2.5	-14.18	-2.9	-20	*	-5.852	-11.0
	Summary Statistics														
	Observations	3,142		1,462		600		1,446		1,307		399		1,080	
	Final log likelihood	-820.7		-281.8		-442.7		-725.2		-411.4		-47.5		-251.9	
	Rho-sqd(0)	0.762		0.825		0.328		0.544		0.713		0.892		0.788	
	Rho-sqi(constants)	0.114		0.084		0.093		0.054		0.112		0.292		0.092	

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 6: Day Pattern Activity Generation Models", July 31, 2006.

Table 8-17. Day Pattern Choice Estimated and Calibrated or Final Model Coefficients (Part 1 of 2)

Coeff. No.	Variable Description	Work (X=1)		School (X=2)		Escort (X=3)		Per.Bus. (X=4)		Shop (X=5)		Meal (X=6)		Soc+Rec (X=7)	
		Est.	Calib. /1/	Est.	Calib. /1/	Est.	Calib. /1/	Est.	Calib. /1/	Est.	Calib. /1/	Est.	Calib. /1/	Est.	Calib. /1/
Basic Tour & Stop Constants															
X00	Constant-Tour	0.513	0.885	-4.256	-2.825	-4.077	-2.568	-2.575	-1.492	-2.998	-1.624	-3.671	-2.717	-2.39	-1.228
X01	Constant-Stop														
Person Type Constants															
X02	Part-time worker	-0.784	-0.169	-1.448	-1.841					0.242	0.215	-0.26	0.177		
X03	Retired	-5.769	-1.864			-0.497	-0.764	0.52	0.46	0.306	0.224				
X04	Other non-worker	-4.465	-0.398	-0.385	-3.849			0.252	0.457	0.426	0.569				
X05	University student	-2.305	-0.043												
X06	Student age 16+	-3.136	-1.06					-0.379	-0.221	-0.563	-0.174	-0.514	-0.436		
X07	Student age 5-15							-0.541	-0.513	-0.667	-0.52	-0.914	-0.726	0.323	0.151
X08	Child age 0-4							-0.506	-0.576			-0.206	-0.124	0.528	0.13
Adult Age Group															
X21	Age 18-25			0.849	0.993	0	0	-0.425	-0.397	-0.318	-0.28				
X22	Age 26-35			0.378	0.424	-0.277	-0.283	-0.282	-0.268	-0.261	-0.242				
X23	Age 51-65					-0.254	-0.277	0.15	0.145	0.114	0.123				
Adult Gender / Age of Children															
X19	Male / age 0-4					0.495	0.51			-0.387	-0.378				
X20	Male / age 5-15					1.206	1.224	-0.444	-0.425			-0.493	-0.477	-0.512	-0.474
X16	Female / none	0.163	0.048							0.185	0.169	-0.131	-0.153		
X17	Female / age 0-4	-0.241	-0.344	-1.124	-1.269	1.35	1.319	-0.389	-0.426						
X18	Female / age 5-15							-0.276	-0.273					-0.53	-0.523

Coeff. No.	Variable Description	Work (X=1) Est.	Work (X=1) Calib. /1/	School (X=2) Est.	School (X=2) Calib. /1/	Escort (X=3) Est.	Escort (X=3) Calib. /1/	Per.Bus. (X=4) Est.	Per.Bus. (X=4) Calib. /1/	Shop (X=5) Est.	Shop (X=5) Calib. /1/	Meal (X=6) Est.	Meal (X=6) Calib. /1/	Soc+Rec (X=7) Est.	Soc+Rec (X=7) Calib. /1/
Household Composition															
X13	Only adult in HH					0.345	0.332	0.112	0.126	0.298	0.314			0.112	0.119
X14	Only worker in HH					-0.484	-0.449								
X15	Non-family , 2+ Pers											0.158	0.193		
Household Income															
X09	Income $0-25K	-0.244	-0.269	0.44	0.375	-0.277	-0.292	-0.131	-0.146	-0.189	-2.009	-0.171	-0.185	-0.489	-0.522
X10	Income $25-45K	-0.131	-0.144	0.449	0.424	-0.168	-0.177					-0.121	-0.133	-0.25	-0.273
X11	Income over $75K	0.131	0.147					0.166	0.175	0.109	0.117			0.061	0.064
Household Composition															
X13	Only adult in HH					0.345	0.332	0.112	0.126	0.298	0.314			0.112	0.119
X14	Only worker in HH					-0.484	-0.449								
X15	Non-family , 2+ Pers											0.158	0.193		
Other Variables															
X12	Cars per adult in HH	0.473	0.577					0.472	0.521	0.578	0.629	0.421	0.455	0.134	0.155
X24	Work at home	-2.54	-2.688												
X25	Hm. MU dens.									0.156	0				
X26	Hm. Intersect. Dens.														
X27a	Hm. Agg. Access.					0.043	0.046								
X27b	Hm.-wk./sch. Access.	0.198	0.183	1.4	1.434										
X28	Hm.-wk. stop access.					0.011	0.014					0.013	0.017		

Source: SACOG, Septebmer 2008.
/1/ True calibration adjustments were focused on coefficients X00 to X08. All other changes to coefficients were based on re-estimations after the initial technical memorandum was published.

Table 8-18. Day Pattern Choice Estimated and Calibrated Coefficients (Part 1 of 2)

Coeff. No.	Variable Description	Estimated/ Tech.Memo Values	Final Model Values
Tour Purpose and Stop Frequency Specific Variables			
804	Other non-worker	0.596	0.522
807	Student age 5-15	0.547	0.464
824	Work at home	1.011	0.904
826	Home intersection density	0.002	0.003
827	Home aggregate accessibility	0.044	0.022
907	Student age 5-15	0.678	0.607
Tour + Stop Combination Purpose Variables			
1013	Work + Escort	0.551	0.488
1014	Work + Per.Bus	-0.169	-0.27
1015	Work + Shop	0.047	-0.017
1016	Work + Meal	0.176	0.128
1024	School + Per.Bus	-0.384	-0.457
1025	School + Shop	-0.385	-0.451
Tour + Tour Combination Purpose Variables			
1112	Work + School	-1.454	-1.725
1113	Work + Escort	-0.743	-0.872
1114	Work + Per.Bus	-1.22	-1.404
1115	Work + Shop	-1.025	-1.175
1116	Work + Meal	-0.266	-0.356
1117	Work + Soc/Rec	-0.49	-0.597
1123	School + Escort	-1.01	-1.117
1124	School + Per.Bus	-0.967	-1.127
1125	School + Shop	-0.856	-1.01
1126	School + Meal	-0.436	-0.532
1127	School + Soc/Rec	-0.53	-0.629
1134	Escort + Per.Bus	0.559	0.481
1135	Escort + Shop	0.33	0.256
1136	Escort + Meal	-0.042	-0.11
1137	Escort + Soc/Rec	0.467	0.393
1145	Per Bus + Shop	-0.22	-0.287
1146	Per Bus + Meal	0.349	0.283
1147	Per Bus + Soc/Rec	-0.019	-0.095
1156	Shop + Meal	-0.116	-0.178
1157	Shop + Soc/Rec	0.002	-0.071
Tour + Tour Combination Purpose Variables			
1226	School + Meal	-0.01	-0.019
Source: SACOG, Septebmer 2008.			

Table 8-19. Exact Number of Tours Estimated and Calibrated Values

Coeff. No.	Description	Est.	Calib.
152	2 Tours (Work)	-3.264	-2.616
153	3+ Tours (Work)	-6.720	-5.919
252	2 Tours (School)	-4.515	-4.570
253	3+ Tours (School)	-7.928	-7.906
352	2 Tours (Escort)	-2.802	-2.965
353	3+ Tours (Escort)	-4.704	-4.857
452	2 Tours (Pers.Bus.)	-2.165	-1.821
453	3+ Tours (Pers.Bus.)	-4.379	-4.078
552	2 Tours (Shop)	-7.469	-6.649
553	3+ Tours (Shop)	-14.180	-13.244
652	2 Tours (Meal)	-2.416	-1.172
653	3+ Tours (Meal)	-20.000	-20.000
752	2 Tours (Soc./Rec.)	-3.034	-2.619
753	3+ Tours Soc./Rec.)	-5.852	-5.284

Source: SACOG, Septebmer 2008.

Table 8-20. Year 2000 Work Tours Per Person, Per Day, By Person Type

Tours / Day	Person Type: Full-Time Worker			Part-Time Worker			All Other Persons		
	Survey (Unadj.)[1]	Survey (Adj)[2]	Model	Survey (Unadj.)[1]	Survey (Adj)[2]	Model	Survey (Unadj.)[1]	Survey (Adj)[2]	Model
Persons									
0	120,789	94,077	100,545	39,730	37,628	47,857	948,826	948,826	1,062,093
1	466,081	490,666	510,073	49,697	51,619	59,576	32,212	32,212	20,495
2	38,614	40,651	38,324	4,054	4,211	5,068	2,826	2,826	1,218
3+	1,697	1,787	1,654	589	612	249	74	74	53
	627,181	627,181	650,596	94,070	94,070	112,750	983,938	983,938	1,083,859
Tours Per Person	0.88	0.92	0.91	0.64	0.66	0.63	0.04	0.04	0.02
Percent									
0	19%	15%	15%	42%	40%	42%	96%	96%	98%
1	74%	78%	78%	53%	55%	53%	3%	3%	2%
2	6%	6%	6%	4%	4%	4%	0%	0%	0%
3+	0%	0%	0%	1%	1%	0%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: SACOG, Septebmer 2008.
"Survey" based on SACOG 2000 Household Travel Survey, expanded per discussion in Chapter 7.
[1] Survey is based on standard expansion factors, with no additional factoring or adjustment.
[2] "Adjusted" survey based on reducing the percentage of full-time workers to 15%, and rolling the adjustment down to the 1+ tours per day categories.

Table 8-21. Year 2000 School Tours Per Person, Per Day, By Person Type

Tours / Day	Person Type: Workers – Survey	Workers – Model	University Students – Survey	University Students – Model	K12 Students – Survey	K12 Students – Model	All Other Persons – Survey	All Other Persons – Model
Persons								
0	712,700	762,901	31,896	33,994	61,887	67,986	529,584	583,476
1	7,745	528	40,472	41,099	274,516	325,382	29,392	15,533
2	806	15	5,223	4,436	9,445	11,002	53	0
3+	0	2	1,259	479	208	672	0	0
Total	721,251	763,446	78,850	80,008	346,056	405,042	559,029	599,009
Tours Per Person	0.01	0.00	0.70	0.64	0.85	0.86	0.05	0.03
Percent								
0	99%	100%	40%	42%	18%	17%	95%	97%
1	1%	0%	51%	51%	79%	80%	5%	3%
2	0%	0%	7%	6%	3%	3%	0%	0%
3+	0%	0%	2%	1%	0%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	100%	100%

Source: SACOG, November 2008.
"Survey" based on SACOG 2000 Household Travel Survey, expanded per discussion in Chapter 7.

Table 8-22. Year 2000 Non-Work/Non-School Tours Per Person, Per Day, By Person Type

	Person Type								
	Workers			Non-Working Adult (incl.Retired)			Students / Children		
Tours / Day	Survey (Unadj.)[1]	Survey (Adj)[2]	Model	Survey (Unadj.)[1]	Survey (Adj)[2]	Model	Survey (Unadj.)[1]	Survey (Adj)[2]	Model
Persons x Purposes (Escort, Shop, Meal, Personal Business, Social/Recreational)									
0	3,233,457	3,214,376	3,350,265	1,863,089	1,769,935	1,758,810	2,385,696	2,266,411	2,615,234
1	326,862	341,386	405,414	328,794	400,151	435,677	233,549	338,105	446,720
2	39,861	43,918	52,798	69,625	87,627	93,695	19,901	33,081	46,658
3+	6,073	6,572	8,253	16,210	20,005	14,343	2,820	4,368	8,158
	3,606,253	3,606,253	3,816,730	2,277,718	2,277,718	2,302,525	2,641,966	2,641,966	3,116,770
Tours Per Person[3]	0.59	0.63	0.71	1.14	1.41	1.46	0.53	0.79	0.91
Percent									
0	90%	89%	88%	82%	78%	76%	90%	86%	84%
1	9%	9%	11%	14%	18%	19%	9%	13%	14%
2	1%	1%	1%	3%	4%	4%	1%	1%	1%
3+	0%	0%	0%	1%	1%	1%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: SACOG, Septebmer 2008.
"Survey" based on SACOG 2000 Household Travel Survey, expanded per discussion in Chapter 7.
[1] Survey is based on standard expansion factors, with no additional factoring or adjustment.
[2] "Adjusted" survey based on reducing the percentage of non-full-time workers aggregate percentage of 0-tour persons by 5 percent.
[3] Total person-tours divided by number of persons, not persons x purposes.

Tour 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. Table 8-23 provides details and estimation results of the work tour destination submodel.

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. Table 8-24 provides details and estimation results for the non-work/non-school tour destination submodel.

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.

<u>Submodel Calibration and Application</u>

Non-work/non-school destination choice has no process to constrain destinations to either parcel or TAZ employment totals. Destination choice results are effectively singly-constrained, then, at the home end by the day pattern and tour frequency submodels. No constraint is applied at the non-home ends.

For work and school tour destinations, no calibration was required, in large measure because of the calibration done for the usual location submodels.

For non-work/non-school destinations, no calibration was performed.

Table 8-25 provides summary comparisons of model to household travel survey for key distance distribution from home to primary tour destinations (average, median, and 90th percentile distances). Also, coincidence ratio between the survey and model distributions are reported. Note that model work tour destination distance distribution is significantly longer than the survey distribution on all measures reported in the table. The usual work location model was calibrated to match the Census worker flow distance distribution, as reported above; the Census distribution was significantly longer than the household travel survey, and the inconsistency with the survey was accepted without further calibration. The other trip purpose tour destination distance distributions were also accepted as is without further calibration. Figures 8-14 through 8-21 illustrate the distributions compared to the household travel survey.

Table 8-23. Work Tour Destination Estimation Results

Coeff. No.	Variable Description	Person/Tour Characteristics		Est.	T-stat
Constants					
2	Usual location	Constant		57.1879	12.8
	CALIBRATION			52.525	
3	Usual location	PT worker		-7.7853	-2.5
4	Usual location	Child or univ. stud.		-8.7800	-1.9
12	Usual location	Pattern has 2+ work tours	primary tour	-11.4371	-3.5
13	Usual location	Pattern has intermediate work stop(s)		-14.2930	-5.3
16	Usual location		secondary tour	-18.2026	-6.0
LogSum and Accessibility Variables					
994	Dest choice LogSum (in usual location vs other choice)			0.0750	
17	Mode choice LogSum	FT worker	usual location	1.0000	
18	Mode choice LogSum	FT worker	tour dest.	1.0000	
19	Mode choice LogSum	PT worker		1.0000	
20	Mode choice LogSum	not FT/PT worker		1.0000	
21	Ln(1 + OW drive dist (10s of mi))	FT worker	usual location	-1.5039	-27.9
22	Ln(1 + OW drive dist (10s of mi))	FT worker	tour dest.	-0.8291	-2.8
23	Ln(1 + OW drive dist (10s of mi))	PT worker		-3.0011	-18.3
24	Ln(1 + OW drive dist (10s of mi))	not FT/PT worker		-3.5019	-11.3
35	Ln(1 + OW drive dist (10s of mi))		secondary tour	-2.3438	-3.5
37	Ln(1+OW drive dist from work (mi x 10))		tour dest.	-0.2761	-1.0
38	Ln(1+OW drive dist from sch. (mi x 10))	child or univ. stud.		-1.8451	-5.7
39	Aggr. mode-dest LogSum at dest	FT worker		0.0867	2.5
41	Aggr. mode-dest LogSum at dest	not FT/PT worker		0.0386	0.3
52	Mix of daily parking & empl. in parcel: Ln(1+prkg*empl/(prkg+empl))			0.1974	8.8
Parking Supply and Street Pattern Variables					
54	Mix of daily parking & (empl+stud) in TAZ: Ln(1+prkgdens*(empldens+studdens)/(prkgdens+empldens+studdens)), (dens in units/Msqft)			0.1259	11.5
56	Good intersection ratio: (# 3 & 4 link nodes)/(# 1,3,4-link nodes) within ¼ mi.		usual location	0.7782	6.5
57	Good intersection ratio: (# 3 & 4 link nodes)/(# 1,3,4-link nodes) within ¼ mi.	HH has 0 cars or less than drivers	tour dest.	2.3027	1.6
Density and Mix Variables					
68	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	FT worker	HH inc <$50K	-0.0484	-2.5
69	Dens of households in TAZ (ln[1+HH*100/Msqft])	FT worker	HH inc <$50K	-0.0680	-5.6
70	Dens of educ empl in TAZ (ln[1+empl*100/Msqft])	FT worker	HH inc >$50K	-0.0231	-2.7
71	Dens of gov empl in TAZ (ln[1+empl*100/Msqft])	FT worker	HH inc >$50K	0.0281	3.8
72	Dens of office empl in TAZ	FT worker	HH inc >$50K	0.1244	5.5

Coeff. No.	Variable Description	Person/Tour Characteristics		Est.	T-stat
	(ln[1+empl*100/Msqft])				
73	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	FT worker	HH inc >$50K	-0.0889	-3.9
74	Dens of households in TAZ (ln[1+HH*100/Msqft])	FT worker	HH inc >$50K	-0.0725	-8.1
82	Dens of office empl in TAZ (ln[1+empl*100/Msqft])	PT worker	HH inc >$50K	0.1372	2.0
83	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	PT worker	HH inc >$50K	-0.1410	-1.9
89	Dens of households in TAZ (ln[1+HH*100/Msqft])	not FT/PT worker	HH inc reported	-0.0970	-3.5
92	Dens of office empl in TAZ (ln[1+empl*100/Msqft])		HH inc unreported	0.1861	3.4
93	Dens of service empl in TAZ (ln[1+empl*100/Msqft])		HH inc unreported	-0.1343	-2.3
94	Dens of households in TAZ (ln[1+HH*100/Msqft])		HH inc unreported	-0.0424	-1.8
Size Variables					
999	Size function scale			0.4950	43.5
100	Service empl. in parcel	FT worker	HH inc <$50K	-0.7498	-2.4
101	Education empl. in parcel	"	"	-0.8826	-2.2
102	Restaurant empl. in parcel	"	"	-1.4107	-3.3
103	Gov empl. in parcel	"	"	0.0000	
104	Office empl. in parcel	"	"	-0.6592	-2.2
105	Other empl. in parcel	"	"	-1.3898	-2.1
106	Retail empl. in parcel	"	"	-0.9463	-2.7
107	Medical empl. in parcel	"	"	-0.2649	-0.7
108	Industrial empl. in parcel	"	"	-1.0914	-3.4
110	# Households in parcel	"	"	-10.8318	-18.0
113	Service empl. in parcel	FT worker	HH inc >$50K	-1.3080	-5.8
114	Education empl. in parcel	"	"	-0.4178	-1.7
115	Restaurant empl. in parcel	"	"	-2.7440	-8.3
116	Gov't. empl. in parcel	"	"	0.0000	
117	Office empl. in parcel	"	"	-0.9488	-4.5
118	Other empl. in parcel	"	"	-0.6469	-1.9
119	Retail empl. in parcel	"	"	-2.1131	-7.7
120	Medical empl. in parcel	"	"	-0.8517	-3.3
121	Industrial empl. in parcel	"	"	-2.0475	-8.3
123	# Households in parcel	"	"	-11.6581	-21.9
124	Univ. enrollment in parcel	"	"	-3.2596	-2.7
126	Service empl. in parcel	PT worker	HH inc <$50K	-0.6245	-1.0
127	Education empl. in parcel	"	"	0.0000	
128	Restaurant empl. in parcel	"	"	-1.1490	-1.4
129	Gov't. empl. in parcel	"	"	-0.7867	-0.8
130	Office empl. in parcel	"	"	-0.5929	-1.0
131	Other empl. in parcel	"	"	-1.9033	-1.0
132	Retail empl. in parcel	"	"	-0.8655	-1.3
133	Medical empl. in parcel	"	"	-2.7120	-2.0
134	Industrial empl. in parcel	"	"	-2.0559	-2.9
136	# Households in parcel	"	"	-11.3527	-9.6
139	Service empl. in parcel	PT worker	HH inc >$50K	-0.6517	-0.8

Coeff. No.	Variable Description	Person/Tour Characteristics		Est.	T-stat
140	Education empl. in parcel	PT worker	HH inc >$50K	0.8319	0.8
141	Restaurant empl. in parcel	"	"	-2.0638	-1.8
142	Gov't empl. in parcel	"	"	0.3718	0.4
143	Office empl. in parcel	"	"	0.1608	0.2
144	Other empl. in parcel	"	"	-1.0027	-0.7
145	Retail empl. in parcel	"	"	-0.6300	-0.8
146	Medical empl. in parcel	"	"	0.3197	0.4
147	Industrial empl. in parcel	"	"	-1.7929	-2.1
149	# Households in parcel	"	"	-12.5391	-7.7
151	K-12 enrollment in parcel	"	"	0.0000	
152	Service empl. in parcel	not FT/PT worker	HH inc reported	-1.7889	-3.1
153	Education empl. in parcel	"	"	-1.7642	-2.3
154	Restaurant empl. in parcel	"	"	0.0000	
155	Gov't empl. in parcel	"	"	-0.7816	-1.0
156	Office empl. in parcel	"	"	-0.2222	-0.5
157	Other empl. in parcel	"	"	-1.3686	-1.1
158	Retail empl. in parcel	"	"	-0.9169	-1.6
159	Medical empl. in parcel	"	"	-2.2593	-2.4
160	Industrial empl. in parcel	"	"	-3.2709	-4.4
162	# Households in parcel	"	"	-11.1263	-11.4
163	University enrollment in parcel	"	"	-1.5327	-0.7
174	Total empl. in parcel		HH inc unreported	0.8463	0.7
175	# Households in parcel		HH inc unreported	-8.4416	-5.7
176	University enrollment in parcel		HH inc unreported	0.0000	
177	K-12 enrollment in parcel		HH inc unreported	-0.3387	-0.2
188	# Households in parcel		tour dest.	-5.6565	-11.0
Scaling and Other Variables					
1	Sampling adj.factor for estimation			1.0000	
992	Scale of usual location data			1.1702	11.1
993	Scale of tour data			1.0000	

Summary statistics	
Number observed choices	6,538
Number of estimated parameters	86
Log likelihood w coeffs=0	-29,957.4
Final Log likelihood	-15,527.5
Rho squared	0.482
Adjusted rho squared	0.479

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 8: Usual Location and Tour Destination Models", October 28, 2005.

Table 8-24. Non-work/Non-school Tour Destination Estimation Results

Coeff. No.	Variable Description	Person/Tour Characteristics		Est.	T-stat
LogSum and Accessibility Variables					
2	Mode choice LogSum			1.0000	
3	OW drive dist--0-1 mi (mi. x 10)	Escort		-10.3465	-4.6
4	OW drive dist--1-3.5 mi (mi. x 10)	"		-3.5546	-6.4
5	OW drive dist--3.5-10 mi (mi. x 10)	"		-2.4826	-9.2
7	OW drive dist--0-1 mi (mi. x 10)	Pers.Bus.		-13.4222	-6.8
8	OW drive dist--1-3.5 mi (mi. x 10)	"		-4.1386	-9.4
9	OW drive dist--3.5-10 mi (mi. x 10)	"		-2.1585	-11.6
10	OW drive dist—10+ mi (mi. x 10)	"		-0.7635	-8.5
11	OW drive dist--0-1 mi (mi. x 10)	Shop		-9.6628	-4.5
12	OW drive dist--1-3.5 mi (mi. x 10)	"		-7.1718	-15.4
13	OW drive dist--3.5-10 mi (mi. x 10)	"		-2.6892	-12.5
14	OW drive dist—10+ mi (mi. x 10)	"		-0.8238	-7.5
15	OW drive dist--0-1 mi (mi. x 10)	Meal		-15.6510	-5.7
16	OW drive dist--1-3.5 mi (mi. x 10)	"		-6.4441	-8.9
17	OW drive dist--3.5-10 mi (mi. x 10)	"		-1.9888	-6.3
18	OW drive dist—10+ mi (mi. x 10)	"		-1.1556	-5.3
19	OW drive dist--0-1 mi (mi. x 10)	Soc./Rec.		-16.1538	-6.5
20	OW drive dist--1-3.5 mi (mi. x 10)	"		-3.4164	-5.8
21	OW drive dist--3.5-10 mi (mi. x 10)	"		-2.0259	-8.6
22	OW drive dist—10+ mi (mi. x 10)	"		-0.4468	-4.3
23	OW drive dist--0-1 mi (mi. x 10)	Secondary tour	work/school pattern	3.2248	1.5
24	OW drive dist--1-5 mi (mi. x 10)	"	"	-1.1027	-3.4
25	OW drive dist--5-10 mi (mi. x 10)	"	"	0.0240	0.1
26	OW drive dist—10+ mi (mi. x 10)	"	"	-0.4439	-3.5
27	OW drive dist--0-1 mi (mi. x 10)	Secondary tour	not wk./sch. pattern	-3.7189	-1.8
28	OW drive dist--1-5 mi (mi. x 10)	"	"	-0.8124	-2.6
29	OW drive dist--5-10 mi (mi. x 10)	"	"	-0.3132	-1.1
30	OW drive dist—10+ mi (mi. x 10)	"	"	-0.3648	-3.1
31	Ln (1 + OW drive dist (mi. x 10))	Work based tour		-1.2039	-4.3
32	Ln (1 + OW drive dist (mi. x 10))		HH inc<$15K	0.5535	2.6
33	Ln (1 + OW drive dist (mi. x 10))		HH inc unreported	0.4300	2.5
34	Ln (1 + OW drive dist (mi. x 10))		Nonworker age 65+	-0.4296	-3.3
35	Ln (1 + OW drive dist (mi. x 10))		Univ. stud.	0.3536	1.3
36	Ln (1 + OW drive dist (mi. x 10))		Child age 5-15	-0.8487	-3.3
37	Ln (1 + OW drive dist (mi. x 10))		Child age <5	-0.9308	-3.4
38	Ln (1 + OW drive dist (mi. x 10))	Home based tour	1/(hs. avail. in 18 hr. day)/(remaining HB tours, including this one)	-2.3372	-2.1
40	Ln (1 + OW drive dist from sch. (mi. x 10))	Home based tour		-0.5644	-3.1
41	Aggr. mode-dest LogSum at dest	Escort		0.1648	2.0
42	Aggr. mode-dest LogSum at dest	Pers.Bus.		0.0206	0.4
43	Aggr. mode-dest LogSum at dest	Shop		0.1892	3.1
Parking Supply and Street Pattern Variables					
56	Mix of hourly parking & commercial empl in parcel:		Cars < drivers	0.2506	4.2

Coeff. No.	Variable Description	Person/Tour Characteristics		Est.	T-stat
	ln(1+prkg*empl/(prkg+empl))				
57	Mix of hourly parking & commercial empl in parcel: ln(1+prkg*empl/(prkg+empl))		1+ Cars / driver	0.1561	3.7
58	Mix of hourly parking & commercial empl.in TAZ: ln(1+ prkgDens*emplDens/ (prkgDens+emplDens)), (Dens in units/Msqft)		Cars < drivers	0.0607	2.5
59	Mix of hourly parking & commercial empl.in TAZ: ln(1+ prkgDens*emplDens/ (prkgDens+emplDens)), (Dens in units/Msqft)		1+ cars per driver	0.0479	3.3
60	Street connectivity: (# 3 & 4 link nodes)/(# 1,3,4-link nodes) within a qtr mile		0-Car HH	0.7290	0.7
62	Street connectivity: (# 3 & 4 link nodes)/(# 1,3,4-link nodes) within a qtr mile		1+ Cars / driver	0.2101	1.8
Density and Mix Variables					
64	Dens of gov empl in TAZ (ln[1+empl*100/Msqft])	Escort	HH w/o kids	0.0570	2.8
67	Dens of households in TAZ (ln[1+HH*100/Msqft])	“	“	-0.1676	-4.7
68	Dens of univ enroll. in TAZ (ln[1+students*100/Msqft])	“	“	0.1113	2.4
74	Dens of households in TAZ (ln[1+HH*100/Msqft])	Escort	HH w kids	-0.2159	-7.8
75	Dens of K-12 enroll. in TAZ (ln[1+students*100/Msqft])	“	“	0.0926	6.5
76	Dens of educ empl in TAZ (ln[1+empl*100/Msqft])	Pers.Bus.	All HH’s	0.0218	2.2
78	Dens of office empl in TAZ (ln[1+empl*100/Msqft])	“	“	0.0674	2.6
79	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	“	“	-0.1216	-4.8
80	Dens of medical empl in TAZ (ln[1+empl*100/Msqft])	“	“	0.0618	5.3
81	Dens of households in TAZ (ln[1+HH*100/Msqft])	“	“	-0.0790	-6.3
82	Dens of univ enroll. in TAZ (ln[1+students*100/Msqft])	“	“	0.0739	3.0
83	Dens of educ empl in TAZ (ln[1+empl*100/Msqft])	Shop	All HH’s	-0.0513	-5.6
86	Dens of retail empl in TAZ (ln[1+empl*100/Msqft])	“	“	-0.0821	-5.4
98	Dens of office empl in TAZ (ln[1+empl*100/Msqft])	Soc./Rec.	All HH’s	0.0636	2.2
99	Dens of service empl in TAZ (ln[1+empl*100/Msqft])	“	“	-0.0662	-2.2

Coeff. No.	Variable Description	Person/Tour Characteristics		Est.	T-stat
100	Dens of households in TAZ (ln[1+HH*100/Msqft])	"	"	-0.1166	-7.1
Size Variables					
101	education empl. in parcel	Escort	HH w/o kids	-0.9176	-1.2
102	restaurant empl. in parcel	"	"	-5.6366	-2.8
103	gov empl. in parcel	"	"	-3.0659	-2.5
104	office empl. in parcel	"	"	-2.3159	-3.7
105	other empl. in parcel	"	"	-2.9968	-1.5
106	retail empl. in parcel	"	"	-3.1226	-3.7
107	service empl. in parcel	"	"	-1.1827	-2.3
108	medical empl. in parcel	"	"	-1.7080	-2.3
109	industrial empl. in parcel	"	"	-6.0840	-4.4
111	# households in parcel	"	"	-5.6072	-11.2
113	K-12 enrollment in parcel	"	"	0.0000	
114	education empl. in parcel	Escort	HH w kids	-2.7619	-5.6
116	gov empl. in parcel	"	"	-4.1676	-4.0
117	office empl. in parcel	"	"	-5.5261	-8.0
118	other empl. in parcel	"	"	-2.5723	-3.7
119	retail empl. in parcel	"	"	-4.6152	-8.8
120	service empl. in parcel	"	"	-3.3857	-9.4
121	medical empl. in parcel	"	"	-5.3776	-5.3
122	industrial empl. in parcel	"	"	-6.8507	-7.8
124	# households in parcel	"	"	-6.7705	-19.9
126	K-12 enrollment in parcel	"	"	0.0000	
127	education empl. in parcel	Pers.Bus.	All HH's	-2.6366	-7.5
128	restaurant empl. in parcel	"	"	-4.3771	-8.3
129	gov empl. in parcel	"	"	-2.4465	-6.7
130	office empl. in parcel	"	"	-2.2034	-10.1
132	retail empl. in parcel	"	"	-2.7544	-9.7
133	service empl. in parcel	"	"	-1.2135	-6.2
134	medical empl. in parcel	"	"	0.0000	
135	industrial empl. in parcel	"	"	-5.4169	-13.4
137	# households in parcel	"	"	-6.5677	-24.3
139	K-12 enrollment in parcel	"	"	-4.2720	-8.7
141	restaurant empl. in parcel	Shop	All HH's	-3.8967	-10.2
143	office empl. in parcel	"	"	-7.4857	-19.5
145	retail empl. in parcel	"	"	0.0000	
146	service empl. in parcel	"	"	-4.7453	-21.9
154	restaurant empl. in parcel	Meal	All HH's	0.0000	
156	office empl. in parcel	"	"	-8.2240	-9.1
162	total empl. in parcel	"	"	-8.2056	-23.9
163	# households in parcel	"	"	-11.1591	-29.0
166	education empl. in parcel	Soc./Rec.	All HH's	-3.0254	-5.0
167	restaurant empl. in parcel	"	"	-2.0484	-3.7
168	gov empl. in parcel	"	"	-4.2847	-4.1
169	office empl. in parcel	"	"	-3.7599	-9.0
170	other empl. in parcel	"	"	-4.6129	-3.3
171	retail empl. in parcel	"	"	-3.8140	-7.2
172	service empl. in parcel	"	"	0.0000	
173	medical empl. in parcel	"	"	-1.4894	-4.0
176	# households in parcel	"	"	-4.6660	-21.5

Coeff. No.	Variable Description	Person/Tour Characteristics		Est.	T-stat
177	University enrollment in parcel	"	"	-2.5902	-2.0
178	K-12 enrollment in parcel	"	"	-3.4295	-5.4
Scaling Variables					
1	Sampling adj. factor for estimation			1.0000	
999	Size function scale			0.5114	45.6
	Summary statistics				
	Number observed choices	5,772			
	Number of estim. parameters	106			
	Log likelihood w coeffs=0	-26,382.2			
	Final Log likelihood	-21,818.1			
	Rho squared	0.173			
	Adjusted rho squared	0.169			

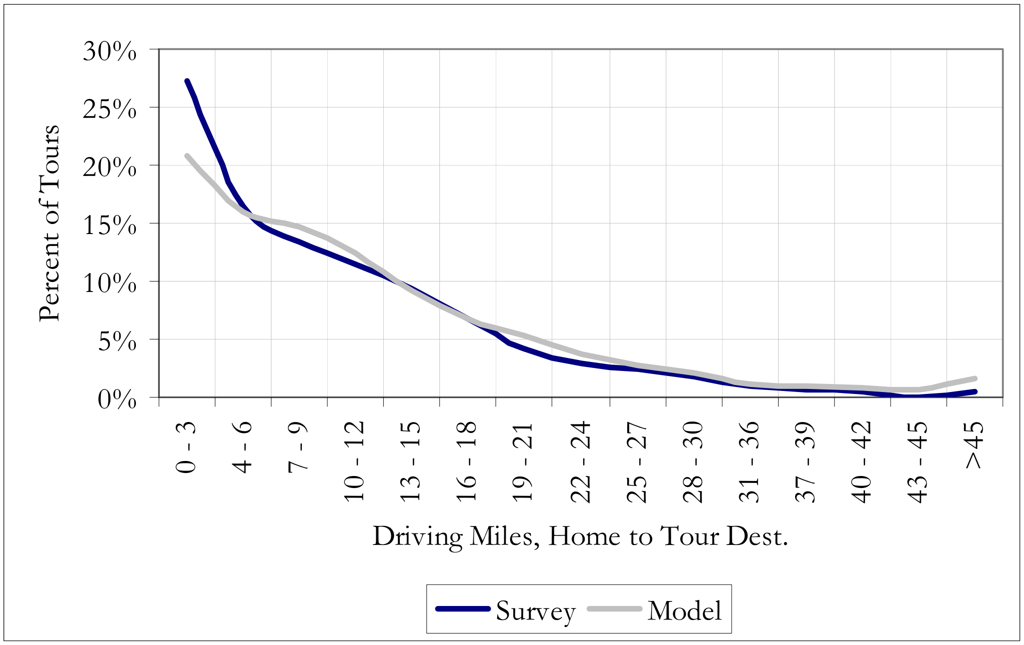
Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 8: Usual Location and Tour Destination Models", October 28, 2005.

Table 8-25. Tour Destination Distance from Place of Residence Distribution

Tour Purpose		Mean Drive Dist. from Home (Mi.)	Median[2] Drive Dist. from Home (Mi.)	90th Percentil Dist. From Home (Mi.)	Model/ Survey Coin-cidence Ratio
Work	Survey[1]	10.2[3]	6.7	21	0.87
	Census	11.8[3]	8	23	
	Model	12.0[3]	8.0	25	
School	Survey[1]	3.8	1.0	9	0.95
	Model	3.5	1.0	8	
Escort Passenger	Survey[1]	3.6	1.2	7	0.83
	Model	4.8	1.7	10	
Personal Business	Survey[1]	6.4	3.0	14	0.93
	Model	6.7	3.3	15	
Shop	Survey[1]	5.6	1.8	12	0.88
	Model	6.0	2.3	14	
Meal	Survey[1]	8.2	4.7	17	0.84
	Model	7.1	3.5	15	
Social/Recreational	Survey[1]	6.6	2.5	16	0.82
	Model	7.0	3.3	16	
All Non-Work/Non School	Survey[1]	5.9	2.2	13	0.91
	Model	6.2	2.7	14	

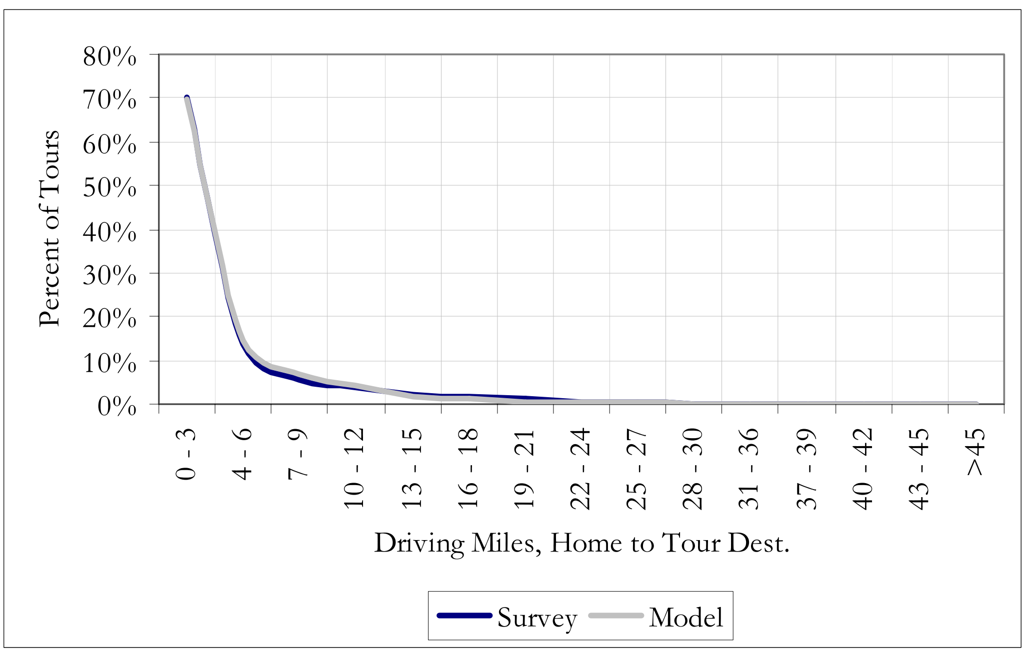
Source: SACOG, November 2008.
[1] SACOG 2000 Household Travel Survey
[2] Computed from integer miles of drive time.
[3] Usual work location distance distribution was calibrated to match Census worker flows; Census trip length frequency is significantly longer than that in the Household Travel Survey.

Figure 8-14. Work Tour Driving Distance Distribution



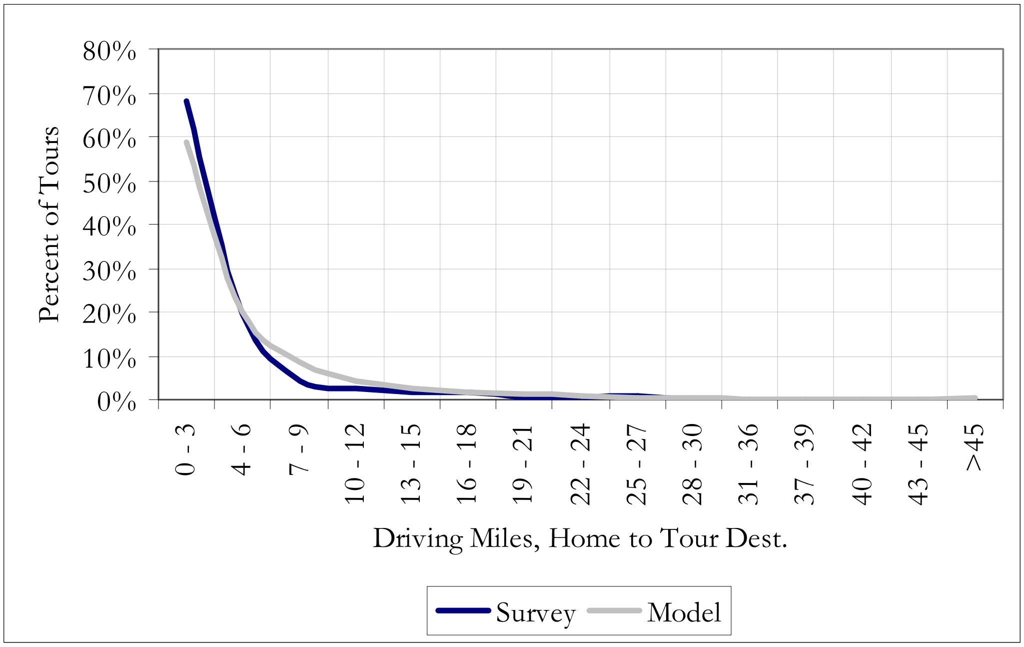
Source: SACOG, November 2008.
Survey data from 2000 SACOG Household Travel Survey.

Figure 8-15. School Tour Driving Distance Distribution



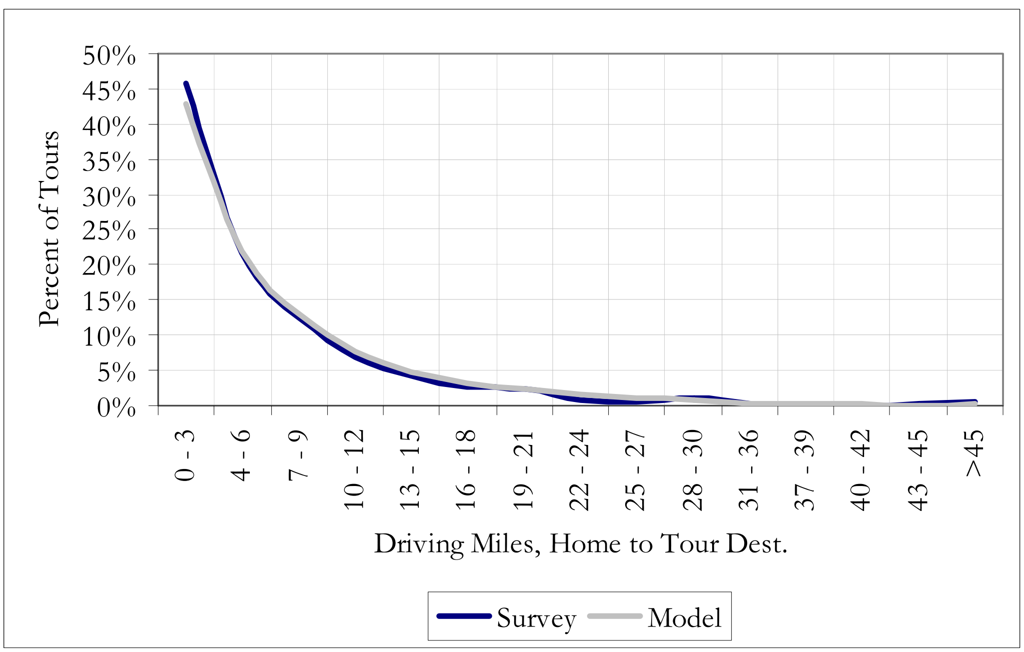
Source: SACOG, November 2008.
Survey data from 2000 SACOG Household Travel Survey.

Figure 8-16. Escort Passenger Tour Driving Distance Distribution



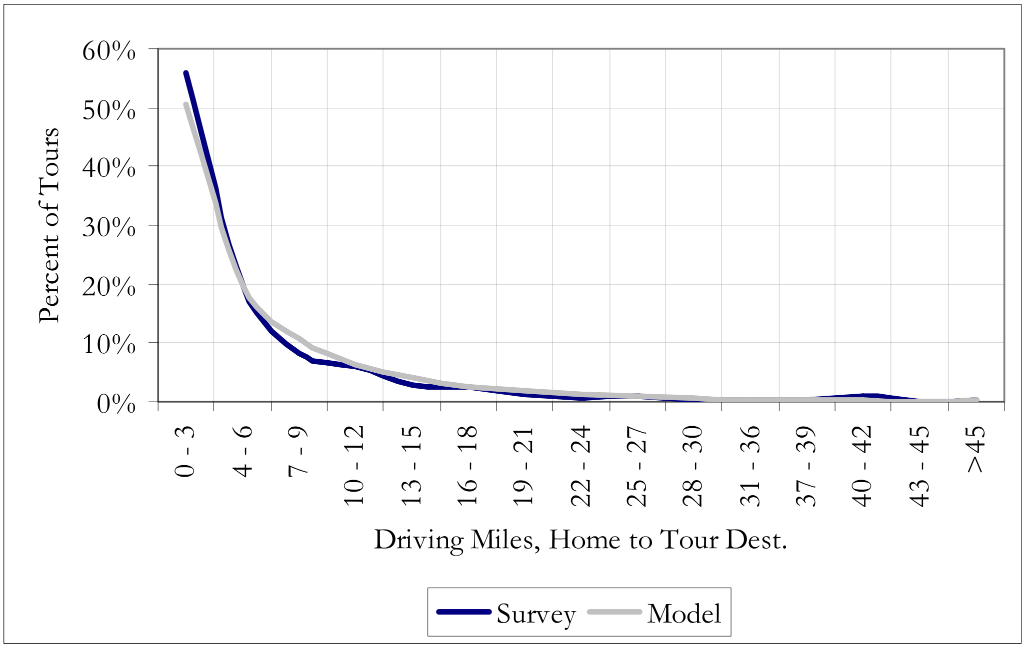
Source: SACOG, November 2008.
Survey data from 2000 SACOG Household Travel Survey.

Figure 8-17. Personal Business Tour Driving Distance Distribution



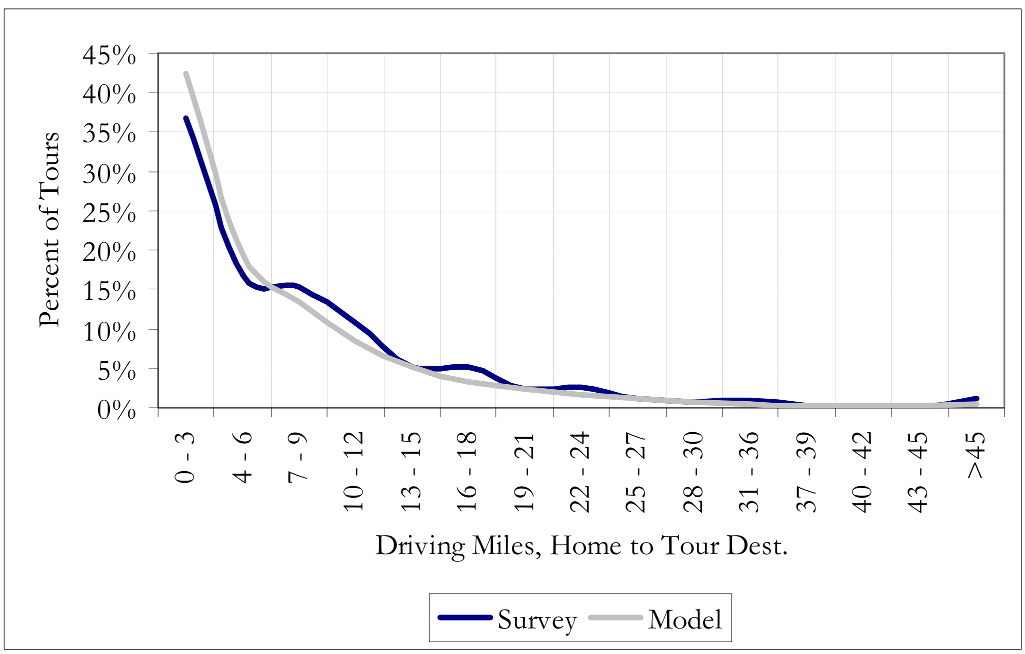
Source: SACOG, November 2008.
Survey data from 2000 SACOG Household Travel Survey.

Figure 8-18. Shopping Tour Driving Distance Distribution



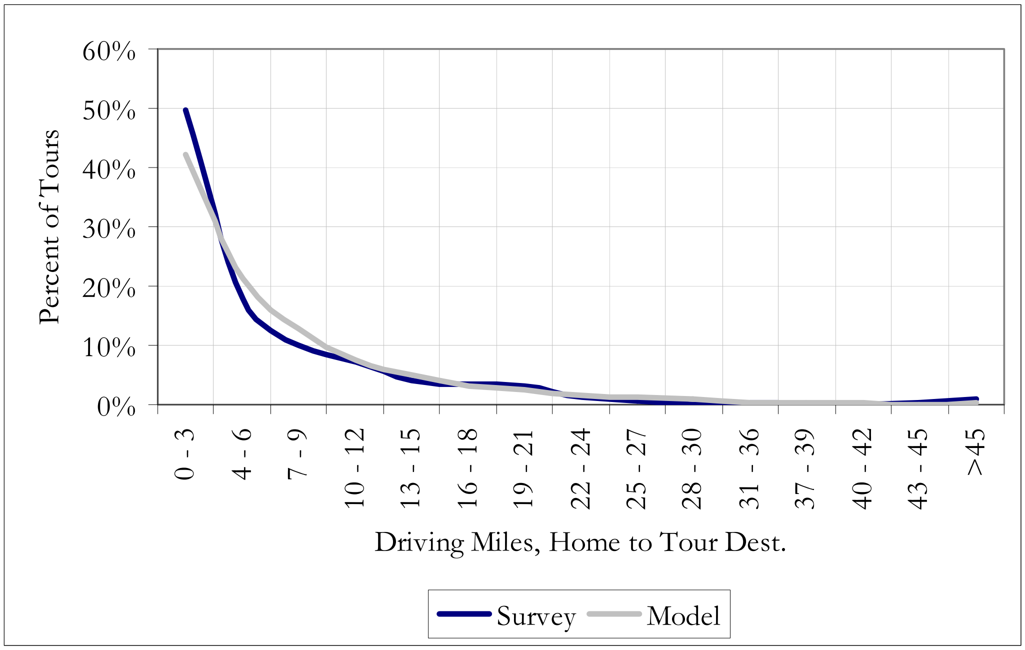
Source: SACOG, November 2008.
Survey data from 2000 SACOG Household Travel Survey.

Figure 8-19. Meal Tour Driving Distance Distribution



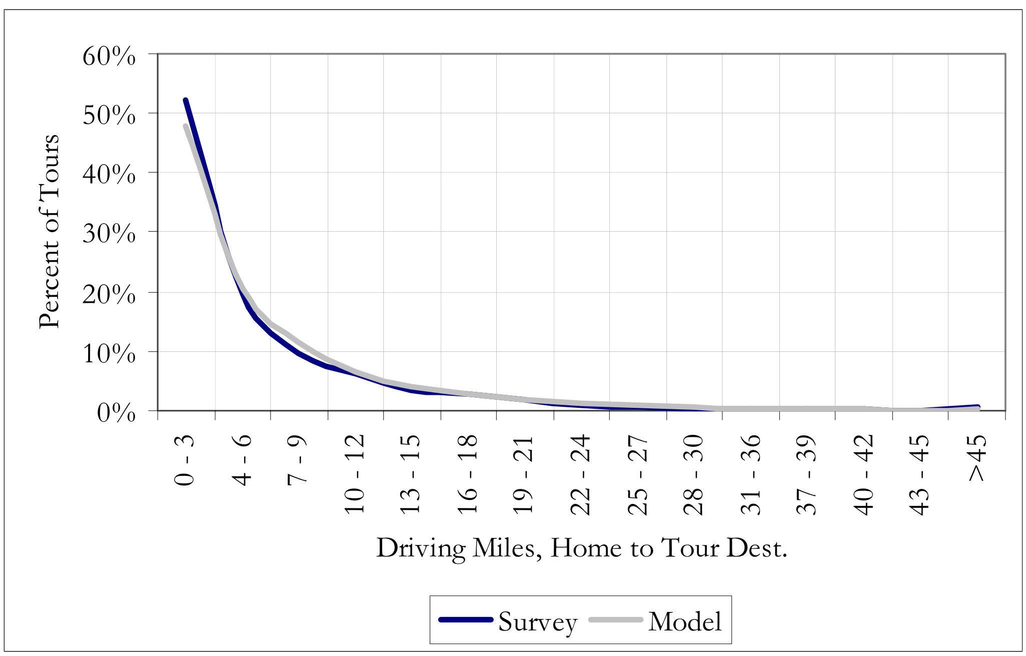
Source: SACOG, November 2008.
Survey data from 2000 SACOG Household Travel Survey.

Figure 8-20. Social/Recreational Tour Driving Distance Distribution



Source: SACOG, November 2008.
Survey data from 2000 SACOG Household Travel Survey.

Figure 8-21. All Non-Work/Non-School Tour Driving Distance Distribution



Source: SACOG, November 2008.
Survey data from 2000 SACOG Household Travel Survey.

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 eight mode options:

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

As with many random household travel surveys, the SACOG 2000 Household Travel Survey did not capture sufficient transit trips to estimate separate models for all trip purposes. Table 8-26 and 8-27 provide a tabulation of observed tours, and mode availablility for tour, for the household travel survey. A total of 179 transit tours were available in the estimation dataset; non-work/non-school trip purposes, only 26 transit tours were available in the estimation dataset. 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 sub-tours

Also, several key coefficients were fixed in the estimation, due to a failure to estimate significant coefficients based solely on the household survey. This is not a unusual result with revealed preference surveys, especially when few transit travelers were surveyed. For this reason, in-vehicle time and out-of-vehicle time (non including walk times) were fixed in the estimations, with all other coefficients estimated. The resulting values of time are shown in Table 8-28.

Two unique land use and street pattern variables are included in the submodels. One variable combines residentially-oriented land use mix and density, and is defined as:

$(0.001 * RS * HH) / (RS + HH)$

Where:
RS = sum of retail and service employment within ½ mile
HH = sum of households within ½ mile

The variable equals zero in homogenous areas, and increases with density and mix.

Work Tour Mode Choice

Estimation results for work tour mode choice are shown in Table 8-29. 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. See Table 8-28 above for implied values of time and ratios of in-vehicle to walk/bike and wait time. The remaining variables applied to specific modes or mode groups.

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 chosing 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.

School Tour Mode Choice

Estimation results for school tour mode choice are shown in Table 8-30. Three generic level-of-service variables are included: cost and in-vehicle time (both constrained); and combined out-of-vehicle time).

School bus mode is more 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.

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).

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. Table 8-31 provides the estimation results.

Work-Based Sub-Tour Mode Choice

Work-based sub-tours are the only non-home-based tours in DAYSIM. Work-based sub-tours 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 sub-tours. Table 8-32 provides the estimation results.

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.

Submodel Calibration and Application

The submodels were calibrated by adjusting mode constants only to match either Census Journey-to-Work mode split (for work tours), or the weighted household survey percentages (for all other purposes. Final calibrated coefficients are shown in Table 8-34.

Table 8-35 provides a comparison of model and observed mode splits for all trip purposes. Because Census Journey-to-Work modes are more aggregate than the modeled modes (e.g. all public transit is combined, all shared ride modes are combined), the survey proportions of the combined Census modes were used to split the Census shares for calibration. Figures 8-22 through 8-25 provide graphical comparisons.

Table 8-26. Work, School and Escort Tour Mode Choice Estimation Data: Availability of Mode and Number of Observations (Part 1 of 2)

Mode	Tour Purpose							
	Work		School		Escort		Work-Based	
	Chosen	Available	Chosen	Available	Chosen	Available	Chosen	Available
Drive to Transit	30	1,539						
Walk to Transit	68	1,720	55	868			2	362
Shared Ride 3+	208	3,063	540	1,484	388	877	49	573
Shared Ride 2	480	3,063	295	1,484	443	877	100	573
Drive Alone	2,172	3,035	188	504			321	570
Bike	58	2,530	80	1,429			6	545
Walk	47	1,221	157	1,191	46	715	95	428
School Bus			169	1,484				
TOTAL	3,063	3,063	1,484	1,484	877	877	573	573

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 4: Mode Choice Models", August 2, 2006—Draft 3.

Table 8-27. Non-Mandatory Tour Mode Choice Estimation Data: Availability of Mode and Number of Observations

Mode	Tour Purpose							
	Personal Business		Shop		Meal		Soc./Rec.	
	Chosen	Available	Chosen	Available	Chosen	Available	Chosen	Available
Walk to Transit	14	1,031	4	926	3	252	3	649
Shared Ride 3+	256	1,643	184	1,382	127	398	270	1,103
Shared Ride 2	511	1,643	473	1,382	166	398	344	1,103
Drive Alone	801	1,472	655	1,244	81	361	389	881
Bike	18	1,539	15	1,301	2	378	17	1,017
Walk	43	1,040	51	1,035	19	252	80	719
TOTAL	1,643	1,643	1,382	1,382	398	398	1,103	1,103

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 4: Mode Choice Models", August 2, 2006—Draft 3.

Table 8-28. Values of Time and Ratios of Out- vs. In- Vehicle Times

Tour Purpose	Value of Time (Avg. $ / hour)	Ratio of Walk to In-Vehicle Time	Ratio of Wait to In-Vehicle Time
Work[1]	$11.20	2.95	2.50
School[2]	$6.00	2.20	2.20
Escort[2]	$7.50	3.00	n/a
Work-Based[2]	$7.50	2.84	2.84
All Other[2]	$7.50	2.72	2.72

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 4: Mode Choice Models", August 2, 2006—Draft 3.
[1] For work tours, VOT estimated on fixed coefficients of out-of-vehicle vs. in-vehicle time coefficients.
[2] For all other tour purposes, out-of-vehicle coefficients were estimated around fixed cost and in-vehicle time coefficients.

Table 8-29. Work Tour Main Mode Choice Estimation Results

Coeff. No.	Modes	Variable Description	Est.	T-Stat
Level of Service				
1	DA,S2,S3,DT,WT	Cost ($)	-0.161	-4.9
2	DA,S2,S3,DT,WT	In-vehicle time (min)	-0.030	Const
3	DT,WT	Wait time (min)	-0.075	Const
7	DT,WT,BI,WK	Walk and bike time (min)	-0.089	-7.3
Mode Specific Variables				
10	DT	Constant	-4.089	-3.2
11	DT	No cars in HH	-2.000	Const
13	DT	HH fewer cars than workers	-1.563	-2.2
18	DT	Drive time/total in-vehicle time	-3.393	-1.6
20	WT	Constant	-4.195	-3.7
8	WT	LRT walk access	3.552	2.3
168	WT,DT	Mixed use density at destination	0.018	3.8
30	S3	Constant	-3.772	-5.2
38	S3	One person HH	-3.624	-5.1
39	S3	Two person HH	-1.729	-6.5
40	S2	Constant	-3.143	-4.4
48	S2	One person HH	-3.145	-4.8
31	S2,S3	HH # children under age 5	0.744	2.6
32	S2,S3	HH # children age 5-15	0.546	3.6
34	S2,S3	HH # non-working adults 18+	-0.287	-1.3
35	S2,S3	Log of auto distance (miles)	-0.376	-3.5
41	S2,S3	No cars in HH	-5.246	-3.6
42	S2,S3	HH fewer cars than drivers	1.024	3.0
133	S2,S3	Escort stop purpose / # tours in day	6.643	5.3
134	S2,S3	Other stop purposes / # tours in day	0.709	2.3
50	DA	Constant	1.512	2.4
53	DA	HH fewer cars than workers	-1.304	-3.7
54	DA	HH income under $25K	-1.174	-3.0
131	DA	Escort stop purpose / # tours in day	-4.232	-3.9
132	DA	Other stop purposes / # tours in day	0.342	1.3
60	BI	Constant	-5.407	-6.2
61	BI	Male	1.822	2.9
63	BI	Age over 50	-1.369	-2.4
64	BI	Davis zones	4.957	6.6
67	BI	Mixed use density at origin	0.019	3.0
71	WK	Male	-1.487	-2.4
77	WK	Mixed use density at origin	0.013	2.1
99	All	Mode nesting parameter	0.510	7.6

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 4: Mode Choice Models", August 2, 2006—Draft 3.

Table 8-30. Home-Based School Tour Main Mode Choice Estimation Results

Coeff. No.	Modes	Variable Description	Est.	T-Stat
Level of Service				
1	DA,S2,S3,WT	Cost ($)	-0.150	Const
2	DA,S2,S3,WT	In-vehicle time (min)	-0.015	Const
3	WT,BI,WK	Out-of-vehicle time (min)	-0.033	-6.9
Mode Specific Variables				
10	SB	Constant	-1.294	-3.5
17	SB	Child under age 5	-0.612	-0.5
18	SB	Adult age 18+	-3.011	-2.4
20	WT	Constant	-2.331	-3.4
21	WT	No cars in HH	1.113	1.9
22	WT	HH fewer cars than drivers	0.716	1.8
27	WT	Child under age 5	-5.000	Const
28	WT	Adult age 18+	1.993	4.0
29	WT	Child age 16-17	1.566	3.0
167	WT	Mixed use density at origin	0.013	2.3
168	WT	Mixed use density at destination	0.007	1.4
30	S3	Constant	0.345	1.0
37	S3	One or two person HH	-1.412	-4.8
40	S2	Constant	-0.311	-0.9
38	S2	One person HH	-1.768	-1.6
41	S2,S3	No cars in HH	-2.803	-3.2
44	S2,S3	HH income under $25K	-0.675	-2.5
45	S2,S3	HH income $25-50K	-0.520	-2.6
47	S2,S3	Child under age 5	1.646	2.6
133	S2,S3	Escort stop purpose / # tours in day	2.762	4.3
134	S2,S3	Other stop purposes / # tours in day	0.433	2.5
50	DA	Constant	2.287	4.6
52	DA	HH fewer cars than drivers	-1.111	-3.7
54	DA	HH income under $25K	-1.409	-3.3
56	DA	HH income over $75K	0.583	1.8
59	DA	Child age 16-17	-2.245	-5.7
131	DA	Escort stop purpose / # tours in day	-1.575	-1.5
132	DA	Other stop purposes / # tours in day	0.464	1.8
60	BI	Constant	-2.873	-6.8
61	BI	Male	0.564	1.8
64	BI	Davis zones	3.739	9.0
69	BI	Adult age 18+	0.760	1.9
75	WK	Intersection density at origin	0.009	2.3
99	All	Mode nesting parameter	0.865	7.7

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 4: Mode Choice Models", August 2, 2006—Draft 3.

Table 8-31. Home-Based Escort Tour Main Mode Choice Estimation Results

Coeff. No.	Modes	Variable Description	Est.	T-Stat
Level of Service Variables				
7	S2,S3,WK	Cost ($)	-0.400	Const
7	S2,S3,WK	In-vehicle time (min)	-0.050	Const
7	S2,S3,WK	Out-of-vehicle time (min)	-0.150	-5.8
Mode Specific Variables				
40	S2	Constant	0.267	0.4
30	S3	Constant	-0.629	-0.8
31	S3	HH # children under age 5	0.915	5.8
32	S3	HH # children age 5-15	0.469	7.1
33	S3	HH # children age 16-17	-0.372	-2.8
41	S2,S3	No cars in HH	-5.914	-3.4
73	WK	Age over 50	-0.703	-1.0
76	WK	Intersection density at destination	0.020	2.9
81	WK	HH # children under age 5	0.986	2.7
82	WK	HH # children age 5-15	0.437	2.3
83	WK	HH # children age 16-17	-1.626	-2.9

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 4: Mode Choice Models", August 2, 2006—Draft 3.

Table 8-32. Work-Based Tour Main Mode Choice Estimation Results

Coeff. No.	Modes	Variable Description	Est.	T-Stat
Level of Service Variables				
1	DA,S2,S3,WT	Cost ($)	-0.200	Const
2	DA,S2,S3,WT	In-vehicle time (min)	-0.025	Const
3	WT,BI,WK	Out-of-vehicle time (min)	-0.071	-6.1
Mode Specific Variables				
20	WT	Constant	-3.436	-3.4
30	S3	Constant	-4.748	-3.4
40	S2	Constant	-3.978	-2.8
88	S2,S3	Drive alone to work	2.720	2.1
89	S2,S3	Shared ride to work	3.222	2.4
50	DA	Constant	-4.595	-2.5
54	DA	HH income under $25K	-0.827	-1.3
55	DA	HH income $25-50K	-0.428	-1.3
58	DA	Drive alone to work	5.502	3.1
59	DA	Shared ride to work	4.368	2.5
60	BI	Constant	-12.436	-6.0
61	BI	Male	2.032	1.2
64	BI	Davis zones	10.299	6.3
69	BI	Bike to work	10.000	Const
77	WK	Mixed use density at origin	0.015	4.8
79	WK	Walk to work	7.000	Const
99	All	Mode nesting parameter	0.750	Const

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 4: Mode Choice Models", August 2, 2006—Draft 3.

Table 8-33. Home-Based Other Tour Main Mode Choice Estimation Results

Coeff. No.	Modes	Variable Description	Est.	T-Stat
Level of Service Variables				
1	DA,S2,S3,WT	Cost ($)	-0.200	Const
2	DA,S2,S3,WT	In-vehicle time (min)	-0.025	Const
7	WT,BI,WK	Out-of-vehicle time (min)	-0.068	-8.9
Mode Specific Variables				
20	WT	Constant	-4.660	-4.3
21	WT	No cars in HH	3.594	3.9
165	WT	Intersection density at origin	0.008	1.3
168	WT	Mixed use density at destination	0.014	2.5
171	WT	Shopping tour	-1.928	-2.1
172	WT	Meal tour	2.000	2.0
30	S3	Constant	-0.643	-1.7
38	S3	One person HH	-4.149	-9.8
39	S3	Two person HH	-1.779	-16.8
40	S2	Constant	-0.650	-1.7
48	S2	One person HH	-2.454	-6.8
31	S2,S3	HH # children under age 5	0.657	3.7
32	S2,S3	HH # children age 5-15	0.127	1.7
34	S2,S3	HH # non-working adults 18+	0.244	3.8
35	S2,S3	Log of auto distance (miles)	0.317	4.5
41	S2,S3	No cars in HH	-1.323	-2.4
43	S2,S3	HH fewer cars than workers	0.439	2.5
133	S2,S3	Escort stop purpose / # tours in day	1.742	3.1
134	S2,S3	Other stop purposes / # tours in day	0.514	2.6
174	S2,S3	Shopping tour	0.243	2.0
175	S2,S3	Meal tour	2.329	7.0
176	S2,S3	Social/recreation tour	0.580	3.9
50	DA	Constant	1.590	3.7
52	DA	HH fewer cars than drivers	-0.432	-2.7
131	DA	Escort stop purpose / # tours in day	-1.020	-1.8
132	DA	Other stop purposes / # tours in day	0.294	1.5
60	BI	Constant	-4.085	-7.1
61	BI	Male	0.911	2.7
63	BI	Age over 50	-0.619	-1.7
64	BI	Davis zones	2.845	5.6
65	BI	Intersection density at origin	0.011	1.9
67	BI	Mixed use density at origin	0.011	2.0
182	BI	Social/recreation tour	0.881	2.2
73	WK	Age over 50	-0.471	-1.9
74	WK	Davis zones	1.367	3.4
75	WK	Intersection density at origin	0.012	4.1
178	WK	Meal tour	1.390	3.2
179	WK	Social/recreation tour	1.349	4.5
99	All	Mode nesting parameter	0.730	8.6

Source: SACOG, November 2008. Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 4: Mode Choice Models", August 2, 2006—Draft 3.

Table 8-34. Tour Main Mode Choice Calibrated Coefficients

Coeff. No.	Mode	Variable Description	Est.	Calib.
Work				
10	DT	Constant	-4.089	-5.385
20	WT	Constant	-4.195	-4.715
30	S3	Constant	-3.772	-4.716
40	S2	Constant	-3.143	-4.202
50	DA	Constant	1.512	0.721
60	BI	Constant	-5.407	-5.856
School				
20	WT	Constant	-2.331	-2.358
30	S3	Constant	0.345	-0.040
40	S2	Constant	-0.311	-0.776
50	DA	Constant	2.287	1.987
60	BI	Constant	-2.873	-2.155
Non-Mandatory Combined (Pers.Bus., Shop, Meal, Soc./Rec.)				
20	WT	Constant	-4.660	-5.104
30	S3	Constant	-0.643	-0.807
40	S2	Constant	-0.650	-0.742
50	DA	Constant	1.590	1.878
60	BI	Constant	-4.085	-3.973
All Work-Based				
20	WT	Constant	-3.436	-3.432
30	S3	Constant	-4.748	-4.978
40	S2	Constant	-3.978	-4.185
50	DA	Constant	-4.595	-4.737
Source: SACOG, November 2008.				

Table 8-35. Tour Main Mode Choice: Comparison of Model to Survey

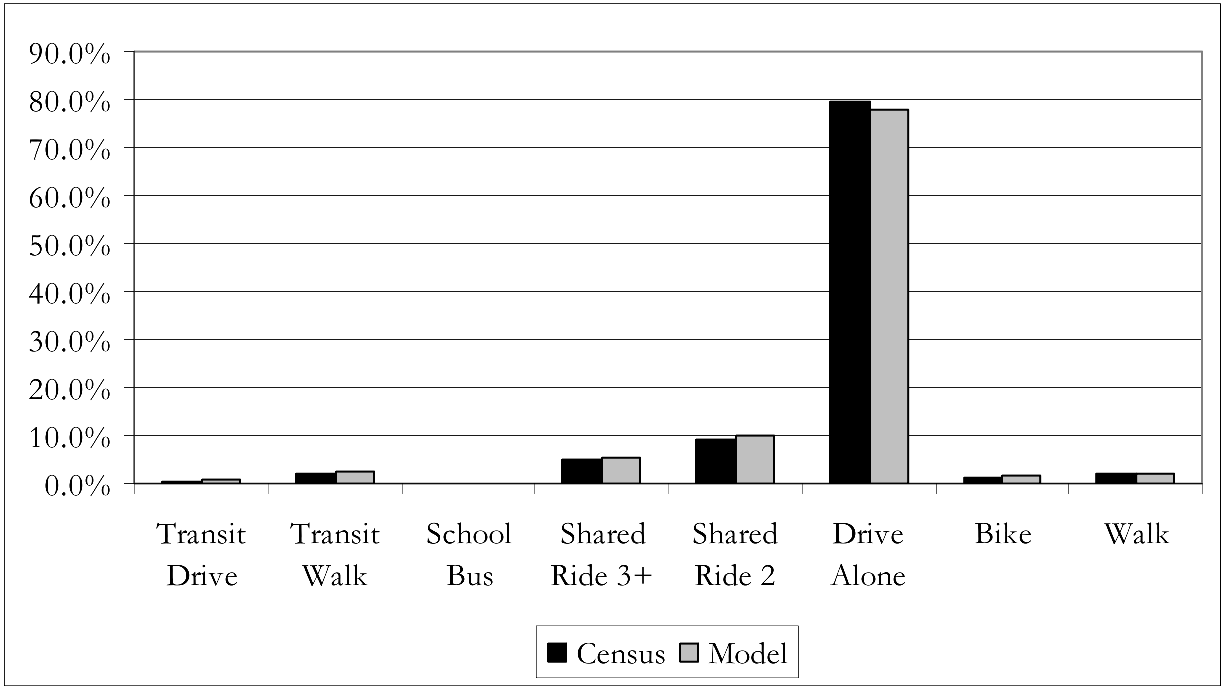
Main Mode	Work	Census J-T-W[2]	Adj Work	WB Tour (All Purposes)	School	Escort	Pers.Bus.	Shop	Meal	Soc/Rec	Total
2000 Survey[1]+Adjustments / 2000 Census[2]											
Transit Drive	0.7%	**2.7%**	**0.6%**	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Transit Walk	2.6%		**2.1%**	0.6%	2.7%	0.0%	0.6%	0.6%	0.6%	0.6%	1.4%
School Bus	0.1%	**n/a**	**n/a**	0.0%	14.7%	0.0%	0.0%	0.0%	0.7%	0.0%	2.6%
Shared Ride 3+	5.4%	**14.3%**	**5.1%**	8.5%	34.4%	47.6%	20.9%	21.7%	34.5%	28.7%	23.0%
Shared Ride 2	9.8%		**9.2%**	13.4%	16.8%	46.4%	31.0%	31.6%	40.1%	31.8%	24.5%
Drive Alone	77.9%	**79.4%**	**79.4%**	61.1%	11.6%	0.4%	43.6%	41.9%	20.0%	31.3%	40.5%
Bike	1.6%	**1.4%**	**1.4%**	1.0%	6.3%	0.1%	1.0%	0.9%	0.3%	1.1%	1.9%
Walk	1.9%	**2.2%**	**2.2%**	15.6%	12.5%	5.3%	2.5%	3.5%	3.5%	6.8%	5.7%
Total	0.3%	**100.0%**	**100.0%**	0.0%	0.0%	0.0%	0.3%	0.1%	0.4%	0.1%	0.2%
2000 Model											
Transit Drive	0.6%	**3.3%**	**0.6%**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Transit Walk	2.6%		**2.6%**	0.4%	4.4%	0.0%	1.2%	0.2%	1.3%	0.5%	1.5%
School Bus	n/a	**n/a**	**n/a**	n/a	15.2%	n/a	n/a	n/a	n/a	n/a	n/a
Shared Ride 3+	5.3%	**15.3%**	**5.3%**	7.9%	34.6%	48.7%	21.3%	23.0%	29.6%	27.2%	23.0%
Shared Ride 2	10.0%		**10.0%**	16.6%	17.0%	42.3%	29.4%	31.0%	45.6%	34.9%	25.5%
Drive Alone	77.8%	**77.8%**	**77.8%**	59.2%	8.3%	0.0%	44.0%	42.0%	19.6%	30.3%	39.6%
Bike	1.6%	**1.6%**	**1.6%**	1.3%	6.5%	0.0%	1.2%	1.1%	0.4%	1.4%	1.8%
Walk	2.0%	**2.0%**	**2.0%**	14.6%	13.9%	9.0%	3.0%	2.7%	3.5%	5.6%	6.3%
Total	100.0%	**100.0%**	**100.0%**	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: SACOG, November 2008.

[1] Survey based on 2000 SACOG Household Travel Survey, with expansion factors.

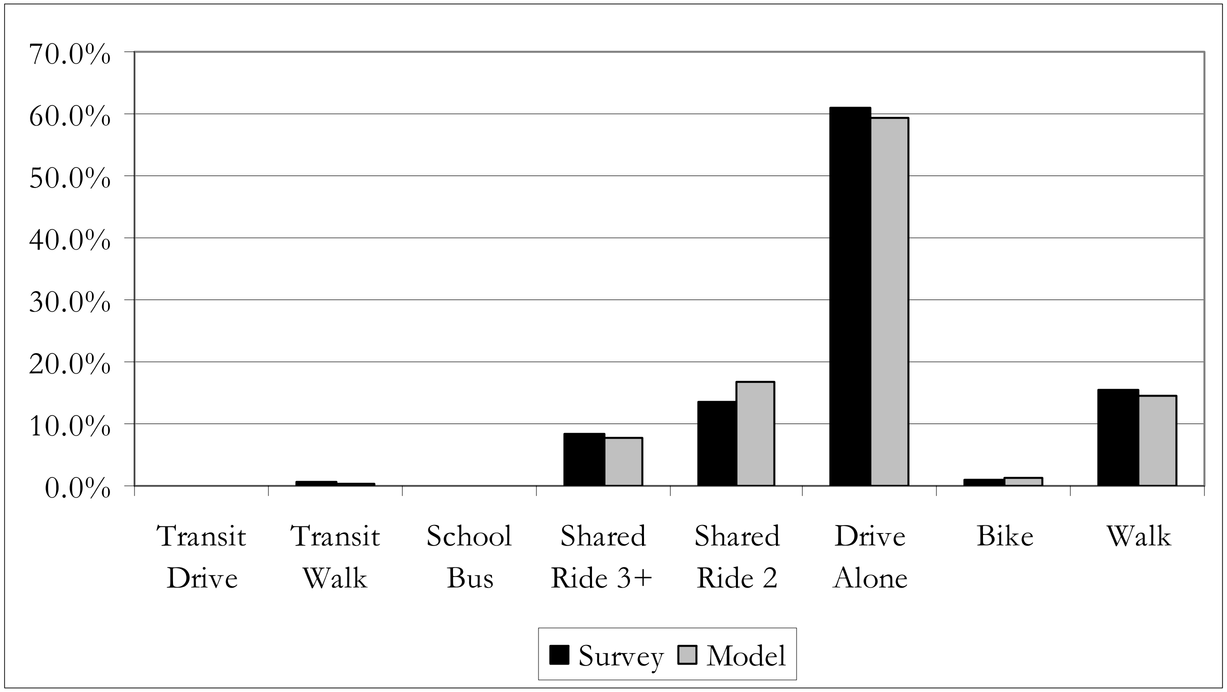
[2] Adjustments to work-tour survey mode split to match the comparable-mode percentages in the Year 2000 Census Journey-to-Work statistics.

Figure 8-22. Work Tour Mode Choice: Census vs. Model



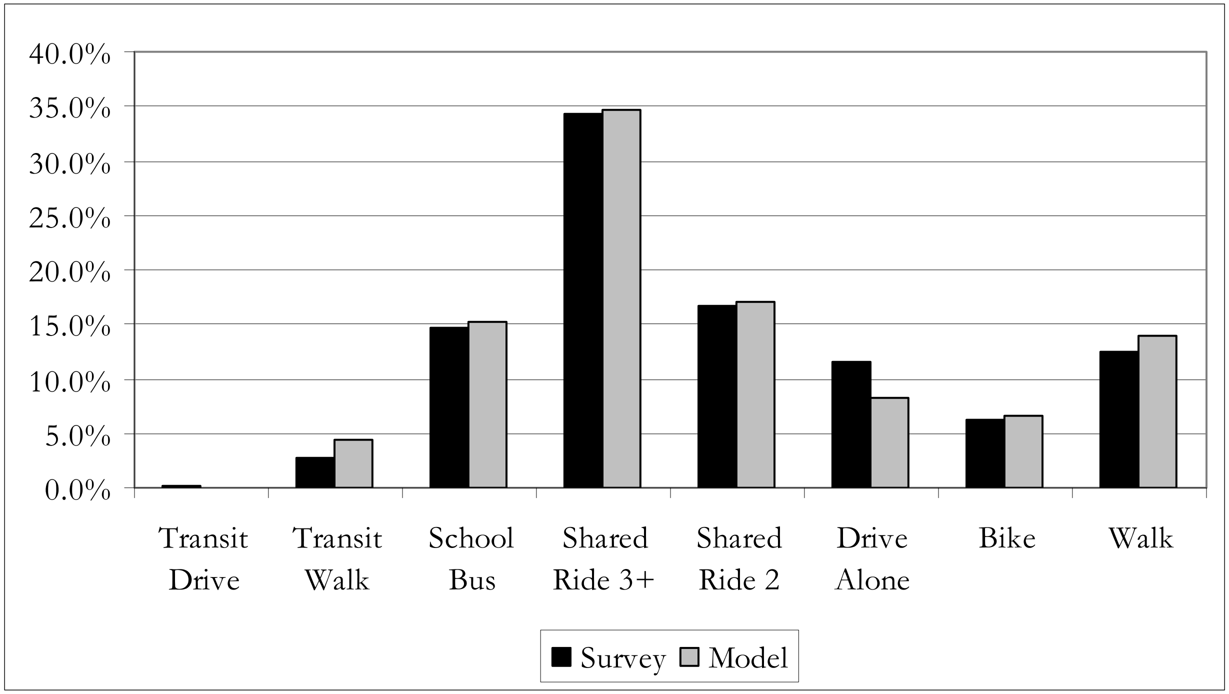
Source: SACOG, November 2008.

Figure 8-23. Work-Based Sub-Tour Mode Choice: Survey vs. Model



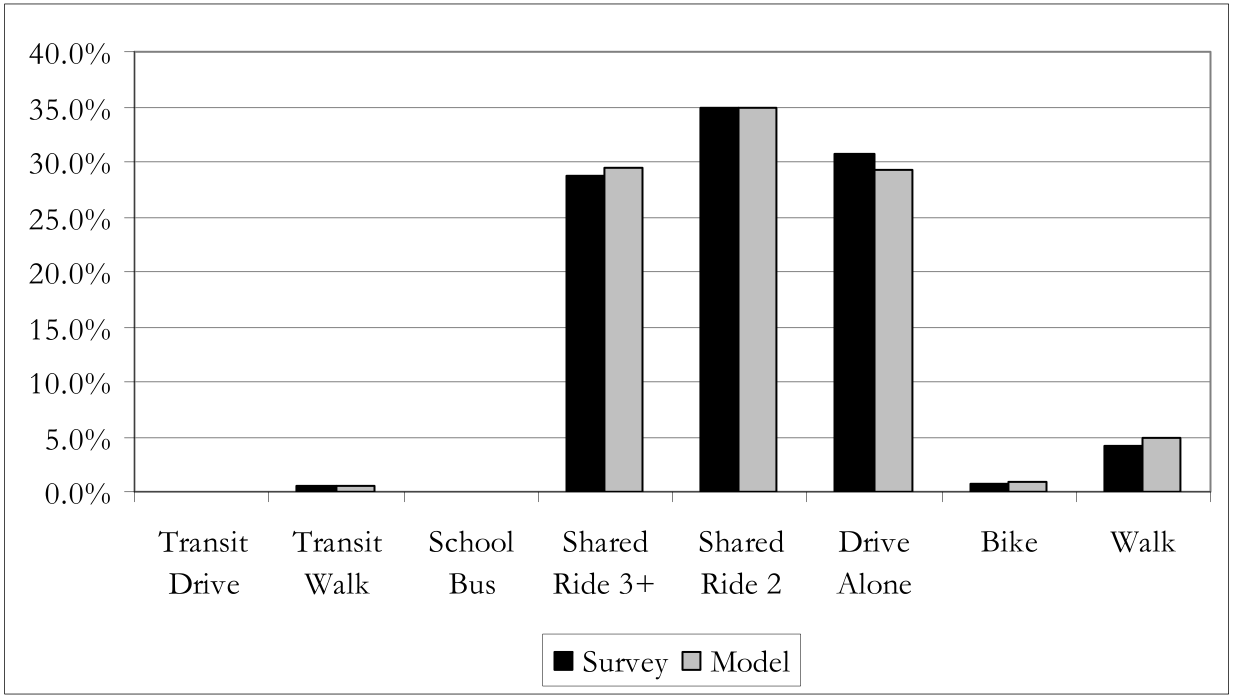
Source: SACOG, November 2008.

Figure 8-24. School Tour Mode Choice: Survey vs. Model



Source: SACOG, November 2008.

Figure 8-25. Non-Mandatory Tour Mode Choice: Survey vs. Model



Source: SACOG, November 2008.

Tour Primary Activity Scheduling Submodel

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 sub-tours

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 (see Table 8-36 for estimation results)
  - 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 (see Table 8-37 for estimation results)
  - Many time pressure/constraint effects are similar to work activities and tours.
- Non-mandatory activities and tours (see Table 8-38 for estimation results)
  - 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 (see Table 8-39 for estimation results)
  - 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 (see Table 8-40 for estimation results)
  - 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.

Overall goodness-of-fit for the estimated models are shown in Table 8-41.

Submodel Calibration and Application

The calibration approach used for these submodels was similar to that used for the day pattern submodel, described above: The submodels were calibrated to match the travel time and duration distributions observed in the SACOG 2000 Household Travel Survey, with specific attention to person type. Calibration adjustments were made only to the time block constants, however. After an initial round of calibration, comparison of the overall results to observed traffic volumes by the four primary demand periods (AM peak 3 hours, midday 5 hours, PM peak 3 hours, late evening/early morning 13 hours—see detailed discussion in Chapter 9) indicated significant inconsistencies on time of travel. In particular, the following were observed:

- Overall travel during PM peak period was over-estimated
- Overall travel during the late-evening/early morning period was under-estimated

Final calibration was accomplished by making manual adjustments to the survey non-mandatory tour arrivals and departures, and re-calibrating to the adjusted survey time distribution. The adjustments are illustrated in Figures 8-26 and 8-27.

Table 8-42 through 8-44 present the estimated and final calibrated time block constants. Table 8-45 presents a summary comparison of survey (with adjustments) to model, for arrival times, departure times and activity durations. A series of figures illustrate survey to model comparisons of arrival time, departure time, and activity duration for different activities and person types.

- Figures 8-28 and 8-29 arrival and departure times for work tours for full time and part time workers, respectively.
- Figure 8-30 shows arrival and departure times for school tours for all person types.
- Figure 8-31 shows arrival and departure times for non-mandatory tours for all person types.
- Figure 8-32 shows arrival and departure times for all tours and person types.
- Figures 8-33 through 8-35 illustrate activity duration distributions for work, school and non-mandatory activities.

Table 8-36. Work Tour Scheduling Choice Estimation Results

Coeff. No.	Variable Description	Est.	T-stat
Arrival, Departure, and Duration Constants			
11	Arrival 03:00 – 05:59	-2.1958	-13.1
12	Arrival 06:00 – 06:59	-0.6919	-6.6
13	Arrival 07:00 – 07:59	-0.1168	-1.7
14	Arrival 08:00 – 08:59	0.0000	Constr.
15	Arrival 09:00 – 09:59	-0.9072	-11.5
16	Arrival 1:000 – 12:59	-1.7580	-13.1
17	Arrival 13:00 – 15:59	-1.8168	-7.9
18	Arrival 16:00 -18:59	-2.4870	-7.5
19	Arrival 19:00 – 21:59	-3.8442	-7.7
20	Arrival 22:00 – 02:59	-5.1755	-6.3
21	Depart 03:00 – 06:59	-0.8102	-1.8
22	Depart 07:00 – 09:59	-0.9947	-3.6
23	Depart 1:000 – 12:59	-0.1798	-1.1
24	Depart 13:00 – 15:59	-0.0962	-1.3
25	Depart 16:00 – 16:59	0.0000	Constr.
26	Depart 17:00 - 17:59	0.0029	0.0
27	Depart 18:00 - 18:59	-0.8363	-8.1
28	Depart 19:00 - 20:59	-2.2834	-15.0
29	Depart 21:00 - 23:59	-2.7267	-12.5
30	Depart 24:00 - 02:59	-4.5953	-13.2
31	Duration 0 - 2:59	-0.4520	-1.5
32	Duration 3:00 - 4:59	0.1503	0.6
33	Duration 5:00 - 6:59	0.1030	0.5
34	Duration 7:00 - 8:59	0.4339	2.8
35	Duration 9:00 - 9:59	0.0000	Constr.
36	Duration 1:000 - 10:59	-0.4829	-7.2
37	Duration 11:00 - 11:59	-1.3272	-11.8
38	Duration 12:00 - 13:59	-2.3789	-14.1
39	Duration 14:00 - 17:59	-4.5120	-14.2
40	Duration 18:00 - 23:59	-7.0030	-8.2
Time-of-Travel Shift Constants			
41	Part-time worker-Arrival shift	0.0307	2.8
42	Part-time worker-Duration shift	-0.0442	-2.9
45	Uinversity student -Arrival shift	0.0927	5.3
46	University student-Duration shift	0.0224	0.9
49	K12 student 16+ -Arrival shift	0.1889	7.3
50	K12 student 16+ -Duration shift	-0.0190	-0.5
43	Other non-worker -Arrival shift	0.0559	2.3
44	Other non-worker -Duration shift	-0.1011	-3.0
71	Full-time worker - Duration < 900	-1.3676	-8.6
51	Income <$15K - Arrival shift	0.0155	1.3
52	Income <$15K - Duration shift	-0.0307	-2.1

Coeff. No.	Variable Description	Est.	T-stat
53	Income >$75K - Arrival shift	0.0097	0.9
54	Income >$75K - Duration shift	0.0259	2.5
72	Income <$75K - Arrival before 06:00	-0.3683	-3.0
73	Income >$75K - Depart after 22:00	-0.8499	-3.4
61	# stop purposes/only tour - Arrival shift	-0.0048	-0.8
62	# stop purposes/only tour - Duration shift	-0.0759	-12.5
63	# stop purposes/mult. tours - Arrival shift	0.0084	1.7
64	# stop purposes/mult. tours - Duration shift	-0.0506	-8.2
67	Escort stops in day - Arrival shift	-0.0269	-2.6
68	Escort stops in day - Duration shift	0.0430	3.7
69	# subtours in tour - Arrival shift	0.0171	1.8
70	# subtours in tour - Duration shift	0.1487	14.3
57	Lower of 2+ work tours – Arrival shift	0.0597	2.2
58	Lower of 2+ work tours – Duration shift	0.1964	4.3
Time Window/Constraint Variables			
81	Higher of 2+ work tours- Duration<8:00	1.9103	8.7
82	Lower of 2+ work tours- Duration<8:00	5.0000	Constr.
83	Higher of 2+ different tours- Duration<8:00	-0.4524	-3.8
91	Arrival period partially used	-1.5832	-4.0
92	Departure period partially used	-1.5249	-2.5
93	Empty window remaining before- 1st tour	-0.1084	-3.9
94	Empty window remaining after – 1st tour	-0.2046	-7.5
95	Empty window remaining before- 2nd+ tour	0.0962	1.9
96	Empty window remaining after – 2nd+ tour	0.0946	2.5
97	Remaining tours/total remaining window	-77.5309	-6.1
98	Remaining tours/maximum remaining window	-20.7164	-5.0
99	Remaining tours/adjacent window before	-0.8229	-3.1
100	Remaining tours/adjacent window after	-0.0679	-0.3
Level of Service/Travel Time Variables			
85	Auto travel time (min) - outbound period	-0.0526	-1.7
86	Auto travel time (min) - return period	-0.0400	Constr.
87	Transit travel time (min) - outbound period	-0.0410	-1.7
88	Transit travel time (min) - return period	-0.0433	-1.9
89	No transit path in period	-2.8379	-1.9
101	Auto AM congested time - shift earlier	0.0323	5.5
103	Auto PM congested time - shift earlier	0.0347	5.2
105	Auto AM time missing - shift earlier	0.1380	1.3
106	Auto AM time missing - shift later	-0.1187	-1.0
107	Auto PM time missing - shift earlier	0.1672	1.7
108	Auto PM time missing - shift later	-0.3751	-3.3

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A., "Technical Memo Number 7: Time of Day / Activity Scheduling Models", July 31, 2006 – Draft 2.

Table 8-37. School Tour Scheduling Choice Estimation Results

Coeff. No.	Variable Description	Est.	T-stat
Arrival, Departure, and Duration Constants			
11	Arrival 03:00 – 05:59	-10.0000	Constr
12	Arrival 06:00 – 06:59	-3.1769	-15.4
13	Arrival 07:00 – 07:59	-0.1488	-2.0
14	Arrival 08:00 – 08:59	0.0000	Constr
15	Arrival 09:00 – 09:59	-1.2758	-10.9
16	Arrival 1:000 – 12:59	-2.3804	-12.9
17	Arrival 13:00 – 15:59	-3.1937	-9.4
18	Arrival 16:00 -18:59	-2.3961	-5.2
19	Arrival 19:00 – 21:59	-4.0757	-6.2
20	Arrival 22:00 – 02:59	-10.0000	Constr
21	Depart 03:00 – 06:59	-10.0000	Constr
22	Depart 07:00 – 09:59	-0.9307	-2.3
23	Depart 1:000 – 12:59	0.9092	4.2
24	Depart 13:00 – 15:59	1.7734	14.1
25	Depart 16:00 – 16:59	0.0000	Constr
26	Depart 17:00 – 17:59	-0.1961	-1.3
27	Depart 18:00 – 18:59	-1.3392	-6.2
28	Depart 19:00 – 20:59	-1.9347	-7.6
29	Depart 21:00 – 23:59	-2.7719	-8.1
30	Depart 24:00 – 02:59	-10.0000	Constr
31	Duration 00:00 - 2:59	-2.2150	-5.9
32	Duration 3:00 – 4:59	-1.2738	-4.4
33	Duration 5:00 – 6:59	-1.0923	-5.2
34	Duration 7:00 – 8:59	-0.0272	-0.2
35	Duration 9:00 – 9:59	0.0000	Constr
36	Duration 1:000 - 10:59	0.3146	1.8
37	Duration 11:00 - 11:59	-0.5924	-1.9
38	Duration 12:00 - 13:59	-2.3843	-4.2
39	Duration 14:00 - 17:59	-2.7444	-3.8
40	Duration 18:00 - 23:59	-10.0000	Constr
Time-of-Travel Shift Constants			
41	Part-time worker-Arrival shift	0.1900	3.4
42	Part-time worker-Duration shift	-0.0236	-0.3
139	Full-time worker-Arrival shift	0.2606	8.5
140	Full-time worker-Duration shift	0.0974	2.7
47	Non-worker 65+ -Arrival shift	0.1900	3.4
48	Non-worker 65+ -Duration shift	-0.0236	-0.3
43	Other non-worker -Arrival shift	0.1900	3.4
44	Other non-worker -Duration shift	-0.0236	-0.3
45	Uinversity student -Arrival shift	0.1728	8.4
46	University student-Duration shift	-0.0380	-1.9
49	K12 student 16+ -Arrival shift	-0.0701	-2.1

50	K12 student 16+ -Duration shift	0.0741	3.6
143	Child age 0-4 –Arrival shift	0.0920	2.2
144	Child age 0-4 -Duration shift	0.1670	5.8
61	# stop purposes/only tour - Arrival shift	-0.0101	-0.7
62	# stop purposes/only tour - Duration shift	-0.0510	-4.3
65	# stop purposes/mult. tour - Arrival shift	-0.0262	-2.0
66	# stop purposes/mult. tour - Duration shift	-0.0661	-5.3
67	Escort stops in day - Arrival shift	-0.0342	-1.4
68	Escort stops in day - Duration shift	0.0750	3.4
Time Window/Constraint Variables			
91	Arrival period partially used	-1.8658	-3.1
92	Departure period partially used	-2.7304	-2.6
93	Empty window remaining before- 1st tour	-0.0230	-0.8
94	Empty window remaining after - 1st tour	-0.0641	-2.7
95	Empty window remaining before- 2nd+ tour	0.0965	2.4
96	Empty window remaining after - 2nd+ tour	0.0607	2.0
97	Remaining tours/total remaining window	-78.6755	-5.6
99	Remaining tours/adjacent window before	-2.0269	-2.1
100	Remaining tours/adjacent window after	-1.59	-1.5

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A., "Technical Memo Number 7: Time of Day / Activity Scheduling Models", July 31, 2006 – Draft 2.

Table 8-38. Other Tour Scheduling Choice Estimation Results

Coeff. No.	Variable Description	Est.	T-stat
Arrival, Departure, and Duration Constants			
11	Arrival 03:00 – 05:59	-4.1869	-17.1
12	Arrival 06:00 – 06:59	-1.9909	-13.1
13	Arrival 07:00 – 07:59	-0.7600	-8.9
14	Arrival 08:00 – 08:59	0.0000	Constr
15	Arrival 09:00 – 09:59	-0.0294	-0.4
16	Arrival 1:000 – 12:59	0.2904	3.1
17	Arrival 13:00 – 15:59	0.5652	4.1
18	Arrival 16:00 -18:59	1.0069	5.6
19	Arrival 19:00 – 21:59	0.6179	2.8
20	Arrival 22:00 – 02:59	-1.1000	-3.6
21	Depart 03:00 – 06:59	-0.2679	-0.9
22	Depart 07:00 – 09:59	0.0319	0.2
23	Depart 1:000 – 12:59	0.1363	1.1
24	Depart 13:00 – 15:59	0.2635	3.5
25	Depart 16:00 – 16:59	0.0000	Constr
26	Depart 17:00 - 17:59	-0.3129	-4.0
27	Depart 18:00 - 18:59	-0.5627	-6.1
28	Depart 19:00 - 20:59	-0.4799	-4.5
29	Depart 21:00 - 23:59	-0.7410	-4.8
30	Depart 24:00 - 02:59	-2.2996	-9.2
31	Duration 00:00 - 2:59	-0.8314	-8.7
32	Duration 3:00 - 4:59	-0.1588	-2.5
33	Duration 5:00 - 6:59	0.0000	Constr
34	Duration 7:00 - 8:59	-0.4028	-5.5
35	Duration 9:00 - 9:59	-0.8494	-5.3
36	Duration 1:000 - 10:59	-0.8150	-3.2
37	Duration 11:00 - 11:59	-0.7825	-2.2
38	Duration 12:00 - 13:59	-2.7541	-3.2
39	Duration 14:00 - 17:59	-1.6635	-2.2
40	Duration 18:00 - 23:59	-10.0000	Constr
169	Escort tour - Duration 00:00 – 00:59 constant	1.3779	9.8
170	Shopping tour – Duration 00:00 -00:59 constant	1.3456	7.4
171	Meal tour - Duration 00:00 -00:59 constant	-0.5644	-2.6
173	Shopping tour – Duration 1:00 – 1:59 constant	1.2175	8.8
174	Meal tour - Duration 100 -1:59 constant	0.3127	2.1
Time-of-Travel Shift Constants			
41	Part-time worker-Arrival shift	-0.0085	-1.2
42	Part-time worker-Duration shift	-0.0140	-0.6
43	Other non-worker -Arrival shift	-0.0049	-0.9
44	Other non-worker -Duration shift	-0.0344	-2.2
45	Uinversity student -Arrival shift	0.0239	2.4
46	University student-Duration shift	0.0201	0.8
47	Non-worker 65+ -Arrival shift	-0.0261	-4.9

Coeff. No.	Variable Description	Est.	T-stat
48	Non-worker 65+ -Duration shift	-0.0467	-3.3
49	K12 student 16+ -Arrival shift	0.0325	2.2
50	K12 student 16+ -Duration shift	0.0509	1.6
141	Child age 5-15 -Arrival shift	0.0123	1.4
142	Child age 5-15 -Duration shift	0.0165	0.9
143	Child age 0-4 -Arrival shift	-0.0115	-1.2
144	Child age 0-4 -Duration shift	0.0154	0.7
145	Escort tour - Arrival shift	-0.0271	-3.8
146	Escort tour - Duration shift	-0.4407	-8.7
147	Shopping tour - Arrival shift	0.0245	4.4
148	Shopping tour – Duration shift	-0.1175	-3.5
149	Meal tour - Arrival shift	0.0872	8.9
150	Meal tour - Duration shift	0.0530	1.6
151	Social/recreation tour - Arrival shift	0.0353	6.1
152	Social/recreation tour - Duration shift	0.1839	13.3
176	Shopping tour - Arrival before 07:00	-1.6702	-3.9
177	Meal tour - Arrival before 07:00	0.6782	1.6
178	Escort tour - Depart after 21:00	0.5536	3.0
179	Shopping tour - Depart after 21:00	-0.9987	-6.2
180	Meal tour - Depart after 21:00	-0.6477	-3.8
55	Higher of 2+ same tours - Arrival shift	0.0077	0.6
56	Higher of 2+ same tours - Duration shift	0.1535	3.6
57	Lower of 2+ same tours - Arrival shift	-0.0689	-4.5
58	Lower of 2+ same tours - Duration shift	-0.5021	-9.0
155	Higher of 2+ diff. tours - Arrival shift	-0.0027	-0.2
156	Higher of 2+ diff. tours - Duration shift	0.1213	2.1
157	Lower of 2+ diff. tours - Arrival shift	-0.0594	-4.5
158	Lower of 2+ diff. tours - Duration shift	-0.1947	-7.1
84	Lower of 2+ different tours- Duration<4:00	0.4969	3.9
59	Only tour of the day - Arrival shift	-0.0207	-1.2
60	Only tour of the day - Duration shift	0.0636	1.2
61	# stop purposes/only tour - Arrival shift	0.0034	0.9
62	# stop purposes/only tour - Duration shift	-0.0068	-0.9
63	# stop purposes/mult. tour - Arrival shift	0.0039	1.9
64	# stop purposes/mult. tour - Duration shift	-0.0083	-1.2
67	Escort stops in day - Arrival shift	-0.0010	-0.2
68	Escort stops in day - Duration shift	0.0562	3.7
Time Window/Constraint Variables			
91	Arrival period partially used	-1.2923	-13.4
92	Departure period partially used	-0.8166	-5.0
93	Empty window remaining before- 1st tour	0.1674	2.8
94	Empty window remaining after - 1st tour	0.2213	3.8
95	Empty window remaining before- 2nd+ tour	0.0006	0.1
96	Empty window remaining after - 2nd+ tour	0.0220	4.1
97	Remaining tours/total remaining window	-131.4534	-6.1

Coeff. No.	Variable Description	Est.	T-stat
98	Remaining tours/maximum remaining window	-2.7639	-1.1
99	Remaining tours/adjacent window before	-0.2774	-3.1
100	Remaining tours/adjacent window after	-0.1569	-1.5
Level of Service/Travel Time Variables			
85	Auto travel time (min) - outbound period	-0.1675	-5.0
86	Auto travel time (min) - return period	-0.1210	-3.5
89	No transit path in period	-5.0000	Constr
103	Auto PM congested time - shift earlier	0.0435	4.1
104	Auto PM congested time - shift later	0.0301	2.5
105	Auto AM time missing - shift earlier	-0.0686	-0.6
106	Auto AM time missing - shift later	0.0345	0.4
107	Auto PM time missing - shift earlier	0.0390	0.5
108	Auto PM time missing - shift later	0.0971	1.2

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A., "Technical Memo Number 7: Time of Day / Activity Scheduling Models", July 31, 2006 – Draft 2.

Table 8-39. Work-Based Tour Scheduling Choice Estimation Results

Coeff. No.	Variable Description	Est.	T-stat
Arrival, Departure, and Duration Constants			
11	Arrival 03:00 – 05:59	-0.4519	-0.2
12	Arrival 06:00 – 06:59	-5.0000	Constr
13	Arrival 07:00 – 07:59	-0.2749	-0.7
14	Arrival 08:00 – 08:59	0.0000	Constr
15	Arrival 09:00 – 09:59	-0.4405	-1.8
16	Arrival 1:000 – 12:59	-0.1867	-0.7
17	Arrival 13:00 – 15:59	-1.6032	-4.4
18	Arrival 16:00 -18:59	-2.6232	-4.7
19	Arrival 19:00 – 21:59	-4.4149	-5.2
20	Arrival 22:00 – 02:59	-10.0000	Constr
21	Depart 03:00 – 06:59	2.5150	0.9
22	Depart 07:00 – 09:59	0.0470	0.1
23	Depart 1:000 – 12:59	0.5978	2.0
24	Depart 13:00 – 15:59	0.6220	2.7
25	Depart 16:00 – 16:59	0.0000	Constr
26	Depart 17:00 - 17:59	0.0969	0.3
27	Depart 18:00 - 18:59	0.1199	0.2
28	Depart 19:00 - 20:59	1.0428	2.0
29	Depart 21:00 - 23:59	2.1327	3.0
30	Depart 24:00 - 02:59	-10.0000	Constr
31	Duration 00:00 - 2:59	0.3405	1.4
32	Duration 3:00 - 4:59	0.7208	4.1
33	Duration 5:00 - 6:59	0.0000	Constr
34	Duration 7:00 - 8:59	-0.2508	-1.0
35	Duration 9:00 - 9:59	-0.5567	-1.1
36	Duration 1:000 - 10:59	0.4981	0.7
37	Duration 11:00 - 11:59	0.0520	0.0
38	Duration 12:00 - 13:59	-10.0000	Constr
39	Duration 14:00 - 17:59	-10.0000	Constr
40	Duration 18:00 - 23:59	-10.0000	Constr
Time-of-Travel Shift Constants			
41	Part-time worker-Arrival shift	0.0026	0.1
42	Part-time worker-Duration shift	0.1281	1.6
145	Escort subtour - Arrival shift	0.1819	3.1
146	Escort subtour - Duration shift	-1.9103	-3.4
147	Shopping subtour - Arrival shift	0.0581	1.8
148	Shopping subtour - Duration shift	-0.8893	-7.1
149	Meal subtour - Arrival shift	0.0473	1.8
150	Meal subtour - Duration shift	-0.3517	-6.6
151	Social/recreation subtour - Arrival shift	0.1500	2.9
152	Social/recreation subtour - Duration shift	-0.0377	-0.5
153	Personal business subtour - Arrival shift	0.0162	0.5
154	Personal business subtour - Duration shift	-0.2996	-4.9

Time Window/Constraint Variables			
91	Arrival period partially used	-5.0000	Constr
92	Departure period partially used	-2.0366	-3.5
93	Empty window remaining before	0.1606	2.9
94	Empty window remaining after	0.0665	1.3

Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A., "Technical Memo Number 7: Time of Day / Activity Scheduling Models", July 31, 2006 – Draft 2.

Table 8-40. Intermediate Stop Scheduling Choice Estimation Results

Coeff. No.	Variable Description	Est.	T-stat
Arrival, Departure, and Duration Constants			
11	Arrival 03:00 – 05:59	-2.6105	-8.1
12	Arrival 06:00 – 06:59	-1.3833	-7.0
13	Arrival 07:00 – 07:59	-0.2411	-1.9
14	Arrival 08:00 – 08:59	0.0000	Constr
15	Arrival 09:00 – 09:59	0.2108	1.7
16	Arrival 1:000 – 12:59	0.1696	1.0
17	Arrival 13:00 – 15:59	0.0331	0.1
18	Arrival 16:00 -18:59	0.2444	0.8
19	Arrival 19:00 – 21:59	-0.5341	-1.3
20	Arrival 22:00 – 02:59	0.5407	0.4
21	Depart 03:00 – 06:59	0.9533	1.0
22	Depart 07:00 – 09:59	-0.6163	-2.3
23	Depart 1:000 – 12:59	-0.2667	-1.8
24	Depart 13:00 – 15:59	-0.1694	-2.0
25	Depart 16:00 – 16:59	0.0000	Constr
26	Depart 17:00 - 17:59	0.0819	0.9
27	Depart 18:00 - 18:59	-0.2144	-1.7
28	Depart 19:00 - 20:59	-0.3800	-2.3
29	Depart 21:00 - 23:59	-0.6197	-2.6
30	Depart 24:00 - 02:59	-1.1813	-3.0
31	Duration 00:00 - 2:59	1.3863	14.0
32	Duration 3:00 - 4:59	0.8280	11.0
33	Duration 5:00 - 6:59	0.0000	Constr
34	Duration 7:00 - 8:59	-0.7698	-6.9
35	Duration 9:00 - 9:59	-2.4074	-10.1
36	Duration 1:000 - 10:59	-4.3928	-8.8
37	Duration 11:00 - 11:59	-5.0901	-7.7
38	Duration 12:00 - 13:59	-10.0000	Constr
39	Duration 14:00 - 17:59	-10.0000	Constr
40	Duration 18:00 - 23:59	-10.0000	Constr
46	University student-Duration shift	0.1407	4.6
50	K12 student 16+ -Duration shift	0.2022	6.3
52	Child age 5-15 -Duration shift	0.2147	8.4
54	Child age 0-4 -Duration shift	0.1067	2.7
145	Escort stop - Arrival shift	0.1862	4.1
146	Escort stop - Duration shift	-1.3598	-29.4
147	Shopping stop - Arrival shift	0.0867	2.8
148	Shopping stop - Duration shift	-0.6900	-21.8
149	Meal stop - Arrival shift	0.0169	0.7
150	Meal stop - Duration shift	-0.1512	-6.0
151	Social/recreation stop - Arrival shift	0.0678	3.1
152	Social/recreation stop - Duration shift	-0.0021	-0.1
153	Personal business stop - Arrival shift	0.1178	4.7

154	Personal business stop - Duration shift	-0.5103	-19.6
155	School stop - Arrival shift	0.0466	1.3
156	School stop - Duration shift	0.0391	1.0

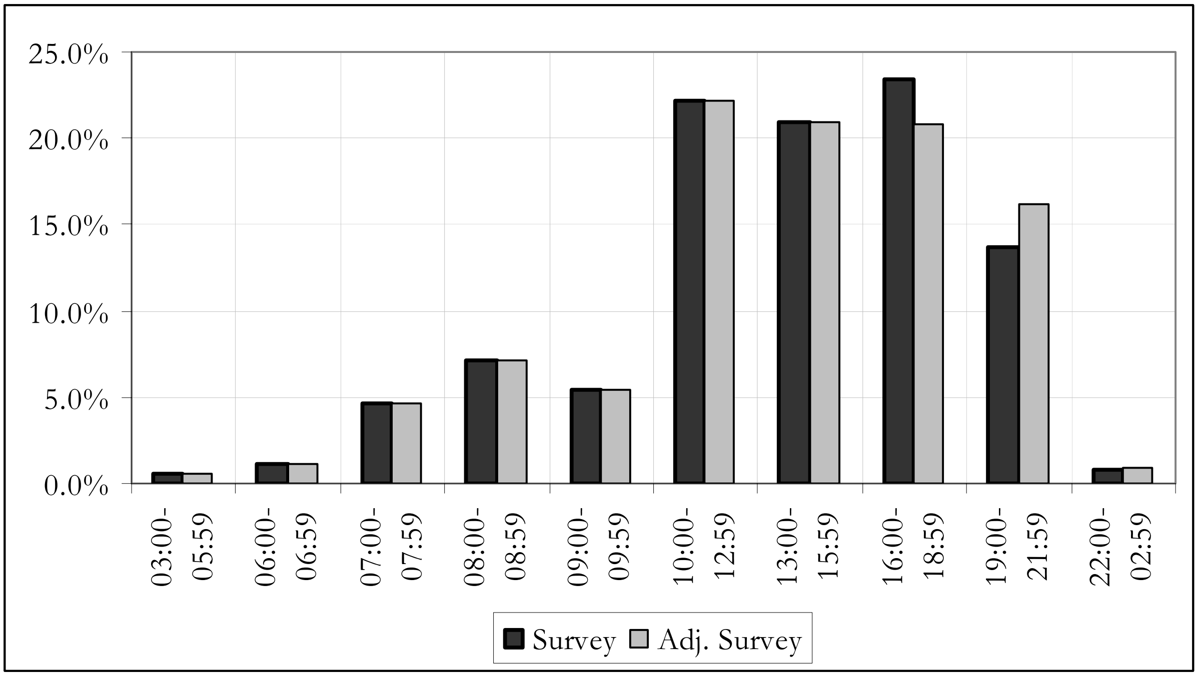
Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A., "Technical Memo Number 7: Time of Day / Activity Scheduling Models", July 31, 2006 – Draft 2.

Table 8-41. Time-of-Travel /Activity Scheduling Model Goodness-of-Fit Statistics

Model	Home-based Work Tours	Home-based School Tours	Home-based Other Tours	Work-based Sub-tours	Inter-mediate Stops
# Observations	3,532	1,561	6,062	682	8,508
Final log(likelihood)	-18,785.9	-7,142.7	-29,569.4	-2817.5	-10,531.6
Rho-squared (0)	0.239	0.343	0.239	0.162	0.550

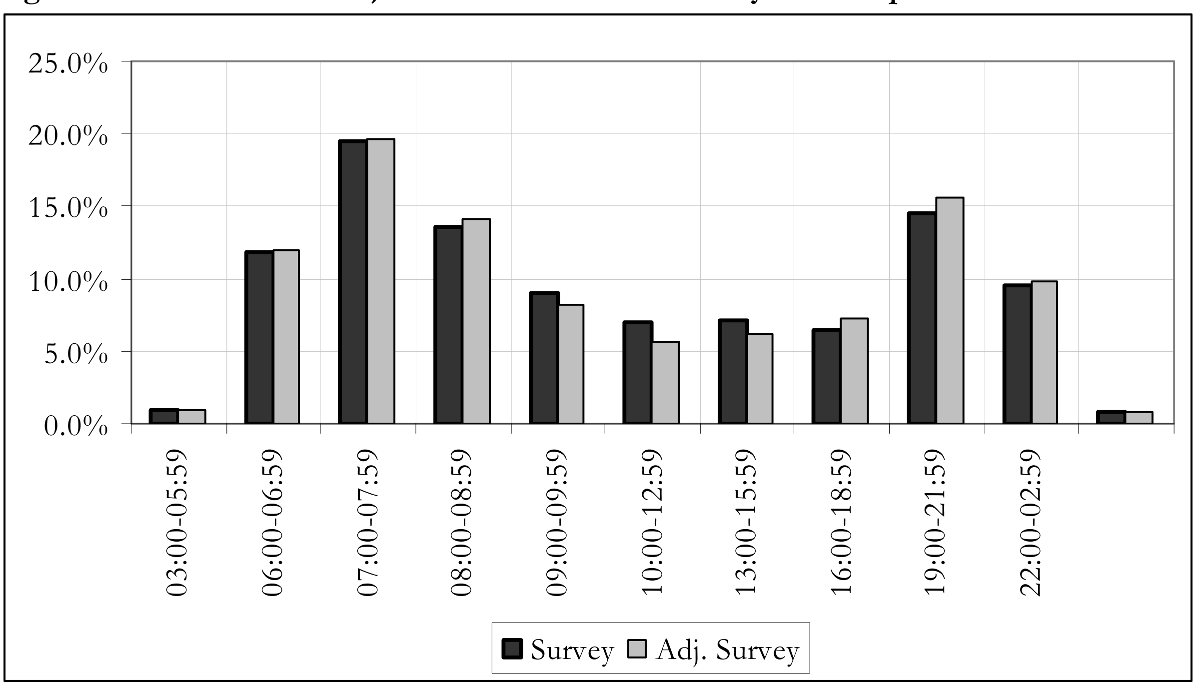
Source: SACOG, November 2008.
Based on Bowman, John L. and Bradley, Mark A., "Technical Memo Number 7: Time of Day / Activity Scheduling Models", July 31, 2006 – Draft 2.

Figure 8-26. Calibration Adjustments to Non-Mandatory Tour Arrivals



Source: SACOG, November 2008.

Figure 8-27. Calibration Adjustments to Non-Mandatory Tour Departures



Source: SACOG, November 2008.

Table 8-42. Work Activity Scheduling Model Calibrated Coefficients

Coeff. No.	Variable Description	Est.	Calib.
11	Arrival 03:00 – 05:59	-2.1958	-2.232
12	Arrival 06:00 – 06:59	-0.6919	-0.557
13	Arrival 07:00 – 07:59	-0.1168	-0.169
15	Arrival 09:00 – 09:59	-0.9072	-0.969
16	Arrival 1:000 – 12:59	-1.758	-1.738
17	Arrival 13:00 – 15:59	-1.8168	-1.608
18	Arrival 16:00 -18:59	-2.487	-2.295
19	Arrival 19:00 – 21:59	-3.8442	-3.406
20	Arrival 22:00 – 02:59	-5.1755	-6.076
21	Depart 03:00 – 06:59	-0.8102	-0.955
22	Depart 07:00 – 09:59	-0.9947	-1.097
23	Depart 1:000 – 12:59	-0.1798	-0.207
24	Depart 13:00 – 15:59	-0.0962	-0.472
26	Depart 17:00 - 17:59	0.0029	0.032
27	Depart 18:00 - 18:59	-0.8363	-0.707
28	Depart 19:00 - 20:59	-2.2834	-1.609
29	Depart 21:00 - 23:59	-2.7267	-2.824
30	Depart 24:00 - 02:59	-4.5953	-5.300
31	Duration 0 - 2:59	-0.452	-0.292
32	Duration 3:00 - 4:59	0.1503	0.620
33	Duration 5:00 - 6:59	0.103	0.159
34	Duration 7:00 - 8:59	0.4339	0.509
36	Duration 1:000 - 10:59	-0.4829	-0.893
37	Duration 11:00 - 11:59	-1.3272	-1.850
38	Duration 12:00 - 13:59	-2.3789	-2.932
39	Duration 14:00 - 17:59	-4.512	-5.065
40	Duration 18:00 - 23:59	-7.003	-7.557

Source: SACOG, November 2008.

Table 8-43. School Activity Scheduling Model Calibrated Coefficients

Coeff. No.	Variable Description	Est.	Calib.
12	Arrival 06:00 – 06:59	-3.1769	-3.239
13	Arrival 07:00 – 07:59	-0.1488	-0.338
15	Arrival 09:00 – 09:59	-1.2758	-1.484
16	Arrival 1:000 – 12:59	-2.3804	-2.527
17	Arrival 13:00 – 15:59	-3.1937	-3.521
18	Arrival 16:00 -18:59	-2.3961	-2.387
19	Arrival 19:00 – 21:59	-4.0757	-4.632
22	Depart 07:00 – 09:59	-0.9307	-1.812
23	Depart 1:000 – 12:59	0.9092	0.594
24	Depart 13:00 – 15:59	1.7734	1.874
26	Depart 17:00 - 17:59	-0.1961	-0.421
27	Depart 18:00 - 18:59	-1.3392	-1.401
28	Depart 19:00 - 20:59	-1.9347	-2.024
29	Depart 21:00 - 23:59	-2.7719	-3.018
31	Duration 00:00 - 2:59	-2.215	-1.968
32	Duration 3:00 - 4:59	-1.2738	-1.206
33	Duration 5:00 - 6:59	-1.0923	-1.266
34	Duration 7:00 - 8:59	-0.0272	0.255
36	Duration 1:000 - 10:59	0.3146	0.131
37	Duration 11:00 - 11:59	-0.5924	-1.447
38	Duration 12:00 - 13:59	-2.3843	-2.505
39	Duration 14:00 - 17:59	-2.7444	-2.866
40	Duration 18:00 - 23:59	-10	-10.000
Source: SACOG, November 2008.			

Table 8-44. Non-Mandatory Tour Scheduling Model Calibrated Coefficients

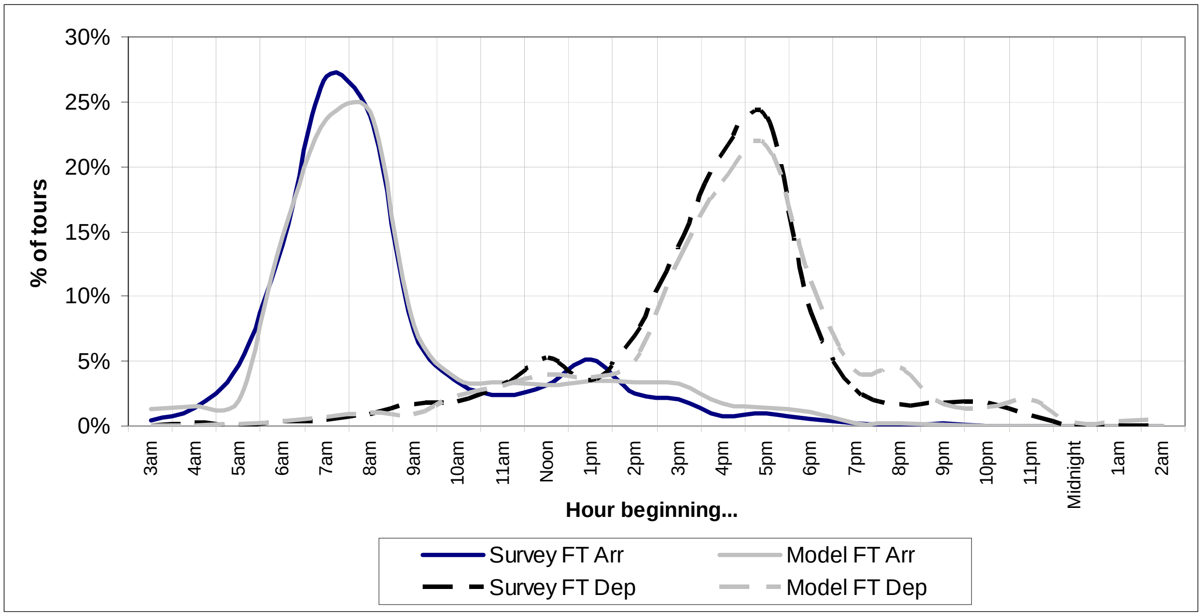
Coeff. No.	Variable Description	Est.	Calib.
11	Arrival 03:00 – 05:59	-4.1869	-4.611
12	Arrival 06:00 – 06:59	-1.9909	-2.045
13	Arrival 07:00 – 07:59	-0.76	-0.698
15	Arrival 09:00 – 09:59	-0.0294	-0.095
16	Arrival 1:000 – 12:59	0.2904	0.082
17	Arrival 13:00 – 15:59	0.5652	0.219
18	Arrival 16:00 -18:59	1.0069	0.485
19	Arrival 19:00 – 21:59	0.6179	0.819
20	Arrival 22:00 – 02:59	-1.1	-0.621
21	Depart 03:00 – 06:59	-0.2679	0.154
22	Depart 07:00 – 09:59	0.0319	-0.170
23	Depart 1:000 – 12:59	0.1363	-0.149
24	Depart 13:00 – 15:59	0.2635	0.117
26	Depart 17:00 - 17:59	-0.3129	-0.142
27	Depart 18:00 - 18:59	-0.5627	-0.197
28	Depart 19:00 - 20:59	-0.4799	-0.312
29	Depart 21:00 - 23:59	-0.741	-0.979
30	Depart 24:00 - 02:59	-2.2996	-2.741
31	Duration 00:00 - 2:59	-0.8314	-0.605
32	Duration 3:00 - 4:59	-0.1588	0.266
34	Duration 7:00 - 8:59	-0.4028	-0.362
35	Duration 9:00 - 9:59	-0.8494	-0.662
36	Duration 1:000 - 10:59	-0.815	-0.975
37	Duration 11:00 - 11:59	-0.7825	-1.065
38	Duration 12:00 - 13:59	-2.7541	-3.417
39	Duration 14:00 - 17:59	-1.6635	-2.327
40	Duration 18:00 - 23:59	-10	-11.108

Source: SACOG, November 2008.

Table 8-45. Activity Scheduling and Duration: Survey to Model Comparisons

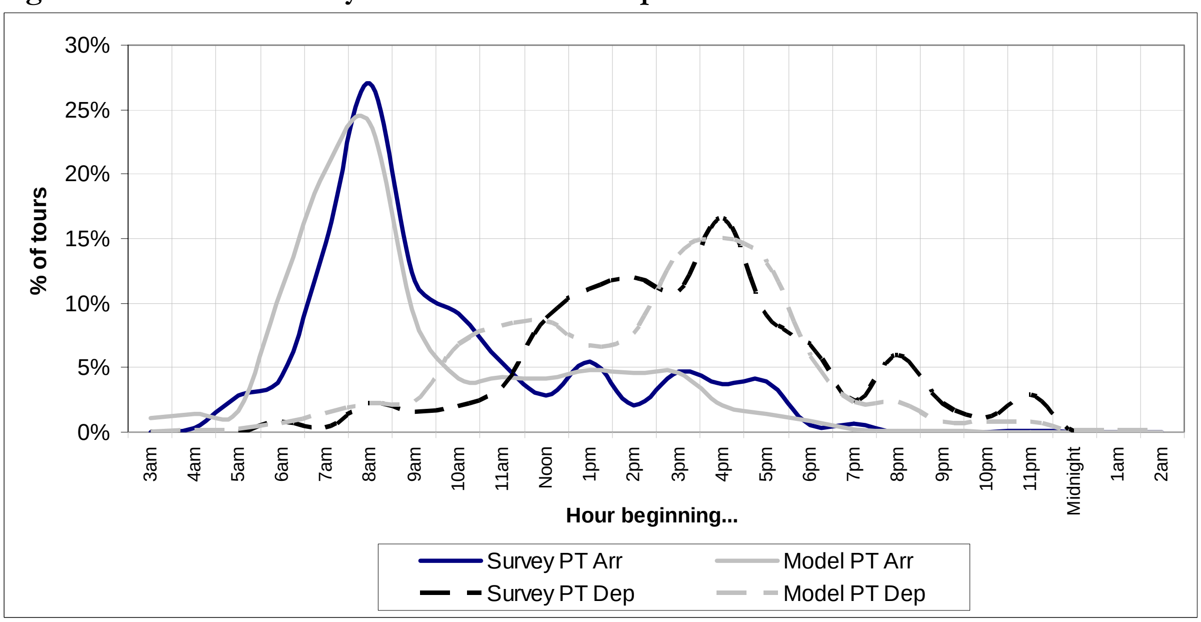
Purpose		Modal Values		% in Modal Value		Coin-cidence Ratio
		Survey	Model	Survey	Model	
Work Tours						
Full Time Workers	Arrivals	7:00-7:59am	8:00-8:59am	27%	24%	0.86
	Departures	5:00-5:59pm	5:00-5:59pm	24%	22%	0.82
	Activity Duration	9 hours	9 hours	29%	24%	0.75
Part Time Workers	Arrivals	8:00-8:59am	8:00-8:59am	27%	24%	0.60
	Departures	4:00-4:59pm	4:00-4:59pm	17%	15%	0.68
	Activity Duration	4 hours	8 hours	12%	13%	0.74
School Tours						
All Students	Arrivals	8:00-8:59am	7:00-7:59am	39%	39%	0.95
	Departures	3:00-3:59pm	2:00-2:59pm	32%	27%	0.74
	Activity Duration	7 hours	7 hours	38%	27%	0.69
All Other Tours						
All Person Types	Arrivals	6:00-6:59pm	6:00-6:59pm	9%	8%	0.86
	Departures	3:00-3:59pm	8:00-8:59pm	9%	9%	0.84
	Activity Duration	<1/2 hour	<1/2 hour	43%	40%	0.95
Source: SACOG, November 2008.						

Figure 8-28. Work Activity Tour Arrival and Departure Times: Full Time Workers



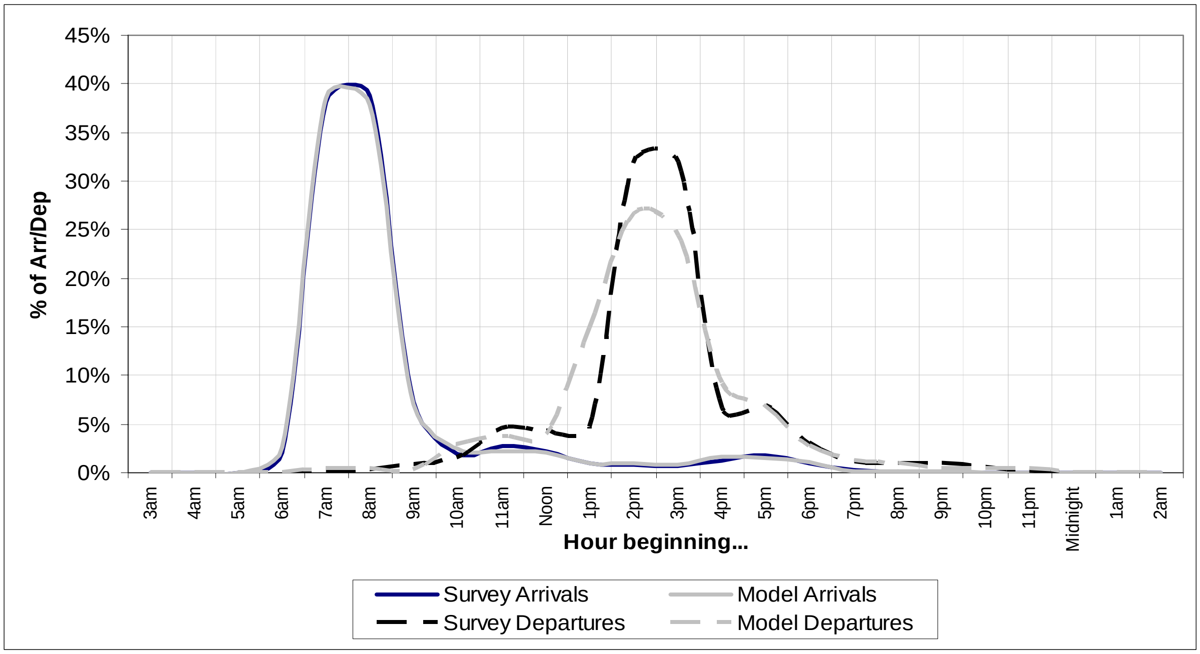
Source: SACOG, November 2008.

Figure 8-29. Work Activity Tour Arrival and Departure Times: Part Time Workers



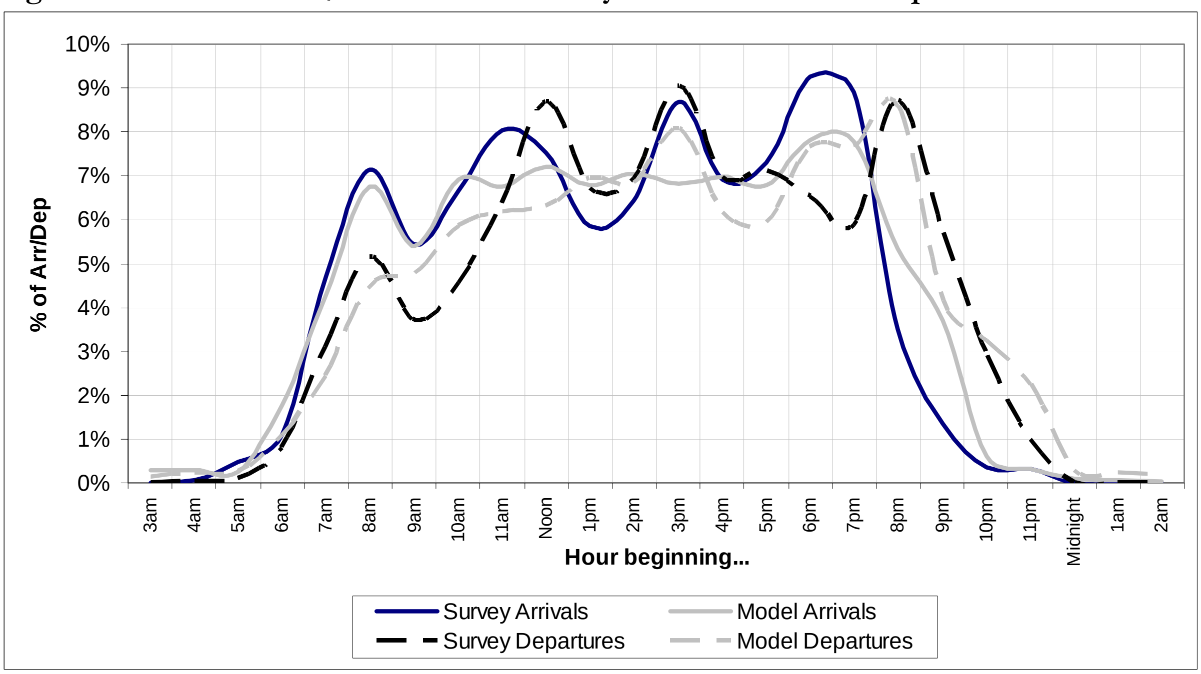
Source: SACOG, November 2008.

Figure 8-30. School Activity Tour Arrivals and Departure Times



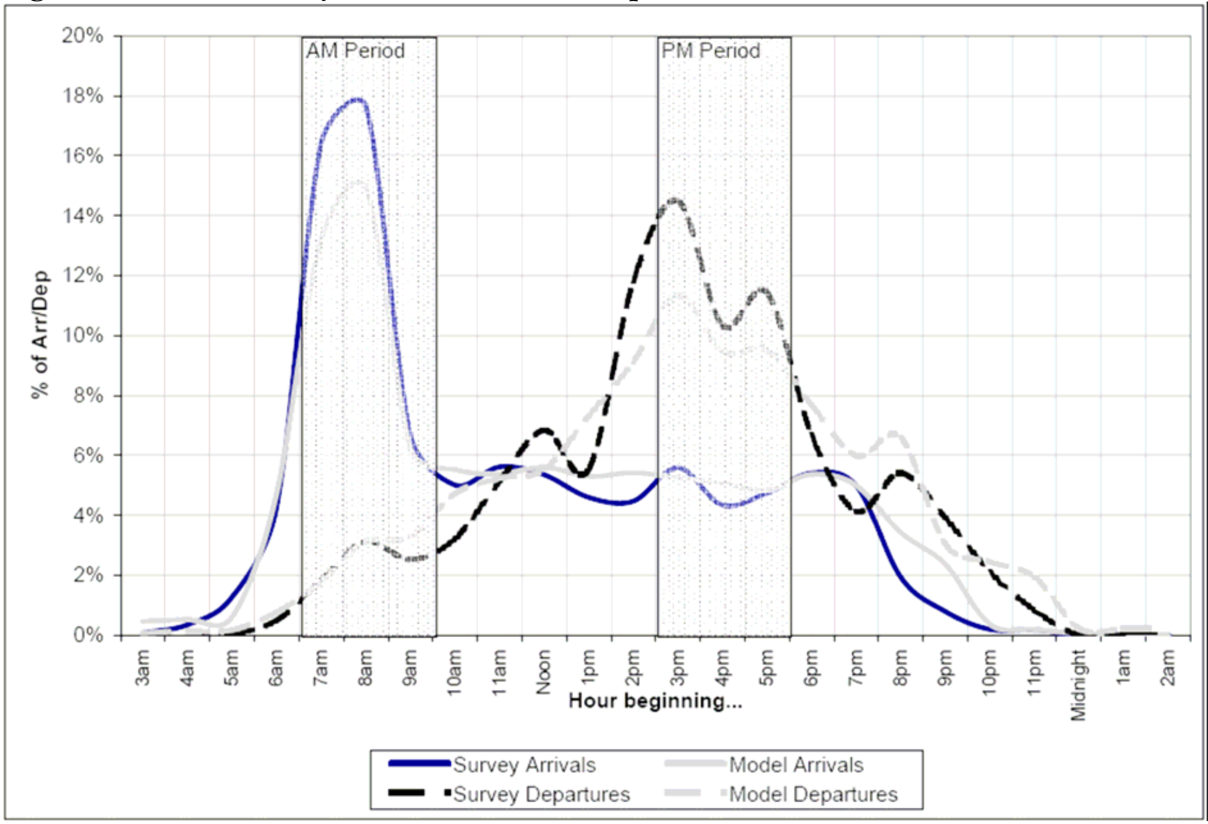
Source: SACOG, November 2008.

Figure 8-31. Non-Work/Non-School Activity Tour Arrivals and Departure Times



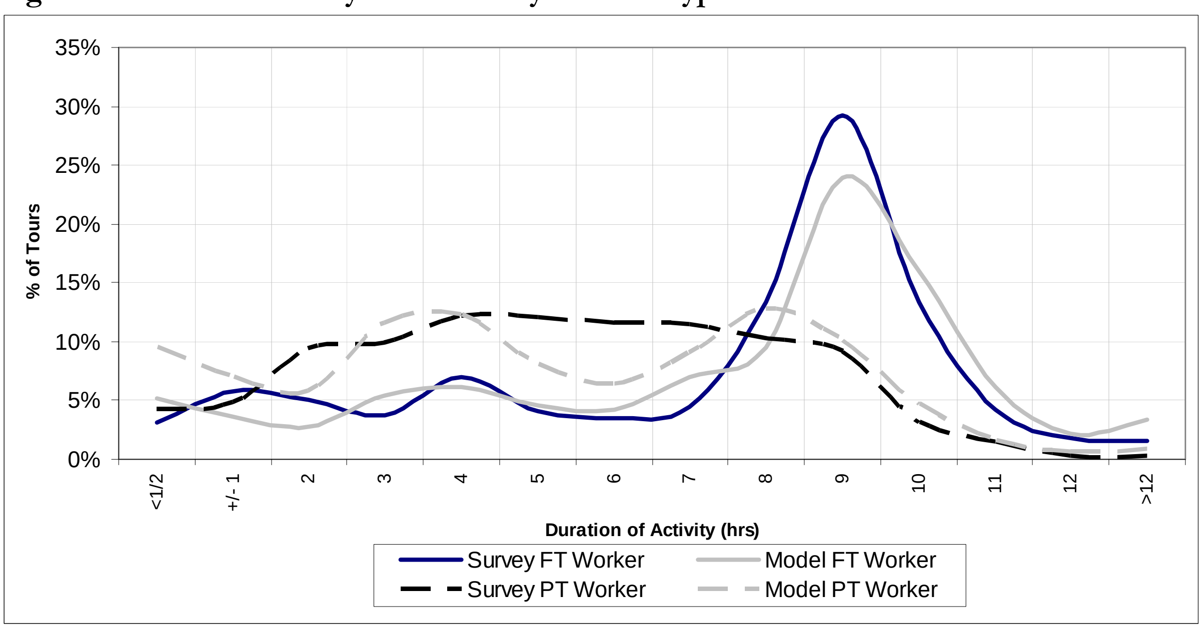
Source: SACOG, November 2008.

Figure 8-32. All Activity Tour Arrivals and Departure Times



Source: SACOG, November 2008.

Figure 8-33. Work Activity Durations by Worker Type



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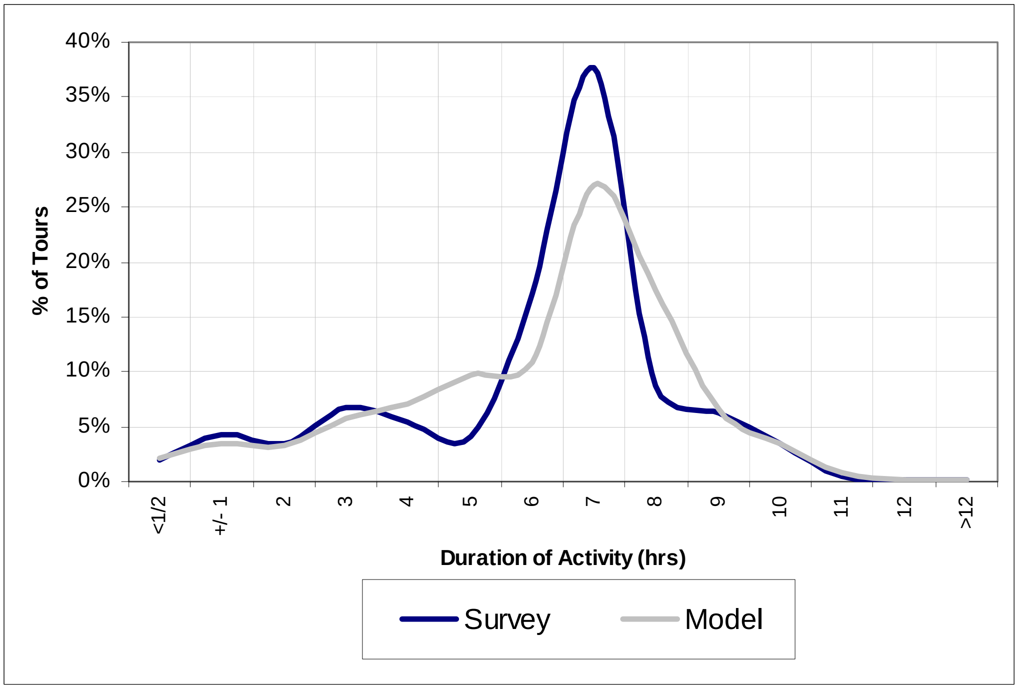
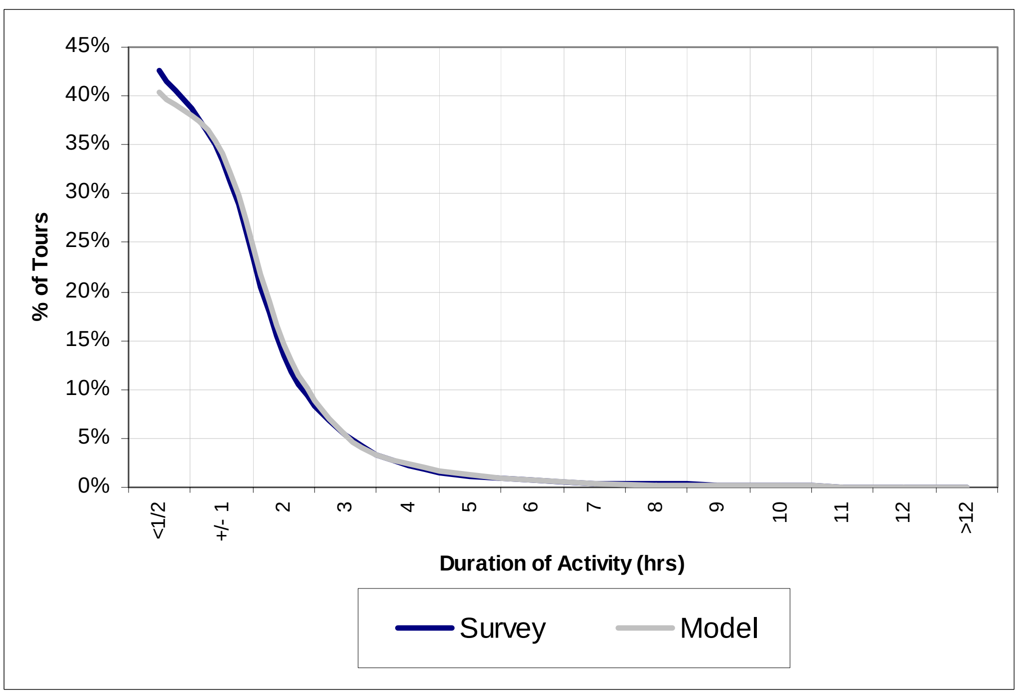
Source: SACOG, November 2008.

Figure 8-34. School Activity Durations



Source: SACOG, November 2008.

Figure 8-35. Non-Work/Non-School Activity Durations



Source: SACOG, November 2008.

Number and Purpose of Intermediate Stops Submodel

<<tba—discussion on model logic>>

<<tba—discussion on estimation results>>

<<tba—discussion on calibration approach>>

<<tba—validation/reasonableness checking>>

Destination of Intermediate Stop Submodel

<<tba—discussion on model logic>>

<<tba—discussion on estimation results>>

<<tba—discussion on calibration approach>>

<<tba—validation/reasonableness checking>>

Trip Mode Submodel

<<tba—discussion on model logic>>

<<tba—discussion on estimation results>>

<<tba—discussion on calibration approach>>

<<tba—validation/reasonableness checking>>

Activity and Trip Scheduling Submodel

<<tba—discussion on model logic>>

<<tba—discussion on estimation results>>

<<tba—discussion on calibration approach>>

<<tba—validation/reasonableness checking>>

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Airport Passenger Ground Access Models

The airport passenger ground access model is actually 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[22]. Figure 8-36 illustrates the major model components and flow.

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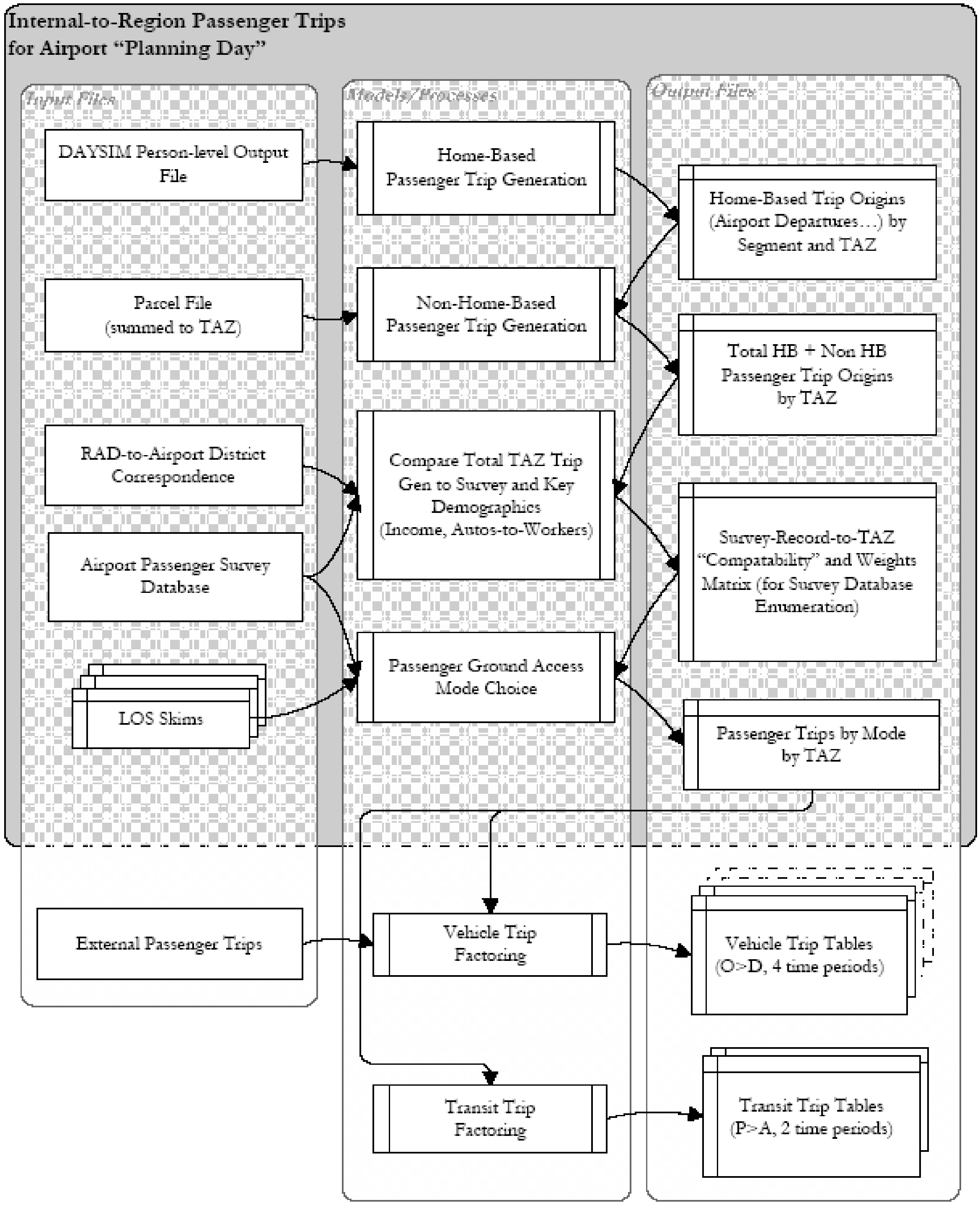
[22] PB Aviation, "Sacramento International Airport Master Plan Study", March 8, 2001.

Figure 8-36. Airport Passenger Ground Access Model



Source: SACOG, November 2008, based on work by DKS Associates.

Trip Generation for Internal Passengers

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. The aggregate airport trip generation rates used in this application were:

Home-based trips: 0.007 per household;

Non-home-based trips: 0.003 per non-retail employee, except the Downtown Sacramento RAD, with 0.010 per non-retail employee.

This application uses the same trip generation factors for non-home-based trips. But for home-based trips, trip generation methods accounting for zonal demographics were compared.

Table 8-46 compares the regional distribution of Year 2000 household size (number of persons) to the weighted distribution of household size of home-based trip survey respondents (499 cases). The implied trip generation rates are computed as the overall average rate times the ratio of the category's survey distribution percentage to the regional distribution. One-person households are relatively less frequent in the survey than in the region, implying a less-than-average trip generation rate; two- and three-person households are slightly more frequent, implying an above-average rate, while the rate goes back down to average for four-or-more-person households.

Table 8-46. Home-Based Airport Trip Generation based on Persons per Household

Persons per Household	Regional Distribution	Airport Passenger Survey (HB) Distribution	Implied Trip Generation Rate per Household
1	25%	17%	0.0056
2	33%	36%	0.0079
3	16%	21%	0.0088
4+	27%	26%	0.0073
Source: SACOG, November 2008, based on draft documentation provided by DKS Associtiates.			

Table 8-47 makes a similar comparison based on autos owned in the household. The difference in distributions is quite distinct, implying a sharply increasing relationship of more trips from households with more autos. There is wide uncertainty, however, with the zero-auto category, having only 6 survey records.

Table 8-47. Home-Based Airport Trip Generation based on Autos in Household

Autos in Household	Regional Distribution	Survey (HB) Distribution	Implied Trip Generation Rate per Household
0	8%	1%	0.0013
1	34%	20%	0.0049
2	40%	42%	0.0077
3+	18%	36%	0.0121
Source: SACOG, November 2008, based on draft documentation provided by DKS Associtiates.			

Table 8-48 makes a comparison likewise on household income categories. There were 437 survey cases reporting an identifiable income category. A relationship is clearly discerned of increasing airport trip frequency with increasing income.

Table 8-48. Home-Based Airport Trip Generation based on Household Income

Household Income	Regional Distribution (Approx.)	Survey (HB) Distribution	Implied Trip Generation Rate per Household
Under $15k	15%	5%	0.0030
$15 to 35k	30%	11%	0.0034
$35 to 50k	10%	15%	0.0066
$50k to 75k	20%	22%	0.0078
$75k or more	25%	47%	0.0135
Source: SACOG, November 2008, based on draft documentation provided by DKS Associtiates.			

The rates based on household income categories are the tentative home-based trip generation model. But in the SACMET model's income categories, the second boundary ($35k) may be actually closer to $25k, so the second rate may be lowered and the third raised slightly.

This application of the airport model directly uses households simulated by DAYSIM. Each household's number of persons, vehicles, and income is taken from person number 1's simulation output. 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.

Enumertion 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 fanother 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, implemented in the TP+ Fratar program. 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*.)

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 8-49 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 8-49. Airport Ground Access Mode Choice Logit Model Coefficients

Coeff No.	Variable	Passenger Market 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 Egeress 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, 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.

External Passenger Trips

Based on prior passenger surveys, SACOG estimated that approximately 40 percent of total passengers travel to the airport from origins outside the SACOG region. Airport passenger trip origins were added to the external trip file to represent these passengers. Ground access mode choice was limited to automobile and shuttle modes, using the following assumptions: drive-park or return rental car (50%); dropped-off (45%); shuttle/van (5%).

Airport Passenger Time-of-Travel and Trip Factoring

Airport passenger trips were allocated to assignable trip matrices using times of commercial airplaine arrival and departure time distributions (see Table 8-50). Conversion of passenger trips to vehicle trips is discussed in detail in Chapter 10.

Table 8-50. Weekday Airline Departures and Arrivals at Sacramento International Airport

Adjusted Hour	Number of Flights		
	Depart	Arrive	Total
Midnite-5:59 AM	1	2	2
6:00-6:59 AM	1	18	19
7:00-7:59 AM	10	8	18
8:00-8:59 AM	16	18	34
9:00-9:59 AM	12	12	24
10:00-10:59 AM	12	13	25
11:00-11:59 AM	10	4	14
Noon-12:59 PM	9	16	25
1:00-1:59 PM	8	10	18
2:00-2:59 PM	7	9	16
3:00-3:59 PM	8	3	11
4:00-4:59 PM	9	9	18
5:00-5:59 PM	10	12	22
6:00-6:59 PM	8	9	17
7:00-7:59 PM	11	8	19
8:00-11:59 PM	39	20	59
Grand Total	171	171	342

Source: SACOG, November 2008.
Based projected operations for Year 2005 in PB Aviation, "Sacramento International Airport Master Plan Study", March 8, 2001.

Table 8-51. Time-Of-Travel Factors for Sacramento Air Passenger Ground Access Trips

SACSIM Travel Period	Number of Flights			Percent of Flights		
	Depart	Arrive	Total	Depart	Arrive	Total
AM	27	26	53	8%	8%	15%
Mid-Day	51	63	114	15%	18%	33%
PM	24	22	46	7%	6%	13%
Evening	69	60	129	20%	18%	38%
Grand Total	171	171	342	50%	50%	100%

Source: SACOG, November 2008.
Based projected operations for Year 2005 in PB Aviation, "Sacramento International Airport Master Plan Study", March 8, 2001.

Airport Model Reasonable-ness Checking and Validation

Table 8-52. Airport Passenger Ground Access Mode Choice: Model to Survey Comparison

Mode/Mode Combination	2002 Survey		1999 Survey	Model	
	#	%	%	#	%
Auto Drop-Offf	327	42%	n/a	3,426	45%
Drive-and-Park (Residents)	244	31%	n/a	n/a	n/a
Combined Auto Drop+Drive/Park[1]	571	73%	73%	n/a	n/a
Return Rental Car (Visitors)	131	17%	18%	n/a	n/a
Combined Drive/Park +Return Rental[2]	375	48%	n/a	3,669	48%
All Auto Modes	702	90%	91%	7,094	93%
Taxi	30	4%	2%	141	2%
Van Shuttle	43	6%	6%	365	5%
Transit (Walk Access)	0	0%	0%	0	0%
Transit (Drive Access)	0	0%	0%	1	0%
Transit (Drop Off)	0	0%	0%	3	0%
Combined Transit	2	0%	1%	3	0%
Totals	777	100%	100%	7,604	100%

Source: SACOG, November 2008.
Shaded are comparable cells.
[1] 1999 passenger survey did not report "auto drop-off" and "drive-and-park" separately. This combined subtotal shown to allow comparison between 1999 and 2002 surveys.
[2] Air passenger ground access model combines "drive-and-park" and "return rental car" modes. This combined subtotal shown to allow comparison between 2002 survey and model estimate.

Commercial Vehicle Travel

The commercial vehicle trip generation and distribution models were adapted directly from the current SACMET four-step, trip-based model system. These models create trip matrices in two trip categories: 2 axle commercial vehicle trips, and 3+ axle commercial vehicle trips.

Commercial vehicle trip rates for SACMET are based on surveys of commercial vehicles in the Sacramento region[23], and surveys of commercial vehicle trip generation from the San Francisco Bay Area. Trip rates are shown in Table 8-53. 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*[24]. For 2-axle trucks, the old SACMET all-commercial vehicle friction factors, derived from the Chicago Area Transportation Study factors, which compared reasonably well with the available local data, were retained for use in SACSIM. Friction factors are shown in Figure 8-37. Trip distribution was calculated using congested midday travel times, using a simple gravity model. The resulting trip length distribution for both types of commercial vehicle trips are shown in Figure 8-38. Trip lengths for 3+ axle commercial vehicles are significantly longer than those for 2 axle commercial vehicles. Table 8-54 provides additional comparisons of the trip lengths for the two types of trips: median travel times for 3+ axle trips is 2.5 times that of 2 axle trips (49.4 minutes, compared to 20.0 minutes); and a far higher percentage of 3+ axle commercial vehicle trips travel to or from points outside the SACOG region (28 percent, compared to 2 percent).

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 8-55 shows the time-of-travel factors used.

<u>Reasonable-ness of the Commercial Vehicle Sub-Model</u>

So little robust data are available, either locally or statewide, on commercial vehicle travel that strong statements on the reasonable-ness of the model are impossible to make. In general, the trip generation, distribution, and time-of-travel factors are consistent with models in other areas, where comparisons can be drawn.

The "lumpiness" of the trip length distribution for 3+ axle commercial vehicle trips is fundamentally related to the high percentage of these trips which go to or from points outside the SACOG region. For purposed of trip distribution, single-point estimates of trip times from the gateways to final origins or destinations outside the region are coded. These times, combined with the high percentage of 3+ axle trips which travel to or from the model gateways, result in the odd trip length distributions. In fact, it is impossible to model the actual distribution of trip lengths for 3+ axle commercial vehicle trips outside the region, since this category includes everything from a relatively small "bobtail" truck, plying from a warehouse in a nearby

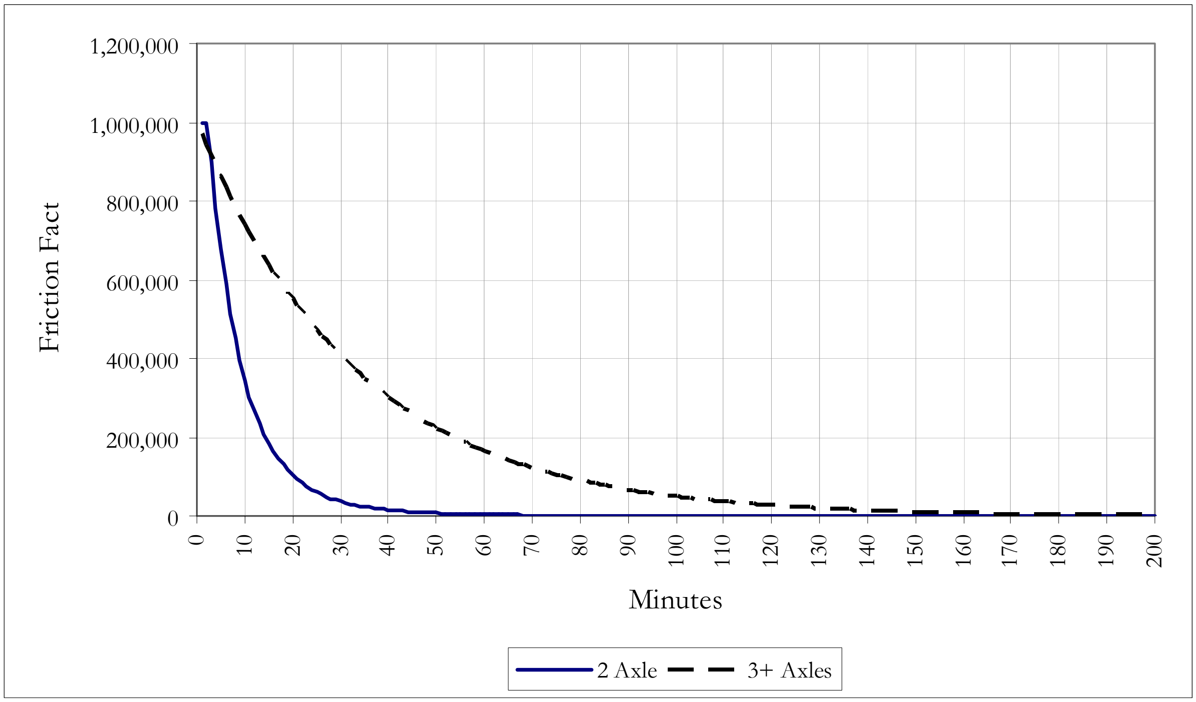
[23] SACOG, "Commercial Vehicle Activity Survey Report: Phase One Project Report", July 23, 1998.
[24] FHWA (by Cambridge Systematics), "Quick Response Freight Manual", September 1996.

city like Stockton or Dixon, and delivering to a store in the SACOG region, to a large, 80,000-pound GVWR tractor-trailer taking locally produced goods to a distribution center across the country. The relative trip lengths are shown to demonstrate

Table 8-53. Commercial Vehicle Trip Rates

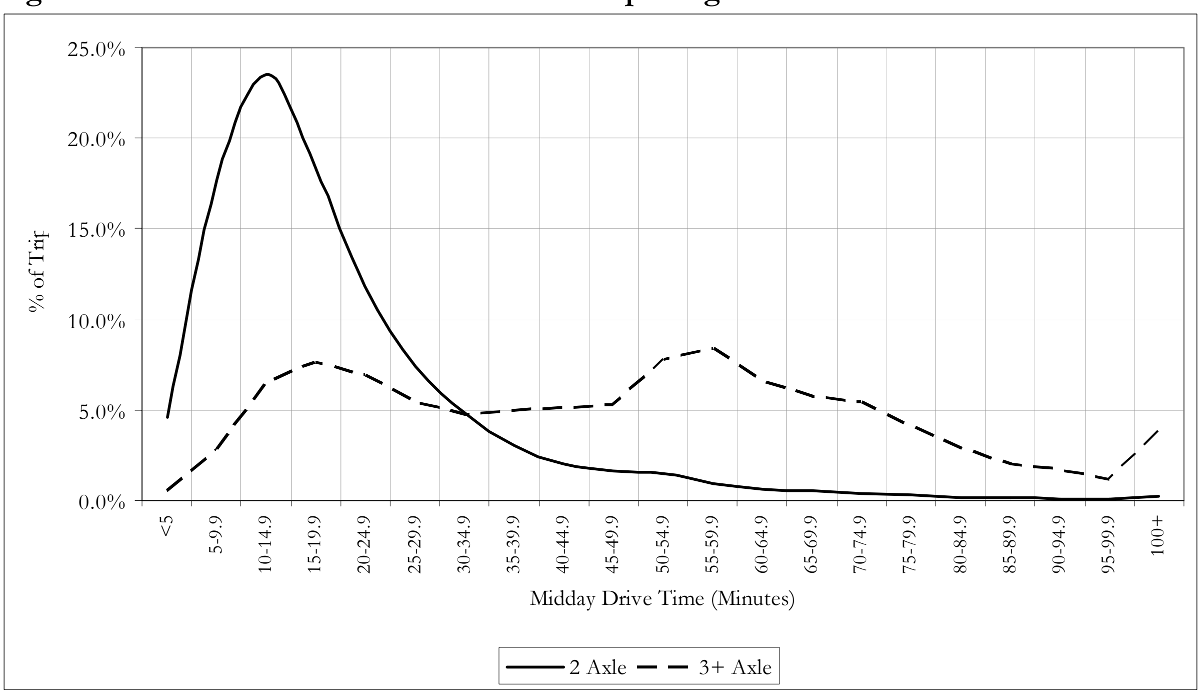
Variable	2-Axles	3+ Axles
Household		
Single Family	0.28	0.003
MF 2-4	0.23	0.003
MF 5+	0.17	0.003
Employment		
Retail	0.68	0.045
Office	0.4	0.057
Medical	0.4	0.057
Education	0.4	0.057
Manufacture/Other	0.4	0.11

Figure 8-37. SACSIM Commercial Vehicle Friction Factors



Source: SACOG, November 2008.

Figure 8-38. SACSIM Commercial Vehicle Trip Length Distribution



Source: SACOG, November 2008.

Table 8-54. Other Commercial Vehicle Trip Length Indictators

Trip Length Indicator	2 Axles	3+ Axles
Mean Travel Time (Minutes)	20.0	49.4
Median Travel Time Range (Minutes)	10-14.9	40-44.9
90th %-Tile Time Range (Minutes)	30-34.9	75-79.9
% Trips to/from Gateways	2.3%	28.1%

Source: SACOG, November 2008.

Table 8-55. SACSIM Commercial Vehicle Times-of-Travel

SACSIM Time Period	2 Axle	3+ Axle
AM Period (3 Hours)	23%	30%
Midday (5 Hours)	41%	33%
PM Period (3 Hours)	14%	9%
Evening/Early AM (13 Hours)	22%	28%
Total	100%	100%

Source: SACOG, November 2008.

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 zone (not parcel) level.

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

- *Gateways*--TAZ's representing the areas outside of the SACOG region, connected to highways exiting or entering the region are called "gateways". Typically each exiting highway is represented as a gateway TAZ, but some groups of highways that converge to practically the same external place share a single TAZ. Table 8-56 lists the SACSIM gateways.
- *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, again, 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-exongenous", 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 us wholly exogenous, with no real relevance to any internal travel activity, outside of vehicle trip assignment, where the impact of through trips on capacity affect the level-of-service for internally modeled trips, and I-X and X-I trips.

Table 8-56. SACSIM Gateways

TAZ No.	Gateway Roadway	Segment	Gateway Represents…	Gateway Travel Time
1	SR-99 N	Sutter-Butte CL	Chico/Butte Co., via SR 99	5
2	SR-70 N	Yuba-Butte CL	Chico/Butte Co., via SR 70	5
3	E20/Marysville Rd NE	W. of SR 49/Yuba-Nevada CL	Nevada Co., via Marysville Rd.	10
4	SR-20 NE	Yuba-Nevada CL	Nevada Co., via SR 20 (from Yuba Co.)	5
5	SR-49 NE	Placer-Nevada CL	Nevada Co., via SR 49 (from Placer Co.)	17
6	I-80 NE	E. of Yuba Gap	North Lake Tahoe Basin to east of region, via I-80	28
7	SR 174 NE	Placer-Nevada CL	Nevada Co., via SR 174 (from Colfax)	15
8	SR 20 NE	Placer-Nevada CL	Nevada Co., via SR 20 (from Placer Co.)	30
9	Omo Ranch Road E	N. of SR-88	Amador Co., via Omo Ranch Rd (from South Central El Dorado Co.	30
10	US-50 E	Btwn. Ice House Rd & Echo Lake	South Lake Tahoe Basin, via US50	10
13	SR 16, 49 East	Sacramento-Amador CL	Amador Co., via SR 16 and 49	5
15	SR-99 S	Sacramento-San Joaquin CL	San Joaquin Co. and Central Valley, via SR 99	13
16	Lincoln Road S	Sacramento-San Joaquin CL	San Joaquin Co., via Lincoln Rd.	7
17	Franklin Road S	Sacramento-San Joaquin CL	San Joaquin Co., via Franklin Rd.	1.5
18	I-5 S	Sacramento-San Joaquin CL	San Joaquin Co. and Central Valley, via I-5	28
19	SR-160 S	S. of SR-12	E.Solano Co., N.Contra Costa Co., N.San Joaquin Co.	10
20	CR-95A	Yolo-Solano CL	N.Solano Co.	15
21	CR-104/Mace Blvd. SW	S. of CR-32D/Montgomery	N.Solano Co.	6
22	I-80 W./I-505 S.	W. of I-505	Solano Co. and Greater SF Bay Area	15
23	SR-128 W	Yolo-Solano CL	Solano and Napa Counties	25
24	Putah Creek Rd. W	W. of Winters Rd. Bridge	N.Solano Co.	15
25	SR-12 SE	E. of SR-160	NW.San Joaquin Co.	20
26	SR-12 SW	W. of SR-160	E.Solano Co.	18
27	SR 16	Yolo-Colusa CL	Colusa and Lake Co.	20
28	I-5 N	Yolo-Colusa CL	Colusa Co. and N.Sacramento Valley, Redding etc. via I-5	30
29	SR 45	Sutter-Colusa CL	Colusa Co.	10
30	SR-20 NW	Sutter-Colusa CL	Colusa Co. and N.Sacramento Valley, Redding etc., via SR 20	10

Source: SACOG, November 2008.

Trip Generation for I-X and X-I Travel

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

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

Tables 8-57 and 8-58 provide the exogenously set worker flow, home-based non-work and commercial vehicle trip ends, and airport passengers for external gateway zones. The worker flows, home-based non-work and commercial vehicle trips were adapted from the SACMET07 external trip file. The SACMET07 file, in turn, was generated 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 8-57 SACSIM External Gateway Worker Flows and Home-Based Non-Work Trip Ends

Gate-way No.	Gateway Desc.	Worker Flows		Pers.Bus. Trip Ends		Shop Trip Ends		Soc./Rec. Trip Ends	
		X-I	I-X	X-I (P's)	I-X (A's)	X-I (P's)	I-X (A's)	X-I (P's)	I-X (A's)
1	SR-99 N	1,347	664	2,548	1,536	4,016	724	3,822	1,024
2	SR-70 N	1,102	543	2,042	2,845	3,214	481	3,063	1,897
3	E20/Marysville Rd NE	0	0	214	298	336	49	321	199
4	SR-20 NE	0	0	990	1,378	1,561	235	1,486	919
5	SR-49 NE	5,872	2,038	2,826	3,942	4,450	1,166	4,239	2,628
6	I-80 NE	457	906	1,844	4,201	2,904	2,114	2,766	9,802
7	SR 174 NE	653	226	663	906	1,045	270	995	604
8	SR 20 NE	0	0	659	423	1,008	249	989	987
9	Omo Ranch Road E	0	0	196	367	305	87	293	245
10	US-50 E	75	178	867	2,635	1,369	1,374	1,300	6,148
13	SR 16, 49 East	1,417	894	1,334	1,860	2,102	649	2,001	2,790
15	SR-99 S	3,518	4,430	5,226	10,017	8,232	4,325	7,839	6,678
16	Lincoln Road S	352	443	496	761	784	327	745	507
17	Franklin Road S	0	0	182	282	285	123	273	188
18	I-5 S	2,462	3,101	3,054	6,278	4,813	2,712	4,581	4,185
19	SR-160 S	704	886	623	1,152	983	297	935	768
20	CR-95A	0	0	101	173	159	43	151	116
21	CR-104/Mace Blvd. SW	0	0	373	645	591	165	559	430
22	I-80 W	9,270	13,323	17,374	18,436	7,200	7,150	26,061	27,654
23	SR-128 W	0	0	397	497	628	194	596	745
24	Putah Creek Rd. W	0	0	0	0	0	0	0	0
25	SR-12 SE	0	0	70	118	111	51	106	79
26	SR-12 SW	189	272	223	436	351	114	334	290
27	SR 16	0	0	160	105	249	0	240	157
28	I-5 N	765	700	1,963	1,274	3,093	0	2,944	1,912
29	SR 45	0	0	104	103	163	0	156	69
30	SR-20 NW	16	14	1,143	688	1,803	328	1,715	459

Source: SACOG, November 2008, based on draft documentation provided by DKS Associtiates.

Table 8-58. External Gateway Commercial Vehicle Trip Ends and Airport Passengers

Gate-way No.	Gateway Desc.	Commercial Vehicle Trip Ends		External Airport Passengers[1]
		2 Axle	3+ Axle	
1	SR-99 N	1,347	664	267
2	SR-70 N	1,102	543	215
3	E20/Marysville Rd NE	0	0	16
4	SR-20 NE	0	0	76
5	SR-49 NE	5,872	2,038	526
6	I-80 NE	457	906	166
7	SR 174 NE	653	226	85
8	SR 20 NE	0	0	51
9	Omo Ranch Road E	0	0	15
10	US-50 E	75	178	71
13	SR 16, 49 East	1,417	894	177
15	SR-99 S	3,518	4,430	587
16	Lincoln Road S	352	443	57
17	Franklin Road S	0	0	14
18	I-5 S	2,462	3,101	365
19	SR-160 S	704	886	85
20	CR-95A	0	0	8
21	CR-104/Mace Blvd. SW	0	0	29
22	I-80 W	9,270	13,323	1,826
23	SR-128 W	0	0	31
24	Putah Creek Rd. W	0	0	0
25	SR-12 SE	0	0	5
26	SR-12 SW	189	272	27
27	SR 16	0	0	12
28	I-5 N	765	700	191
29	SR 45	0	0	8
30	SR-20 NW	16	14	89

Source: SACOG, November 2008, based on draft documentation provided by DKS Associtiates.
[1] Assumes 40% of total passenger origins at airport are external to the SACOG region, with distribution of passengers to gateways based on the combined percentage of work, personal business and social recreational X-I trip ends.

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 Tables 8-57 and 8-58.

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, in Table 6 of Technical Memo 8, Usual Location and Tour Destination Models. 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.

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 8-59. 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

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.

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.

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.

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) thus:

Table 8-60. 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, November 2008.
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 Associtiates.

Table 8-61. 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, November 2008.
Based on draft documentation provided by DKS Associtiates.

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, since all external passenger trips to to or from the airport.

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 8-62.

Time-of-travel for I-X and X-I trips were also allocated to the four time periods using fixed factors. Table 8-63 shows the factors used.

Table 8-62. 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, November 2008.
[1] Based on 2000 SACOG Household Survey data, adapted to SACSIM external trip purposed by DKS Associates.
[2] Based on 2002 airport passenger survey, adapted to external passengers by SACOG.

Table 8-63. Time-of-Travel for I-X and X-I Travel

Purpose	Demand Time Period								
	AM 3-Hour		Midday 5-Hours		PM 3-Hours		Evening 13-Hours		
	P>A	A>P	P>A	A>P	P>A	A>P	P>A	A>P	Total
Work	29.5%	1.8%	10.1%	9.8%	3.0%	28.0%	7.4%	10.4%	100.0%
Pers.Bus.	8.8%	3.7%	26.4%	22.6%	9.2%	14.5%	5.6%	9.2%	100.0%
Shop	2.8%	2.7%	23.1%	21.7%	16.1%	15.8%	8.0%	9.8%	100.0%
Soc./Rec.	6.0%	2.9%	17.3%	14.9%	12.7%	9.7%	14.0%	22.5%	100.0%
Airport	10.0%	5.0%	16.0%	16.0%	6.0%	9.0%	18.0%	20.0%	100.0%

Source: SACOG, November 2008.
[1] Based on 2000 SACOG Household Survey data, adapted to SACSIM external trip purposed by DKS Associates.
[2] Based on 2005 airline operations, adapted to external passengers by SACOG.

Treatment of Through Travel

Through trips are a completely exongenous model input, which are read in directly from a prepared through trips file. SACSIM through trips and times-of-travel were taken from SACMET07 files.

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

The assignment to highway networks is made for four demand periods (AM peak, midday, PM peak, and late evening/early morning) using a conventional, TAZ-to-TAZ, origin-destination, static equilibrium assignment using Citilabs® TP+/HWYLOAD software.

Transit passenger trips are assigned using Citilabs® TP+/TRNBLD software, which requires P-to-A formatted trips. Two demand periods are assigned: combined AM and PM peak periods, and combined midday and late evening/early morning periods.

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.

Time periods based on the SACOG 2000 Household Travel Survey and diurnal patterns of traffic counts in the region. In fact, travel demand and observed traffic volumes peak at different times in different areas, and the demand periods defined here are necessary simplifications required to do the static equilibrium traffic assignments used in SACSIM. These are shown in Table 9-1. For purposes of comparison to traffic counts, the travel times based on 15-minute break points from the household travel survey were generalized to the nearest hour of clock time, in part for simplicity and in part to establish unit-hour period durations for the entire day. The two peak periods each cover three hour periods. The midday period is five hours, and the late evening/early morning period is thirteen hours.

Table 9-1. SACSIM Demand Period Definition

Time Period	Survey Trip Midpoint Times		Nominal Times for Defining Peak		
	Begin	End	Begin	End	Hours
AM Peak	6:45	9:44	7:00	9:59	3
Mid-Day	9:45	14:44	10:00	14:59	5
PM Peak	14:45	17:44	15:00	17:59	3
Late Evening/ Early Morning	17:45	6:29	18:00	6:59	13

DAYSIM Person Trip Segments

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

Auto person-trips are already stratified by occupancy (drive alone, 2 person shared ride, and 3+ person shared ride), and 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).

In the DAYSIM trip output file, transit person-trips are distinguished by walk-access and drive-access, and the drive-access trips are distinguished by direction (drive-transit-walk versus walk-transit-drive). The transit drive-access trips from DAYSIM are generated in O-to-D format, without explicit reference to the location of the transition the between transit and auto. The O-to-D person trips were split and converted to P-to-A format, then split into the two transit service periods (AM + PM periods combined for peak transit demand, and midday + late evening periods combined for off-peak transit demand).

A simple park-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.

External Trips

The external models create partial matrices of daily person-trips between the gateways and the internal zones in P-to-A format. These are converted to vehicle trips split by occupancy and time of day to be included in the vehicle trip assignments. The auto mode split, directionality, and time-of-travel factors were presented in Chapter 8. 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.

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 Chapter 8. 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 Chapter 8.

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 Chapter 8 were used to split the vehicle trips into the four demand periods for highway assignment. Transit passenger trips were converted to P-to-A format and split into the two transit demand periods (peak and off-peak) for assignment with the other transit passenger trips. Transit-drive access airport passenger trips are split into the drive portion (e.g. from home to park-and-ride, or from park-and-ride to home), and the transit portion in the same manner as non-airport transit-drive access trips, which will be discussed in greater detail below.

Auto Assignment

Auto assignment in this model system uses a standard deterministic user equilibrium algorithm which iterates the Dijkstra tree-building algorithm for paths and a form of Frank-Wolfe 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 auto 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. The classes are (1) single-occupant vehicles, including commercial vehicles, (2) a portion of the multi-occupant vehicles designated to have all HOV facilities available, and (3) the remainder of the multi-occupant vehicles that are kept off from freeway HOV lanes but allowed though ramp meter bypass lanes.

Controls for the equilibrium assignment are set to maximum 40 iterations, with relative gap closure of 0.0002.

One of the most efficient procedures for the full SACSIM system equilibrium solution is to apply the method of successive averages (MSA) to the assigned volumes. In this method, only the new iteration vehicle trips are assigned; the previous solution volumes are kept but downscaled. During the *n*th iteration of a MSA cycle, the new solution volume equals the previous iteration volume times $(n-1)/n$ taken as a preloading, plus an assignment of the new iteration vehicle trips times $1/n$. The assignment's (conditional) equilibrium calculations account for this preloading and scaling: in effect, the iteration trips being assigned are allowed to change routes until optimal, accounting for preloaded traffic, although the preloaded traffic does not have this route-change choice.

Congestion Delay Functions

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

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

Where:

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

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

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

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

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

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

T_C =congested travel time
T_O =”free flow” travel time
L= VC ratio factor, adjusted so that TC=+/- 1.5 when VC=1.0
$\max(T_C) = M + N(VC)$

Table 9-2 reports the variable values utilized for SACSIM. The A and B values were calibrated to 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 (thus meeting a necessary condition for unique solution). Table 9-3 provides a comparison of the current speed-flow functions.

Table 9-2. 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	Maximum coeff.
Freeway	6	1.1	0.9	0.88	11	0.0002
2 Lane Transitional Arterial	8.52	1.07	0.93	0.92	11	0.0002
Other Arterial	6.44	1.09	0.91	0.89	7	0.0002

Source: SACOG, November 2008.

Table 9-3. Range of Congestion Factor Calculations

Class of Roadway	Congestion Factor				Max TF	Max. @ VC=…
	@VC=0	@VC=0.85	@VC=1.0	@VC=2.0		
Freeway	1.00	1.26	1.49	10.26	11+	2.20
2 Lane Trans. Art.	1.00	1.21	1.52	11.00	11+	1.80
Urb./Suburb. Art.	1.00	1.25	1.50	7.00	7+	1.70
Source: SACOG, November 2008.						

Traffic Flow Intensity Factors

The four time periods of traffic assignment depend on vehicle trip tables factored by the directional time-of-day factors in Table 41. 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:

$$\text{Avg Intensity} = \frac{\text{SUM}_{\text{15 min increments in period}}(\text{VMT})^2}{(\text{SUM}_{\text{15 min increments in period}}(\text{VMT}))^2} \times 4$$

Table 9-4 lists the traffic intensity factors thus computed for those time periods. Average intensities were also computed for the peak hours, but it was suspected that the data were subject to sample size and reporting-error problems. Therefore a "time-mean" was applied to both peak hours.

Table 9-4 Traffic Flow Intensity Factors

Period	Computed Flow Intensity Factors--2000 HH Survey	Factors Applied in SACSIM
AM 3-hour	0.35	0.36
Midday	0.20	0.20
PM 3-hour	0.34	0.36
Evening	0.16	0.16
Off-Peak	0.10	n/a
AM Peak Hour	n/a	1.00
PM Peak Hour	n/a	1.00
Source: SACOG, November 2008.		

Metered On-Ramps

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

- 0 = not a metered on-ramp (most links in the network)
- 1 = metered in the AM peak period
- 2 = metered in the PM peak period

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 three hour peak AM and PM time periods modeled, the relative distribution of demand was derived from the Caltrans/SACOG household travel surveys. 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 maximum delay of 15 minutes, a small minimum delay (6 seconds), and a constantly increasing delay with respect to v/c ratio. Table 9-5 lists this delay curve.

Table 9-5. Vehicular Delay at Metered Freeway Entrance Ramps

V/C	Delay
0.17	6 Seconds
0.87	7 Seconds
0.90	12 Seconds
0.95	60 Seconds
1.00	2.6 Minutes
1.05	5 Minutes
1.15	10 Minutes
1.55	13 Minutes
3.33	14 Minutes
Very High	15 Minutes

Note: "Capacity" is 900 vehicles/hour/lane.
Source: SACOG, November 2008 .

Bypass Lanes for HOVs at Metered On-Ramps

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

- DELCURV = 0 (0 for all links except metered on-ramps)
- HOVLINK = 3 (only for ramp meter bypass links)

HOV Lane Users and Non-Users.

As part of the implementation of a model of the choice of HOVs to use or not use HOV lanes in freeways (discussed below), the traffic assignment was modified to assign four trip tables, according to the path building rules listed in Table 9-6. Default "seed" factors splitting SOV and HOV trip tables into these four are used in an assignment required before beginning the HOV path choice model. The default factors appear in Table 9-7.

Table 9-6. Definitions and Network Assignment Rules of the Four Trip Tables in Traffic Assignment

Trip Table	Description	Vehicle Occup.	Use HOV Lanes?	Use HOV bypass lanes at metered on-ramps?
1	Normal SOVs	1	No	No
2	HOVs not using HOV lanes	2+	No	Yes
3	Violators, exempt vehicles	1	Yes	Yes
4	HOVs using all HOV lanes	2+	Yes	Yes

Source: SACOG, November 2008 .

Table 9-7. Default Factors for the Use of HOV Lanes

Vehicle Occupancy	Percentages	
	Use of HOV Lane	Not Use HOV Lane
1 (SOV)	1%	99%
2 or more (HOV)	70%	30%
Source: SACOG, November 2008 .		

Validation of Highway Assignment

Year 2005 is the primary year of highway assignment validation. Table 9-8 provides a comparison of forecasted 2005 traffic volumes to traffic counts. The table includes comparisons of average weekday volumes, and volumes for each of the four travel demand periods.

Total validation ratios by time period are all within 5 percent of counts:

- Weekday daily volumes: 0.99
- Weekday AM period volumes: 1.02
- Weekday midday period volumes: 1.01
- Weekday PM period volumes: 0.97
- Weekday late evening/early morning volumes: 0.95

Root-mean-squared-error (RMSE) is less than 0.40 for all time periods:

- Weekday daily volumes: 0.35
- Weekday AM period volumes: 0.39
- Weekday midday period volumes: 0.40
- Weekday PM period volumes: 0.35
- Weekday late evening/early morning volumes: 0.37

A regression of weekday traffic counts on predicted model volumes was performed. The regression statistics were:

- Adjusted R-squared = 0.97
- Regression coefficient = 0.97

A scatterplot of model volumes to all counted links is shown in Figure 9-1. Table 9-9 provides a tally of the numbers of links for which the modeled daily volume meets FHWA guidance on maximum desired deviation from ground counts for individual links. In total, 51 percent of links meet the guidance; the percentage which meet the guidance for higher volume links is higher, and lower for lower volume links.

Table 9-8. Year 2005 Highway Volume Validation by Functional Class of Roadway

Functional Class	N of Counts	Sum of Counts	Model (if Counted)	Validation Ratio	Avg. Link Error	RMSE
Weekday 24-Hour Volumes						
Freeway (Complex Seg)	41	6,034,423	6,199,810	1.03	0.11	0.14
Freeway (Other)	68	1,664,022	1,839,131	1.11	0.17	0.25
Expressway	22	702,255	716,399	1.02	0.15	0.20
Major Arterial	262	4,223,290	4,211,448	1.00	0.23	0.30
Minor Arterial	148	1,595,256	1,226,496	0.77	0.32	0.41
Collector	94	633,324	512,585	0.81	0.37	0.47
Ramp	218	894,430	857,397	0.96	0.46	0.74
Rural Maj.Arterial	66	264,608	284,936	1.08	0.29	0.40
Rural Minor Arterial	82	353,823	363,979	1.03	0.40	0.52
Total	**1,001**	**16,365,431**	**16,212,181**	**0.99**	**0.21**	**0.35**
Weekday AM Peak Period (3 Hours)						
Freeway (Complex Seg)	36	985,895	1,014,795	1.03	0.13	0.17
Freeway (Other)	66	298,353	317,356	1.06	0.20	0.31
Expressway	20	122,225	125,522	1.03	0.17	0.25
Major Arterial	253	738,227	784,064	1.06	0.26	0.35
Minor Arterial	144	273,801	239,763	0.88	0.39	0.51
Collector	94	117,808	99,309	0.84	0.48	0.62
Ramp	0	0	0	0.00	0.00	0.00
Rural Maj.Arterial	64	47,677	49,496	1.04	0.37	0.55
Rural Minor Arterial	82	76,246	74,555	0.98	0.44	0.61
Total	**759**	**2,660,232**	**2,704,860**	**1.02**	**0.23**	**0.39**
Weekday Midday Period (5 Hours)						
Freeway (Complex Seg)	36	1,379,412	1,542,694	1.12	0.15	0.19
Freeway (Other)	66	443,993	547,983	1.23	0.28	0.39
Expressway	20	176,460	188,855	1.07	0.16	0.21
Major Arterial	254	1,278,072	1,213,660	0.95	0.24	0.31
Minor Arterial	144	486,007	345,820	0.71	0.37	0.46
Collector	94	195,805	148,536	0.76	0.42	0.55
Ramp	0	0	0	0.00	0.00	0.00
Rural Maj.Arterial	64	66,216	81,816	1.24	0.41	0.52
Rural Minor Arterial	82	113,884	107,971	0.95	0.42	0.58
Total	**760**	**4,139,849**	**4,177,335**	**1.01**	**0.24**	**0.40**

Table 9-8. Year 2005 Highway Volume Validation (cont'd)

Functional Class	N of Counts	Sum of Counts	Model (if Counted)	Validation Ratio	Avg. Link Error	RMSE
Weekday PM Peak Period (3 Hours)						
Freeway (Complex Seg)	36	1,036,444	1,082,127	1.04	0.12	0.16
Freeway (Other)	66	343,862	371,385	1.08	0.19	0.27
Expressway	20	131,620	139,268	1.06	0.23	0.33
Major Arterial	254	937,646	880,037	0.94	0.21	0.28
Minor Arterial	144	363,448	280,025	0.77	0.36	0.46
Collector	94	149,181	114,983	0.77	0.42	0.53
Ramp	0	0	0	0.00	0.00	0.00
Rural Maj.Arterial	64	56,588	59,687	1.05	0.31	0.44
Rural Minor Arterial	82	83,114	83,421	1.00	0.38	0.53
Total	**760**	**3,101,903**	**3,010,933**	**0.97**	**0.21**	**0.35**
Weekday Late Evening/Early Morning Period (13 Hours)						
Freeway (Complex Seg)	36	1,681,564	1,550,021	0.92	0.13	0.16
Freeway (Other)	66	523,824	509,101	0.97	0.16	0.23
Expressway	20	196,950	193,327	0.98	0.16	0.21
Major Arterial	254	1,177,681	1,194,051	1.01	0.29	0.38
Minor Arterial	144	408,834	321,557	0.79	0.35	0.45
Collector	94	170,530	149,614	0.88	0.40	0.50
Ramp	0	0	0	0.00	0.00	0.00
Rural Maj.Arterial	64	72,733	69,329	0.95	0.35	0.54
Rural Minor Arterial	82	80,577	97,909	1.22	0.53	0.70
Total	**760**	**4,312,693**	**4,084,909**	**0.95**	**0.22**	**0.37**

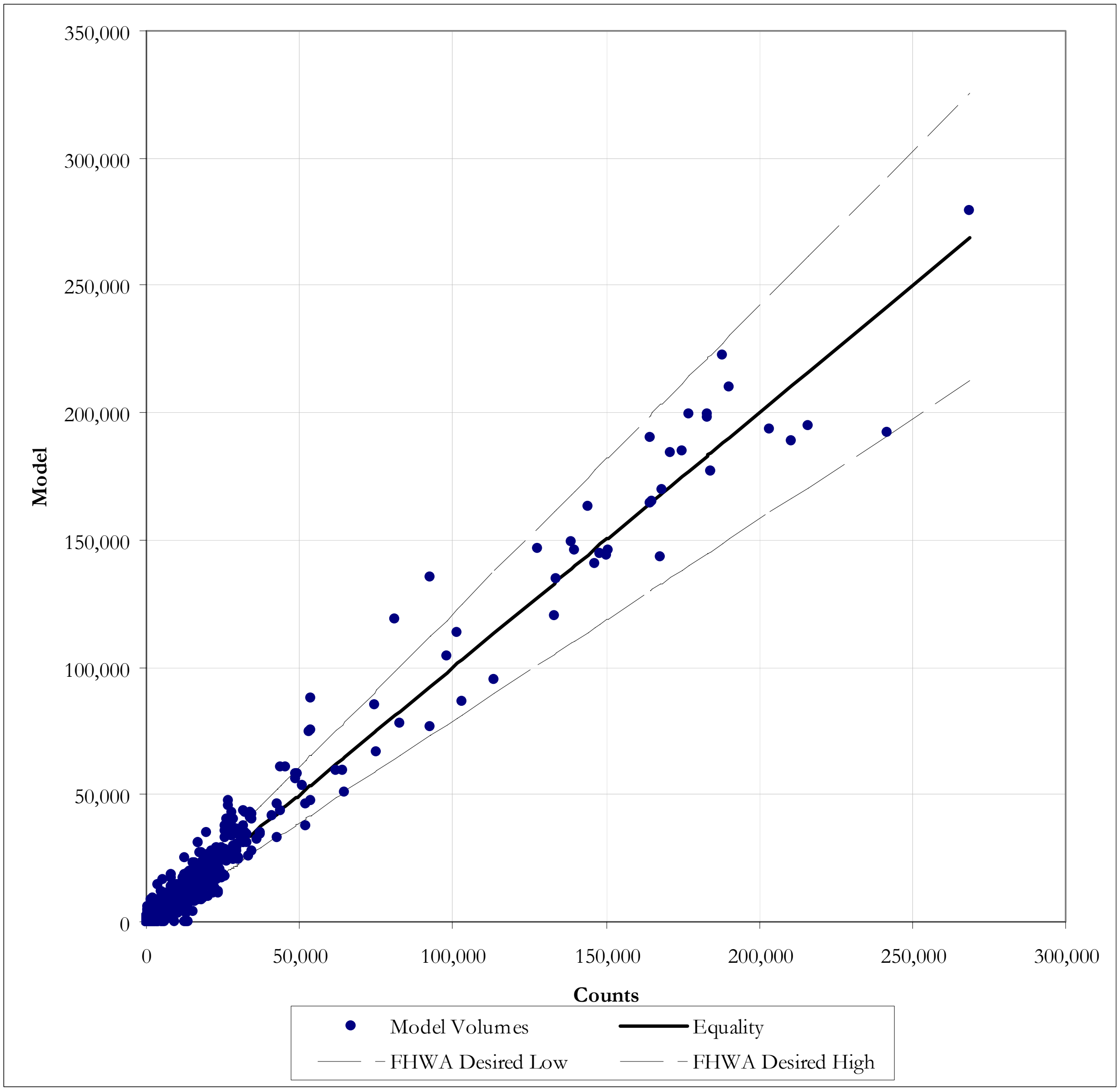
Source: SACOG, November 2008.

Table 9-9. Year 2005 Maximum Desired Deviation from Counts

Volume Range	Max. Desired Deviation (FHWA)1	N of Links	Meet Desired Deviation Threshold?	
			Number	Percent
< 500	60%	41	11	27%
500 to 1,000	60%	62	20	32%
1,000 to 2,500	47%	95	40	42%
2,500 to 5,000	36%	137	58	42%
5,000 to 10,000	29%	217	107	49%
10,000 to 20,000	25%	283	151	53%
20,000 to 30,000	22%	100	69	69%
30,000 to 50,000	22%	35	27	77%
50,000 to 100,000	21%	17	10	59%
100,000 +	21%	31	31	100%
Total	n/a	1018	524	51%

Source: SACOG, November 2008.
1 From "Model Validation and Reasonableness Checking Manual", June 2001, p.98.

Figure 9-1. Year 2005 Weekday Volumes Model vs. Count Scatterplot



Source: SACOG, November 2008.

Transit Assignment

Transit assignment is performed in two periods, peak and off-peak. The peak period is the combination of the AM and PM 3-hour periods used in auto assignment; the off-peak period is the combination of mid-day and evening.

Four trip tables are assigned:

- Peak period, walk access;
- Peak period, drive access;
- Off-peak period, walk access; and
- Off-peak period, drive access.

For Citilabs® TRNBLD software, all access at the A-end of a trip is assumed to be walk. At the P-end of the trip, walk and drive access are differentiated. This limitation makes true O-to-D assignment with TRNBLD impractical[25]. Trips are assigned in approximate P-to-A orientation, rather than in the actual O-to-D direction of travel. (This means actual boardings at a station should be taken as half the sum of modeled "boardings" and modeled "alightings."). The assignment is single-shortest-path, all-or-nothing, without capacity constraint. Paths include time only, with paths build using the perceived weight factors shown in Table 9-10. Higher weighting of transfer time is used for airport ground access, based on higher sensitivity to transfers for airport passengers.

Table 9-10. SACSIM Transit Path Building Factors

	Factor	
Transit Path Building Variable	Non-Airport Trip Purposes	Airport Ground Access
Initial Wait Time	2.0	2.0
Transfer Wait time	1.3	5.0
Drive Access Time	3.0	3.0
Initial Wait Time Maximum	15 minutes	15 minutes
Initial Wait Time Minimum	4 minutes	4 minutes
Source: SACOG, November 2008.		

[25] Options were explored for modifying all transit networks, and assignment and skimming scripts to allow for O-to-D transit assignment, but the time and budget available did not allow for systematic changes to be made.

Walk access transit trips are assigned from zonal matrices aggregated from DAYSIM trip output into the two time periods. PM and evening trips are assigned in the reverse direction, to approximate a production-to-attraction orientation.

Each pair of auto-access transit trips (leaving and returning to the car) is first assigned a parking zone by the park-and-ride lot choice model described above; then the transit portions of those trips are aggregated into their respective time periods, with both trips oriented from the parking zone to the other zone(s) in keeping with production-to-attraction orientation.

SACSIM applies a new model of park-and-ride lot choice for drive-to-transit trips that accounts for parking lot capacities, and splits the trips into their respective auto and transit parts for separate assignment. This model replaces the drive-to-transit methodology provided in TP+. It provides coordinated modules for splitting trips into the auto and transit parts, and calculating level-of-service matrices. First the general methodology is described, then its application in calculating performance measure skims (before DAYSIM) and trip processing (after DAYSIM and before auto trip assignment).

Park-and-Ride Lot Assignment

SACMET uses the standard methodology provided in TP+ for generating drive-to-transit level-of-service matrices, and transit assignment. But TP+ does not provide for assignment of the auto-access vehicle trips to the highway network, so a custom program calculates auto-access vehicle trips from the drive-to-transit trip matrices, so they can be added to the assignment vehicle trips. The standard methodology in TP+ for drive-to-transit handling requires the user to code a "catchment area" list of all zones (TAZs) that are given access to each park-and-ride lot. In transit studies, these zone lists can be difficult to code and maintain, and are subject to the judgment and individual variations in coding technique of the modeler. If the model overloads a park-and-ride lot beyond its capacity (actual or foreseeable), the only recourse is to remove zones from association with the lot, and associate them to other lots, and run the model again. Capacity-constraint adjustments are judgmental, and require time-consuming trial-and-error. Consequently, an alternative methodology was sought for SACSIM that avoids user-coded catchment areas or similar judgmental inputs, avoids special programs, and automatically satisfies parking capacity limits.

Since at least 1994, users of the travel model software EMME/2® have been applying models of park-and-ride choice that calculate with "convolutions" - explicit loops through each possible intermediate zone between each origin and destination zone[26]. EMME/2 does not build drive-to-transit paths in its transit assignment module, so this mode must be handled by matrix processes. These have both a skimming stage and a trip-splitting stage which converts the transit-drive trips into separate drive trips (for inclusion in auto assignment) and transit trips (for inclusion in transit assignment).

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[26] Blain, Larry, "Park-and-Ride Choice using Matrix Convolutions" presented at the 9th Annual International EMME/2 Users' Group Conference, 1994.

Many of these models, including Blain's, are multinomial logit choice among all accessible zones designated for transit-access parking. Consequently, drive-to-transit trips from any origin to any destination are split in some amount to all accessible park-and-ride lots. Estimated or calibrated coefficients of these models commonly weight the drive access time between three and six times compared to transit in-vehicle time.

Soon afterwards, parking lot capacity restraint methodologies were added to these models[27]. An additional "shadow cost" imposed on potentially each parking lot is iteratively solved, so that every park-and-ride lot satisfies the rule that either its demand matches capacity, or it has no shadow cost and demand is less than capacity.

TP+ permits explicit user-coded loop control and matrix cell addressing capabilities in its matrix processing program, unlike those in MINUTP and most other modeling software, which basically process matrices sequentially cell-by-cell. These capabilities are more general than EMME/2's "matrix convolutions," and permit TP+ to apply these and a wide range of other possible park-and-ride models.

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

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

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

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

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[27] Spiess, Heinz, "A Logit Parking Choice Model with Explicit Capacities", November 1996, available at http://emme2.spiess.ch/parkcap/parkcap.html)

Implementation

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

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

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

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

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

$GC(auto)_{ik}$ = {3*Auto $Time_{ik}$ + 2*($TermTime_i$ + $TermTime_k$) + 2*($AutoDist_{ik}$ * 12 cents/mile + $ParkCost_k$ /2) * 0.0558 minutes equivalent/cent } / 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)

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

Costs are in 2000 cents, consistent with SACSIM. The factors on costs are taken from the SACSIM model's middle stratum of cost factors for work trips, and imply a value of time of $5.38/hour. Parking cost is specific to park-and-ride activity, being taken from the park-and-ride capacity database file, not the zonal land use or parcel data.

Ideally, the park-and-ride zones would be special zones coded at the actual locations of the parking lots. However, presently they are in ordinary zones, and some of their centroids are some distance away from the parking and the transit station. The ordinary walk-access transit skims would include walk time from the parking zone centroid to the transit stops, which is excessive in some zones. TP+ is not able to isolate or exclude walk time from the origin to the first boarding, which would solve this problem. The current solution to transit skimming for park-and-ride is to actually run customary drive-to-transit skimming, with the requirement that all park-and-ride zones be coded in their own catchment areas. (Not all had been in the Sacmet data.) 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.

Validation of Transit Assignment

Year 2005 was the primary year for transit assignment validation. Table 9-11 provides an operator and service type tally of Year 2005 weekday boardings. Total model boardings match total observed boardings. LRT boardings are underpredicted by 12 percent, and total bus boardings are overpredicted by 8 percent.

A scatterplot of model boardings by line to counts is shown in Figure 9-2. Overall RMSE for model predictions of line boardings is 0.68; for lines with observed boardings greater than 1,000 per day, RMSE=0.35. Line boarding counts were regressed on model line boardings:

- Adjusted R-squared = 0.96 (all lines); 0.84 (bus lines only)
- Regression coefficient = 1.08 (all lines); 0.85 (bus lines only)

Table 9-12 and Figure 9-3 provide comparisons of weekday passenger boardings at LRT stations. Some stations, especially those in the Downtown Sacramento area, are grouped, due to close stations spacing relative to TAZ's in that area. LRT station boarding counts were regressed on model boardings of the same:

- Adjusted R-squared = 0.87

- Regression coefficient = 0.88

Figure 9-2 provides a scatterplot of model estimated peak parking demand at LRT stations, compared to observed peak parking demand at the stations. LRT station peak parking demand counts were regressed on model estimates of the same:

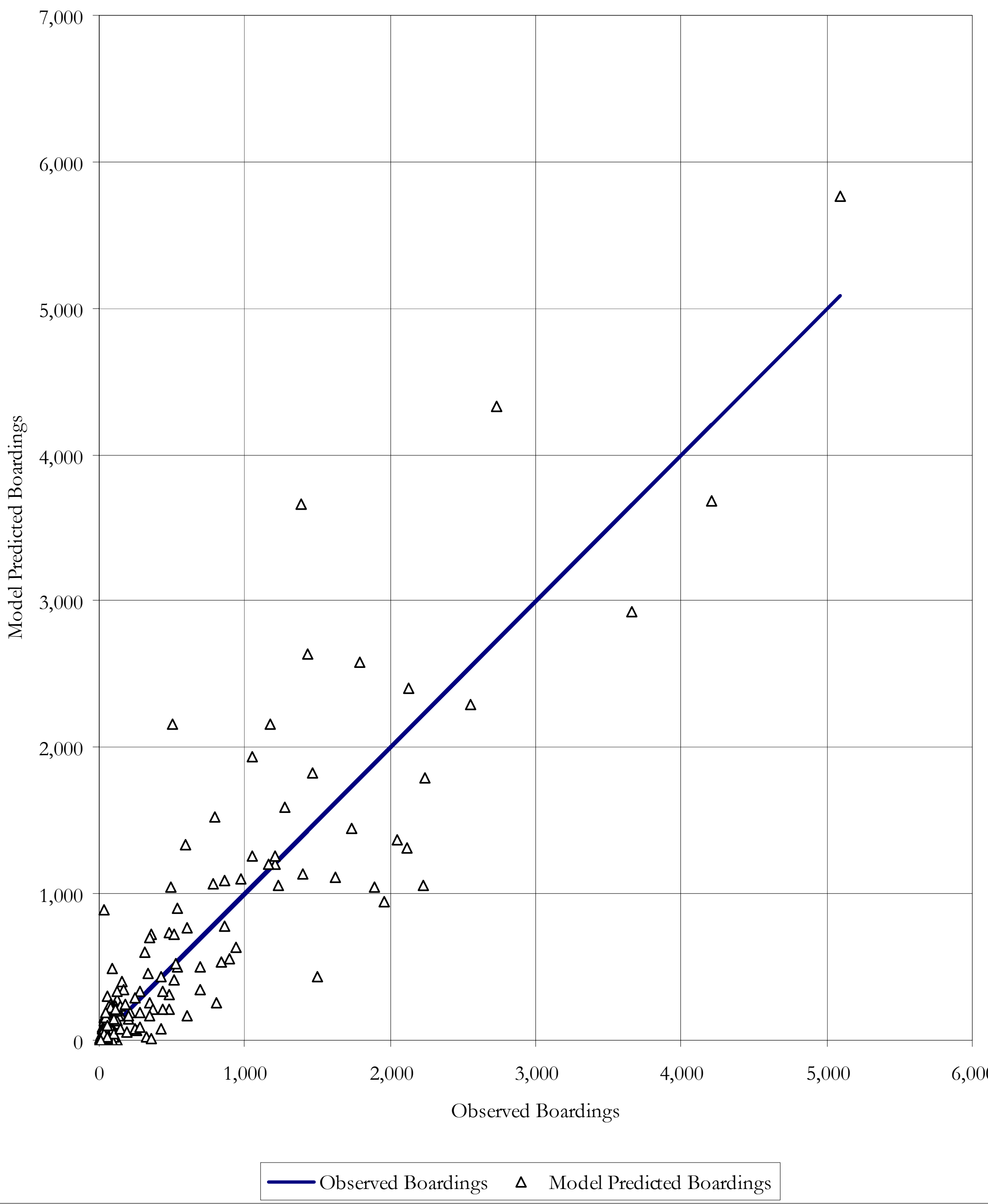
- Adjusted R-squared = 0.84
- Regression coefficient = 0.88

Table 9-11. Year 2005 Weekday Transit Passenger Boardings by Operator: Comparison of Model to Counts

Operator	Service Type	Count	Model	Validation Ratio
SRTD	LRT	48,300	42,278	0.88
	Bus	70,510	74,709	1.06
	Subtotal	118,810	116,987	0.98
Elk Grove Transit	Downtown Express	1,196	1,410	1.18
	All Other Bus	1,540	1,149	0.75
	Subtotal	2,736	2,559	0.94
Yolobus	42 Bus	1,740	1,450	0.83
	Downtown Express	1,059	986	0.93
	All Other Bus	1,664	2,142	1.29
	Subtotal	4,463	4,578	1.03
Placer County Transit	Downtown Bus	99	48	0.48
	All Other Bus	882	323	0.37
	Subtotal	981	371	0.38
Roseville Transit	Downtown Bus	180	260	1.44
	All Other Bus	1,014	2,296	2.26
	Subtotal	1,194	2,556	2.14
Folsom Transit	Downtown Bus	0	0	0.00
	All Other Bus	152	510	3.36
	Subtotal	152	510	3.36
El Dorado Transit	Downtown Bus	534	273	0.51
	All Other Bus	338	215	0.64
	Subtotal	872	488	0.56
Yuba-Sutter Transit	Downtown Bus	355	96	0.27
	All Other Bus	2,128	3,266	1.53
	Subtotal	2,483	3,362	1.35
All Operators	LRT	48,300	42,278	0.88
	Express Bus+42 Rte.	5,163	4,523	0.88
	Local Bus/Other	79,968	86,060	1.08
	Total	133,431	132,861	1.00

Source: SACOG, November 2008. Based on passenger boarding counts provided by operators.

Figure 9-2. Year 2005 Weekday Boarding By Line: Comparison of Model to Counts



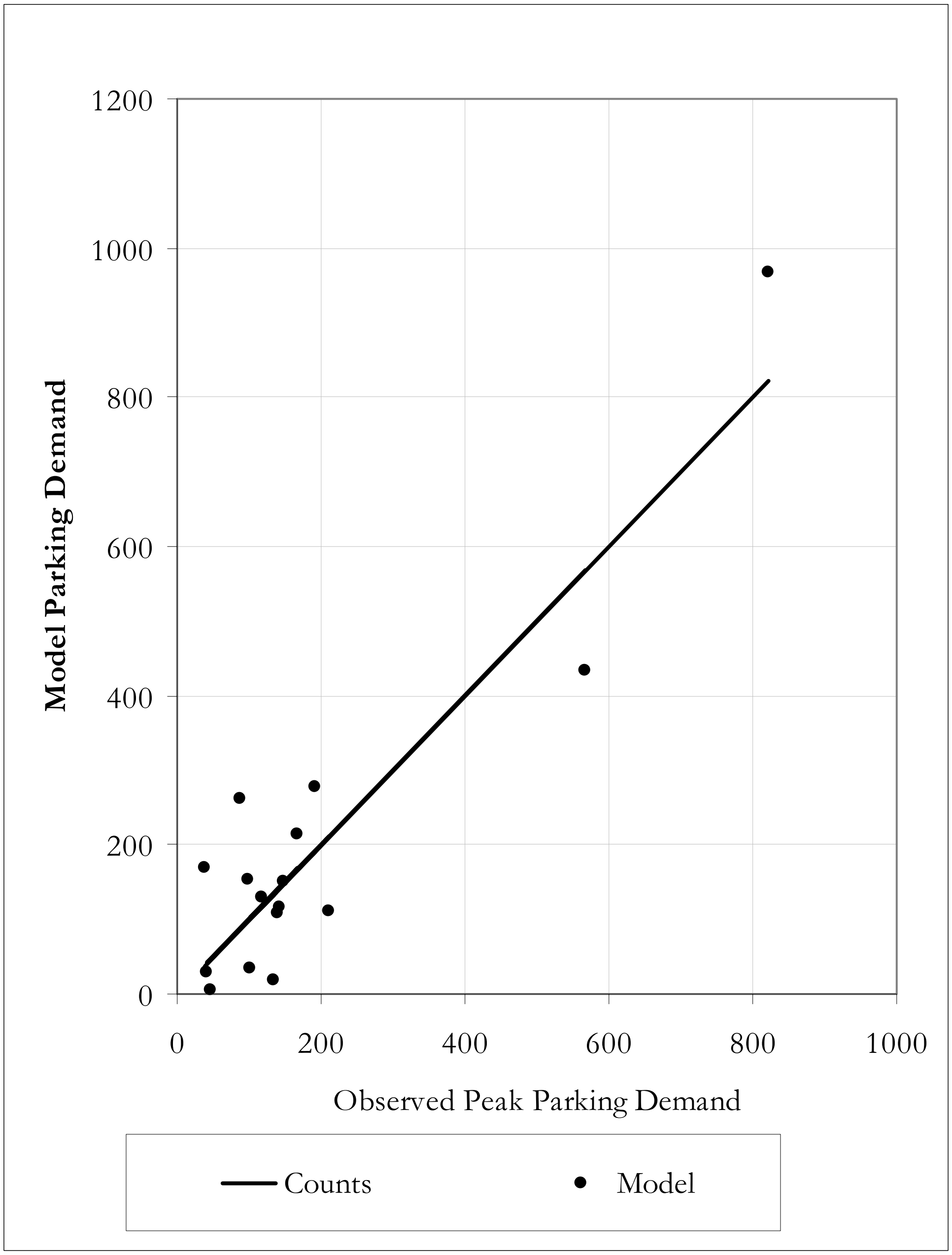
Source: SACOG, Septermber 2008.

Table 9-12. Year 2005 Weekday Passenger Boardings at LRT Stations: Comparison of Model to Counts

Station Group	Model	Counts	Mod/Obs
Watt/I80 to Roseville Rd	2,706	3,198	0.85
Marconi	951	976	0.97
Swanston to Globe	2,697	2,579	1.05
Alkalai Flats + 12th/I	1,231	1,850	0.67
Cathedral to 7th-8th/Capitol	8,111	7,927	1.02
8th/O + Archives Plaze	3,689	2,560	1.44
13th+16th	2,706	4,862	0.56
23rd+29th	1,659	2,687	0.62
39th	528	446	1.18
48th	457	241	1.90
59th	230	486	0.47
65th	2,529	1,504	1.68
Power Inn+College Greens	1,382	2,110	0.65
Watt/Manlove + Starfire	1,740	1,806	0.96
Tiber+Butterfield	702	1,206	0.58
Mather Field/Mills	1,076	1,959	0.55
Zinfandel+Sunrise+Hazel	2,004	2,490	0.80
Folsom Stations	541	1,572	0.34
Broadway+Wayne Hultgren	842	1,826	0.46
City College	2,299	1,163	1.98
Fruitridge+47th	1,220	1,165	1.05
Florin+Meadowview	2,996	3,681	0.81
Total	42,291	48,294	0.88

Source: SACOG, September 2005.

Figure 9-3. Year 2005 Peak Parking Demand at LRT Stations: Comparison of Model to Counts



Source: SACOG, November 2008.

10—Model System Equilibration

In the overall system design of SACSIM, Figure 0-1 shows 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).

Trip-based model systems with this same requirement have existed for at least thirty years[28], and the theory of system equilibrium for them is well developed now. 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 ($\mathbf{y}_i$): $\mathbf{x}_i = (1-\lambda)\mathbf{x}_{i-1} + \lambda \mathbf{y}_i$, 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. 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.

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: $\mathbf{x}_i = \dfrac{\mathbf{y}_1 + \mathbf{y}_2 + \ldots + \mathbf{y}_i}{i}$. Some trip-based models converge reliable and more efficiently with a fixed step size[29], though care must be taken in the choice of that step size, which depends on the problem.

[28] Evans, Suzanne P. "Derivation and Analysis of Some Models for Combining Trip Distribution and Assignment", *Transportation Research*, Vol. 10, pp. 37-57 (1976).
[29] 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.

Equilibrium theory of trip-based models has unfortunately not been extended into activity-based models. 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).

Fortunately, trips from DAYSIM can be subjected to convex combination methods such as the method of successive averages, or with fixed step sizes.

With the unit of analysis being households instead of origin-destination pairs, come options not normally available to trip-based models. DAYSIM need not simulate the entire synthetic population in an iteration; it is able to run a selected sample of the population. Since its runtimes are long but proportional to the number of households modeled, early system-iterations can be sped up by simulating small samples. DAYSIM's sample processing scheme partitions the households, so successive iterations may run successive partitions. Coordinating this approach with MSA enables the modeled flows to be constituted from the entire population with each member represented with equal weight. Preserving equal weights is not required, but it minimizes the random variance of trip flows. An example of this approach with MSA is:

> Iteration 1: Simulate households numbered 1, 11, 21,… All have expansion weight of 10, to scale the trips to the scale of the whole population.
>
> Iteration 2: Simulate households 2, 12, 22,… The expansion weight is still 10. MSA combines flows to 1/2(Iteration 1 flows) + 1/2(Iteration flows). Now 2 out of 10 households are present, each with an effective expansion factor of 5.
>
> Iteration 3: Simulate households 3, 13, 23,… with expansion factor 10. MSA combines flows to 2/3(Iteration 2's MSA flows) + 1/3(Iteration 3 flows). Now 3 out of 10 households are present, each with an effective expansion factor of 3.3333.
>
> When iteration 10 is performed and combined by MSA, trips from all the households are present, each with a weight of 1.

This method, if enough iterations are specified, can converge flows and travel times within the range of random uncertainty.

Since the unit of analysis is individual households and their members, post-model analysis may examine their individual choices and travel costs incurred. A conflict between the MSA method and post-hoc analysis of the simulated trips is that households in the early iterations incur significantly different travel costs than the converged costs, and make their choices based on these. Three solutions are:

1) After completing all households by MSA, re-simulate all the households' activity and travel based on the final MSA result's travel times, and/or
2) Cut the MSA process short after reasonable early convergence, and start it over, beginning with the latest travel times, and running it though to completion.
3) Rerun the system with more iterations and a proportionately lower sampling rate.

Solution 1 ought to give the "cleanest" post-analysis of all individuals, since all input travel times are consistent, and all simulation data records are in single files rather than split among several. Note that the travel times resulting from assignment of the final total simulation will still not exactly match those used to perform that simulation, because the final simulation yields randomly different trips than those accumulated in the MSA process. Solution 2 is valid for some post-analyses of the individuals that don't depend on all individuals having exactly equal travel times. It is also a potential strategy to reach the neighborhood of equilibrium with less simulation effort, and may be combined with solution 1. Solution 3 reduces the number of households simulated during early iterations.

Equilibrium Solution Procedure

The equilibration procedure employs equilibrium assignment iteration loops (a-iterations) nested within iterations between the demand and assignment models (da-iterations). This is similar to the nested iteration in many trip-based model systems.

Assignment is run for four 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 TP+ software, and closure criteria determined by the user: maximum number of iterations (N_i), and relative gap as defined by TP+ (g_i). Iterations stop when one of the closure criteria is satisfied.

There are a number of points in the model stream where it is possible to apply the 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[30]. Then assign these new blended trips in equilibrium.
(2) "Post-assignment blending" - assign the new iteration trips alone in equilibrium, and afterwards blend those volumes with the previous system-iteration's blended link volumes[31].
(3) Assign each iteration's trips in an all-or-nothing assignment on the same paths used to derive the skims[32]. Most modeling software, and the several whole-matrix processes in

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30 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.
31 Boyce, David, et.al. (1994), ibid.

the SACSIM system (and most trip-based models) conspire against the practicality of such an approach. Consequently, the Evans model and numerous generalizations[33] are rarely used in practice.

An alternative blending method during assignment was studied and found to reduce run-times considerably. In this method, the step-size fraction of the new demand is assigned while the complementary proportion of the previous system-iteration's final volumes is kept as a preloading. Link time calculations always include this blended volume. In effect, preloaded traffic (from previous system iterations) is fixed on its route choices, while the iteration's demand trips are allowed to change routes until optimal, accounting for the preloaded traffic. Several tests indicate this method yields assignments that compare reasonably (though not identical) to assignments of blended trip matrices, but converge with far fewer assignment iterations.

In the *i-th* da-iteration, DAYSIM is run on a subset of the synthetic population, consisting of the fraction $1/s_i$ (i.e. $100/s_i$ percent) of the households, starting with the m_i-th household and proceeding uniformly every s_i households. The user determines s_i and m_i. DAYSIM scales up the synthesized trips by the factor s_i before they are combined with the estimated external, airport and commercial trips in mode-specific OD matrices for the four assignment time periods. During the *n-th* a-iteration within the *i-th* da-iteration, link volumes are estimated for the iteration *i* OD matrices, and combined in a convex combination with link volumes from the prior da-iteration, using a user-specified combination factor (or step-size) λ_i. This is the preloading method intended to prevent link volume oscillation between da-iterations. The resulting estimated volumes are then combined with link volumes from the prior a-iteration using the TP+-determined step size α as described in the previous paragraph. This is intended to prevent link volume oscillation between a-iterations.

The above description corresponds with the following algorithm:

0. Set starting link times $\{t_a^1\}$ using free flow times.
1. Calculate shortest paths and skim OD matrices *C*, with elements $C_{krs}^i(\{t_a^i\})$, where *k* indexes skim variables, and *r* and *s* index origin and destination zones.
2. Run DAYSIM and trip-based demand models, generating OD flow matrices *f*, with elements $f_{rs}^i(C)$.
3. Run multi-class user equilibrium assignment:

3.0. Set $t_a^{i,0} = t_a^{i-1}$ for all links *a*, the final link time from iteration *i*-1, or freeflow if *i*=1. Set *n*=1.

3.1. Perform all or nothing assignment based on the current link travel times, yielding this a-iteration's shortest-path link volumes $\tilde{y}_a^{i,n}(\{t_a^{i,n-1}\},\{f_{rs}^i\})$ for all links *a*.

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[32] Evans (1976) ibid.

[33] 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.

3.2. Adjust this a-iteration's new link volumes by blending with link volumes from the previous da-iteration, $y_a^{in} = \lambda_i \tilde{y}_a^{in} + (1-\lambda_i) x_a^{(i-1)}$ for all *a*. (Notes: This step is intended to prevent link flow oscillation between da-iterations. λ_1 must be set to 1 if there are no previous da-iteration link volumes. $x_a^{(i-1)}$ refers to the values at the final *n* during the prior *i*.)

3.3. Solve for α for which $\sum_a t_a((1-\alpha)x_a^{i,n-1} + \alpha y_a^{i,n})(y_a^{i,n} - x_a^{i,n-1}) \approx 0$. ($\alpha$ = 1 in a-iteration 1.) Set new a-iteration's link volumes by blending this a-iteration's new link volumes with the a-iteration's link volumes: $x_a^{i,n} = (1-\alpha)x_a^{i,n-1} + \alpha y_a^{in}$ for all *a*. Compute new link times from those volumes, $t_a^{i,n}(x_a^{i,n})$. (This step is intended to prevent link flow oscillation between a-iterations.)

3.4. Check that the closure test statistic, "relative gap" = $\dfrac{\sum_a (t_a^{i,n-1} x_a^{i,n-1} - t_a^{i,n-1} y_a^{in})}{\sum_a t_a^{i,n-1} x_a^{i,n-1}}$, is less than a user-specified tolerance criterion.
IF fail, THEN increment *n* and go to step 3.1
ELSE IF *i*<*I* THEN increment *i* and go to step 1
ELSE DONE and final values of link volume, link time, zone-to-zone travel costs, and zone-to-zone flow are $\{x_a^i\}, \{t_a^i(\{x_a^i\}\}, \{C_{krs}^i(t_a^{i-1})\}, \{f_{rs}^i\}$. (Note: final link volumes and times come from last d-a iteration's assignment, but final OD flows come from prior iteration's link times.)

As implemented, the equilibration procedure runs for a user-determined number (*I*) of da-iterations. Within each iteration, the user controls the synthetic population subset used by DAYSIM (via s_i and m_i), their weight (λ_i) given during assignment to the link volumes associated with this iteration's simulated trips, and the assignment closure criteria (N_i and g_i).

Note that, with the above algorithm, although a specified level of convergence (relative gap) is automatically met for assignment within each da-iteration, there is no assurance that a corresponding level of convergence will be met across the da-iterations (da-convergence). Indeed, the algorithm does not yet specify a formal measure for testing the level of da-convergence that has been achieved when it terminates. Work will continue to define such a measure and to also identify appropriate parameter settings to hasten da-convergence. The next section discusses parameter schedules that have been considered, and it is followed by a section of experimental findings related to parameter settings and da-convergence.

Selections for Iteration Parameters

Table 10-1 shows an iteration schedule used in a series of experimental constant step-size runs. This particular sampling scheme can be easily adapted to different numbers of iterations, but not to a different constant step size.

Table 10- 1. SACSIM Constant Step Size Iteration Schedule

Iteration	s_i	m_i	λ_i	Series of households sampled
1	128	128	1	128, 256, 384, 512...
2	128	64	0.5	64, 192, 320, 448...
3	64	32	0.5	32, 96, 160, 224...
4	32	16	0.5	16, 48, 80, 112...
5	16	8	0.5	8, 24, 40, 56...
6	8	4	0.5	4, 12, 20, 28...
7	4	2	0.5	2, 6, 10, 14...
8	2	1	0.5	1, 3, 5, 7... (completes all HH)
9	1	1	0.5	1, 2, 3, 4... (final full pass)

Source: Gibb, John "Application of an Activity-Based Travel Model of the Sacramento Region", September 2006.
Notes:

s_i = Starting household number in population file.

m_i = Sampling rate (e.g. 128 = 1 per 128 households sampled)

λ_i = MSA step size, for combining current-iteration assignment results with combined prior iterations (0.5 indicates that ½ of the current iteration is combined with the cumulative prior iterations.

Figures 10-1, 10-2, and 10-3 show comparable iteration convergence statistics for these runs. When comparing them to those from the staged MSA models, recall that (1) small step sizes dampen changes in some statistics, and (2) this model makes 2 total passes through the population, and the staged MSA model uses just slightly more, 2.13 passes.

Figure 10-1. Iteration Progress of VHT, SACSIM Constant Step Size

Source: Gibb, John "Application of an Activity-Based Travel Model of the Sacramento Region", September 2006.

Figure 10-2. Iteration Progress of Vehicle Trips, SACSIM Constant Step Size

Source: Gibb, John "Application of an Activity-Based Travel Model of the Sacramento Region", September 2006.

Figure 10-3. Largest Change in O-to-D Travel Time, SACSIM Constant Step Size

Source: Gibb, John "Application of an Activity-Based Travel Model of the Sacramento Region", September 2006.

Figure 10-4. Iteration Progress of RMSE Change in O-to-D Travel Time, SACSIM Constant Step Size

Source: Gibb, John "Application of an Activity-Based Travel Model of the Sacramento Region", September 2006.