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To: Project Management Team
Bay Area Regional Airport System Plan Analysis Update

From: Geoff Gosling

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Subject: **High-Speed Rail Scenario Passenger Diversion**

This memo documents the assessment of the potential future diversion of air passengers at the Bay Area airports to the planned California high-speed rail (HSR) system. The High-Speed Rail Scenario forms one of several system development scenarios defined for the Target Analysis undertaken as part of the mid-point scenario screening in the current phase of the Bay Area Regional Airport System Plan Analysis (RASPA) update. This scenario has the potential to reduce the number of passenger airline flights at each Bay Area airport compared to the Baseline scenario (which does not consider the effect of high-speed rail service on future travel growth) as some intra-California air passengers select HSR over airline service due to factors such as closer proximity of stations to their final destinations, train fares, train frequency, reliability of service, etc.

General Approach to Estimating Diversion of Air Passengers to High-Speed Rail

The estimated diversion of air trips to HSR is based on the forecasts of future ridership on the planned California HSR system prepared for the California High-Speed Rail Authority (CHSRA) and the Metropolitan Transportation Commission (MTC) by Cambridge Systematics, Inc. No independent estimates of potential HSR ridership have been developed as part of the RASPA update. These forecasts are generally presented in terms of travel in inter-regional markets within the state based on fairly large regional areas, such as the Bay Area. These inter-regional forecasts then have to be adjusted to come up with the number of air passengers diverted to HSR at each of the three primary Bay Area commercial service airports.

The forecasts of future HSR ridership prepared for the CHSRA and MTC were based on an inter-regional travel demand model that projected future inter-regional trips within California by four modes: automobile, air, conventional rail, and high-speed rail (for cases where HSR service is available). By comparing the forecast number of air trips in the No-Build case (no HSR service available) in a given market with the corresponding forecast for a scenario that assumes some level of HSR service, the forecast percentage diversion of air travel to HSR in that market can be calculated. This diversion rate was then applied to the demand forecast for intra-California air travel in the relevant market prepared as part of the RASPA update study.

Since the forecasts of air trips in a given inter-regional market prepared as part of the HSR ridership forecasts did not identify which airport those air passengers used, only that they used air travel, it was necessary to make assumptions about the way in which the overall diversion rate for the Bay Area as a whole varied across the three primary airports in the region.

Recent Forecasts of Future High-Speed Rail Ridership

The most recent forecasts of future HSR ridership were released by the CHSRA in a report to the California Legislature in December 2009.[1] These forecasts differed from earlier forecasts prepared in 2007 as part of a study undertaken for the Metropolitan Transportation Commission and the CHSRA[2] in three important respects:

- The forecast ridership and associated revenue assumed implementation of the Initial Phase of the planned California HSR system rather than the full system on which the earlier forecasts were based.
- The forecasts projected ridership in 2035, rather than 2030 used in the earlier forecasts.
- The forecasts assumed that HSR fares would be set to 83% of the comparable airfares, rather than 50% assumed in the earlier forecasts.

In addition, the results of the revised forecasts presented in the *Report to the Legislature* only provide forecasts of HSR ridership, not the corresponding use of other modes, and are at a somewhat more aggregate zonal level of detail than the summary results of the earlier forecasts prepared in 2007 that had been provided to the RASPA study team by Cambridge Systematics in the form of Microsoft Excel files. It was therefore necessary to use the more detailed results of the earlier forecasts to subdivide the latest forecasts of HSR ridership into a more detailed set of zones and estimate the corresponding use of other modes.

The Initial Phase of the planned HSR system comprises the route from San Francisco through the San Joaquin Valley to the Los Angeles basin, terminating at Anaheim, as shown in Figure 1. The latest ridership forecasts are based on a route alignment between the Bay Area and the Central Valley that uses the Pacheco Pass to the east of Gilroy. However, the CHSRA is currently addressing several environmental issues with this alignment as a result of a recent court case. This phase does not include the planned route between Merced and Sacramento or the planned route from Los Angeles to San Diego that were included in the full system analyzed in the 2007 *Ridership and Revenue Forecasting Study*. The implementation schedule presented in the December 2009 *Report to the Legislature* envisages that the Initial Phase will be operational by 2020. No dates have been established for completion of the subsequent sections of the planned HSR system shown in Figure 2.

The CHSRA's decision to base the revised ridership and revenue forecasts on assumed HSR fares of 83% of the corresponding airfares was based on an analysis that suggested that this fare level would generate the greatest revenue relative to operating costs. Although ridership would of course be less at the higher fare levels, the higher fares would largely offset the loss of revenue due to the lower ridership and the operating costs would be reduced by the need to carry fewer passengers.

[1] California High-Speed Rail Authority, *Report to the Legislature*, Sacramento, California, December 2009.

[2] Cambridge Systematics, Inc., *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study: Ridership and Revenue Forecasts*, Prepared for the Metropolitan Transportation Commission and the California High-Speed Rail Authority, Oakland, California, Draft Report, August 2007.

Source: CHSRA, *Report to the Legislature*, December 2009, p.5.

Figure 1. Initial Phase of the Planned California High-Speed Rail System and Potential Station Locations

The forecast ridership by major market pairs is shown in Table 1. CHSRA projects a total ridership in 2035 of 41 million passengers, of which 11.9 million (or 29%) will be local intra-regional trips within either the Bay Area or the Los Angeles (LA) basin. Of the remaining 29.1 million interregional trips, the largest single market is between the Bay Area and the Los Angeles basin, which accounts for 7.9 million trips, or 19% of the total ridership. The market between the Bay Area and the San Diego region is projected to account for 2.0 million annual trips, or 25% of the ridership between the Bay Area and the Los Angeles basin. During the Initial Phase of the planned system, HSR riders from the San Diego area would have to use a car or conventional rail service to access the Anaheim station.

Despite somewhat long access distances from both regions to HSR stations, CHSRA forecasts 2.9 million annual HSR trips between the Monterey Bay and Central Coast regions and the Bay Area and Los Angeles basin.

Source: CHSRA, *Report to the Legislature*, December 2009, p.5.

Figure 2. Subsequent Sections of the Planned California High-Speed Rail System

Table 1. Ridership and Revenues by Market, Initial Phase, 2035, Fares 83% of Air

Market Pairs (Ultimate trip ends)	Riders (millions)	Revenues (millions, 2009$$)
LA Basin – Bay Area, with intermediate markets	**23.4**	**$2,095**
LA Basin- Bay Area	*7.9*	*$900*
San Joaquin Valley - LA Basin	*6.3*	*$467*
Bay Area - San Joaquin Valley	*5.8*	*$458*
Monterey Bay /Central Coast - LA Basin & Bay Area	*2.9*	*$238*
Within San Joaquin Valley	*0.5*	*$32*
San Diego region - Bay Area	2.0	$234
LA basin – Sacramento region	1.2	$143
Other Inter-regional	1.5	$86
North & Sierra regions - LA Basin	0.5	$43
Sacramento region - San Joaquin Valley	0.5	$42
Inter-regional subtotal	***29.1***	***$2,643***
within LA basin	7.9	$152
within Bay Area Peninsula	4.0	$76
Local within-region subtotal	***11.9***	***$228***
Total Initial Phase	**41.0**	**$2,871**
Source: High-Speed Rail Authority Program Management Team, 2009		

Source: CHSRA, *Report to the Legislature*, December 2009, Table C.

Because of the uncertainty of when the subsequent sections of the planned HSR system will become operational, it has been assumed that only the Initial Phase will be operational by 2035. Even if these subsequent sections become operational before 2035, they would have a relatively small impact on the diversion of Bay Area air trips to HSR, since the major market between the Bay Area and the Los Angeles basin is fairly well served by the Initial Phase. It can be expected that the HSR market share for travel between the Bay Area and the San Diego region would increase, as well as that for travel between the Bay Area and the eastern part of the Los Angeles basin served by the route from Los Angeles to San Diego. However, it is likely that the resulting change in the number of trips diverted from air to HSR would be fairly small, since these markets are much smaller than the Los Angeles basin market that is already well served by the Initial Phase and some diversion to HSR to/from these markets has already been included in the ridership forecasts for the Initial Phase.

Estimating Diversion from Air Travel to High-Speed Rail

The methodology used by Cambridge Systematics, Inc., to forecast HSR ridership did not explicitly model diversion from air or other modes to HSR. Rather, a statewide Interregional Travel Model System (ITMS) was used to project travel by all modes between zone pairs in a system of travel analysis zones covering the entire state. The trips between any zone pair were calculated using trip generation and trip distribution relationships that were estimated from household travel survey data. This resulted in a zone-to-zone trip table that differentiated trips by four trip purposes: business, commute, recreational, and other trips. Then a mode choice model was used to assign inter-regional trips to four primary travel modes: car, air, conventional rail, and high-speed rail (depending on whether conventional rail service is available for a given zone pair, and whether high-speed rail is included in the analysis scenario). The mode choice model was estimated on a combination of revealed preference and stated preference travel survey data. The ITMS was calibrated for trips involving car, air or conventional rail using travel data for the year 2000. The details of the ITMS have been documented in reports prepared for the 2007 Ridership and Revenue Forecasting Study.[3,4]

Intra-regional trips within the Bay Area and Southern California were not modeled using the ITMS. Instead, the existing regional travel models developed and maintained by the Metropolitan Transportation Commission and the Southern California Association of Governments were used to forecast intra-regional HSR ridership by adding the planned HSR service to the modes available in the regional models. Of course, none of the intra-regional trips involve air travel, so these trips do not affect the diversion from air to HSR.

Although the ITMS does not explicitly model the diversion of air trips to HSR, the diversion rate for each major market can be inferred by comparing the number of air trips

[3] Cambridge Systematics, Inc., with Mark Bradley Research and Consulting, *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study: Interregional Model System Development*, Prepared for the Metropolitan Transportation Commission and the California High-Speed Rail Authority, Oakland, California, Draft Report, August 2006.

[4] Cambridge Systematics, Inc., *et al.*, *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study: Draft Final Report*, Prepared for the Metropolitan Transportation Commission and the California High-Speed Rail Authority, Oakland, California, July 2007.

forecast by the ITMS for the No-Build scenario with the corresponding number of air trips in the relevant HSR scenario. This diversion rate can then be applied to the forecast number of air trips in the major market (e.g., Bay Area to LA Basin) in the RASPA Base Case forecast to estimate the potential Bay Area diversion to HSR in that market. In considering the results of applying this approach, there are a number of factors that should be borne in mind:

1. The results of the ITMS show the mode use for a given zone pair, without considering which airports were used by air trips between the zone pair. Thus air trips between Modesto and Los Angeles (for example) would be reported as travel between the Central Valley and the Los Angeles basin, although the travelers might actually have used one of the Bay Area airports.
2. For the same reason, the allocation of air trips to and from the Bay Area to the Bay Area airports has to be done outside of the ITMS results.
3. The RASPA Base Case forecast does not explicitly project future regional air travel in a given market by airport. Rather it forecasts the growth in total regional air travel in a given market. It is therefore necessary to estimate how this regional demand will be distributed among the airports in order to calculate the HSR diversion rate by airport.
4. The RASPA Base Case forecast does not explicitly project future regional air travel in a given market by trip purpose. Therefore it is implicitly assumed that the trip purpose composition of travel in a given market in the RASPA Base Case forecast is the same as that given for air trips in the ITMS.

The December 2009 *Report to the Legislature* includes a discussion of the ridership forecasting methodology but does not provide a more detailed zonal breakdown of the forecast ridership shown in Table 1 or the forecast use of other modes that corresponds to the forecast HSR ridership. However, in September 2009, Cambridge Systematics provided a number of Microsoft Excel files summarizing the details of various earlier forecasts, and we have used this information to develop our HSR diversion estimates. The forecasts that we have relied on for this analysis include:

- A 2030 No-Build scenario.
- A 2030 HSR alternative scenario for the full system using the Pacheco Pass route with HSR fares assumed at 50% of corresponding airfares.
- A 2035 HSR alternative scenario for the Initial Phase using the Pacheco Pass route with HSR fares assumed at 50% of corresponding airfares. The analysis for this scenario appears to have been done subsequent to the earlier work for the 2030 scenarios, but still does not address the change in fare assumptions in the 2009 *Report to the Legislature*.

The Excel files provided more geographic detail than the latest forecasts shown in Table 1 above. In particular, they subdivided the Los Angeles Basin into two regions, North LA Basin and South LA Basin, and the files for the 2030 No-Build Scenario and the 2030 full system HSR alternative provided separate results for travel between each of the regions. This allowed the HSR trips shown in Table 1 to be subdivided into the following sub-regional markets:

- Bay Area to LA Basin (North)
- Bay Area to LA Basin (South)
- Monterey Bay to San Joaquin Valley
- Monterey Bay to LA Basin (North)
- Monterey Bay to LA Basin (South)
- Monterey Bay to San Diego
- San Joaquin Valley (North) to LA Basin (North)
- San Joaquin Valley (North) to LA Basin (South)
- San Joaquin Valley (North) to San Diego.

The division of the San Joaquin Valley to the LA Basin and San Diego regional markets into the separate sub-regional markets of San Joaquin Valley (North) comprising San Joaquin, Stanislaus and Merced counties and San Joaquin Valley (South) comprising the remainder of the valley, allows the air passenger diversion analysis to reflect the potential use of the Bay Area airports by trips to Southern California from counties in the north of the valley. Trips to Southern California from the counties in the south of the valley are unlikely to travel north to the Bay Area in order to take flights back south to airports in Southern California. Rather those trips to Southern California using air from these counties will fly from the airports in the valley.

The use of the other modes (including air) in each of the regional markets in the 2035 scenario that assumed HSR fares at 83% of airfares (for which forecasts of the use of other modes was not provided) was estimated from the proportional use of those modes in the 2035 scenario that assumed HSR fares at 50% of airfares (for which the forecast use of other modes *was* given). Since the relative service levels of the other modes are unaffected by the HSR fares, it can be expected that their proportional use relative to all non-HSR trips in each market will remain unchanged.

Since the sub-regional markets are not shown in Table 1, the number of HSR trips in each of those markets in 2035 was estimated from the 2030 full system HSR alternative by assuming that the percentage of HSR trips in a given regional market in each of the component sub-regional markets in 2035 remains the same as the percentages of 2030 HSR trips in the corresponding sub-regional markets. The HSR service in the Initial Phase and the full system is essentially the same for each of the sub-regional markets listed above with the exception of San Joaquin Valley (North) and Monterey Bay to San Diego, so it seems reasonable that the 2035 HSR trips in the various sub-regional markets apart from these two sub-regional markets would retain the same proportions as in 2030 for the full system at the lower fare level. Similarly, although the HSR service in the Initial Phase and the full system is different for the regional market between the San Joaquin Valley and San Diego, it seems likely that the difference would have a similar effect on HSR ridership in the San Joaquin Valley (North) and San Joaquin Valley (South) to San Diego sub-regional markets. Therefore it seems reasonable to assume that the percentage of HSR trips in the two sub-regional markets would be the same in the 2035 and 2030 scenarios.

The sub-regional market between Monterey Bay and San Diego is a more complicated situation because the forecast HSR ridership in the regional market between Monterey Bay/Central Coast and San Diego is not shown in Table 1, but is included in "Other inter-regional" markets. Therefore the 2035 HSR trips for the Monterey Bay to San Diego sub-regional market were estimated by assuming that the HSR share of total trips by all modes would change from the share in 2030 for the full system in proportion to the corresponding change in the HSR share for the Bay Area to San Diego, while the total number of trips between Monterey Bay and San Diego in 2035 would increase from the 2030 No-Build Scenario in proportion to the growth in total statewide inter-regional trips from 2030 to 2035, where the total number of inter-regional trips in 2035 was given by the 2035 scenario that assumed HSR fares at 50% of airfares.

Similarly, for each of the sub-regional markets (not shown in Table 1) the number of trips by other modes (including air) in 2035 with HSR fares assumed at 83% of airfares was estimated from the proportional use of those modes in the 2030 full system scenario with HSR fares assumed at 50% of airfares, since the relative service levels of the other modes are unaffected by the HSR fares or the extent of the HSR system. This gave estimates of the number of air trips in each market and sub-regional market in 2035 for the Initial Phase with HSR fares assumed at 83% of airfares. Hence the HSR diversion in each market was calculated by comparing the number of air trips in the 2035 Initial Phase scenario with the number of air trips in the 2030 No-Build Scenario extrapolated to 2035 by assuming that the mode use in each market remained constant and the total trips in each market increased in proportion to the growth in total inter-regional trips from 2030 to 2035.

This gave the following percentage diversion of air trips to HSR for each market in 2035:

- Bay Area to San Joaquin Valley 54.4%
- Bay Area to LA Basin (North) 63.1%
- Bay Area to LA Basin (South) 53.4%
- Bay Area to San Diego 19.0%
- Monterey Bay to San Joaquin Valley 44.4%
- Monterey Bay to LA Basin (North) 37.9%
- Monterey Bay to LA Basin (South) 21.3%
- Monterey Bay to San Diego 7.8%
- San Joaquin Valley (North) to LA Basin (North) 25.2%

- San Joaquin Valley (North) to LA Basin (South) 18.8%
- San Joaquin Valley (North) to San Diego 1.4%

<u>External Markets</u>

Air travel to and from the Bay Area airports includes trips from origins or to destinations in the Bay Area as well as trips that begin or end at counties outside the Bay Area but use ground transportation to travel to or from the airports. From the perspective of diversion of Bay Area air trips to HSR, the two external regions of particular concern are the Monterey Bay region, comprising Monterey, San Benito and Santa Cruz counties, and the three counties that form the North San Joaquin Valley region (San Joaquin, Stanislaus and Merced). Given the level of air service between Sacramento International Airport and airports in Southern California it is unlikely that many air travelers between the Sacramento region and markets served by the planned HSR system would use Bay Area airports. Both the Monterey Bay and North San Joaquin Valley regions will be served by HSR in the Initial Phase, with trips to and from the Monterey Bay region having fairly good access to the HSR system at Gilroy, south of San Jose, and trips to and from the North San Joaquin Valley region having fairly good access to the Initial Phase of the HSR system at Merced. In each case, the HSR stations will be significantly closer than any of the Bay Area airports. Therefore air trips from these regions that would otherwise use the Bay Area airports (due to limited air service to Southern California airports at Monterey Peninsula Airport or the North San Joaquin Valley airports or lower airfares in these markets at Bay Area airports) are likely to experience significant diversion to HSR.

For both the Monterey Bay and North San Joaquin Valley regions, air trips to and from the LA Basin and San Diego can use one of three options:

- Flights between the local airport and Los Angeles International Airport (LAX), with possibly a connecting flight at LAX
- Flights between the local airport and San Francisco International Airport (SFO) with a connecting flight to or from an airport in Southern California
- Ground travel to and from one the Bay Area airports (generally SFO and San Jose International Airport (SJC) for the Monterey Bay region and all three Bay Area airports for the North San Joaquin Valley region).

There is likely to be less use of connecting flights at SFO for travel to or from Southern California than direct flights to LAX, since each of the local airports in the external regions generally has as good air service to LAX as to SFO, so the use of SFO would often involve significantly longer travel time. However, the choice of a connecting route depends on more factors than just the travel time, including the available airfares on the different routes, seat availability on particular flights, and how well the flight schedules match the desired departure time. Thus situations will arise in which air travelers may choose to take a longer route. In cases where the trip end in Southern California is better served by another airport than LAX, there may be little difference in overall travel time between connecting at SFO or LAX, and indeed some Southern California airports may not have air service to and from LAX.

Determining the split of air trips between the above three options would ideally involve a fairly detailed model of air service economics and airport choice, although such an analysis is beyond the scope of the current study. Therefore it was necessary to make assumptions about the proportion of trips using each of the three options, as shown in Table 2. Although these assumptions are essentially educated guesses, the overall level of air travel to and from the external regions is so small that even significant errors in the assumptions would have very little effect on the forecast number of air passengers at Bay Area airports likely to be diverted to HSR.

Table 2. Assumed Use of Bay Area Airports by Air Trips from External Regions, 2020 and 2035

Market	Use of Bay Area Airports		To/from or Connect via LAX
	Ground Access/Egress	Connect via SFO	
Monterey Bay – San Joaquin Valley	20%	20%	60%
Monterey Bay – LA Basin (North)	40%	20%	40%
Monterey Bay – LA Basin (South)	40%	25%	35%
Monterey Bay – San Diego	45%	25%	30%
San Joaquin Valley (North) – LA Basin (North)	40%	20%	40%
San Joaquin Valley (North) – LA Basin (South)	40%	25%	35%
San Joaquin Valley (North) – San Diego	45%	25%	30%

These assumptions reflect the shorter travel times for direct flights to LAX or connecting flights through LAX compared to connecting flights through SFO. It is unlikely that trips between the Monterey Bay region and the north of the San Joaquin Valley would use air travel, so most air trips in this market would be to the south of the valley, where connecting flights through LAX would involve significantly shorter travel times than through SFO. It is also unlikely that travelers between either of the two external regions and the LA basin would take connecting flights at LAX to other airports. Therefore many such travelers might find direct flights between one of the Bay Area airports and one of the secondary airports in the LA basin more convenient than the longer access and egress times to and from LAX. Similarly, direct flights between one of the Bay Area airports and San Diego would offer an even greater time advantage than for trips to and from the south of the LA basin.

Combined Diversion of Bay Area and External Trips to High-Speed Rail

The Bay Area air trips projected by the HSR ridership forecasts prepared for the CHSRA only include trips beginning or ending in the nine-county Bay Area. Therefore to project the diversion to HSR of air trips using the Bay Area airports, it is necessary to combine the forecast air trips to and from the Bay Area with the air trips to and from external markets that use ground transportation to access one of the Bay Area airports or their final destination in the external region (a much smaller universe of air passengers, but nevertheless there would be an effect on the overall Bay Area diversion to HSR, as shown below).

Because the trips from the external regions generally had a lower percentage diversion to HSR than trips to and from the Bay Area, this reduced the overall percentage diversion of air trips in the California Corridor between the Bay Area airports and Southern California in 2035 as follows:

- Bay Area airports to LA Basin (North) 60.1%
- Bay Area airports to LA Basin (South) 46.5%
- Bay Area airports to San Diego 18.8%

Diversion of Connecting Passengers

In addition to the diversion to HSR of air passengers to and from Southern California from the Monterey Bay and North San Joaquin Valley external regions who would otherwise connect at SFO, air passengers from the Monterey Peninsula Airport or airports in the San Joaquin Valley who are connecting at SFO to or from flights in other markets could use the HSR system to travel to and from SFO, thereby reducing the number of passengers on the regional airline flights between those external airports and SFO. This potential use of the HSR system does not appear to have been considered in the ridership forecasts prepared for the CHSRA.

Any such diversion to HSR would depend on the airline fare structure for connecting traffic, as well as such factors as the availability of through ticketing on the HSR services. Obviously, if the airfare charged for an itinerary on a connecting flight from an external airport is not significantly different from the airfare to the same destination from SFO, there will be no incentive to use HSR to access SFO. However, the airlines could reduce their costs of operating connecting flights to and from the external airports while retaining the fare revenue for the remainder of the connecting itineraries by adopting fare policies that encourage the use of HSR to access SFO or SJC. Potential diversion percentages were estimated under the assumption that the HSR fare would be 83% of the incremental airfare for the local connecting segment. The diversion percentage for connecting trips that would otherwise use the San Joaquin Valley airports was assumed the same as for other trips between the Bay Area and San Joaquin Valley. The diversion percentage for Monterey Peninsula Airport was set to half of the diversion rate for the San Joaquin Valley airports, due to the greater distance needed to access the HSR service from the Monterey Bay region.

This gave the reduction in connecting passengers at SFO shown in Table 3.

Table 3. Potential Reduction in Connecting Passengers at SFO in 2035

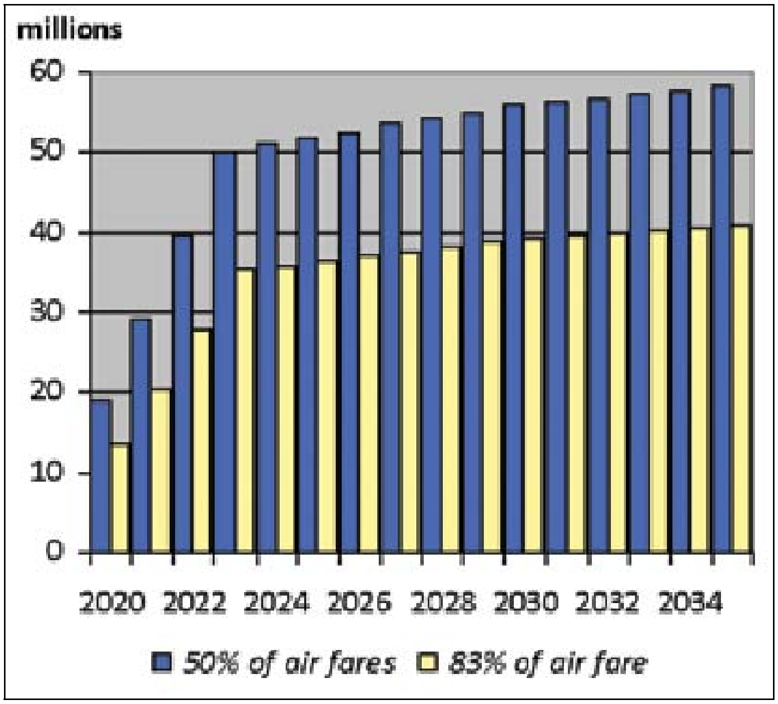
Market/Airport	Connecting Passengers	Diversion to HSR	Diverted HSR Trips	Remaining Air Trips
Domestic Trips				
Bakersfield	37,000	54.4%	20,000	17,000
Fresno-Yosemite	95,000	54.4%	52,000	43,000
Modesto	98,000	54.4%	53,000	45,000
Monterey Peninsula	110,000	27.7%	30,000	80,000
Total	339,000		155,000	184,000
International Trips				
Bakersfield	6,000	54.4%	3,000	3,000
Fresno-Yosemite	47,000	54.4%	25,000	21,000
Modesto	9,000	54.4%	5,000	4,000
Monterey Peninsula	21,000	27.7%	6,000	15,000
Total	83,000		39,000	43,000
Total	422,000		194,000	228,000

Note: Totals may not sum due to rounding

Diversion to High-Speed Rail in 2020

It can be expected that the diversion of air trips to HSR will be much less in the first few years after HSR service begins than in later years. The RASPA Base Case forecast provides regional market-level forecasts of future air passengers for 2020 and 2035. As it happens, 2020 is also the first year of service on the complete Initial Phase of the HSR system according to the implementation schedule given in the CHSRA December 2009 *Report to the Legislature*.

The *Report to the Legislature* forecasts the growth in total HSR riders by year from 2020, as shown in Figure 3. The growth in total ridership from year to year has been estimated from start-up experience with other high-speed rail systems elsewhere in the world. This gives a total ridership of 13.5 million passengers in 2020 and 41.0 million passengers in 2035. Thus it is not possible to derive a different distribution of HSR riders by market for earlier years than 2035, and it has been assumed that the HSR diversion rates for 2035 by market are simply reduced in proportion to the projected total HSR ridership for earlier years.



Source: CHSRA, *Report to the Legislature*, December 2009, Figure 1, p.71.

Figure 3. Forecast Growth in California High-Speed Rail Riders Over Time

Diversion to High-Speed Rail by Airport

The above HSR diversion analysis by market considers the Bay Area as a single region. Thus there are two aspects to calculating the diversion of air trips to HSR for each of the Bay Area airports:

1. Projecting the share of total regional traffic in a given market that will be handled by each airport (e.g., SFO to LAX, SJC to LAX, etc.)
2. Estimating the HSR diversion rate in a given market at each airport (e.g., the percentage of air passengers in the SFO-LAX market diverted to HSR).

In assessing the number of air passengers in a given airport-pair market that could potentially be diverted to HSR, with the exception of the connecting passengers at SFO from the external airports served by the HSR system discussed above it is assumed that only those passengers beginning and ending their air trip at the airports in question would consider using HSR. These are usually referred to as origin-destination (O&D) passengers.

The assumed distribution among the three primary Bay Area airports of the forecast 2035 O&D passenger traffic between the Bay Area and a given airport in Southern California was derived from a review of recent trends in market share between the three airports and the associated airline service changes. The resulting assumptions are necessarily based on professional judgment, recognizing that it is very difficult to predict future airline decisions, as history has evidenced. In some cases the recent trends were assumed to continue or stabilize. In other cases they were assumed to reverse as recent cuts in air service are restored in the future or current airline competition for market share abates. The airport market shares shown in Table 4 were derived on the basis of the following assumptions:

1. The recent growth in the SFO share of traffic in the LAX market due to intense airline competition and the entry of new carriers was assumed to reverse to the regional shares for each airport experienced in 2007.
2. The recent growth in the SFO share of traffic in the Orange County Airport (SNA) market was assumed to continue to just short of an equal share with OAK and SJC.
3. The recent decline in the SFO share of traffic in the Burbank Airport (BUR) market was assumed to reverse, with a growth in the SFO share to approximately twice the share experienced in 2006, while the recent growth in the SJC share of the regional traffic was assumed to continue to a level slightly higher than the share experienced in 2008.
4. The recent decline in the SFO share of traffic in the Ontario International Airport (ONT) market was assumed to reverse, with a growth in the SFO share to slightly more than twice the share experienced in 2006, while the SJC share of the regional traffic was assumed to stabilize at a level around that experienced in 2008.
5. The recent growth in the SFO and SJC shares of traffic in the Long Beach Airport (LGB) market was assumed to continue, with SFO reaching the same share as OAK and the SJC share stabilizing at a level slightly below the OAK and SFO shares.
6. SFO would continue to dominate the Palm Springs Airport (PSP) market, but the recent growth in the SJC share of the market was assumed to continue, to reach a level about 50% above the level in 2009, while the recent decline in the OAK share of the market was assumed to reverse and grow to a level equal to the SJC share of the market in 2009.
7. The recent growth in the SFO share of the San Diego International Airport (SAN) market was assumed to reverse and stabilize at the level experienced in 2008, with OAK and SJC experiencing equal shares.

Identifying an appropriate HSR diversion rate for a given airport pair needs to consider any differences in the diversion rate between airports in the Bay Area as well as the relevant Southern California market diversion rate to use, where each of the Southern California airports was assigned to the appropriate sub-region (North LA Basin, South LA Basin or San Diego) and the diversion rate for that sub-regional market assigned to that airport. It was assumed that airport pair markets involving BUR and LAX would experience the diversion rate for the North

LA Basin market, while those involving SNA and LGB would experience the diversion rate for the South LA Basin market. Airport pair markets involving ONT and PSP were assumed to experience the same diversion rate as the San Diego market, due to the relatively long access distances to the HSR stations in the Initial Phase. It was further assumed that the diversion rate in a given market at OAK would be 75% of the corresponding diversion rate at SFO and SJC, due to the greater distance of the primary OAK market area from the planned HSR stations. Since the overall regional diversion rate in a given market (e.g., the Bay Area to LAX) depends on the diversion rate at each airport as well as the market share of each airport, the diversion rates at each airport were calculated to maintain the desired relationship between the diversion rates at each airport while ensuring that the overall regional diversion rate was correct.

Table 4. Assumed Distribution of California Corridor Traffic Among the Bay Area Airports, 2020 and 2035

Airport Market		OAK	SFO	SJC
LAX	Los Angeles International	35%	40%	25%
SNA	Orange County	34%	32%	34%
BUR	Burbank	45%	20%	35%
ONT	Ontario International	45%	20%	35%
LGB	Long Beach	35%	35%	30%
PSP	Palm Springs	10%	75%	15%
SAN	San Diego International	30%	40%	30%

Combining the two considerations (the regional share of the traffic in each airport-pair market handled by each of the Bay Area airports and the diversion rate to HSR in each of these markets) gave the resulting 2035 diversion rate by airport-pair market shown in Table 5.

Table 5. 2035 Diversion to High-Speed Rail by Market
HSR Initial Phase, Fares 83% of Corresponding Airfares

Airport Market		OAK	SFO	SJC
LAX	Los Angeles International	49.4%	65.8%	65.8%
SNA	Orange County	38.1%	50.8%	50.8%
BUR	Burbank	50.8%	67.7%	67.7%
ONT	Ontario International	15.9%	21.2%	21.2%
LGB	Long Beach	38.2%	50.9%	50.9%
PSP	Palm Springs	14.5%	19.3%	19.3%
SAN	San Diego International	15.3%	20.3%	20.3%

The corresponding diversion rates for 2020 are shown in Table 6, assuming that the number of air trips diverted to HSR in each market is reduced in proportion to the reduction in total HSR trips compared to 2035.

Table 6. 2020 Diversion to High-Speed Rail by Market
HSR Initial Phase, Fares 83% of Corresponding Airfares

Airport Market		OAK	SFO	SJC
LAX	Los Angeles International	16.3%	21.7%	21.7%
SNA	Orange County	12.5%	16.7%	16.7%
BUR	Burbank	16.7%	22.3%	22.3%
ONT	Ontario International	5.2%	7.0%	7.0%
LGB	Long Beach	12.6%	16.8%	16.8%
PSP	Palm Springs	4.8%	6.4%	6.4%
SAN	San Diego International	5.1%	6.8%	6.8%

Resulting Diversion to High-Speed Rail by Airport

Applying the assumed distribution of California Corridor traffic among the Bay Area airports by airport-pair market (Table 4) to the forecast passenger traffic in each market at a regional level from the RASPA Base Case forecast gives the projected passenger traffic in each airport-pair market in 2020 and 2035 shown in Tables 7 and 8.

Table 7. Base Case 2020 Forecast Passengers by California Corridor Market

Airport Market		OAK	SFO	SJC	Total
LAX	Los Angeles International	1,291,000	1,476,000	922,000	3,690,000
SNA	Orange County	713,000	671,000	713,000	2,097,000
BUR	Burbank	780,000	347,000	607,000	1,734,000
ONT	Ontario International	505,000	224,000	393,000	1,122,000
LGB	Long Beach	166,000	166,000	142,000	474,000
		3,456,000	2,884,000	2,777,000	9,117,000
PSP	Palm Springs	21,000	156,000	31,000	208,000
SAN	San Diego International	886,000	1,182,000	886,000	2,955,000
	Total	4,363,000	4,222,000	3,695,000	12,280,000

Note: Totals may not sum due to rounding

Table 8. Base Case 2035 Forecast Passengers by California Corridor Market

Airport Market		OAK	SFO	SJC	Total
LAX	Los Angeles International	1,463,000	1,671,000	1,045,000	4,179,000
SNA	Orange County	840,000	790,000	840,000	2,469,000
BUR	Burbank	820,000	365,000	638,000	1,823,000
ONT	Ontario International	486,000	216,000	378,000	1,081,000
LGB	Long Beach	193,000	193,000	165,000	550,000
		3,801,000	3,235,000	3,066,000	10,102,000
PSP	Palm Springs	25,000	186,000	37,000	248,000
SAN	San Diego International	1,067,000	1,423,000	1,067,000	3,558,000
	Total	4,894.000	4,844,000	4,170,000	13,908,000

Note: Totals may not sum due to rounding

Applying the foregoing diversion rates by airport-pair markets to the corresponding O&D passenger traffic forecast for each market, the resulting diversion to HSR of air travel between the Bay Area airports and Southern California airports in 2035 by airport is shown in Table 9.

Table 9. Diversion of 2035 California Corridor Passengers to High-Speed Rail
Base Case Forecast – HSR Initial Phase, Fares 83% of Corresponding Airfares

	OAK	SFO	SJC
California Corridor O&D Passengers	4,894,000	4,844,000	4,170,000
O&D Passengers Diverted to HSR	1,776,000	2,218,000	1,935,000
Undiverted O&D Passengers	3,178,000	2,626,000	2,235,000
Percent Diversion	36.3%	45.8%	46.4%

Including the assumed diversion of connecting passengers at SFO and comparing the diversion of air trips projected for 2020and 2035 to the total forecast passengers at each airport gives the overall diversion rates shown in Table 10.

The results show that the potential diversion in 2035 is fairly modest, ranging from only about 4% of total passengers at SFO to about 12% at SJC. The low diversion rate at SFO is due to the California Corridor traffic and connecting passengers in markets that would be served by the HSR system forming a relatively small share (about 8%) of the total traffic at the airport. Naturally, the diversion rates are even lower in 2020.

Table 10. Diversion of Bay Area Airport Passengers to High-Speed Rail in 2020 and 2035
Base Case Forecast – HSR Initial Phase, Fares 83% of Corresponding Airfares

	OAK	SFO	SJC
2020			
Total Annual Passengers	16,332,000	46,124,000	12,851,000
O&D Passengers Diverted to HSR	523,000	643,000	568,000
Connecting Passengers Diverted to HSR		48,000	
Undiverted Passengers	15,809,000	45,433,000	12,283,000
Percent Diversion	3.2%	1.5%	4.4%
2035			
Total Annual Passengers	20,655,000	64,356,000	16,305,000
O&D Passengers Diverted to HSR	1,776,000	2,218,000	1,935,000
Connecting Passengers Diverted to HSR		194,000	
Undiverted Passengers	18,880,000	61,945,000	14,371,000
Percent Diversion	8.6%	3.7%	11.9%

Sensitivity Analysis

A number of factors could cause a higher diversion of air passenger trips to HSR than implied by the most recent HSR ridership forecasts prepared by the CHSRA. These forecasts were based on the assumption that HSR fares would be 83% of equivalent airfares. However, future increases in fuel prices or other airline costs relative to the costs implied by the airfare assumptions in the latest HSR forecasts could reduce the HSR fares relative to airfares. Increasing levels of air traffic delay at SFO or Southern California airports could result in the dependability of HSR travel times attracting more riders. Finally, travelers may come to value the greater comfort and longer blocks of uninterrupted time offered by HSR travel more than suggested by the stated preference survey results on which the ridership forecasts are based.

In addition, by 2035 it is possible that the full planned HSR system, or at least the extension to San Diego, would be completed. From the perspective of diversion of Bay Area air passengers to HSR, the extension of the system to San Diego would offer almost all the additional diversion of the full system, since extension of the system to Sacramento is likely to result in very little diversion of air trips between the Bay Area airports and the Sacramento region to HSR, both due to the limited number of such trips and the rather circuitous HSR route between Sacramento and the Bay Area. Although the CHSRA 2009 *Report to the Legislature* did not provide an estimate of when subsequent sections beyond the Initial Phase would be completed, it did indicate that the current implementation schedule would have the Initial Phase completed by 2020. Given that this schedule has the much larger Initial Phase completed in ten years, it is not implausible that at least the section to San Diego could be completed in the following 15 years.

In order to assess how a higher diversion of air passenger trips to HSR could affect the foregoing results, a sensitivity analysis was performed for 2035 based on the earlier forecasts prepared for the CHSRA that were based on the full planned system rather than just the Initial Phase and that assumed that HSR fares would be 50% of corresponding airfares rather than 83% of corresponding airfares assumed in the latest forecasts. Since this was the HSR scenario for which the more detailed forecasts of mode use were available which were used to estimate the diversion rates from air travel to HSR for the sub-regional markets for the latest forecasts, it was a relatively simple matter to repeat the above analysis with the revised HSR fare and system assumptions.

The following tables present the resulting projected diversion rates and number of passengers diverted to HSR under the revised fare and system development assumption:

Table 11. 2035 Diversion to High-Speed Rail by Market
HSR Full System, Fares 50% of Corresponding Airfares

Airport Market		OAK	SFO	SJC
LAX	Los Angeles International	54.6%	72.9%	72.9%
SNA	Orange County	45.8%	61.1%	61.1%
BUR	Burbank	56.2%	74.9%	74.9%
ONT	Ontario International	47.3%	63.0%	63.0%
LGB	Long Beach	46.0%	61.3%	61.3%
PSP	Palm Springs	26.1%	34.8%	34.8%
SAN	San Diego International	27.5%	36.7%	36.7%

Table 12. Diversion of 2035 California Corridor Passengers to High-Speed Rail
Base Case Forecast – HSR Full System, Fares 50% of Corresponding Airfares

	OAK	SFO	SJC
California Corridor O&D Passengers	4,894,000	4,844,000	4,170,000
O&D Passengers Diverted to HSR	2,263,000	2,814,000	2,496,000
Undiverted O&D Passengers	2,631,000	2,030,000	1,674,000
Percent Diversion	46.2%	58.1%	59.9%

Table 13. Diversion of Bay Area Airport Passengers to High-Speed Rail in 2035
Base Case Forecast – HSR Full System, Fares 50% of Corresponding Airfares

	OAK	SFO	SJC
Total Annual Passengers	20,655,000	64,356,000	16,305,000
O&D Passengers Diverted to HSR	2,263,000	2,814,000	2,496,000
Connecting Passengers Diverted to HSR		208,000	
Undiverted Passengers	18,392,000	61,334,000	13,809,000
Percent Diversion	11.0%	4.7%	15.3%

Comparison with European Experience with Diversion of Air Travel to High-Speed Rail

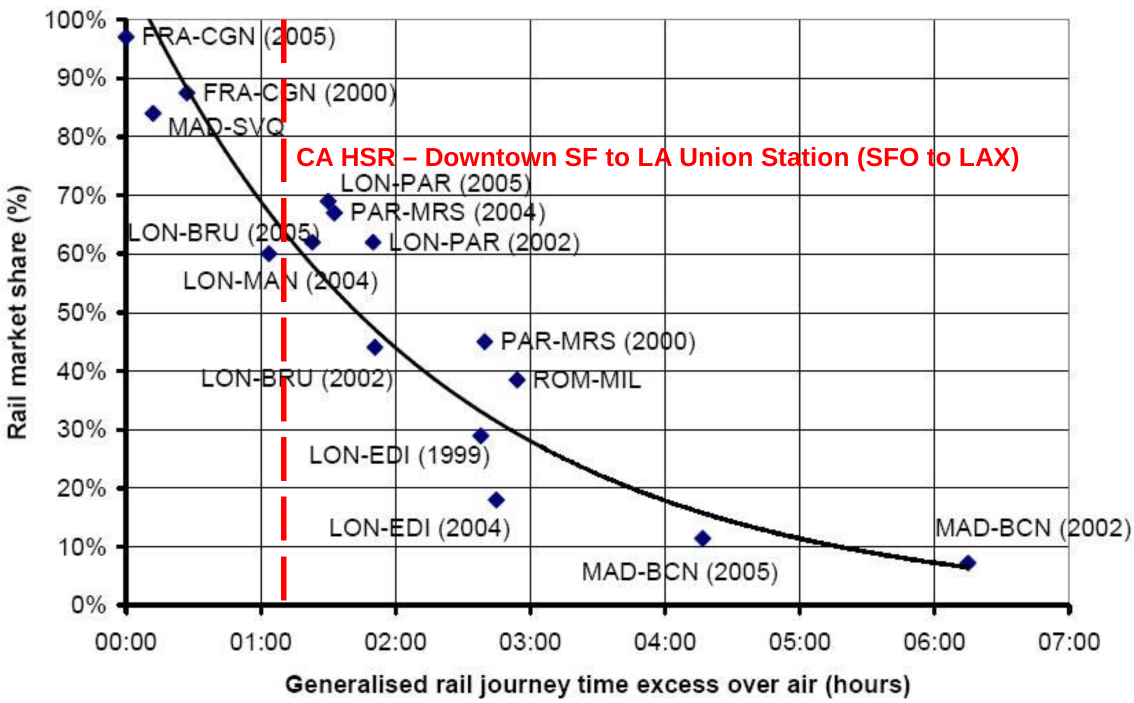
In discussions about the estimated potential diversion of Bay Area air passenger trips to HSR, the RASPA Task Force raised the question of how the forecast diversion rates implied by the CHSRA forecasts compared to the experience with the introduction of HSR in other countries. In 2006 the British consulting firm Steer Davies Gleeve (SDG) undertook a study for the European Commission that examined the rail market share compared to air travel in a number of European city-pair markets where high-speed rail had been introduced.[5] Among other comparisons, the study calculated the rail market share (the percentage of trips by rail or air that used rail) in relation to the difference between the generalized journey time by both modes, where the generalized journey time included time required for check-in at the airport or rail station (including any security screening) and an allowance for differences in service frequency. Although the SDG report recognized that market share is also influenced by other factors, including relative access times and costs to airports and rail stations and differences in fare, and presented comparative data for these factors, they are not included in the generalized travel times used in the comparison of market share.

The results of this analysis are shown in Figure 4, where each data point shows the rail market share and excess generalized rail journey time over air travel for a given city-pair. For many of the markets, data was obtained for two years (shown for each data point) reflecting changes in rail service that had occurred between the two years. SDG also fitted a functional relationship to the data, as shown in Figure 4.

In order to compare these results with the ridership forecasts prepared for the CHSRA, the corresponding generalized excess journey time was calculated for an HSR trip from San Francisco to Los Angeles Union Station. This was based on the air travel and HSR level of service data given in the Excel summary files for the ridership forecast for the full system with HSR fares of 50% of corresponding air fares (the forecast scenario for which the most detailed results were available), using the air travel level of service data for flights between SFO and LAX. The assumed HSR in-vehicle time from downtown San Francisco to Los Angeles Union

[5] Steer Davies Gleeve, *Air and Rail Competition and Complementarity*, Report Prepared for the European Commission DG TREN, London, August 2006.

Station shown in the Excel file (184 minutes) was somewhat higher than the fastest projected scheduled run times given in the 2009 *Report to the Legislature*, which showed seven different operating patterns between downtown San Francisco and Los Angeles Union Station with different intermediate stops and a range of run times between 160 minutes and 194 minutes. There was no effective difference in the headways for air and HSR shown in the Excel file (9 minutes and 8 minutes respectively). In order to calculate the excess journey time it was assumed that air passengers would need to arrive at the airport 60 minutes before flight departure while HSR passengers would need to arrive at the rail station only 20 minutes before train departure. This resulted in an excess generalized journey time by HSR of 69 minutes.



Source: Base figure from Steer Davies Gleeve, *Air and Rail Competition and Complementarity*, 2006, Figure 2.7.

Figure 4. Forecast Growth in California High-Speed Rail Riders Over Time

From the relationship shown in Figure 4, this would give a rail market share of about 65%. For comparison, the HSR market share of air and rail trips for the Bay Area to Los Angeles market in the ridership forecast for the full system with HSR fares of 50% of corresponding air fares is about 77%, while that for the ridership forecast for the Initial Phase with HSR fares of 83% of corresponding air fares is about 62%. Therefore it would appear that the HSR ridership forecasts prepared for the CHSRA are largely consistent with market share experience with high-speed rail services in Europe.

However, it should be noted that the relationship between rail market share and excess rail journey time over air travel from the SDG report and its application to the California Corridor market does not consider access and egress times and costs to airports and rail stations nor differences in fare between air and rail. These are obviously important factors in the choice between rail and air for any given journey, but are difficult factors to represent in a market comparison of this type due to the different urban forms in the various cities, the differing relative locations of the airports and rail stations with respect to the pattern of trip ends, and the range of fares in a given market. The use of yield management systems by both airlines and rail service operators results in a wide range of fares for the same journey, depending on the time and day of travel, how far in advance of the trip the ticket was purchased, and what restrictions the travelers were willing to accept on their ability to change their travel plans or cancel their trip. The extent to which differences in these factors between the planned California HSR service and the various European city-pair examples would cause the rail market share in California to be higher or lower than the European experience is unclear.

One concern that has been raised is that many California travelers do not have the familiarity with rail travel that most Europeans do. While this is undoubtedly true today, the experience with improvements in rail travel in the Northeast Corridor, including the introduction of the Acela service, as well as the growing ridership on existing rail services in California, suggests that U.S. travelers are willing to try new rail services if they provide advantages over driving or flying. New HSR services in the U.S. may take somewhat longer to achieve full market penetration than comparable service in Europe, but by 2035 the planned HSR system could have achieved widespread acceptance as a viable alternative to air travel.