Draft Final Report

Independent Ridership and Passenger Revenue Projections for High Speed Rail Alternatives in California

Prepared for

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E-1. INTRODUCTION

This report presents comprehensive forecasts of ridership and passenger revenue on alternative proposed high speed rail (HSR) systems between San Diego, Los Angeles, the Central Valley, the San Francisco Bay Area and Sacramento. The California High-Speed Rail Authority (the "Authority") is evaluating proposals to provide HSR service between these regions.

The results presented in this report build on the work Charles River Associates (CRA) carried out for the predecessor California Intercity High Speed Rail Commission (the "Commission") between 1994 and 1996[1]. CRA was selected by both the Commission and the Authority as the independent consultant to provide the ridership and revenue forecasts for their consideration. CRA's work included:

- Collecting significant new data on California's transportation system, current intercity travel and modal preferences in California;
- Developing state-of-the-art forecasting models for California intercity travel by existing conventional modes (air and private auto) and by high speed rail and maglev, which are new modes in the U.S.;
- Forecasting future intercity travel in California in the absence of HSR service; and
- Estimating HSR ridership and passenger revenue for a large number of system alternatives and operating scenarios.

This report presents the results of our new forecasting work for the Authority, including

[1] See *Independent Ridership and Revenue Projections for High Speed Rail Alternatives in California*, Charles River Associates, Report No. 570-05, prepared for the California Intercity High Speed Rail Commission, July 1996.

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1. Forecasts of *intercity ridership and revenue* on the HSR system, using the most recent available data;

2. Forecasts of potential *commuter travel* on the HSR system within major metropolitan areas;

3. Estimation of the *benefits* that would be produced by the high speed rail system; and

4. The results of a benefit/cost analysis of the HSR system.

In addition, a number of sensitivity analyses of different HSR fares and of different air and private vehicle travel growth, airfare and travel time assumptions were carried out as part of this study. Together, these forecasts and sensitivity analyses represent the most advanced state-of-the-art, comprehensive intercity HSR ridership and revenue forecasts and analyses ever carried out in California, and possibly anywhere. In the process, much has been learned, not only about high speed rail ridership and modal preferences, but also about the existing intercity travel market in California, and its future growth in the absence of high speed rail.

This executive summary is organized as follows (with section numbers E-X):

- Brief descriptions of alternative HSR alignments and two technologies (E-2),
- The intercity HSR ridership and revenue forecasts (E-3),
- Summary of intercity forecasting methodology (E-4),
- The survey data collection (E-5),
- Forecasting future intercity air, private auto, and conventional rail travel in the absence of HSR (E-6),
- Forecasting intercity HSR market shares (E-7),
- Updating the input data for the intercity forecasts (E-8),
- Forecasting commuter ridership and revenue on HSR alignments (E-9),
- Benefit/cost analysis of the HSR system (E-10), *and*

- Organization of the report (E-11).

Readers who are interested only in forecasting results can read sections E-2, E-3 and E-9. Readers who are also interested in an overview of the intercity forecasting methodology can read section E-4.

Finally, readers who are interested in summary descriptions of the new data collection, the forecasts of future intercity travel by the existing modes in California, the intercity HSR market share models, and the benefit/cost analysis should read the entire executive summary. The full report contains detailed descriptions of the transportation system and travel database, the forecasting methods and models and the forecasts themselves. The forecasting models developed in the study are a tool capable of being used to conduct additional detailed analyses of HSR in California.

In some cases, voluminous detailed descriptions of the collection of data used in work for both the Commission and the Authority is not duplicated here. The interested reader is referred to our earler report[2] for this material.

E-2. DESCRIPTION OF PROPOSED HSR SYSTEM

Intercity HSR Service

For the purposes of this study, *intercity* travel is defined as travel *between* cities and regions in California. That is, it does not include any travel wholly within a metropolitan area. Figure E-1 shows that the proposed intercity HSR alignment would run from San Diego to Los Angeles, and then through the Central Valley to both the San Francisco Bay Area and Sacramento. Forecasts are presented in this report for the two Tehachapi crossings shown in Figure E-1 (i.e., Option A through Palmdale and Option B on the so-called I-5 Grapevine alignment).

[2] Ibid

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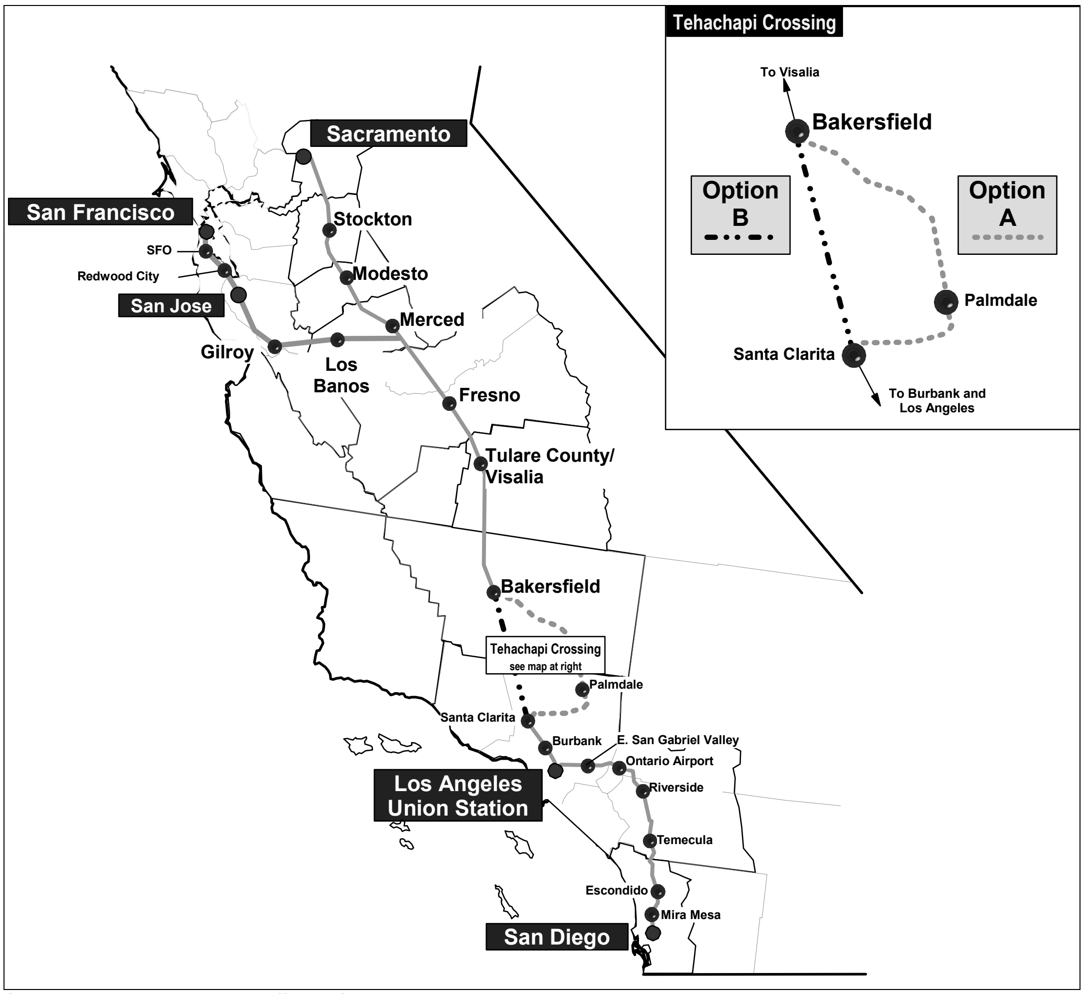
Forecasts were also produced for a large number of additional alternatives to aid in the Authority's decision process.

Figure E- 1. Intercity High Speed Rail System Alignments



Source: Parsons Brinckerhoff and Charles River Associates, 1999.

Forecasts were also produced for two different high speed ground transportation (HSGT) technologies on each of the alignments shown in Figure E-1.

1. *Very high speed rail (VHS)*, for example, the steel wheel on rail technology used by the French TGV system having a top speed in revenue service of approximately 200 mph.; and

2. *Magnetic Levitation (Maglev)*, a technology such as that now in development in Germany, Japan, and the United States, and having a top speed in revenue service of approximately 300 mph.

Information on access/egress times and costs[3] to/from the proposed HSR stations, terminal processing times, and HSR fares were developed by CRA as part of this study. Data on HSR frequencies, HSR travel times, and HSR stopping patterns were provided to us in the form of an operating plan by Parsons Brinckerhoff (PB). In 2020, a total of 86 weekday trains are scheduled to operate in each direction to serve the statewide intercity travel market.

The basic HSR fares assumed for the forecasts are computed based on 50 percent of the average 1997 Los Angeles-Bay Area airfare of $68.09 (in $1999). Twenty dollars is the charge to board HSR for intercity service, plus a fare per kilometer that increases the HSR fare to approximately $34 or 50 percent of the Los Angeles-Bay Area airfare between these two cities. This results in HSR fares that are much less, proportionately, than the comparable airfares in most other markets (e.g., Fresno – San Francisco).

Express Commuter Service

This study also examined the potential for the HSR system to provide express commuter services within the Los Angeles region, the San Francisco Bay Area, and the San Diego metropolitan area. The proposed commuter services would be provided between each of the stations within the metropolitan area (or just outside the area) including the central or downtown station. Alternative commuter alignments were studied in each of the three metropolitan areas.

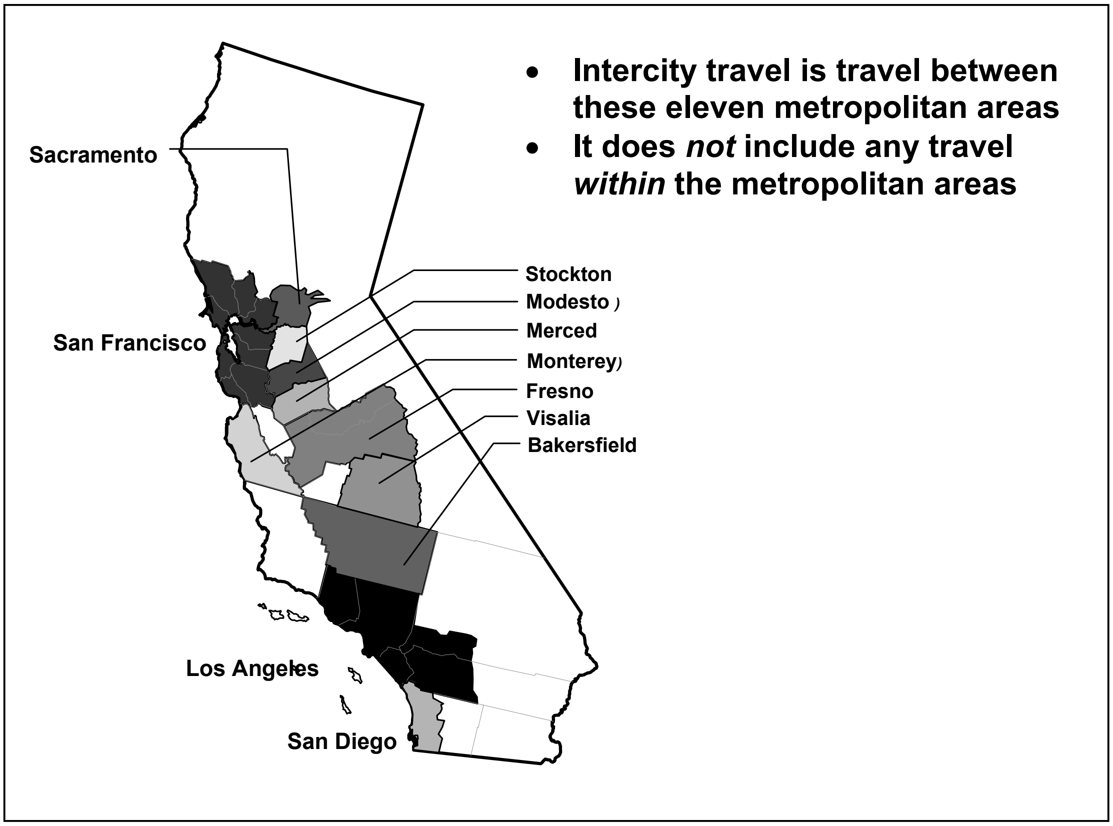
E-3. INTERCITY HSR RIDERSHIP AND REVENUE FORECASTS

Figure E-2 shows the eleven regions or metropolitan areas between which the forecasts of intercity ridership and revenue on HSR system alternatives were made. As noted earlier, forecasts of ridership and revenue *within* the San Diego,

[3] Access/egress times and costs are the times and costs of travel between the starting *or* end points of a trip (e.g., place of business or home) and the HSR stations.

Los Angeles, and San Francisco Bay Areas using express commuter services on the HSR alignments are presented in Section E-9 of this Executive Summary.

Figure E- 2. Defining Intercity Travel



Forecasts For Varying Alignments and Technologies

Table E-1 summarizes the intercity forecasts for the four alternatives described above. The table shows that the maglev technology produces higher ridership and revenue than the VHS technology due to its significantly faster travel times. Revenue is more sensitive than ridership to the speed of maglev because of the importance of speed in diverting air and private vehicle users to HSR on the longer LA-Bay Area O/D pair with its higher fare yield per trip than on the shorter distance city pairs within the corridor. For both technologies, Option B (through the Grapevine) produces both higher ridership and higher revenue than Option A (through Palmdale).

Table E- 1. 2020 Intercity Ridership and Passenger Revenue by Alternative

Route Option	Technology	Ridership	% Change	Revenue ($99)	% Change
Option A	VHS	30,286,332	-	848,339,992	-
	Maglev	38,430,125	26.9%	1,113,370,396	31.2%
Option B	VHS	32,002,103	5.7%	888,177,557	4.7%
	Maglev	39,814,665	31.5%	1,136,530,877	34.0%

Source: Charles River Associates, 1999.

Table E-2 also shows how HSR ridership varies by alignment and technology. In addition, the table shows ridership by eight groups of travelers, in this case, city pair markets in the corridor. The table shows that most of the difference in ridership between the two route options is accounted for by the longer distance northern California-southern California markets (e.g., Los Angeles-San Francisco), which have a more direct routing and therefore faster travel times under Option B. Table E-3 presents the analogous information for passenger revenue, and indicates a similar pattern.

Tables E-4 and E-5 present the ridership and revenue results by *previous mode* for the two alignments and two technologies. The tables show that essentially all the difference between the two route options is in diverted air travel because these longer distance trips are better served by the faster Grapevine (B) alignment. This is consistent with the previous tables, which showed that most of the difference in ridership and revenue between the options is between the longer distance northern California-southern California markets between which most air travel in the corridor occurs.

Table E- 2. 2020 Ridership Summary by Origin-Destination Market Segment

	VHS		Maglev	
O/D Market Segment	**Option A 50%**	**Option B 50%**	**Option A 50%**	**Option B 50%**
Los Angeles – San Francisco	10,149,127	11,269,050	14,125,204	14,981,816
Los Angeles/San Francisco – Valley	5,120,355	5,233,698	5,692,197	5,799,715
Valley – Valley	783,805	768,334	843,067	824,702
Sacramento – Los Angeles	3,084,488	3,384,964	4,082,289	4,267,865
Sacramento – San Francisco	1,690,169	1,690,169	2,020,286	2,020,286
San Diego – Los Angeles	5,426,904	5,304,220	5,877,854	5,737,451
San Diego – San Francisco	2,016,041	2,260,634	3,284,302	3,584,847
Other	2,015,444	2,091,034	2,504,924	2,597,982
Total	**30,286,332**	**32,002,103**	**38,430,125**	**39,814,665**

Source: Charles River Associates, 1999.

Table E- 3. 2020 Revenue Summary by Origin-Destination Market Segment ($1999)

	VHS		Maglev	
O/D Market Segment	**Option A 50%**	**Option B 50%**	**Option A 50%**	**Option B 50%**
Los Angeles – San Francisco	320,519,503	347,881,522	453,962,454	469,025,604
Los Angeles/San Francisco – Valley	122,993,128	129,861,992	137,816,002	138,072,777
Valley – Valley	18,154,513	17,721,242	19,718,605	19,201,292
Sacramento – Los Angeles	97,314,215	104,217,668	130,260,591	132,455,748
Sacramento – San Francisco	40,782,380	40,782,380	49,718,703	49,718,703
San Diego – Los Angeles	127,670,556	124,658,232	139,383,626	135,891,950
San Diego – San Francisco	67,535,678	74,304,949	113,472,630	121,263,656
Other	53,370,020	48,749,572	69,037,786	70,901,146
Total	**848,339,992**	**888,177,557**	**1,113,370,396**	**1,136,530,877**

Source: Charles River Associates, 1999.

Table E- 4. 2020 Ridership Summary by Source

	VHS		Maglev	
Source	**Option A 50%**	**Option B 50%**	**Option A 50%**	**Option B 50%**
Local air	12,844,010	14,373,650	18,471,602	19,693,469
Connect air	278,046	278,046	376,661	376,661
Amtrak rail	1,934,036	1,915,011	2,042,288	2,021,776
Auto	13,207,747	13,404,305	15,198,521	15,364,490
Induced	2,022,492	2,031,091	2,341,052	2,358,268
Total	**30,286,332**	**32,002,103**	**38,430,125**	**39,814,665**

Source: Charles River Associates, 1999.

Table E- 5. 2020 Revenue Summary by Source ($1999)

	VHS		Maglev	
Source	Option A 50%	Option B 50%	Option A 50%	Option B 50%
Local air	423,926,544	463,894,072	620,911,793	645,859,285
Connect air	6,196,978	6,196,978	8,684,945	8,684,945
Amtrak rail	41,764,858	41,139,410	44,318,598	43,644,639
Auto	330,212,251	330,689,538	384,624,630	383,266,444
Induced	46,239,361	46,257,559	54,830,429	55,075,564
Total	**848,339,992**	**888,177,557**	**1,113,370,396**	**1,136,530,877**

Source: Charles River Associates, 1999.

Additional Forecast Results for the Business Plan Funding Scenario Alternative

Additional forecast results are presented here for the VHS option providing the highest return on investment which was used for the funding scenario in the Authority's Draft Business Plan. This is the alignment crossing the Tehachapi mountains via the Grapevine (Option B). Table E-6 shows that 14 percent of all corridor trips are projected to be diverted to HSR in 2020 for this scenario. Over half of all local air trips in the corridor (56 percent) are projected to be diverted to HSR, and over two-thirds of all conventional rail trips (71 percent). The diversion of private vehicle and connecting air trips is projected to be quite small, at 7 percent and 5 percent respectively.

Table E- 6. Percent Diversion to HSR by Mode for 2020 (Funding Scenario)

Mode	Percent of Trips Diverted
Local Air	56%
Connect Air	5%
Rail	71%
Private Vehicle	7%
Total	14%

Source: Charles River Associates, 1999.

Table E-7 shows how these percentages translate into total HSR ridership and revenue. While the percentage of air trips diverted is eight times as large as the percentage of auto trips diverted, diverted auto trips contribute almost as much to total HSR ridership because the *base* of auto trips is so much larger. Local air diversion is nevertheless the largest contributor to HSR ridership at 45 percent of the total, and contributes over half the total revenue (52 percent). Auto trips contribute 42 percent of the total ridership but only 37 percent of the total revenue. These results reflect the fact that airline passengers travel longer distances on average than auto travelers, have a greater tendency to be business travelers, value their time more highly, and for all these reasons, pay higher fares than auto travelers.

Table E- 7. Total Intercity Ridership and Passenger Revenue in 2020 by Source for Funding Scenario

Source	Ridership	Percent of Total	Revenue ($99)	Percent of Total
Local Air	14,373,650	44.9%	$ 463,894,072	52.2%
Connect Air	278,046	0.9%	6,196,978	0.7%
Rail	1,915,011	6.0%	41,139,410	4.6%
Private Vehicle	13,404,305	41.9%	330,689,538	37.2%
Subtotal	29,971,012	93.7%	841,919,998	94.8%
Induced	2,031,091	6.3%	46,257,559	5.2%
Total	32,002,103	100.0%	888,177,557	100.0%

Figure E-3 illustrates the effect of the introduction of HSR on the market shares of the respective modes within the Corridor. It shows that auto would remain far and away the dominant mode, but that HSR would capture nearly 15 percent of all trips (it would divert 14 percent as shown in Table E-6, and would also induce some trips as shown in Table E-7). The figure shows how HSR would capture market share disproportionately from the air mode.

This result is shown even more clearly in Figure E-4, which illustrates the market shares before and after the introduction of HSR for trips over 150 miles. HSR would capture 35 percent of all of these trips, reducing the market share of local air by more than half.

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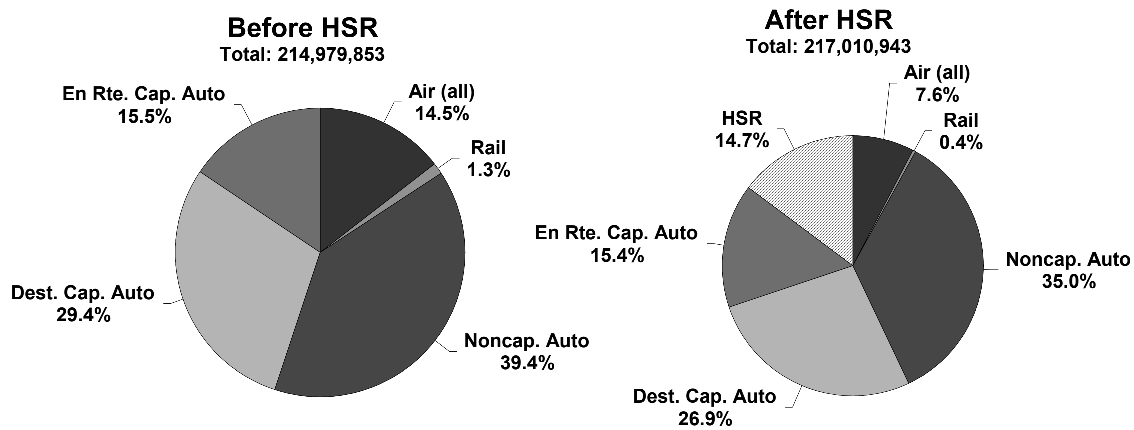
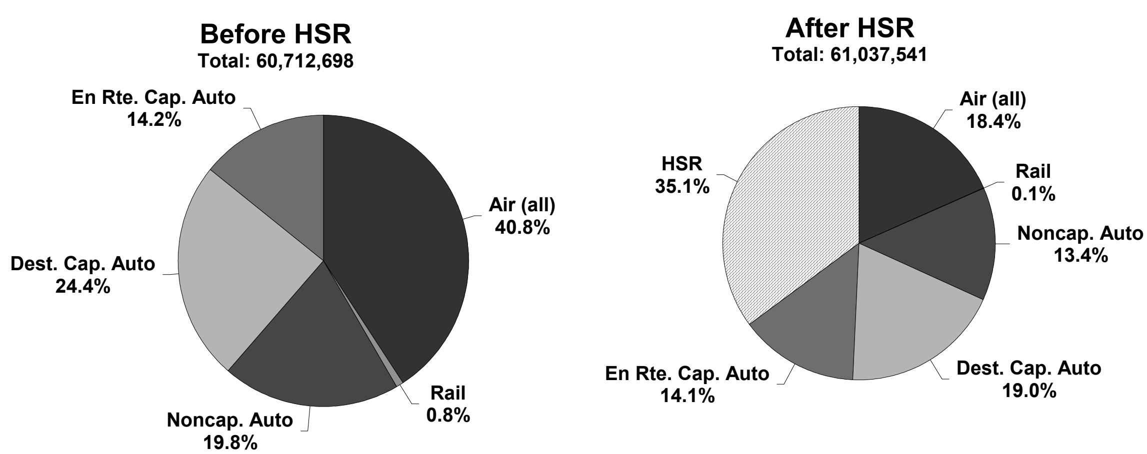
Figure E- 3. 2020 Market Shares Before and After HSR for Funding Scenario



Source: Charles River Associates, 1999.

Figure E- 4. 2020 Market Shares Before and After HSR for Funding Scenario (Trips >150 miles)



Source: Charles River Associates, 1999.

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Table E-8 summarizes the system ridership and revenue by O/D geographic market. These markets include trips between the Los Angeles and San Francisco metropolitan regions (e.g., San Jose to Santa Clarita), trips made between either Los Angeles or San Francisco and the Central Valley (e.g., Los Angeles to Bakersfield), trips between other major metropolitan regions (e.g., Sacramento to Los Angeles) and other trips (e.g., Sacramento to San Diego). Trips between the San Francisco and Los Angeles regions contribute the largest portion of system ridership (35 percent) and revenue (39 percent). The next largest contributions to ridership and revenue are forecast to come from trips between the Los Angeles or San Francisco regions and the Central Valley (16 percent of ridership) and between the San Diego and Los Angeles regions (17 percent of ridership).

Table E- 8. 2020 HSR Ridership and Revenue by O/D Market Segment for Funding Scenario

O/D Market Segment	Ridership	Revenue	% Ridership	% Revenue
Los Angeles – San Francisco	$11,269,050	347,881,522	35	39
Los Angeles/San Francisco – Valley	5,233,698	129,861,992	16	15
Valley – Valley	768,334	17,721,242	2	2
Sacramento – Los Angeles	3,384,964	104,217,668	11	12
Sacramento – San Francisco	1,690,169	40,782,380	5	5
San Diego – Los Angeles	5,304,220	124,658,232	17	14
San Diego – San Francisco	2,260,634	74,304,949	7	8
Other	2,091,034	48,749,572	7	5
Total	32,002,103	888,177,557	100	100

Source: Charles River Associates, 1999.

Table E-9 presents the projected boardings for each HSR station for the funding scenario. The table shows that the major central city stations of Los Angeles Union Station, downtown San Francisco, Sacramento, and Qualcomm Stadium (San Diego) have the highest boardings, together accounting for 46 percent of the total. Other stations within the major metro areas also have very high levels of activity, including San Jose in the Bay Area and the East San Gabriel Valley station in the Los Angeles region, which each have roughly two and a half million annual boardings.

Table E- 9. 2020 Boardings by Station for Funding Scenario

Station Name	Total Annual Boardings	Average Daily Boardings
Sacramento	3,601,244	9,866
Stockton	543,279	1,488
San Francisco	3,916,509	10,730
San Francisco Airport	642,250	1,760
Redwood City	1,146,138	3,140
San Jose	2,497,768	6,843
Gilroy	753,515	2,064
Los Banos	77,206	212
Modesto	651,612	1,785
Merced	205,343	563
Fresno	1,243,184	3,406
Tulare/Kings County	69,018	189
Bakersfield	965,430	2,645
Santa Clarita	1,138,067	3,118
Burbank Airport	1,482,777	4,062
Los Angeles Union Station	4,498,216	12,324
East San Gabriel Valley	2,422,135	6,636
Ontario Airport	512,355	1,404
Riverside	958,502	2,626
Temecula	581,878	1,594
Escondido	915,993	2,510
Mira Mesa	457,997	1,255
Qualcomm Stadium	2,721,685	7,457
Total	32,002,103	87,677

Source: Charles River Associates, 1999.

Sensitivity Analyses

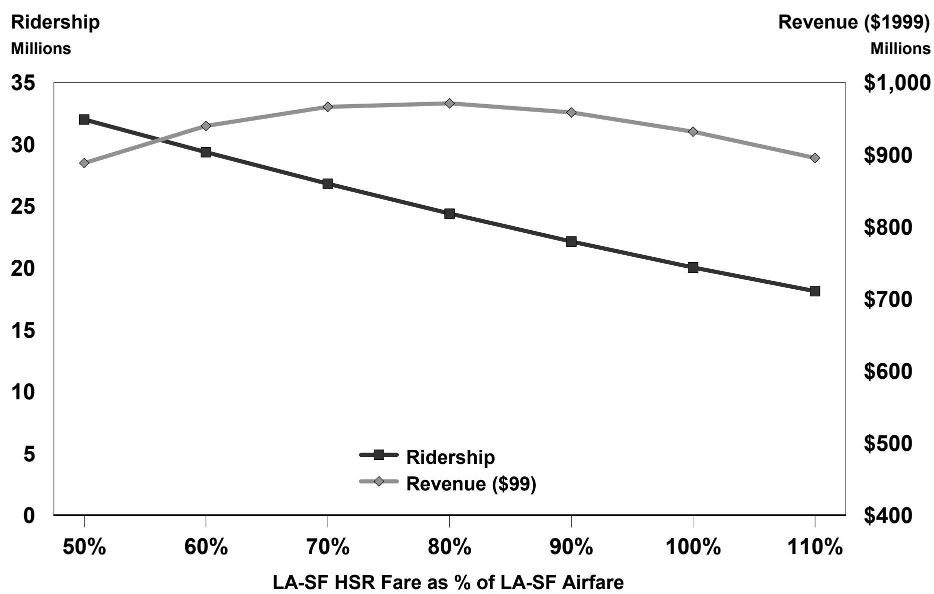
Two types of sensitivity analyses were carried out for the funding scenario to supplement the results described above. In the first analysis, the assumption about the fares that would be charged for HSR service was varied to test the implications for ridership and revenue. We also tested the effects of changes in the assumptions about the competing modes, including both the level of travel that these modes would produce in the future as well as their future level of service characteristics.

Alternate HSR Fare Assumptions

Under the selected fare structure, HSR fares are set to equal 50 percent of the current average airfare for travel between San Francisco and Los Angeles. This results in HSR fares that are much less, proportionately, than the comparable airfares in most other markets (e.g., Fresno – San Francisco).

A number of alternative HSR fare structures were tested to evaluate the sensitivity of ridership and revenue to higher or lower fares. Alternative fare structures were characterized by the percent that the HSR fare is of the comparable average air fare between Los Angeles and San Francisco. Figure E-5 shows that the revenue maximizing fare for the funding scenario is between 70 to 80 percent of the Los Angeles to San Francisco airfare.

Figure E- 5. Sensitivity of 2020 Ridership and Revenue to HSR Fare Assumption (Funding Scenario)



Source: Charles River Associates, 1999.

The HSR structure selected for the funding scenario was set at the level which increased ridership (i.e., user benefits) *without* losing significant revenue. Under the selected 50 percent fare structure, ridership increases by 31 percent over the

80 percent revenue maximizing fare structure, while revenue only decreases by less than 9 percent ($971 million vs. $888 million).

Assumptions about Competing Modes

CRA was requested to carry out six other sensitivity analyses, all dealing with possible variations in the characteristics of the competing modes which would tend to increase HSR ridership and revenue. They are as follows:

1. *Higher growth rates for air and auto travel*. Average growth rates of 3.5 percent and 2.0 percent per year for air and auto, respectively, were compared to the average annual rates of 2.5 percent and 1.3 percent reflected in the base forecasts.

2. *Longer air travel times*. Fifteen minutes was added on each end to all air travel times between zones assigned to LAX, SFO and San Diego Airport. (Thus a half hour would be added to an LAX to SFO trip while an LAX to Oakland trip would increase by 15 minutes).

3. *Longer auto travel times*. A half hour was added to all trips to, from or through the Los Angeles and San Francisco Bay Area regions. Thus for a Los Angeles to San Francisco trip one hour would be added, a San Diego-Sacramento trip would be a half hour longer, as would travel times for all other trips with one trip end in either Los Angeles or the Bay Area.

4. *Increased air fares*. Increases of 50 percent, 100 percent, and 150 percent were tested.

5. *Two combinations of the above*. The increased air and auto travel time cases (2 and 3, above) were combined with both the 50 percent and 150 percent air fare increases.

6. *Two additional combinations of the above.* A combination of all of the first four cases, combining the increased air and auto growth rates and travel times with both the 50 percent and 150 percent air fare increases.

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Each of the sensitivity analyses was carried out for the funding scenario, assuming all other input data would remain the same, including the HSR fares. Table E-10 compares the results for 2020 with the base case funding scenario.

Table E- 10. Summary of Sensitivity Analyses for 2020

Case	Ridership	Revenue	Ridership	Revenue
Base forecast	32,002,103	$888,177,557	N/A	N/A
1. Annual air/auto growth at 3.5%/2.0%	40,170,487	$1,127,131,550	+25.5%	+26.9%
2. Air travel time +15 min SAN, SFO, LAX	32,912,408	$919,547,591	+2.8%	+3.5%
3. Auto travel time +30 min LA, Bay Area	35,062,941	$970,049,577	+9.6%	+9.2%
4. a.) Air fares +50%	37,681,945	$1,086,744,114	+17.7%	+22.4%
b.) Air fares +100%	41,184,703	$1,209,990,416	+28.7%	+36.2%
c.) Air fares +150%	42,673,742	$1,261,102,070	+33.3%	+42.0%
5. a.) Combination of 2, 3, and 4 a.)	41,512,343	$1,195,878,030	+29.7%	+34.6%
b.) Combination of 2, 3, and 4 c.)	45,891,691	$1,348,162,523	+43.4%	+51.8%
6. a.) Combination of 1, 2, 3, and 4 a.)	52,537,431	$1,529,405,709	+64.2%	+72.2%
b.) Combination of 1, 2, 3, and 4 c.)	58,397,253	$1,733,006,817	+82.5%	+95.1%

Source: Charles River Associates, 1999.

As can be seen from Table E-10, the most important impacts on HSR ridership and revenue result from increased annual growth rates for total air and auto travel, and from increased air fares. The higher air fares result in ridership forecasts of between 18 and 34 percent over the base case. Additional increases would result if increased air fares were combined with increased air and auto growth rates and travel times. By comparison, increased air or auto travel times alone would have a modest impact on HSR ridership.

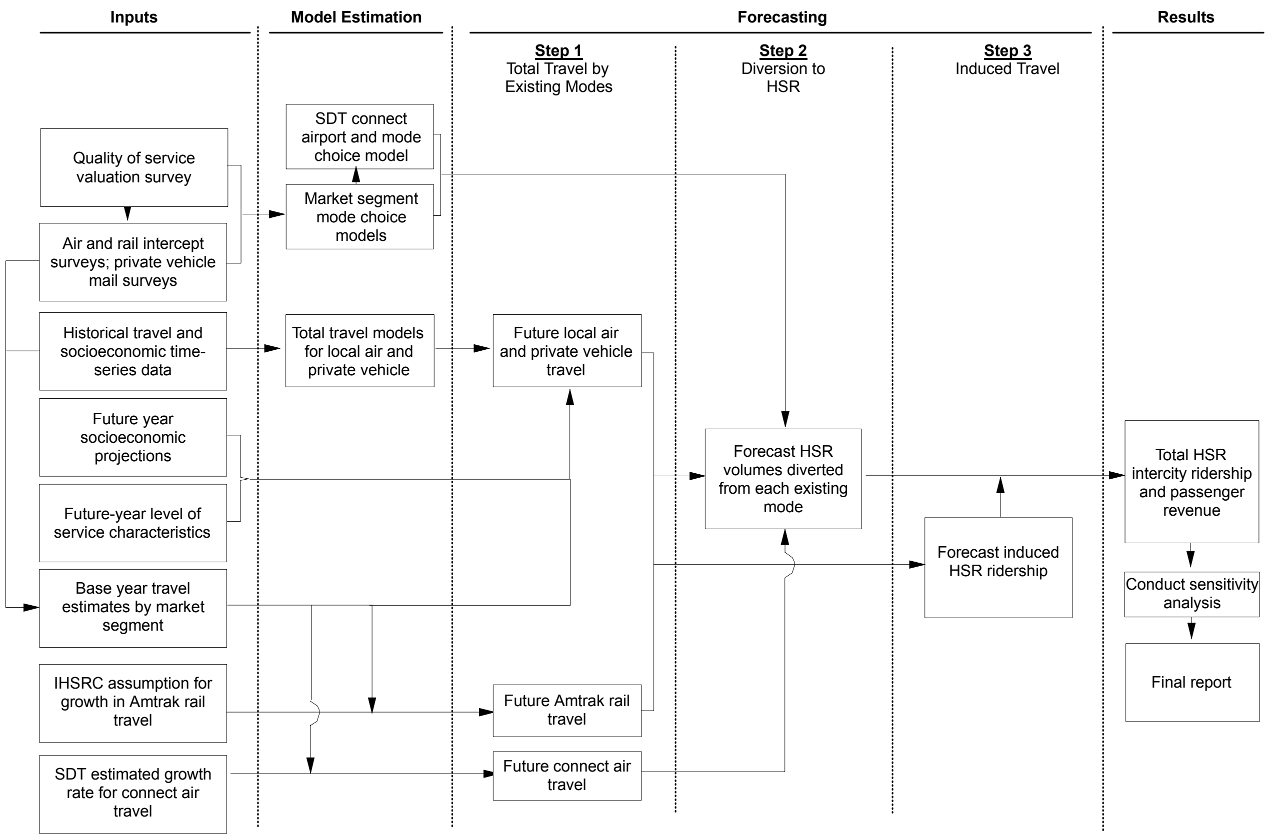
The sensitivity of revenue follows a similar pattern. The maximum impact results from sensitivity analysis 6.b which nearly doubles HSR revenues. Revenue grows faster than ridership when air travel growth or air fares are increased due to the longer, higher yield trips which are affected. When only auto travel is affected, as in case 3, ridership grows faster than revenue since the auto trips are shorter than the average trip length, which includes (diverted) air trips.

E-4. SUMMARY OF INTERCITY FORECASTING METHODOLOGY

The forecasts contained in this report were produced using the same methodology as used in our previous study for the Commission. We estimated intercity HSR ridership by first estimating the size of the total travel market in the initial forecast year (2020) for intercity air (local and connect), conventional rail, and private vehicle travel in the absence of HSR. Then using our mode choice models that incorporate customer preferences developed from our surveys of air, rail, and private vehicle travelers, we estimated HSR's share of the future travel market, given the anticipated service levels on the competing modes. In the third and last step, we estimated induced demand.

A detailed overview of the forecasting process is provided in Figure E-6. The figure shows that an extensive series of *input data*, both historical and future (for the determinants of travel), was required for forecasting future HSR ridership and revenue. Data collection and preparation included large-scale surveys of individuals who made intercity trips by private vehicle and who were in the process of making intercity trips by air and rail; targeted surveys of individuals who made intercity air trips; collection of historical and forecast population, income, and traffic data; and preparation of data for an airline connecting simulation model. (Connect travelers are travelers changing planes at California airports proposed to be served by HSR.)

Figure E- 6. Flow Chart of Intercity HSR Ridership and Passenger Revenue Forecasting Process



Source: Charles River Associates, 1996.

After the preparation of input data, the second stage of the forecasting process shown in Figure E-6 was *model estimation*. In this stage, we estimated the total air and private vehicle travel demand models, and the stated preference (Value Perception Analysis or VPA) mode choice diversion models for 10 market segments (mode and trip purpose combinations).

Finally, the three-step intercity ridership *forecasting* part of the process applied the total air and private vehicle demand models, with the appropriate future-year input data, to forecast air and private vehicle travel; developed future year rail trip tables; applied the separate mode choice models to the future local air, rail, and private vehicle volumes to forecast HSR travel diverted from each mode; applied the airline connecting traffic model to forecast HSR travel diverted from this market segment; and forecast induced travel based on the overall contribution of the HSR improvement to intercity travel service in the corridor. Diverted and induced travel were then combined to produce the total HSR intercity ridership and passenger revenue projections presented in this report.

A three-step approach is standard practice in forecasting intercity travel demand. Usually, however, the models that predict the market share for a new mode assume that travelers will divert from the existing modes to the new mode in direct proportion to the shares of trips on the existing modes. For this study, we developed separate binary choice models, each comparing the attractiveness of HSR with just one of the existing modes of travel (air, rail, or private vehicle). Consequently, intercity travelers' preferences for a new mode can vary not only by trip purpose, but also by the intercity mode they currently use.

E-5. THE NEW SURVEY DATA COLLECTION

In our earlier work for the Commission, CRA designed and carried out a comprehensive program of new surveys to collect new information for use in developing the HSR ridership forecasts in this study.[4] The results of this very important and extensive data collection program were used in the current study and are summarized here. The three primary objectives of this data collection were:

- **To determine the current origin/destination patterns of intercity private vehicle travel**
  Good information about the origins and destinations of current trips by common carriers can be obtained from available ticket sales data. No comparable source of information exists for private vehicle travel.

- **To augment available information about current intercity travel behavior by all modes**
  Ticket-based data provide no information about (for example) the purpose of the trip or other key considerations that influence the propensity to switch to a

[4] Charles River Associates, 1996, op. cit.

new mode. Consequently, such information needs to be gathered in new surveys.

- **To measure traveler preferences for the service features provided by HSR alternatives**
  Forecasting the extent to which intercity trips can be diverted from their existing modes requires an understanding of the ways in which service features affect mode choice decisions.

In total, the study team designed and carried out *four* different types of surveys to collect the new information to develop the forecasting models and to help develop the necessary intercity trip tables. These are labeled A through D, as follows:

A. A *household mail survey* detailing recent intercity travel made by members of corridor-resident households;

B. *"Intercept surveys" of passengers* in which existing travelers are sampled in the course of making an intercity trip by common carrier (air or rail) within the corridor;

C. A mail survey of recent *private vehicle tripmakers*, identified as a sample of the household mail survey based on their response to survey A; *and*

D. A computer-assisted *quality of service (QoS) survey* of recent travelers in the corridor.

The fieldwork for the surveys was carried out between May and August, 1995. Table E-11 summarizes the sample sizes of the surveys.

Table E- 11. Numbers of Responses to the California Traveler Surveys

Survey	Interview Contacts	Households or Qualifying Travelers Administered Surveys	Usable Detailed Responses	Percent of Total
A. Household Total Travel Survey	26,400	26,400	15,713	60%
B. Air Intercept Survey	8,728	4,711	1,495	32%
Rail Intercept Survey	4,672	4,007	2,818	70%
C. Private Vehicle Travel Survey	2,479	2,479	1,983	80%
D. Quality of Service (QoS) Survey	6,771	1,620	957	59%
Total	49,050	39,217	22,966	59%

E-6. FORECASTING FUTURE INTERCITY AIR, PRIVATE VEHICLE, AND CONVENTIONAL RAIL TRAVEL

The first step in the three-step HSR ridership forecasting process shown in Figure E-6 was to forecast total intercity air, private vehicle, and conventional rail travel between the eleven metropolitan areas making up the California HSR Corridor. These eleven regions or metropolitan areas and their constituent counties were shown in Figure E-2.

Future travel on the three existing modes was forecast through the application of total travel demand models. In our previous study for the Commission we developed separate travel demand models which forecast total trips by air and auto based on changes in the underlying socioeconomic variables that are important drivers of travel. Conventional rail (Amtrak) trips were held constant at the base year level at the direction of the Commission.

For the current study, conventional rail (Amtrak) trips were assumed to increase at the rate of population growth of the metropolitan areas served by the HSR system. The total travel demand models for air and auto were reestimated with more recent data available through 1997, in order to include the effects of changes occurring since the previous study was completed. Annual historical data from 1982-1997 were used to estimate these "time-series" demand models of intercity air and private vehicle travel in the Corridor. The data used to develop these models included:

- Level of service characteristics of the subject and competing modes (including costs);
- Socioeconomic characteristics of the origin and destination cities (population, employment, and income; *and*
- Travel volumes by mode (air, private vehicle) — the dependent variable.

The final specifications of the models chosen are consistent with those used previously, as are the estimated coefficients, such that all else being equal, the substitution of the new models does not materially affect the forecasts of future travel.

Population, per capita income, airfares, travel time, and travel distance were the significant variables in the air and private vehicle demand forecasting models estimated with the historical data. For forecasting purposes future airfares were held constant in real terms at 1997 levels in the Corridor for all the basic forecasting alternatives. We assume the intense airline competition which exists in the Corridor will continue and not allow fares to rise faster than the rate of inflation.

The new air and auto total demand models were then used to forecast future-year air and private vehicle travel in the Corridor in the absence of HSR.

E-7. FORECASTING INTERCITY HIGH SPEED RAIL MARKET SHARES

After future air, private vehicle, and intercity conventional rail travel volumes have been forecast between each of the eleven metropolitan areas in the California corridor, the future market shares of HSR in each of these markets must be forecast. Customer preferences and the total size of each market determine the travel volumes diverted to HSR. The mechanism for forecasting future market shares is to develop detailed relationships between the market shares and the travel times, costs, and comfort levels of the competing modes. These relationships are called mode choice models. The mode choice models described here were developed in our previous work for the Commission. These models were used unchanged in the current study.

Market Segmentation

We developed separate mode choice models for ten major intercity travel market segments within the Corridor:

- Local air travel (business and nonbusiness separately),
- Connect air travel (business and nonbusiness),
- Intercity private vehicle travel (business and nonbusiness),
  - Short (up to 150 miles)
  - Long (greater than 150 miles)
- Conventional rail travel

This market segmentation approach to mode choice modeling is based on our prior experience that intercity travelers using the different modes behave very differently in terms of modal preferences and valuation of modal characteristics such as travel times and out-of-pocket costs. We expect travelers with high values of time to travel by air, other things being equal (including trip purpose). We also expect business travelers in general to value time more than nonbusiness travelers, other things being equal.

Indeed, people's selection of their current intercity travel modes reveals a great deal about their preferences for the various features of those modes. We segmented the market by the *revealed* preferences of travelers to use air, private vehicle, and conventional rail for their intercity travel in California.

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Mode Choice Model Estimation

In developing the mode choice models for each of the ten market segments, we tested a variety of explanatory variables, including separate line-haul (in-vehicle) time, access and egress time, wait time (calculated as half of the headway), and travel cost (or fare) variables. In addition, we examined various combinations of variables. We also tested alternative combinations of travel time, including defining travel time by using differential weights for line-haul time, access/egress time, and wait time.

A separate HSR *constant* was also estimated for each model, to measure the preference for HSR based on existing perceptions while controlling for the effects of all the other variables explicitly included in each model. This constant was modified in the air market segment models to incorporate travelers' willingness to pay for certain quality of service (QoS) attributes of HSR service.

In summary, the mode choice models relate traveler preferences for the existing modes and HSR to their level of service values and to the attributes inherent in the modes themselves. The values of time and the modal constants in the models exhibit very strong face validity and conform very well to the findings in our several previous HSR ridership studies, and to values of time reported in the literature (where available).

These mode choice models were used to estimate HSR market shares of travel in each market segment, given the anticipated service levels on the competing modes. These market shares were then applied to the future-year forecasts of travel on each mode made using the new total demand models described previously, using the updated input data described in the next section to determine the number of travelers (riders) diverted from each mode.

The third and final step in the three-step HSR ridership forecasting process shown in Figure E-6 was to forecast induced travel. Induced travel was estimated using the attribute values in the mode choice models to measure the attractiveness of the new mode to travelers in the Corridor. Diverted and induced travel in the intercity travel markets were then combined with the forecasts of connect air travel diversion to HSR to produce the total HSR intercity ridership forecasts (see forecasting results in section E-3).

E-8. UPDATING THE INPUT DATA FOR THE INTERCITY FORECASTS

This section summarizes our update for this study of the socioeconomic, travel, and transportation system database which was used in the previous Commission study. The previous study used 1994 as the "base" year, as this was the most recent year for which a consistent and complete set of data was available. For the current study, the base year was updated to 1997, as follows:

- New 1997 trip tables were developed for the existing modes;
- Forecasts of future trips by the existing modes were revised to take into account the effects of both changes in the travel market and revisions in socioeconomic forecasts that have occurred between 1994 and 1997; *and*
- The transportation level of service input data for the existing modes (times, costs, and service frequencies on the existing modes) were revised to reflect 1997 conditions.

The key changes to the forecasting database can be summarized as follows:

- *Total intercity travel increased more than 8% between 1994 and 1997*. Auto grew by an estimated 7.9 percent, while air traffic increased nearly 13 percent and Amtrak rail trips grew by almost 12 percent.
- *Projections of total future intercity travel by the existing modes have also increased slightly*. Our 2015 forecast of total air travel was revised upward from a previously forecast total growth in the corridor (from 1994) of 64.2 percent to the currently forecast growth of 66.6 percent. The total 2015 auto forecast changes from a 28.6 percent increase in travel over 1994 to a 35.4 percent increase in auto travel. Amtrak rail travel increased 41 percent from 1994 over our previous assumption of constant future ridership at 1994 levels. The revisions reflect the effect of three factors:
  - The changes in base year travel volumes described above;
  - The updating of the total travel demand models; *and*

- Extensive revisions to the state-sponsored forecasts of population and income which are the primary inputs to the total travel demand models

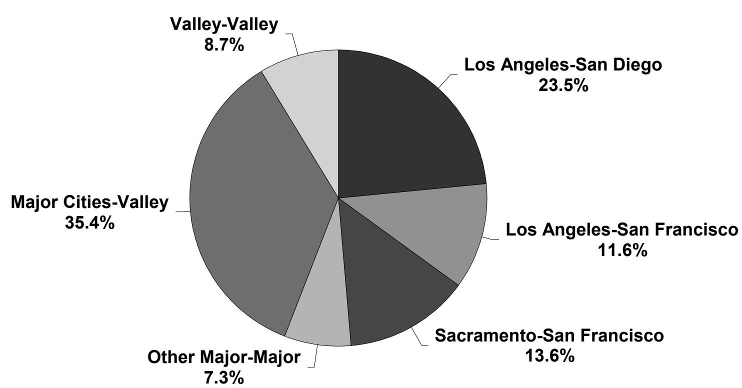
- *Real air fares have changed significantly but not consistently*. Fares in important markets have both increased and decreased in real terms, in some cases by 15 percent or more. The overall average fare for Los Angeles-San Francisco increased 3.5 percent in real terms between 1994 and 1997.

The first of these changes is described next. The reader is encouraged to read the full report for the complete input data update.

Existing Intercity Travel Market

An estimated 154 million intercity trips were made between the eleven California metropolitan areas of interest to this study in 1997, up from about 142 million in 1994, an increase of about 8.5 percent. Figure E-7 shows that the largest total travel market in the corridor is between Los Angeles and San Diego.

Figure E- 7. Total California Corridor Intercity Trips by Market - 1997[5]



Source: US DOT, Caltrans, and Charles River Associates, 1998.

The proximity of these two major metropolitan areas produces a large number of auto trips which help contribute to its 23 percent share of all corridor intercity

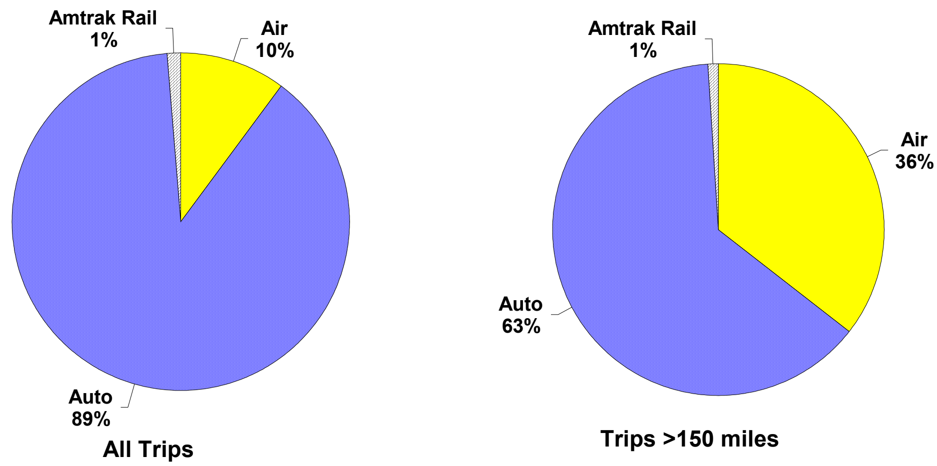
[5] The "major" metropolitan areas are Los Angeles, San Francisco, San Diego, and Sacramento.

trips. Sacramento-San Francisco is the next largest followed by Los Angeles-San Francisco with 14 percent and 12 percent of the total, respectively. Together, these three city pair markets account for nearly half of all intercity travel in the California corridor.

The figure also shows that travel between the Central Valley cities doesn't contribute a large portion of the total travel (just 9 percent), but travel between these cities and the four major metropolitan areas is substantial, accounting for over a third of all trips.

Figure E-8 provides a breakdown by mode of travel for all intercity trips and trips over 150 miles in length. Auto is by far the dominant mode, accounting for nearly 90 percent of all intercity trips in the corridor, with air trips representing most of the rest at 10 percent. The figure also shows that many of the auto trips are made at shorter distances, however, as the auto share drops to 63 percent and the air share increases to 36 percent for trips over 150 miles.[6] In either case, the figure shows that only 1 percent of intercity trips in California are made using Amtrak services.

Figure E- 8. California Corridor Intercity Trips by Mode (1997)



Source: US DOT, Caltrans, and Charles River Associates, 1998.

[6] Air travel between the Los Angeles and San Francisco regions is far larger than for any other city pair in the US.

E-9. FORECASTING COMMUTER RIDERSHIP AND REVENUE ON HSR ALIGNMENTS

Preliminary ridership and revenue forecasts have been made on *express commuter services* that could be provided on the proposed HSR alignments to the San Diego, Los Angeles, and the Bay Area (San Francisco, San Jose, and Oakland) urban centers. These ridership and revenue forecasts were made by transportation planning agencies in each of these three regions using their own regional forecasting models, maintained and used by those agencies for commuter and other travel demand forecasts within their regions.[7]

Urban and interregional commuters are additional travel markets that could benefit from the long-distance intercity HSR/maglev system. Ridership and revenue from these commuters is in addition to the *intercity* ridership and revenue for the statewide HSR system presented so far in this report. The new commuter information presented here is important for its own sake, and because it illustrates the relative magnitude of commuter and intercity ridership and revenue that would result from an HSR system in California.

The Alternatives that Were Tested

A basic assumption in undertaking this work is that express commuter services would be provided by HSR trains that travel as fast as the intercity service on the alignments shown in Figure E-1, with stops at all the HSR stations within and near each metropolitan area. As with the intercity system both high speed rail (HSR) and magnetic levitation (maglev) systems were evaluated. At each station, 2 or 4 trains per hour service could be provided for the three-hour A.M. and P.M. peak periods. In the off-peak, trains would operate hourly. A two-minute dwell time was assumed at each intermediate station. Fares were calculated based on a $5.00 boarding charge plus 6.2 cents per mile traveled. These fares are higher than most commuter rail services operating now in California, reflecting the higher quality of service to be provided on these “express commuter” systems.

[7] The three agencies making these forecasts were the Metropolitan Transportation Commission (MTC) for the nine-county San Francisco Bay Area region, the Orange Transportation Authority (OCTA) and its consultants for the Los Angeles metropolitan area, and the San Diego Association of Governments (SANDAG) and its consultants for San Diego County.

Executive Summary

However, fares would be approximately equal to the current $10.00 one-way fare charged on the Altamont Commuter Express (ACE) for the 86-mile trip between Stockton and San Jose.

Forecast Results

Table E-12 provides a summary of the forecasts. The table shows projected 2020 ridership and revenue for each alternative, for each technology and frequency assumption, and includes both daily and annual ridership figures. The table shows that projected commuter ridership and revenue for San Diego is quite small compared to that of the other two regions. Daily ridership is between 500 and 1,000 per day or 140,000-250,000 per year, depending on the frequency of service and technology. Annual revenue ranges between $1.0 and $1.7 million. For Los Angeles, the ridership and revenue potential on HSR alignments is much larger, reaching 15-20,000 riders per day and $35 million or more revenue on some alignments. The Bay Area forecasts fall between these two, but are relatively large. Daily ridership reaches 10-15,000 per day and $30 million revenue for the four train per hour service.

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Table E- 12. Summary of Year 2020 Preliminary Ridership and Revenue Forecasts for Express Commuter Alternatives

Location	Alignment	Tech-nology	Frequency (Peak Hour)	2020 Ridership Daily	2020 Ridership Annual (000s)	Annual 2020 Revenue (000) ($1999)
San Diego	Stadium	VHS	2	550	138	$938
		Maglev	2	650	162	$1,108
		VHS	4	880	220	$1,495
		Maglev	4	994	249	$1,689
Los Angeles*	Riverside County	VHS	4	14,200	3,545	$28,042
		Maglev	4	17,000	4,262	$33,571
	Los Angeles County**	VHS	4	17,100	4,275	$32,131
		Maglev	4	19,850	4,961	$37,298
San Francisco	Pacheco Pass	VHS	2	5,170	1,422	$9,700
		Maglev	2	7,300	2,008	$14,440
		VHS	4	11,900	3,272	$22,728
		Maglev	4	14,600	4,015	$30,777

*Two trains per peak hour were not tested for Los Angeles.
**Forecasts shown are for the service extending to Palmdale (Option A)

Source: Charles River Associates, 1999.

These results reflect the relative sizes of these regions, and importantly the relative sizes and densities of their major downtown areas. Commuter rail ridership is normally very downtown oriented and sensitive to the ease and cost of automobile parking as well as to highway congestion in the region. Nevertheless, commuter ridership, and especially the revenue potential on the HSR alignments is very small compared to the statewide intercity totals presented in Section E-3. The maximum commuter revenue on any one line is less than five percent of the intercity revenue for the Business Plan scenario shown in Table E-1. That is, even though commuter ridership on some of these alignments is relatively high, these trips are short compared to the intercity trips, and the yield (revenue per rider) on commuter trips is much lower than for intercity trips (e.g., $6 or $7 versus $30-$40).

However, based on these preliminary forecasts, it is clear that considerable potential exists for commuter ridership on the same HSR infrastructure as envisioned for the intercity system. The frequency of service is also a more important determinant of ridership than the technology used, consistent with the fact that both technology options tested would provide very fast travel times.

E-10. BENEFIT/COST ANALYSIS OF THE HSR SYSTEM

Benefit cost analysis (BCA) is a public sector evaluation tool that compares all the benefits of a project to society to all the costs of a project. The question to be answered in a BCA is: do these benefits exceed the costs? If the answer is yes, the benefit/cost ratio (BCR) is greater than one, and the project is said to be *economically* "feasible" or economically "justified." *Commercial* feasibility, the analogous private sector criterion, is much narrower in the benefits and costs it compares. Benefits are restricted to commercial *revenue*, and costs are limited only to those paid directly by the project developer.

In the case of the proposed California HSR system, considerable public benefits can be expected, in addition to farebox revenue. The benefits considered in this BCA don't include every conceivable benefit of HSR, but they do include the major categories of benefits:

- Intercity passenger revenue
- User benefits (over and above fares paid)
- Nonuser benefits
    - To intercity air and auto users (e.g., delay reductions)
    - To urban auto users (e.g., delay reductions)

The *costs* included in the BCA include all the construction, operating and maintenance costs. All costs and benefits occurring each year between FY 2001 and FY 2050 are included in the BCA and each is discounted back to 1999 using a 4 percent real discount rate to calculate the present value of the benefits and costs in 1999 dollars. The use of a 4 percent real discount rate in these benefit/cost calculations has been recommended by economists at the Center for the Continuing Study of the California Economy (CCSCE) based on their own work and the work of others.[8]

[8] For example, U.S. EPA, "Guidelines for Preparing Economic Analyses," June 11, 1999, Chapter 6: recommends a real rate of 2-3 percent for some public projects.

The results of the BCA for the Business Plan funding scenario alternative are summarized in Table E-13. The benefit/cost ratio is over 2 (using the 4 percent discount rate), meaning the total benefits of the proposed HSR system are over twice as large as the total costs. Therefore, the proposed system easily passes this important BCR criterion for determining whether the system is economically justified.

Table E- 13. Summary of Benefit/Cost Analysis Results for HSR Funding Scenario (Present Value in $1999, Discounted at 4 percent)

Total Benefits Total Costs	$44,148,761,000 $21,458,483,000
Net Present Value	$22,690,278,000
Benefit/Cost Ratio	2.06

E-11. ORGANIZATION OF THE REPORT

After this Executive Summary, Chapter 1 provides an introduction describing the purpose and objectives of this study and provides details of the HSR alternatives for which ridership and revenue forecasts are presented in the report. Chapter 2 describes our methodology for making projections of HSR ridership and revenue including the forecasting models developed to forecast HSR ridership and revenue and the extensive survey activities we carried out for this study. Chapter 3 describes our update of the comprehensive database developed as input to our projections of HSR ridership and revenue. Chapter 4 presents our forecasting results for the HSR alternatives and the various sensitivity analyses we carried out. Chapter 5 describes the ridership and revenue forecasts that were made by the various regional planning agencies on express commuter rail services that could be provided on the HSR alignments to the San Diego, Los Angeles, and Bay Area urban centers. Finally, Chapter 6 describes the estimation of benefits that would be produced by the HSR system, and the results of a benefit/cost analysis of the system.

1
Introduction

STUDY PURPOSE

This report presents comprehensive forecasts of ridership and passenger revenue on alternative proposed high speed rail (HSR) systems between San Diego, Los Angeles, the Central Valley, the San Francisco Bay Area and Sacramento. The California High-Speed Rail Authority (the "Authority") is evaluating proposals to provide HSR service between these regions.

The results presented in this report build on the work Charles River Associates (CRA) carried out for the predecessor California Intercity High Speed Rail Commission (the "Commission") between 1994 and 1996[9]. CRA was selected by both the Commission and the Authority as the independent consultant to provide the ridership and revenue forecasts for their consideration. CRA's work included:

- Collecting significant new data on California's transportation system, current intercity travel and modal preferences in California;
- Developing state-of-the-art forecasting models for California intercity travel by existing conventional modes (air and private auto) and by high speed rail and maglev, which are new modes in the U.S.;
- Forecasting future intercity travel in California in the absence of HSR service; and
- Estimating HSR ridership and passenger revenue for a large number of system alternatives and operating scenarios.

In some cases, voluminous detailed descriptions of the collection of data used in work for both the Commission and the Authority is not duplicated in this report.

[9] See *Independent Ridership and Revenue Projections for High Speed Rail Alternatives in California*, Charles River Associates, Report No. 570-05, prepared for the California Intercity High Speed Rail Commission, July 1996.

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The interested reader is referred to our earlier report[10] for this material. This report presents the results of our new forecasting work for the Authority.

Specifically, it includes:

1. Forecasts of *intercity ridership and revenue* on the HSR system, using the most recent available data;

2. Forecasts of potential *commuter travel* on the HSR system within major metropolitan areas;

3. Estimation of the *benefits* that would be produced by the high speed rail system; and

4. The results of a benefit/cost analysis of the HSR system

In addition, a number of sensitivity analyses of different HSR fares and of different air and private vehicle travel growth, airfare and travel time assumptions were carried out as part of this study. Together, these forecasts and sensitivity analyses represent the most advanced state-of-the-art, comprehensive intercity HSR ridership and revenue forecasts and analyses ever carried out in California, and possible anywhere. In the process, much has been learned, not only about high speed rail ridership and modal preferences, but also about the existing intercity travel market in California, and its future growth in the absence of high speed rail.

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[10] Ibid

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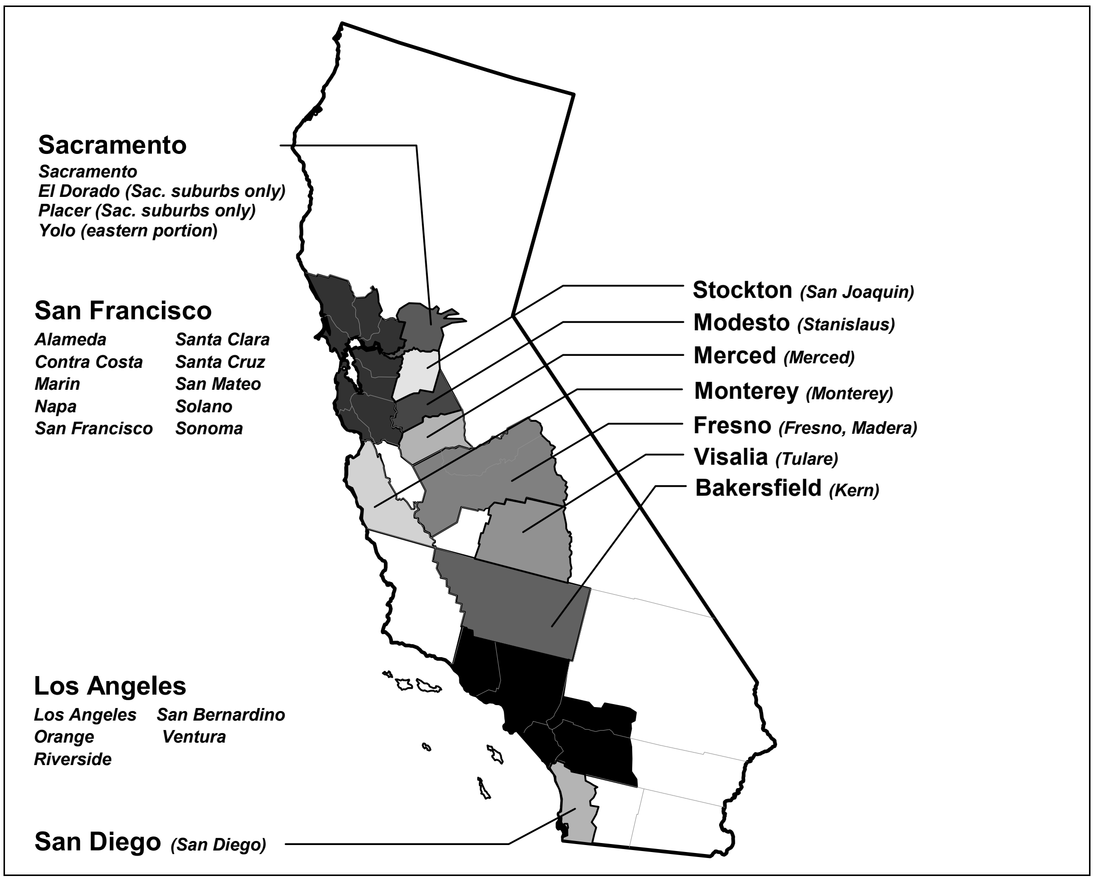
DESCRIPTION OF PROPOSED HSR SYSTEM

The proposed HSR system would serve directly each of the eleven metropolitan areas shown in Figure 1-1. Each of the alignment alternatives for which forecasts are presented in this report contain at least one station in each of these areas.

Figure 1- 1. Metropolitan Areas Making Up the California HSR Corridor (constituent counties in italics)



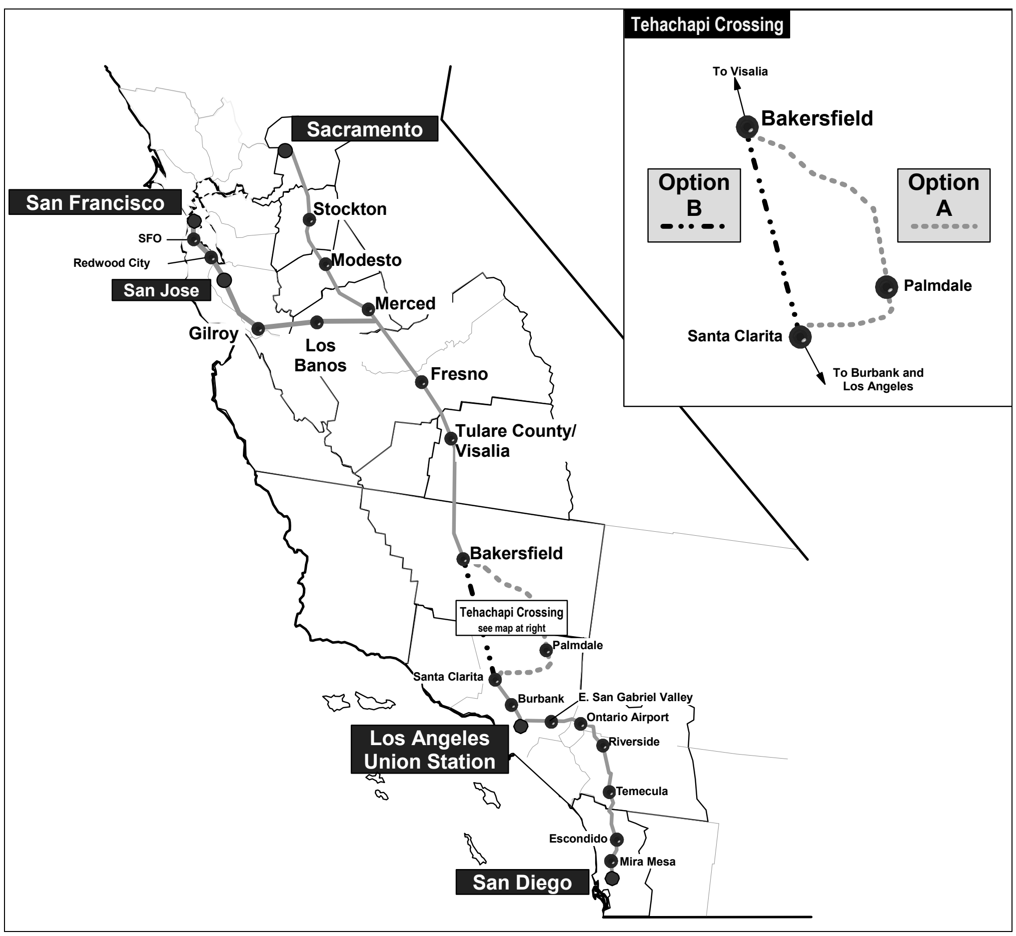
Source: Charles River Associates.

Introduction

Intercity HSR Services

For the purposes of this study, intercity travel is defined as travel *between* the metropolitan areas in California shown in Figure 1-1. That is, it does not include any travel wholly within these areas. The proposed intercity HSR alignment would run from San Diego to Los Angeles, and then through the Central Valley to both the San Francisco Bay Area, and Sacramento. Forecasts are shown in this report for the two Tehachapi Crossing alternatives shown in Figure 1-2 (i.e., Option A through Palmdale and Option B on the so-called I-5 Grapevine alignment).

Figure 1- 2. Intercity High Speed Rail System Alignments



Source: Parsons Brinckerhoff and Charles River Associates, 1999.

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Forecasts are also presented in this report for two different high speed ground transportation (HSGT) technologies on each of the alignments shown in Figure 1-2.

1. *Very high speed rail (VHS)*, for example, the steel wheel on rail technology used by the French TGV system having a top speed in revenue service of approximately 200 mph.; and
2. *Magnetic Levitation (Maglev)*, a technology such as that now in development in Germany, Japan, and the United States, and having a top speed in revenue service of approximately 300 mph.

Forecasts were also produced during the course of our work for a large number of additional HSR alternatives to aid in the Authority's decision process.[11]

The proposed HSR system was defined in sufficient detail to be able to predict the numbers of travelers who will choose the new HSR option over their existing intercity travel mode (private vehicle, air, or conventional rail). This means defining the station locations, inter-station (or origin/destination, O/D) line-haul travel times, fares, and operating frequencies, or more generally, the operating plans. The development of these level of service measures reflects a particular alignment, technology (VHS, maglev), routing plan, dwell times, and other related factors.

Information on access/egress times and costs[12] to/from the proposed HSR stations, terminal processing times, and HSR fares were developed CRA as part of this study. Data on HSR frequencies, HSR travel times, and HSR stopping patterns were provided to us in the form of an operating plan by Parsons Brinckerhoff (PB). PB's original operating plans were used by us to make our initial ridership forecasts. The initial forecasts were then evaluated and used by PB to revise or "equilibrate" the frequency and service patterns in the operating plan (i.e., so that trains and seats supplied are consistent with trains and seats

[11] For a description of the alternatives for which forecasts were made, see Parsons Brinkerhoff, "Draft Final Report: California HSR Corridor Evaluation" prepared for the Authority, January 2000. The forecasts themselves were presented at several Authority public meetings including April 21, and May 19, 1999 and are available in PowerPoint format.
[12] Access/egress times and costs are the times and costs of travel between the starting *or* end points of a trip (e.g., place of business or home) and the HSR stations.

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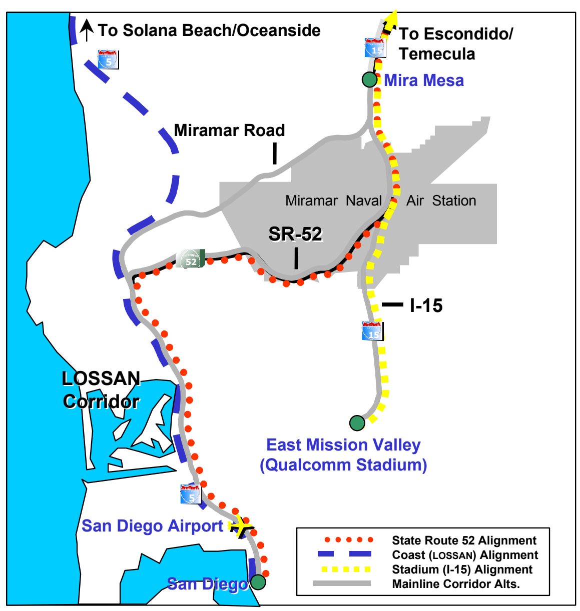
demanded using reasonable load factors). This process used our forecasting models as a tool to help determine appropriate operating plans for each alignment. In 2020, a total of 86 weekday trains are scheduled to operate in each direction to serve the statewide intercity travel market.

Express Commuter Services

This study also examined the potential for the HSR system to provide express commuter services within the Los Angeles region, the San Francisco Bay Area, and the San Diego metropolitan area. The proposed commuter services would be provided between each of the stations within the metropolitan area (or just outside the area) including the central or downtown station. Alternative commuter alignments were studied in each of the three metropolitan areas.

This report presents ridership and revenue forecasts for the commuter services which could be provided on the HSR alignments shown in Figure 1-2. For San Diego, the selected alignment, shown in Figure 1-3, is the "Stadium" alignment. Express commuter service would be provided between Temecula and Qualcomm Stadium, with intermediate stations at Escondido and Mira Mesa.

Figure 1- 3. Express Commuter Alignments – San Diego



Source: Parsons Brinkerhoff,1999

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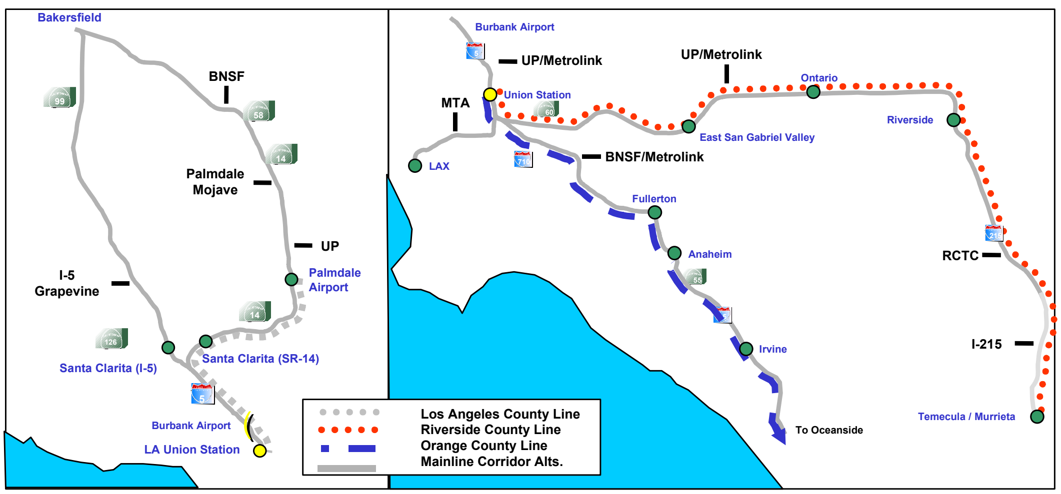
Figure 1-4 shows the alignments examined for the Los Angeles region. The selected alignments are:

1. *Riverside County*: Temecula to Los Angeles (Union Station), with intermediate stations at Riverside, Ontario and East San Gabriel.
2. *Los Angeles County A*: Palmdale to Los Angeles (Union Station), with intermediate stations at Santa Clarita and Burbank.
3. *Los Angeles County B*: Santa Clarita to Los Angeles (Union Station) with an intermediate station at Burbank.

Figure 1- 4. Express Commuter Alignments – Los Angeles



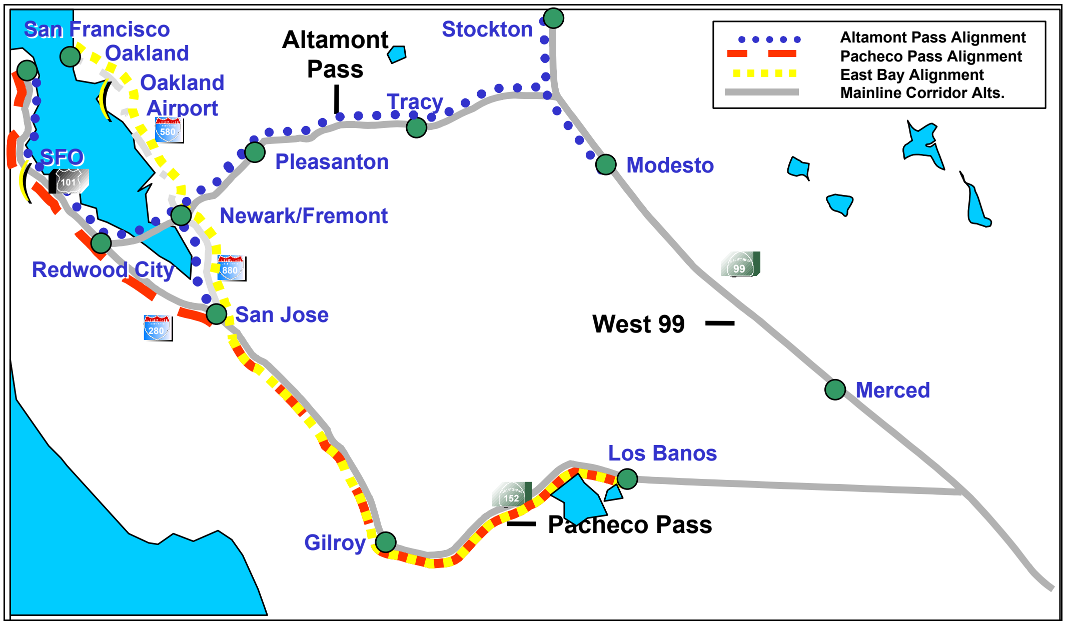
Source: Parsons Brinkerhoff, 1999

Finally, the selected alignment for the Bay Area shown in Figure 1-5 is the Pacheco Pass Alignment. Express commuter service is provided between Los Banos and downtown San Francisco with intermediate stations at Gilroy, San Jose, Redwood City, and Millbrae/SFO[13].

[13] Millbrae/SFO is the station on the BART extension to SFO that will be in service well before the 2020 design year.

Introduction

Figure 1- 5. Express Commuter Alignments - San Francisco Bay Area



Source: Parsons Brinkerhoff, 1999

2
Methodology for Intercity Forecasts

OVERVIEW

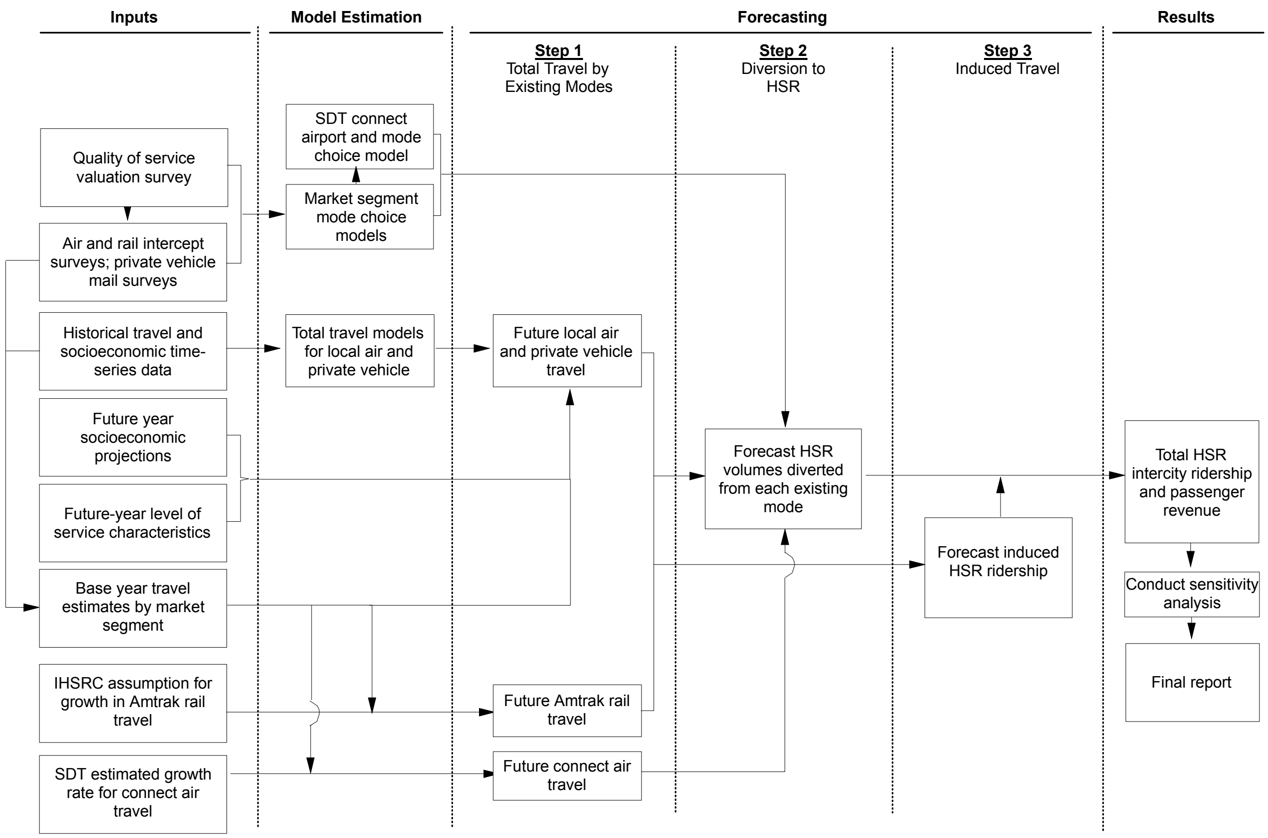
The forecasts contained in this report were produced using the same methodology as used in our previous study for the Commission.[14] We estimated intercity HSR ridership by first estimating the size of the total travel market in the initial forecast year (2020) for intercity air (local and connect), conventional rail, and private vehicle travel in the absence of HSR. Then using our mode choice models that incorporate customer preferences developed from our surveys of air, rail, and private vehicle travelers, we estimated HSR's share of the future travel market, given the anticipated service levels on the competing modes. In the third and last step, we estimated induced demand.

A detailed overview of the forecasting process is provided in Figure 2-1. The figure shows that an extensive series of *input data*, both historical and future (for the determinants of travel), was required for forecasting future HSR ridership and revenue. Data collection and preparation included large-scale surveys of individuals who made intercity trips by private vehicle and who were in the process of making intercity trips by air and rail; targeted surveys of individuals who made intercity air trips; collection of historical and forecast population, income, and traffic data; and preparation of data for an airline connecting simulation model. (Connect travelers are travelers changing planes at California airports proposed to be served by HSR.)

[14] Additional details of this methodology are described in CRA's report for the California Intercity High Speed Rail Commission referenced previously.

Methodology for Intercity Forecasts

Figure 2- 1. Flow Chart of Intercity HSR Ridership and Passenger Revenue Forecasting Process



Source: Charles River Associates, 1996.

After the preparation of input data, the second stage of the forecasting process shown in Figure 2-1 was *model estimation*. In this stage, we estimated the total air and private vehicle travel demand models, and the stated preference (Value Perception Analysis or VPA) mode choice diversion models for 10 market segments (mode and trip purpose combinations).

Finally, the three-step intercity ridership *forecasting* part of the process applied the total air and private vehicle demand models, with the appropriate future-year input data, to forecast air and private vehicle travel; developed future year rail trip tables; applied the separate mode choice models to the future local air, rail, and private vehicle volumes to forecast HSR travel diverted from each mode; applied the airline connecting traffic model to forecast HSR travel diverted from this market segment; and forecast induced travel based on the overall contribution of the HSR improvement to intercity travel service in the corridor. Diverted and induced travel were then combined to produce the total HSR intercity ridership and passenger revenue projections presented in this report.

A three-step approach is standard practice in forecasting intercity travel demand. Usually, however, the models that predict the market share for a new mode assume that travelers will divert from the existing modes to the new mode in direct proportion to the shares of trips on the existing modes. For this study, we developed separate binary choice models, each comparing the attractiveness of HSR with just one of the existing modes of travel (air, rail, or private vehicle). Consequently, intercity travelers' preferences for a new mode can vary not only by trip purpose, but also by the intercity mode they currently use.

Values Revealed by Choices

We adopted this market-segmentation modeling approach because people's selections of their current intercity travel modes reveal a great deal about their preferences for the various features of those modes. Travelers have already provided us with important behavioral information by their *revealed* preferences to use air and private vehicle for their intercity travel in California. Values are revealed by choices. We made use of the critical finding that people currently traveling by air, rail, and private vehicle exhibit different behaviors from each other when confronted with the choice or opportunity to use HSR. Air, rail, and private vehicle users will divert to HSR in different proportions when offered the same HSR option, because existing air, rail, and private vehicle users have different values of time and different demand elasticities. Business and nonbusiness travelers also place different values on the attributes of the various modes.

For example, other factors being equal, we can expect that people who choose to drive six or more hours between Los Angeles and the San Francisco Bay Area place a lower value on line-haul time[15] than those who take a one-hour and ten

[15] "Line-haul time" is travel time spent in the (line-haul) vehicle. In-vehicle time (on the primary intercity travel mode) is another name for line-haul time.

minute flight to cover the same distance. Conversely, we expect that in the same Los Angeles-Bay Area travel market, private vehicle users place a high value on the privacy and convenience of their vehicle, which allows them complete departure time flexibility, control over the rest of their travel schedule (such as making stops along the way, or using the vehicle at the destination), and the ability to take companions and extra luggage at no additional cost.

Travelers whose existing behavior already reveals these different values will therefore respond quite differently to the travel time, fare, and comfort levels offered by HSR service relative to their current mode. Segmenting the market in this manner yields results that represent how individuals actually behave in making intercity travel decisions. We have found from our previous intercity HSR ridership survey research that there is much more substitutability between the common carrier (fixed route and schedule, "for hire") modes — air and/or rail and HSR — than there is between private vehicle and HSR. While there will clearly be some diversion of private vehicle trips to a new HSR system, we can expect a much higher proportion of air than private vehicle trips to divert to a competing high speed common carrier service.

Of course, the actual diversion to HSR from air, rail, and private vehicle will depend on the actual speeds, fares, frequencies, station locations, and amenities of the new HSR service.

Refinements to the Forecasting Process

During forecasting, the three-step forecasting process is refined further by differentiating between private vehicle travelers who need a vehicle at their final destination, those who do not, and those who need to make stops en route during their trip. Most analyses of intercity travel assume that all tripmakers are "choosers" (i.e., that they are not captive to a particular mode), but prior work indicates that this is not the case, particularly for private vehicle travelers. The likelihood of selecting HSR for intercity travel will be very different for the three groups of private vehicle travelers, since, for example, those who need a vehicle at their final destination will have to arrange for other transportation, most often paying for the additional cost of renting a vehicle for the duration of their stay and spending extra time renting and returning the vehicle. In addition, private vehicle travelers who need to make stops en route during their trip are not "choosers;" that is, we assume they are not eligible for diversion to HSR.

Two additional important methodological improvements to the state of the art of HSR ridership forecasting were made in our previous work for the Commission and carried forward in the current study. The two improvements are:

- Explicitly valuing intercity air travelers' willingness to pay for certain quality of service (QoS) attributes of HSR service; and
- Using the SABRE Decision Technologies (SDT) hub airport and carrier choice model to forecast the diversion to HSR of connecting air travel at the SFO Airport.

With regard to the first improvement, HSR ridership forecasting models are normally only sensitive to the so-called "traditional" level of service variables used to characterize competing transportation modes. These are the standard descriptors of travel times and costs for each mode, including access/egress times and costs, waiting times, line-haul times, and terminal processing times. However, the proposed HSR service is capable of improving the quality of service over that experienced by air or conventional rail travelers as measured by attributes other than the traditional level of service improvements. Therefore, it was important in this study to be able to include these QoS attributes in our ridership forecasting models. This was done by measuring travelers' willingness to pay for these QoS attributes using data collected in a computer-assisted personal interview survey of air travelers in the corridor.

The four QoS attributes explicitly valued for inclusion in the mode choice diversion models (step 2) used in this study were:

- Spacious seating (lower seating density).
- "Business seating," including tables between seats providing work space for laptop computers, etc. and free telephone calls to origin and destination cities.
- Additional on-board luggage storage space.
- More reliable service (higher on-time arrival percentages).

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Values for three of the four QoS attributes were included in the air mode choice models. The fourth, additional luggage space, was not valued highly enough by intercity travelers in California to include it in the HSR scenarios for which forecasts are provided in this report. We also concluded that further work is needed to estimate the QoS valuations by private vehicle travelers. Therefore, the QoS attributes were not included in the private vehicle mode choice models.

The second important methodological improvement made in our work for the Commission and continued in this study was the use of the SDT hub airport and carrier choice model to forecast the diversion to HSR of connecting air travel at hub airports in alternatives with an airport station(s). The model forecasts the selection of a particular connect alternative given a number of variables, including how the connection is displayed on travel agents' computerized reservation system (CRS). This "CRS screen presence" is an extremely important factor in customer choice of flight: on the SABRE CRS, for example, over 80 percent of flights are sold off the first screen and over 40 percent of flights sold are the first flight displayed on the first screen. The rules for screen presence are complicated and involve total flight time (nonstop flights are normally displayed first), nearness to desired departure time, connection times at airports etc.

The SDT model carries out its simulations of screen presence and flight choice for approximately 15,000 origin-destination city pairs. For any combination of HSR/air connecting service, the SDT model forecasts both total connecting air passengers through the SFO airport (which had a HSR station) and the market shares of the competing air/air and air/rail connecting services.

The use of the SDT model represents a significant advance in forecasting HSR ridership in the connecting air travel market segment. The availability of many nonstop airline and connecting flight choices involving other hub airports for travelers with origins or destinations outside the HSR corridor makes it impossible to characterize the connecting travel mode choice simply as an air versus HSR choice alone. Most previous HSR studies have treated the choice of connecting mode as a completely independent event from all the other relevant choices. In reality, the choice of connecting airport and continuing flight, or the choice of a nonstop flight, subsumes or eliminates the choice of connecting mode at a given airport. Clearly, all of the relevant choices are not separable and capable of being modeled sequentially. The SDT model is a necessary and important advance in forecasting HSR travel in the connecting air market segment.

Fgure 2-1 showed that the intercity ridership forecasting process involves an extensive series of input data, required for both the development and application of the travel demand models used to forecast future HSR ridership and revenue. This data collection effort was carried out as part of our previous study for the Commission, including several large-scale surveys of current corridor travelers. The data were used to develop models that project future trips on the existing modes, as well as the mode choice models that predict diversion to the HSR system. Each of these aspects of the forecasting process is described in more detail below.

THE NEW SURVEY DATA COLLECTION

In our earlier work for the Commission, CRA designed and carried out a comprehensive program of new surveys to collect new information for use in developing the HSR ridership forecasts in the study.[16] The results of this very important and extensive data collection program were used in the current study and are summarized here. The three primary objectives of this data collection were:

- **To determine the current origin/destination patterns of intercity private vehicle travel**
  Good information about the origins and destinations of current trips by common carriers can be obtained from available ticket sales data. No comparable source of information exists for private vehicle travel.

- **To augment available information about current intercity travel behavior by all modes**
  Ticket-based data provide no information about (for example) the purpose of the trip or other key considerations that influence the propensity to switch to a new mode. Consequently, such information needs to be gathered in new surveys.

[16] Charles River Associates, 1996, op. cit.

Methodology for Intercity Forecasts

- **To measure travel preferences for the service features provided by HSR alternatives**
  Forecasting the extent to which intercity trips can be diverted from their existing modes requires an understanding of the ways in which service features affect mode choice decisions.

In total, the study team designed and carried out *four* different types of surveys to collect the new information to develop the forecasting models and to help develop the necessary intercity trip table. These are labeled A through D, as follows:

A. A *household mail survey* detailing recent intercity travel made by members of corridor-resident households;

B. *"Intercept surveys" of passengers* in which existing travelers are sampled in the course of making an intercity trip by common carrier (air or rail) within the corridor;

C. A mail survey of recent *private vehicle tripmakers*, identified as a sample of the household mail survey based on their response to survey A; and

D. A computer-assisted *quality of service (QoS) survey* of recent travelers in the corridor.

The primary purposes of the household mail survey (Survey A) were to count the volumes of intercity person- and vehicle-trips made between corridor origins and destinations in private vehicles, and to provide a representative sample of such trips for Survey C. The surveys of existing travelers (Surveys B and C) were intended primarily to provide information about their preferences, along with more information about their trips.

The quality of service survey (Survey D) was substantially different in both its design and objective. People who had experience making intercity trips between the California cities proposed to be served by HSR in the last twelve months were sampled at seven shopping malls located throughout the length of the corridor. The shopping malls provided a less hurried environment than is feasible in intercept surveys. A computer-assisted personal interview was completed by each respondent which explored how mode choice decisions between air and HSR

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might be influenced by a wider set of considerations that the prices and travel times customarily incorporated in mode choice models. In particular, the survey data were used to value the four QoS attributes which were identified during focus group sessions at the beginning of the study. These attributes were spacious seating, on-board luggage space, business seating, and schedule reliability. The fieldwork for the surveys was carried out between May and August, 1995. Table 2-1 summarizes the sample sizes of the surveys.

Table 2- 1. Numbers of Responses to the California Travel Surveys

Survey	Interview Contacts	Households or Qualifying Travelers Administered Surveys	Usable Detailed Responses	Percent of Total
A. Household Total Travel Survey	26,400	26,400	15,713	60%
B. Air Intercept Survey Rail Intercept Survey	8,728 4,672	4,711 4,007	1,495 2,818	32% 70%
C. Private Vehicle Travel Survey	2,479	2,479	1,983	80%
D. Quality of Service (QoS) Survey	6,771	1,620	957	59%
Total	49,050	39,217	22,966	59%

Source: Charles River Associates, 1996.

The first column in Table 2-1 shows the number of households or persons initially contacted and, for the intercept surveys, given brief personally administered screener interviews to determine if they qualified for the actual surveys. As shown in the table, a total of 49,050 households or persons in all four types of surveys were contacted (and screened in the intercept surveys) to determine if they were travelers making trips between cities proposed to be served by HSR. For the *intercept* surveys, these random-sample screener interviews along with complete counts of air and rail passengers were used to determine the base year numbers of travelers between the relevant cities and regional analysis zones. Including the QoS survey, 10,338 of these persons were traveling between the relevant cities and were administered surveys, of which 5,270 of the surveys, or 51 percent, were returned and were completely usable for developing the mode choice diversion models described below.

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Including the household total travel survey (survey A) and the household private vehicle travel survey (survey C), the total number of usable surveys was 22,966 for an overall response rate of 59 percent. The household total travel survey included persons not making intercity trips in order to obtain a random sample with which to accurately determine total intercity trips in California. The response rates to each survey varied by mode in typical fashion, but were much higher than normally expected from these kinds of surveys. Any remaining response biases were minimized by reweighting the returned usable surveys by the income, trip purpose, and origin–destination volume data obtained from the corresponding random personal interview screener surveys for the intercept surveys, and the known characteristics of the consumer panel we used for the household travel survey and the private vehicle travel survey.

FORECASTING FUTURE INTERCITY AIR, PRIVATE VEHICLE, AND CONVENTIONAL RAIL TRAVEL

The first step in the three-step HSR ridership forecasting process was to forecast total intercity air, private vehicle, and conventional rail travel between the eleven metropolitan areas making up the California HSR Corridor. These eleven regions or metropolitan areas and their constituent counties were shown in Figure 1-1.

Future travel on the three existing modes was forecast through the application of total travel demand models. In our previous study we developed separate travel demand models which forecast total trips by air and auto based on changes in the underlying socioeconomic variables that are important drivers of travel. Conventional rail (Amtrak) trips were held constant at the base year level at the direction of the Commission.

For the current study, conventional rail (Amtrak) trips were assumed to increase at the rate of population growth of the metropolitan areas served by the HSR system. The total travel demand models for air and auto were reestimated with more recent data available through 1997, in order to include the effects of changes occurring since the previous study was completed. The final specifications of the models chosen are consistent with those used previously, as are the estimated coefficients, such that all else being equal, the substitution of the new models does not materially affect the forecasts of future travel. The air and auto models are described in more detail below.

Air total travel demand model

Future air travel was projected using an air total travel demand model estimated using historical air travel volumes as the dependent variable, and socioeconomic and level of service measures as the explanatory variables. The general specification of the model used in the previous study is:

Air Trips = f(Population, income, air fare, travel time)

The new model was estimated as a time series/cross sectional model, using data for trips to and from Los Angeles, San Francisco, San Diego, Sacramento and Fresno from the years 1982 through 1992. The historical air trip data was compiled from the same US Department of Transportation databases used to develop the base year trip table, as were the data on historical air fares. The California Department of Finance provided historical population and income data, and travel time information was obtained from the Official Airline Guide.

The new model was estimated with the addition of data for 1993-1997 to the estimation dataset. In addition, the historical population figures were updated with the more recent data. The exact specification of the previous model was first run with the updated dataset, but the results proved unsatisfactory as some of the coefficients had either the wrong sign or were of unreasonable magnitudes. Various alternative specifications were then tested, as were models using a subset of the city pair markets used for the previous model. Upon review of the revised dataset, it was determined that reporting problems in the USDoT databases have made data for three of the smaller markets unreliable, and thus to improve the quality of the results, data for these markets were removed from the dataset.[17]

The resulting final model includes the same measures of population, income, and air fare as the previous model, but does not have the travel time term because a

[17] This unreliability is only with respect to comparing the reported air volumes *over time*, and therefore does not affect the estimates of total air travel for these markets in the base year trip table. The city pairs removed are Fresno-San Francisco, Sacramento-San Francisco, and Fresno-Sacramento.

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consistent statistical relationship could not be established between travel time and the travel volume with the new dataset.[18] Also, while the previous model included individual dummy variables for each city pair, the new model instead employs a city pair-specific dummy variable indicating the presence (or lack) of Southwest Airlines service in that market for each year. Finally, the updated model includes a "recession dummy," used to control for the two major economic downturns that occurred during the estimation period (one beginning in 1982, the other beginning in 1991 and extending for several years in California).

A comparison of the final estimated coefficients of the two models is presented in Table 2-2. The table shows that like the previous model, each of the coefficients has the expected sign and is statistically significant. Both models are log-log models and therefore the coefficients can be interpreted as demand elasticities.

[18] This is not surprising as the relationship between travel time and *total air travel* (not the choice of the air mode vs. other modes in the same city pair market) is ambiguous. While all else being equal, less time is obviously better, as distances increase air travel becomes more desirable.

Table 2- 2. Updated Air Total Travel Demand Model

	Previous Model		Updated Model	
Parameter	Coefficient	t-Stat	Coefficient	t-Stat
O-D population sum	0.92	7.64	1.08	33.55
Fare/O-D Per capita income	-0.83	-39.75	-0.58	-7.48
O-D travel time	-0.70	-9.53	NA	NA
Southwest Airlines dummy	NA	NA	0.36	6.52
Recession dummy	NA	NA	-0.06	-2.11
O-D specific dummy variables:				
Los Angeles-San Francisco	3.94	12.62	NA	NA
Los Angeles-San Diego	0.91	3.04	NA	NA
Los Angeles-Sacramento	2.61	9.35	NA	NA
Los Angeles-Fresno	0.70	2.39	NA	NA
San Francisco-San Diego	3.16	14.57	NA	NA
San Francisco-Sacramento	-0.25	-1.20	NA	NA
San Francisco-Fresno	0.27	1.07	NA	NA
San Diego-Sacramento	2.45	19.55	NA	NA

Source: Charles River Associates, 1996 and 1999.

The new model again uses the ratio of average air fare to per capita income, although in this case the elasticity is lower, -0.58 instead of –0.83. This is consistent with the fact that the extended dataset now includes more years of data representing a Southwest Airlines-dominated low fare environment.[19] The coefficient is also equivalent to a real income elasticity of +0.58. The population elasticity, by contrast, is higher than before, increasing from 0.92 to 1.08.

The Southwest Airlines dummy is positive, as expected, indicating that Southwest has had the effect of increasing travel when and where it has operated in the corridor.[20] The recession dummy has a negative sign, also as expected, indicating the negative effect of these conditions on air travel.

[19] The new model includes data through 1997, but the previous model was estimated with data only for 1982-1992. While Southwest has served the San Diego-San Francisco market since 1983, its large-scale entry into California did not begin until the end of this period, between 1989 and 1991.

[20] In addition to lowering fares in the markets it enters, Southwest is also known to increase service frequency, another important determinant of travel demand but one that is difficult to model directly in this context.

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Auto total travel demand model

Unlike the air mode, data on origin-destination flows by private vehicle are not collected on a regular basis, with the result that the development of an auto total travel demand model is necessarily more complex. Conceptually, the auto model employed in the previous study was quite consistent with the air model in that it described total trips as a function of socioeconomic and level of service variables. But because the O/D trips cannot be observed directly, the model instead used the traffic counts routinely collected by Caltrans as the dependent variable. The model assumes that the count is a function of the socioeconomic and level of service conditions of *all* of the O/D pairs represented within it:

$$\text{Private vehicle count}_t^A = f\Big(\sum_{ij} S_t^{ij}, \sum_{ij} LOS_t^{ij}\Big)$$

(Where ij are origin/destination cities/regions contributing to the count observed at location A.) To make the model practical for estimation, we used data for the explanatory variables from the three primary O/D pairs represented in the flow observed at each counting station. The specification is that of a standard "gravity model":

$$\text{Private vehicle count} = \frac{S_{i_1}^{\alpha} \cdot S_{j_1}^{\beta}}{d_{ij_1}^{\gamma}} + \frac{S_{i_2}^{\alpha} \cdot S_{j_2}^{\beta}}{d_{ij_2}^{\gamma}} + \frac{S_{i_3}^{\alpha} \cdot S_{j_3}^{\beta}}{d_{ij_3}^{\gamma}}$$

Like the air model, this is a time-series/cross sectional model, including data representing several major markets and (for the earlier model) the years 1982-1993. The above formula shows that the specification is not linear in parameters, and so a nonlinear regression procedure was used to estimate the coefficients. To update the model, the same specification was rerun with the addition of data for 1994-1997. The results are extremely consistent with the original, and are therefore used as the new model. A comparison is shown in Table 2-3.

Table 2- 3. Updated Auto Total Travel Demand Model

	Previous Model		Updated Model	
Parameter	Coefficient	t-Stat	Coefficient	t-Stat
Total real income	0.43	30.94	0.44	36.79
Distance	-2.26	-15.91	-2.32	-18.69

Source: Charles River Associates, 1996 and 1999.

DIVERSION OF INTERCITY TRIPS TO HSR

After future air, private vehicle, and intercity conventional rail travel volumes have been forecast between each of the eleven metropolitan areas in the California corridor, the future market shares of HSR in each of these markets must be forecast. Customer preferences and the total size of each market determine the travel volumes diverted to HSR. The mechanism for forecasting future market shares is to develop detailed relationships between the market shares and the travel times, costs, and comfort levels of the competing modes. These relationships are called mode choice models. The mode choice models described here were developed in our previous work for the Commission. These models were used unchanged in the current study.

Market Segmentation

We developed separate mode choice models for ten major intercity travel market segments within the Corridor:

- Local air travel (business and nonbusiness),
- Connect air travel (business and nonbusiness),
- Intercity private vehicle travel (business and nonbusiness),
    - Short (up to 150 miles)
    - Long (greater than 150 miles)

- Conventional rail travel (business and nonbusiness)

Market shares for connecting air travel to/from the Corridor were estimated by SDT, as described earlier, but mode choice models were developed by CRA for this market segment for use in the SDT forecasting process.

As discussed earlier, our market segmentation approach to mode choice modeling is based on our prior experience that intercity travelers using the different modes behave very differently in terms of modal preferences and valuation of modal characteristics such as travel times and out-of-pocket cost. We expect travelers with high values of time to travel by air, other things being equal (including trip purpose). We also expect business travelers in general to value time more than nonbusiness travelers, other things being equal.

Indeed, people's selection of their current intercity travel modes reveals a great deal about their preferences for the various features of those modes. We segmented the market by the *revealed* preferences of travelers to use air, private vehicle, and conventional rail for their intercity travel in California.

Value Perception Analysis

The technique we used to collect data on traveler valuations of the level of service attributes of HSR, described in the context of their existing modes, is called Value Perception Analysis (VPA). VPA is a survey technique that infers how people's stated preferences for existing or potential products and services are affected by differing features or attributes of those products. This procedure has been applied successfully to a wide variety of transportation and other marketing research problems. With this methodology it is possible to estimate the share of trips that would be made on a *new* mode and to assess how individuals trade off various attributes of the new and existing mode(s) (e.g., access time versus cost, in-vehicle time versus waiting time, etc.).

The VPA surveys designed for this study asked (pre)qualified respondents to *rank* a number of transportation alternatives, including two involving their current mode (air, private vehicle, or conventional rail) and two involving the *new* HSR mode. Each alternative was characterized by its technology (name) and its service characteristics: frequency of service, access and egress time (for common carrier

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modes), line-haul (in-vehicle) travel time, and trip cost. The respondents were asked to rank the alternatives from the most attractive to the least attractive. Respondents therefore had to make a series of choices among alternatives that involved *tradeoffs* among different components of time, cost, and mode.

Mode Choice Model Estimation

Each model is a "binary choice" model, which predicts the probability that a traveler would choose HSR over their existing mode given the respective attributes of the two modes.

The models relate the overall "utility" experienced by travelers in each market segment to the respective price and service levels of their respective modes. The general specification for each model is as follows:

$$U = \alpha + \beta_1 Cost + \beta_2 Travel\ Time + \beta_3 Access/Egress\ Time + \beta_4 Waiting\ Time$$

Where α represents the "modal constant" (the preference for the mode with all other attributes being equal), and waiting time represents a transformation of service frequency.

In developing the mode choice models for each of the ten market segments, we tested a variety of explanatory variables, including separate line-haul (in-vehicle) time, access and egress time, wait time (calculated as half of the headway), and travel cost (or fare) variables. In addition, we examined various combinations of variables. We also tested alternative combinations of travel time, including defining travel time by using differential weights for line-haul time, access/egress time, and wait time.

The HSR *constant* estimated for each model measured the preference for HSR based on existing perceptions while controlling for the effects of all the other variables explicitly included in each model. This constant was modified in the air market segment models to incorporate travelers' willingness to pay for certain QoS attributes of HSR service, described previously.

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Values of Time

Table 2-4 presents the *values of time* of travelers in each market segment calculated from the estimated mode choice models for the various components of travel time (and the terminal transfer penalty for connecting air passengers). These values of time strongly support our findings in previous HSR studies. First, as expected, the values of line-haul time for air travelers are higher than for private vehicle travelers, and both are much higher in general than for rail travelers.[21] Line-haul time savings on HSR are much more important to air travelers than private vehicle travelers, and more important in both cases (except for short nonbusiness private vehicle trips) than they are to conventional rail travelers. This means that conventional rail travelers are relatively much more sensitive to price differences between modes than they are to time differences.

Also, as expected, the values of line-haul time for business travelers are higher than for nonbusiness travelers traveling on the same mode.

[21] The segmentation of private vehicle travel into long and short trips results in short intercity (<150 miles) nonbusiness travelers having a low value of time — an expected result. It is reasonable to expect short intercity *business* trip values of time to stay high for higher-value business trips for which air service competition is poor to nonexistent. On the other hand, nonbusiness auto values of time at these short trip lengths are not qualitatively different from urban values.

Table 2- 4. Implied Values of Time and the Terminal Transfer Penalty From the HSR Mode Choice Models ($1999)

Trip Purpose	Current Mode	Line-haul Time	Access/ Egress Time	Wait Time	Transfer[1]
Business	Air local	$46.68	$49.89	$27.06	-
	Air connect	$66.73	-	-	$10.33
	Private vehicle (short)	$20.84[3]	[2]	[2]	-
	Private vehicle (long)	$27.93	$46.73	$15.13	-
	Rail	$16.03	$20.51	$14.17	-
Nonbusiness	Air local	$33.10	$36.42	$28.49	-
	Air connect	$33.99	-	-	$5.10
	Private vehicle (short)	$6.84[3]	[2]	[2]	-
	Private vehicle (long)	$14.88	$20.95	$6.99	-
	Rail	$15.12	$16.28	$11.06	-

[1]Transfer is defined as follows: 0 = transfer in the same terminal, 1 = transfer in different terminal.

[2]These travel characteristics appear in the equation as part of a ratio of wait and access/egress time over line-haul time (WALH). The value of time for these characteristics is therefore not constant.

[3]Line-haul time appears in the model as a separate variable as well as in the composite WALH term (see Note 2). The value of time indicated is computed for the separate variable only.

Source: Charles River Associates, 1995

In studies of *urban* fixed-route and schedule (common carrier) transit competing with private vehicle, the value of access and egress time is commonly observed to be greater that the value of line-haul time. As can be seen in Table 2-4, this result was observed for every market segment. However, the usual urban multiple of two to three times the value of “out of vehicle time” to “in vehicle time” does not hold for intercity travel. This is because access dominates line-haul in urban travel choice of (transit) mode, while for longer distance intercity travel, the importance of access relative to line-haul decreases.

For air travelers, the values of access/egress time reflect a roughly 10 percent premium relative to line-haul time due both to the higher uncertainty (or variance) associated with airport access times within a metropolitan area, and to the higher penalty or delay risk associated with access delay (you miss your flight). For auto

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travelers, the access/egress value of time premium over line-haul time is higher by roughly 50 percent (when considering diversion to a high speed rail station) reflecting both the delay risk and the segmentation of the value of access time distribution by mode choices that do and don't involve access/egress times (i.e., common carrier vs. private auto).

We should note that the value of wait time shown in Table 2-4 depends on its definition. The value of schedule delay, or "wait time," defined simply and understandably as half the headway (other fractions or frequency transformations don't help explain the value of this component of travel time) is roughly two-thirds the value of line-haul time. Changing the wait time definition to $h/4$ (which does not affect the forecasts) would increase the value of wait time relative to line-haul time shown in the table.

Modal Constants

The values of the HSR modal constants shown in Table 2-5 also strongly support our findings in other HSR studies that air and HSR are much more similar in the effect of the unobserved attributes of each mode on ridership than are private vehicle and HSR. Private vehicle travel, on the other hand, is valued quite highly relative to HSR if all the travel times and costs are held equal ($33.84 for long business travelers and $32.97 for long nonbusiness travelers). Of course, HSR is capable of shorter travel times than are private vehicles over longer distances. Nevertheless, the HSR constants in the private vehicle mode choice models mean that certain attributes of private vehicle (privacy, flexibility, etc.) are valued very highly relative to HSR (and to other common carrier modes).

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Table 2- 5. Implied Values of the Modal Constants From the HSR Mode Choice Models, with QoS Adjustments ($1999)

Current Mode	Business	Nonbusiness
Air local	$6.79	$5.23
Air connect	$9.09	$4.15
Private vehicle (short)	-$16.14	-$20.64
Private vehicle (long)	-$33.84	-$32.97
Rail	$8.25	$6.69

Note: Values are equal to the fare advantage of HSR over the existing mode, keeping all times and costs equal for the competing modes.
Source: Charles River Associates, 1995

The HSR modal constants in the conventional rail models imply that conventional rail users perceive HSR as inherently more attractive than their current mode in terms of the attributes incorporated in the modal constant (comfort, privacy, etc.). Finally, the HSR modal constants in the connect air models are moderately large and positive in dollar terms, and measure the utility (disutility) of transferring from one line-haul mode to another in this corridor.

Diversion of Connecting Air Trips at SFO Airport

Because the HSR system is planned to serve San Francisco International Airport (SFO), the HSR system could potentially serve trips to and from points outside the corridor that are currently served by air services connecting at SFO. As discussed earlier, use of a conventional mode choice model is not appropriate for this market segment, because the choice of modes for each leg of a multi-part journey is in practice not made sequentially. That is, one generally decides upon the mode for each leg of the trip before departing on the first leg.

In our previous study for the commission, the diversion of connecting air trips was therefore estimated by SABRE Decision Technologies (SDT) using our connect air mode choice model described above and their hub airport and carrier choice model. The estimates of connect air diversion derived in the previous study were used in the present study.

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ESTIMATION OF INDUCED HSR TRIPS

The third and final step in the three step intercity HSR ridership forecasting process is to forecast the amount of induced travel on the HSR mode.

New travel induced by the introduction of the HSR system is defined as follows:

$$Induced\ Travel = Total\ \ Travel_{With\ HSR} - Total\ \ Travel_{Before\ HSR} \tag{1}$$

The number of induced trips will be a function of the change in the overall "impedance" to travel in the corridor; by providing another transportation option, some trips will be made that wouldn't otherwise have occurred absent the HSR system. We estimated induced demand in the same manner as in our previous study. Total travel on all modes is related to a composite generalized price computed over all of the modes, as follows:

$$T_{all\ m} = (S / E)^{a}\ x\ U_{composite} \tag{2}$$

Where

$T_{all\ m}$	=	Total travel volume between O/D on all modes m;
S/E	=	Socioeconomic factors for O and D;
$U_{composite}$	=	Utility of travel between O and D (negative of the generalized price); and
α,θ	=	estimation coefficients.

This composite generalized price is calculated as the *logsum* of the generalized prices of each of the modes, calculated using the utility estimates for each mode from the market segment mode choice models:

$$U_{composite} = ln(e^{U_{air}} + e^{U_{rail}} + e^{U_{private\ vehicle}} + e^{U_{hsr}}) \tag{3}$$

Methodology for Intercity Forecasts

Consequently, we can write:

Total travel before HSR: $$T_B = (S/E)^a \ x\ (U_{composite_B})^q \tag{4}$$

Total travel after HSR: $$T_A = (S/E)^a \ x\ (U_{composite_A})^q \tag{5}$$

And the percent increase in total travel becomes:

$$Induced\ Demand\ \% = \frac{T_A - T_B}{T_B} = \frac{U^q_{composite_A} - U^q_{composite_B}}{U^q_{composite_B}} \tag{6}$$

This calculation is done for each market segment. Total HSR trips are computed as the sum of local trips diverted from the existing modes, trips diverted from connecting air services at SFO, and these new trips induced by the introduction of the HSR system.

3
Input Data for Intercity Forecasts

OVERVIEW

This chapter describes our update for this study of the socioeconomic, travel, and transportation system database which was used in the previous Commission study. The previous study used 1994 as the "base" year, as this was the most recent year for which a consistent and complete set of data was available. For the current study, the base year was updated to 1997, as follows:

- New 1997 trip tables were developed for the existing modes;
- Forecasts of future trips by the existing modes were revised to take into account the effects of both changes in the travel market and revisions in socioeconomic forecasts that have occurred between 1994 and 1997; *and*
- The transportation level of service input data for the existing modes (times, costs, and service frequencies on the existing modes) were revised to reflect 1997 conditions.

The key changes to the forecasting database can be summarized as follows:

- *Total intercity travel increased more than 8% between 1994 and 1997*. Auto grew by an estimated 7.9 percent, while air traffic increased nearly 13 percent and Amtrak rail trips grew by almost 12 percent.
- *Projections of total future intercity travel by the existing modes have also increased slightly*. Our 2015 forecast of total air travel was revised upward from a previously forecast total growth in the corridor (from 1994) of 64.2 percent to the currently forecast growth of 66.6 percent. The total 2015 auto forecast changes from a 28.6 percent increase in travel over 1994 to a 35.4 percent increase in auto travel. Amtrak rail travel increased 41 percent from 1994 over our previous assumption of constant future ridership at 1994 levels. The revisions reflect the effect of three factors:

Input Data for Intercity Forecasts

- The changes in base year travel volumes described above;
- The updating of the total travel demand models (see Chapter 2); *and*
- Extensive revisions to the state-sponsored forecasts of population and income which are the primary inputs to the total travel demand models

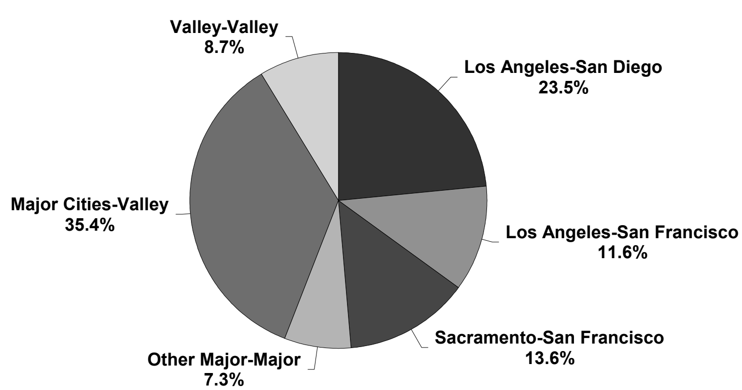
■ *Real air fares have changed significantly but not consistently*. Fares in important markets have both increased and decreased in real terms, in some cases by 15 percent or more. The overall average fare for Los Angeles-San Francisco increased 3.5 percent in real terms between 1994 and 1997.

Each of these changes and the changes to the other data items are discussed in more detail in the following sections.

EXISTING INTERCITY TRAVEL MARKET

An estimated 154 million intercity trips were made between the eleven California metropolitan areas of interest to this study in 1997, up from about 142 million in 1994, an increase of about 8.5 percent. Figure 3-1 shows that the largest total travel market in the corridor is between Los Angeles and San Diego.

Figure 3- 1. Total California Corridor Intercity Trips by Market - 1997[22]



Source: US DOT, Caltrans, and Charles River Associates, 1998.

[22] The “major” metropolitan areas are Los Angeles, San Francisco, San Diego, and Sacramento.

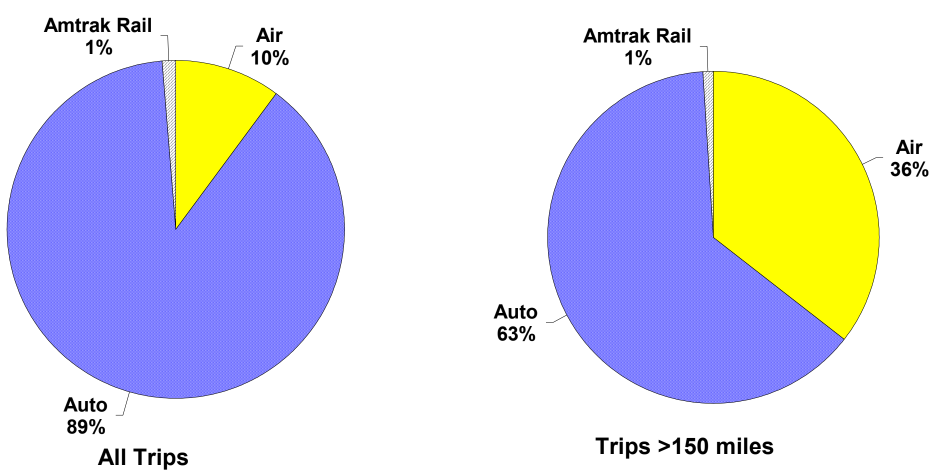
Input Data for Intercity Forecasts

The proximity of these two major metropolitan areas produces a large number of auto trips which help contribute to its 23 percent share of all corridor intercity trips. Sacramento-San Francisco is the next largest followed by Los Angeles-San Francisco with 14 percent and 12 percent of the total, respectively. Together, these three city pair markets account for nearly half of all intercity travel in the California corridor.

The figure also shows that travel between the Central Valley cities doesn't contribute a large portion of the total travel (just 9 percent), but travel between these cities and the four major metropolitan areas is substantial, accounting for over a third of all trips.

Figure 3-2 provides a breakdown by mode of travel for all intercity trips and trips over 150 miles in length. Auto is by far the dominant mode, accounting for nearly 90 percent of all intercity trips in the corridor, with air trips representing most of the rest at 10 percent. The figure also shows that many of the auto trips are made at shorter distances, however, as the auto share drops to 63 percent and the air share increases to 36 percent for trips over 150 miles.[23] In either case, the figure shows that only 1 percent of intercity trips in California are made using Amtrak services.

Figure 3- 2. California Corridor Intercity Trips by Mode (1997)



Source: US DOT, Caltrans, and Charles River Associates, 1998.

[23] Air travel between the Los Angeles and San Francisco regions is far larger than for any other city pair in the US.

Input Data for Intercity Forecasts

Procedure for updating base trip tables

The base year trip tables provide intercity travel volumes on each mode in each city pair market. Each of these tables was updated to reflect the change in travel patterns between 1994 and 1997, as described below.

Air

The air trip table was updated using essentially the same procedure employed for CRA's 1996 study. Air traffic volumes by airport pair for 1997 were obtained from the US Department of Transportation's DB1A and 298-C commuter databases. While an allocation procedure is required in some cases to estimate the amount of "local" (as opposed to "connect") traffic in the smaller markets dominated by commuter carriers, in general the DoT databases contain information on actual flights by actual passengers, and therefore provide a very accurate count of air travel.[24]

Auto

Conversely, no such ready and objective source of annual auto trip data is available. CRA's prior 1994 trip table was developed using the results of a large-scale household survey, designed specifically to accurately measure private vehicle travel in the corridor. Given the lack of other available data sources, this survey (and the corresponding 1994 trip table) remain by far the best available measure of current auto travel. To estimate the 1997 base year trip table, therefore, we scaled up the 1994 O/D volumes using the percent change in volumes predicted by our revised auto total travel demand model presented in Chapter 2 (using as inputs the 1994-1997 changes in the underlying socioeconomic variables).

[24] The DB1A database represents a 10% sample of all flight coupons on carriers operating aircraft with 60 or more seats, and all of the major markets in California are served by these carriers. Because the coupons contain the true origin and final destination of each passenger, the database allows a precise accounting of local travel between airports. The smaller markets are generally operated by smaller commuter carriers, which report only route segment passenger totals to the DoT, without distinguishing between local and connecting passengers. Calculation of total local trips for these markets therefore required that we first estimate the percentage of traffic made up of local travel.

Input Data for Intercity Forecasts

Amtrak Rail

The rail trip table was updated using data from Amtrak's train-level ridership database obtained through Caltrans. Because Amtrak has not compiled ridership data on a true origin-destination basis since 1992, a 1997 trip table cannot be obtained from the database directly. Instead, therefore, the 1992 volumes for each city pair were scaled up using the overall growth rate in the corresponding route-level ridership totals between 1992 and 1997 (the Capitols route total was used for Sacramento-San Francisco, San Diegans for Los Angeles-San Diego, etc.). The resulting matrix was then adjusted slightly so that the sum of all city pairs would equal the actual total of 1997 Amtrak trips (while the actual O/D distribution for years after 1992 cannot be determined from the Amtrak database, the total ridership for each year is correct). This is similar to the procedure used to create the previous base year trip tables, in which the 1992 volumes were factored up to estimate total O/D trips for 1994.

Base year trip comparison

A comparison of the resulting new 1997 base year trip tables and the previous 1994 trip tables is presented in Table 3-1. The table shows that travel on all modes has increased during the period, with air travel increasing the most at nearly 13 percent. Some very large gains in air travel of 30 percent or more are evident, but these are confined to the smaller markets; the major markets show more modest gains in the range of 10-14 percent.

As described above, 1997 auto volumes are estimated using the total travel demand model, but nevertheless positive growth is clearly indicated, generally of about 7-9 percent. Amtrak trips have increased almost 12 percent overall during this period, but the largest two markets show opposite results. While Sacramento-San Francisco Amtrak ridership has climbed by more than 60 percent, estimated 1997 ridership for the much larger Los Angeles-San Diego market is more than 15 percent below that used in the previous 1994 base trip table.[25] The complete

[25] In the process of compiling the new 1997 base year trip tables, an anomaly was discovered in the calculation of the previous 1994 base trip table for Amtrak. The table reflects the correction of this problem for 1997 (but not 1994) and thus the percentages in the table exaggerate somewhat the true changes in Amtrak trips between 1994 and 1997. Comparing the "corrected" 1994 to 1997, the changes are a 13% decrease for Los Angeles-San Diego, an 11%increase for total

base year trip table by mode for all city pair markets is presented at the end of this chapter in Table 3-16.

Table 3- 1. Updated Base Year Intercity Trip Table Summary[26]

Market	1994 Base Trips (previous study)			Updated 1997 Base Trip Tables			% Change 94-97		
	Air	Auto	Amtrak Rail	Air	Auto	Amtrak Rail	Air	Auto	Amtrak Rail
Los Angeles-Sacramento	1,907,845	2,676,488	7,257	2,179,140	2,861,527	9,129	14.2%	6.9%	25.8%
Los Angeles-San Diego	298,018	32,609,224	1,112,355	407,185	34,870,032	934,322	36.6%	6.9%	-16.0%
Los Angeles-San Francisco	8,470,408	7,850,457	19,223	9,376,455	8,442,469	36,525	10.7%	7.5%	90.0%
Sacramento-San Francisco	26,216	18,780,889	308,643	40,797	20,475,524	502,956	55.6%	9.0%	63.0%
Sacramento-San Diego	567,155	679,261	*	613,341	736,732	*	8.1%	8.5%	*
San Diego-San Francisco	2,159,758	2,194,551	*	2,417,203	2,387,001	*	11.9%	8.8%	*
LA/SF-Valley Cities	308,520	22,023,771	183,612	368,805	23,747,021	290,896	19.5%	7.8%	58.4%
Other	161,387	39,898,748	161,368	250,059	43,157,606	225,434	54.9%	8.2%	39.7%
Total	13,899,307	126,713,390	1,793,044	15,652,986	136,677,910	2,000,351	12.6%	7.9%	11.6%

*Amtrak trips for these markets are essentially zero and are therefore excluded from the table for clarity.

Source: USDOT, Caltrans, and Charles River Associates.

Trip purpose distribution

In our previous study, trip purpose distributions for each mode and O/D pair were derived from the results of our several travel surveys. These trip purpose data have not been updated because of the great expense of these primary data collection activities (and no better information is available at this point). However, nothing about these markets gives us reason to suspect that these distributions have changed significantly between 1994 and 1997. For reference, the complete trip purpose distribution of intercity trips by mode as derived in our previous study is provided at the end of this chapter in Table 3-17.

ridership, a 63% increase for Sacramento-San Francisco, and increases of approximately 30% for the other entries in the table.

[26] Air trips in this table are "local" (or true O/D) air trips between metropolitan areas. Connect air trips (which are not destined to a city within the corridor), and their potential for diversion to HSR were forecast in the previous study using a separate procedure and subcontractor. The diversion to HSR of connect trips is small in absolute numbers, and limited to a few shorter distance intercity markets. The previous connect air forecasts of HSR ridership are used in this study as appropriate for the applicable system alternatives.

Input Data for Intercity Forecasts

FORECASTS OF THE FUTURE INTERCITY TRAVEL MARKET

Future year trip tables were created from the base year trip tables described above using separate estimates of the growth in travel on each of the existing modes. As described in Chapter 2, air and auto growth was forecast through the application of total travel demand models which predict total trips as a function of the underlying socioeconomic variables that are the primary determinants of travel. Growth in conventional rail (Amtrak) trips was assumed to occur at the rate of population growth of the metropolitan areas to be served by the proposed HSR system. The updated projections of these socioeconomic variables are described below.

Updated socioeconomic projections

The most recent available population projections for California counties, released in mid-December 1998, were obtained from the California Department of Finance. Updated forecasts of per capita income were obtained from the 1998 edition of *California County Projections* published by the Center for the Continuing Study of the California Economy. Tables 3-2 and 3-3 compare these forecasts with those used in our previous study for the Commission.

Input Data for Intercity Forecasts

Table 3- 2. Updated Population Forecasts for California Corridor Metropolitan Areas

	Forecasts for 2005			Forecasts for 2015			Forecasts for 2020		
Area	Previous	Updated	Change	Previous	Updated	Change	Previous	Updated	Change
Bakersfield	919,850	764,386	-16.9%	1,173,900	959,381	-18.3%	1,310,100	1,073,748	-18.0%
Fresno	1,244,550	1,031,275	-17.1%	1,606,500	1,223,120	-23.9%	1,803,800	1,338,970	-25.8%
Los Angeles	19,039,500	17,826,785	-6.4%	22,123,300	20,026,132	-9.5%	23,766,800	21,509,771	-9.5%
Merced	276,300	239,005	-13.5%	357,750	289,839	-19.0%	401,900	319,785	-20.4%
Modesto	593,800	523,558	-11.8%	755,100	644,148	-14.7%	840,200	708,950	-15.6%
Monterey	449,650	439,812	-2.2%	529,700	521,318	-1.6%	574,100	575,102	0.2%
Sacramento	1,454,200	1,327,435	-8.7%	1,709,400	1,538,106	-10.0%	1,839,500	1,651,765	-10.2%
San Diego	3,247,250	3,217,204	-0.9%	3,728,300	3,644,076	-2.3%	3,980,500	3,917,001	-1.6%
San Francisco	7,533,500	7,663,476	1.7%	8,095,350	8,308,080	2.6%	8,354,900	8,661,006	3.7%
Stockton	699,350	647,294	-7.4%	867,450	800,739	-7.7%	956,500	884,375	-7.5%
Visalia	469,250	423,932	-9.7%	582,800	514,910	-11.6%	644,400	569,896	-11.6%
Total	35,927,200	34,104,162	-5.1%	41,529,550	38,469,849	-7.4%	44,472,700	41,210,369	-7.3%

Source: California Dept. of Finance, with calculations by Charles River Associates.

Table 3- 3. Updated Forecasts of Real Per Capita Income for California Corridor Metropolitan Areas ($1999)

	Forecasts for 2005			Forecasts for 2015			Forecasts for 2020		
Area	Previous	Updated	Change	Previous	Updated	Change	Previous	Updated	Change
Bakersfield	23,358	22,030	-5.70%	23,958	22,098	-7.80%	24,258	22,132	-8.80%
Fresno	23,915	23,730	-0.80%	24,819	24,613	-0.80%	25,270	25,067	-0.80%
Los Angeles	30,504	29,652	-2.80%	33,095	32,256	-2.50%	34,391	33,643	-2.20%
Merced	21,403	20,994	-1.90%	22,229	21,697	-2.40%	22,643	22,057	-2.60%
Modesto	24,207	24,784	2.40%	25,981	27,126	4.40%	26,867	28,379	5.60%
Monterey	29,123	29,682	1.90%	31,833	33,250	4.50%	33,188	35,191	6.00%
Sacramento	28,470	30,980	8.80%	31,191	35,743	14.60%	32,552	38,393	17.90%
San Diego	29,586	29,814	0.80%	32,684	33,766	3.30%	34,234	35,934	5.00%
San Francisco	36,902	41,074	11.30%	40,918	48,676	19.00%	42,925	52,990	23.40%
Stockton	24,305	24,784	2.00%	25,498	26,323	3.20%	26,095	27,127	4.00%
Visalia	21,173	21,126	-0.20%	22,058	22,060	0.00%	22,500	22,542	0.20%

Source: 2005 from Center for the Continuing Study of the California Economy, *California County Projections*, 2015 and 2020 extrapolated by Charles River Associates.

Table 3-2 shows that the current population forecasts are generally lower than those used earlier, with the exception of San Francisco, which for which the new forecast is about 3-4 percent higher.[27] The figures for the Valley cities reflect a substantial downward revision, but most important for the purposes of the high speed rail forecasts are the roughly 10 percent declines in the projected populations of the Los Angeles and Sacramento regions.

Table 3-3 similarly compares the forecasts of real per capita income. The CCSCE includes three sets of projections, reflecting “low”, “moderate”, and “high” scenarios. We have used the “moderate” projections again, consistent with those used in the prior study. While the forecasts for some of the Valley cities have been revised downward, the table shows that projected per capita real income for Sacramento and San Francisco has increased significantly. Our extrapolated 2020 forecast for Sacramento is nearly 18 percent higher than before, and for San Francisco it has increased over 23 percent.

Updated Forecasts of Travel by Existing Modes

The air and auto models described in chapter 2 were applied using the updated socioeconomic forecasts in Tables 3-2 and 3-3 to produce updated forecasts of total air and auto travel in the corridor.[28] The models are applied incrementally, in that the change in the socioeconomic data from the new base year to the future year is used to predict the percentage growth in trips, and this factor is then applied to the new base year trip table to produce the total travel forecast. The forecasts therefore also account for the effects of changes in actual travel between the previous base year of 1994 and the new base year of 1997.

Table 3-4 provides a summary comparison of the revised 2015 trip tables for air and auto with those used in our previous forecasts (the full trip tables are provided at the end of this chapter in Tables 3-18 and 3-19). While the combined effects of

[27] Since population forecasts for some of the counties making up the San Francisco CMSA have been revised downward, others show upward revisions higher than for the region as a whole. For example, the 2015 forecasts for the counties of Santa Cruz and Santa Clara (the greater San Jose area) have both been increased by about 10%. Our HSR ridership forecasts are, of course, sensitive to these different rates of growth within each region.
[28] For the purposes of the forecasts it was assumed that air fares remain constant in real terms. In addition, no change was assumed in the California markets served by Southwest Airlines.

Input Data for Intercity Forecasts

the new base year trip tables, updated model coefficients and revised socioeconomic forecasts vary by city pair, the overall effect is that total projected travel has increased about 5 percent in the case of auto and 1.5 percent in the case of air. The largest changes occur for the Sacramento-San Francisco market, consistent with the fact that these cities show the largest upward revisions in projected real income in Table 3-3 (the causes of which have also contributed to the 1994-1997 growth in observed volumes).

Table 3- 4. Updated Future Year Trip Summary for Air and Auto

	Previous 2015 Forecast		New 2015 Forecast		Change in 2015 Forecast	
Market	Air	Auto	Air	Auto	Air	Auto
Los Angeles-Sacramento	3,321,813	3,519,899	3,186,152	3,501,542	-4.1%	-0.5%
Los Angeles-San Diego	516,194	42,784,986	597,813	42,753,295	15.8%	-0.1%
Los Angeles-San Francisco	13,897,027	10,030,479	13,763,712	10,422,642	-1.0%	3.9%
Sacramento-San Francisco	39,229	22,950,991	61,576	25,912,262	57.0%	12.9%
Sacramento-San Diego	975,923	888,186	973,130	940,451	-0.3%	5.9%
San Diego-San Francisco	3,273,609	2,699,422	3,660,384	3,016,535	11.8%	11.7%
LA/SF-Valley Cities	526,285	27,928,779	541,244	29,513,875	2.8%	5.7%
Other	273,045	52,103,711	378,359	55,465,110	38.6%	6.5%
Total	22,823,126	162,906,452	23,162,371	171,525,712	1.5%	5.3%

Source: Charles River Associates, 1996 and 1998.

Forecasts for the largest air market remain nearly constant, however, with projected LA-San Francisco volumes declining 1 percent. Air travel between San Diego-San Francisco has increased nearly 12 percent however, again reflecting the upward revisions in projected San Francisco population and income. The nearly 16 percent jump in projected air trips for LA-San Diego between the old and new forecasts is lower than the big gain in travel that has occurred in the last few years (shown in Table 3-1) due to the downward revisions in projected Los Angeles and San Diego populations and Los Angeles income.

The auto forecasts also mirror the effects of changes in the population and income forecasts. The forecast for the biggest auto market of LA-San Diego remains virtually unchanged, while most of the other large markets mirror the overall increase at between 4 and 6 percent. The large jump of 13 percent in the

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Sacramento-San Francisco market results in nearly three million additional auto trips being forecast for this city pair.

Table 3-5 provides an analogous summary comparison of the revised 2015 trip tables for conventional rail (Amtrak). (The full trip tables are provided in the Appendix in Tables A-3 and A-4). In our earlier study, we kept Amtrak rail volumes constant (future volumes equal to base year volumes) per agreement with the Commission. For the new study, we have grown the new 1997 city pair base year volumes at a rate equal to the population growth of the city pairs between 1997 and the forecast year. Therefore, like the auto forecasts, the conventional rail (Amtrak) forecasts mirror the effects of changes in the city pair population growths.

Table 3- 5. Updated Future Year Trip Summary for Amtrak Rail

Market	Previous 2015 Forecast (zero growth assumption)	New 2015 forecast (mirrors population growth)	Change in 2015 forecast
Los Angeles-Sacramento	7,257	11,483	58.2%
Los Angeles-San Diego	1,112,355	1,178,775	6.0%
Los Angeles-San Francisco	19,223	45,239	135.3%
Sacramento-San Francisco	308,643	617,089	99.9%
Sacramento-San Diego	157	262	66.7%
San Diego-San Francisco	429	1,104	157.5%
LA/SF-Valley Cities	183,612	359,991	96.1%
Other	161,368	307,866	90.8%
Total	1,793,044	2,521,810	40.6%

Source: Charles River Associates, 1996 and 1998.

The largest market, Los Angeles-San Diego, grows the least in percentage terms, but this is due to the decline in this intercity market between 1994 and 1997 (shown in Table 3-1). The growth in all the other markets shown in Table 7 is higher than the growth in total conventional rail trips of nearly 41 percent. These conventional rail growth projections assume no significant changes in service such as rail travel time reductions (speed increases) or real fare changes.

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INTERCITY LEVEL OF SERVICE DATA

This section describes updates to the level of service data for the existing modes. In some cases, future levels of service are assumed to equal current values (e.g., real air fares). In other cases, future levels of service developed (often at considerable expense) in the previous study are used again in this study (e.g., most importantly the highway travel times). Therefore, the only the level of service updates needed for the existing modes were to reflect 1997 conditions. Generally, these data include times, costs, and service frequencies for the common carrier modes. Each of the updated data items is described in more detail below.

Air

Fares

Updated air fares for the 1997 base year were obtained using the same procedure used in the previous study. For the major markets, the average fare paid was computed directly from the traffic and revenue statistics provided by the USDOT's 10 percent sample of flight coupons (Databank 1A). For the smaller markets where these data are not available, an average of current fares from our travel agent's Computerized Reservation System (CRS) was used.

Table 3-6 compares the updated fares to those used in the previous study. For the purposes of this comparison, the previous 1995 fares have been converted to $1999. The table shows that there have been significant changes in real air fares during this period, but that they are not consistent across markets, or even across the various airport pairs serving each market. While real fares have increased 14 and 16 percent between LAX-SFO and BUR-OAK, respectively, they have fallen almost 20 percent between SFO-SNA and ONT-SFO. The other airport pairs serving the Los Angeles-San Francisco market have changed more modestly, increasing by around 10 percent in several cases and falling by about 2-6 percent in others. The effect of these changes has generally been to reduce the differences in fares between all airport pairs. Overall, the result is that the weighted average Los Angeles-San Francisco airfare has increased slightly, by about 3.5 percent.

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Table 3- 6. Updated Average Air Fare Summary for Major Markets (One-Way)

Market	Airport Pair	1995 Fares (as used in previous study)	1995 Fares in $1999	Updated Fares ($1999)	% Change in real fares
Los Angeles-San Francisco	BUR-OAK	$50.55	$55.64	$64.30	15.6%
	BUR-SFO	$80.34	$88.42	$86.26	-2.4%
	BUR-SJC	$51.74	$56.94	$62.91	10.5%
	LAX-OAK	$49.63	$54.62	$60.31	10.4%
	LAX-SFO	$65.69	$72.29	$82.21	13.7%
	LAX-SJC	$53.12	$58.46	$60.86	4.1%
	OAK-ONT	$49.46	$54.43	$59.72	9.7%
	ONT-SFO	$79.19	$87.15	$71.35	-18.1%
	ONT-SJC	$49.31	$54.27	$59.70	10.0%
	OAK-SNA	$58.82	$64.74	$66.90	3.3%
	SFO-SNA	$79.57	$87.57	$70.81	-19.1%
	SJC-SNA	$61.09	$67.24	$63.30	-5.9%
	Average	$59.75	$65.76	$68.09	3.5%
Los Angeles-Sacramento	BUR-SMF	$51.80	$57.00	$57.89	1.6%
	LAX-SMF	$70.51	$77.60	$60.09	-22.6%
	ONT-SMF	$52.85	$58.16	$57.20	-1.7%
	SMF-SNA	$81.73	$89.94	$88.99	-1.1%
	Average	$62.37	$68.65	$62.41	-9.1%
Los Angeles-San Diego	LAX-SAN	$55.91	$61.53	$50.20	-18.4%
Sacramento-San Diego	SAN-SMF	$49.39	$54.36	$57.86	6.4%
San Diego-San Francisco	OAK-SAN	$50.63	$55.72	$62.64	12.4%
	SAN-SFO	$50.89	$56.00	$62.43	11.5%
	SAN-SJC	$63.02	$69.36	$63.83	-8.0%
	Average	$54.57	$60.06	$62.91	4.8%
Sacramento-San Francisco	SFO-SMF	$91.00	$100.15	$123.30	23.1%
Fresno-Los Angeles	FAT-LAX	$84.25	$92.72	$136.23	46.9%
Fresno-San Francisco	FAT-SFO	$104.50	$115.00	$152.58	32.7%
Bakersfield-Los Angeles	BFL-LAX	$112.25	$123.54	$122.24	-1.0%
Bakersfield-San Francisco	BFL-SFO	$125.50	$138.12	$150.21	8.8%

Source: USDOT DB1A database, Apollo CRS system, and Charles River Associates, 1998. 1995 fares converted to $1999 using Bureau of Labor Statistics Consumer Price Index for all Urban Consumers (CPI-U).

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While all four Los Angeles area airports also offer service to Sacramento, only the LAX-SMF airport pair shows a large change in real fare, falling about 23 percent, consistent with the decline of nearly 20 percent between LAX and San Diego. Conversely the Sacramento-San Francisco market shows a 23 percent *increase*. Real fares for San Diego-San Francisco have gone up or down about 10 percent depending on the airport pair. Changes in the three largest Central Valley markets vary widely, with Bakersfield-Los Angeles remaining nearly constant, Fresno-Los Angeles increasing by 47 percent and Fresno-San Francisco increasing about 33 percent.

In summary, real air fares have changed in the last few years in the California corridor, but these changes show no consistent pattern in one direction or the other except to decrease the differences in fares between airport pairs serving the same city pair. There has also been no basic *structural* change in air fares in the corridor, in that the major markets remain dominated by Southwest Airlines and its very low fares, while fares in the Valley markets remain not only relatively much higher, but quite high in absolute terms as well.

Separate business and nonbusiness fares will be computed based on the same factors used in our previous study. Based on data from our intercept survey of local air travelers, business fares are estimated to be 27 percent above the overall average shown in Table 8, while nonbusiness fares are assumed to be 29 percent below this average.

Service Frequencies

Updated air frequencies for 1997 are shown in Table 3-7, with the corresponding changes between 1994 and 1997 shown in Table 3-8. As with the previous study, the figures were compiled from the Official Airline Guide online database, and are computed as the total number of scheduled flights in 1997 divided by 365.

Input Data for Intercity Forecasts

Table 3- 7. Daily 1997 Average Air Frequencies by Airport Pair (each direction)*

	BFL	BUR	CLD	FAT	LAX	MCE	MOD	MRY	OAK	ONT	SAN	SCK	SFO	SJC	SMF	SNA
Bakersfield																
Burbank	0															
Carlsbad	0	0														
Fresno	0	4	0													
Los Angeles	19	0	13	30												
Merced	0	0	0	1	0											
Modesto	0	0	0	0	0	0										
Monterey	0	0	0	0	20	0	0									
Oakland	0	15	0	0	35	0	0	0								
Ontario	0	0	0	4	15	0	0	0	12							
San Diego	0	6	0	3	76	0	0	0	11	0						
Stockton	0	0	0	0	0	0	0	0	0	0	0					
San Francisco	5	13	0	17	49	2	5	15	0	8	25	0				
San Jose	0	8	0	0	27	0	0	0	1	7	14	0	0			
Sacramento	3	10	0	2	13	0	0	0	0	10	11	0	20	0		
Orange County	0	0	0	4	17	0	0	3	13	0	1	0	10	14	5	
Visalia	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0

* Three digit codes for airports used as the column headings correspond to the airport names in the row headings.

Source: Official Airline Guide online database, with calculations by Charles River Associates.

Table 3- 8. Changes in Average Daily Air Frequencies (each direction): 1994-1997*

	BFL	BUR	CLD	FAT	LAX	MCE	MOD	MRY	OAK	ONT	SAN	SCK	SFO	SJC	SMF	SNA
Bakersfield																
Burbank	0															
Carlsbad	0	0														
Fresno	0	-2	0													
Los Angeles	2	0	8	6												
Merced	0	0	0	0	0											
Modesto	0	0	0	0	0	0										
Monterey	0	0	0	0	3	0	0									
Oakland	0	2	0	-1	17	0	0	0								
Ontario	0	0	0	-1	0	0	0	0	0							
San Diego	0	-2	0	1	10	0	0	0	0	-1						
Stockton	0	0	0	0	-3	0	-1	0	0	0	0					
San Francisco	1	5	0	-1	-3	-1	-2	-2	0	2	4	-2				
San Jose	0	-2	0	0	5	0	0	0	0	-5	7	0	0			
Sacramento	1	0	0	0	6	0	0	0	0	2	2	0	-1	-1		
Orange County	0	0	0	0	0	0	0	0	1	0	-1	0	-4	6	-1	
Visalia	-3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0

* Three digit codes for airports used as the column headings correspond to the airport names in the row headings.

Source: Official Airline Guide online database, with calculations by Charles River Associates.

Input Data for Intercity Forecasts

Table 3-8 shows that in a few cases there have been marked changes in frequency, with LAX-OAK increasing by 17 flights per day, each way, effectively doubling the amount of service in this airport pair. This increase is partially offset by declines in frequencies between other Los Angeles-San Francisco airport pairs, with BUR-SJC, LAX-SFO, ONT-SJC, and SFO-SNA losing 2, 3, 5, and 4 flights respectively. Other pairs show increases, however, ranging from 1 to 6 flights per day, such that overall 23 flights each way have been added between Los Angeles-San Francisco between 1994 and 1997, a 12 percent increase in air frequency. This closely matches the 11 percent increase in air travel between these two metropolitan areas (see Table 3-1).

Los Angeles-Sacramento and San Diego-San Francisco also show strong overall frequency gains of 20 percent and 26 percent, respectively. Frequency between Los Angeles and Fresno has increased 10 percent overall, while declining about 6 percent between Fresno and San Francisco. The declines in airport pairs serving Stockton reflect the fact that all scheduled air service has been eliminated at this airport.

Line-haul travel times

Air travel times for 1997 are shown in Table 3-9, with the corresponding changes between 1994 and 1997 shown in Table 3-10. As expected, most of the changes are very small, on the order of only a few minutes plus or minus. This is to be expected as schedules are periodically adjusted based on changes in on-time performance, equipment types, or other airline prerogatives. The largest changes are for travel to and from Orange County airport, where times have increased by about 10-13 minutes.

Input Data for Intercity Forecasts

Table 3- 9. Air Travel Times by Airport Pair – 1997*

	BFL	BUR	CLD	FAT	LAX	MCE	MOD	MRY	OAK	ONT	SAN	SCK	SFO	SJC	SMF	SNA
Bakersfield																
Burbank	NA															
Carlsbad	NA	NA														
Fresno	NA	60	NA													
Los Angeles	46	NA	41	65												
Merced	NA	NA	NA	NA	NA											
Modesto	NA	NA	NA	NA	NA	NA										
Monterey	NA	NA	NA	NA	76	NA	NA									
Oakland	NA	63	NA	NA	70	NA	NA	NA								
Ontario	NA	NA	NA	60	NA	NA	NA	NA	69							
San Diego	NA	50	NA	90	48	NA	NA	NA	80	NA						
Stockton	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA					
San Francisco	70	70	NA	53	80	40	35	35	NA	74	89	NA				
San Jose	NA	60	NA	NA	65	NA	NA	NA	NA	65	78	NA	NA			
Sacramento	NA	70	NA	NA	79	NA	NA	NA	NA	75	85	NA	41	NA		
Orange County	NA	NA	NA	60	NA	NA	NA	NA	78	NA	NA	NA	86	74	84	
Visalia	NA	NA	NA	NA	50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

* Three digit codes for airports used as the column headings correspond to the airport names in the row headings.
Source: Official Airline Guide.

Table 3- 10. Changes in Air Travel Times 1994-1997*

	BFL	BUR	CLD	FAT	LAX	MCE	MOD	MRY	OAK	ONT	SAN	SCK	SFO	SJC	SMF	SNA
Bakersfield																
Burbank	NA															
Carlsbad	NA	NA														
Fresno	NA	0	NA													
Los Angeles	-1	NA	-1	0												
Merced	NA	NA	NA	NA	NA											
Modesto	NA	NA	NA	NA	NA	NA										
Monterey	NA	NA	NA	NA	2	NA	NA									
Oakland	NA	0	NA	NA	0	NA	NA	NA								
Ontario	NA	NA	NA	5	NA	NA	NA	NA	0							
San Diego	NA	0	NA	0	0	NA	NA	NA	1	NA						
Stockton	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA					
San Francisco	8	2	NA	0	-2	1	-7	1	NA	6	-4	NA				
San Jose	NA	3	NA	NA	5	NA	NA	NA	NA	3	4	NA	NA			
Sacramento	NA	-2	NA	NA	9	NA	NA	NA	NA	-2	0	NA	0	NA		
Orange County	NA	NA	NA	13	NA	NA	NA	NA	12	NA	NA	NA	11	2	-1	
Visalia	NA	NA	NA	NA	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

* Three digit codes for airports used as the column headings correspond to the airport names in the row headings.
Source: Official Airline Guide.

Input Data for Intercity Forecasts

Private Vehicle

As part of our previous study, a future year highway network was developed using the future year networks of all the local metropolitan planning organizations (MPOs) and the statewide highway network of the California Department of Transportation (Caltrans). For this update, we have discussed with the major MPO's in the corridor the current status of their future year networks. In most instances, estimates of future year travel times, particularly for intercity travel, have not changed materially. In a few instances, changes have been made in zone *structure*, but these don't warrant revising the travel time matrix calculated for the previous study. Consequently, we have not revised the private vehicle travel times for the purposes of the current analysis.

For reference, Table 3-11 presents future year city center to city center travel times by private vehicle for the major interchanges. The travel times in the table are weighted averages of peak and off peak travel times. We use the appropriate trip purpose travel times in our market segment HSR ridership forecasting procedure.

Table 3- 11. Year 2015 Average Center City to Center City Line-haul Travel Times by Private Vehicle for Major Interchanges (minutes)

	Bakersfield	Fresno	Los Angeles	Modesto	Sacramento	San Diego	San Francisco	Stockton
Bakersfield								
Fresno	121							
Los Angeles	128	240						
Modesto	220	120	331					
Sacramento	302	190	400	78				
San Diego	255	370	138	457	525			
San Francisco	291	216	401	103	103	531		
Stockton	262	155	366	51	35	493	103	

Source: Local MPO and Caltrans networks with calculations by Deakin/Harvey/Skabardonis.

It was likewise unnecessary to revise the auto travel costs as these values were derived directly from our extensive surveys and are measured on a per person, per mile basis for compatibility with our forecasting models. As appropriate, the forecasting procedure will inflate these costs to 1999 dollars.

Input Data for Intercity Forecasts

Amtrak Rail

Fares

Amtrak fares were updated to 1997 levels in a manner analogous to that used to update the base year Amtrak trip table. For those markets for which Amtrak's 1997 train-level database contains "true O/D" ridership and revenue data, the average fare paid was computed directly as the quotient of these two measures. Fares for Los Angeles-San Diego, Sacramento-San Francisco, and a few intermediate San Joaquin markets were computed in this fashion. Percentage changes in these fares between 1992 and 1997 were then used to scale up the 1992 fares for the remaining city pairs. The result is that fares in current dollars declined somewhat, about 7 percent in the case of the San Diegan route, 4 percent for the Capitols, and about 11 percent for the San Joaquins. Table 3-12 contains the complete 1997 fare matrix, shown in $1999 for comparison to other figures in this report.

Table 3- 12. 1997 Average One-Way Amtrak Fares by O/D Pair ($1999)

	Bakersfield	Fresno	Los Angeles	Merced	Modesto	Monterey	Sacramento	San Diego	San Francisco	Stockton
Bakersfield										
Fresno	$14.93									
Los Angeles	$15.24	$23.05								
Merced	$21.13	$8.29	$26.67							
Modesto	$23.50	$12.29	$28.89	$5.81						
Monterey	$34.38	$23.41	$39.50	$17.73	$12.13					
Sacramento	$34.07	$20.02	$36.77	$15.51	$11.98	$19.19				
San Diego	$18.50	$30.44	$14.65	$34.53	$41.70	$51.50	$39.23			
San Francisco	$31.33	$22.01	$37.82	$16.78	$11.50	$15.52	$10.78	$48.59		
Stockton	$26.95	$15.98	$32.07	$10.30	$4.70	$8.00	$11.17	$44.07	$9.37	
Visalia	$11.45	$4.47	$19.43	$10.90	$15.66	$26.17	$21.73	$26.76	$24.83	$18.74

Source: Amtrak with calculations by Charles River Associates.

Service frequencies

Using 1997 Amtrak schedules, an average daily frequency was computed for each city pair, calculated by weighting each train by the number of days per week on which it operates. The updated Amtrak frequencies are shown in Table 3-13. There are only two changes from 1994 - the Sacramento-San Francisco frequency has gone from an average of 4 per day to an average of 7.7, and Los Angeles-San Diego has increased from 9 to 9.7. The only other change is that the frequency between Monterey and the Valley Cities and between Monterey and San Francisco has decreased by one train per day.

Table 3- 13. 1997 Average Daily Amtrak Frequencies by O/D Pair (each direction)

	Bakersfield	Fresno	Los Angeles	Merced	Modesto	Monterey	Sacramento	San Diego	San Francisco	Stockton
Bakersfield										
Fresno	4.0									
Los Angeles	4.0	4.0								
Merced	4.0	4.0	4.0							
Modesto	4.0	4.0	4.0	4.0						
Monterey	2.0	2.0	1.0	2.0	2.0					
Sacramento	4.0	4.0	4.0	4.0	4.0	3.0				
San Diego	4.0	4.0	9.7	4.0	4.0	1.0	4.0			
San Francisco	4.0	4.0	4.0	4.0	4.0	3.0	7.0	4.0		
Stockton	4.0	4.0	4.0	4.0	4.0	3.0	NA	4.0	4.0	
Visalia	4.0	4.0	4.0	4.0	4.0	3.0	4.0	4.0	4.0	4.0

Source: Amtrak schedules.

Line-haul travel times

Travel times for 1997 were computed from the Amtrak schedules, using the scheduled time between the main stations of each city pair. The updated values are shown in Table 3-14, with a comparison to the previous figures provided in Table 3-15. In some cases, the times are not completely comparable because of alignment changes occurring in the interim, such as the addition of the extension from Emeryville to Oakland. However, there are other significant differences not explained by such factors. This is most likely the result of the fact that the times used in the previous study were not computed in the same manner as the new times in Table 3-14.

Most important are the changes in travel time for Los Angeles-San Diego and Sacramento-San Francisco, which together represent two-thirds of all Amtrak

Input Data for Intercity Forecasts

trips taken in 1997, as shown in Table 3-1. The travel time for Los Angeles-San Diego has been revised upward by 26 percent, while Sacramento-San Francisco has dropped about 6 percent.

Table 3- 14. 1997 Average Amtrak Travel Times by O/D Pair (one way in minutes)

	Bakersfield	Fresno	Los Angeles	Merced	Modesto	Monterey	Sacramento	San Diego	San Francisco	Stockton
Bakersfield										
Fresno	122.3									
Los Angeles	142.5	243.8								
Merced	172.5	59.3	339.5							
Modesto	215.5	100.3	380.5	41.0						
Monterey	606.0	488.0	544.0	431.0	390.0					
Sacramento	301.3	183.5	463.8	124.3	83.3	352.0				
San Diego	327.5	458.8	165.5	518.8	563.0	694.0	698.8			
San Francisco	400.0	272.3	552.5	213.0	172.0	220.0	153.7	736.3		
Stockton	250.5	132.8	423.0	73.5	32.5	345.0	NA	604.3	133.8	
Visalia	65.8	42.8	229.5	103.0	147.3	533.5	243.0	420.8	309.3	175.5

Source: Amtrak schedules.

Table 3- 15. Effect of Revision in Amtrak Travel Times

	Bakersfield	Fresno	Los Angeles	Merced	Modesto	Monterey	Sacramento	San Diego	San Francisco	Stockton
Bakersfield										
Fresno	-1.1%									
Los Angeles	-27.5%	-24.4%								
Merced	-5.0%	6.0%	-10.8%							
Modesto	-3.5%	2.6%	-9.9%	2.5%						
Monterey	17.7%	25.4%	-4.1%	30.2%	34.5%					
Sacramento	-5.1%	-4.2%	-10.2%	-7.0%	-9.2%	9.9%				
San Diego	-7.1%	-4.0%	26.0%	-3.3%	-2.6%	-7.1%	3.9%			
San Francisco	10.9%	15.8%	-1.3%	53.0%	27.2%	42.3%	-6.4%	2.9%		
Stockton	-1.7%	2.8%	-6.7%	3.4%	8.3%	32.7%	-17.5%	-0.8%	28.7%	
Visalia	-25.4%	-59.3%	-20.0%	12.6%	10.5%	8.0%	7.0%	-4.9%	14.3%	6.6%

Source: Charles River Associates, 1998.

Input Data for Intercity Forecasts

Table 3- 16. Complete Intercity Base Year Trip Tables for 1997

O/D Pair	Air	Auto	Rail	Total
Bakersfield-Fresno	16	1,166,073	15,611	1,181,700
Bakersfield-Los Angeles	38,827	7,334,507	13,885	7,387,219
Bakersfield-Merced	0	57,647	3,208	60,855
Bakersfield-Modesto	0	214,632	7,098	221,730
Bakersfield-Monterey	190	45,095	0	45,285
Bakersfield-Sacramento	14,991	448,114	12,887	475,992
Bakersfield-San Diego	6,805	438,600	391	445,796
Bakersfield-San Francisco	11,698	758,607	42,186	812,492
Bakersfield-Stockton	0	84,029	7,964	91,993
Bakersfield-Visalia	9	211,922	9,773	221,704
Fresno-Los Angeles	237,588	2,448,051	38,087	2,723,726
Fresno-Merced	0	1,016,614	3,541	1,020,154
Fresno-Modesto	0	495,743	6,964	502,707
Fresno-Monterey	60	258,370	0	258,430
Fresno-Sacramento	4,267	1,025,409	19,860	1,049,536
Fresno-San Diego	41,053	256,094	888	298,035
Fresno-San Francisco	58,092	3,302,921	79,133	3,440,146
Fresno-Stockton	0	356,555	9,134	365,689
Fresno-Visalia	0	576,934	28,142	605,076
Los Angeles-Merced	400	312,189	9,799	322,389
Los Angeles-Modesto	8,020	702,554	14,290	724,864
Los Angeles-Monterey	124,514	829,268	0	953,782
Los Angeles-Sacramento	2,179,140	2,861,527	9,129	5,049,796
Los Angeles-San Diego	407,185	34,870,032	934,322	36,211,539
Los Angeles-San Francisco	9,376,455	8,442,469	36,525	17,855,449
Los Angeles-Stockton	0	553,924	11,391	565,315
Los Angeles-Visalia	4,144	186,054	20,438	210,636
Merced-Modesto	0	2,373,446	2,523	2,375,970
Merced-Monterey	0	191,068	0	191,068
Merced-Sacramento	0	578,682	4,562	583,244
Merced-San Diego	190	31,754	353	32,297
Merced-San Francisco	1,203	1,456,750	38,794	1,496,747
Merced-Stockton	0	404,779	2,015	406,794
Merced-Visalia	0	42,282	1,527	43,809
Modesto-Monterey	0	242,829	0	242,829
Modesto-Sacramento	0	2,379,318	2,540	2,381,857
Modesto-San Diego	2,520	56,790	372	59,682
Modesto-San Francisco	8,833	6,691,463	22,892	6,723,188
Modesto-Stockton	0	5,310,423	2,345	5,312,768
Modesto-Visalia	0	63,264	3,882	67,147
Monterey-Sacramento	950	604,293	8,118	613,360
Monterey-San Diego	24,259	119,861	0	144,120
Monterey-San Francisco	28,860	10,250,239	4,244	10,283,343
Monterey-Stockton	0	93,465	0	93,465
Monterey-Visalia	0	9,820	0	9,820
Sacramento-San Diego	613,341	736,732	198	1,350,271
Sacramento-San Francisco	40,797	20,475,524	502,956	21,019,278
Sacramento-Stockton	0	3,374,004	699	3,374,703
Sacramento-Visalia	0	118,357	9,216	127,573
San Diego-San Francisco	2,417,203	2,387,001	891	4,805,095
San Diego-Stockton	0	69,451	170	69,621
San Diego-Visalia	721	28,530	1,076	30,328
San Francisco-Stockton	0	9,106,442	24,683	9,131,124
San Francisco-Visalia	653	150,750	27,062	178,465
Stockton-Visalia	0	76,660	4,587	81,247
Total	15,652,986	136,677,910	2,000,351	154,331,247

Source: Charles River Associates, 1998.

Input Data for Intercity Forecasts

Table 3- 17. Trip Purpose Shares by Mode and O/D Pair

O/D Pair	Air		Rail		Private Vehicle	
	Business	Nonbusiness	Business	Nonbusiness	Business	Nonbusiness
Bakersfield-Fresno	52.0%	48.0%	28.0%	72.0%	29.0%	71.0%
Bakersfield-Los Angeles	68.0%	32.0%	28.0%	72.0%	12.0%	88.0%
Bakersfield-Merced	52.0%	48.0%	28.0%	72.0%	75.2%	24.8%
Bakersfield-Modesto	52.0%	48.0%	28.0%	72.0%	5.5%	94.5%
Bakersfield-Monterey	52.0%	48.0%	28.0%	72.0%	31.3%	68.7%
Bakersfield-Sacramento	52.3%	47.7%	28.0%	72.0%	53.5%	46.5%
Bakersfield-San Diego	52.0%	48.0%	28.0%	72.0%	10.2%	89.8%
Bakersfield-San Francisco	70.0%	30.0%	28.0%	72.0%	13.9%	86.1%
Bakersfield-Stockton	52.0%	48.0%	28.0%	72.0%	26.2%	73.8%
Bakersfield-Visalia	52.0%	48.0%	28.0%	72.0%	13.2%	86.8%
Fresno-Los Angeles	68.0%	32.0%	28.0%	72.0%	21.7%	78.3%
Fresno-Merced	52.0%	48.0%	28.0%	72.0%	17.5%	82.5%
Fresno-Modesto	52.0%	48.0%	28.0%	72.0%	20.2%	79.8%
Fresno-Monterey	52.0%	48.0%	28.0%	72.0%	10.0%	90.0%
Fresno-Sacramento	52.3%	47.7%	28.0%	72.0%	24.1%	75.9%
Fresno-San Diego	52.0%	48.0%	28.0%	72.0%	24.4%	75.6%
Fresno-San Francisco	70.0%	30.0%	28.0%	72.0%	30.4%	69.6%
Fresno-Stockton	52.0%	48.0%	28.0%	72.0%	24.7%	75.3%
Fresno-Visalia	52.0%	48.0%	28.0%	72.0%	35.7%	64.3%
Los Angeles-Merced	68.0%	32.0%	28.0%	72.0%	16.4%	83.6%
Los Angeles-Modesto	68.0%	32.0%	28.0%	72.0%	9.2%	90.8%
Los Angeles-Monterey	68.0%	32.0%	28.0%	72.0%	12.7%	87.3%
Los Angeles-Sacramento	47.0%	53.0%	28.0%	72.0%	23.0%	77.0%
Los Angeles-San Diego	77.0%	23.0%	28.0%	72.0%	23.4%	76.6%
Los Angeles-San Francisco	50.0%	50.0%	28.0%	72.0%	16.6%	83.4%
Los Angeles-Stockton	68.0%	32.0%	28.0%	72.0%	10.9%	89.1%
Los Angeles-Visalia	68.0%	32.0%	28.0%	72.0%	10.2%	89.8%
Merced-Modesto	52.0%	48.0%	28.0%	72.0%	24.7%	75.3%
Merced-Monterey	52.0%	48.0%	28.0%	72.0%	9.8%	90.2%
Merced-Sacramento	52.3%	47.7%	28.0%	72.0%	23.1%	76.9%
Merced-San Diego	52.0%	48.0%	28.0%	72.0%	3.6%	96.4%
Merced-San Francisco	70.0%	30.0%	28.0%	72.0%	14.4%	85.6%
Merced-Stockton	52.0%	48.0%	28.0%	72.0%	40.1%	59.9%
Merced-Visalia	52.0%	48.0%	28.0%	72.0%	4.4%	95.6%
Modesto-Monterey	52.0%	48.0%	28.0%	72.0%	10.5%	89.5%
Modesto-Sacramento	52.3%	47.7%	28.0%	72.0%	19.0%	81.0%
Modesto-San Diego	52.0%	48.0%	28.0%	72.0%	4.6%	95.4%
Modesto-San Francisco	70.0%	30.0%	28.0%	72.0%	21.2%	78.8%
Modesto-Stockton	52.0%	48.0%	28.0%	72.0%	10.5%	89.5%
Modesto-Visalia	52.0%	48.0%	28.0%	72.0%	18.4%	81.6%
Monterey-Sacramento	52.3%	47.7%	28.0%	72.0%	13.3%	86.7%
Monterey-San Diego	52.0%	48.0%	28.0%	72.0%	11.1%	88.9%
Monterey-San Francisco	70.0%	30.0%	28.0%	72.0%	19.5%	80.5%
Monterey-Stockton	52.0%	48.0%	28.0%	72.0%	21.2%	78.8%
Monterey-Visalia	52.0%	48.0%	28.0%	72.0%	7.6%	92.4%
Sacramento-San Diego	52.4%	47.6%	28.0%	72.0%	8.3%	91.7%
Sacramento-San Francisco	65.0%	35.0%	28.0%	72.0%	21.9%	78.1%
Sacramento-Stockton	52.3%	47.7%	28.0%	72.0%	21.3%	78.7%
Sacramento-Visalia	52.3%	47.7%	28.0%	72.0%	29.9%	70.1%
San Diego-San Francisco	81.0%	19.0%	28.0%	72.0%	19.5%	80.5%
San Diego-Stockton	52.0%	48.0%	28.0%	72.0%	10.5%	89.5%
San Diego-Visalia	52.0%	48.0%	28.0%	72.0%	3.6%	96.4%
San Francisco-Stockton	70.0%	30.0%	28.0%	72.0%	23.8%	76.2%
San Francisco-Visalia	70.0%	30.0%	28.0%	72.0%	5.5%	94.5%
Stockton-Visalia	52.0%	48.0%	28.0%	72.0%	11.1%	88.9%

Source: Charles River Associates, 1995.

Input Data for Intercity Forecasts

Table 3- 18. Complete Future Year Intercity Trip Tables for 2015

	New Projected 2015			
O/D Pair	Air	Auto	Rail	Total
Bakersfield-Fresno	26	1,481,641	22,318	1,503,985
Bakersfield-Los Angeles	56,645	8,949,349	17,519	9,023,513
Bakersfield-Merced	0	73,804	4,792	78,596
Bakersfield-Modesto	0	282,687	10,739	293,426
Bakersfield-Monterey	318	57,777	0	58,095
Bakersfield-Sacramento	24,787	577,750	18,069	620,606
Bakersfield-San Diego	10,857	557,540	530	568,927
Bakersfield-San Francisco	17,656	958,047	52,040	1,027,744
Bakersfield-Stockton	0	108,928	11,914	120,841
Bakersfield-Visalia	15	271,677	14,515	286,207
Fresno-Los Angeles	346,147	2,987,205	47,916	3,381,268
Fresno-Merced	0	1,287,124	4,896	1,292,019
Fresno-Modesto	0	643,566	9,870	653,436
Fresno-Monterey	96	328,155	0	328,251
Fresno-Sacramento	6,883	1,314,657	26,894	1,348,434
Fresno-San Diego	64,738	324,820	1,183	390,741
Fresno-San Francisco	87,357	4,168,600	97,063	4,353,020
Fresno-Stockton	0	457,456	12,887	470,343
Fresno-Visalia	0	732,176	39,114	771,290
Los Angeles-Merced	581	380,518	12,289	393,388
Los Angeles-Modesto	11,704	858,225	17,985	887,914
Los Angeles-Monterey	181,094	1,011,592	0	1,192,686
Los Angeles-Sacramento	3,186,152	3,501,542	11,483	6,699,177
Los Angeles-San Diego	597,813	42,753,295	1,178,775	44,529,883
Los Angeles-San Francisco	13,763,712	10,422,642	45,239	24,231,594
Los Angeles-Stockton	0	676,331	14,343	690,673
Los Angeles-Visalia	6,026	226,870	25,667	258,563
Merced-Modesto	0	3,182,379	3,756	3,186,136
Merced-Monterey	0	244,717	0	244,717
Merced-Sacramento	0	747,141	6,183	753,324
Merced-San Diego	300	40,327	468	41,094
Merced-San Francisco	1,800	1,838,753	47,109	1,887,663
Merced-Stockton	0	527,983	2,953	530,937
Merced-Visalia	0	54,206	2,193	56,398
Modesto-Monterey	0	320,964	0	320,964
Modesto-Sacramento	0	3,114,753	3,525	3,118,278
Modesto-San Diego	4,043	72,710	500	77,254
Modesto-San Francisco	13,329	8,469,976	28,059	8,511,364
Modesto-Stockton	0	7,093,859	3,501	7,097,361
Modesto-Visalia	0	84,247	5,742	89,989
Monterey-Sacramento	1,543	779,508	10,966	792,016
Monterey-San Diego	38,283	152,345	0	190,628
Monterey-San Francisco	43,256	12,943,746	5,164	12,992,166
Monterey-Stockton	0	121,344	0	121,344
Monterey-Visalia	0	12,595	0	12,595
Sacramento-San Diego	973,130	940,451	262	1,913,843
Sacramento-San Francisco	61,576	25,912,262	617,089	26,590,927
Sacramento-Stockton	0	4,379,488	968	4,380,456
Sacramento-Visalia	0	152,813	12,571	165,384
San Diego-San Francisco	3,660,384	3,016,535	1,104	6,678,023
San Diego-Stockton	0	88,587	229	88,816
San Diego-Visalia	1,140	36,255	1,434	38,829
San Francisco-Stockton	0	11,513,627	30,298	11,543,926
San Francisco-Visalia	979	190,333	32,994	224,306
Stockton-Visalia	0	99,834	6,701	106,535
Total	23,162,371	171,525,712	2,521,810	197,209,893

Source: Charles River Associates, 1998.

Input Data for Intercity Forecasts

Table 3- 19. Complete Future Year Intercity Trip Tables for 2020

	New Projected 2020			
O/D Pair	Air	Auto	Rail	Total
Bakersfield-Fresno	29	1,555,649	24,672	1,580,351
Bakersfield-Los Angeles	62,742	9,406,997	18,853	9,488,592
Bakersfield-Merced	0	77,603	5,345	82,949
Bakersfield-Modesto	0	298,818	11,939	310,757
Bakersfield-Monterey	363	61,244	0	61,606
Bakersfield-Sacramento	27,990	613,011	19,719	660,720
Bakersfield-San Diego	12,195	590,682	575	603,452
Bakersfield-San Francisco	19,459	1,012,503	54,664	1,086,627
Bakersfield-Stockton	0	114,913	13,254	128,167
Bakersfield-Visalia	17	286,036	16,182	302,235
Fresno-Los Angeles	383,196	3,139,643	51,523	3,574,363
Fresno-Merced	0	1,350,708	5,367	1,356,075
Fresno-Modesto	0	678,604	10,825	689,428
Fresno-Monterey	108	346,805	0	346,913
Fresno-Sacramento	7,726	1,392,431	29,130	1,429,286
Fresno-San Diego	72,491	343,820	1,277	417,588
Fresno-San Francisco	96,187	4,404,370	101,837	4,602,394
Fresno-Stockton	0	481,644	14,157	495,801
Fresno-Visalia	0	769,325	42,959	812,284
Los Angeles-Merced	643	399,976	13,205	413,823
Los Angeles-Modesto	12,961	902,395	19,332	934,689
Los Angeles-Monterey	200,587	1,063,829	0	1,264,416
Los Angeles-Sacramento	3,530,374	3,684,330	12,333	7,227,038
Los Angeles-San Diego	662,843	45,005,829	1,266,252	46,934,924
Los Angeles-San Francisco	15,208,364	10,979,651	48,171	26,236,187
Los Angeles-Stockton	0	711,069	15,422	726,491
Los Angeles-Visalia	6,672	238,487	27,589	272,748
Merced-Modesto	0	3,375,442	4,137	3,379,579
Merced-Monterey	0	260,737	0	260,737
Merced-Sacramento	0	794,499	6,668	801,168
Merced-San Diego	336	42,761	504	43,601
Merced-San Francisco	1,979	1,943,639	49,207	1,994,825
Merced-Stockton	0	558,044	3,261	561,305
Merced-Visalia	0	57,142	2,424	59,566
Modesto-Monterey	0	342,510	0	342,510
Modesto-Sacramento	0	3,315,685	3,814	3,319,499
Modesto-San Diego	4,540	77,160	540	82,240
Modesto-San Francisco	14,674	8,956,194	29,369	9,000,237
Modesto-Stockton	0	7,526,122	3,861	7,529,983
Modesto-Visalia	0	89,352	6,335	95,687
Monterey-Sacramento	1,745	831,017	11,857	844,620
Monterey-San Diego	43,026	161,792	0	204,818
Monterey-San Francisco	47,624	13,690,265	5,401	13,743,291
Monterey-Stockton	0	129,096	0	129,096
Monterey-Visalia	0	13,408	0	13,408
Sacramento-San Diego	1,091,774	998,781	282	2,090,836
Sacramento-San Francisco	67,866	27,416,110	646,332	28,130,308
Sacramento-Stockton	0	4,655,368	1,049	4,656,417
Sacramento-Visalia	0	162,463	13,604	176,067
San Diego-San Francisco	4,043,662	3,191,457	1,162	7,236,281
San Diego-Stockton	0	93,945	247	94,192
San Diego-Visalia	1,279	38,444	1,547	41,270
San Francisco-Stockton	0	12,172,116	31,751	12,203,867
San Francisco-Visalia	1,077	201,198	34,520	236,794
Stockton-Visalia	0	105,570	7,407	112,978
Total	25,624,530	181,110,689	2,689,862	209,425,082

Source: Charles River Associates, 1998.

4
Forecasts of Intercity Ridership and Revenue

OVERVIEW

This chapter contains our forecasts of *intercity* ridership and revenue on the proposed HSR system. As described in Chapter 1, these forecasts include only the ridership and revenue resulting from travel *between* the metropolitan areas that would be served by the system. Presented first is a summary of the total ridership and revenue results for the four alternative combinations of alignment and technology described in Chapter 1. Next we present more detailed results for the one of these four cases used as the basis for the Authority's business plan. Finally, the chapter concludes with the results of several sensitivity analyses that show the changes in forecast ridership and revenue with selected important changes to the input data described in the preceding chapter.

FORECASTS FOR VARYING ALIGNMENTS AND TECHNOLOGIES

HSR Technology

Table 4-1 summarizes the forecasts for the four alternatives described in Chapter 1. As noted earlier, we made forecasts for two different technologies: (1) VHS, and (2) a faster HSR system (maglev). The table shows that the maglev technology produces higher ridership and revenue than the VHS technology due to its significantly faster travel times. The faster maglev system increases ridership by 27 percent to 31.5 percent over the VHS system, depending on the alignment. The faster maglev system also increases revenue by 31 percent to 34 percent over the VHS system. Revenue is more sensitive than ridership to speed because of the importance of speed in diverting air and private vehicle users to HSR on the longer LA-Bay Area O/D pair with its higher fare yield per trip than on the shorter distance city pairs within the corridor.

Forecasts of Intercity Ridership and Revenue

Table 4- 1. 2020 Intercity Ridership and Passenger Revenue by Alternative

Route Option	Technology	Ridership	% Change	Revenue ($99)	% Change
Option A	VHS	30,286,332	-	848,339,992	-
	Maglev	38,430,125	26.9%	1,113,370,396	31.2%
Option B	VHS	32,002,103	5.7%	888,177,557	4.7%
	Maglev	39,814,665	31.5%	1,136,530,877	34.0%

Source: Charles River Associates, 1999.

HSR Alignments

For both technologies, Option B (through the Grapevine) produces both higher ridership and higher revenue than Option A (through Palmdale). Ridership and revenue are higher by 5.7 percent and 4.7 percent respectively for the VHS technology, and by 3.6 percent and 2.1 percent respectively for the maglev technology. In this case, the increases are less for maglev because Option B is already significantly faster than Option A, and thus relatively more attractive for diverting longer, higher yield trips.

Table 4-2 also shows how HSR ridership varies by alignment and technology. In addition, the table shows ridership by eight groups of travelers, in this case, city pair markets in the corridor. The table shows that most of the difference in ridership between the two route options is accounted for by the longer distance northern California-southern California markets (e.g., Los Angeles-San Francisco), which have a more direct routing and therefore faster travel times under Option B. Table 4-3 presents the analogous information for passenger revenue, and indicates a similar pattern.

Tables 4-4 and 4-5 present the ridership and revenue results by *previous mode* for the two alignments and two technologies. The tables show that essentially all the difference between the two route options is in diverted air travel because these longer distance trips are better served by the faster Grapevine (B) alignment. This is consistent with the previous tables, which showed that most of the difference in ridership and revenue between the options is between the longer distance northern California-southern California markets between which most air travel in the corridor occurs.

Forecasts of Intercity Ridership and Revenue

Table 4- 2. 2020 Ridership Summary by Origin-Destination Market Segment

	VHS		Maglev	
O/D Market Segment	**Option A 50%**	**Option B 50%**	**Option A 50%**	**Option B 50%**
Los Angeles – San Francisco	10,149,127	11,269,050	14,125,204	14,981,816
Los Angeles/San Francisco – Valley	5,120,355	5,233,698	5,692,197	5,799,715
Valley – Valley	783,805	768,334	843,067	824,702
Sacramento – Los Angeles	3,084,488	3,384,964	4,082,289	4,267,865
Sacramento – San Francisco	1,690,169	1,690,169	2,020,286	2,020,286
San Diego – Los Angeles	5,426,904	5,304,220	5,877,854	5,737,451
San Diego – San Francisco	2,016,041	2,260,634	3,284,302	3,584,847
Other	2,015,444	2,091,034	2,504,924	2,597,982
Total	**30,286,332**	**32,002,103**	**38,430,125**	**39,814,665**

Source: Charles River Associates, 1999.

Table 4- 3. 2020 Revenue Summary by Origin-Destination Market Segment ($1999)

	VHS		Maglev	
O/D Market Segment	**Option A 50%**	**Option B 50%**	**Option A 50%**	**Option B 50%**
Los Angeles – San Francisco	320,519,503	347,881,522	453,962,454	469,025,604
Los Angeles/San Francisco – Valley	122,993,128	129,861,992	137,816,002	138,072,777
Valley – Valley	18,154,513	17,721,242	19,718,605	19,201,292
Sacramento – Los Angeles	97,314,215	104,217,668	130,260,591	132,455,748
Sacramento – San Francisco	40,782,380	40,782,380	49,718,703	49,718,703
San Diego – Los Angeles	127,670,556	124,658,232	139,383,626	135,891,950
San Diego – San Francisco	67,535,678	74,304,949	113,472,630	121,263,656
Other	53,370,020	48,749,572	69,037,786	70,901,146
Total	**848,339,992**	**888,177,557**	**1,113,370,396**	**1,136,530,877**

Source: Charles River Associates, 1999.

Table 4- 4. 2020 Ridership Summary by Source

	VHS		Maglev	
Source	**Option A 50%**	**Option B 50%**	**Option A 50%**	**Option B 50%**
Local air	12,844,010	14,373,650	18,471,602	19,693,469
Connect air	278,046	278,046	376,661	376,661
Amtrak rail	1,934,036	1,915,011	2,042,288	2,021,776
Auto	13,207,747	13,404,305	15,198,521	15,364,490
Induced	2,022,492	2,031,091	2,341,052	2,358,268
Total	**30,286,332**	**32,002,103**	**38,430,125**	**39,814,665**

Source: Charles River Associates, 1999.

Forecasts of Intercity Ridership and Revenue

Table 4- 5. 2020 Revenue Summary by Source ($1999)

	VHS		Maglev	
Source	**Option A 50%**	**Option B 50%**	**Option A 50%**	**Option B 50%**
Local air	423,926,544	463,894,072	620,911,793	645,859,285
Connect air	6,196,978	6,196,978	8,684,945	8,684,945
Amtrak rail	41,764,858	41,139,410	44,318,598	43,644,639
Auto	330,212,251	330,689,538	384,624,630	383,266,444
Induced	46,239,361	46,257,559	54,830,429	55,075,564
Total	**848,339,992**	**888,177,557**	**1,113,370,396**	**1,136,530,877**

Source: Charles River Associates, 1999.

DETAILED FORECASTS FOR THE BUSINESS PLAN FUNDING SCENARIO ALTERNATIVE

This section provides further detailed results for the VHS option providing the highest return on investment which was used for the funding scenario in the Authority's Draft Business Plan. This is the alignment crossing the Tehachapi mountains via the Grapevine (Option B). Table 4-6 shows that 14 percent of all corridor trips are projected to be diverted to HSR in 2020 for this scenario. Over half of all local air trips in the corridor (56 percent) are projected to be diverted to HSR, and over two-thirds of all conventional rail trips (71 percent). The diversion of private vehicle and connecting air trips is projected to be quite small, at 7 percent and 5 percent respectively.

Forecasts of Intercity Ridership and Revenue

Table 4- 6. Percent Diversion to HSR by Mode for 2020 (Funding Scenario)

Mode	Percent of Trips Diverted
Local Air	56%
Connect Air	5%
Rail	71%
Private Vehicle	7%
Total	14%

Source: Charles River Associates, 1999.

Table 4-7 shows how these percentages translate into total HSR ridership and revenue. While the percentage of air trips diverted is eight times as large as the percentage of auto trips diverted, diverted auto trips contribute almost as much to total HSR ridership because the *base* of auto trips is so much larger. Local air diversion is nevertheless the largest contributor to HSR ridership at 45 percent of the total, and contributes over half the total revenue (52 percent). Auto trips contribute 42 percent of the total ridership but only 37 percent of the total revenue. These results reflect the fact that airline passengers travel longer distances on average than auto travelers, have a greater tendency to be business travelers, value their time more highly as described in Chapter 2, and for all these reasons, pay higher fares than auto travelers.

While Table 4-6 shows that 71 percent of all conventional rail trips would be diverted, the total number of these trips is much lower than the number of air or auto trips, and as result diversion of this mode contributes less than 10 percent to total ridership and revenue. The diversion of connecting air trips is likewise insignificant, at less than 1 percent of the total. Induced HSR trips represent only about 6 percent of the total ridership and a slightly lower percentage of revenue. Because very high frequency, low fare service is already available in the major markets such Los Angeles-San Francisco, the introduction of HSR should not be expected to induce a large amount of additional travel overall.

Forecasts of Intercity Ridership and Revenue

Table 4- 7. Total Intercity Ridership and Passenger Revenue in 2020 by Source for Funding Scenario

Source	Ridership	Percent of Total	Revenue ($99)	Percent of Total
Local Air	14,373,650	44.9%	$ 463,894,072	52.2%
Connect Air	278,046	0.9%	6,196,978	0.7%
Rail	1,915,011	6.0%	41,139,410	4.6%
Private Vehicle	13,404,305	41.9%	330,689,538	37.2%
Subtotal	29,971,012	93.7%	841,919,998	94.8%
Induced	2,031,091	6.3%	46,257,559	5.2%
Total	32,002,103	100.0%	888,177,557	100.0%

Source: Charles River Associates, 1999.

Table 4-8 shows that, overall, about 38 percent of the projected HSR ridership would come from business travelers, while these travelers would contribute 52 percent of the revenue. This is consistent with the higher values of time observed for business travelers, as well as the higher HSR fares that would be paid by business travelers. The remainder of the passengers, accounting for about 62 percent of the ridership and 48 percent of the revenue, are estimated to be traveling for nonbusiness purposes.

Table 4- 8. 2020 Ridership and Revenue by Trip Purpose for Funding Scenario

Trip Purpose	Ridership	Revenue	Ridership	Revenue
Business	12,170,572	$464,822,473	38.0%	52.3%
Nonbusiness	19,831,511	$423,355,084	62.0%	47.7%
Total	32,002,103	$888,177,557	100.0%	100.0%

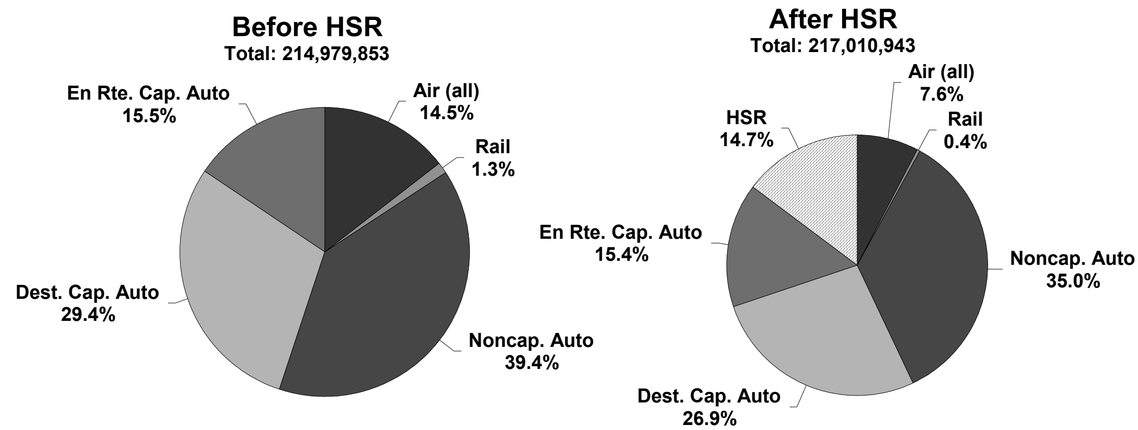
Source: Charles River Associates, 1999.

Figure 4-1 illustrates the effect of the introduction of HSR on the market shares of the respective modes within the Corridor. It shows that auto would remain far and away the dominant mode, but that HSR would capture nearly 15 percent of all trips (it would divert 14 percent as shown in Table 4-6, and would also induce some trips as shown in Table 4-7). The figure shows how HSR would capture market share disproportionately from the air mode.

Forecasts of Intercity Ridership and Revenue

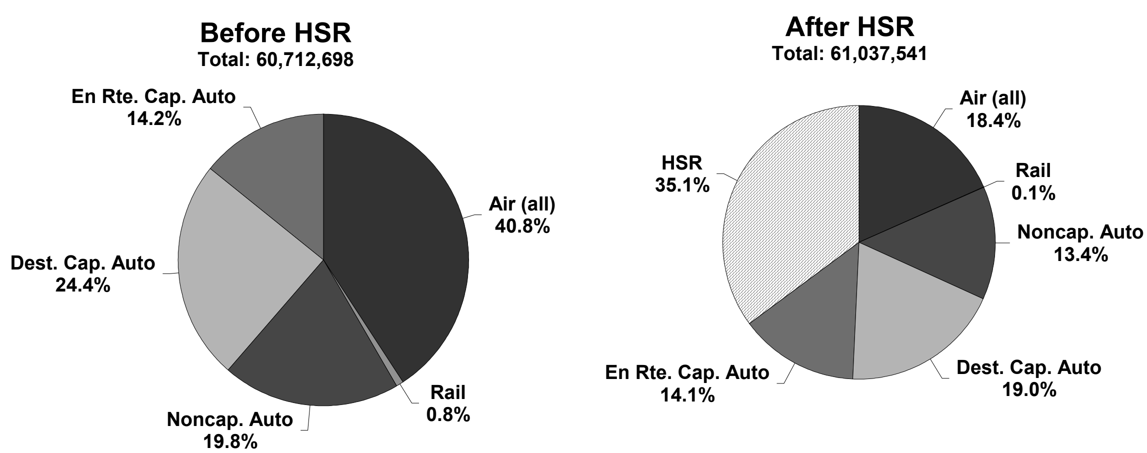
This result is shown even more clearly in Figure 4-2, which illustrates the market shares before and after the introduction of HSR for trips over 150 miles. HSR would capture 35 percent of all of these trips, reducing the market share of local air by more than half.

Figure 4- 1. 2020 Market Shares Before and After HSR for Funding Scenario



Source: Charles River Associates, 1999.

Figure 4- 2. 2020 Market Shares Before and After HSR for Funding Scenario (Trips > 150 miles)



Source: Charles River Associates, 1999. Figure 4-7. 2020 Market Shares by O/D Segment for Business Plan Scenario

Forecasts of Intercity Ridership and Revenue

The portion of intercity travel HSR will capture varies by geographic market (Figure 4-3). The private auto will continue to serve the majority of shorter distance trips, such as between the San Francisco and Sacramento regions. For the longest journeys, such as between Sacramento and San Diego, HSR will split most of the market with air. In regions without frequent low cost air service, such as between Fresno and San Francisco or Los Angeles, HSR will play a key intercity transportation role alongside the private auto. For the whole corridor, Figure 4-3 shows that HSR serves nearly 15 percent of all trips, repeating the result shown in Figure 4-1.

Figure 4- 3. 2020 Market Shares by O/D Segment for Funding Scenario

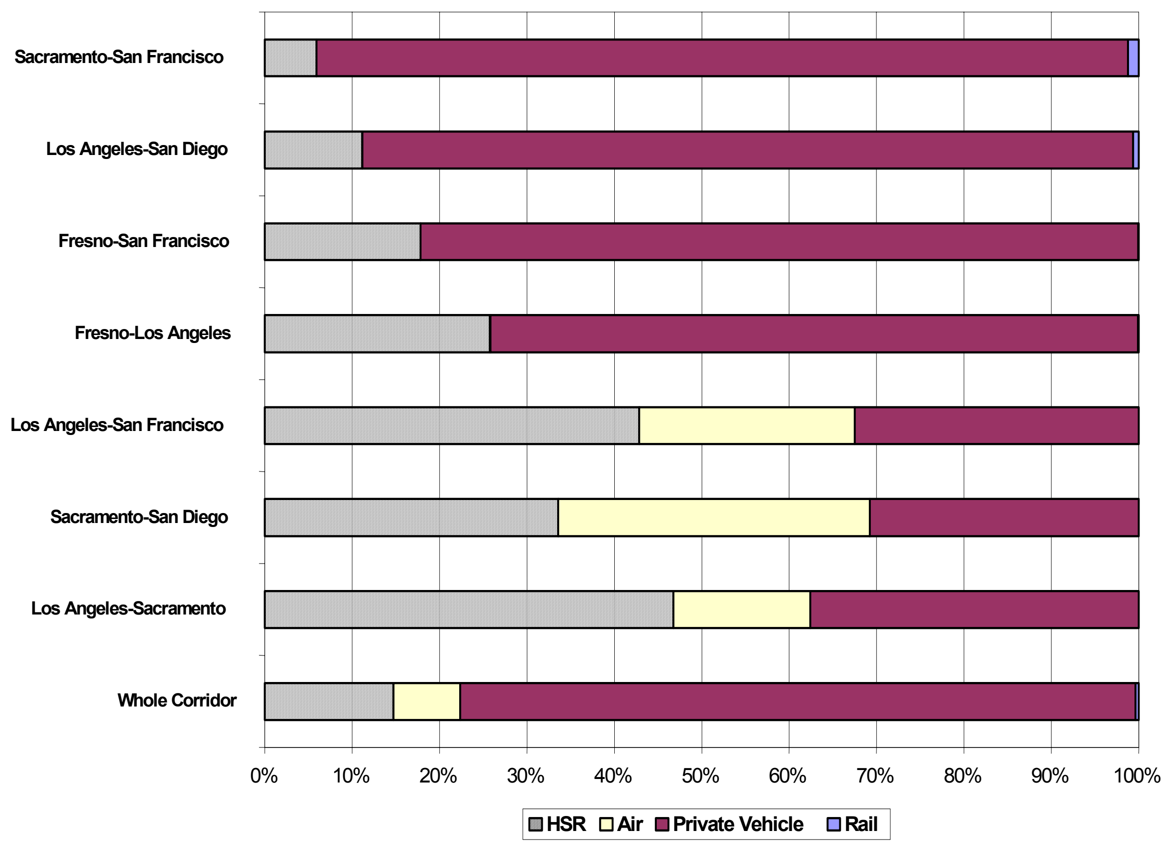


Table 4-9 summarizes the system ridership and revenue by O/D geographic market. These markets include trips between the Los Angeles and San Francisco metropolitan regions (e.g., San Jose to Santa Clarita), trips made between either

Forecasts of Intercity Ridership and Revenue

Los Angeles or San Francisco and the Central Valley (e.g., Los Angeles to Bakersfield), trips between other major metropolitan regions (e.g., Sacramento to Los Angeles) and other trips (e.g., Sacramento to San Diego). Trips between the San Francisco and Los Angeles regions contribute the largest portion of system ridership (35 percent) and revenue (39 percent). The next largest contributions to ridership and revenue are forecast to come from trips between the Los Angeles or San Francisco regions and the Central Valley (16 percent of ridership) and between the San Diego and Los Angeles regions (17 percent of ridership).

Table 4- 9. 2020 HSR Ridership and Revenue by O/D Market Segment for Funding Scenario

O/D Market Segment	Ridership	Revenue	% Ridership	% Revenue
Los Angeles – San Francisco	$11,269,050	347,881,522	35	39
Los Angeles/San Francisco – Valley	5,233,698	129,861,992	16	15
Valley – Valley	768,334	17,721,242	2	2
Sacramento – Los Angeles	3,384,964	104,217,668	11	12
Sacramento – San Francisco	1,690,169	40,782,380	5	5
San Diego – Los Angeles	5,304,220	124,658,232	17	14
San Diego – San Francisco	2,260,634	74,304,949	7	8
Other	2,091,034	48,749,572	7	5
Total	32,002,103	888,177,557	100	100

Source: Charles River Associates, 1999.

Table 4-10 presents the projected boardings for each HSR station for the funding scenario. The table shows that the major central city stations of Los Angeles Union Station, downtown San Francisco, Sacramento, and Qualcomm Stadium (San Diego) have the highest boardings, together accounting for 46 percent of the total. Other stations within the major metro areas also have very high levels of activity, including San Jose in the Bay Area and the East San Gabriel Valley station in the Los Angeles region, which each have roughly two and a half million annual boardings.

Forecasts of Intercity Ridership and Revenue

Table 4- 10. 2020 Boardings by Station for Funding Scenario

Station Name	Annual Local Boardings	Annual Connect Boardings	Total Annual Boardings	Average Daily Boardings
Sacramento	3,541,745	59,499	3,601,244	9,866
Stockton	543,279	0	543,279	1,488
San Francisco	3,916,509	0	3,916,509	10,730
San Francisco Airport	503,227	139,023	642,250	1,760
Redwood City	1,146,138	0	1,146,138	3,140
San Jose	2,497,768	0	2,497,768	6,843
Gilroy	753,515	0	753,515	2,064
Los Banos	77,206	0	77,206	212
Modesto	651,612	0	651,612	1,785
Merced	205,343	0	205,343	563
Fresno	1,211,659	31,525	1,243,184	3,406
Tulare/Kings County	69,018	0	69,018	189
Bakersfield	956,652	8,779	965,430	2,645
Santa Clarita	1,138,067	0	1,138,067	3,118
Burbank Airport	1,482,777	0	1,482,777	4,062
Los Angeles Union Station	4,475,095	23,121	4,498,216	12,324
East San Gabriel Valley	2,422,135	0	2,422,135	6,636
Ontario Airport	512,355	0	512,355	1,404
Riverside	958,502	0	958,502	2,626
Temecula	581,878	0	581,878	1,594
Escondido	915,993	0	915,993	2,510
Mira Mesa	457,997	0	457,997	1,255
Qualcomm Stadium	2,705,586	16,099	2,721,685	7,457
Total	31,724,056	278,046	32,002,103	87,677

Source: Charles River Associates, 1999.

Table 4-10 also breaks out boardings by connecting air passengers from all other (i.e., local) boardings. As can be seen, San Francisco Airport (SFO) is the only hub airport with a HSR station. As such, it has exactly half the connect boardings. (Symmetry is assumed — trips *to*/connecting to a plane at SFO equal trips *from*, or connecting to HSR at SFO.) The table shows the distribution of places to/from which connecting air passengers use HSR as their connecting mode. Volume of connecting air trips, distance from SFO, and frequency of air service are all determinants of HSR volumes serving the connect air travel market.

SENSITIVITY ANALYSES

Two types of sensitivity analyses were carried out for the funding scenario to supplement the results described above. In the first analysis, the assumption about the fares that would be charged for HSR service was varied to test the implications for ridership and revenue. We also tested the effects of changes in the assumptions about the competing modes, including both the level of travel that these modes would produce in the future as well as their future level of service characteristics. Each of these analyses are described in the following sections.

HSR Fare Assumption

The HSR fare structure used to produce the above forecasts was selected because it increased ridership (e.g., user benefits) while not losing significant passenger revenue. Under the selected fare structure, HSR fares are set to equal 50 percent of the current average airfare for travel between San Francisco and Los Angeles (Table 3-4). This results in HSR fares that are much less, proportionately, than the comparable airfares in most other markets (e.g., Fresno-San Francisco). Table 4-11 provides a sample of these HSR fares assumed for intercity travel. These were calculated as the sum of a $20 boarding charge plus an additional fare per mile.

The survey market research conducted for this study showed that business air travelers paid fares about 27 percent greater than the average fare paid by all travelers, while nonbusiness travelers paid fares that averaged 71 percent of the overall average fare. The HSR fares were therefore adjusted accordingly, resulting in the different HSR fares for business and nonbusiness passengers shown in Table 4-11.

Forecasts of Intercity Ridership and Revenue

Table 4- 11. Sample HSR Fares Assumed for the Funding Scenario ($1999)

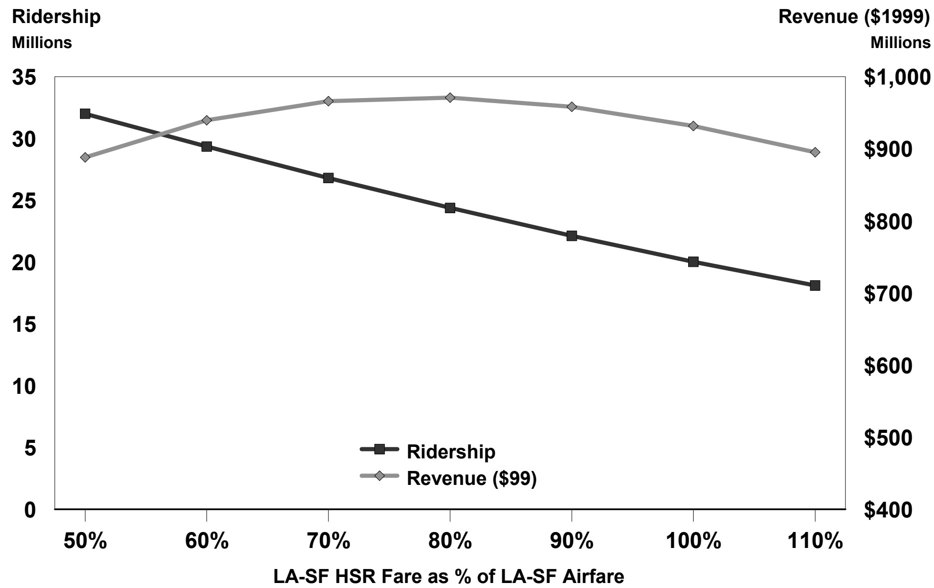
City Pair	Average One Way Business Fare	Average One Way Nonbusiness Fare
Downtown Los Angeles – Downtown San Francisco	$42	$24
Merced – Downtown San Francisco	$33	$18
Fresno – Downtown Los Angeles	$35	$20
Downtown Los Angeles – San Diego	$32	$18
Bakersfield – Sacramento	$37	$21
Burbank – San Jose	$40	$22
Sacramento – San Jose	$35	$20

Source: Charles River Associates, 1999.

A number of alternative HSR fare structures were tested to evaluate the sensitivity of ridership and revenue to higher or lower fares. Alternative fare structures were characterized by the percent that the HSR fare is of the comparable average air fare between Los Angeles and San Francisco. Figure 4-4 shows that the revenue maximizing fare for HSR (Option B) is between 70 to 80 percent of the Los Angeles to San Francisco airfare. Table 4-12 provides the forecast numbers that are plotted in Figure 4-4.

Forecasts of Intercity Ridership and Revenue

Figure 4- 4. Sensitivity of 2020 Ridership and Revenue to HSR Fare Assumption (Funding Scenario)



Source: Charles River Associates, 1999.

With fares above 80 percent of the LA-SF air fare, HSR revenues slowly begin to decline, while HSR ridership declines at a much greater rate. For example, a fare policy based upon 110 percent of the LA-SF air fare, produces only about 18 million annual intercity riders, while the revenue from passengers remains relatively constant at nearly $900 million a year. With fares below 70 to 80 percent of the LA-SF air fare, HSR revenues also slowly decline. However, HSR ridership *increases* at a much greater rate. Thus at rail fares below 70 to 80 percent of the LA-SF air fare there is a tradeoff between system ridership and system revenue. That is, a lower fare produces more ridership but less revenue. Under the selected 50 percent fare structure, ridership (related to system benefits — see Chapter 6) increases by 31 percent over the 80 percent revenue maximizing fare structure, while revenue only decreases by less than 9 percent ($971 million vs. $888 million).

Table 4- 12. Sensitivity of 2020 HSR Ridership and Revenue to HSR Fare Assumption (Funding Scenario)

LA-SF HSR Fare as % of LA-SF Air Fare	Annual Ridership	Annual Revenue ($99)
50%	32,002,000	888,178,000
60%	29,349,000	939,429,000
70%	26,804,000	965,937,000
80%	24,389,000	970,917,000
90%	22,125,000	958,111,000
100%	20,029,000	931,517,000
110%	18,111,000	895,070,000

Source: Charles River Associates, 1999.

Assumptions about Competing Modes

CRA was requested to carry out six other sensitivity analyses, all dealing with possible variations in the characteristics of the competing modes which would tend to increase HSR ridership and revenue. They are as follows:

1. *Higher growth rates for air and auto travel*. Average growth rates of 3.5 percent and 2.0 percent per year for air and auto, respectively, were compared to the average annual rates of 2.5 percent and 1.3 percent reflected in the base forecasts.

2. *Longer air travel times*. Fifteen minutes was added on each end to all air travel times between zones assigned to LAX, SFO and San Diego Airport. (Thus a half hour would be added to an LAX to SFO trip while an LAX to Oakland trip would increase by 15 minutes).

3. *Longer auto travel times*. A half hour was added to all trips to, from or through the Los Angeles and San Francisco Bay Area regions. Thus for a Los Angeles to San Francisco trip one hour would be added, a San Diego-

Sacramento trip would be a half hour longer, as would travel times for all other trips with one trip end in either Los Angeles or the Bay Area.

4. *Increased air fares*. Increases of 50 percent, 100 percent, and 150 percent were tested.

5. *Two combinations of the above*. The increased air and auto travel time cases (2 and 3, above) were combined with both the 50 percent and 150 percent air fare increases.

6. *Two additional combinations of the above.* A combination of all of the first four cases, combining the increased air and auto growth rates and travel times with both the 50 percent and 150 percent air fare increases.

Each of the sensitivity analyses was carried out for the funding scenario, assuming all other input data would remain the same, including the HSR fares. Table 4-13 compares the results for 2020 with the base case Business Plan scenario.

Forecasts of Intercity Ridership and Revenue

Table 4- 13. Summary of Sensitivity Analyses for 2020

Case	Ridership	Revenue	Ridership	Revenue
Base forecast	32,002,103	$888,177,557	N/A	N/A
1. Annual air/auto growth at 3.5%/2.0%	40,170,487	$1,127,131,550	+25.5%	+26.9%
2. Air travel time +15 min SAN, SFO, LAX	32,912,408	$919,547,591	+2.8%	+3.5%
3. Auto travel time +30 min LA, Bay Area	35,062,941	$970,049,577	+9.6%	+9.2%
4. a.) Air fares +50%	37,681,945	$1,086,744,114	+17.7%	+22.4%
b.) Air fares +100%	41,184,703	$1,209,990,416	+28.7%	+36.2%
c.) Air fares +150%	42,673,742	$1,261,102,070	+33.3%	+42.0%
5. a.) Combination of 2, 3, and 4 a.)	41,512,343	$1,195,878,030	+29.7%	+34.6%
b.) Combination of 2, 3, and 4 c.)	45,891,691	$1,348,162,523	+43.4%	+51.8%
6. a.) Combination of 1, 2, 3, and 4 a.)	52,537,431	$1,529,405,709	+64.2%	+72.2%
b.) Combination of 1, 2, 3, and 4 c.)	58,397,253	$1,733,006,817	+82.5%	+95.1%

Source: Charles River Associates, 1999.

As can be seen from Table 4-13, the most important impacts on HSR ridership and revenue result from increased annual growth rates for total air and auto travel, and from increased air fares. The higher air fares result in ridership forecasts of between 18 and 34 percent over the base case. Additional increases would result if increased air fares were combined with increased air and auto growth rates and travel times. By comparison, increased air or auto travel times alone would have a modest impact on HSR ridership.

The sensitivity of revenue follows a similar pattern. The maximum impact results from sensitivity analysis 6.b which nearly doubles HSR revenues. Revenue grows faster than ridership when air travel growth or air fares are increased due to the longer, higher yield trips which are affected. When only auto travel is affected, as in case 3, ridership grows faster than revenue since the auto trips are shorter than the average trip length, which includes (diverted) air trips.

5
Preliminary Forecasts of Intercity Ridership and Revenue

INTRODUCTION

This chapter presents preliminary year 2020 ridership and revenue forecasts on express commuter services that could be provided on high speed rail/maglev alignments to San Diego, Los Angeles, and Bay Area (San Francisco, San Jose, and Oakland) urban centers. Urban and interregional commuters are additional travel markets that could benefit from the long-distance intercity HSR/maglev system. Ridership and revenue from these commuters is in addition to the *intercity* ridership and revenue for the statewide HSR system presented so far in this report. The new commuter information presented here is important for its own sake, and because it illustrates the relative magnitude of commuter and intercity ridership and revenue that would result from an HSR system in California.

We first describe the methodology used for the forecasts, and specifically the important role of the local planning agencies in producing them, then provide a detailed discussion of the forecast results for each of the three metropolitan areas.

METHODOLOGY

Express commuter travel consists of two components: *intraregional* and *interregional* tripmaking. Intraregional travel consists of trips made entirely within a region. Strictly speaking, intraregional travel is not only commuter (i.e., work purpose) travel, but all daily travel within a region which might use the express "commuter" services on the HSR alignments. Interregional travel consists of regular (i.e., daily or near daily) travel made between regions. It is a safe assumption that essentially all of these daily interregional trips that would use the express commuter services between adjacent regions are journey to work trips. These daily commutation trips were specifically excluded from the trip tables and

Forecasts of Intercity Ridership and Revenue

subsequent analyses of intercity tripmaking that form the basis for our *intercity* travel forecasts on the HSR/maglev system.[29]

The three regional planning agencies listed below (in some cases with the assistance of their consultants) made the forecasts of intraregional commuter travel. Charles River Associates provided oversight and coordination of these forecasts, as well as the forecasts of interregional commuter trips.

- The Metropolitan Transportation Commission (MTC) for the nine-county San Francisco Bay Area region,
- The Orange County Transportation Authority (OCTA) and its consultants for the Los Angeles metropolitan area, and
- The San Diego Association of Governments (SANDAG) and its consultants for San Diego County.

In making these projections of ridership and revenue for the express commuter market, a primary objective was to capitalize as much as possible on the modeling systems and future year networks that are regularly used by the Metropolitan Planning Organizations (MPOs) representing each area. In the case of OCTA[30] and SANDAG, the forecasts of intraregional tripmaking was carried out by consultants to these agencies with the cooperation and models used by the agencies. Although these are *not investment quality forecasts*, the intraregional portion of these forecasts, which represent the bulk of potential *commuter* ridership on the HSR system, have the advantage of being produced by the responsible public agency in the San Francisco Bay area and utilizing the existing regional models in the two other metropolitan areas. The High Speed Rail Authority and its consultants are grateful for the cooperation and assistance of the three agencies in making these forecasts.

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[29] Charles River Associates, "Ridership and Revenue Analysis for High Speed Ground Transportation in California -- Task 1 Report: Initial Update of Forecasting Database", prepared for the California High-Speed Rail Authority, December 1998.

[30] SCAG (Southern California Association of Governments) is the MPO for the Los Angeles region. However, OCTA maintains models for the Los Angeles region that are based on the SCAG models.

Forecasts of Intercity Ridership and Revenue

To a large extent, the difference between intra- and interregional commuter travel is an accident of history. Regions were defined and regional planning agencies were established in the U.S. in the 1950s-1970s using, in large part the criterion that they be self contained in terms of daily commuting travel. While they still succeed in large part in fulfilling this criterion (as indicated above, they capture the "bulk" of this type of travel), the three large metropolitan areas vary in the extent to which they encompass the very long-distance commuter trips that are a growing trend in certain corridors in California, given the disparity in housing costs and other life style changes.[31]

Consequently, to make the commuter forecasts as complete and comparable as possible among the three regions, CRA undertook an analysis of "journey-to-work" (JTW) data from the 1990 US Census in order to obtain evidence on the extent of this out of region commuter travel.[32] CRA's analysis of interregional commuter tripmaking was combined with the intraregional forecasts to produce the express commuter ridership and revenue forecasts presented herein.

INPUT ASSUMPTIONS

A basic assumption in undertaking this work is that express commuter services would be provided by HSR trains that travel as fast as the intercity service, with stops at all the HSR stations within and near each metropolitan area. The alignments of the alternatives for which commuter forecasts are presented in this report were described in Chapter 1. A common set of assumptions concerning frequency, fares, and dwell times was used as much as possible for all the alternatives. As with the intercity system, both high speed rail (HSR) and magnetic levitation (maglev) systems were evaluated.

[31] An analysis of these trends between 1970 and 1990 for the San Francisco Bay Area is contained in the report, Metropolitan Transportation Commission, "Detailed Interregional Commute Characteristics", May 1994.
[32] Although frequently referred to as trips, JTW data really report on where people live and where they work (primary job only). It is necessary to make adjustments for trips taken on a typical day, and to understand that the mode given is for the longest segment of the trip in question.

Forecasts of Intercity Ridership and Revenue

At each station, 2 or 4 trains per hour service would be provided for the three-hour A.M. and P.M. peak periods. In the off-peak, trains would operate hourly. A two-minute dwell time was assumed at each intermediate station. Fares were calculated based on a $5.00 boarding charge plus 6.2 cents per mile traveled. These fares are higher than most commuter rail services operating now in California, reflecting the higher quality of service to be provided on these "express commuter" systems. However, fares would be approximately equal to the current $10.00 one-way fare charged on the Altamont Commuter Express (ACE) for the 86-mile trip between Stockton and San Jose.

HSR Commuter Fares

Fares for the express commuter system were calculated on the basis of 6.2 cents per mile with a $5.00 boarding charge. Tables 5-1 through 5-3 show the assumed station to station fares computed with this formula for the alignments in San Diego, Los Angeles, and the San Francisco Bay Area, respectively.

Table 5- 1. Assumed Fares For the San Diego Express Commuter Service ($1999)

Qualcomm Stadium Alignment				
Station	**Temecula**	**Escondido**	**Mira Mesa**	**Qualcomm**
Temecula	$0.00	$6.77	$7.81	$8.42
Escondido		$0.00	$6.04	$6.67
Mira Mesa			$0.00	$5.63
Qualcomm				$0.00

Source: Charles River Associates, 1999.

Forecasts of Intercity Ridership and Revenue

Table 5- 2. Assumed Fares for the Los Angeles Express Commuter Services

Riverside County Alignment

Station	Temecula	Riverside	Ontario	E. San Gabriel	Los Angeles
Temecula	$0.00	$7.25	$8.25	$9.22	$10.75
Riverside		$0.00	$6.00	$6.96	$8.50
Ontario			$0.00	$5.98	$7.50
E. San Gabriel				$0.00	$6.58
Los Angeles					$0.00

Los Angeles County Alignments

Station	Palmdale	Santa Clarita	Burbank	Los Angles
Palmdale	$0.00	$7.25	$8.25	$9.00
Santa Clarita		$0.00	$6.00	$6.75
Burbank			$0.00	$5.75
Los Angeles				$0.00

Source: Charles River Associates, 1999.

Table 5- 3. Assumed Fares for the San Francisco Bay Area Express Commuter Service

Pacheco Pass Alignment

Station	Los Banos	Gilroy	San Jose	Redwood City	Millbrae	San Francisco
Los Banos	$0.00	$7.00	$9.25	$10.50	$11.75	$12.25
Gilroy		$0.00	$6.85	$8.19	$8.91	$10.00
San Jose			$0.00	$6.33	$7.06	$8.00
Redwood City				$0.00	$5.73	$6.75
Millbrae					$0.00	$5.50
San Francisco						$0.00

Source: Charles River Associates, 1999.

Forecasts of Intercity Ridership and Revenue

HSR Travel Times

As noted earlier, it was assumed that the express commuter services would be provided by HSR trains that travel as fast as those used for the intercity services. Tables 5-4 through 5-6 show the distances and travel times that were assumed in making the projections of commuter ridership and revenue for each of the three respective regions. These travel times were produced by Parsons Brinckerhoff and reflect both acceleration and deceleration travel times. They do not include the assumed 2 minute dwell time at each intermediate station.

Table 5- 4. Assumed Travel Times for the San Diego Express Commuter Service

Qualcomm Stadium Alignment			
Station Pair	**Distance (miles)**	**VHS Time (minutes)**	**Maglev Time (minutes)**
Temecula-Escondido	28.5	13	10
Escondido-Mira Mesa	16.8	10	9
Mira Mesa-Qualcomm	10.1	7	5

Source: Parsons Brinckerhoff, 1999

Table 5- 5. Assumed Travel Times for the Los Angeles Express Commuter Services

Riverside County Alignment			
Station Pair	**Distance (miles)**	**VHS Time (minutes)**	**Maglev Time (minutes)**
Temecula-Riverside	35.3	14	12
Riverside- Ontario	16.2	13	8
Ontario-E. San Gabriel	18.8	15	8
E. San Gabriel-Union Station	20.8	16	12
Los Angeles County Alignments			
Station Pair	**Distance (miles)**	**VHS Time (minutes)**	**Maglev Time (minutes)**
Palmdale-Santa Clarita	36.8	16	12
Santa Clarita-Burbank	16.0	11	8
Burbank-Union Station	11.1	9	7

Source: Parsons Brinckerhoff, 1999

Table 5- 6. Travel Times for San Francisco Bay Area Express Commuter Service

Pacheco Pass Alignment			
Station Pair	**Distance (miles)**	**VHS Time (minutes)**	**Maglev Time (minutes)**
Los Banos-Gilroy	34.1	14	11
Gilroy-San Jose	34.8	15	11
San Jose-Redwood City	20.8	16	12
Redwood City-SFO Airport	18.7	15	11
San Francisco Airport-Downtown	8.7	8	6

Source: Parsons Brinckerhoff, 1999

FORECAST RESULTS

Summary Comparison

Table 5-7 provides a summary of the results. The table shows projected 2020 ridership and revenue for each alternative, for each technology and frequency assumption, and includes both daily and annual ridership figures. The table shows that projected commuter ridership and revenue for San Diego is quite small compared to that of the other two regions. Daily ridership is between 500 and 1,000 per day or 140,000-250,000 per year, depending on the frequency of service and technology. Annual revenue ranges between $1.0 and $1.7 million. For Los Angeles, the ridership and revenue potential on HSR alignments is much larger, reaching 15-20,000 riders per day and $35 million or more revenue on some alignments. The Bay Area forecasts fall between these two, but are relatively large. Daily ridership reaches 10-15,000 per day and $30 million revenue for the four train per hour service.

Forecasts of Intercity Ridership and Revenue

Table 5- 7. Summary of Year 2020 Preliminary Ridership and Revenue Forecasts for Express Commuter Alternatives

Location	Alignment	Tech-nology	Frequency (Peak Hour)	2020 Ridership Daily	2020 Ridership Annual (000s)	Annual 2020 Revenue (000) ($1999)
San Diego	Stadium	VHS	2	550	138	$938
		Maglev	2	650	162	$1,108
		VHS	4	880	220	$1,495
		Maglev	4	994	249	$1,689
Los Angeles*	Riverside County	VHS	4	14,200	3,545	$28,042
		Maglev	4	17,000	4,262	$33,571
	Los Angeles County**	VHS	4	17,100	4,275	$32,131
		Maglev	4	19,850	4,961	$37,298
San Francisco	Pacheco Pass	VHS	2	5,170	1,422	$9,700
		Maglev	2	7,300	2,008	$14,440
		VHS	4	11,900	3,272	$22,728
		Maglev	4	14,600	4,015	$30,777

*Two trains per peak hour were not tested for Los Angeles.
**Forecasts shown are for the service extending to Palmdale (Option A)

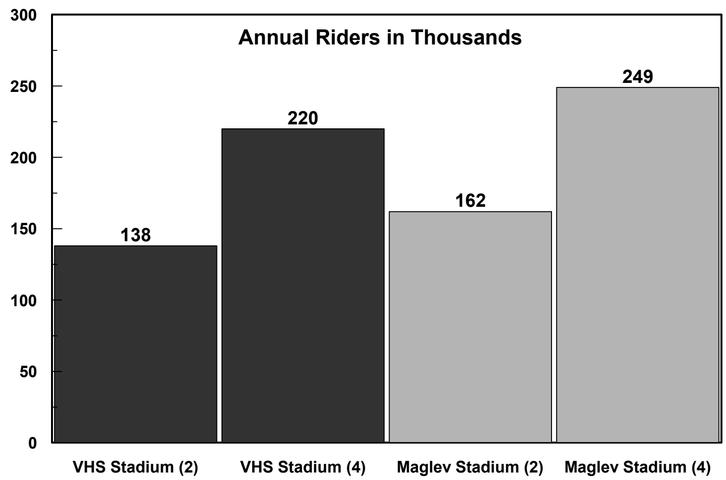
Source: Charles River Associates, 1999.

These results reflect the relative sizes of these regions, and importantly the relative sizes and densities of their major downtown areas. Commuter rail ridership is normally very downtown oriented and sensitive to the ease and cost of automobile parking as well as to highway congestion in the region. Nevertheless, commuter ridership, and especially the revenue potential on the HSR alignments is very small compared to the statewide intercity totals presented in Chapter 4. The maximum commuter revenue on any one line is less than five percent of the intercity revenue for the Businss Plan scenario shown in Table 4-1. That is, even though commuter ridership on some of these alignments is relatively high, these trips are short compared to the intercity trips, and the yield (revenue per rider) on commuter trips is much lower than for intercity trips (e.g., $6 or $7 versus $30-$40).

Detailed Forecasts for San Diego

Figure 5-1 graphs the ridership results in Table 5-7 and shows that annual ridership on the San Diego alternatives ranges from about 140,000 riders on the VHS Stadium alternative with two trains per peak hour, to about 250,000 riders on the maglev alternative with four trains per peak hour. As noted earlier, this ridership is small both relative to the other regions and relative to statewide intercity ridership. Also, fare revenue from commuters in San Diego is small, with a maximum revenue of $1.7 million per year for any of the alternatives. Interregional commuting from Riverside, Orange, and Los Angeles Counties to San Diego County represents about 10 percent of the riders shown, but up to 15 percent of the revenues, as interregional commuters make longer trips.

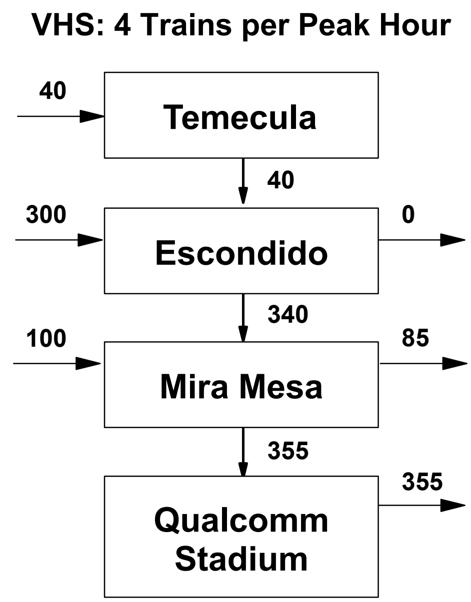
Figure 5- 1. San Diego Annual 2020 Ridership Forecasts (000)



While San Diego ridership is small, it is very interesting to note the impact of additional frequency versus additional speed on ridership for these relatively short distance commuter trips on trains which must stop at stations which are only 10 to 20+ miles apart. On these alignments, increasing the peak period frequency from 2 to 4 trains per hour increases ridership by about half (or 50 percent). Conversely, increasing the speed by using maglev only increases ridership by about 15 percent. Clearly, for these shorter distance commuter trips, increasing frequency is more important than increasing speed for the alternative alignments tested here.

Looking more closely at ridership, most riders on these commuter services would be traveling in the "in-bound" direction during the AM peak period with a virtual mirror image during the PM peak periods. Figure 5-2 shows the number of individuals on the stadium alignment who would board and alight at each station for the VHS 4 trains per peak hour alternative. Note that there is relatively little intermediate riding (i.e., most riders alight at the station that serves downtown oriented trips).

Figure 5- 2. Average Daily One-way Flows for the San Diego Stadium Alignment



Finally, based on the fares paid by riders between their boarding and alighting stations, the annual revenue associated with individuals whose home end is served by each station on the VHS 4 trains per peak hour alternative is given in Table 5-8. The largest amount of passenger revenue, $1.0 million, is associated with the Escondido station.

Forecasts of Intercity Ridership and Revenue

Table 5- 8. 2020 Revenue by Station for the San Diego Stadium Alignment

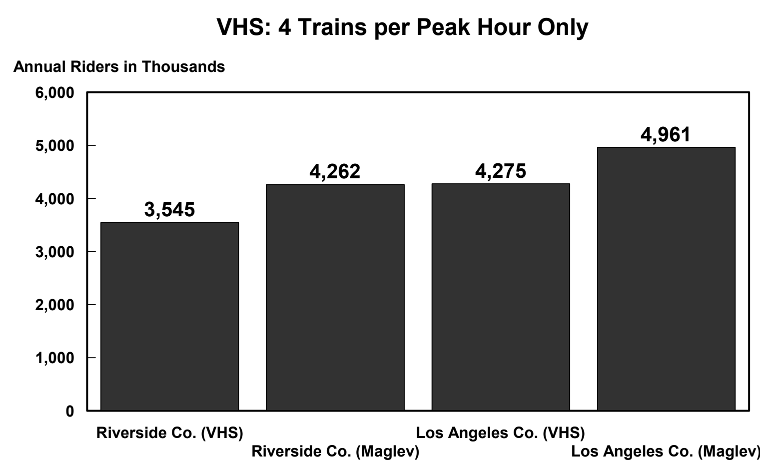
VHS: 4 trains per peak hours		
Alignment	**Station**	**Annual Revenue ($1999)**
Stadium	Temecula	$175,000
	Escondido	$1,039,000
	Mira Mesa	$281,000
	Qualcomm Stadium	0
	Total	$1,495,000

Source: Charles River Associates, 1999

Detailed Forecasts for Los Angeles

Figure 5-3 graphs the ridership results presented in Table 5-7 and shows that annual ridership on the Los Angeles region alternatives for the four trains per peak hour case ranges from a low of about 3.5 million riders on the Riverside County Line with VHS, to a high of about 5 million riders on maglev on the Los Angeles County Line (Palmdale to Union Station). Total annual passenger revenue on both lines together is about $60 million for VHS and about $70 million for maglev. These results suggest that there is considerable potential for commuter ridership and revenue in the Los Angeles region, but the results are still small relative to intercity ridership and revenue.

Figure 5- 3. 2020 Ridership for Los Angeles Alternatives (000)



Forecasts of Intercity Ridership and Revenue

Interregional commuting from San Diego County represents about 10 percent of ridership on the Riverside County Line. Commuting from Kern County represents about 5 percent of ridership on the Los Angeles County Line. The revenue impact of interregional ridership is greater given the fares for these longer distance trips: about 14 percent for the Riverside County Line, and 8 percent for the Los Angeles County Line.

Since commuter ridership forecasts for the Los Angeles region were only made for the four trains per peak hour case, we cannot measure the sensitivity of these forecasts to change in frequency. However, it is very interesting to note that increasing the speed of the trains by using maglev rather than VHS technology increases the ridership by about 20 percent. This is slightly greater than the 15 percent impact of the speed increase for San Diego, but is entirely consistent with the San Diego result, given the larger market and relatively increased competitiveness of commuter rail in Los Angeles, relative to San Diego.

Looking more closely at ridership on each line, Figures 5-4 and 5-5 show the number of individuals boarding and alighting at each station in the “in-bound” direction for the VHS 4 train per peak hour alternatives in Los Angeles.

Forecasts of Intercity Ridership and Revenue

Figure 5- 4. Daily Inbound Flows for Los Angeles Region Riverside County Service

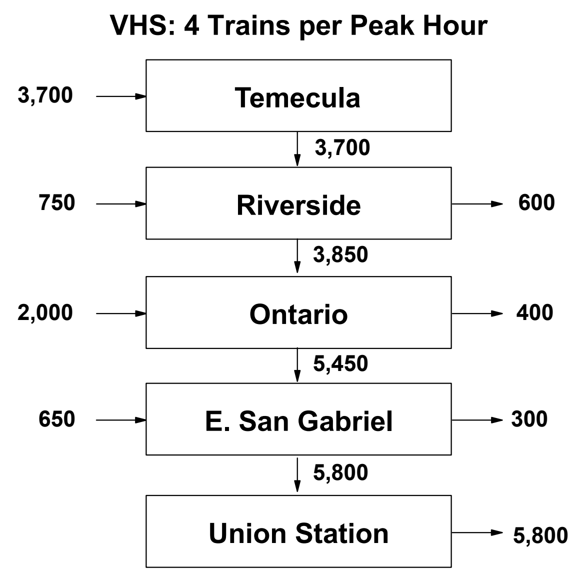
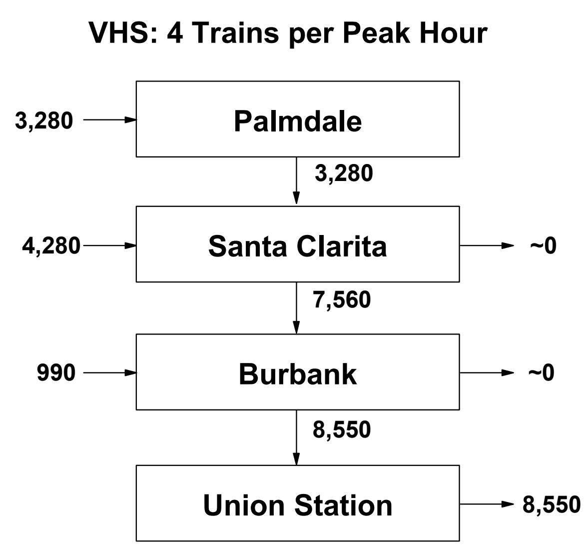


Figure 5- 5. Daily Inbound Flows for Los Angeles Region Los Angeles County Service to Palmdale (Option A)



Forecasts of Intercity Ridership and Revenue

On the Riverside County Line (Figure 5-4), over half the riders would board at the Temecula station (which is not served by Metrolink), with the rest using the Riverside, Ontario and East San Gabriel Valley stations. Note that this line has a fair amount of intermediate riding with inbound riders alighting at intermediate stations as well as at Union Station in downtown Los Angeles. The Los Angeles County Line is very downtown oriented with essentially no intermediate ridership (Figure 5-5). Santa Clarita is the most heavily used boarding station followed closely by Palmdale. If the line did not go to Palmdale, as in Option B, Palmdale boarders would still be served by the Antelope Valley Metrolink line.

Table 5-9 shows the annual revenue from riders whose home end is served by each station on the two Los Angeles Lines for the VHS 4 trains per peak hour alternatives. The largest revenues, at $14-15 million per year, are associated with the Temecula, Palmdale, and Santa Clarita stations. Total revenue for the two lines is about $60 million per year in 2020 (Option A). Without the Palmdale station, total revenue would be about $45 million (Option B).

Table 5- 9. Los Angeles Area: Year 2020 Annual Revenue by Line and Station

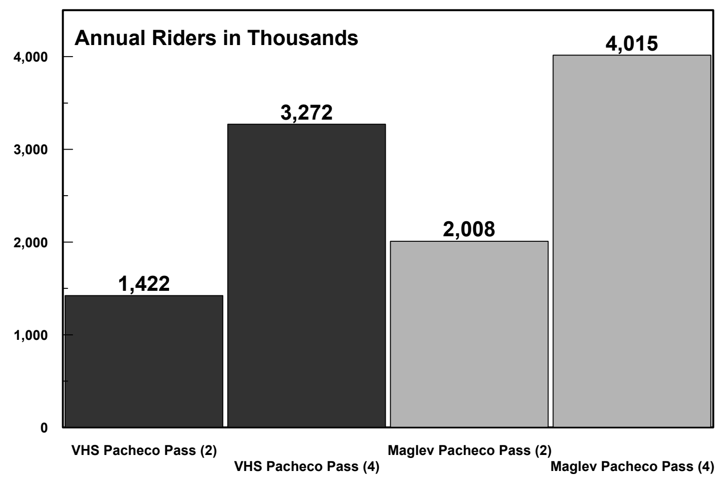
VHS: 4 trains per peak hours		
Line	**Station**	**Annual Revenue ($1999)**
Riverside County	Temecula	14,510,000
	Riverside	3,506,000
	Ontario	7,882,,000
	E.San Gabriel	2,128,000
	Union Station	16,000
	Subtotal	**$28,042,000**
Los Angeles	Palmdale	14,850,000
	Santa Clarita	14,438,000
	Burbank	2,843,000
	Union Station	0
	Subtotal	**$32,131,000**
	Total Revenue for the two lines	$60,173,000

Source: Charles River Associates, 1999

Detailed Forecasts for the San Francisco Bay Area

Figure 5-6 graphs the ridership results in Table 5-7 and shows that annual ridership on the Pacheco Pass alternatives ranges from about 1.4 million on the 2 train per peak hour VHS alternative to 4 million riders on the 4 trains per peak hour maglev alternative. Annual revenue on these Pacheco Pass alternatives ranges from $9.7 million to $30.8 million. Commuting from outside the MTC region on the Pacheco Pass alternatives using the Los Banos station is quite small, accounting for only about 2 percent of total ridership and a little over 2 percent of revenue.

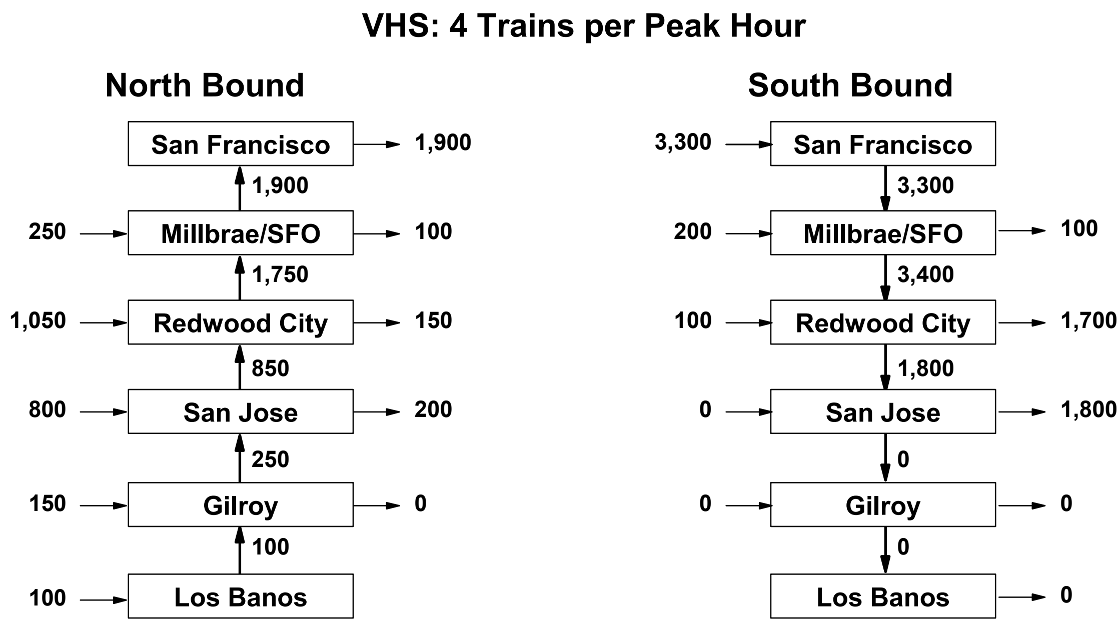
Figure 5- 6. Bay Area: Annual 2020 Ridership on Alternative Alignments (000)



It is very interesting to note once again the different impacts of increasing frequency versus increasing speed. Figure 5-6 shows that doubling the frequency doubles the ridership. Increasing the speed using maglev instead of VHS technology increases ridership by a quarter to nearly a half, depending on the service frequency. The increase is less for already good service (i.e., four trains per hour). These impacts in the Bay Area are larger than for the Los Angeles and San Diego regions which is again consistent with the fact that these commuter lines (and transit in general) are more competitive with auto in the Bay Area than in the other two regions.

The number of individuals boarding and alighting at each station on the Pacheo Pass Line is shown in Figure 5-7. Note that ridership is shown in *both* the north bound (i.e., what would typically be thought of as the "in bound") and south bound directions. This shows the large amount of "reverse commuting" that originates in San Francisco that is destined to either Redwood City and San Jose. The fact that the flows are relatively balanced in both directions on the Pacheco Pass alternatives means that trains will not run empty in one direction in the peak hours. This increases significantly the efficiency of train operations and would reduce or possibly eliminate any subsidies required for running these commuter services.

Figure 5- 7. Daily AM Directional Flows for the Bay Area Pacheco Pass Service



As before, Table 5-10 shows the annual revenues paid by riders whose home end is served by each station for the VHS 4 trains per peak hour service. Quite surprisingly for a commuter rail operation, by far the largest revenue, about $12 million, is associated with individuals whose home is in the biggest central city, San Francisco.

Table 5- 10. San Francisco Area: Year 2020 Annual Revenue by Station

VHS: 4 trains per peak hours		
Alignment	**Station**	**Annual Revenue ($1999)**
Pacheco Pass	Los Banos	$578,000
	Gilroy	$669,000
	San Jose	$3,428,000
	Redwood City	$4,238,000
	SFO	$1,437,000
	San Francisco	$12,378,000
	Total	**$22,728,000**

Source: Charles River Associates, 1999

CONCLUSIONS

Based on the preliminary forecasts presented here, it is clear that considerable potential exists for commuter ridership on the same HSR infrastructure as envisioned for the intercity system. The frequency of service is projected to be a more important determinant of ridership than the technology used, consistent with the fact that both technology options tested would provide very fast travel times, and the distances involved in commuter travel are not long enough for the higher speed maglev technology to provide significant time savings over the VHS technology. The express commuter service in San Diego would contribute far less ridership and revenue to the system than those proposed for the Los Angeles region and the San Francisco Bay Area. And in general, the projected ridership and revenue from express commuter services is relatively small in comparison to the totals for intercity travel on the HSR system.

6
Benefit/Cost Analysis of the HSR System

OVERVIEW

Benefit cost analysis (BCA) is a public sector evaluation tool that compares all the benefits of a project to society to all the costs of a project. The question to be answered in a BCA is: do these benefits exceed the costs? If the answer is yes, the benefit/cost ratio (BCR) is greater than one, and the project is said to be *economically* "feasible" or economically "justified." *Commercial* feasibility, the analogous private sector criterion, is much narrower in the benefits and costs it compares. Benefits are restricted to commercial *revenue*, and costs are limited only to those paid directly by the project developer.

In the case of the proposed California HSR system, considerable public benefits can be expected, in addition to farebox revenue. The benefits considered in this BCA don't include every conceivable benefit of HSR, but they do include the major categories of benefits:

- Intercity passenger revenue
- User benefits (over and above fares paid)
- Nonuser benefits
    - To intercity air and auto users (e.g., delay reductions)
    - To urban auto users (e.g., delay reductions)

The *costs* included in the BCA include all the construction, operating and maintenance costs. All costs and benefits occurring each year between FY 2001 and FY 2050 are included in the BCA and each is discounted back to 1999 using a 4 percent real discount rate to calculate the present value of the benefits and costs in 1999 dollars. The use of a 4 percent real discount rate in these benefit/cost calculations has been recommended by economists at the Center for the

Continuing Study of the California Economy (CCSCE) based on their own work and the work of others.33

Results

In summary, the results of the BCA for the Business Plan funding scenario alternative (VHS, Option B) are shown in Table 6-1. The benefit/cost ratio is over 2 (using the 4 percent discount rate), meaning the total benefits of the proposed HSR system are over twice as large as the total costs. Therefore, the proposed system easily passes this important BCR criterion for determining whether the system is economically justified.

Table 6- 1. Summary of Benefit/Cost Analysis Results for HSR Funding Scenario (Present Value in $1999, Discounted at 4 percent)

Total Benefits Total Costs	$44,148,761,000 $21,458,483,000
Net Present Value	$22,690,278,000
Benefit/Cost Ratio	2.06

The main text which follows describes the BCA in more detail, including that the project is economically justified using higher real discount rates (e.g., 7 percent) recommended by some public agencies and economists.

INTRODUCTION

In the public sector, benefit/cost analysis helps maximize economic efficiency, or the total net benefits to the public from an investment. The California HSR project will provide benefits to California's intercity and urban travelers, both users and nonusers of the system. At California's major airports, the benefits can extend to

[33] e.g., U.S. EPA, "Guidelines for Preparing Economic Analyses," June 11, 1999, Chapter 6: recommends a real rate of 2-3 percent for some public projects.

interstate and even international travelers. These public benefits, net of the commercial benefits (farebox revenue) from the project, are obviously important in justifying the public expenditures needed to construct and operate the system.

The question to be answered in this BCA is whether all the benefits exceeded all the costs. This means that all the benefits and costs input to a BCA must have some inherent value to society. It is important for government to consider all such impacts, even if the private sector does not. And while the actual summing of the benefits and costs in a BCA is straightforward, identifying the right inputs and observing or estimating their values is not.

In particular, for a benefit or cost to be included in a BCA, it must be:

- Quantifiable
- Monetizable
- Not duplicative
- Not a transfer

Benefits must be quantifiable in order to attach a monetary value to them. However, not all quantifiable benefits have economic value to society. Not duplicative, means that we can’t double count the same benefits and costs, even though they may appear to some not to be duplicative. And finally, transfers between affected groups are not net changes to society, and therefore can’t be included in a BCA.

Each of the benefits and costs in a BCA is discounted to a present value over the economic life of a project. For this HSR system, benefits are assumed to begin with its opening to riders on July 1, 2016 (the beginning of FY 2017), and extend through FY 2050. This allows 33 years of economic returns for the project, similar to the typical 35-year franchise payback period given to privately financed infrastructure projects (e.g., toll roads). Costs are assumed to begin in FY 2001 (i.e., planning and engineering) with the major capital costs of the HSR system beginning in 2007 and stopping at the end of FY 2016. Operating, maintenance and additional rolling stock acquisition and replacement continue through FY 2050.

THE BENEFITS INCLUDED IN THIS BCA

Individuals change their travel behavior when they derive more value or benefit from a transportation service improvement than the fare they pay. These net benefits are the *user* benefits. And by switching to a new mode such as HSR, travelers reduce the load on the "old" modes. In that process, they can reduce the congestion on the old modes experienced by the remaining travelers on those modes. These congestion cost savings are the largest component of the *nonuser* benefits – principally time and operating costs savings to remaining air and auto travelers.

As is the case for most major transportation improvements in California, considerable public benefits can be expected to occur with the implementation of the proposed HSR system. The benefits included in this BCA are as follows:

- Passenger Revenue (intercity only)[34]
- User Benefits (net of fares paid)
  - Intercity
  - Urban Commuter
- Nonuser Benefits
  - Intercity
    - Air Delay
      - Airline Passengers

[34] Revenue forecasts from commuter services on the HSR infrastructure are not considered investment quality and are not included in this BCA. However, it is expected that the revenues will exceed the increased capital, operating and maintenance costs of the added rolling stock needed to carry commuters. For this reason, both the added costs and the added revenues of HSR commuter services are omitted from this BCA. In any event, relative to intercity costs and revenues, both are quite small.

- Aircraft Operating Costs

- ♦ Highway Delay
- ♦ Highway Accident Costs
- ♦ Highway Air Pollution

■ Urban

- Highway Delay
- Highway Accident Costs
- Highway Air Pollution

In a publicly financed project, passenger revenue reduces the costs that must be funded from other sources. However, in a BCA, passenger revenues are counted as a benefit, along with the benefits from the HSR system which users obtain, over and above the fares they pay.[35] Therefore, passenger revenue plus the user benefits, net of fares paid, represent the total benefit to *users* of the HSR system.

Two basic approaches are possible to quantify the public benefits from investments in HSR in California. To use both approaches would double count the same benefits. The first approach is to use a simulation model of the California economy to derive the overall "economic impact" that can be expected to accrue as a result of the investment. However, there is a consensus that such a regional economic impact model relies on too many uncertain parameters relating HSR to the long-term economic growth of the California economy. There is also the issue of which impacts such a model produces that are transfers, and which are uniquely describable public benefits.

The approach we have used in this BCA is to estimate user and nonuser benefits directly. This approach has the advantage of being much more transparent and tangible as well as using directly the detailed information on HSR ridership that CRA has produced. In addition, the methodology used is consistent with the way benefits have been estimated in the federally produced "HSGT Commercial

[35] The calculation of user benefits for intercity HSR system riders is described in Appendix 3.

Feasibility Study"[36] so that considerable confidence can be placed in the values produced.

METHODOLOGY

The calculation of both the user and nonuser intercity travel benefits from the proposed HSR system in California come directly from our travel forecasts for the system, and both, therefore, are closely related. As user benefits increase when more travelers change their behavior by diverting in larger numbers to HSR, there will be more benefits to the remaining users and operators of the old modes. This is the reason for using the so-called "benefit maximizing" HSR fare structure in our forecasts based on 50 percent of the LA-SF air fare, rather than the revenue maximizing fare structure based on 80 percent of the LA-SF air fare for the Grapevine Option (B). Less than 9 percent of the passenger revenue is lost by decreasing the fares to the "benefit maximizing" fares, while the user and nonuser public benefits increase significantly.

The main components of intercity nonuser benefits are categorized by the prior mode used by intercity travelers -- mainly air and private vehicle. We calculate the savings in travel time by the remaining users of each mode, as well as airline operating cost savings. Since both the travel time savings and the diversion rate to HSR vary by O/D pair, we are in the fortunate position of having the detailed information we need as part of our ongoing intercity ridership and revenue analysis. Our forecasts of diverted and remaining intercity travel by mode are also disaggregated by trip purpose to provide the differential values of time with which to value the nonuser benefits. Higher values of time are associated with business travel than nonbusiness travel.

The intercity nonuser benefits quantified for the *air* mode and included in the BCA consist of 1) reductions in airport congestion delays to remaining air passengers and 2) reductions in aircraft operating costs due to reduced airport congestion. Appendix 1 describes the calculation of these air nonuser benefits.

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[36] Federal Railroad Administration, *High-Speed Ground Transportation For America*, September 1997.

Benefit/Cost Analysis of the HSR System

The nonuser benefits quantified for the *highway* mode and included in the BCA consist of three items: 1) reductions in delays to remaining intercity auto users, 2) savings as a result of fewer accidents (and deaths) due to reduced vehicle miles traveled (VMT), and 3) reductions in air pollution from reduced VMT. Appendix 2 describes the calculation of these highway nonuser benefits.

The user benefits that result from express commuter services, and the nonuser benefits that result from intercity and commuter services in California's *urban areas* have been estimated and are included in the BCA (only) for the Los Angeles, San Diego and San Francisco Bay Area regions. The estimates of the nonuser benefits from reduced urban auto travel within these regions due to the intercity and express commuter services serving these regions were made by the MTC in the Bay Area, Orange County Transportation Authority (OCTA) and their consultants using the OCTA models that cover the entire Los Angeles region,[37] and SANDAG in San Diego County who produced estimates of reduced auto vehicle miles traveled and vehicle hours traveled (VHT), with and without the commuter and intercity services on the recommended HSR alignments.[38] CRA then converted the VHT savings to dollar savings using values of travel time promulgated by US DOT for urban (local) travel in the U.S.[39] To calculate pollution and safety impacts, we applied the same per mile auto pollution and accident rates used by several university researchers in California to the VMT reductions as were used to calculate the corresponding intercity highway nonuser benefits (see Appendix 2).

The user benefits from the express commuter services within the three metropolitan areas was calculated using estimates of the time savings provided by the HSR service improvement over the previous transit options used by, or

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[37] The Southern California Association of Governments (SCAG), is the Metropolitan Planning Organization (MPO) for the Los Angeles region. However, OCTA maintains models for the Los Angeles region that are based on the SCAG models.

[38] See CRA Task 6 Report "Express Commuter Ridership and Revenue Forecasts on HSR Alignments" for the commuter ridership forecasts on the express commuter services on the HSR infrastructure made using the regional models developed and maintained by the three local agencies. CRA supplied the reduced numbers of internal-external (I-E) and external-external (E-E) intercity trips to the local agencies who assigned the regional trip tables estimated with and without the auto trips diverted to the commuter and intercity services on the HSR system to produce the reduced VMT and VHT estimates.

[39] U.S. DOT, Office of the Secretary, "Departmental Guidance for the Valuation of Travel Time in Economic Analysis," April 9, 1997, Table 4.

available for use by transit and auto travelers who divert to the new HSR service. These time savings were converted to dollar savings using the same values of time as for the urban nonuser benefits, in accordance with U.S. DOT's recommended guidance.[40]

The costs used in the benefit/cost analysis include both the capital cost required to construct the system and purchase rolling stock and other equipment, as well as the operating and maintenance costs that would be incurred once the system is operational. These cost figures were supplied by Parsons Brinkerhoff as inputs for our analysis, and are summarized in Table 6-14.

No assumptions were made in this analysis about conventional rail operating cost savings or user benefits to conventional (Amtrak) rail riders who take advantage of the intercity HSR service. For example, essentially all riders on the San Joaquins will use the new HSR service and benefit considerably from their time savings, while paying essentially the same fares as before. However, we have (conservatively) not assumed any cost savings from possible conventional rail service changes, nor have we included user benefits to these riders in the BCA. In addition, possible additional revenues or revenue surpluses from express freight services were also not included in the BCA.

RESULTS

Table 6-2 shows the present values of all the benefits that we have included in the BCA and compares these to the total system costs produced by Parsons Brinckerhoff (PB). In each case, the benefits and costs which are received and paid at different times over the course of the next 50 years have been discounted back to 1999 dollars using a four (4) percent real discount rate. Discounting future values to calculate a present value in 1999 dollars is necessary to be able to compare these future streams of costs and benefits.

The four percent discount rate is applied to the future benefits and costs estimated in real (constant 1999) dollars, not inflated dollars. If the future costs and benefits were estimated in inflated (current) dollars, the "nominal" discount rate would

[40] Ibid.

have to be 4 percent plus the rate of inflation. If we assume today's modest 2.5 percent annual inflation rate going forward, the 4 percent real discount rate is equivalent to a 6.5 percent nominal discount rate.

Table 6-2 shows that using a 4 percent real discount rate, the benefit/cost ratio for the proposed HSR system is over 2. This means that the present value in 1999 dollars of the total benefits (roughly $44 billion) is over twice the present value of the total project costs (roughly $21.5 billion). This means the project is economically justified (or "feasible").[41]

The use of a 4 percent real discount rate in these benefit/cost calculations has been recommended by economists at the Center for the Continuing Study of the California Economy (CCSCE) based on their own work and the work of others.[42] However, other economists have recommended using higher real discount rates for some projects. Indeed, a widely quoted, but now perhaps out of date discount rate is the 7 percent in real terms required for use in BCA's of federal programs by the US Office of Management and Budget (OMB).

Rather than compile many BCA tables using different discount rates, we have computed the "internal rate of return" (IRR) for the HSR project. The IRR is the (real) discount rate that makes the net present value of the project equal to zero (i.e., the discounted present value of the benefits minus the costs equal to zero). If the IRR is less than 4 percent or 7 percent (say), the benefits will be less than the costs, discounted at those rates, and the benefit/cost ratio will be less than one (i.e., the project will not be economically justified). However, as shown in Table 2, the real IRR for the project is 8.8 percent, so the project remains economically justified even at discount rates well above 4 percent or even 7 percent.

Tables 6-3 through 6-14 show the detailed year by year forecasts for all the benefits and costs included in this BCA, including the discounted present value for each benefit or cost at each future year, discounted at 4 percent. Examination of these tables can be very helpful in understanding the relative importance of

[41] This is the economic or public sector analogue to "commercially feasible" (i.e., when commercial revenues exceed only those costs borne by the developer, and the bottom line is positive).
[42] e.g., U.S. EPA, "Guidelines for Preparing Economic Analyses," June 11, 1999, Chapter 6: recommends a real rate of 2-3 percent for some public projects.

Benefit/Cost Analysis of the HSR System

each category of HSR project benefits, how these benefits are projected to increase over time, and how the arithmetic of discounting decreases the present value of a benefit or cost, the farther into the future it occurs.[43]

[43] The present value of a benefit or cost that occurs n years into the future using discount rate i is simply the future value divided by $(1 + i)^n$.

Benefit/Cost Analysis of the HSR System

Table 6- 2. Benefit/Cost Comparison for HSR Funding Scenario (Present Value in $1999, Discounted at 4 percent)

Benefits	**Passenger Revenue**	$9,650,926,420
	User Benefits	
	Intercity	$8,518,652,569
	Urban	$316,746,428
	E-1 Subtotal - User Benefits	$8,835,398,998
	Nonuser Benefits	
	Intercity	
	Airline Passenger Delay	$7,764,937,372
	Aircraft Operating Delay	$4,282,723,974
	Highway Delay*	$3,540,019,945
	Highway Accident Cost*	$780,025,968
	Highway Air Pollution*	$103,074,860
	Subtotal	$16,470,782,118
	Urban**	
	Highway Delay	$8,822,192,155
	Highway Accident Cost	$326,337,736
	Highway Air Pollution	$43,123,201
	Subtotal	$9,191,653,092
	Subtotal – Nonuser Benefits	$25,662,435,210
	Total Benefits	$44,148,760,628
Costs	Capital	-$15,443,321,236
	Operating and Maintenance	-$6,015,161,411
	Total Costs	-$21,458,482,647
	Total (Net Present Value)	$22,690,277,981
	Benefit/Cost Ratio	2.06
	Internal Rate of Return	8.8%

*Outside the Los Angeles, San Francisco, and San Diego metropolitan areas.

**Includes intercity highway non-user benefits within the three metropolitan areas.

Source: Charles River Associates and Parsons Brinckerhoff, 1999.

Benefit/Cost Analysis of the HSR System

Table 6- 3. Intercity Passenger Revenue ($1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$417,129,726	$0	$0
2017	$847,738,978	$714,849,333	$352,869,733
2018	$861,218,504	$811,754,804	$385,293,268
2019	$874,698,031	$867,958,268	$396,124,823
2020	$888,177,557	$881,437,794	$386,804,522
2021	$903,282,430	$895,729,993	$377,958,096
2022	$918,387,303	$910,834,866	$369,549,691
2023	$933,492,176	$925,939,739	$361,228,976
2024	$948,597,049	$941,044,612	$353,001,646
2025	$963,701,921	$956,149,485	$344,872,824
2026	$978,806,794	$971,254,358	$336,847,105
2027	$993,911,667	$986,359,231	$328,928,582
2028	$1,009,016,540	$1,001,464,104	$321,120,882
2029	$1,024,121,413	$1,016,568,977	$313,427,193
2030	$1,039,226,286	$1,031,673,850	$305,850,295
2031	$1,054,331,159	$1,046,778,723	$298,392,586
2032	$1,069,436,032	$1,061,883,596	$291,056,106
2033	$1,084,540,905	$1,076,988,469	$283,842,561
2034	$1,099,645,778	$1,092,093,342	$276,753,348
2035	$1,114,750,651	$1,107,198,215	$269,789,574
2036	$1,129,855,524	$1,122,303,087	$262,952,076
2037	$1,144,960,397	$1,137,407,960	$256,241,442
2038	$1,160,065,270	$1,152,512,833	$249,658,029
2039	$1,175,170,143	$1,167,617,706	$243,201,977
2040	$1,190,275,016	$1,182,722,579	$236,873,227
2041	$1,205,379,889	$1,197,827,452	$230,671,538
2042	$1,220,484,762	$1,212,932,325	$224,596,498
2043	$1,235,589,635	$1,228,037,198	$218,647,539
2044	$1,250,694,508	$1,243,142,071	$212,823,948
2045	$1,265,799,380	$1,258,246,944	$207,124,883
2046	$1,280,904,253	$1,273,351,817	$201,549,379
2047	$1,296,009,126	$1,288,456,690	$196,096,363
2048	$1,311,113,999	$1,303,561,563	$190,764,659
2049	$1,326,218,872	$1,318,666,436	$185,553,003
2050	$1,341,323,745	$1,333,771,309	$180,460,047
Total	$37,558,055,419	$36,718,519,728	$9,650,926,420

Source: Charles River Associates, 1999.

Benefit/Cost Analysis of the HSR System

Table 6- 4. Intercity User Benefits ($1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$357,259,235	$0	$0
2017	$727,785,248	$612,979,080	$302,583,711
2018	$741,052,026	$697,697,705	$331,156,930
2019	$754,318,804	$747,685,415	$341,233,863
2020	$767,585,581	$760,952,192	$333,931,392
2021	$782,636,163	$775,110,872	$327,062,208
2022	$797,686,745	$790,161,454	$320,589,309
2023	$812,737,326	$805,212,035	$314,130,506
2024	$827,787,908	$820,262,617	$307,694,290
2025	$842,838,489	$835,313,198	$301,288,477
2026	$857,889,071	$850,363,780	$294,920,250
2027	$872,939,652	$865,414,361	$288,596,193
2028	$887,990,234	$880,464,943	$282,322,330
2029	$903,040,815	$895,515,525	$276,104,154
2030	$918,091,397	$910,566,106	$269,946,662
2031	$933,141,978	$925,616,688	$263,854,386
2032	$948,192,560	$940,667,269	$257,831,417
2033	$963,243,141	$955,717,851	$251,881,437
2034	$978,293,723	$970,768,432	$246,007,739
2035	$993,344,304	$985,819,014	$240,213,259
2036	$1,008,394,886	$1,000,869,595	$234,500,591
2037	$1,023,445,468	$1,015,920,177	$228,872,015
2038	$1,038,496,049	$1,030,970,758	$223,329,511
2039	$1,053,546,631	$1,046,021,340	$217,874,786
2040	$1,068,597,212	$1,061,071,921	$212,509,285
2041	$1,083,647,794	$1,076,122,503	$207,234,216
2042	$1,098,698,375	$1,091,173,084	$202,050,558
2043	$1,113,748,957	$1,106,223,666	$196,959,084
2044	$1,128,799,538	$1,121,274,247	$191,960,370
2045	$1,143,850,120	$1,136,324,829	$187,054,814
2046	$1,158,900,701	$1,151,375,411	$182,242,642
2047	$1,173,951,283	$1,166,425,992	$177,523,929
2048	$1,189,001,864	$1,181,476,574	$172,898,605
2049	$1,204,052,446	$1,196,527,155	$168,366,465
2050	$1,219,103,027	$1,211,577,737	$163,927,185
Total	$33,374,088,751	$32,619,643,526	$8,518,652,569

Source: Charles River Associates, 1999.

Benefit/Cost Analysis of the HSR System

Table 6- 5. Urban User Benefits ($1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$11,164,094	$0	$0
2017	$23,184,826	$19,343,031	$9,548,264
2018	$24,041,464	$22,432,488	$10,647,410
2019	$24,898,101	$24,469,782	$11,167,689
2020	$25,754,739	$25,326,420	$11,114,084
2021	$26,611,376	$26,183,057	$11,048,082
2022	$27,468,013	$27,039,695	$10,970,716
2023	$28,324,651	$27,896,332	$10,882,958
2024	$29,181,288	$28,752,970	$10,785,722
2025	$30,037,926	$29,609,607	$10,679,866
2026	$30,894,563	$30,466,245	$10,566,198
2027	$31,751,201	$31,322,882	$10,445,475
2028	$32,607,838	$32,179,519	$10,318,408
2029	$33,464,476	$33,036,157	$10,185,664
2030	$34,321,113	$33,892,794	$10,047,867
2031	$35,177,751	$34,749,432	$9,905,601
2032	$36,034,388	$35,606,069	$9,759,416
2033	$36,891,026	$36,462,707	$9,609,823
2034	$37,747,663	$37,319,344	$9,457,299
2035	$38,604,300	$38,175,982	$9,302,293
2036	$39,460,938	$39,032,619	$9,145,220
2037	$40,317,575	$39,889,257	$8,986,468
2038	$41,174,213	$40,745,894	$8,826,400
2039	$42,030,850	$41,602,532	$8,665,352
2040	$42,887,488	$42,459,169	$8,503,634
2041	$43,744,125	$43,315,806	$8,341,538
2042	$44,600,763	$44,172,444	$8,179,332
2043	$45,457,400	$45,029,081	$8,017,264
2044	$46,314,038	$45,885,719	$7,855,562
2045	$47,170,675	$46,742,356	$7,694,440
2046	$48,027,312	$47,598,994	$7,534,090
2047	$48,883,950	$48,455,631	$7,374,693
2048	$49,740,587	$49,312,269	$7,216,413
2049	$50,597,225	$50,168,906	$7,059,398
2050	$51,453,862	$51,025,544	$6,903,786
Total	$1,280,021,998	$1,249,700,734	$316,746,428

Source: Charles River Associates, 1999.

Benefit/Cost Analysis of the HSR System

Table 6- 6. Airline Passenger Delay Benefits ($1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$120,131,012	$0	$0
2017	$265,335,674	$214,879,022	$106,070,328
2018	$290,409,324	$263,978,874	$125,295,573
2019	$315,482,974	$302,946,149	$138,260,668
2020	$340,556,623	$328,019,798	$143,946,110
2021	$421,741,914	$381,149,269	$160,827,987
2022	$502,927,204	$462,334,559	$187,581,305
2023	$584,112,494	$543,519,849	$212,038,765
2024	$665,297,785	$624,705,140	$234,337,394
2025	$746,483,075	$705,890,430	$254,607,078
2026	$827,668,366	$787,075,720	$272,970,902
2027	$908,853,656	$868,261,011	$289,545,486
2028	$987,758,193	$948,305,924	$304,075,636
2029	$1,041,016,333	$1,014,387,263	$312,754,530
2030	$1,080,463,367	$1,060,739,850	$314,467,209
2031	$1,119,910,402	$1,100,186,885	$313,617,007
2032	$1,159,357,437	$1,139,633,919	$312,367,017
2033	$1,161,509,592	$1,160,433,514	$305,834,678
2034	$1,163,661,747	$1,162,585,670	$294,617,195
2035	$1,165,813,903	$1,164,737,825	$283,810,177
2036	$1,167,966,058	$1,166,889,980	$273,398,644
2037	$1,170,118,213	$1,169,042,136	$263,368,161
2038	$1,172,270,368	$1,171,194,291	$253,704,818
2039	$1,174,422,524	$1,173,346,446	$244,395,210
2040	$1,176,574,679	$1,175,498,601	$235,426,424
2041	$1,178,726,834	$1,177,650,757	$226,786,012
2042	$1,180,878,990	$1,179,802,912	$218,461,984
2043	$1,183,031,145	$1,181,955,067	$210,442,784
2044	$1,185,183,300	$1,184,107,222	$202,717,276
2045	$1,187,335,455	$1,186,259,378	$195,274,732
2046	$1,189,487,611	$1,188,411,533	$188,104,814
2047	$1,191,639,766	$1,190,563,688	$181,197,560
2048	$1,193,791,921	$1,192,715,844	$174,543,372
2049	$1,195,944,077	$1,194,867,999	$168,133,001
2050	$1,198,096,232	$1,197,020,154	$161,957,535
Total	$32,613,958,248	$31,963,096,678	$7,764,937,372

Source: Charles River Associates, 1999.

Benefit/Cost Analysis of the HSR System

Table 6- 7. Aircraft Operating Delay Benefits ($1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$81,896,948	$0	$0
2017	$168,909,389	$141,398,897	$69,798,472
2018	$191,804,816	$171,339,247	$81,324,876
2019	$205,810,275	$198,807,545	$90,733,168
2020	$219,815,734	$212,813,004	$93,389,497
2021	$258,751,822	$239,283,778	$100,967,079
2022	$297,687,910	$278,219,866	$112,881,126
2023	$336,623,997	$317,155,953	$123,729,348
2024	$382,590,407	$359,607,202	$134,894,704
2025	$422,405,286	$402,497,847	$145,176,640
2026	$462,220,164	$442,312,725	$153,401,382
2027	$502,035,042	$482,127,603	$160,778,694
2028	$538,443,653	$520,239,347	$166,815,483
2029	$563,161,667	$550,802,660	$169,822,742
2030	$580,393,349	$571,777,508	$169,509,307
2031	$597,625,030	$589,009,190	$167,901,746
2032	$614,856,712	$606,240,871	$166,167,090
2033	$616,377,912	$615,617,312	$162,247,229
2034	$617,899,112	$617,138,512	$156,392,447
2035	$619,420,312	$618,659,712	$150,748,021
2036	$620,941,512	$620,180,912	$145,306,433
2037	$622,462,712	$621,702,112	$140,060,428
2038	$623,983,912	$623,223,312	$135,003,012
2039	$625,505,112	$624,744,512	$130,127,438
2040	$627,026,312	$626,265,712	$125,427,199
2041	$628,547,512	$627,786,912	$120,896,021
2042	$630,068,712	$629,308,112	$116,527,852
2043	$631,589,912	$630,829,312	$112,316,855
2044	$633,111,112	$632,350,512	$108,257,403
2045	$634,632,312	$633,871,712	$104,344,068
2046	$636,153,512	$635,392,912	$100,571,614
2047	$637,674,712	$636,914,112	$96,934,993
2048	$639,195,912	$638,435,312	$93,429,339
2049	$640,717,112	$639,956,512	$90,049,955
2050	$642,238,312	$641,477,712	$86,792,314
Total	$17,752,578,217	$17,397,488,461	$4,282,723,974

Source: Charles River Associates, 1999.

Benefit/Cost Analysis of the HSR System

Table 6- 8. Intercity Highway Delay Benefits (Outside the LA, SF, and SD Metropolitan Areas, $1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$31,420,375	$0	$0
2017	$71,889,342	$57,260,289	$28,265,289
2018	$80,937,934	$72,592,956	$34,455,697
2019	$89,986,525	$85,462,229	$39,003,846
2020	$99,035,117	$94,510,821	$41,474,524
2021	$127,780,096	$113,407,607	$47,852,951
2022	$156,525,076	$142,152,586	$57,675,047
2023	$185,270,055	$170,897,565	$66,670,810
2024	$214,015,034	$199,642,545	$74,889,273
2025	$242,760,013	$228,387,524	$82,376,921
2026	$271,504,993	$257,132,503	$89,177,813
2027	$300,249,972	$285,877,482	$95,333,700
2028	$328,994,951	$314,622,462	$100,884,137
2029	$357,739,931	$343,367,441	$105,866,592
2030	$386,484,910	$372,112,420	$110,316,544
2031	$415,229,889	$400,857,400	$114,267,585
2032	$443,974,869	$429,602,379	$117,751,509
2033	$472,719,848	$458,347,358	$120,798,404
2034	$501,464,827	$487,092,337	$123,436,734
2035	$530,209,806	$515,837,317	$125,693,420
2036	$558,954,786	$544,582,296	$127,593,915
2037	$587,699,765	$573,327,275	$129,162,282
2038	$616,444,744	$602,072,255	$130,421,257
2039	$645,189,724	$630,817,234	$131,392,319
2040	$673,934,703	$659,562,213	$132,095,753
2041	$702,679,682	$688,307,193	$132,550,710
2042	$731,424,661	$717,052,172	$132,775,262
2043	$760,169,641	$745,797,151	$132,786,459
2044	$788,914,620	$774,542,130	$132,600,383
2045	$817,659,599	$803,287,110	$132,232,190
2046	$846,404,579	$832,032,089	$131,696,165
2047	$875,149,558	$860,777,068	$131,005,763
2048	$903,894,537	$889,522,048	$130,173,653
2049	$932,639,516	$918,267,027	$129,211,755
2050	$961,384,496	$947,012,006	$128,131,285
Total	$16,710,738,174	$16,216,120,487	$3,540,019,945

Source: Charles River Associates, 1999.

Benefit/Cost Analysis of the HSR System

Table 6- 9.Intercity Highway Accident Cost Benefits (outside the LA, SF, and SD Metropolitan Areas, $1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$36,139,365	$0	$0
2017	$73,068,113	$61,772,408	$30,492,598
2018	$73,857,497	$69,789,665	$33,125,136
2019	$74,646,880	$74,252,189	$33,887,730
2020	$75,436,264	$75,041,572	$32,930,763
2021	$76,274,659	$75,855,461	$32,007,621
2022	$77,113,054	$76,693,856	$31,116,717
2023	$77,951,448	$77,532,251	$30,246,996
2024	$78,789,843	$78,370,646	$29,398,146
2025	$79,628,238	$79,209,041	$28,569,848
2026	$80,466,633	$80,047,435	$27,761,777
2027	$81,305,028	$80,885,830	$26,973,602
2028	$82,143,422	$81,724,225	$26,204,988
2029	$82,981,817	$82,562,620	$25,455,597
2030	$83,820,212	$83,401,015	$24,725,086
2031	$84,658,607	$84,239,409	$24,013,113
2032	$85,497,002	$85,077,804	$23,319,330
2033	$86,335,397	$85,916,199	$22,643,394
2034	$87,173,791	$86,754,594	$21,984,956
2035	$88,012,186	$87,592,989	$21,343,672
2036	$88,850,581	$88,431,384	$20,719,194
2037	$89,688,976	$89,269,778	$20,111,180
2038	$90,527,371	$90,108,173	$19,519,287
2039	$91,365,765	$90,946,568	$18,943,174
2040	$92,204,160	$91,784,963	$18,382,502
2041	$93,042,555	$92,623,358	$17,836,937
2042	$93,880,950	$93,461,752	$17,306,145
2043	$94,719,345	$94,300,147	$16,789,797
2044	$95,557,739	$95,138,542	$16,287,567
2045	$96,396,134	$95,976,937	$15,799,134
2046	$97,234,529	$96,815,332	$15,324,178
2047	$98,072,924	$97,653,727	$14,862,386
2048	$98,911,319	$98,492,121	$14,413,447
2049	$99,749,714	$99,330,516	$13,977,057
2050	$100,588,108	$100,168,911	$13,552,913
Total	$2,986,089,626	$2,921,221,418	$780,025,968

Source: Charles River Associates, 1999.

Table 6- 10. Intercity Highway Air Pollution Benefits (outside the LA, SF, and SD Metropolitan Areas, $1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$4,775,559	$0	$0
2017	$9,655,429	$8,162,783	$4,029,379
2018	$9,759,741	$9,222,206	$4,377,250
2019	$9,864,052	$9,811,896	$4,478,021
2020	$9,968,363	$9,916,208	$4,351,565
2021	$10,079,151	$10,023,757	$4,229,578
2022	$10,189,939	$10,134,545	$4,111,852
2023	$10,300,727	$10,245,333	$3,996,924
2024	$10,411,515	$10,356,121	$3,884,755
2025	$10,522,303	$10,466,909	$3,775,301
2026	$10,633,091	$10,577,697	$3,668,521
2027	$10,743,879	$10,688,485	$3,564,369
2028	$10,854,667	$10,799,273	$3,462,802
2029	$10,965,454	$10,910,060	$3,363,775
2030	$11,076,242	$11,020,848	$3,267,244
2031	$11,187,030	$11,131,636	$3,173,161
2032	$11,297,818	$11,242,424	$3,081,483
2033	$11,408,606	$11,353,212	$2,992,163
2034	$11,519,394	$11,464,000	$2,905,155
2035	$11,630,182	$11,574,788	$2,820,414
2036	$11,740,970	$11,685,576	$2,737,894
2037	$11,851,758	$11,796,364	$2,657,549
2038	$11,962,545	$11,907,151	$2,579,334
2039	$12,073,333	$12,017,939	$2,503,205
2040	$12,184,121	$12,128,727	$2,429,116
2041	$12,294,909	$12,239,515	$2,357,024
2042	$12,405,697	$12,350,303	$2,286,883
2043	$12,516,485	$12,461,091	$2,218,652
2044	$12,627,273	$12,571,879	$2,152,286
2045	$12,738,061	$12,682,667	$2,087,743
2046	$12,848,848	$12,793,455	$2,024,981
2047	$12,959,636	$12,904,242	$1,963,958
2048	$13,070,424	$13,015,030	$1,904,634
2049	$13,181,212	$13,125,818	$1,846,968
2050	$13,292,000	$13,236,606	$1,790,921
Total	$394,590,414	$386,018,544	$103,074,860

Source: Charles River Associates, 1999.

Table 6- 11. Urban Highway Delay Benefits (Includes Urban and Intercity Benefits within the LA, SF, and SD Metropolitan Areas, $1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$228,642,547	$0	$0
2017	$493,370,641	$404,028,687	$199,439,922
2018	$529,456,189	$485,842,744	$230,601,578
2019	$565,541,736	$547,498,962	$249,871,379
2020	$601,627,283	$583,584,510	$256,096,493
2021	$637,712,831	$619,670,057	$261,473,119
2022	$673,798,378	$655,755,604	$266,057,317
2023	$709,883,926	$691,841,152	$269,902,090
2024	$745,969,473	$727,926,699	$273,057,536
2025	$782,055,020	$764,012,247	$275,570,991
2026	$818,140,568	$800,097,794	$277,487,173
2027	$854,226,115	$836,183,341	$278,848,306
2028	$890,311,662	$872,268,889	$279,694,253
2029	$926,397,210	$908,354,436	$280,062,630
2030	$962,482,757	$944,439,983	$279,988,921
2031	$998,568,305	$980,525,531	$279,506,588
2032	$1,034,653,852	$1,016,611,078	$278,647,173
2033	$1,070,739,399	$1,052,696,626	$277,440,395
2034	$1,106,824,947	$1,088,782,173	$275,914,247
2035	$1,142,910,494	$1,124,867,720	$274,095,080
2036	$1,178,996,041	$1,160,953,268	$272,007,691
2037	$1,215,081,589	$1,197,038,815	$269,675,405
2038	$1,251,167,136	$1,233,124,363	$267,120,147
2039	$1,287,252,684	$1,269,209,910	$264,362,520
2040	$1,323,338,231	$1,305,295,457	$261,421,869
2041	$1,359,423,778	$1,341,381,005	$258,316,354
2042	$1,395,509,326	$1,377,466,552	$255,063,005
2043	$1,431,594,873	$1,413,552,099	$251,677,789
2044	$1,467,680,421	$1,449,637,647	$248,175,663
2045	$1,503,765,968	$1,485,723,194	$244,570,626
2046	$1,539,851,515	$1,521,808,742	$240,875,776
2047	$1,575,937,063	$1,557,894,289	$237,103,355
2048	$1,612,022,610	$1,593,979,836	$233,264,794
2049	$1,648,108,157	$1,630,065,384	$229,370,763
2050	$1,684,193,705	$1,666,150,931	$225,431,207
Total	$37,247,236,430	$36,308,269,726	$8,822,192,155

Source: Charles River Associates, 1999.

Benefit/Cost Analysis of the HSR System

Table 6- 12. Urban Highway Accident Cost Benefits (Includes Urban and Intercity Benefits within the LA, SF, and SD Metropolitan Areas, $1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$11,902,140	$0	$0
2017	$24,627,440	$20,583,480	$10,160,585
2018	$25,450,601	$23,787,070	$11,290,352
2019	$26,273,763	$25,862,182	$11,803,162
2020	$27,096,924	$26,685,343	$11,710,425
2021	$27,920,085	$27,508,504	$11,607,362
2022	$28,743,246	$28,331,666	$11,494,903
2023	$29,566,408	$29,154,827	$11,373,924
2024	$30,389,569	$29,977,988	$11,245,247
2025	$31,212,730	$30,801,150	$11,109,643
2026	$32,035,892	$31,624,311	$10,967,835
2027	$32,859,053	$32,447,472	$10,820,501
2028	$33,682,214	$33,270,633	$10,668,276
2029	$34,505,375	$34,093,795	$10,511,753
2030	$35,328,537	$34,916,956	$10,351,490
2031	$36,151,698	$35,740,117	$10,188,004
2032	$36,974,859	$36,563,279	$10,021,782
2033	$37,798,020	$37,386,440	$9,853,274
2034	$38,621,182	$38,209,601	$9,682,904
2035	$39,444,343	$39,032,762	$9,511,063
2036	$40,267,504	$39,855,924	$9,338,117
2037	$41,090,666	$40,679,085	$9,164,405
2038	$41,913,827	$41,502,246	$8,990,242
2039	$42,736,988	$42,325,407	$8,815,919
2040	$43,560,149	$43,148,569	$8,641,706
2041	$44,383,311	$43,971,730	$8,467,853
2042	$45,206,472	$44,794,891	$8,294,589
2043	$46,029,633	$45,618,053	$8,122,128
2044	$46,852,794	$46,441,214	$7,950,662
2045	$47,675,956	$47,264,375	$7,780,371
2046	$48,499,117	$48,087,536	$7,611,418
2047	$49,322,278	$48,910,698	$7,443,952
2048	$50,145,440	$49,733,859	$7,278,109
2049	$50,968,601	$50,557,020	$7,114,011
2050	$51,791,762	$51,380,181	$6,951,769
Total	$1,311,028,577	$1,280,248,365	$326,337,736

Source: Charles River Associates, 1999.

Table 6- 13. Urban Highway Air Pollution Benefits (Includes Urban and Intercity Benefits within the LA, SF, and SD Metropolitan Areas, $1999)

Year	Calendar Year Basis	Fiscal Year Basis with Rampup	Discounted at 4%
2000	$0	$0	$0
2001	$0	$0	$0
2002	$0	$0	$0
2003	$0	$0	$0
2004	$0	$0	$0
2005	$0	$0	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$0	$0	$0
2009	$0	$0	$0
2010	$0	$0	$0
2011	$0	$0	$0
2012	$0	$0	$0
2013	$0	$0	$0
2014	$0	$0	$0
2015	$0	$0	$0
2016	$1,572,782	$0	$0
2017	$3,254,340	$2,719,960	$1,342,649
2018	$3,363,115	$3,143,291	$1,491,939
2019	$3,471,890	$3,417,503	$1,559,704
2020	$3,580,665	$3,526,277	$1,547,449
2021	$3,689,440	$3,635,052	$1,533,830
2022	$3,798,215	$3,743,827	$1,518,969
2023	$3,906,990	$3,852,602	$1,502,983
2024	$4,015,764	$3,961,377	$1,485,979
2025	$4,124,539	$4,070,152	$1,468,060
2026	$4,233,314	$4,178,927	$1,449,321
2027	$4,342,089	$4,287,702	$1,429,852
2028	$4,450,864	$4,396,477	$1,409,736
2029	$4,559,639	$4,505,251	$1,389,053
2030	$4,668,414	$4,614,026	$1,367,875
2031	$4,777,189	$4,722,801	$1,346,272
2032	$4,885,964	$4,831,576	$1,324,307
2033	$4,994,738	$4,940,351	$1,302,040
2034	$5,103,513	$5,049,126	$1,279,527
2035	$5,212,288	$5,157,901	$1,256,819
2036	$5,321,063	$5,266,676	$1,233,965
2037	$5,429,838	$5,375,451	$1,211,011
2038	$5,538,613	$5,484,225	$1,187,996
2039	$5,647,388	$5,593,000	$1,164,961
2040	$5,756,163	$5,701,775	$1,141,940
2041	$5,864,937	$5,810,550	$1,118,966
2042	$5,973,712	$5,919,325	$1,096,071
2043	$6,082,487	$6,028,100	$1,073,281
2044	$6,191,262	$6,136,875	$1,050,623
2045	$6,300,037	$6,245,650	$1,028,120
2046	$6,408,812	$6,354,424	$1,005,795
2047	$6,517,587	$6,463,199	$983,665
2048	$6,626,362	$6,571,974	$961,750
2049	$6,735,137	$6,680,749	$940,066
2050	$6,843,911	$6,789,524	$918,627
Total	$173,243,061	$169,175,677	$43,123,201

Source: Charles River Associates, 1999.

Benefit/Cost Analysis of the HSR System

Table 6- 14. Capital, Operating, and Maintenance Costs of the HSR System

Year	Capital Cost (Fiscal Year Basis)	Discounted at 4.0%	O&M Cost (Fiscal Year Basis)	Discounted at 4.0%
2000	$0	$0	$0	$0
2001	$10,000,000	$9,245,562	$0	$0
2002	$10,000,000	$8,889,964	$0	$0
2003	$75,000,000	$64,110,314	$0	$0
2004	$100,000,000	$82,192,711	$0	$0
2005	$100,000,000	$79,031,453	$0	$0
2006	$75,000,000	$56,993,836	$0	$0
2007	$1,180,047,164	$862,248,904	$0	$0
2008	$2,067,608,434	$1,452,674,260	$0	$0
2009	$2,006,556,721	$1,355,557,823	$0	$0
2010	$2,598,330,262	$1,687,825,792	$0	$0
2011	$3,435,717,611	$2,145,939,083	$0	$0
2012	$2,985,167,618	$1,792,814,314	$0	$0
2013	$3,467,521,165	$2,002,407,072	$0	$0
2014	$3,467,521,165	$1,925,391,415	$0	$0
2015	$2,445,616,935	$1,305,734,876	$0	$0
2016	$949,993,126	$487,701,055	$0	$0
2017	$0	$0	$559,114,500	$275,994,640
2018	$0	$0	$564,597,064	$267,981,719
2019	$0	$0	$570,133,389	$260,201,436
2020	$0	$0	$575,724,001	$252,647,037
2021	$76,000,000	$32,068,609	$581,369,434	$245,311,964
2022	$0	$0	$587,070,225	$238,189,850
2023	$0	$0	$592,826,917	$231,274,511
2024	$0	$0	$598,640,058	$224,559,944
2025	$0	$0	$604,510,201	$218,040,321
2026	$76,000,000	$26,358,059	$610,437,906	$211,709,981
2027	$0	$0	$616,423,737	$205,563,429
2028	$0	$0	$622,468,263	$199,595,329
2029	$0	$0	$628,572,061	$193,800,501
2030	$0	$0	$634,735,711	$188,173,913
2031	$76,000,000	$21,664,403	$640,959,801	$182,710,681
2032	$0	$0	$647,244,923	$177,406,062
2033	$0	$0	$653,591,676	$172,255,452
2034	$0	$0	$660,000,664	$167,254,379
2035	$0	$0	$666,472,497	$162,398,501
2036	$76,000,000	$17,806,560	$673,007,791	$157,683,604
2037	$0	$0	$679,607,170	$153,105,594
2038	$0	$0	$686,271,260	$148,660,497
2039	$0	$0	$693,000,697	$144,344,453
2040	$0	$0	$699,796,122	$140,153,717
2041	$76,000,000	$14,635,695	$706,658,181	$136,084,650
2042	$0	$0	$713,587,528	$132,133,720
2043	$0	$0	$720,584,823	$128,297,496
2044	$0	$0	$727,650,732	$124,572,650
2045	$0	$0	$734,785,928	$120,955,946
2046	$76,000,000	$12,029,474	$741,991,090	$117,444,246
2047	$0	$0	$749,266,905	$114,034,500
2048	$0	$0	$756,614,064	$110,723,750
2049	$0	$0	$764,033,269	$107,509,119
2050	$0	$0	$771,525,224	$104,387,819
Total	$25,430,080,201	$15,443,321,236	$22,433,273,814	$6,015,161,411

Source: Parsons Brinckerhoff, 1999.

Appendix A
Benefits from Diversion of Air Travel

INTRODUCTION

We restricted our calculations of nonuser benefits in the aviation sector to airside delay reductions to passengers and aircraft operators at the eight major airports in the California Corridor listed in Table A-1. A review of the other airports in the corridor indicated that even the largest of the remaining airports that are affected by HSR – airports such as Fresno, Bakersfield, and Modesto – were unlikely to face congestion problems in the foreseeable future. Indeed, in the words of an aviation planner at Caltrans, these airports are doing all they can to *increase* patronage. Further, we restricted our attention to the value of airside delay time savings to passengers and aircraft operators. Our estimates do not include savings from reduced ground access congestion at these airports.

Table A- 1. Major California Airports Included in the Calculation of Nonuser Benefits

Burbank-Glendale-Pasadena (BUR)
Los Angeles International (LAX)
San Francisco International (SFO)
John Wayne Airport-Orange County (SNA)
San Diego International – Lindbergh Field (SAN)
San Jose International (SJC)
Ontario International (ONT)
Sacramento International (SMF)
Metropolitan Oakland International (OAK)

METHODOLOGY FOR CALCULATING DELAY SAVINGS

We estimated delay savings as the difference in average air delay at each airport with and without HSR. The value of these delay savings to the remaining passengers using the airports used values-of-time for Californian air passengers

Appendix A
Benefits From Diversion of Air Travel

estimated by CRA as part of our ridership and revenue forecasting work. These values-of-time were $45/hour for business travelers and $33/hour for nonbusiness travelers, both in 1999 dollars. In addition, aircraft operation savings were estimated using $2695/hour for jet aircraft, $825/hour for commuter aircraft and $55/hour for general aviation and military aircraft. These estimates were obtained by inflating to 1999 dollars, estimates used by the Federal Railroad Administration (FRA) in their 1997 HSGT "Commercial Feasibility Study"[44] and subsequently published in Shearin (1997)[45].

We now briefly describe each of the three methods to calculate average annual delays.

1. The Federal Aviation Administration (FAA) Airport Capacity Circular[46] provides graphs that can be used to calculate average annual delay at airports for planning purposes. Estimates of average annual delay were calculated as a function of each airport's *annual service volume* (a measure of capacity) and the *annual demand* at the airport.

2. In their paper titled "The Full Cost of Air Travel in the California Corridor," Levinson and Gillen (1999)[47] calculate delays at airports using the polynomial function:

$$D_i = 0.19 + 2.33\left(\frac{Q}{Q_i}\right)^6$$

where, for a given airport

[44] Federal Railroad Administration *High-Speed Ground Transportation For America*, September 1997.
[45] Gui Shearin "Methodology development for estimating external benefits and costs of high-speed ground transportation in the United States." *Transportation Research Record* 1584. 1997.
[46] Federal Aviation Administration "Airport Capacity and Delay." Advisory Circular. FAA-US DOT January 1995.
[47] Levinson David & Gillen David, "The Full Cost of Air Travel in the California Corridor" Presented at the Annual Meeting of the Transportation Research Board, Washington DC. January 1999.

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D_i=average delay per operation in minutes

Q=number of annual operations

Q_i=annual service volume (operations per year)

The authors estimated this equation from data in the FAA Capacity Circular. This estimate is useful because the Circular does not provide estimates over the whole range of volume to capacity ratios that characterize the eight airports over the entire forecast period out to the year 2050.

3. Volpe Transportation Systems Center econometric estimates. Researchers at the Volpe Transportation Systems Center used 1993 data from the 52 largest airports in the US to estimate an econometric relationship between average delay, demand and airport capacities. This relationship was used to estimate airside delay savings in the 1996 FRA Commercial Feasibility Study.[48] The relationship is as follows:

$$D_i = \exp[-2.158520 + 0.812011 \times \frac{V_i}{C_i}]$$

where, for a given airport

D_i=average delay per operation in minutes

V_i=annual number of operations in thousands

C_i=hourly operational capacity

[48] FRA, op. cit.

Appendix A
Benefits From Diversion of Air Travel

This equation was used by Wilbur Smith Associates in their prior 1996 study of HSR related congestion delay benefits at California airports.[49]

Assumptions about Future Airport Conditions

We used the latest update of the Federal Aviation Administration's Terminal Area Forecasts (FAA 1998[50]) to estimate total operations and passenger volume for each of the airports of interest.

Researchers at the Virginia facilities of MITRETEK maintain estimates of *current* hourly capacity at all significant commercial airports in the country. We used MITRETEK capacity estimates obtained by Volpe Center researchers.[51] Hourly operating capacities were translated into measures of annual service volume (capacities) using tables in the FAA airport advisory circular.

An important question we needed to address in this context was how to forecast airport capacities as far as 50 years into the future. As previous studies have noted (WSA 1996), "most airport master plans are of 10 – 15 year duration and tend not to deal with serious capacity problems that would occur after these dates in the future. Long range technological advances or policy changes tend not to be addressed." We obtained capacity plans for each of the eight airports, some going out to 2020 from the planning sections of the airports themselves, or the aviation planning departments of the regional transportation agencies involved.

Briefly, most airport and regional plans have a time horizon of about 20 years. In that period, three of the airports listed in Table A-1 – Lindbergh Field in San Diego (SAN), Los Angeles International (LAX), and San Francisco International (SFO) – are forecast to face 'unacceptable' levels of congestion at their current capacities. In response to this, efforts are underway at each of these airports to

[49] Wilbur Smith Associates, Flight Transportation Associates, and J. R. Ramos Associates "Cost comparison of mode alternatives: California HSR Economic Impact." Working paper prepared for Intercity High Speed Association. June 20, 1996.
[50] Federal Aviation Administration, "1998 Aviation Capacity Enhancement Plan." Prepared jointly by the FAA Office of System Capacity, JIL Systems and Fu Associates. December 1998.
[51] Estimates provided by Simon Prensky at the Volpe Transportation Systems Center to Charles River Associates. September 1999

enhance airside airport capacity. However, in each of these cases, there is considerable uncertainty in the plans and it is not clear that these capacity enhancement plans will be implemented.

In each case for the plans to succeed a regional consensus is needed that includes diverse community groups, many concerned with noise pollution and environmental issues. Given the level of uncertainty and the institutional hurdles, even the documents issued by the airports themselves forecast 15-20 year time-horizons for the completion of *any* significant capacity enhancements. In view of this highly uncertain institutional environment, we conducted our analysis for two capacity scenarios.

The first scenario assumed that there would be *no* airside capacity enhancements at LAX, SAN or SFO airports. However, though this scenario cannot be dismissed out of hand, given the prevailing institutional environment, it produced levels of delay (at each of the three airports) that were very high and simply unacceptable.

We then analyzed (and report here) the results of a scenario that makes three quite conservative assumptions for purposes of estimating the delay reduction impact of diverting air passenger to HSR. The first assumption is that the three aforementioned airports will successfully implement significant airside capacity increases. We obtained enhanced airside capacity estimates for each of these three airports from the airport's own planning documents. Briefly these, were:

- For SFO we assumed that the runway reconfiguration proposal currently favored by SFO will be implemented. This would increase annual service volumes at SFO from 441,870 operations to 650,600.

- For LAX we assumed that the airside expansion alternative currently favored by LAX management (the so-called Alternative 1) will be implemented. This would increase annual service volumes at LAX from 775,500 operations to 916,500.

- For San Diego's Lindbergh Field, we assumed that the airside enhancement plan based on a new runway currently proposed by the San Diego Unified

Port District would be implemented. This would increase annual service volumes at SAN from 270,270 operations to 337,000.

The second conservative assumption is that we capped *maximum* delays at all airports at 15 minutes per aircraft. The maximum delay reduction savings is therefore much less than this amount. And third, consistent with the assumption made in earlier studies (FRA 1996, WSA 1996, Shearin 1997) we assume "a shift of some flights from airports with unacceptable levels of delay to less congested airports in the region if such capacity is available." Specifically, we assume that there will be a shift of flights from LAX airport to Burbank airport, and from SFO to Oakland airport. In effect, the capacity at the smaller airports is assumed to be interchangeable with capacity at the nearby large hub airport.

This is a conservative assumption because we don't take credit for reducing the costs associated with such shifts. Passengers in a multi-airport system choose the airport that serves their needs best, offers the best combination of access (how easy is it to get to the airport), and service (choice of carriers, fares and frequencies). Airlines in turn influence this choice by the flight schedules they choose to provide at an airport. Airlines' observed choice of schedule and the observed passengers' choice of airport are the result of a complex equilibrium that is influenced by multiple factors and in which airport delays play only a marginal role (Harvey 1987[52]). Thus, if delays at major airports such as SFO force some passengers to fly from Oakland, and airlines who currently concentrate service at SFO distribute their Bay Area offerings between SFO and OAK, there is a net loss of welfare: passengers are unable to take advantage of high frequency SFO service and the connecting opportunities at the SFO hub, and airlines are unable to utilize their airport specific capital and labor as effectively as they would like to. Therefore, ignoring the contribution of HSR to reducing these added costs to air passengers and airlines results in conservative estimates of the nonuser delay reduction benefits of HSR.

[52] Harvey, Greig. 1987. Airport Choice in a Multiple Airport Region. *Transportation Research*. Part A, General. Vol. 21A, no. 6. November.

Appendix A
Benefits From Diversion of Air Travel

Effect on Operations from HSR diversion

HSR is assumed to begin full service on July 1, 2016. Our results assume a ramp-up of ridership in the first two years of operation (85 percent of steady state ridership in the first year and 95 percent in the second year).

Our ridership forecasts provide the number of one way *trips* diverted from air to HSR in each *city pair* market. In metropolitan markets characterized by multiple airports, such as the Los Angeles basin to the San Francisco Bay Area, we apportion trip diversions from an airport-pair in proportion to their current share of the air travel market between the city pair.

To translate these diverted trips to estimates of reductions in airport operations we need information on the kinds of aircraft that will serve California Corridor markets in 2020. We assume the mix of aircraft will change from the present, both in terms of size and propulsion mechanisms. Valuable information on changes in aircraft technology is implicitly provided in the FAA Terminal Area Forecasts (TAF) because of the differential growth rates projected for aircraft operations and passengers. These differential growth rates show that the average number of passengers per aircraft – a statistic that subsumes both changes in load factor and the aircraft size and technology in use – in 2016 (the year the HSR service is expected to be operational) will be 50 percent higher than the corresponding figure for 1997. Also, by the extrapolation of the TAF growth rates, the corresponding estimate for 2050 is 80 percent higher than 1997. Our estimates of delay, with and without HSR assume these significant increases in the average number of passengers per aircraft.

RESULTS

For each airport, Table A-2a presents year 2020 estimates of capacity (annual service volume), demand (operations and enplanements) both with and without HSR, the reduction in average delay at each airport associated with the introduction of the HSR system (and its associated diversions), the value to the remaining air passengers of this reduction in delay, and finally the value of the aircraft operating cost savings from the delay reduction. We used only the minimum of the three sets of delay reductions calculated using the three methods outlined above to estimate the benefits. Table A-2b presents the same calculations for the year 2050.

As Table A-2a shows, in 2020 we estimate almost no delay savings for airports such as Ontario (ONT), and significant savings (about 3.06 minutes per operation) in capacity constrained airports such as San Diego's Lindbergh Field (SAN). The total value of the delay reduction passenger benefits in the year 2020 is estimated to be $341 million in 1999 dollars. The total value of savings in aircraft operating costs is estimated to be $220 million. Table A-2b indicates that increased growth results in significantly higher benefits in the year 2050: $1,198 million for passenger related benefits and $642 million in aircraft operating cost savings (all in 1999 dollars).

Table A-3 presents the estimated present values of the (discounted) passenger benefits and aircraft operating cost savings over the period 2016-2050. The table indicates that passenger delay savings equal $8,528 million (at a discount rate of 4 percent) when discounted to 1999 (all amounts in 1999 dollars). Aircraft operating cost savings equal $4.282 million when discounted to 1999 (all amounts in 1999 dollars). Total benefits are the sum of the passenger and operating cost savings, as shown in the table.

Appendix A
Benefits From Diversion of Air Travel

Table A- 2. Delay Reduction Benefits with Runway Enhancements at LAX, SAN, and SFO with Delay Capped at 15 minutes and Airplane Capacity Increased by 50% in 2016 and 80% in 2050

Table A-2A -- 2020 Summary Information

	Operational Capacity (Annual Service Volume)	**Annual Demand** Operations		Enplanements + Deplanements		Change in Average Delay (Minutes per Operation)	Total Passenger Savings (in millions)	Total Operating Savings (in millions)
		NO HSR	*w/HSR*	*NO HSR*	*w/HSR*			
SNA	557,700	700,180	682,765	18,290,079	16,231,923	0.94	$ 10.42	$ 25.15
BUR/LAX	1,251,120	1,452,556	1,321,635	135,450,592	127,555,417	2.01	$ 173.76	$ 93.38
ONT	484,770	215,533	200,010	13,623,830	11,924,649	0.01	$ 0.05	$ 0.05
SMF	315,000	287,535	255,667	17,534,889	14,665,272	0.68	$ 6.06	$ 5.68
SAN	337,000	400,408	347,385	31,043,801	29,659,774	3.06	$ 60.69	$ 35.80
SFO/OAK	935,600	1,102,924	1,039,262	95,077,347	88,500,135	1.48	$ 88.34	$ 58.61
SJC	540,540	382,529	363,534	25,498,422	23,324,788	0.08	$ 1.23	$ 1.15
						Total Benefits	$ 340.56	$ 219.82

Table A-2B -- 2050 Summary Information

	Operational Capacity (Annual Service Volume)	**Annual Demand** Operations		Enplanements + Deplanements		Change in Average Delay (Minutes per Operation)	Total Passenger Savings (in millions)	Total Operating Savings (in millions)
		NO HSR	*w/HSR*	*NO HSR*	*w/HSR*			
SNA	557,700	982,104	965,717	33,515,611	31,181,217	1.30	$ 26.39	$ 49.00
BUR/LAX	1,251,120	2,084,640	1,960,719	233,089,241	224,121,632	4.10	$ 621.30	$ 281.90
ONT	484,770	292,533	277,968	23,608,561	21,677,225	0.03	$ 0.42	$ 0.28
SMF	315,000	424,543	394,811	31,298,941	28,055,348	3.54	$ 62.81	$ 49.67
SAN	337,000	596,938	551,212	53,454,524	52,033,014	5.55	$ 184.99	$ 103.18
SFO/OAK	935,600	1,473,888	1,415,296	161,647,835	154,271,654	2.82	$ 293.51	$ 152.14
SJC	540,540	512,013	494,203	46,604,120	44,159,568	0.25	$ 8.68	$ 6.07
						Total Benefits	$ 1,198.10	$ 642.24

Average delay without HSR was capped at 15 mins. This affected BUR/LAX, SAN, SFO/OAK and SNA.

[1] LAX Master Plan Comparison of Alternatives; Modification listed as Alternative 1
[2] San Diego Unified Port District AGENDA SHEET pp. 7.
[3] Analysis of SFIA Runway Reconfiguration Impact on Regional Air Transportation Systems. Prepared by P&D Aviation Summary, Section 4, table 4-4.

Airport Enhancements

	Current	Modified
[1] LAX	775,500	916,500
LAX/BUR	1,110,120	1,251,120
[2] SAN	270,270	337,000
[3] SFO	441,870	650,600
SFO/OAK	726,870	935,600

Table A- 3. Delay reduction benefits from HSR diversions. Airport runway capacities at LAX, SFO & SAN enhanced as described in the text. 2016-2050 benefits in millions of 1999 dollars discounted to 1999.

	Passenger savings	Aircraft operating cost savings	Total Benefits
Discounted to 1999 at 4%	$7,764	$4,282	$12,048

Source. Calculations by Charles River Associates, 1999.

Appendix B
Benefits from Reduced Intercity Auto Travel

OVERVIEW

This section describes the procedure used to estimate the nonuser benefits outside the Los Angeles, San Francisco, and San Diego metropolitan areas resulting from the diversion of intercity auto travelers to the HSR system. The benefits calculated in this analysis are derived from three principal sources:

1. Travel time saved by remaining intercity auto travelers due to reduced congestion;

2. The dollar value of accidents (and deaths) saved by intercity auto travelers as a result of the diversion of auto travelers to HSR; and

3. The dollar value of air pollution reductions that occur as a result of the reduced level of auto travel.

The estimation of each of the above categories of benefits is described below.

TIME SAVINGS

Intercity auto travelers who divert to the HSR system will reduce the load on the future intercity highway network. The result is less congestion experienced by the remaining auto travelers. The value of the time saved by remaining auto travelers was therefore computed by estimating the difference in intercity travel times with and without the implementation of the HSR system.

To estimate the future travel times, the intercity highway network in California was first divided into sections or “links”, comprising the highway sections between the city pairs served by the HSR system. Peak hour, peak direction (PDH) traffic flows for 1998 were obtained for representative locations along each of these links from Caltrans, as were hourly traffic counts by hour of the day.

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Benefits From Reduced Intercity Auto Travel

The hourly traffic counts were used to create an hourly distribution of traffic whose highest volume matched the PDH volume. (The PDH volumes are a separate dataset from the hourly traffic counts.).

This hourly distribution of traffic on a given link was then grown to the future years based on the weighted average growth in auto person trips forecast by CRA's auto total travel demand model for all city pair markets passing through that link. Total vehicle trips diverted to HSR in each hour were estimated by applying this same distribution to the average daily vehicle trips diverted to HSR. The annual forecast of auto person trips diverted to HSR was converted to daily vehicle trips by dividing by 365 and by the auto occupancy from CRA's surveys of intercity auto travelers. These auto occupancies are 1.9 and 2.6 persons per vehicle for business and nonbusiness travelers, respectively.

Travel times on each link were estimated by dividing the distance of the link by a travel speed calculated using the following speed-flow function:

$$\text{Speed} = \text{Uncongested Speed} / (1 + 0.2*(\text{Volume/Capacity})^{10})$$

This function is an update to the one originally developed by the Bureau of Public Roads (BPR) and is used by the Metropolitan Transportation Commission, the Metropolitan Planning Organization in the San Francisco Bay Area.[53]

For each forecast year, the function was applied to each link for each hour of the day using the projected vehicle volume with and without HSR, with the difference representing the time savings on that link for that hour. An uncongested speed of 60 miles per hour was assumed for each link. Current capacity at the representative location chosen for each link was obtained from Caltrans. The future capacity was assumed to be equal to the current capacity, with the

[53] For a comparison of these and other speed-flow functions, see Rupinder Singh (Bay Area Metropolitan Transportation Commission), *Improved Speed-Flow Relationships: Application to Transportation Planning Models*, presented at the 7th Transportation Research Board Conference on the Application of Transportation Planning Models, Boston, MA, March 1999.

exception of the following links, for which it was assumed that one additional lane would be added in each direction:[54]

- Between Bakersfield and Visalia on SR-99 (added in 2035);
- Between Modesto and Stockton on SR-99 (added in 2015);
- Between Stockton and Sacramento on I-580 (added in 2015); *and*
- Between Bakersfield and Stockton on I-5 (added in 2015)

The time savings for each hour due to auto trip diversions were then summed to produce the total time savings on each link. The total time savings in each city pair market was computed as the sum of the total time savings for all of the links comprising that city pair market. This total time savings for each city pair was then multiplied by the total number of auto person trips remaining in that market after HSR to obtain the total person-hours saved. This result was then converted to a dollar value using the values of travel time for intercity auto travelers shown in Table B-1, which were derived from the mode choice models used to estimate the diversion of auto trips to HSR in the ridership study.

Table B- 1. Assumed Values of Auto Travel Time ($1999)

Market Segment	Business	Nonbusiness
Short distance (<150 miles)	$20.83	$6.83
Long distance (150 miles or more)	$27.93	$14.88

Source: Charles River Associates, 1996.

The valuations were done separately for business and nonbusiness travelers, by trip length using the respective values shown in the table and separate estimates of

[54] Additional lanes were added on the links with the highest time savings. These capacity increases were targeted to reduce the time savings attributable to HSR, and appear to be (much) more effective in this regard than the future highway projects identified in the California Transportation Commission's 1999 report *Inventory of Ten-Year Funding Needs for California's Transportation Systems*.

Appendix B
Benefits From Reduced Intercity Auto Travel

the number of remaining auto travelers by each trip purpose. These values of time savings for each city pair market were then aggregated across all city pair markets to obtain the total nonuser benefit.

ACCIDENT AND POLLUTION COSTS

The methodology for calculating non-user benefits from reductions in accidents and air pollution is fairly standardized. Typically the cost of these factors is estimated per mile of automobile travel, and this unit cost is multiplied by the reduction in vehicle miles of auto travel (VMT) to estimate the relevant benefits. This technique was employed by the Federal Railroad Administration in its Commercial Feasibility Study for high speed rail in 1997. Estimates of incremental accident and pollution costs have been derived in a number of studies of the "full cost" or "social cost" of transportation modes.[55] The cost factors assumed for the purposes of this study are shown in Table B-2.

Table B- 2. Assumed Factors for Accident and Pollution Costs (Dollars per Vehicle Mile Traveled in $1999)

Category	Cost Factor
Accident Cost	$0.0599
Air Pollution Cost	$0.0079

Source: Levinson, Gillen, Kanafani and Mathieu, "The Full Cost of Intercity Transportation—A Comparison of High Speed Rail, Air and Highway Transportation in California," 1996; adjusted to 1999 dollars by Charles River Associates.

These values were taken from a 1996 study that examined the full cost of intercity travel by automobile in the California Corridor.[56] The study estimated accident

[55] A good review of these studies can be found in James Murphy and Mark Delucchi "A Review of the Literature on the Social Cost of Motor Vehicle Use in the United States," *Journal of Transportation and Statistics*, January 1998.
[56] David Levinson, et al., The Full Cost of Intercity Transportation—A Comparison of High Speed Rail, Air and Highway Transportation in California, University of California at Berkeley, June 1996.

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Benefits From Reduced Intercity Auto Travel

costs by determining the value of life, property, and personal injury per accident and multiplying by the prevailing accident rate to achieved an incremental rate of $0.056 per VMT. The value in Table 2-2 reflects this figure converted to 1999 dollars. This figure equals the value of $0.06 per VMT derived from a nationwide analysis of accident costs by the National Highway Traffic Safety Administration (NHTSA). [57]

The authors of the California study note that because of the exceedingly high safety rates of existing HSR systems, it can be assumed that there is no offsetting accident cost factor for HSR. They note that one should not assume there is absolutely no accident cost, but rather that it is incorporated into the costs to design the HSR system to be safer.[58]

The same California study estimated the incremental air pollution cost in 1996 dollars to be $0.0074 per VMT. (The value in Table B-2 is again converted to 1999 dollars.) In deriving the factor, the study examined the four categories of smog, acid deposition (acid rain), ozone depletion, and global warming.

Total non-user benefits resulting from reduced auto accident and air pollution costs were estimated by multiplying the factors in Table A2-2 by the reduction in VMT resulting from the diversion of auto trips to the high speed rail system. The reduction in VMT was calculated by dividing the number of person trips diverted to HSR in each city pair market by an average auto occupancy factor (to obtain vehicle trips diverted), and then multiplying this result by the associated distance of that city pair. Benefits were then summed across all city pair markets.

RESULTS

The total estimated non-user benefits related to the diversion of intercity highway traffic are shown in Table B-3. The table shows that reduction in highway delay is the most significant source of these benefits, contributing nearly $100 million in

[57] Lawrence Blincoe, National Highway Traffic Safety Administration, *The Economic Cost of Motor Vehicle Crashes*, 1994.
[58] Levinson et al., *op.cit*. pp. 6-17.

Appendix B
Benefits From Reduced Intercity Auto Travel

2020, over half of the total. Benefits due to accident reduction are the next largest category, and pollution costs contribute only about 5 percent of the total.

Table B- 3. Highway-Related Nonuser Benefits for 2020 ($1999)

Category	Total Benefit
Highway Delay	$99,035,117
Accident Cost	$75,436,264
Air Pollution Cost	$9,968,363
Total	$184,439,744

Source: Charles River Associates, 1999.

For purposes of the BCA, the benefits were estimated for each year between the project start up in FY2017 and FY2050. The discounted present value of the benefits is shown in Table B-4, computed at a 4 percent discount rate. The total present value of benefits from highway delay are significantly higher than those from the other categories as these benefits grow at a much faster rate in the years beyond 2020.

Table B- 4. Discounted Present Value of Benefits FY2017-FY2050 ($1999)

Category	4% Discount Rate
Highway Delay	$3,540,019,945
Highway Accident Cost	$780,025,968
Highway Air Pollution	$103,074,860
Total	$4,423,120,773

Source: Charles River Associates, 1999.

Appendix C
Estimating Intercity HSR User Benefits

INTRODUCTION

User benefits from the HSR system are the benefits users obtain from riding the HSR system over and above the amount they actually pay (the fare). Technically, we measure *consumer surplus* or the *net* user benefits from riding the system. This is the difference between the amount a traveler would be willing to pay for the HSR service, and the amount they actually pay to ride the system.

As discussed in Chapter 4, HSR fares have been set in the Business Plan to achieve as much commercial benefit as possible (i.e., to maximize farebox revenue in competition with other modes), while at the same time maximizing as much as possible the user benefits from the service without significant loss of farebox revenue. Fares set in this way maximize the users *consumer surplus*, without significantly reducing the commercial benefit from the system.

METHODOLOGY

For this study, the net change in user benefits (consumer surplus) resulting from the introduction of high speed rail was computed following the now widely-accepted formula developed by Small and Rosen for the derivation of welfare changes with discrete choice models.[59] This formula calculates the net change in welfare due to a price or service change as the *compensating variation*, the amount that travelers would have to be paid after the change to be as well off as they were before the change.[60] Generally, it is expressed as follows:

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[59] Kenneth Small and Harvey Rosen, "Applied Welfare Economics with Discrete Choice Models," *Econometrica*, Vol. 49, No. 1, January 1981.
[60] For a discussion of the application of the Small and Rosen formula see Steven Morrison and Clifford Winston, *The Economic Effects of Airline Deregulation*, (Washington, DC: The Brookings Institution), 1986, pp. 15-21.

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$$CV = -(1/\lambda)\left[\ln \sum_{i=1}^{N} \exp(V_i)\right]_{v_0}^{v_i}$$

where λ is the marginal utility of income, V is the "utility" of mode i, and N is the total number of mode alternatives (the square brackets indicate the difference in the expression before and after the service change). In the current study, the diversion of trips to HSR was calculated separately for each mode-trip purpose combination, using a separate mode choice model. In the same manner we therefore calculated the compensating variation separately for each market segment, as follows:

$$CV_{mktseg} = \frac{U_{existing\ mode_{mktseg}} - \log(e^{U_{existing\ mode_{mktseg}}} + e^{U_{hsr_{mktseg}}})}{\beta_{cost_{mktseg}}}$$

The formula calculates the difference in utility before and after the introduction of HSR for each market segment (existing mode/trip purpose combination), using the mode choice model for that market segment. The utility after the introduction of HSR is calculated as a "composite" utility, measured as the "log sum" of the utilities of HSR and the existing mode.[61] The cost coefficient in the denominator (β_{cost}) represents the negative of the marginal utility of income, the initial term in the Small and Rosen equation.[62] The compensating variation for each market segment is multiplied by the respective diverted HSR passengers in that market segment to obtain the user benefit for that market segment, and these results are summed over all market segments to obtain total user benefits.

This methodology does not calculate benefits experienced by users *induced* to travel on the HSR system (those who would not have traveled were it not for the introduction of HSR). While these travelers would by definition experience an

[61] The log sum is calculated by exponentiating the two terms and then taking the logarithm of their sum. Also referred to as the "maximum average utility", the log sum of the utilities will always be strictly larger than either of the two utilities by themselves. This construction is used because a choice of two alternatives is strictly better than having only one option available.

[62] The cost coefficient measures "utils" per dollar of cost, and is negative because higher fares produce less utility. The marginal utility of income equals the negative of the cost coefficient, so -1 times the marginal utility of income is simply the cost coefficient.

Appendix C
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increase in benefits (otherwise they would not choose to travel), the alternative against which their utility must be measured is whatever activity they would have pursued instead of making their respective journeys. This is very difficult to estimate, particularly given the number of alternatives involved and it is therefore (conservatively) excluded from the calculation. However, the number of induced HSR travelers is relatively small compared to those diverted from existing travel on other modes.

RESULTS

Table C-1 shows the estimated net change in consumer surplus produced by the introduction of high speed rail, calculated as described above for the year 2020.

Table C- 1. Net Change in Intercity User Benefits (Consumer Surplus) for 2020 ($1999)

Basis	Value of Intercity User Benefits
Total	$767,585,581
Per Diverted HSR Rider	$34.46

Source: Charles River Associates, 1999.

It is interesting to note that these user benefits are quite large. The $767 million annual benefit in 2020 is almost as large as the passenger revenue from the system of $888 million dollars.

For purposes of the cost/benefit analysis, user benefits were estimated for each year between the project start up in FY2017 and FY2050. The discounted present value of the benefits is shown in Table C-2, computed with a 4 percent discount rate.

Appendix C
Estimating Intercity HSR User Benefits

Table C- 2. Discounted Present Value of User Benefits FY2017-FY2050 ($1999)

Discount Rate	Total User Benefit
4%	$8,518,652,569

Source: Charles River Associates, 1999.