CAMBRIDGE SYSTEMATICS

Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study

draft final report

prepared for

Metropolitan Transportation Commission and the California High-Speed Rail Authority

prepared by

Cambridge Systematics, Inc.

with

Corey, Canapary & Galanis
Mark Bradley Research & Consulting
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1.0 Introduction

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1.1 Overview

The California High-Speed Rail Authority (CHSRA) and the Metropolitan Transportation Commission (MTC) are developing an innovative statewide model to support evaluation of high-speed rail alternatives in the State of California. This statewide model will also support future planning activities of the California Department of Transportation (Caltrans). The approach to this statewide model explicitly recognizes the unique characteristics of intraregional travel demand and interregional travel demand. As a result, interregional travel models capture behavior important to longer-distance travel, such as induced trips, business and commute decisions, recreational travel, attributes of destinations, reliability of travel, party size, and access and egress modal options. Intraregional travel models rely on local highway and transit characteristics and behavior associated with shorter-distance trips (such as commuting and shopping).

The project objectives were to develop a new ridership forecasting model that would serve a variety of planning and operational purposes:

- To evaluate high-speed rail ridership and revenue on a statewide basis;
- To evaluate potential alternative alignments for high-speed rail into and out of the San Francisco Bay Area; and
- To provide a foundation for other statewide planning purposes and for regional agencies to better understand interregional travel.

The core model design feature is the recognition that interregional and urban area travel is distinct and should be modeled separately to capture these distinctions accurately. This led to our approach to develop separate, but integrated, interregional and intraregional models. There are two primary reasons for developing separate models for interregional and urban area travel: first, the trip purposes are different and second, the interregional travel models need to explicitly estimate induced demand. These models are applied to both peak and off-peak conditions for an average weekday. Weekend travel demand and annual ridership estimates are developed using annualization factors developed from observed data on high-speed rail systems around the world.

1.2 Contents of The Report and Related Reports

This executive summary is an overview of the full project, but the details of the work conducted are documented in separate task reports. All relevant reports are detailed below.

- *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Findings from the First Peer Review Panel Meeting*, Cambridge Systematics, Inc., July 2005.
- *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Findings from the Second Peer Review Panel Meeting*, Cambridge Systematics, Inc., July 2006.
- *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Model Design, Data Collection, and Performance Measures*, Cambridge Systematics, Inc.; with Citilabs; Corey, Canapary & Galanis; HLB Decision Economics; Mark Bradley Research and Consulting; and SYSTRA Consulting, May 2005.
- *Metropolitan Transportation Commission High-Speed Rail Study, Overview and Documentation of Surveys (Air/Rail/Auto Trips),* Corey, Canapary & Galanis, December 2005.
- *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Socioeconomic Data, Transportation Supply, and Base Year Travel Patterns Data*, Cambridge Systematics, Inc., December 2005.
- *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Interregional Model System Development*, Cambridge Systematics, Inc., with Mark Bradley Research & Consulting, August 2006.
- *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Statewide Model Networks*, Cambridge Systematics, Inc., July 2007.
- *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Statewide Model Validation*, Cambridge Systematics, Inc., March 2007.
- *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Levels of Service Assumptions and Forecast Alternatives*, Cambridge Systematics, Inc., with SYSTRA Consulting, Inc.; and Citilabs, August 2006.
- *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Ridership and Revenue Forecasts*, Cambridge Systematics, Inc., July 2007.

These reports are available from the MTC or the CHSRA[1].

There are nine sections in this report:

1. The introduction;
2. An overview of the model system;
3. A summary of the data collection;
4. Descriptions of the modal networks;

[1] http://www.cahighspeedrail.ca.gov/ridership/.

5. An overview of the model development by component, along with model validation and the 2030 no project forecasts;
6. Forecast assumptions by mode;
7. Ridership and revenue forecasts;
8. Peer review panel; and
9. A final summary of the forecasting process and potential model improvements, along with acknowledgments for the work.

Data sources include travel surveys, ridership counts, and traffic volumes. Model components include trip frequency, destination choice, mode choice, and trip assignment models.

2.0 Model System Overview

2.0 Model System Overview

The Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study includes the following components:

- Intraregional travel,
- Interregional travel,
- External travel, and
- Trip assignment.

Intraregional trips include all trips with both ends in one of the 14 regions in the State, as shown in Figure 2.1. The intraregional trips for the San Francisco and Los Angeles metropolitan regions are developed by integrating their regional travel forecasting models with new mode choice models that identify potential high-speed rail riders. In addition, high-speed rail riders were estimated for the San Diego region using existing and previous forecasting data sources. The metropolitan planning organizations (MPO) representing these areas are the MTC, the San Diego Association of Governments (SANDAG), and the Southern California Association of Governments (SCAG). None of the other California regions have more than one proposed high-speed rail station and do not generate intraregional high-speed rail trips, so mode choice models for these regions were not necessary. Instead, intraregional auto trips were estimated from the Caltrans Statewide Model[2] and included in auto assignments to accurately reflect congestion for these other regions.

Interregional trips include all trips with both ends in California and whose origin and destination are in different regions (shown in Figure 2.1). These interregional trips were estimated using a new set of estimated models, derived from survey data collected for this study combined with other relevant survey data sources. The model estimates all interregional trips by purpose and length, identifies which region the interregional trips will be going to, and then estimates which access, egress, and line-haul mode the interregional trip will use.

External trips include trips with one end outside California and one end in an urban area with a proposed high-speed rail station. External auto trips were included in auto assignments to accurately reflect the congestion caused by these external trips, but air and rail trips were not included explicitly.

[2] California Department of Transportation and Dowling Associates, Inc., *California Statewide Model Description*, January 20, 2004.

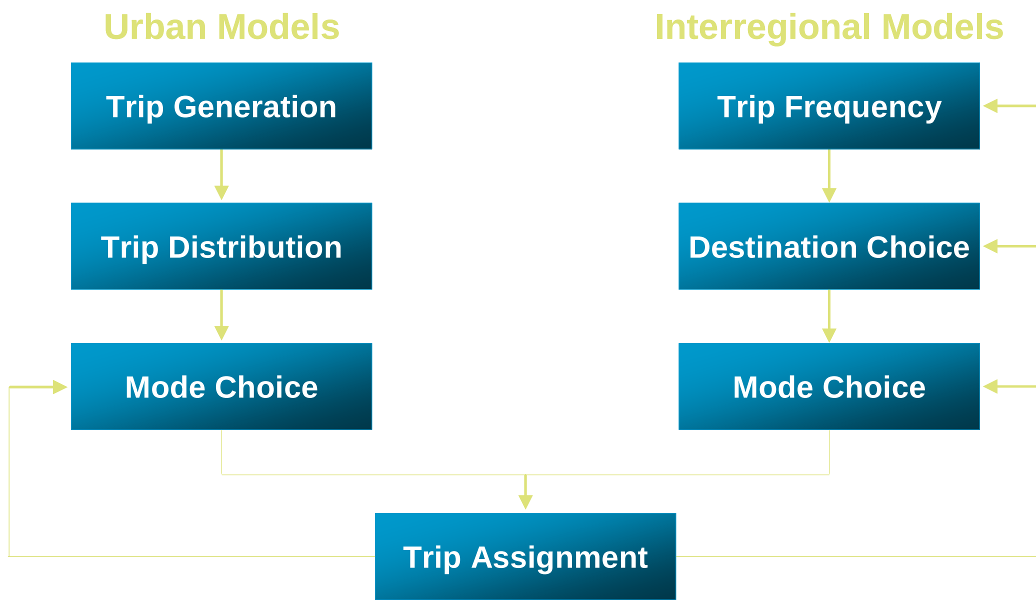
Figure 2.1 California Urban Areas and High-Speed Rail Station Locations

We recognize that some intraregional trips may be longer than some interregional trips by this definition and vice-versa. However, these definitions do clearly fit in with regional and statewide planning definitions, and do identify most interregional trips as those that begin or end outside an urban area. One example of an anomaly is a trip from Modesto to San Jose (defined as an interregional trip), which is similar in distance to a trip from Palmdale to Los Angeles (defined as an intraregional trip). Even taking these anomalies into consideration, there was consensus that the definition of intraregional and interregional trips fits well with most trips in the system, and that the models proposed for each would adequately address the behavioral nature of each trip type. In addition, as discussed below, we have segmented the interregional trips into short trips (less than 100 miles) and long trips (longer than 100 miles) to help address this issue.

Trip assignment includes the merging of the intraregional, interregional, and external trips into modal trip tables that are assigned to highway, rail, and air networks. These assignments were validated in the base year and forecast year to evaluate reasonableness and accuracy compared to observed data sources. The model base year is 2000 and the forecast year is 2030. The California interregional models explicitly model peak and off-peak travel for both intraregional and interregional trip movements.

The integrated modeling process for the development of the statewide model is presented in Figure 2.2. This process shows that the accessibility of the system (represented by travel time) is included in the mode choice models and in the interregional trip frequency and destination choice models. This feature allows us to estimate the induced travel for the interregional travel market.

Figure 2.2 Integrated Modeling Process



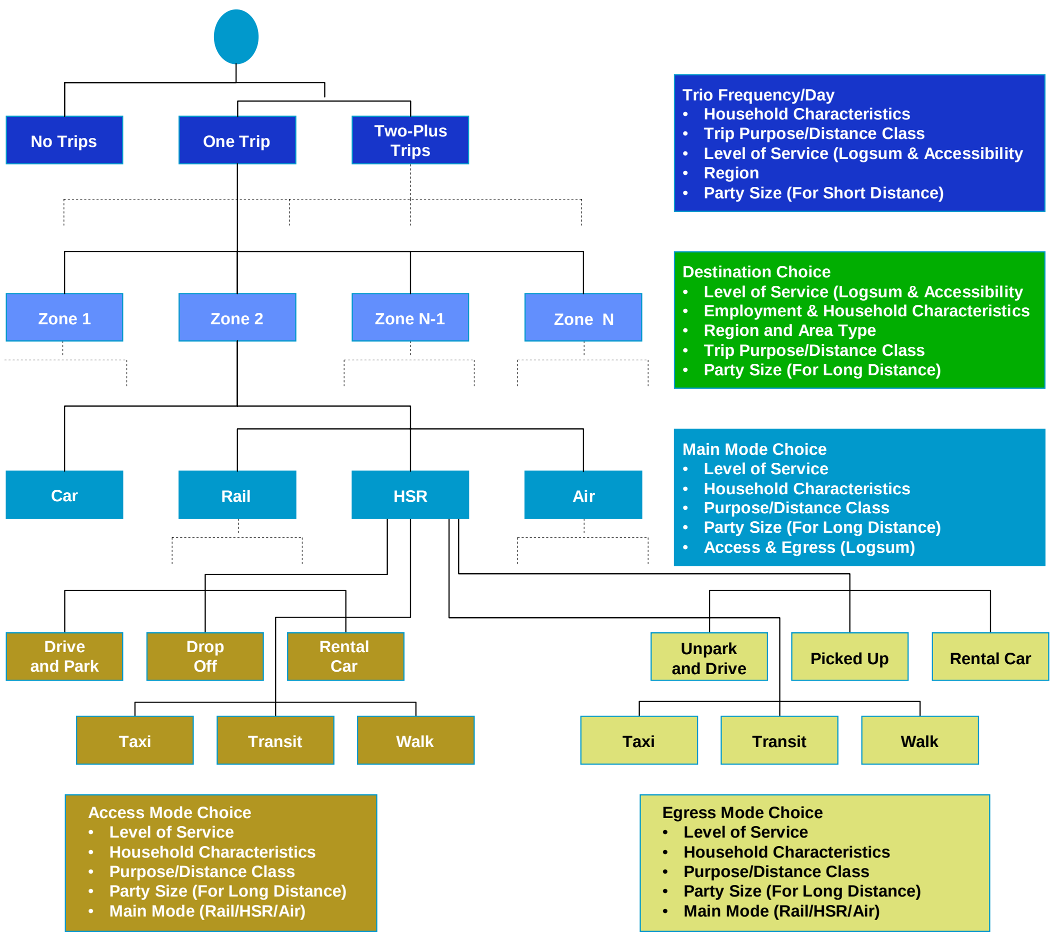
There are 14 regions established in the State that define interregional and intraregional travel. An interregional trip is any trip that terminates in a different region that it started in. Accordingly, an intraregional trip terminates in the same region that it began. Interregional models estimate trip frequency, destination choice, and mode choice stratified by trip purpose (business, commute, recreation, and other), as well as by distance (trips greater than or less than 100 miles) and by trip type (trips made by residents of the four largest cities in California versus other trips). The interregional trip frequency models allow estimate induced travel based on improved accessibilities due to high-speed rail options. Intraregional models are based on trip tables generated from the MPO models and estimate mode choice of urban area trips. These mode choice models reflect local urban area highway and transit systems, as well as options for high-speed rail within the region. Intraregional travel is stratified by trip purpose (work, school, college, other, and nonhome-based).

The interregional and intraregional area models are based on travel survey data collected for these purposes. These are further described below.

2.1 Interregional Models

The interregional models are comprised of four sets of models: trip frequency, destination choice, main mode choice, and access/egress mode choice. The structure and contents of the interregional modeling system is presented in Figure 2.3.

Figure 2.3 Interregional Model Structure



The trip frequency model component predicts the number of interregional trips that individuals in a household will make based on the household's characteristics and location. The destination choice model component predicts the destinations of the trips generated in the trip frequency component based on zonal characteristics and travel impedances. The mode choice components predict the modes that the travelers would choose based on the mode service levels and characteristics of the travelers and trips. The mode choice models include a main mode choice, where the primary interregional mode is selected; and access/egress components, where the modes of access and egress for the air and rail trips are selected.

Because of the way that the model components were linked, model development occurs in the reverse order of model application:

- **Access and egress mode choice models** determine choice of mode to and from airports, conventional rail stations, and high-speed rail stations. The available modes include drive and park, picked up/dropped off, rental car, taxi, transit, and walk. These were based on the actual and hypothetical access and egress modes reported in the stated-preference (SP) surveys – either four or six observations per respondent.
- **Main mode choice models** choose the main, line-haul mode, from among car, air, conventional rail, and high-speed rail. This is based on the four hypothetical SP responses for each respondent in the SP surveys. This model uses information from the access and egress mode choice component for each mode (except car).
- **Destination choice models** pick the destination zone outside the region. The model is segmented for destinations within and beyond 100 miles, and the alternatives are all traffic analysis zones (TAZ) applicable for the distance segments. For the long-distance model, we use a two-stage structure of predicting "macro-zone" and then TAZ, because that seems to be more behaviorally realistic. The model input data are a mix of trips from the statewide survey and the SP survey. The models use information from the mode choice model components, calculated for each TAZ as the key measure of impedance between zones.
- **Trip frequency models** establish the number of interregional trips made during a person-day (0, 1, or 2) for a given purpose/distance segment. The California Statewide survey diary-days are the data source. The models use information from the destination choice model component calculated across all possible TAZs as a measure of zone accessibility.

The market segmentations used for the models are:

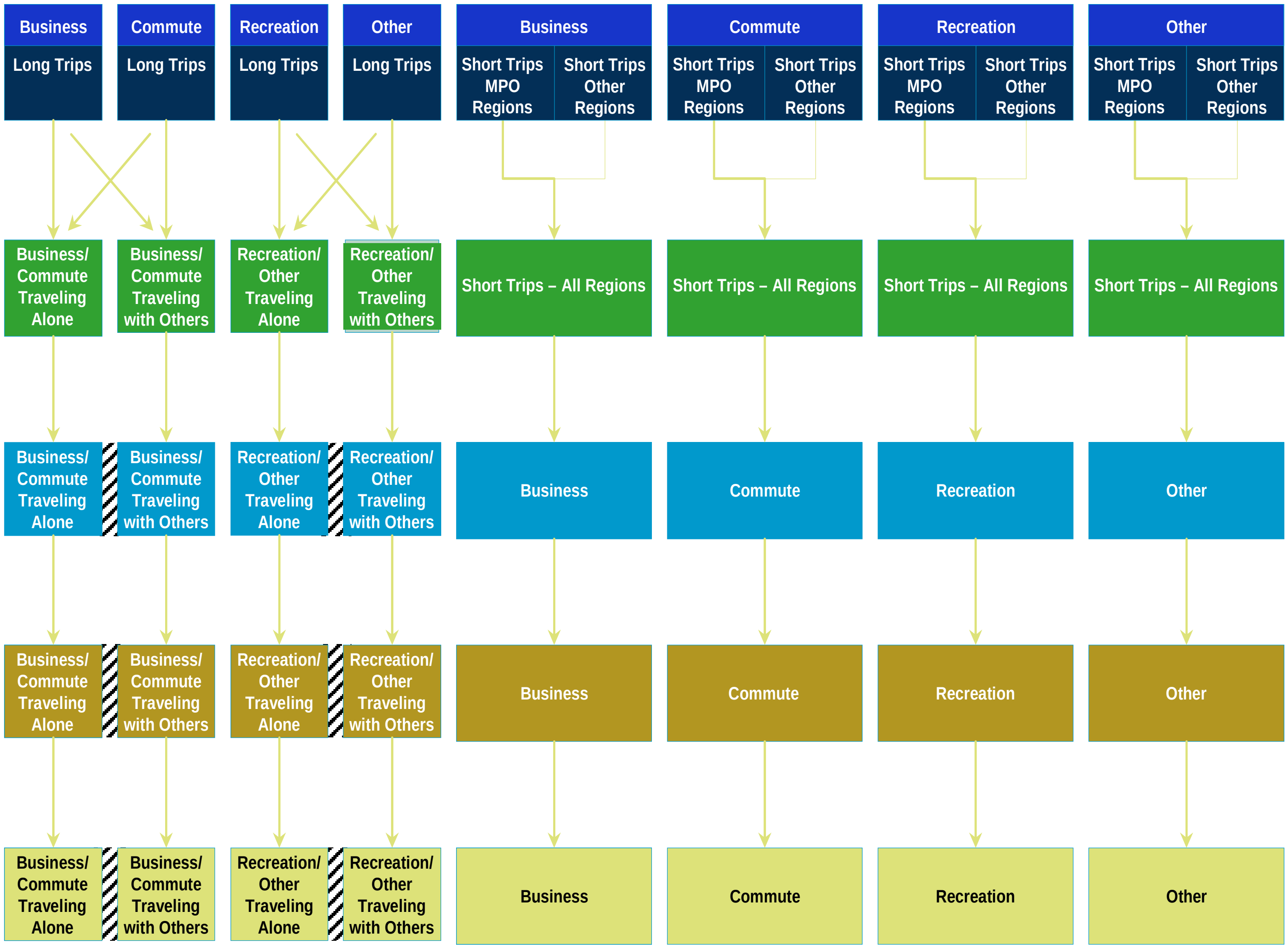
- Purpose:
  - Business;
  - Commute;
  - Recreation; and
  - Other.

- Distance range/residence area type:
  - Less than 100 miles, from large MPO regions;
  - Less than 100 miles, from small MPO regions; and
  - More than 100 miles.
- Household size – 1 person, 2 people, 3 people, and more than 4 people.
- Household income range – Low, medium, and high.
- Household auto-ownership – 0, 1, and 2+.
- Household number of workers – No worker, 1 worker, and 2+ workers.
- Party size: Traveling alone, and traveling with others.

The distance ranges of less than or greater than 100 miles were determined by reviewing the trip length distributions from the surveys and applying judgment about behavior for short versus long trips. Party size is a segmentation variable primarily for the recreation and other segments, because it has a large effect on the travel cost of the car mode versus the other modes, and thus on the choices throughout the model chain.

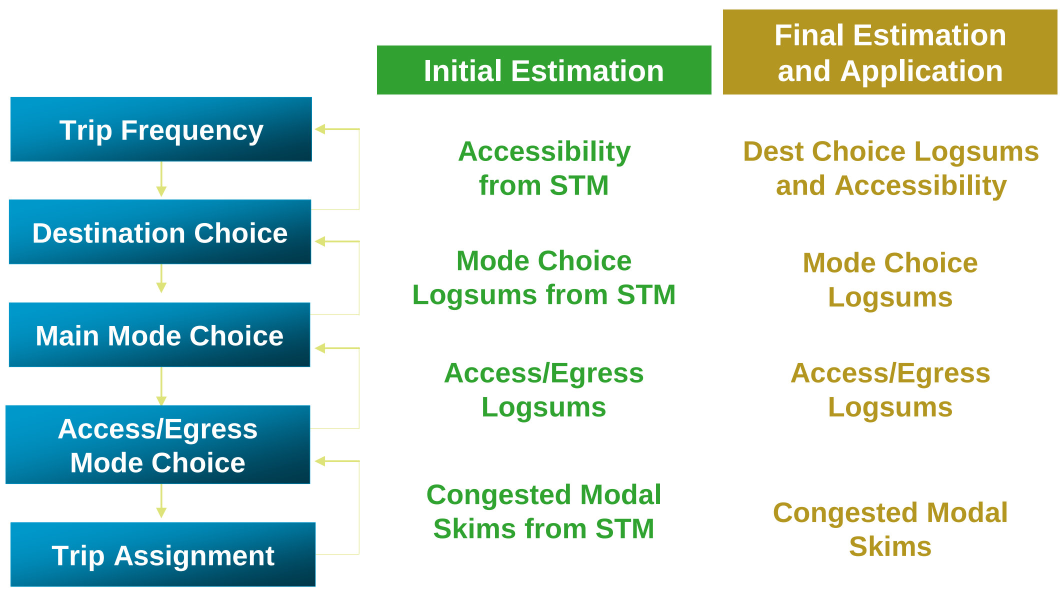
These market segments vary by model component to take advantage of additional detail in some areas or aggregation of market segments in other areas. The market segments in each model component are presented in Figure 2.4 and are described further in the report, *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Interregional Model System Development.*

Figure 2.4 Market Segments in Each Model



The trip frequency, destination choice, and mode choice models all use accessibility or impedance measures as inputs to the logit choice equations. For each model component, these measures were calculated from subsequent model components and as a result, were not available during the initial model estimation. So, for each model component, a substitute accessibility or impedance measure was calculated to use for initial model estimation, and then replaced with the actual measure. These linkages are presented in Figure 2.5.

Figure 2.5 Model Component Linkages



2.2 Intraregional Models

Intraregional models were used to forecast high-speed rail trips with both ends within a region that has more than one proposed high-speed rail station. These areas are the San Francisco Bay Area, Greater Los Angeles, and San Diego regions. In addition, intraregional auto trips were estimated and included in auto assignments for all 14 regions in the State.

Regional travel forecasting models for the San Francisco and Los Angeles regions were modified to forecast intraregional high-speed rail trips for these areas. The market segments for intraregional travel include typical trip purposes, such as home-based work, school, university, shopping, social-recreational, and other trips, as well as work- and nonwork-related nonhome-based trips. Due to the small amount of potential for high-speed rail trips wholly contained within the San Diego region, these were estimated based on expected high-speed rail trips per person rather than by applying the local regional travel model.

To model intraregional trips, we relied on the trip generation and distribution models in each of the urban areas and modified existing mode choice models.

The urban mode choice models include a variety of transit modes, but not specifically a high-speed rail mode in any model. San Francisco urban mode choice models were modified to insert a high-speed rail mode based on coefficients and constants from the commuter rail mode. Following is a brief description of the model implementation for each of the urban areas:

- **San Francisco Bay Area –** The MTC regional model was enhanced to include transit submodes (San Francisco Bay Area Rapid Transit District (BART), commuter rail, light rail, ferry, local bus, and express bus) in the mode choice model. This allowed for easier inclusion of the high-speed rail mode in the model. The new mode choice model was validated at the regional level to match observed ridership numbers by mode, purpose, and time period.
- **Los Angeles Region –** The SCAG region was modeled using an adaptation of the MTC mode choice model combined with SCAG networks and modes (urban rail, commuter rail, local bus, express bus, and high-speed rail). This new mode choice model was validated at the regional level to match observed ridership numbers by mode, purpose, and time period.

Intraregional trip tables by mode and time period from the MTC and SCAG metropolitan areas were added to the interregional trips for the assignment.

3.0 Data Collection

3.0 Data Collection

There were three types of data compiled for the study: travel surveys, socioeconomic data, and base year travel patterns.

3.1 Travel Surveys

The travel survey data used for this project was a combination of new surveys collected for the project and existing surveys from regional and state agencies. There were three surveys available from MPOs around the State (SCAG, MTC, and Sacramento Association of Governments (SACOG)), and there was a Caltrans statewide survey available. The interregional models were based on revealed- and stated-preference surveys, collected specifically for this study, of air and rail travelers, as well as additional households in the State to capture auto travelers. These new data were collected in 14 regions in California. These were combined with revealed-preference surveys of households across the State collected by Caltrans and interregional travel extracted from the MPO regional travel surveys (San Francisco, Sacramento, and Los Angeles). Intraregional mode choice models were based on urban area travel surveys in combination with a stated-preference survey for high-speed rail conducted in Los Angeles. By combining the various available data sources, we were able to provide more robust datasets for model estimation than was otherwise possible. After combining these surveys, 6,882 completed surveys were available to use for model estimation, as shown in Table 3.1. There were different estimation datasets used for each model component, depending on the requirements for the model. This is described in more detail in the *Interregional Model System Development Report* (Cambridge Systematics, Inc., 2006).

Table 3.1 Total of All Survey Interregional Trips by Mode, Distance, and Purpose

	Drive	Air	Rail	Bus	Other	Total
Long Trips						
Business	314	620	27	18	17	996
Commute	263	15	9	1	74	362
Recreation	1114	228	80	3	23	1448
Other	365	85	17	8	91	566
Short Trips						
Business	381	14	48	3	15	461
Commute	1136	0	168	9	108	1421
Recreation	873	2	29	3	52	959
Short Other	591	1	10	23	44	669
Total	5,037	965	388	68	424	6,882

3.2 Socioeconomic Data

The core drivers of demand for interregional travel in California are the socioeconomic characteristics of Californians and the State's economic and employment picture. The relevant sources of current year data and 2030 socioeconomic projections are:

- Decennial Census data products, specifically the Census Transportation Planning Package (CTPP) and the Summary Tape File (STF) 1;
- Local agency socioeconomic estimates and projections, such as those developed and updated by the Association of Bay Area Governments (ABAG), SCAG, SANDAG, and SACOG; and
- State Department of Finance (DOF) and Caltrans projections.

To the extent that commercial sources and state employment data are used to develop the local agency socioeconomic estimates and projections, they were included, but these were not evaluated and incorporated separately for this study because there is a desire to remain consistent with current local agency forecasts.

At the heart of any travel forecast is the growth in population and employment. Since the California statewide model is based on households, we present growth based on households and employment in Table 3.2. This table shows that the three largest urban areas (SANDAG, MTC, and SCAG) are growing slower than the average, which is intuitive since these areas are more saturated than other parts of the State.

Table 3.2 Socioeconomic Forecasts from 2000 to 2030 by Region

	Households			Employment		
	2000	2030	Percent Increase	2000	2030	Percent Increase
AMBAG	226,349	395,421	75%	286,937	436,369	52%
Central Coast	227,200	401,234	77%	278,494	450,493	62%
Far North	376,965	627,175	66%	335,737	522,011	55%
Fresno / Madera	287,110	548,198	91%	365,397	678,786	86%
Kern	207,413	465,913	125%	242,283	707,966	192%
South SJ Valley	144,050	271,240	88%	170,813	336,868	97%
Merced	63,225	125,328	98%	63,403	130,516	106%
SACOG	571,978	817,389	43%	946,259	1,469,041	55%
SANDAG	988,205	1,305,990	32%	1,168,880	1,875,810	60%
San Joaquin	180,276	341,230	89%	202,498	345,819	71%
Stanislaus	143,942	311,488	116%	159,900	354,453	122%
W. Sierra Nevada	68,929	110,703	61%	55,358	99,057	79%
MTC	2,465,287	3,088,370	25%	3,753,533	5,120,598	36%
SCAG	5,631,180	7,623,778	35%	7,393,491	10,740,549	45%
Total	11,582,109	16,433,457	42%	15,422,983	23,268,336	51%

3.3 Base Year Travel Patterns

Travel surveys were combined to create a comprehensive set of data for use in calibrating the trip frequency, destination choice, and mode choice models. The following surveys were used for each of the interregional trip purposes:

- The American Traveler Survey (ATS)[3] was used to validate the business, recreation, and other long-trip purposes. The ATS, developed and conducted by the Bureau of Transportation Statistics (BTS) in 1995, obtained information about long-distance travel of persons living in the United States. The information was used to identify characteristics of current use of the nation's transportation system, forecast future demand, analyze alternatives for investment in and development of the system, and assess the effects of

[3] U.S. Department of Transportation Bureau of Transportation Statistics, *1995 American Traveler Survey, Technical Documentation*, http://www.bts.gov/publications/1995_american_travel_survey/index.html.

Federal legislation and Federal and state regulations on the transportation system and its use.

- The Census Transportation Planning Package (CTPP)[4] was used to validate the commute for long- and short-trip purposes. CTPP is a set of special tabulations from the decennial census designed for transportation planners. CTPP contains tabulations by place of residence, place of work, and for flows between home and work. CTPP is a cooperative effort sponsored by the state Departments of Transportation (DOT) under a pooled funding arrangement with the American Association of State Highway and Transportation Officials (AASHTO). The data are tabulated from answers to the Census 2000 long-form questionnaire mailed to one in six U.S. households. Because of the large sample size, the data are reliable and accurate. CTPP provides comprehensive and cost-effective data, in a standard format, across the United States.
- The California Statewide Travel Survey[5] was used to validate the business, recreation and other short trip purposes. The California Statewide Travel Survey was conducted in 2000 to 2001 for weekday travel. This survey was an activity-based survey and included all in-home activities and travel completed in accessing activity locations over a 24-hour period. The survey of 17,040 households was conducted in each of the 58 counties throughout the State. The survey reported 8.6 total trips per household.

The datasets were summarized by major market (based on city-to-city trip movements), because this was a focus of the model validation effort. Table 3.3 presents the validation dataset for the long-interregional trips, and Table 3.4 presents the validation dataset for the short-interregional trips.

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[4] U.S. Department of Transportation, Federal Highway Administration, Census Transportation Planning Package, September 11, 2006, http://www.fhwa.dot.gov/ctpp/.

[5] State of California, Department of Transportation, Division of Transportation System Information, Office of Travel Forecasting and Analysis, Statewide Travel Analysis Branch, *2000-2001 California Statewide Travel Survey Weekday Travel Report*, June 2003.

Table 3.3 2000 Average Daily Interregional Trips Over 100 Miles (Long)

Source→	CTPP	American Traveler Survey			
Trip Purpose→	Commute	Business	Recreation	Other	Total
Market					
LA to Sacramento	5,103	5,169	7,127	1,467	18,866
LA to San Diego	29,665	10,313	61,763	13,567	115,308
LA to SF	22,124	17,356	44,108	6,787	90,375
Sacramento to SF	16,986	5,645	21,443	7,306	51,380
Sacramento to San Diego	886	1,227	1,227	218	3,558
San Diego to SF	4,840	5,966	16,443	2,258	29,507
LA/SF to SJV	53,741	4,396	19,777	5,690	83,604
Other to SJV	10,950	12,538	12,886	4,725	41,099
To/from Monterey/ Central Coast	28,809	8,271	19,829	6,796	63,705
To/from Far North	16,982	3,129	12,359	2,366	34,836
To/from W. Sierra Nevada	9,730	531	7,528	1,510	19,299
Total	199,817	74,540	224,491	52,691	551,539

Table 3.4 2000 Average Daily Interregional Trips Under 100 Miles (Short)

Source→	CTPP	Caltrans Travel Survey			
Trip Purpose→	Commute	Business	Recreation	Other	Total
Market					
LA to Sacramento	0	0	0	0	0
LA to San Diego	69,728	19,244	42,340	27,512	158,824
LA to SF	0	0	0	0	0
Sacramento to SF	37,192	17,805	17,383	12,394	84,774
Sacramento to San Diego	0	0	0	0	0
San Diego to SF	0	0	0	0	0
LA/SF to SJV	77,112	11,769	16,565	25,518	130,964
Other to SJV	128,792	20,223	24,382	8,341	181,738
To/from Monterey/ Central Coast	96,448	16,351	44,784	67,024	224,607
To/from Far North	36,658	15,626	47,494	89,480	189,258
To/from W. Sierra Nevada	17,672	2,421	10,566	6,840	37,499
Total	463,603	103,439	203,514	237,108	1,007,664

Air passenger data was acquired from the U.S. DOT Federal Aviation Administration (FAA) origin-destination (O&D) 10-percent sample database. This includes actual ticket information for 10 percent of the tickets collected by large air carriers. While the 10-percent ticket sample data represent a robust data of air fares and travel times, these data are subject to sampling error. In addition, the O&D databases generally do not include tickets for passengers with itineraries that begin on airlines classified by the FAA as “Small Certificated Air Carriers,” those airlines who do not fly any planes with more than 60 seats.

Rail passenger data were obtained from interregional rail operators in California and from MPOs in the State for intraregional area rail travel. The data have been aggregated for each urban area and for each interregional rail market. The allocation of rail boardings to interregional and intraregional for the San Francisco Bay Area is based on estimates provided by the MTC.

Highway traffic counts were obtained primarily from the Caltrans traffic count database and from the MTC and SCAG traffic count databases. Sacramento and San Diego urban area traffic count databases were not required since the Caltrans traffic count data has sufficient locations in these regions, and because the networks were largely compatible with the Caltrans database rather than the MPO databases.

4.0 Existing Modal Services

4.0 Existing Modal Services

The base year service levels were used in model calibration/validation, and forecast year service levels were used in model application to evaluate alternative scenarios. The primary sources of this supply information were the California Statewide Travel Demand Model[6], which includes both highway, and public mode transportation networks (base and forecast), the regional travel demand models, and the base year published timetables and fare tables for public modes.

The Statewide Model and the MTC, SCAG, SANDAG, and SACOG demand models were used to develop base year and forecast year highway networks that reflect congested travel times by time of day. The Statewide Model is the primary source of the intercity highway network, and we retained that model's zone system for most of the state geography. Where the Statewide Model overlaps with one of the large regional model systems, we added detail from the regional models.

We also updated the Statewide Model's public mode networks using airline schedule and fare information from the Official Airline Guide, the airline web sites, and the U.S. DOT's T-100 reports. We assembled intercity rail schedules and fares from Amtrak and other rail operators in the corridor. We used the regional models to develop base year and forecast year intraregional transit networks for the new zone system.

4.1 Air Service

Base and future year air networks included 18 airports within California that offer significant commercial airline passenger service between California cities. Table 4.1 lists these airports and provides estimates of their numbers of annual passenger boardings for intrastate travel for the years 2000 and 2005. Los Angeles International (LAX) is the busiest airport in California with more than 2.6 million boardings in 2000; and Oakland International Airport (OAK) is the busiest California airport in 2005 with almost 2.6 million boardings. The Long Beach Airport had almost no intrastate service in 2000, but JetBlue began significant California operations at Long Beach Airport between 2000 and 2005, which significantly increased ridership at this Airport.

[6] California Department of Transportation and Dowling Associates, Inc., *California Statewide Model Description*, January 20, 2004.

Table 4.1 Annual Intrastate Passengers for California Airports

Airport	Airport Code	Annual Passengers 2000	Annual Passengers 2005	Percent Change
San Diego	SAN	1,814,410	1,563,190	-14%
Santa Ana	SNA	1,259,160	1,141,630	-9%
Long Beach	LGB	130	231,380	18%
Los Angeles	LAX	2,648,790	1,723,580	-35%
Ontario	ONT	962,530	874,900	-9%
Burbank	BUR	1,230,590	1,045,620	-15%
San Jose	SJC	1,930,020	1,510,660	-22%
San Francisco	SFO	1,960,230	812,650	-59%
Oakland	OAK	2,341,300	2,593,880	11%
Sacramento	SMF	1,555,760	1,634,400	5%
Palm Springs	PSP	87,610	88,410	1%
Oxnard	OXR	5,310	2,060	-61%
Santa Barbara	SBA	84,560	22,310	-74%
Bakersfield	BFL	5,440	3,050	-44%
Fresno	FAT	25,790	22,850	-11%
Monterey	MRY	18,620	21,810	17%
Arcata/Eureka	ACV	29,440	37,000	26%
Modesto	MOD	5,920	3,300	-44%
Total		15,965,610	13,332,680	-16%

In addition to those listed, there were 17 other airports in California that offered scheduled air service, but did not provide significant intrastate service or passengers to warrant being included in the air network for this study. These airports include Crescent City (CEC), Chico Municipal (CIC), Carlsbad McClennan Palomar (CRQ), Imperial County (IPL), Inyokern (IYK), Merced Municipal (MCE), Palmdale (PMD), Redding Municipal (RDD), Riverside March (RIV), San Luis County Regional (SBP), Stockton Metropolitan (SCK), Santa Maria (SMX), Sonoma County (STS), Lake Tahoe (TVL), Victorville (VCV), Visalia (VIS), and Van Nuys (VNY).

Fifty-seven airport-to-airport pairs had nonstop commercial intrastate air traffic for both 2000 and 2005. Airport-to-airport pairs that required a connecting flight were not considered. Air level of service information, including gate-to-gate travel time, fares, and reliability, are based on averages of the FAA data obtained from the 10-percent ticket sample, supplemented with Internet queries in August 2006.

Figure 4.1 California Statewide Air Network

4.2 Highway Supply and Traffic Counts

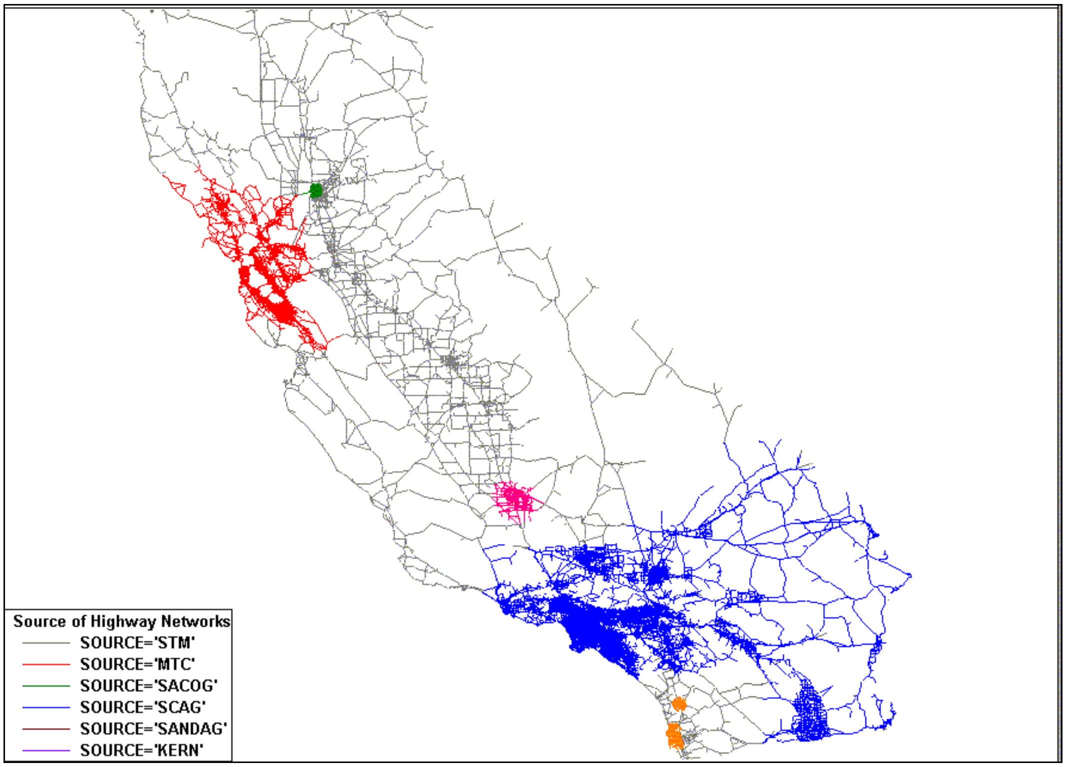
The representation of highway network supply is primarily determined by the level of detail in the highway network and the attributes associated with the roadway system, such as lanes, distances, speed, and capacity. A brief summary of these networks is provided here.

Beginning with the existing statewide highway network, detail was added using the following regional models:

- **MTC region –** The entire highway network was incorporated into the model;
- **SCAG region –** The entire highway network was incorporated into the model;
- **SANDAG region –** Highway network was incorporated only within a five-mile radius of the three proposed high-speed rail stations;
- **SACOG region –** Highway network was incorporated only within a five-mile radius of the proposed high-speed rail station; and
- **Kern County region –** Highway network was incorporated only within a five-mile radius of the proposed high-speed rail station.

Figure 4.2 shows the highway network in CUBE software. The new highway network includes 4,667 zones; 127,600 links; and 206,150 nodes.

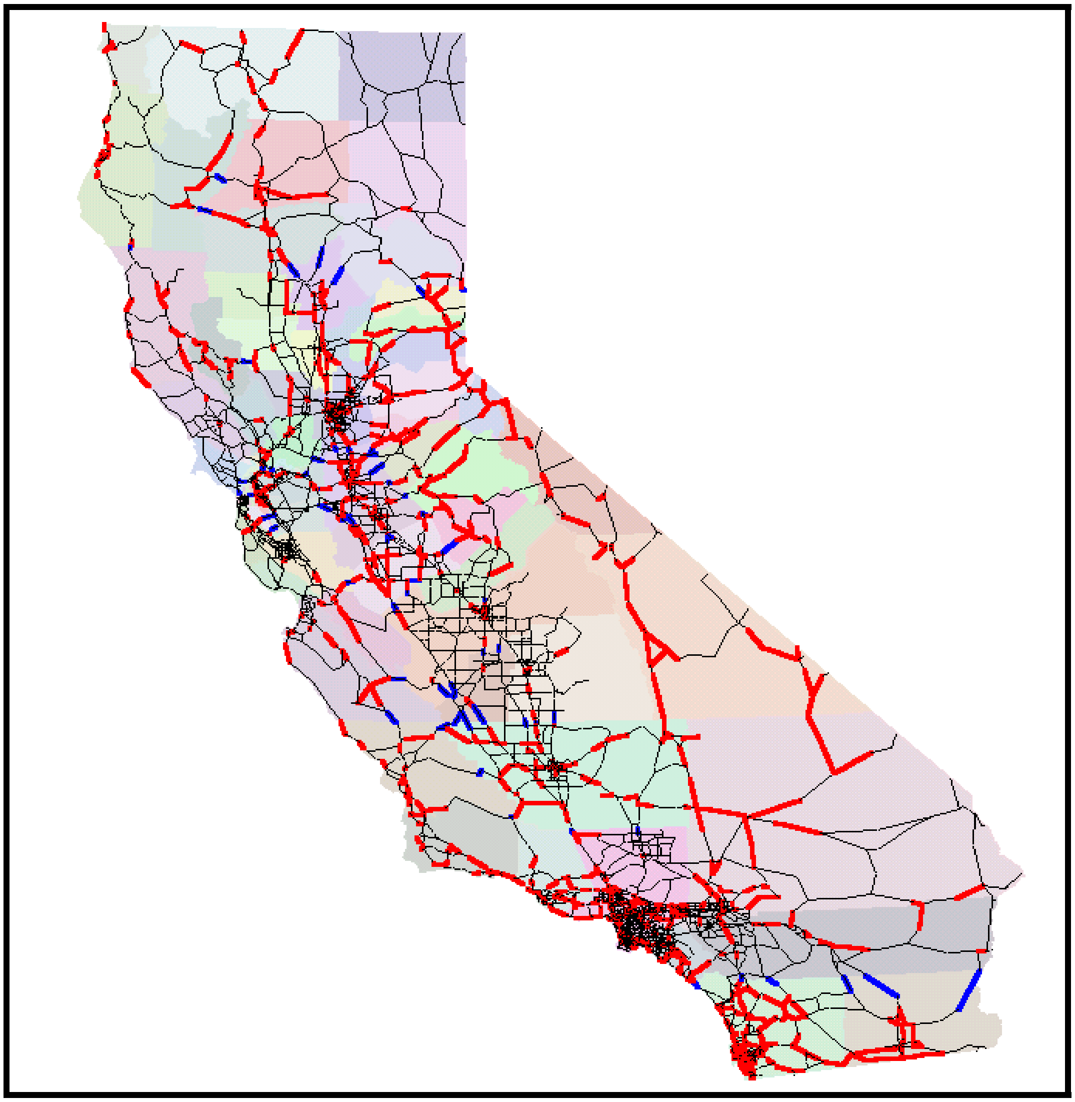
Figure 4.2 New Statewide Model Highway Network



Roadway and area type classifications from the various regional models have been consolidated to eight functional classifications and three area types. Speed and capacity definitions by functional class and area type are different for each regional model. These values are based on local conditions in each region, and some minor modifications were made during model validation. To take advantage of the work done in each region, values from the individual models were kept intact instead of developing a new look-up table based on area type and functional class.

Traffic counts were obtained from the Caltrans traffic count database. It included detailed daily and hourly traffic counts from approximately 1,100 permanent count census station locations. Two-way total daily traffic volumes were also input from the 2000 Caltrans *Traffic Volumes* for 75 locations on screenlines. These are displayed in Figure 4.3. This traffic count data was also supplemented from the individual regional models. These include the Los Angeles, Sacramento, San Francisco, San Diego and Kern county regions.

Figure 4.3 Caltrans Count Stations (Red) and Screenline Locations (Blue)



4.3 PASSENGER RAIL SERVICES

Year 2000 passenger rail services consist of a variety of intraregional and interregional services. Passenger rail services were also subdivided by mode – metro rail (i.e., BART), conventional rail (both intercity and commuter services), and light rail. These rail services for interregional travel are as follows.

- The San Diego Region has two rail operators – San Diego Trolley (light rail) and the Coaster (conventional rail).
- The SCAG region has metro, conventional, and light-rail services. The Los Angeles Metropolitan Transportation Authority (MTA) operates metro and light-rail services. The Southern California Regional Rail Authority (SCCRA) operates Metrolink conventional commuter rail services. The MTA Rail system is comprised of the Metro Blue, Green, Red, and Gold Lines. The Metro Red Line subway operates between Union Station, the Mid-Wilshire area, Hollywood, and the San Fernando Valley. The remaining light-rail lines are the Blue Line (Long Beach to Los Angeles), the Green Line (Norwalk to Redondo Beach), and the Gold Line (Los Angeles Union Station (LAUS) to Pasadena).
- Within the MTC region, metro, convention and light-rail services are provided. Services include BART, Caltrain, Muni Metro, and Santa Clara Valley Transportation Authority (VTA) light-rail systems. In 2000, the BART system consisted of 39 stations serving four East Bay lines (Fremont, Dublin/Pleasanton, Pittsburg/Bay Point, and Richmond), as well as the Daly City/Colma line through San Francisco and the West Bay. In 2002, BART service was extended south of Colma to San Francisco Airport and to Millbrae, and four new stations were added. Caltrain currently operates 86 daily trains between San Jose and San Francisco, including three daily peak-period, peak direction round trips to Gilroy. There are five light-rail (metro) lines that operate in the Market Street subway, three cable car routes, and the historic trolley line operating on Market Street. Santa Clara light-rail lines were extended in 2000 to East San Jose (Alum Rock) and to Winchester (Vasona line).
- The SACOG region's rail services are limited to the Sacramento RT light-rail system. Since 2000, two RT extensions have come on-line: in 2003, the South Line extension was implemented. This new extension resulted in RT running two lines for the first time. More recently, the Folsom extension became operational. The Folsom Line is an extension of the existing line that operates along the U.S. 50 corridor.

Interregional rail services are all conventional rail systems. These include the Capitol Corridor, Altamont Commuter Express (ACE), Surfliner, and the San Joaquin systems. The intraregional and interregional rail services are shown in Figure 4.4

Figure 4.4 California Statewide Conventional Rail Network

Table 4.2 presents the conventional rail passenger boardings for the year 2000 by operator and route for both intraregional and interregional travel. These data were developed from daily ridership estimates and annualized using 260 days per year for ACE (which only has weekday services), 300 days per year for all remaining intraregional services, and 335 days per year for all interregional services.

Table 4.2 California Statewide Conventional Rail Passengers

		2000 Annual Passengers		
Operator/Route	Market Served	Total Boardings	Intraregional	Interregional
Amtrak Capital Corridor	Sacramento to San Francisco	1,070,500	300,000	770,500
Amtrak Surfliner	Santa Barbara to San Diego	1,610,500	840,000	770,500
Amtrak San Joaquin	San Joaquin Valley to San Francisco	703,350	30,000	673,350
ACE	Stockton to San Jose	806,000	182,000	624,000
Coaster, San Diego Trolley	San Diego region	29,220,000	29,220,000	0
Metrolink, Metro Rail	Los Angeles region	70,971,000	70,770,000	201,000
BART, Caltrain, SF Muni, Santa Clara VTA	San Francisco region	166,770,000	166,770,000	0
Regional Transit LRT	Sacramento region	11,280,000	11,280,000	0
Total		282,431,350	279,392,000	3,039,350

5.0 Ridership Model Development

5.0 Ridership Model Development

5.1 INTERREGIONAL MODELS

The interregional models are comprised of four sets of models: trip frequency, destination choice, main mode choice, and access/egress mode choice. The structure and contents of the interregional modeling system are presented in Figure 2.3. The trip frequency model component predicts the number of interregional trips that individuals in a household will make based on the household's characteristics and location. The destination choice model component predicts the destinations of the trips generated in the trip frequency component based on zonal characteristics and travel impedances. The mode choice components predict the modes that the travelers would choose based on the mode service levels and characteristics of the travelers and trips. The mode choice models include a main mode choice, where the primary interregional mode is selected; and access/egress components, where the modes of access and egress for the air and rail trips are selected. These are described in more detail below.

Trip Frequency

We used a simple multinomial logit (MNL) model to predict interregional trip frequency. Eight trip frequency models predict interregional person-trips per day, segmented by trip purpose (business, commute, recreation, and other) and length (over or under 100 miles). The MNL formulation allows important explanatory variables, such as accessibility measures, to affect the propensity to make interregional trips. In this case, the composite logsums from the destination choice model are fed back to the trip frequency model to account for travel that is induced due to the presence of high-speed rail (or any other new services). The trip frequency models are segmented by length to allow different model specifications and parameters for short and long trips. For each model, the choice set for each person is zero, one, or two or more interregional trips per day. The final model specification constrains the variable coefficients of one-trip and two-trip choices to be equal, while allowing the alternative-specific constants for one- and two- trip choices to be estimated individually. This overcomes some illogical individual variable coefficients for each market segment, but allows us to retain separate choices for interregional travel.

Three types of variables were tested in the trip frequency models: socioeconomic, accessibility, and geographic region of residence. Even though the trip frequency models are estimated at the person level, estimation variables were constrained to be at the household level to be consistent with existing future year socioeconomic predictions. Socioeconomic variables that were tested in model specifications include household size; household size greater than two dummy variable; number of household workers; zero-worker household dummy variable; number of household vehicles; number of household vehicles is less than the number of household workers dummy variable; zero-vehicle household dummy variable; high household income (greater than $75,000); medium household income (between $35,0000 and $75,000); low household income (less than or equal to $35,000); and a missing income dummy variable for survey records with no income collected. The missing income dummy variable is used during model estimation, but is not included in the final model specification for application.

The estimation results follow an intuitive pattern. More household workers increase one's propensity to make interregional business and commute trips, but decrease one's propensity to make interregional recreation and other trips. The income coefficients indicate that as income increases, more interregional trips are taken. Households with fewer cars than workers are less likely to have the resources to undertake interregional travel. Three-person households are less likely to undertake interregional recreation and other trips, perhaps substituting this type activity closer to home.

As discussed above, the trip frequency models include measures that capture the accessibility of all relevant travel opportunities from travelers' home zones. For each residence, we calculated three peak/work and three off-peak/nonwork accessibility measures for destinations in 1) their home region; 2) outside their region, within 100 miles of home; and 3) over 100 miles from home. The final model specifications rely on synthesized accessibility measures (a weighted travel time) for the within home region destinations and on logsums calculated from the destination choice models for the remaining accessibility measures. The synthesized accessibility measure is necessary within the home region since the urban area models are not destination choice models (they are gravity models), and are therefore not able to produce logsums for the destination choices within the region. Logsums are a means to produce a weighted average of all potential destinations.

A high calculated "regional accessibility" to jobs, goods, and services within one's region of residence indicates less need to travel outside of the region. Therefore, as expected, this variable has a negative effect on all interregional travel. Separate short (within 100 miles of residence and outside the residence region) and long (outside 100 miles of residence and outside the residence region) logsums were calculated to represent accessibility to goods and services outside of one's home region. A higher logsum outside a home region increases the likelihood that an interregional trip will be undertaken.

Regional dummy variables for the MTC, SANDAG, SACOG, and SCAG regions are included to account for the different interregional trip-making patterns observed for residents of large, metropolitan areas compared to residents in the rest of California. These were calibrated to match observed trips in these regions.

Destination Choice

The destination choice models were estimated with a simple multinomial logit model structure using ALOGIT software. The destination choice estimation dataset used the trip frequency dataset combined with the SP survey (used in the mode choice models) to increase the number of "long" (more than 100 miles) trips in the dataset (By nature, the household surveys are generally better at capturing the more typical "short" trips.). Since the trip frequency models already differentiate between the two, we can use this information as a valuable input to the destination choice models. This not only constrains an individual's choice set based on destinations being greater or less than 100 miles, but it recognizes that an individual may value different trip characteristics for different distance-categories of travel.

The short-trip destination choice models used all four trip purposes modeled in the trip frequency step: business, commute, recreation, and other. Due to sample size considerations, only two aggregate trip purposes were estimated for the long-trip destination choice models: business/commute and recreation/other.

The models use multimodal composite logsums from the mode choice models. This variable measures the combined utility of all available modal choices and level of service characteristics. All the destination choice models use a distance power series, including distance, distance-squared, and distance-cubed. An area type is assigned to each destination zone: rural, suburban, or urban. The models use several interaction terms to capture whether travelers were starting and ending in the same area type: rural to rural, suburban to suburban, and urban to urban.

Similar to the area type interaction variables, the location type interaction variables relate where you want to go, to where you currently are, based on the location of the origin and destination. We tested four origin-destination location type interaction variables for all the "long" destination choice models: Los Angeles to/from San Francisco, Sacramento to/from San Francisco, San Francisco to/from San Diego, and Sacramento to/from Los Angeles. These were adjusted during model calibration to match observed travel. Size functions measure the amount of activity that occurs at each destination zone, and incorporate this into the utility of alternative variables. This variable is used in the destination choice models to account for differences in zone sizes and employment levels. Four size variables are used in these models: retail employment, service employment, other employment, and households. Other employment is used as the base size variable for business and commute trips and is constrained to 1.0, while retail and service are further segmented by household income levels – low, medium, high, and missing. Households are used as the base size variable for recreation and other trips. Income is used as a per person variable as an interaction between employment and income to show that different income levels of the destination choices will affect the attractiveness of the zone for particular travelers. For commute trips, short and long, as income increases, retail employment has a bigger impact on destination choice than service employment.

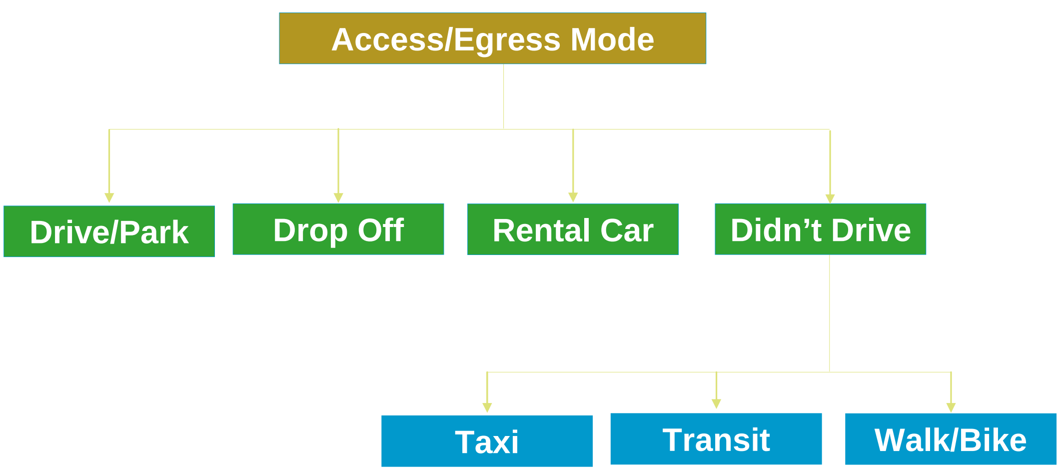
The model estimation results of the destination choice models were reasonable. The distance power series of coefficients for these models are both decreasing functions as expected. All other variables have the sign and size we expect, except for the coefficient of rural to rural for recreation/other trips, which is positive when we expect it to be negative, but it is not significantly different than zero.

Mode Choice

There were two types of mode choice models developed for this study: access and egress models and main mode choice models. Models were estimated to predict the access and egress modes to and from airports and rail stations. The models were based on actual reported and hypothetical-stated data. For people who were intercepted making actual air or rail journeys, the access and egress mode choices are the actual reported ones. For people whose actual journey was by car, the air and conventional rail access/egress mode choices are hypothetical. Obviously, the high-speed rail access and egress mode choices are hypothetical for all respondents.

For access, the majority of respondents reported either driving or parking at the station/airport or else getting dropped off. For egress, the reported mode shares varied more by purpose and distance, with transit more popular for short trips, and rental car and taxi more popular for long trips and business trips. In all there were six modes considered for each. A nested structure was adopted, as shown in Figure 5.1. The auto modes – drive and (un)park, pick up/drop off, and rental car – are all in separate nests, while taxi, transit (bus or light rail), and walk are nested together. This nesting structure gave the most reasonable results for all purposes.

Figure 5.1 Access and Egress Mode Choice Model Structure



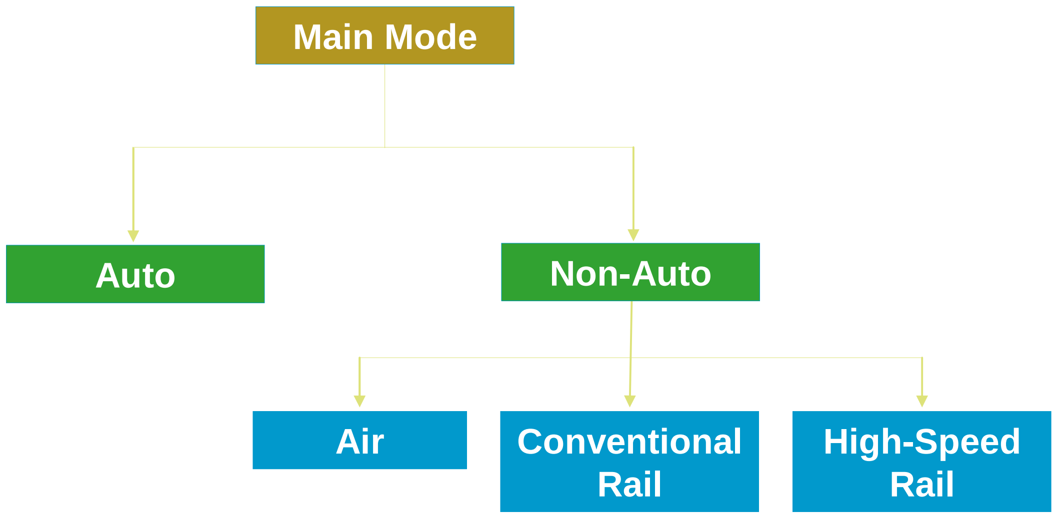
The results of the access/egress mode choice models were within expectations. A reasonable value of time was asserted for each segment based upon a review of other research. As the survey was not designed primarily to estimate access and egress choice models, and the zone size is in a statewide model is quite large for this type of local choice, the fact that access and egress time and cost parameters had to be constrained is perhaps not surprising. Also note that the costs of options, such as taxi and rental car and airport/station parking, are not readily obtained from network data. Other results of note are:

- The out-of-vehicle time coefficients were estimated for most segments, and result in ratios of out-of-vehicle time to in-vehicle time that are in the range of 2.0 to 2.9.
- The drop off and pick up alternatives have an additional negative in-vehicle time effect, capturing the disutility of the driver that has to make the round trip to the airport.
- We did not include taxi cost explicitly, but did include an additional distance coefficient for taxi, which is significant and negative for most segments, typically with an equivalent value of over $1.00 per mile.
- For most segments, transit is less likely to be chosen if there is no reasonable walk access to transit, meaning that a drive to transit path was included instead.
- For most segments, transit, which can include rail and/or bus, is more likely to be chosen if rail is included in the best transit path.
- For the long segments, taxi, parking, and rental cars are generally less desirable to rail stations than to airports, while transit is more desirable from rail stations. Walking is very rare to or from airports, capturing accessibility effects that are not captured well in the zone system.
- Drive-and-park access is less likely at the busiest airports – SFO, LAX, and SAN – and somewhat at SJC as well. This may capture both cost and inconvenience effects at those airports.
- For most segments, those in larger households are more likely to be dropped off.
- In general, high income favors rental car, taxi, and drive and park; and low income slightly favors transit in some segments.
- There is a logsum coefficient less than 1.0 on the nest that includes transit, walk, and taxi. Each of the other three alternatives is in its own "nest," and scaled by the same logsum parameter to preserve equal scaling at the elemental level.
- The scale (the inverse of the residual error variance) for the hypothetical choices relative to the actual choices was significantly lower than 1.0 for most of the egress model segments. This result indicates that many respondents have difficulty making an accurate assessment of mode choice options in less

familiar surroundings at the nonhome end of their trip, so that hypothetical choices should be weighted less in estimation than actual ones.

The main mode choice models produce probabilities that each trip will choose one of the main modes (auto, air, conventional rail, and high-speed rail). Several nesting structures were tested for the main mode choice models, and the final nesting structure chosen is shown in Figure 52 with all the nonauto modes in a single nest. This structure provided the most logical and statistically sound nesting structure for the mode choice models.

Figure 5.2 Main Mode Choice Model Structure



The main mode choice models were based on SP survey data. The overall choice shares in the SP data were around 50 percent for high-speed rail with most of the other choices for the respondents' actual chosen modes. The high-speed rail choice share was highest for business trips and long trips, giving a first indication that high-speed rail substitutes more closely with air than with car.

To prepare the data for estimation, the access and egress mode choice models were first applied to calculate access and egress mode logsums for each alternative. Then, a nested logit model was estimated across the four main modes for each of the segments (only three alternatives for the short segments, as air was not available for those segments).

Some of the results from the mode choice model estimation include the following:

- The residual mode-specific constants for high-speed rail are generally not very much higher than for the other modes. This result indicates that the high choice shares found for high-speed rail are mainly due to the attractiveness of the time and cost by the mode, rather than to SP-related survey effects or biases.

- The cost and in-vehicle time parameters were estimated nonconstrained and give very reasonable values of time (VOT). In general, VOT for the longer, more expensive trips is higher than for the shorter, more frequent trips. This is a typical result.
- The value of frequency (headway) is significant for all segments, but is only about 20 percent as large as the in-vehicle time coefficient. If wait time were half the headway and valued twice as highly as in-vehicle time, then we would expect the same coefficient on headway and in-vehicle time. For these modes, and particularly air, headway is less related to wait time than it is to scheduling convenience. Because none of the levels used in the SP had headways higher than a few hours, the implications for scheduling may not have been large enough to greatly influence mode choice.
- The value of reliability is fairly low for all segments, although with the correct sign. It is very difficult to measure the effect of reliability in a large-scale mailout SP survey, so we decided to use a somewhat higher effect of reliability in application, based on any evidence from elsewhere.
- Those traveling with others are more likely to use car and less likely to use air. This effect was also tested on the cost coefficients and not found to be significant, so this relative mode preference appears to be related to more than just cost – such as the fact that people can share driving for long trips. Party size models were estimated to generate these data, but are not included here for brevity.
- People in larger households are more likely to use car. Even though we already have the group/alone segmentation, people in larger households are likely to be in larger groups.
- Higher income generally favors air and high-speed rail versus auto.
- Low auto availability within the household is related to less chance of choosing the auto.
- A nest with air, rail, and high-speed rail (with car in its own "nest") produced a logsum coefficient below 1.0 for all segments, indicating that this was a reasonable nesting structure for interregional trips.
- The access mode choice logsums were estimated with positive coefficients in the range of 0.11 to 0.46 for all segments.

For the long trips, the egress mode accessibility seems to have somewhat more influence on mode choice than does the access mode. Travelers may be less constrained at the home end, where they know the options and can use their own auto, than they are at the destination end.

5.2 Intraregional Models

The intraregional models were developed to be integrated with existing MPO regional models and the Caltrans Statewide Model. To that end, the intraregional models rely on existing model trip tables as much as possible to provide a more streamlined modeling process. For both the San Francisco Bay Area and the greater Los Angeles region, mode choice models were adapted from existing models to include the high-speed rail mode and applied to the MPO trip tables for each region. San Diego is the only other region that contains the possibility of intraregional high-speed rail trips, but the estimate of these riders is very low relative to the other regions; and the level of effort to develop, calibrate, and apply the regional mode choice model is very high, so we decided to develop intraregional ridership for San Diego using a population-based estimate rather than a traditional mode choice model.

It was also necessary to supplement the three regions with multiple high-speed rail stations with auto trip tables for all other regions. Although there was no need for mode choice models in these regions, it was necessary to accurately represent congestion in these areas to present realistic travel times for auto trips across the State. These auto trip tables were derived from the Caltrans Statewide Model, but could be replaced with local or regional trip tables for statewide corridor or regional planning studies in the future.

MTC Regional Mode Choice Models

Mode choice models for the high-speed rail study were developed using the Transbay Mode Choice Models as a starting point. These mode choice models used a detailed submode version of the MTC mode choice model, and were then calibrated for work and nonwork purposes during peak and off-peak periods. School trips were included as trip tables for auto trips, but were not included in the mode choice models, because they were not likely to produce many high-speed rail trips[7]. The following trip purposes were modeled:

- Home-based work in four income quartiles;
- Home-based shop/other;
- Home-based social/recreation; and
- Non-home-based.

The four income groups for the MTC are households with less than $25,000; $25,000 to $50,000; $50,000 to $75,000; and more than $75,000. The home-based work peak models have walk and drive access for each transit mode: BART,

[7] Cambridge Systematics, *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study: Model Design, Data Collection and Performance Measures*, prepared for the Metropolitan Transportation Commission, May 2005.

commuter rail, light rail, express bus, local bus, and ferry. The updated MTC home-based work mode choice model structure is shown in Figure 5.3. The home-based off-peak and nonwork (both peak and off-peak) models have walk access for each transit mode, but only one drive access mode, which is the best path to drive to any transit mode. The updated MTC home-based work off-peak and nonwork mode choice model structure is shown in Figure 5.4. Modal constants for each mode, purpose, and time period were calibrated to match observed values in year 2000.

Figure 5.3 MTC Updated Mode Choice Structure for Home-Based Work Peak

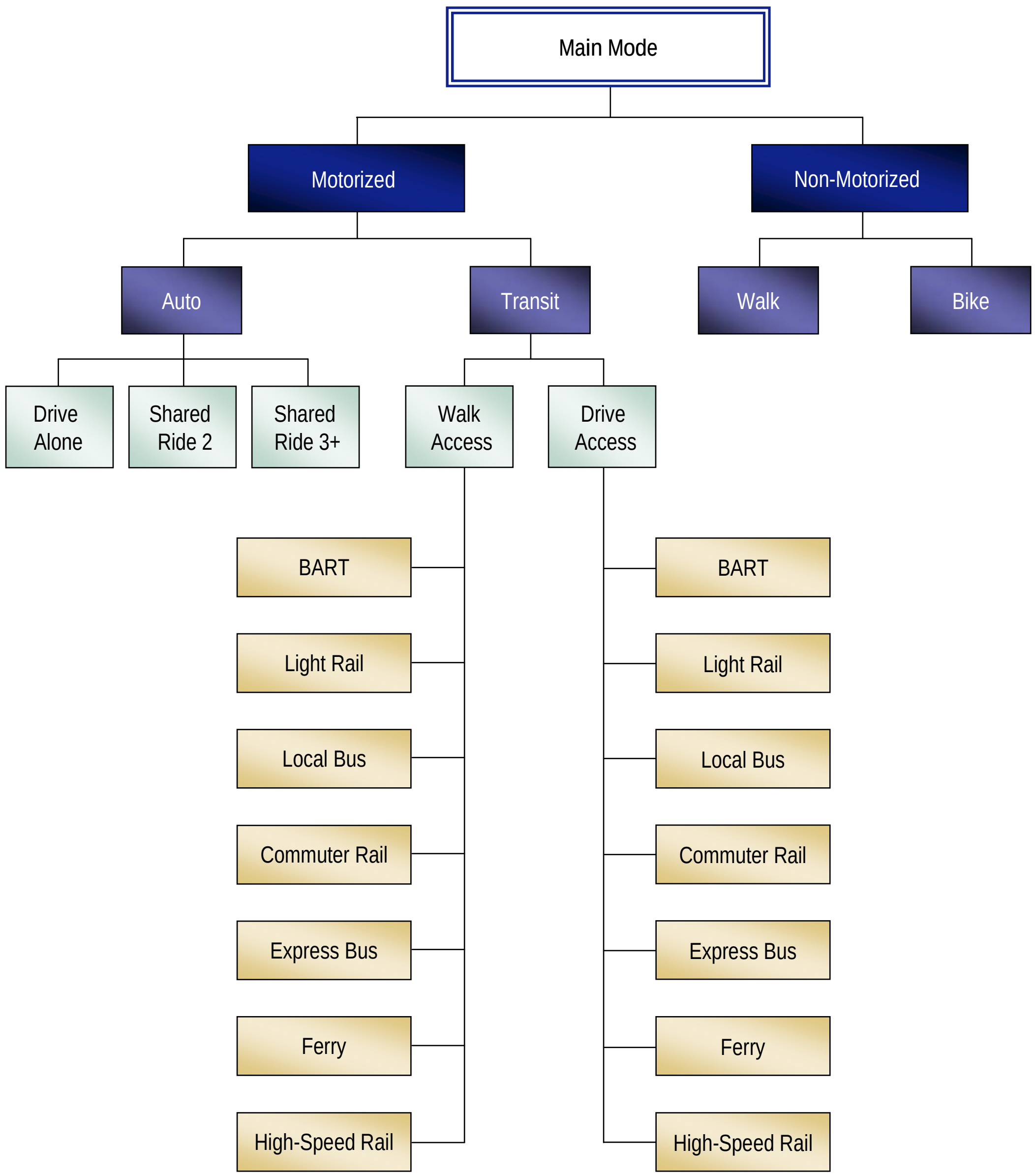
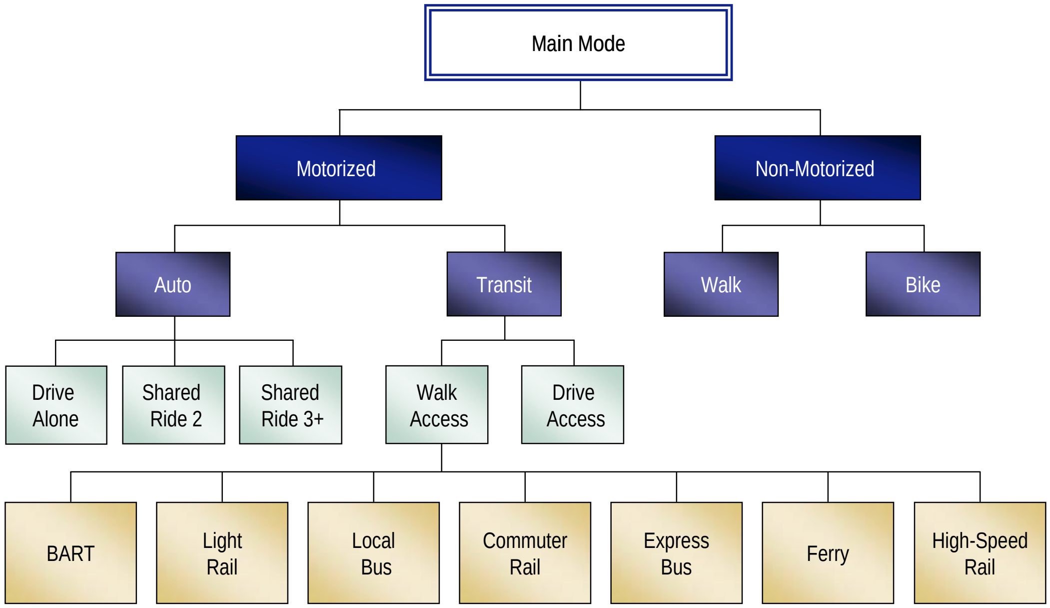


Figure 5.4 Updated MTC Mode Choice Model Structure for Nonwork and Off-Peak Models



The coefficients and utility equations for all modes are the same as the original MTC mode choice models[8]. The high-speed rail mode was established to emulate the commuter rail mode, with the same coefficients and constants for each purpose and time period. The constants were calibrated the same for all geographic areas within the Bay Area, even though the MTC model has the capability to incorporate different constants for different areas.

SCAG Regional Mode Choice Models

The SCAG regional mode choice models were adapted from the MTC regional model choice models for the same purposes and time periods, except that the home-based work off-peak and nonwork purposes retained the full nested model structure with separate submodes for drive access. This procedure was used to meet the schedule for high-speed rail forecasts required for environmental documentation, and is a more simplified mode choice model than is used by SCAG. It was calibrated to match SCAG's validation dataset by mode, purpose, and time period. The high-speed rail forecasting capability in the SCAG model is still under development. SCAG's own regional mode choice model is being used

[8] Metropolitan Transportation Commission, Travel Demand Models for the San Francisco Bay Area (BAYCAST-90) Technical Summary, June 1997. http://www.mtc.ca.gov/maps_and_data/datamart/forecast/BAYCAST%20Travel%20Models%20Tech%20Summary.pdf.

to estimate high-speed rail trips for a local planning study, and once validated could be used for further intraregional trip forecasting.

California Statewide Auto Trip Tables

The Caltrans Statewide Model was used to develop auto trip tables for the 11 other regions in the State beyond San Francisco and Los Angeles regions:

- Sacramento region;
- San Joaquin County;
- Stanislaus County;
- Merced County;
- Fresno/Madera Counties;
- South San Joaquin Valley region;
- Kern County;
- Monterey Bay Area region;
- Central Coast region;
- West Sierra Nevada region; and
- Far North region.

The Caltrans Statewide Model does not distinguish between drive alone and shared ride, so these are all assumed to be drive alone trips. Since the majority of the high-occupancy vehicle (HOV) lanes are contained within the San Francisco and Los Angeles regions in the State, this assumption is reasonable given the available data and resources. It may be preferable in the future to consider incorporating drive alone and shared ride trips from the Sacramento region, since there are additional HOV lanes in this region.

5.3 MODEL VALIDATION

The validation of the combined interregional and intraregional (urban) models was completed for the year 2000, because the available observed data for 2000 was more robust than for any other year. This statewide model was estimated from a combination of existing and new household and intercept traveler surveys collected in California and combined with intraregional trips generated from regional and statewide sources.

The validation work included the calibration process, development of data used for observed travel behavior, and documentation of the resulting calibration parameters for the interregional trips. In addition, this work included summaries and reasonableness checks on the intraregional trips derived from the MPO trip tables. These were not separately validated or calibrated, because each MPO has provided assurances that these trip tables are validated.

2000 Trip Tables

Trips by mode from the interregional models are combined with intraregional trips by mode to assign to the highway, air, and rail networks. Table 5.1 presents a summary of the 2000 interregional trips by mode and market.

Table 5.1 2000 Daily Interregional Trips by Mode

Market	Auto	Air	Rail	Total
LA to Sacramento	7,479	4,935	–	12,414
LA to San Diego	257,441	100	5,395	262,936
LA to SF	28,031	26,867	–	54,898
Sacramento to SF	137,739	25	1,816	139,580
Sacramento to San Diego	175	2,858	–	3,033
San Diego to SF	4,630	10,309	–	14,939
LA/SF to SJV	205,205	3,393	926	209,524
Other to SJV	281,750	243	344	282,337
To/From Monterey/Central Coast	275,794	3,532	1,105	280,431
To/From Far North	184,506	3,005	16	187,527
To/From W. Sierra Nevada	59,192	668	11	59,871
Intraregion	–	–	–	–
Total	1,441,942	55,935	9,613	1,507,490

Source: California Statewide High-Speed Rail Forecasting Model run for 2000 "base year" conditions.

Highway trips are converted from person trips to vehicle trips using vehicle occupancy factors derived from the Caltrans Statewide Travel Survey. In addition, highway trips are separated into peak and off-peak time periods, so that peak and off-peak trip tables can be assigned separately to the highway network. This ensures that peak-period travel times will more accurately reflect congestion that occurs in the peak period.

Following the development of peak and off-peak auto vehicle interregional trips, these were combined with the auto vehicle intraregional trips. These intraregional trips come from four sources: MTC, SANDAG, SCAG, and Caltrans. The Caltrans Statewide Model is used to estimate intraregional trips for all the other regions (except MTC, SANDAG, and SCAG), so that the auto trip table will be representing all statewide travel. This ensures that congestion within each smaller urban area is adequately represented.

2000 Assignments by Mode

Validation of the base year assignments by mode involved detailed review of observed and modeled volumes. For air, these reviews focused on assignments for the major markets. For rail, these reviews focused on assignments by operator.

For highway, these reviews focused on assignments by gateway and by region. A summary of the assignments by mode is provided in Table 5.2.

Table 5.2 2000 Daily Assignments by Mode

Mode	Units	Observed	Model	Difference	Percent Difference
Air	Boardings	54,271*	54,876	605	1%
Rail	Boardings	16,710**	17,743	1,033	6%
Auto	Vehicle Counts	27,145,300***	25,206,373	(1,938,927)	-7%

*Source: U.S. Department of Transportation FAA O&D 10-percent sample database.

**Source: Interregional rail operators and the MTC.

***Source: Caltrans, MTC, and SCAG traffic count databases.

Even though the air and rail assignments were very small compared to auto, these were critical to the evaluation of high-speed rail, so a great attention to the validation of these modes was important. For the major markets and operators, these compared very well with observed numbers. Auto assignments were primarily validated based on gateways along the high-speed rail corridors. These compared very well to observed traffic counts. Additional validation effort to refine and improve the highway assignments is recommended if this model were to be used for highway planning purposes.

2030 Baseline Forecasts

Comparison of the 2030 forecast to a No-Project scenario was completed for validation to ensure that the 2030 forecasts are reasonable for each model component. Overall, there is a 42 percent increase in households and a 51 percent increase in employment (see Table 3.2), and there is a 62 percent increase in interregional trips. The 2030 interregional trip table is presented in Table 5.3.

The higher percent of interregional trips compared to statewide household and employment growth is a reflection of the expansion of the regions beyond their regional borders, causing more travelers to make interregional travel instead of intraregional travel. The auto assignments (represented by total vehicle miles traveled (VMT)) increase by 73 percent from 2000 to 2030, which is also caused by travelers having to go further to reach their destinations. These are presented in Table 5.4. Rail boardings increase at a higher rate than auto, indicating that as congestion increases, more travelers are taking rail as expected. Air boardings do not increase as fast as rail or auto, because the air fares increased and frequencies decreased between 2000 and 2005, making air a less attractive option. The 2005 observed air level of service was kept constant through 2030. The primary reason for significant changes in air service from 2000 to 2005 was the September 11 terrorist attacks in 2001, which affected air travel more than other modes.

Table 5.3 2030 Daily Interregional Trips by Mode

Market	Auto	Air	Rail	Total
LA to Sacramento	12,636	8,105	–	20,741
LA to San Diego	340,862	96	25,898	366,856
LA to SF	30,253	25,351	–	55,604
Sacramento to SF	174,844	26	11,798	186,668
Sacramento to San Diego	164	5,258	–	5,422
San Diego to SF	5,038	18,259	–	23,297
LA/SF to SJV	360,177	9,609	6,237	376,023
Other to SJV	553,466	1,944	4,792	560,202
To/From Monterey/Central Coast	426,056	5,886	2,077	434,019
To/From Far North	320,667	5,957	962	327,586
To/From W. Sierra Nevada	96,404	1,177	335	97,916
Total	2,320,567	81,668	52,099	2,454,334

Source: California Statewide High-Speed Rail Forecasting Model run for 2030 "no-project" conditions.

Table 5.4 2000 and 2030 Assignments by Mode

Mode	Units	2000 Model	2030 Model	Difference	Percent Difference
Air	Boardings	54,876	80,643	25,767	47%
Rail	Boardings	16,430	30,653	14,222	87%
Auto	VMT	748,606,510	1,297,116,168	548,509,657	73%

Source: California Statewide High-Speed Rail Forecasting Model run for 2000 "base year" and 2030 "no project" conditions.

6.0 Level of Service Assumptions

6.0 Level of Service Assumptions

Level of service (LOS) assumptions include costs (i.e., operating costs and fare prices); service frequencies; travel and access/egress times; terminal times; and reliability measures for each of the interregional travel modes under consideration – auto, air, conventional rail (CR), and high-speed rail. Reliability is a newly developed measure for the new statewide model system. Reliability was included in the SP survey choice experiment options, along with the more traditional time and cost variables.

These data come from a variety of sources. Much of the information has been predetermined from earlier bodies of work. For example, assumptions about the future background highway and transit networks generally come from existing regional and metropolitan transportation plans. As appropriate, this report identifies data sources for each assumption. Some other data were newly researched. The consultant team has compiled data on air travel times and fares between California airport pairs. Three sets of data for comparison: observed travel data for the year 2000 base year, year 2005 existing conditions, and previously developed CHSRA network assumptions. All costs and incomes were developed in year 2005 dollars.

This study also included an extensive new data collection effort of interregional revealed- and stated-preference travel patterns. New data collection comprises 3,172 revealed- and stated-preference surveys of California interregional air, auto, and rail passengers. These surveys provide a rich source of data on areas, such as access/egress times and costs, and airport terminal times.

The travel skims have been developed using the new Cube program Public Transport (PT), which varies from previous transit network/assignment modules in development of paths. PT is a significant enhancement over past transit path-building and assignment modules, because the transit path-finding algorithm finds all possible transit paths for the zone pairs with the specified parameters (maximum travel time, access time, number of transfers, etc.); and assigns them to each route based on probability. PT reports average skims; whereas, earlier modules used an “all-or-nothing” process to assign all trips to the best path.

6.1 COST

Cost assumptions include auto operating costs, as well as fares for conventional and high-speed rail and air travel. Cost assumptions also include access and egress costs, such as parking charges at airports. All cost assumptions are in 2005 constant dollars, unless otherwise specified.

Auto Operating Costs

The consultant team prepared the auto operating costs with data that the MTC has compiled on an ongoing basis (up to April 2006). The auto operating costs are comprised of gasoline and nongasoline operating costs. Gasoline operating costs are calculated on a per-mile basis from the price of average retail gasoline divided by the average fuel economy. The MTC obtains monthly retail gasoline costs from the California Energy Commission (CEC). A constant average fuel economy of 21.9 miles per gallon has been assumed.

Nongas operating costs include maintenance and repair, motor oil, parts, and accessories. The California Department of Energy used to track the nongas operating costs, but more recently MTC has assumed that nongas operating costs are fixed to 60 percent that of gasoline operating costs.

The year 2000 model system uses year 2000 automobile operating costs of 16 cents per mile, while the 2005 model runs uses the 2005 value of 20 cents per mile. An important assumption will be future gas prices for the purposes of alternatives evaluation for 2030 forecasts. Gasoline prices are notoriously volatile, and we assume a constant cost of gasoline (with respect to inflation), rather than a real, annual increase in auto operating costs. In addition, we tested the sensitivity of ridership forecasts to changes in gas prices by increasing the cost of gasoline.

Bridge Tolls

Tolls are charged on seven California bridges – all of them in the San Francisco Bay Area. Current tolls are $3.00 on all seven bridges, except the Golden Gate, which is $5.00 in year 2000 and $4.00 on all seven bridges beginning in 2007. The other six bridges include the Dumbarton, San Mateo-Hayward, San Francisco Bay, Carquinez, Benicia-Martinez, and Antioch. There are two bridge facilities that no longer charge tolls. These are the Gerald Desmond Bridge (serving the Ports of Long Beach and Los Angeles) and the Coronado Bridge (serving Coronado Island in San Diego).

Line-Haul Fares

Line-haul air fares were obtained from the FAA and supplemented with data from several web sites over several months to obtain data on air fares for origin-destination pairs in California. The fares were obtained directly for year 2000 and 2005 from the 10-percent ticket sample maintained by the FAA. Business and nonbusiness fares were queried and summarized separately, but there was no significant difference overall in these markets between business and nonbusiness fares, so they were averaged for the purposes of this study. Average air fares typically increased from 2000 to 2005; for example, between Bay Area airports and Los Angeles airports, the air fares increased from $82 to $106 between 2000 and 2005, or a 29 percent increase.

An important part of this project was to evaluate different high-speed rail fare policies in order to maximize benefits. As such, the study team and peer review panel has agreed that, as a **starting** point, fare assumptions similar to those developed by Charles Rivers Associates (CRA) for the previous high-speed rail model would be employed here. CRA's base fare structure for interregional trips was based on 50 percent of the average Los Angeles-Bay Area airfare. Using the average airfare of $106 (in 2005 dollars) in our current model, the high-speed rail fare equates to a boarding charge of $15 and a distance charge of 0.9 cents per mile. The station-to-station high-speed rail fares are used both as an input to the models and to calculate high-speed rail revenue. The revenue is calculated by summing the product of the station-to-station, high-speed rail ridership matrix and the station-to-station, high-speed rail fares.

For intraregional commuter travel, CRA assumed that intraregional high-speed rail fares would be 50 percent higher than commuter rail fares, on average. Using this assumption in our current model, the high-speed rail fare equates to a boarding charge of $7.00 and a distance charge of 0.6 cents per mile. Both the interregional and intraregional per-mile, high-speed rail charges were applied to the driving distance between stations in order to avoid different fare structures for Altamont and Pacheco high-speed rail routings.

Interregional conventional rail (CVR) fares for the San Joaquin, ACE, Capitol Corridor, Pacific Surfliner, and Metrolink (Oceanside) lines were developed from the operators for 2000 and 2005 and assumed to be constant (relative to inflation) from 2005 to 2030.

Access-Egress Costs

Airport hourly and daily on- and off-site parking charges were collected by the MTC staff for San Francisco and Oakland, and by Cambridge Systematics staff for Los Angeles and Ontario airports as part of a recent study. Parking rates for all other airports were collected from an Internet search. Parking costs at SFO and OAK were highest at $26 per day.

Conventional rail parking charges are typically free with some exceptions. Parking charges apply at the Sacramento depot (serving Capitol Corridor and selected San Joaquin line trains), and at Oakland's Jack London Square (served by Capitol Corridor and San Joaquin lines); however, the lot only contains 75 parking spaces and is generally half-filled each day. In Southern California, parking at Los Angeles Union Station is $6.00 per day (served by Metrolink and Surfliner Routes).

High-speed rail is assumed to have ample market rate parking at all stations. For initial forecasts, interregional parking charges at high-speed rail stations will be set to a minimum rate of $3.00 per day, except for areas where parking is already charged, such as San Francisco ($25 per day), Oakland, Los Angeles, Sacramento ($6.00 per day), and San Diego ($12 per day).

6.2 TRAVEL TIMES

Travel times for interregional travel modes are broken down into detailed components: line-haul times (the time spent in an airplane, high-speed, or conventional train or automobile); access and egress times; terminal times; wait times; and transfer times.

Line-Haul Times

Auto travel times are derived by summing the travel time (based on distance and speed) in the highway network. These are available for peak and off-peak or free-flow conditions.

Intra-California airport to airport line-haul times are developed from the FAA data in the 10-percent ticket sample and updated with current schedules in some markets where the FAA data were too low. Airport pairs without direct (non-stop) service show line haul times with transfer times included, since the air network represents all direct service. Travel times were estimated for both 2000 and 2005, and there were small differences in these travel times, but they were within the margin of error and there were many unexplainable anomalies, so travel times for both 2000 and 2005 were set equal. Line-haul times for outbound and return flights have been averaged to produce a single run time for both directions of travel. This includes direct and connecting service for intrastate flights, where demand in 2005 is greater than one trip per day (400 annual trips).

High-speed rail line-haul times were developed for both Pacheco Pass and Altamont Pass alternatives. The high-speed rail times have been developed by the CHSRA's rail operations consultant, Parsons Brinckerhoff.

Conventional rail times include ACE, Capitol Corridor, San Joaquin, Pacific Surfliner, and Metrolink-Orange County Route. These were developed from current schedules for 2005 and were the same for 2000 and 2030.

Frequencies

Observed air travel frequencies were obtained from the FAA reports. These frequencies represent only direct service within California. They were developed for both peak and off-peak conditions.

Generalized peak-period high-speed rail frequencies were developed for the initial northern (Altamont) and southern (Pacheco) alignment alternatives. These frequencies are assumed as an initial starting point for forecasting purposes. Testing of alternative service scenarios was conducted during sensitivity testing. High-speed rail schedules are a fairly complex mix of local, express, regional, semi-express, and suburban express trains.

Conventional rail frequencies are not as complex as air or high-speed rail services. These were derived from current conventional rail schedules.

Access-Egress Times

Access and egress times are compiled for all mass transportation modes – air travel, and conventional and high-speed rail. There are no access-egress times for auto modes; out-of-vehicle time for auto is identified as terminal time and this is covered in a separate section below. Access-egress times cover the time required to travel from home (or activity location, such as from a workplace) to the curb of the train station/airport terminal. Times inside the stations/terminals include both terminal and wait times, and are covered in the next two subsections.

The choice of mode to and from airports, conventional rail stations, and high-speed rail stations includes drive and park, picked up/dropped off, rental car, taxi, transit, and walk. The auto-based modes (drive and park/picked up/dropped off, rental car, and taxi) will all use highway network travel times for peak or off-peak travel. The walk network is based on the highway network, with freeways and expressways removed, and walk speeds are set to 3 miles per hour on all remaining arterial and collector links.

Wait Times

Wait time refers to the time between arriving at the airline gate or train platform, and closing of the airplane or train door after everyone has boarded. The time spent prior to arriving at the airline gate or train platform is the terminal time, and is discussed further below.

For air travel, the wait time includes both the time spent waiting at the gate for the plane to arrive; the actual boarding time; and the time up until the plane, loaded with passengers, leaves the gate area. Once the plane leaves the gate, line-haul time begins. An initial review of wait times for air travelers in the surveys collected for this project revealed no significant difference between wait times for business and nonbusiness travelers. In addition, we believe that air traveler wait times are not a function of the air service frequencies, as recommended by the peer review panel. The rationale for using set wait times is each seat must be reserved in advance, so the presence of more or less frequent service between airport pairs does not influence the wait times. As a result, air wait times for air passengers were based on a review of the surveys' reported wait times at 55 minutes. The air wait times was derived from self-reported data on arrival time before departure in the air passenger travel surveys collected for this study, which include both wait and terminal times.

For rail travel, the wait times are lower than air for a number of reasons. First, trains will have numerous doors, making boarding a train a much faster proposition than boarding an airplane. In addition, the hassle and time variance of getting a boarding pass, checking luggage, and getting through security requires arrival at the airport earlier than at a train station without security checkpoints. It is explicitly assumed that high-speed rail will not have the elaborate security check-in procedures, boarding passes will not be required to wait for a train, seats are not assigned, and that luggage is typically self-carried on the train. The rail wait time was set at 15 minutes for both high-speed and conventional rail travelers.

Terminal Times

Terminal time is the amount of time it takes someone to travel between their access mode and the airport boarding area or train platform. It also includes the time it takes an auto traveler to walk from their car to their destination. Terminal times are defined for both access and egress ends. At the origin/access end of a trip, terminal time includes the following:

- Time to walk (or ride a shuttle) between the parking area and terminal;
- Time to receive a ticket or boarding pass;
- Time to check luggage;
- Time to clear security; and
- Time to walk from security to the boarding area or platform.

Destination/egress end of a trip, terminal time includes:

- Time to deboard the airplane or train;
- Time to walk from the plane/train to baggage claim;
- Time to pick up baggage; and
- Time to walk (or ride a shuttle) between the terminal and parking area, or to other ground transportation modes.

Terminal times for public modes were determined from a combination of peer review recommendations and subsequent refinements made by Cambridge Systematics. The following terminal times were used:

- Ten minutes for high-speed rail stations;
- Twenty minutes for nonbusiness/commute trips at airports;
- Twenty-two minutes for business/commute trips at airports; and
- Three minutes for conventional rail stations.

Terminal times for auto were added to represent the average time to access one's vehicle at each end of the trip. The Caltrans Statewide Model assumes an average terminal time at the production (home) end of trips and at the trip attraction based on the area type of the zone, ranging from one to five minutes, depending on the location of the trip (urban, suburban, or rural). Longer terminal times in central urban areas are assumed, because of the extra time involved in finding parking and walking between a parking space and the final destination.

Transfer Times

Transfer times apply when connecting from one mass transportation mode to another. In typical urban travel models, transfer wait times are defined as half the headway of the connecting modes. For interregional travel, transfer times are somewhat more complicated because local transit access/egress to/from the high-speed rail modes is part of the access/egress time.

Because the interregional travel mode will be the primary mode of travel, it is assumed the traveler will know the schedule of the interregional mode, and will plan their trip accordingly. As a result, no time will be assessed for trips that include using local transit to access the interregional mode.

For example, consider a traveler living in San Francisco and traveling to Southern California. This traveler will take BART to SFO, followed by a flight to a Southern California airport. The notion of assessing a transfer time of half the airline headway (or some similar such measure) does not make sense since the traveler will obviously take a BART train that gets him/her to the airport on time for his/her flight. In this case, all of the relevant access travel time components are applied – a walk to the BART station, a wait for the BART train to arrive, and the actual BART ride. From there, the traveler will walk from the BART platform to the SFO entrance. The times, in total, comprise the access time. This traveler will have the airport terminal and wait times, as well as the airline flight time, for their trip, so an assessment of a transfer time for this trip would be redundant and unrealistic.

Nevertheless, the egress mode for the return trip would assess the typical transfer time – for the airline to BART connection. In this case, the traveler will have flown back to SFO and will need to transfer to BART. Coming off a relatively long flight and egress terminal time, the traveler will likely have to wait half the BART headway. The peer review panel suggested that the transfer egress time be capped at 15 minutes, and that recommendation has been implemented.

Total Travel Times

To compare travel times across modes, selected city pairs have been identified and compared across modes and between the base year (2000) and the forecast year (2030) in Table 6.1. The forecast year travel times reflect one of the baseline build scenarios, so that the high-speed rail mode can be compared to competing modes in these markets.

Table 6.1 Total Peak Travel Times by Mode for Selected City Pairs

City to City Pair	Auto 2000	Auto 2030	Air 2000	Air 2030	High-Speed Rail 2030	Conventional Rail 2000/2030
Los Angeles downtown to San Francisco downtown	6:28	6:32	3:30	3:38	3:23	No service
Fresno downtown to Los Angeles downtown	3:32	3:38	3:17	3:24	2:14	No service
Los Angeles downtown to San Diego downtown	2:37	2:39	2:51	3:01	2:13	3:26
Burbank (airport) to San Jose downtown	5:31	5:40	2:46	2:43	3:07	No service
Sacramento downtown to San Jose downtown	2:29	2:24	2:41	2:41	2:15	4:06

High-speed rail total travel times compete with air favorably in many markets, because of the recognition that the terminal and wait times are lower for high-speed rail than air. In many cases, the access and egress times are also shorter, because in many areas there are more high-speed rail stations than airports. High-speed rail also competes well with auto in these longer-distance markets (over 100 miles) because it is faster. Conventional rail is longer than high-speed rail in all competing markets.

6.3 Reliability

Reliability is a new measure that was included directly into the interregional mode choice models currently under development. Information collected was from correspondences with conventional rail system planners, the FAA data, and previous high-speed rail environmental documentation (2003).

The SP surveys, collected for this study, included the following reliability options across modes as part of the overall choice experiments. The reliability question was posed for each of four modes as the percent variations in the frequency of encountered delays.

- **Travel by auto –** Percent of the time there are no extra delays of more than 15 minutes;
- **Travel by air –** Percent of flights that arrive within 15 minutes of schedule;
- **Travel by conventional rail –** Percent of trains that arrive within 15 minutes of schedule; and
- **Travel by high-speed rail –** Percent of trains that arrive within 5 minutes of schedule.

These data did not result in a significant parameter in the mode choice models. In conjunction with the peer review panel, we hypothesized that this was because the survey questions on reliability were too narrow (i.e., percent of flights or trains that arrive within 15 minutes), making it difficult for travelers to distinguish between the modes for longer interregional travel decisions. As a result, Cambridge Systematics modified the definition of the reliability measure to reflect the percent of flights or trains that arrive within 60 minutes, which increased the impact this reliability has on a person's modal choice. In turn, the consultant team, in consultation with the MTC and other study participants, has constrained the reliability measure in the mode choice models to reflect this change.

Highways tend to be the least reliable of the four modes on a day-in, day-out basis. Reliability on highways is highly susceptible to incidents, weather, volume variation, and inadequate base capacity. On two of these factors (construction and special events), auto is more susceptible than the other modes. It is only when considering the influence of vehicle availability and routing that highways have a lower susceptibility than all other modes.

The measure of reliability that has been used on a series of studies by Cambridge Systematics is the freeway vehicle hours of delay. This measure indicates that, as delay on the freeway increases, the overall reliability of the system would tend to decrease. The probability, expressed in decimal terms, of an auto traveler arriving within 60 minutes of the congested travel time can be found with the following function:

$$P = \left(\frac{(TC + 60)}{TC + 0.0073 * \left[\frac{(TC/TO - 1)^{0.117647}}{0.18} \right]^{5.2695} * 60 * TO} \right)$$

Where:

TO = Free-flow travel time in minutes; and

TC = Congested travel time in minutes.

The prior equation uses the concept of "travel time index," and essentially looks at the likelihood that someone's trip will be delayed by 60 minutes or more by nonrecurring incident delay. The probability is referenced against congested travel time, since auto travelers presumably already account for the effects of recurring congestion in their mode choice decisions. The portion of the equation shown in bold represents the estimate of incident delay, measured in minutes.

This auto reliability measure relies on existing research to define the function for determining auto reliability, but is applied on an origin-destination basis, rather than a link basis for the purposes of this study. The resulting percent reliability estimates for a trip from Los Angeles to San Francisco are in the range of 67 to

92 percent, depending on the specific details of a trip. Trips with no congestion will have 100 percent reliability.

Airline reliability data for 2000 and 2005, as well as forecasts for 2025, were compiled from the FAA data. This reflects an average reliability for air of 91 percent in 2000, 95 percent in 2005, and 94 percent in 2030. Airline travel shows reliability improvements since 2000, probably due to the airline practice of increasing scheduled air times to allow for better on-time performance.

There was no available on-time performance data for conventional rail services arriving within 60 minutes of the scheduled time. The proposed measurement takes into account the same relationship that air performance has between 5 and 60 minutes, and assesses individual performance for each service. The following reliability measures were obtained and estimated: ACE on-time performance within 60 minutes was estimated at 97 percent; Metrolink on-time performance within 60 minutes was estimated at 98 percent; San Joaquin's on-time performance within 60 minutes was estimated at 89 percent; Capitol Corridor on-time performance within 60 minutes was estimated at 94 percent; and Surfliner's on-time performance within 60 minutes was estimated at 94 percent.

Typical high-speed rail reliability for European and Japanese systems was analyzed by SYSTRA staff. On dedicated high-speed rail track, even with express and local trains, both the French and Japanese have reported average delays of 29 to 40 seconds per train (including weather and earthquake delays), which is more than 99 percent on time (within 10 minutes of schedule in European practice). In California, there will be origin-destination pairs that will have 100 percent dedicated right of ways (ROW), where a very high on-time performance (OTP) could be expected. This translates to 99 percent reliability for the defined criteria of OTP within 60 minutes.

6.4 Future No-Project Networks

The future baseline networks were developed for 2030, with assumptions about transportation infrastructure improvements. The 2030 horizon year presents the best source of information, since this year is close to the horizon year for regional and metropolitan transportation plans (RTPs and MTPs, respectively). RTPs/MTPs for the four major urban areas have been identified and coded into the baseline transit and highway networks. The consultant team used the statewide travel model (STM) for other areas of the State – particularly the Central Valley. Assumptions about network improvements were identified by comparing the base and future networks.

The details of these transportation infrastructure investments are documented in detail in the level of service report[9].

[9] Cambridge Systematics, Inc., with Systra Consulting, Inc., and Citilabs, *Bay Area/ California High-Speed Rail Ridership and Revenue Forecasting Study Levels of Service Assumptions and Forecast Alternatives*, prepared for Metropolitan Transportation Commission and the California High-Speed Rail Authority, August 2006.

7.0 Ridership and Revenue Forecasts

7.0 Ridership and Revenue Forecasts

This section outlines aggregate high-speed rail ridership and revenue forecasts for sensitivity tests, network, and alignment alternatives. These results are detailed and discussed further in *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Ridership and Revenue Forecasts*.

7.1 Sensitivity Tests

A series of sensitivity tests were conducted to test the impacts of changes in level of service on high-speed rail ridership and revenue. These tests were designed to assist in developing an improved operating plan and optimum fares, and to understand the impacts of potential changes in assumptions to the air and auto modes. The results of the sensitivity tests are provided in Table 7.1.

Table 7.1 Sensitivity Tests for High-Speed Rail

		Percent Change from Base	
Sensitivity Test	Change in Level of Service	Boardings	Revenues
High-speed rail level of service tests			
Higher high-speed rail fares	25% increase	-13%	2%
Average daily headways	High-speed rail headways*	-15%	-14%
Higher high-speed rail freq	100% increase	15%	16%
Express service SF/LA	Double freq SF/LA to SJV, SD/SF to SAC	22%	24%
Air and auto level of service tests			
Higher air/auto times	6% increase**	6%	6%
Higher air/auto costs	50% increase	46%	53%
Combined level of service tests			
Higher high-speed rail fares and higher air/auto costs	25% increase in fares, 50% increase in costs	13%	19%
Higher high-speed rail fares and higher air/auto costs	50% increase in both	31%	40%
Higher high-speed rail fares and higher air/auto costs	100% increase in fares, 50% increase in costs	-6%	1%

* Average daily headways assume that the headways in the peak and off-peak periods are equal. This effectively increases peak headways and decreases off-peak headways.

** The 6-percent increase in travel time was based on a 30-minute increase in travel time from San Francisco to Los Angeles by car.

The results show that improvements in high-speed rail frequencies can support much higher high-speed rail ridership; increased high-speed rail frequencies in the major corridors (San Francisco to Los Angeles, Los Angeles to San Joaquin Valley, San Diego to Sacramento, and San Francisco to Sacramento) were then retained for the alternatives analysis. These results also show that raising high-speed rail fares will not significantly increase revenues, unless this is combined with different assumptions of air and auto costs. Assumptions regarding air and auto cost increases remain a difficult issue, given the volatility in these costs in the past 5 years alone. The sensitivity tests do show that high-speed rail ridership is highly sensitive to the assumptions of air and auto costs, and can increase as much as 46 percent with a 50-percent increase in air and auto costs, which seems quite reasonable compared to current trends in these costs.

7.2 Network Alternatives

There are 6 network alternatives for the Pacheco Pass (southern alignment into the Bay Area) alternative and 11 network alternatives for the Altamont Pass (northern alignment alternative) alternative. These network alternatives are described in detail in the Environmental Impact Statement (EIS) report[10]. The interregional and intraregional models were run for the 2030 forecast year for each alternative and ridership, and revenues were summarized and compared for each.

The Pacheco Pass alternative results are summarized in Table 7.2. For each alternative, the amount of service is held constant in order to better compare the network changes. In the case of the combined San Francisco and Oakland alternative (P3), service from San Jose is split proportionally between the two cities, which causes overall level of service in each destination to be lower than in the base. So even though this alternative reaches more travelers directly in terms of station location, the lesser level of service causes lower ridership and revenues. The Transbay alternatives (P5 and P6) both have higher ridership and revenue than the base because service is not split and every train serves all three destinations (San Francisco, San Jose, and Oakland), but are not as likely to be cost effective, given the expense of constructing an additional Transbay tube.

The Altamont Pass alternative results are summarized in Table 7.3. The Altamont Pass alternatives generally do not compare favorably to the Pacheco Pass alternatives; only because many of these alternatives have split service to multiple destinations, rather than a single line, as is the case in most of the Pacheco alternatives. Some of the Altamont alternatives go to single destinations and compare well with similar Pacheco alternatives, such as the alternatives to San Francisco (A5), to Oakland (A6), and to San Jose (A4). In addition, the Transbay tube alternative (A10) compares reasonably well with the same Pacheco Pass alternative (P5).

[10] California High-Speed Rail Authority, *Draft Bay Area to Central Valley High-Speed Train (HST) Program Environmental Impact Report/ Environmental Impact Statement (EIR/EIS)*, June 2007.

Table 7.2 Pacheco Pass Network Alternative Results

	Network Alternative Name and Description	Annual Ridership	Annual Revenues
P1	Pacheco to San Jose and San Francisco	93,890,000	$3,098,000,000
	From San Francisco to San Jose, this network alternative would use the existing Caltrain rail ROW. The Pacheco and Henry Miller (to the UPRR) alternatives would be used between San Jose and the Central Valley. The BNSF N/S (north of Merced) and UPRR N/S (south of Merced) alignments would be used in the Central Valley.		
P2	Pacheco to San Jose and Oakland		
	From Oakland to San Jose, this network alternative would use the Niles/I-880 alignment. The Pacheco and Henry Miller (to the UPRR) alternatives would be used between San Jose and the Central Valley. The BNSF N/S (north of Merced) and UPRR N/S (south of Merced) alignments would be used in the Central Valley.	91,720,000 -2.3%*	$3,083,000,000 -0.5%*
P3	Pacheco to San Jose, San Francisco, and Oakland		
	From San Francisco to San Jose, this Network Alternative would use the existing Caltrain ROW. From Oakland to San Jose, the Niles/I-880 alignment would be used. The Pacheco and Henry Miller (to the UPRR) alternatives would be used between San Jose and the Central Valley, and the BNSF N/S (north of Merced) and UPRR N/S (south of Merced) alignments would be used in the Central Valley.	86,080,000 -8.3%*	$2,790,000,000 -9.9%*
P4	Pacheco to San Jose	80,040,000	$2,678,000,000
	The Pacheco and Henry Miller (to the UPRR) alternatives would be used between San Jose and the Central Valley, and the BNSF N/S (north of Merced) and UPRR N/S (south of Merced) alignments would be used in the Central Valley.	-14.0%*	-14.8%*
P5	Pacheco to San Jose, San Francisco, and Oakland via Transbay Tube	95,760,000	$3,160,000,000
	From Oakland to San Francisco, this network alternative would use a Transbay tube crossing. From San Francisco to San Jose, this network alternative would use the existing Caltrain ROW. From San Jose, this network alternative would use the Pacheco and Henry Miller (to the UPRR) alignment alternatives and the BNSF N/S (north of Merced) and UPRR N/S (south of Merced) alignments would be used in the Central Valley.	2.0%*	2.0%*
P6	Pacheco to San Jose, Oakland, and San Francisco via Transbay Tube	92,410,000	$ 3,049,000,000
	This network alternative would require a new Transbay tube from San Francisco to Oakland. From Oakland to San Jose, this network alternative would use the Niles/I-880 alignment. From San Jose, this network alternative would use the Pacheco and Henry Miller (to the UPRR) alignment alternatives and the BNSF N/S (north of Merced) and UPRR N/S (south of Merced) alignments in the Central Valley.	-1.6%*	-1.6%*

Note: The P5 and P6 alternatives were inferred from a combination of the Pacheco base and the Altamont Transbay alternatives.

*Percent Difference Compared to P1 Scenario.

Table 7.3 Altamont Pass Alternative Results

	Network Alternative Name and Description	Annual Ridership	Annual Revenues
A1	Altamont to San Jose and San Francisco	87,910,000	$2,844,000,000
	From San Francisco to Redwood City, this network alternative would use the existing Caltrain rail ROW, and would cross the San Francisco Bay in the Dumbarton corridor. To San Jose, the Niles/I-880 alignment would be utilized south of Niles. The Altamont Pass would use the UPRR alignment through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.	-6.4%*	-8.2%*
A2	Altamont to San Jose and Oakland	88,010,000	$2,881,000,000
	From Oakland to San Jose, this network alternative would use the Niles/I-880 alignment. The Altamont Pass would use the UPRR alignment through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.	0.1%**	0.1%**
A3	Altamont to San Jose, Oakland, and San Francisco		
	From Oakland to San Jose, this network alternative would use the Niles/I-880 Alignment. From San Francisco to Redwood City, this network alternative would use the existing Caltrain rail ROW. This network alternative would cross the San Francisco Bay in the Dumbarton corridor. The Altamont Pass would use the UPRR alignment through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.	81,130,000 -7.7%**	$2,625,000,000 -7.7%**
A4	Altamont to San Jose	94,650,000	$3,176,000,000
	From San Jose, this network alternative would use the Niles/I-880 alignment between San Jose and Niles. The Altamont Pass would use the UPRR alignment through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.	4.9%**	7.7%**
A5	Altamont to San Francisco	93,880,000	$3,127,000,000
	From San Francisco to Redwood City, this network alternative would use the existing Caltrain rail ROW north of Redwood City and would cross the San Francisco Bay in the Dumbarton Corridor. The Altamont Pass would use the UPRR alignment through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.	6.8%**	10.0%**
A6	Altamont to Oakland	94,390,000	$3,153,000,000
	From Oakland to Union City, this network alternative would use the Niles/I-800 alignment north of Niles. The Altamont Pass would use the UPRR alignment through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.	7.4%**	10.9%**
A7	Altamont to Union City	83,490,000	$2,701,000,000
	From Union City, the Altamont Pass alignment would follow the UPRR through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.	-5.0%**	-5.0%**
A8	Altamont to San Jose and San Francisco – Peninsula Route	90,750,000	$2,743,000,000
	This network alternative would cross the San Francisco Bay in the Dumbarton corridor. From San Francisco to San Jose, this network alternative would use the existing Caltrain alignment The Altamont Pass alignment would follow the UPRR through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.	3.2%**	-3.6%**

	Network Alternative Name and Description	Annual Ridership	Annual Revenues
A9	Altamont to San Jose, San Francisco, and Oakland – No Bay Crossing Route	85,220,000	$2,733,000,000
This network alternative would not cross the San Francisco Bay. From San Francisco to San Jose, this network alternative would use the existing Caltrain ROW and the Niles/I-880 alignment south of Niles in the East Bay. The Altamont Pass alignment would follow the UPRR through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.		-3.1%**	-3.9%**
A10	Altamont to Oakland and San Francisco via Transbay Tube	95,940,000	$3,164,000,000
From San Francisco to Oakland, this network alternative would use a new Transbay tube between San Francisco and Oakland and would use the Niles/I-880 Alignment north of Shinn. The Altamont Pass alignment would follow the UPRR through downtown Tracy, and the Central Valley would use the UPRR N/S alignment.		9.1%**	11.3%**
A11	Altamont to San Jose, Oakland, and San Francisco via Transbay Tube	89,620,000	$2,884,000,000
From San Francisco to Oakland this network alternative would use a new Transbay tube. The Niles/I-880 alignment would be used between Oakland and San Jose, with the UPRR Alignment through the Tri-Valley to Tracy, and the UPRR N/S alignment through the Central Valley.		1.9%**	1.4%**

Note: The A3 and A7 alternatives were inferred from a combination of the Altamont base and the Pacheco alternatives.

*Percent Difference Compared to P1 Scenario.

**Percent Difference Compared to A1 Scenario.

7.3 Alignment Alternatives

There were seven alignment alternatives for the Pacheco Pass alternatives and nine alignment alternatives for Altamont Pass alternatives. These alignment alternatives are described in detail in the EIS report[11]. The interregional and intraregional models were run for the 2030 forecast year for each alternative, and ridership and revenues were summarized and compared for each.

The Pacheco Pass alignment alternatives are presented in Table 7.4. These alternatives are not significantly better than the Pacheco base, but they are intended to determine if a certain alignment is better, so it is not expected that there would be significant increases or decreases in systemwide ridership. The Palo Alto alternative (NP3) has similar ridership for the Palo Alto station compared to the Redwood City station, but the loss of riders at Morgan Hill results in an overall lower ridership. The Henry Miller alignment (NP1) is preferred by riders to the GEA North alignment. The Henry Miller alignment has quicker service between the Bay Area and Southern California, and while the GEA North alignment provides faster travel times between Sacramento and the Bay Area, it does not include the Merced station on these lines. The King Street station (NP2) does not attract as many riders as the Transbay station in downtown San Francisco, as expected. The downtown Modesto station (NP5) has higher ridership than the Briggsmore station (15 percent more), as expected, but it is not a large enough difference to affect systemwide ridership significantly. The Castle Air Force Base (AFB) (NP6) is not as attractive to riders as the Merced downtown station (3 percent less), but again, not enough to make a significant difference to overall system ridership. The 12th Street station in downtown Oakland (NP7) is preferred by riders to the 7th Street station (8 percent increase), but the overall ridership is not as much as the Pacheco base, which goes to San Francisco.

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[11] California High-Speed Rail Authority, *Draft Bay Area to Central Valley High-Speed Train (HST) Program Environmental Impact Report/ Environmental Impact Statement (EIR/EIS)*, June 2007.

Table 7.4 Pacheco Pass Alignment Alternative Results

Network Alternative Name and Description	Annual Ridership	Annual Revenues
NP1 Pacheco to San Jose and San Francisco via GEA North	91,690,000	$3,066,000,000
P1 service using GEA north instead of Henry Miller. This adds Merced to local trains from Southern California to/from Bay Area.	-2.3%*	-1.0%*
NP2 Pacheco to San Jose and San Francisco (King Street Station).	91,310,000	$3,079,000,000
P1 service terminating at 4th and King (Townsend St) rather than Transbay	-2.7%*	-0.6%*
NP3 Pacheco to San Jose, Palo Alto, and San Francisco.	93,330,000	$3,090,000,000
P1 service eliminating Morgan Hill and substituting Palo Alto for Redwood City.	-0.6%*	-0.3%*
NP4 Pacheco to San Jose and San Francisco – BNSF Alignment	93,320,000	$3,079,000,000
P1 service using BNSF alignment between Fresno and Merced.	-0.6%*	-0.6%*
NP5 Pacheco to San Jose and San Francisco via downtown Modesto	94,170,000	$3,107,000,000
P1 using Modesto Downtown (13) instead of Briggsmore (40).	0.3%*	0.3%*
NP6 Pacheco to San Jose and San Francisco via Castle AFB	93,860,000	$3,098,000,000
P1 using Castle rather than downtown Merced (14).	0.0%*	0.0%*
NP7 Pacheco to San Jose and Oakland (12th Street Station)	91,120,000	$3,007,000,000
P2 using 12th Oakland City Center terminus instead of 7th Street; eliminates Warm Springs Station.	-3.0%*	-2.9%*

Note: The NP5 and NP7 alternatives were inferred from a combination of the Pacheco base and an analysis of the land uses surrounding the station options.

*Percent Difference Compared to P1 Scenario.

The Altamont Pass alignment alternatives are presented in Table 7.5. These alternatives are not significantly better than the Pacheco base, but they are intended to determine if a certain alignment is better, so it is not expected that there would be significant increases or decreases in systemwide ridership. The three alternatives comparing alternatives to the Bernal/I-680 alternative (NA1, NA2, and NA4) do not have higher ridership than the Bernal/I-680 station in the Altamont base. The Tracy ACE station (NA3) is not as attractive to riders as the Tracy downtown station (30 percent lower). The downtown Modesto station (NA5) has higher ridership than the Briggsmore station (13 percent more), as expected, but it is not a large enough difference to affect systemwide ridership significantly. The Fremont Bridge alignment (NA6) ridership is the same as the Dumbarton Bridge crossing, because there is not a large enough difference in travel times to affect systemwide ridership. The King Street station (NA7) does not attract as many riders as the Transbay station in downtown San Francisco, as expected (8 percent fewer riders). The 12th Street station in downtown Oakland

(NA8) is preferred by riders to the 7th Street station (8 percent increase), but the overall ridership is not as much as the Pacheco base, which goes to San Francisco. The BNSF alignment (NA9) is not preferred by riders over the UP alignment in the base alternative from Merced to Fresno.

Table 7.5 Altamont Pass Alignment Alternative Results

	Network Alternative Name and Description	Annual Ridership	Annual Revenues
NA1	Altamont to San Jose and San Francisco via Pleasanton BART	86,530,000	$2,806,000,000
Pleasanton Bart Station instead of Bernal/I-680.		-1.6%*	-1.3%*
NA2	Altamont to San Jose and San Francisco via I-580/UPRR station	84,510,000	$2,693,000,000
I-580/UPRR station instead of Bernal/I-680.		-3.9%*	-5.3%*
NA3	Altamont to San Jose and San Francisco via Tracy ACE station	87,720,000	$2,846,000,000
A1 using Trace ACE instead of Tracy downtown.		-0.2%*	0.1%*
NA4	Altamont to San Jose and San Francisco via Livermore downtown station	86,500,000	$2,786,000,000
A1 using Livermore downtown (34) instead of Pleasanton Bernal/I-680 (35).		-1.6%*	-2.0%*
NA5	Altamont to San Jose and San Francisco via Briggsmore station.	87,600,000	$2,834,000,000
A1 using Briggsmore/Modesto (40) rather than downtown Modesto (13).		-0.4%*	-0.4%*
NA6	Altamont to San Jose and San Francisco via the Fremont Bridge	87,910,000	$2,844,000,000
A1 using Fremont Bridge instead of Dumbarton Bridge.		0.0%*	0.0%*
NA7	Altamont to San Jose and San Francisco (King St station)	85,650,000	$2,771,000,000
A1 terminating at 4th and King (Townsend St) instead of Transbay Transit Center.		-2.6%*	-2.6%*
NA8	Altamont to San Jose and Oakland (12th St station)	90,420,000	$2,925,000,000
A2 termination at Oakland 12th St City Center instead of West Oakland.		2.9%*	2.8%*
NA9	Altamont to San Jose and Oakland – BNSF alignment	86,600,000	$2,802,000,000
A1 using BNSF alignment instead of UP alignment between Merced and Fresno.		-1.5%*	-1.5%*

Note: The NA5, NA7, NA8, and NA9 alternatives were inferred from a combination of the Altamont base and related Pacheco alternatives.

*Percent difference compared to A1 Scenario.

7.4 Combined Altamont and Pacheco Alternatives

Four alternatives were tested using a combination of the Altamont and Pacheco alignments. These scenarios took advantage of the quicker route between the Bay Area and Southern California (Pacheco), as well as the quicker route between the Bay Area and Sacramento (Altamont). The assumed number of train operations was increased to take advantage of the expanded rail network. The ridership for these alternatives is expected to be higher than other scenarios, both due to improved service, expanded number of stations, and an increase in the overall number of assumed trains. The Altamont plus Pacheco base scenario performs better than both the Altamont and Pacheco Base scenarios (A1 and P1); however, the projected revenues for these scenarios do not. The combined scenario that terminates in San Jose, San Francisco, and Oakland (AP3) performs the worst out of this set. Its service frequency suffers from train service being split three-ways upon arriving in the Bay Area.

Table 7.6 Combined Altamont/Pacheco Alternative Results

Network Alternative Name and Description	Annual Ridership	Annual Revenues
AP1 Altamont plus Pacheco to San Jose and San Francisco	96,150,000	$2,992,000,000,000
From San Francisco to San Jose, this network alternative would use the existing Caltrain rail ROW. From San Jose, this network alternative would use the Pacheco and Henry Miller (to the UPRR) alignment alternatives and the UPRR N/S alignment in the Central Valley. From Redwood City, this network alternative would also cross the San Francisco Bay in the Dumbarton Corridor. The Altamont Pass would use the UPRR alignment through downtown Tracy.	2.4%*	-3.4%*
AP2 Altamont plus Pacheco to San Jose and Oakland	92,880,000	$3,065,000,000
From Oakland to San Jose, this network alternative would use the Niles/I-880 alignment. From San Jose, this network alternative would use the Pacheco and Henry Miller (to the UPRR) alignment alternatives and the UPRR N/S alignment in the Central Valley. The UPRR alignment through Downtown Tracy would be used for the Altamont Pass.	-1.1%**	-1.1%**
AP3 Altamont plus Pacheco to San Jose, Oakland, and San Francisco	87,810,000	$2,897,000,000
From Oakland to San Jose, this network alternative would use the Niles/I-880 alignment. From San Francisco to San Jose, this network alternative would use the existing Caltrain ROW. From San Jose, this Network Alternative would use the Pacheco and Henry Miller (to the UPRR) alignment alternatives and the UPRR N/S alignment in the Central Valley. The UPRR alignment through downtown Tracy would be used for the Altamont Pass	-6.5%**	-6.5%**
AP4 Altamont_plus Pacheco to San Jose	89,790,000	$2,963,000,000
From San Jose, this network alternative would use the Pacheco and Henry Miller (to the UPRR) Alignment alternatives and the UPRR N/S alignment in the Central Valley. The Altamont Pass would use the UPRR alignment through downtown Tracy.	-4.4%**	-4.4%**

Note: The AP2, AP3, and AP4 alternatives were inferred from a combination of related alternatives.

*Percent Difference Compared to P1 Scenario.

**Percent Difference Compared to AP1 Scenario.

8.0 Peer Review

8.0 Peer Review

The purpose of the peer review panel was to provide technical guidance in the model design, model development, and forecasting of ridership and revenue for a statewide and Bay Area high-speed rail system. The panel provided comments on the development and application of the models to the evaluation of high-speed rail, suggested areas in which additional analyses were required, provided a review of basic assumptions and the design of alternatives to be tested, and commented on the interim and final results. The peer review panel enhanced the credibility of the process by providing an objective and independent review of the models, assumptions, methodologies, and results.

The peer review panel members included several members from the private sector, affected public agencies, and academics, as follows.

- Frank Koppelman (Northwestern University);
- Kostas Goulias (University of California, Santa Barbara);
- David Valenstein (FRA);
- Billy Charlton (SFCTA);
- Gordon Garry (SACOG);
- Keith Killough (SCAG);
- Bill McFarland (SANDAG);
- Mike Bitner (Fresno Council of Governments);
- Tim Byrne (OCTA);
- Brad McAllester (LAMTA);
- Ayalew Adamu (Caltrans HQ);
- Chris Brittle (MTC);
- Kazem Oryani (URS); and
- Jean-Pierre Arduin (Independent).

There were a number of invited observers to the peer review panel meetings, including Malcolm Quint (BART), Carl Schiermeyer (Riverside County Transportation Commission), Jay Kim (LADOT), Laura Biery (City of Palmdale), and Beth Thomas (Caltrain).

There were two meetings of the peer review panel and a final review (being conducted now), as follows.

1. First peer review meeting in June 2005 was to review the model system design (Task 3), data collection plan (Task 4), and development of performance measures (Task 8);
2. Second peer review meeting in June 2006 was to review the models developed (Task 5) and the network alternatives (Task 6); and
3. Final peer review is being conducted now to review the ridership and revenue forecasts (Task 8).

The peer review summaries are described below.

8.1 First Peer Review

Cambridge Systematics hosted the first peer review panel meeting on June 8, 2005, in Oakland, California. There were four primary technical areas of work covered in the first peer review: study work plan, model design, survey data collection, and performance measures.

There were many discussions of the proposed approach to model design and data collection and development of performance measures discussed during the course of the peer review panel meeting. In addition, there were a number of suggestions from peer review panel members that resulted in a change in the proposed approach or an agreement that further information was warranted before proceeding. These were documented in the report[12], but are summarized here with additional notes on the implementation of these recommendations:

- Urban mode choice models were reviewed to consider using existing models adapted to include a high-speed rail mode, rather than developing a generic mode choice model for all urban areas in the State. We implemented the peer review panel's recommendation on using the existing urban mode choice models rather than developing a separate generic mode choice model.
- The panel suggested that the study team consider a minimum travel time parameter (like 15 minutes) for high-speed rail to preclude short trips on this mode. However, this parameter could cause unintended results when modeling urban high-speed rail trips, and therefore was carefully reviewed. This recommendation was not implemented as there were no issues with short, illogical high-speed rail trips.

[12] Cambridge Systematics, Inc., *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Findings from the First Peer Review Panel Meeting*, prepared for Metropolitan Transportation Commission and the California High-Speed Rail Authority, July 2005.

- Urban area household travel surveys were reviewed to identify potential intercity trips that could be used to expand the California Household Travel Survey sample size. In addition, the household survey data collection could be used to supplement these surveys. This recommendation was implemented and increased the overall survey sample size from 2,678 to 6,882 surveys.
- The proposed model validation year was 2005, but since some significant data sources are from the year 2000, changes between these years will need to be studied and understood. The study team proposes to conduct separate validation tests for the year 2000 and 2005 data, rather than combining these datasets and tests. Both the 2005 and 2000 data were prepared and reviewed, but there was not enough data for 2005 conduct a comprehensive model validation.
- The study team should reallocate resources to increase the sample size of the new survey data collection to 2,500 samples for mode choice model development. The increase in survey sample size will be achieved by expanding the household auto travel survey to 1,450 surveys. Air surveys will continue to have a sample size of 600 and rail surveys will have 450 samples. This recommendation was implemented and the final number of completed surveys (2,678) exceeded the target of 2,500.
- Survey questionnaires should be revised and resubmitted to the peer review panel working group. In addition, the household pretest should be delayed to test these changes in the field. Both of these recommendations were completed. The survey questionnaires went through extensive review and revisions with the peer review panel members and other members of the consulting team.
- The study team should reconsider allocation of resources for the 2040 and 2050 forecasts for the third peer review panel meeting. This recommendation was implemented. The sources of data for 2040 and 2050 were not detailed and the level of effort to develop 2040 and 2050 models was quite high, so it was felt that these forecasts could be reasonably generated using trend analysis, rather than implementing a full set of models for these forecast years.
- Performance measures should be reduced to provide a more limited set of robust measures for consideration. SUMMIT analyses will not be used to estimate performance measures due to its limitations. This recommendation was implemented and the performance measures were limited to those required for environmental documentation[13].

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[13] California High-Speed Rail Authority, *Draft Bay Area to Central Valley High-Speed Train (HST) Program Environmental Impact Report/ Environmental Impact Statement (EIR/EIS)*, June 2007.

The majority of the recommendations from the first peer review panel meeting were implemented and provided useful direction for the model development and forecasting activities.

8.2 SECOND PEER REVIEW

The purpose of the second peer review panel meeting was to provide technical guidance in the model specification and estimation, and on the forecasting assumptions. The elements of the model reviewed at this meeting included the following: review of model design, interregional travel models, forecast assumptions, and summary.

There were two reports that were delivered to the peer review panel for review:

1. *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Interregional Model System Development*, Cambridge Systematics, Inc., May 2006.
2. *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Level of Service Assumptions and Forecast Alternatives*, Cambridge Systematics, Inc., May 2006.

These reports were both updated based on comments from the peer review panel and consultant team members, and the final versions submitted in August 2006.

There were a series of recommendations mentioned for consideration or inclusion into the modeling or forecasting approach. These are described below with additional notes on the implementation of these recommendations.

Model Development

There were a series of recommendations by the peer review panel that were agreed to during the meeting, as follows.

- We proposed consideration of estimating nonresident, high-speed rail travel by separating current air demand into resident and nonresident segments, and then assuming that nonresident mode shares for air and high-speed rail will mimic resident mode shares for air and high-speed rail. This approach serves to include nonresident demand for high-speed rail directly and assists in the calibration of air demand by including only resident air demand. We will review available data sources to estimate the resident/nonresident air demand shares to support this analysis. This recommendation was not implemented due to time and resources constraints, but should be considered for future reference.
- We should develop annualization factors from an evaluation of the high-speed rail systems in operation around the world. These annualization factors will allow us to predict annual ridership from our modeled estimates of

average weekday ridership. This recommendation was implemented and documented in a separate technical memorandum[14].

- There were a series of recommended changes to the model development report, which should be included into the final model development report along with the final models. These included changing the wording of the MPO and non-MPO market segments to large MPO and other regions market segments, showing distributions of data from model application rather than model estimation data, and revising mode choice model nests to reflect that the walk mode includes bike. These recommendations were implemented.
- We should finalize the trip frequency, destination, and mode choice models, which involve calculating the actual logsums from each lower-level model and using these data to re-estimate the logsum variable in the upper-level model (This will be done for trip frequency and destination choice.). It also involves reviewing insignificant variables in each model to determine if we should drop them from the model specification, or if they add value to the models (and are logical) indicating that we should retain them. These recommendations were implemented.

There were also a series of recommendations by the peer review panel that were suggested for consideration. These are described below, along with the final actions determined by subsequent meetings between the MTC, the CHSRA, and consultant team staff.

- One peer review panel member requested that we consider replacing mode choice logsums in the urban distribution models to estimate the impacts of high-speed rail travel on urban trip lengths. This request was considered, but would result in a high level of effort and is not expected to result in any significant differences in high-speed rail ridership, so we did not pursue this recommendation. This option can be pursued by MPOs wishing to evaluate this impact on their own urban models for those purposes (such as work) that are currently already incorporating mode choice logsums.
- One peer review panel member asked us to consider changing the name of the trip frequency models to mobility models to indicate the relationship of these models to travel demand. This was discussed further, but we concluded that trip frequency was a common term understood by model developers in the U.S. and we should retain this terminology.
- There was a substantive discussion about the need to include some measure of a reservation system or the convenience/inconvenience of having to make reservations ahead of time or at the station. There were some responses that

[14]Systra Consulting, *Review of Overseas HSR Traffic Seasonality and Recommendations for California HSR Forecasting*, prepared for Metropolitan Transportation Commission and the California High-Speed Rail Authority, September 8, 2006.

this type of information would not significantly influence travel behavior, and therefore would not warrant inclusion in the models. In addition, these data were not collected in our surveys, so it would not be possible to include in the estimated models.

Forecast Assumptions

There were a series of recommendations by the peer review panel that were agreed to during the meeting, as follows:

- One suggestion from the peer review panel was to increase the auto operating cost to include insurance and other items consistent with the Federal reimbursement policies. After discussing this with the panel, we agreed that this would create auto operating costs that were too high, and that the research the MTC had done in creating the auto operating cost assumptions was sound and should be retained as is.
- Another consideration from the peer review panel was to vary the cost inputs for auto operating cost by region. After reviewing the northern and southern California gas prices, we concluded that this difference was not significant enough to warrant including separate auto operating costs by region.
- The high-speed rail fares were reviewed and revised according to a series of suggested relationships to air and conventional rail fares. These fares were also reviewed in the context of the previous CHSRA fares used in prior ridership evaluations and set according to the same assumptions. These high-speed rail fares were subsequently updated and were used as a starting point for ridership evaluations. In addition, high-speed rail fares were tested during the sensitivity analyses.
- The wait, terminal, and transfer time assumptions for rail and air modes were reconsidered following extensive discussion from the peer review panel. In addition, we should test including the wait and terminal times by mode in the mode choice model during calibration as separate variables, so that changes in these policy variables can be tested. This recommendation was implemented.
- While the peer review panel felt that the inclusion of reliability measures was an important component of the models, there was much discussion on the specifics. The reliability measure was refined to provide consistency across modes and was included with a more significant coefficient in the mode choice model, established during the model calibration phase.
- Financially constrained and unconstrained plans for inclusion into the future baseline were discussed statewide. There was consensus that financially constrained plans should be used, that the unconstrained plans were not necessary to incorporate, and that all the projects identified were from financially unconstrained plans, except for SCAG. The SCAG's financially constrained plans were obtained and incorporated into the model.

- Sensitivity tests were proposed and discussed by the panel. Two other tests were suggested (socioeconomic data and value of time), but were not considered to be necessary by the panel. One test for more or less expensive electricity was eliminated, because it is not a significant portion of the operating cost for high-speed rail.

8.3 Third Peer Review

The third peer review will be conducted individually with panel members rather than conducting a formal meeting of the panel. This review will include reviewing the model validation and initial forecasting results. Due to time constraints in the development of the forecasts, this review is just not being conducted, but any comments or modifications to the models that are identified will be incorporated into future updates of the model and subsequent forecasts.

9.0 Conclusions

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As is the case with most travel demand forecasting models of this magnitude, it is difficult to provide a summary at a single point in time, because the forecasting model is a dynamic tool that can and should be adapted and improved over time to provide additional insight on ridership and revenue forecasts for high-speed rail, but also to be a foundation for use in other types of regional and state planning projects. The California Statewide High-Speed Rail Forecasting Model did successfully achieve its objectives in providing reliable, objective, and detailed ridership and revenue forecasts of high-speed rail for use in evaluating the environmental impacts, as well as making route decision, operating plans, and financial plans.

The model also succeeded in providing a foundation for future regional planning activities throughout the State, including the Regional Rail Study in the San Francisco Bay Area and the I-80 corridor growth study between Sacramento and San Francisco. The model builds off the previous Caltrans Statewide Model and offers more accuracy and detail in the modeling components that was possible with the earlier version. The primary difference is the inclusion of separate models for interregional and intraregional travel, which is a significant improvement because of the very different travel behavior associated with interregional travel.

While the California Statewide High-Speed Rail Forecasting Model did achieve the majority of the detailed design and objectives set out in the project, there were a series of smaller improvements to the model that were identified during model application that will be considered for possible future enhancements to the model. These improvements will not impede the use of the current ridership and revenue forecasts, since they should have minimal effect on these, but may be useful if the model is used for another purpose (such as highway planning) or may be used to shed additional light on the results (such as more sensitivity tests) or may be used to make the models more user-friendly or efficient for future use. These potential improvements are identified below for future consideration, along with a summary of the ridership forecasts.

9.1 Ridership Forecasts

There were 37 alternatives conducted to evaluate various network and alignment alternatives for the high-speed rail system in California. These were designed primarily to identify the individual components of a preferred alternative (yet to be defined), so that future planning for high-speed rail can review these results and compare them to other environmental and cost factors in selecting the preferred operating and fare plans for high-speed rail.

In addition, there were dozens of sensitivity runs conducted to evaluate the impact of changes in level of service for high-speed rail, air, and auto modes on the high-speed rail ridership and revenues. Nine of these sensitivity runs were reported herein to highlight the significant factors in achieving higher ridership for high-speed rail. The two most significant factors tested for increasing high-speed rail ridership and revenues were increasing high-speed rail frequencies and increasing air and auto costs.

9.2 POTENTIAL MODEL IMPROVEMENTS

There are many potential improvements to the California Statewide High-Speed Rail Forecasting Model that would both expand its capabilities to other application, as well as improve model robustness. Major improvements categories include interregional model enhancements, intraregional model enhancements, improved integration and usability, and expanded forecasting years.

The Python code the interregional model is developed in could be sped up from its current run time. This would make feedback loops between the congested highway times and the interregional model feasible. In its present form, the model only predicts travel for households residing within California. While residents comprise the majority of travel, a visitor/nonresident travel component would ensure that all potential travel within California was included. The access egress mode choice models were calibrated on a high level. Additional data and time would allow further calibration of these models.

There are a number of improvements that could be made to the integration of the intraregional models with the interregional models, as well as with the intraregional models themselves. Both the MTC and SCAG intraregional models use high constants in their mode choice model to achieve base year calibration. However, the high constants dampen their sensitivity to level of service changes. There are a number of ways to address this issue, including revisiting the mode choice model structure and estimation. In addition, if station options in the vicinity of San Diego are to be evaluated in detail, an intraregional model for this region should also be developed. It also is possible to implement feedback loops between the statewide highway assignment and the intraregional models using auto skims. This would increase the posterity between the interregional and intraregional models. The integration of the interregional skims, interregional model, and the intraregional models could be coded into one Cube application to enhance usability and reduce the possibility of error.

A number of things can be done to update the base year and extend the horizon years beyond 2030. The base year could be updated to 2005. This could include some further calibration and validation based on 2005 conditions. The 2005 forecasts could be compared to the 2000 and 2030 forecasts. A trend analysis could be developed for 2040 and 2050 forecasts. Although the highway assignments were adequately validated for the purpose of high-speed rail forecasts, further validation of the highway networks could be done to enable the model to be used for statewide highway forecasting.

9.3 ACKNOWLEDGMENTS

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