3.2 Travel Conditions

This section addresses the existing and future potential for travel conditions to change related to the No Project and HST alternatives.[1] Automobile transportation and air transportation currently carry more than 99% of intercity trips and are therefore the focus of this analysis, together with the HST mode. For this analysis, *travel conditions* are defined as the experience, quality, sustainability, safety, reliability, and cost of intercity travel in the study region and state. Travel factors were developed based on the purpose and need (Chapter 1) for the proposed HST system and are used to evaluate the general impact of the No Project Alternative and the HST alternatives on the transportation system.

In contrast to other sections in this chapter, this section broadly compares the HST system to other modes of travel, rather than focusing on comparison of alignment alternatives. HST Alignment Alternatives and Network Alternatives are referred to collectively as *HST alternatives*.[2]

3.2.1 Methods of Evaluation

The overall method used to evaluate travel conditions is described below. To evaluate the relative differences in travel conditions that would result from the No Project or HST alternatives, five travel factors were considered that relate directly to the purpose and need and the goals and objectives defined in Chapter 1. These factors are described below.

- **Travel Time:** Travel time is the total time required to complete a journey. With the exception of the automobile, intercity transportation options require multiple modes to complete a trip. For example, an air trip is not just the time spent in the air (the line-haul portion of the trip) but also includes the time required to travel to the airport, check in, pass through security, board the plane, and travel to the final destination. The total travel time of a mode also depends on its reliability. If a mode is unreliable, a traveler must allow more time to complete a trip, effectively lengthening the total travel time.
- **Reliability:** Reliability is the delivery of predictable and consistent travel times and is a key factor in attracting passengers to use a particular mode of travel. Travel time and reliability directly affect productivity because they determine the ease and speed with which workers and products arrive at their destinations. Greater travel demand on capacity-constrained facilities results in further congestion and is one of the primary reasons for longer travel times. Reliability is primarily a function of unexpected delays, which can be caused by many factors, including traffic congestion, accidents, mechanical breakdowns, roadwork, and inclement weather.
- **Safety:** Projected growth in the movement of people and goods in California by road and air underscores the need for improved travel safety. National and statewide statistics indicate that the rate of fatality or serious injury by private motor vehicle is increasing, primarily because more people are traveling by this mode. Nationally, over the last 10 years, accident and injury rates have remained fairly constant for commercial airline travel, which remains a safe mode compared to the private automobile.
- **Connectivity (Modal):** Connections between modes of transportation are an element in the development and operation of a successful total transportation system. The ability to transfer easily between modes and the frequency of service are additional key factors that can determine a traveler's modal choice. Statewide, connections between airports and the extensive regional

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[1] See Section 3.0, Introduction, for an explanation of how this section fits together with the HST Network Alternatives presented in Chapter 7, as well as for an overview of the information presented in the other chapters.

[2] Representative Pacheco Pass and Altamont Pass network alternatives are used for evaluation in this section. See Chapter 2 for a description of network alternatives.

urban and commuter transit systems are limited. Under existing conditions and the No Project Alternative, modal connections at airports are limited, and connections and services are fragmented and not provided as an integrated system with coordinated fares, schedules, and amenities. With the exception of the new BART extension to SFO and the Metrolink connection to Burbank Airport, other airports do not have direct rail connections to city centers, other transit systems, or the region. Airport transit connections can be cumbersome, often requiring multiple transfers and long waiting times; are not well advertised to potential passengers; and lack coordinated fares and schedules.

- **Connectivity (Geographic):** Connecting the San Francisco Bay Area to other parts of northern California, the Central Valley, and southern urban areas of the state with an additional transportation system could significantly improve statewide mobility. In addition, connecting the San Francisco Bay Area with the cities and communities of the Central Valley could yield other potential benefits. Due to poor connectivity, limited services, and weather impacts, travel options to and from Central Valley cities are limited, travel times are long, and the potential for delay is high.
- **Cost:** Direct, passenger-borne costs are another key factor in passenger travel choice. Most travel demand studies have found that travel costs are highly variable, depending on the type of traveler and the purpose of travel. Business travelers may be willing to pay high fares for urgent needs, but leisure travelers may constrain themselves to the lowest fare possible. In some cases, travelers are also willing to pay a premium for a reliable, comfortable, and safe journey.

The five travel factors are summarized in Table 3.2-1. These travel factors are used to evaluate the relative difference between alternatives both qualitatively and quantitatively. The method by which the travel factors have been applied to the alternatives is summarized in Table 3.2-2. Each of the travel factors is described in greater detail as they are applied in the potential environmental consequences of travel conditions discussion.

In general, the No Project Alternative would include the same intercity travel modes that are available under existing conditions, which are the automobile, airplane, intercity bus, and conventional rail. This Program EIR/EIS is to broadly assess the highest reasonably foreseeable potential level of impact. Therefore, the high ridership forecasts for the HST (117 million trips) are used to describe the operations and required facilities for the proposed alternatives. However, in a few areas where the high ridership forecast produced the lowest impacts or highest benefit, analysis of conditions based on the base case HST forecast (88 million trips) is also included. The high ridership forecast and the base case include 31 and 22 million long-distance commute trips, respectively.

Table 3.2-1
Relation of Travel Factors and Purpose and Need/Objectives

	Travel Factors				
	Connectivity	**Travel Time**	**Reliability**	**Safety**	**Passenger Cost**
Project Purpose					
Improve intercity travel experience	X	X	X	X	
Maximize intermodal transportation opportunities	X	X			
Meet future intercity travel demand	X	X			
Increase efficiency of intercity transportation system	X		X		
Maximize use of existing transportation corridors	X		X		
Develop a practical and feasible transportation system by 2020 and in phases	X				X
Provide a sustainable reduction in travel time		X			
Project Need					
Limited modal connections	X	X			
Future growth in travel demand					
Capacity constraints			X		
Unreliability of travel			X	X	
Project Goals and Objectives					
Maximize mobility	X				X
Minimize travel times		X			
Minimize environmental impacts					
Maximize system safety			X	X	
Maximize reliability			X		

X = Directly applies.
Source: Parsons Brinckerhoff 2003.

Table 3.2-2
Application of Transportation Factors to Alternatives

Typology	Description	Measurement
Travel Time	Total door-to-door travel time	Total travel time including access and in-vehicle times
Reliability	Ability and perception to arrive at the destination on-time	Accidents Inclement weather Transportation-related construction Volume variation Special events Traffic control devices and procedures Base capacity Vehicle availability
Safety	Loss of life or injury	Comparison of safety performance characteristics by mode (operator, vehicle, and environment)
Connectivity	Transportation options that connect to other systems and destinations	Modal: Number of intermodal connections and options, and frequency of service provided by each alternative Geographic: Connectivity between regions by mode
Passenger cost	One-way travel costs	Total costs, including fares and other costs, for intercity travel by mode
Source: Parsons Brinckerhoff 2003.		

3.2.2 Affected Environment

A. STUDY AREA DEFINED

This program-level analysis of travel conditions and potential impacts does not measure the specific potential impact on individual transportation facilities (e.g., a transit line, highway, or airport). Rather, travel conditions have been evaluated for the state, with a focus on the study region. Specific examples of representative travel conditions in a corridor or for a specific highway, airport, or rail facility are identified where possible.

B. GENERAL DISCUSSION OF TRAVEL CONDITIONS

For travel conditions, the affected environment is California's intercity travel network, which consists of three main components: highways, airports, and rail. Of these, automobiles and air transportation carry more than 99% of intercity trips and are therefore the focus of this section. Congestion in the affected environment is a serious concern, as shown in Figure 3.2-1. According to the Texas Transportation Institute, the urban areas of San Francisco and Los Angeles experience some of the most severe highway congestion and travel delays in the country (Shrank and Lomax 2002). Recent research by the Institute of Transportation Studies at the University of California, Berkeley, indicates that California airports generally experience the highest average air travel delays in the nation (Hansen et al. 2002). Although the main contributors to this congestion are local and commuter highway trips and transcontinental and international flights (at least at major airports such as SFO and LAX), intercity trips compete for the limited capacity on these overburdened facilities.

The highway system is congested near and around urban centers (e.g., San Francisco, Oakland, San Jose) and in rural and suburban communities (e.g., Central Valley) during both the morning and evening peak hours. According to the MTC, seven out of ten of the most congested highway corridors in the Bay Area (including segments of I-880, I-580, and US-101) are key intercity routes in the Bay

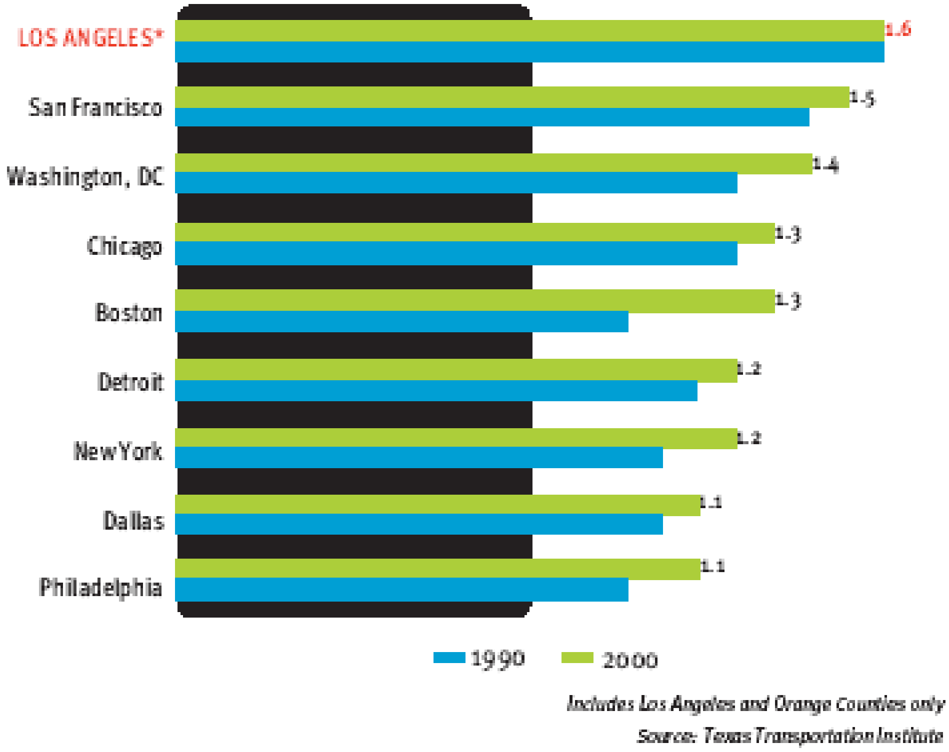


Figure 3.2-1
Nationwide Highway Congestion

Area to Merced region (Figure 3.2-2). Similarly, according to the San Joaquin Council of Governments, several major routes that traverse the Central Valley (I-5, I-205, I-580, SR 120, SR 99) are critical intercity links for passengers and goods traveling between northern and southern California. Section 3.1, Traffic, Transit, Circulation, and Parking, notes that several of these routes are operating during the peak periods at or near congested levels of operations. In fact, I-5 and SR 99 (key intercity routes assessed in this analysis) are designated by Caltrans as "high emphasis focus routes" of critical importance to the movement of goods in California.

California's aviation system provides for intercity, domestic, and international travel. The aviation system is also a significant economic generator that fuels the state's economy. According to the FHWA, in 2002 California's airports contributed to about 9% of the state's employment and total economic output (Federal Highway Administration 2003). According to Caltrans, in 2002 about 159 million passengers in California traveled by air, or about 12% of the national total. Seven California airports are ranked in the top 50 U.S. primary/commercial service airports. As shown in Table 3.2-3, three of these airports are located in the study region.

Table 3.2-3
California Airport National Rankings (2002)

Airport	U.S. Ranking	Region
Los Angeles (LAX)	3	Bakersfield to Los Angeles and Los Angeles to San Diego (via Inland Empire and Orange County)
San Francisco (SFO)	8	Bay Area to Central Valley
San Diego (SAN)	30	Los Angeles to San Diego (via Inland Empire and Orange County)
San Jose (SJC)	34	Bay Area to Central Valley
Oakland (OAK)	37	Bay Area to Central Valley
Sacramento (SMF)	44	Sacramento to Bakersfield
John Wayne/Orange County (SNA)	45	Los Angeles to San Diego via Orange County
Source: Aviation in California Fact Sheet, California Department of Transportation, Division of Aeronautics, 2002.		

The National Center of Excellence for Aviation Operations and Research predicted that demand at California airports, which dropped by as much as 33% after the September 11, 2001, terrorist attacks, will recover to 2000 levels in 2002 or 2003 or shortly thereafter. As a result, the seven major airports in Table 3.2-3 currently operating at or near capacity are all planning major improvements to accommodate existing and future projected demand. In 2000, almost 25% of all flight arrivals were delayed for 9 minutes or more, a number significantly higher than the national average (Hansen et al. 2002).

Congested airways are one source of passenger delay for intercity trips; congested highways are another. According to the California Transportation Commission, California's major airports suffer from poor ground access and severe congestion, which directly impacts international trade (California Transportation Commission 2000). As shown in Section 3.1, Traffic, Transit, Circulation, and Parking, many of the highway segments and primary airport access routes to the study region airports have a LOS of E and F. *Level of service* describes the condition of traffic flow, ranging from excellent conditions at LOS A to overloaded conditions at LOS F. LOS D is typically recognized as an acceptable service level in urban areas.

3.2.3 Environmental Consequences

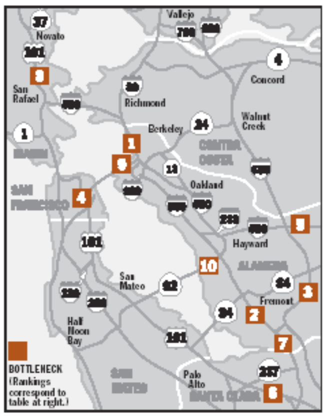
A. NO PROJECT ALTERNATIVE

The No Project Alternative includes programmed and funded transportation improvements to the existing transportation system that will be implemented and operational by 2030. The No Project Alternative involves increased intercity travel demand and the implementation of new infrastructure. Improvements (programmed and funded) focus on existing modes; therefore, the same modes of intercity transport will continue to be available. The programmed or funded transportation improvements assumed to be in operation by 2030 are not major systemwide capacity improvements (e.g., major new highway construction or widening, or additional runways) and will not result in a general improvement or stabilization of existing highway or air travel conditions across the study region. Connectivity is not expected to improve with the No Project Alternative because few major intermodal terminals are expected to be built over the next 20 years.

As described in Section 3.1, Traffic, Transit, Circulation, and Parking, existing facilities are operating at congested levels of service at many locations, and traffic conditions are projected to deteriorate further under the No Project Alternative. Of the 18 intercity highway locations analyzed in Section 3.1, more than half are operating during the peak period at LOS D or a volume-to-capacity (V/C) ratio more than 0.80 under existing conditions—with two of the locations at LOS F (V/C over 1.0). These conditions are expected to deteriorate further under the No Project Alternative for 2030. On average, across the 18 locations evaluated in the study region, the V/C ratios are estimated to deteriorate by more than 35% and have substantially more LOS F segments (11 of the 18 locations) under the No Project Alternative. Capacity in the No Project Alternative is insufficient to accommodate the projected growth in highway travel in the study region, including both the San Francisco Bay Area and the emerging urban areas in the Central Valley. Consequently, there would be no sustainable capacity improvement to the transportation system.

Although intercity travel is only a small percentage of all highway trips, it must compete for limited capacity on already congested infrastructure, which will become more congested by 2030. For instance, according to MTC, between years 2000 and 2020 in the Bay Area, total vehicles per household will increase by 5%, and average vehicle miles traveled per weekday will increase by about 30%, and even more by 2030. This projection is representative of conditions throughout the state (Metropolitan Transportation Commission 2003). In the Central Valley, the San Joaquin Council of Governments estimates that the percentage of time vehicles are delayed relative to the total travel time will increase in 2025, and that the percentage of miles traveled at congested levels of service (LOS E or F) will increase from 1.25% in 1999 to more than 6% in 2025—a more than six-fold increase (San Joaquin Council of Governments 2002). In most cases, these conditions could become manifest in deteriorating levels of service on highway segments and local streets or extended peak-period congestion on links that are already operating at near or total breakdown conditions. In many instances, the morning peak period could extend to 4 hours.

According to the California Aviation System Plan, almost 173 million passengers enplaned and deplaned in California in 1999, a number that is expected to more than double by 2020 (California Department of Transportation 2001). Under the No Project Alternative, no additional runways or other major capacity expansion projects would be implemented by 2030. Many of the airports in the study region that are currently at or near capacity could become severely congested under the No Project Alternative. Capacity constraints are likely to result in significant future aircraft delays, particularly at California's three largest airports. SFO has "one of the worst flight delay records of major U.S. airports—only 64% of SFO flights were on time during 1998" (San Francisco International Airport 2003). According to SFO, within 10 years the three Bay Area airports will not have the sufficient capacity to meet regional air traffic demand even on a good weather day. The projected delays at heavily used airports and forecasted highway congestion would continue to delay travel, negatively affecting the California economy and quality of life.



10 Worst Congestion Locations in 2001*

2001 Rank	Location	Delay in Vehicle Hours	2000 Rank
1	**Interstate 80, westbound, a.m.** — Alameda/Contra Costa County Route 4 to Bay Bridge metering lights	9,410	1
2	**Interstate 880, southbound, a.m.** — Alameda County South of Route 84 to north of Dixon Landing Road	8,880	3
3	**Interstate 680, southbound, a.m.** — Alameda County Sunol Road to south of Route 262	8,510	2
4	**Interstate 80, eastbound and U.S. 101, northbound, p.m.** — San Francisco County Army Street to west end of Bay Bridge	5,050	5
5	**Interstate 580, eastbound, p.m.** — Alameda County Hopyard Road to west of El Charro	5,030	13
6	**U.S. 101, southbound, p.m.** — Santa Clara County Great America Parkway to 13th Street	4,100	4
7	**Interstate 880, northbound, p.m.** — Santa Clara/Alameda County U.S. 101 to Dixon Landing Road	4,000	12
8	**U.S. 101, southbound, a.m.** — Marin County Rowland Boulevard to Interstate 580	3,230	6
9	**Interstate 880, northbound, a.m.** — Alameda County 1 mile north of 7th Street to Bay Bridge	2,920	10
10	**Route 84, westbound, a.m.** — Alameda County Newark to Dumbarton Bridge toll plaza	2,860	11

Source: Caltrans District 4

*Rankings are for routes in which continuous stop-and-go conditions occur with few, if any, breaks in the queue. Thus, corridors that have equally severe delays but where congestion is broken into several segments may rank lower in this

Figure 3.2-2
Bay Area Locations of Worst Congestion
(as of 2001)

Given these travel trends, overall travel safety is also expected to worsen. As VMT continues to rise over the next 20 years under the No Project Alternative, the accident rate will not change appreciably, but the net number of accidents, injuries, and fatalities could increase, particularly for highway-based trips. As evidence of this trend, the National Highway Traffic Safety Administration reported that between 1998 and 2001 fatalities on California's roadways increased by an average 4% annually (National Highway Traffic Safety Administration 2001).

Travel costs are also expected to rise because of capacity constraints. Regions could attempt to control demand through congestion pricing for both the auto and air modes. This approach could result in more congestion-priced toll roads like SR-91 in Orange and Riverside Counties, and peak-period landing fees for airports statewide. Both of these costs would be passed along to the consumer either directly in tolls or indirectly in ticketed fares.

As summarized in Table 3.2-4, the No Project Alternative would result in either a deteriorated level of service or no change compared to existing conditions.

Table 3.2-4
Existing Conditions Compared to No Project Alternative

	No Project Alternative (2030)	
Travel Factor	**Change from Existing Conditions**	**Comment**
Travel Time	Deteriorate	Increased congestion could result in further delays.
Reliability	Deteriorate	Increased congestion and no change in modal options or characteristics could result in greater unreliability.
Safety	Deteriorate	No change in modal options would maintain existing fatality and injury rates; however, increased demand could result in greater number of fatalities.
Connectivity	None	No additional intercity intermodal connections or options, or increased frequencies will be available.
Passenger Cost	Deteriorate	Airfares are anticipated to increase beyond their current fare structures.

There are no travel-time benefits associated with the No Project Alternative because there are no significant improvements to capacity or modal options. The No Project Alternative would likely result in longer travel times in all cases as compared to existing conditions, and these increases would range between 18 and 64 minutes for the representative city pairs.

Reliability under the No Project Alternative is likely to be lower than under the HST alternatives for the following reasons.

- The No Project Alternative depends heavily on the automobile, which has been shown to have the worst reliability of the three modes.
- Existing congestion and reliability problems continue because the No Project Alternative provides no new highway or airport base capacity.
- Greater highway and aviation congestion and more reliability problems accrue because the No Project Alternative absorbs an increasing demand for travel with little increase in base capacity.

Although the rate of injury or fatality is not expected to increase under the No Project Alternative, the increase in highway travel would be expected to cause the number of injuries and fatalities to increase as compared to existing conditions.

Under the No Project Alternative, there would be no net improvement to the connectivity options in the state over the existing conditions. There would no introduction of new modes, no new intermodal terminals or connections, and no improvements in air transportation frequencies.

There is little to no sustainable capacity in the No Project Alternative. The future transportation infrastructure is severely constrained by the limited number of capacity improvements funded or programmed for 2020. Improvements associated with the No Project Alternative are generally to existing interchanges versus line capacity expansion or improvement projects. The highway system's sustainable capacity would require additional infrastructure to accommodate any growth in demand. To accommodate the theoretical system capacity of 31,500 passengers per hour, the highway system would require at least three additional lanes in each direction and the capacity of airports would also have to be significantly expanded. Therefore, the No Project Alternative would not accommodate the theoretical demand and would require extensive infrastructure expansion to have sustainable capacity.

With the No Project Alternative, auto passenger costs are considerably lower for short- and mid-range trips than airfares for short haul routes, such as Los Angeles to San Diego, Los Angeles to Fresno, or Sacramento to San Jose. For long-range trips, such as Los Angeles to San Francisco or Burbank to San Jose, the automobile remains competitive because of the access and egress costs associated with air travel.

B. HIGH-SPEED TRAIN ALTERNATIVES

This section presents expected travel conditions for the HST alternatives and compares relative differences between No Project and the HST. This section is organized by the five travel factors identified earlier. Implementation of the HST system would introduce a new mode to the California intercity transportation system. This new mode would result in major differences in expected travel conditions that would be similar for all the HST alternatives being considered in the study region. Some differences are noted that would occur, depending on the choice of network alternative. Each travel factor begins with a summary of the specific methods used to define and evaluate the effect of the HST system, followed by an evaluation of potential effects.

Travel Time

Travel time is a key travel factor that determines the attractiveness of a particular mode of travel to passengers. Travel time is also an important economic factor that directly affects productivity (travel time for workers and products to get to their destination). For the purpose of this analysis, improved travel time is a benefit to the traveler because it can improve the intercity travel experience. Travel time for this analysis was measured as the total (door-to-door) travel time for the example city pairs presented in Chapter 1.

Automobile Mode Characteristics

Travel time in an automobile largely depends on three factors: distance traveled, roadway design speed (and associated speed limit), and congestion levels. The design of a roadway dictates the time that will be required to travel between two destinations. The time of day and associated congestion also plays a role in how long a trip will take. For this analysis, it is assumed that the top speed of the automobile is 70 mph (113 kph).

Automobile travel times are based on driving times between the representative city pair origins and destinations (Table 3.2-5). The travel time for existing conditions is based on the *California High-Speed Rail Statewide Forecasting* model, which was validated using observed traffic counts in the year 2000. The 2030 No Project travel times were estimated using the same forecasting model, with 2030 land use and financially constrained networks from each of the four largest metropolitan transportation organizations (MPOs) in the state (San Francisco Metropolitan Transportation

Commission, Southern California Association of Governments, Sacramento Area Council of Governments, and the San Diego Association of Governments) and Caltrans (for all other areas of the state). The 2030 forecast assumptions and models used for the HST alternatives included a 50% increase in air and auto costs, representing the high ridership forecasts. As a result, the auto travel times for the HST alternatives were forecast to be 4–6% shorter because of the increased auto costs and the diversion of highway trips to the HST system (Cambridge Systematics 2007).

Table 3.2-5
Total Door-to-Door Peak Automobile Travel Times (Hours:Minutes)

City Pairs	Existing Conditions (2000)[a]	2030 Automobile Total Door-to-Door Travel Times[b]	
		No Project	HST
Los Angeles downtown to San Francisco downtown	6:28	6:50	6:32
Fresno downtown to Los Angeles downtown	3:32	3:41	3:38
Los Angeles downtown to San Diego downtown	2:37	2:41	2:39
Burbank (airport) to San Jose downtown	5:31	5:54	5:40
Sacramento downtown to San Jose downtown	2:29	2:32	2:24

[a] Metropolitan Transportation Commission and California High Speed Rail Authority High-Speed Rail Ridership and Revenue Forecasting Study, prepared by Cambridge Systematics 2007.
[b] 2030 No Project was estimated as the congested travel time for peak conditions by assigning the 2030 No Project trip table generated by the California High-Speed Rail Statewide Forecasting model to the statewide highway network for 2030, which is a financially constrained future year network.

Air Mode Characteristics

Air travel is the fastest line-haul mode at 530 mph (853 kph) maximum cruising speed. However, a significant portion of a passenger’s trip is spent accessing the airport, passing through one or more security checkpoints, boarding and alighting from the aircraft, and egress travel from the airport. The components of a door-to-door air trip include the components listed below.

- Access time: time spent driving to the airport.
- Terminal time: time spent getting through the airport terminal.
- Wait time: time spent waiting at the gate for the aircraft to leave.
- Line-haul time: time spent on the aircraft.
- Arrival time: time spent getting to the final destination.

It is assumed that all air trips would require travel on the regional highway system with the exception of San Francisco, where some passengers could use the newly opened BART to SFO rail link. Also, passengers in the Los Angeles area could use a Metrolink connection to Burbank.

Total air travel times are summarized in Table 3.2-6. As shown, No Project travel times would increase between 0 and 10 minutes compared to existing conditions, depending on city pairs.[3] These changes are the result of increases in line-haul travel time that were observed between 2000 and 2005 and carried forward to 2030. It is estimated that air travel times would not change with the

3 This assumption is consistent with the high-end revenue and ridership assumptions for the Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study, Cambridge Systematics 2007.

HST system compared to No Project because the diversion of trips to HST does not significantly reduce airside congestion levels, and all other factors (arrival, terminal, and departure times) would remain constant. Although there would be an improvement of intercity highway travel times, this improvement is not meaningful for access trips to and from the airports.

Table 3.2-6
Total Door-to-Door Peak Air Travel Time (Hours:Minutes)

City Pairs	Airports	Existing Conditions (1999)	2030 Air Mode Total Door-to-Door Travel Times	
			No Project Alternative[a]	HST
Los Angeles downtown to San Francisco downtown	LAX, LGB, BUR, SNA, ONT, SFO, OAK, SJC	3:30	3:38	3:38
Fresno downtown to Los Angeles downtown	FAT, SNA, ONT, LAX, LGB, BUR	3:17	3:24	3:24
Los Angeles downtown to San Diego downtown	LAX, LGB, BUR, SNA, ONT, SAN	2:51	3:01	3:01
Burbank (Airport) to San Jose downtown	BUR and SJC	2:46	2:43	2:43
Sacramento downtown to San Jose downtown	SMF and SJC	3:33	3:33	3:33

[a] Total travel time for air is unaffected by the high-speed rail service or changing demand in air trips.
Source: Cambridge Systematics 2007.

High-Speed Train Mode Characteristics
With a maximum operating speed of 220 mph (354 kph), the HST is slower in line-haul speed than an airplane but considerably faster than an automobile. However, for most intercity trips within California, the quick arrival, terminal, and departure times make the overall HST travel time competitive with that of air travel. The HST would also connect closer city pairs, those less than 150 mi (241 km) apart, and for those trips would compete strongly with the automobile. For example, HST travel between Los Angeles and Bakersfield or Sacramento and Modesto would likely be faster than air transportation as well as automobile travel.

In Europe and the United States, rail travel time improvements have shifted travel demand from air to rail travel. Within a decade of its inauguration, France's TGV Sud-Est succeeded in capturing more than 90% of the travel market between Paris and Lyon (Meunier 2002). Amtrak's Acela and regional trains have 50% of the total air-rail market between New York and Washington. In Germany, recent passenger rail improvements between Frankfurt and Cologne were undertaken with the purpose of shifting air trips from congested airports where capacity was constrained and could not be expanded to high-speed rail that could more quickly serve the same markets. This same principle could apply to the major airports in California, including San Francisco and Los Angeles. The air operation time-slots released by substituting HST for local air service at these two airports could provide more opportunities for international and interstate flights.

HST would also provide direct connections to several airports. This connectivity, combined with the line-haul speed of the HST, could result in faster total travel times for air travelers who use a combination of air and HST to reach their final destination. For example, passengers arriving at San

Francisco could transfer to the HST and travel to Merced, and this connection could be competitive with or possibly faster than connecting to another flight, driving, or taking a bus or shuttle[4].

The train in this instance may be quicker for two reasons. First, trains may be boarded swiftly, often in less than 2 minutes because of the number of doors and ability to accommodate extra passengers. In contrast, boarding an airplane must be highly controlled for security and typically takes place through one door (or at most two doors), a process that can take up to half an hour. Second, current airline boarding practice requires passengers to be present at the gate at least 60 minutes before the scheduled departure time.

Another key difference between HST and air travel is the percentage of total travel time spent during the line haul. On a train, this proportion of time is quite high, and can be used for work, pleasure, or relaxation. For example, passengers traveling by HST between any of the below city pairs would be able to use their laptop computers or any number of personal audio, video, or game devices for approximately 70% of the total travel time, while passengers traveling by air would be able to use these devices for just 30% of their trip.[5]

Total travel times are summarized in Table 3.2-7. While these travel times are from downtown to downtown where HST has a distinct advantage over air travel because of terminal locations, the potential for many online stations could make the HST competitive for many other trips. Like air travel, the HST has the following door-to-door trip components. (See Appendix 3.2-B for more detailed explanation.)

- Access time: time spent driving to the train station.
- Terminal time: time spent getting through the train station.
- Wait time: time spent waiting at the gate for the train to leave.
- Line-haul time: time spent on the train.
- Arrival time: time spent getting to the final destination.

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4 Although this opportunity may increase overall ridership, these out-of-state connecting air travelers have not been included in the ridership forecasts provided in this document because of the difficulties in evaluating their competing modal opportunities and because the likely ridership is small compared to in-state ridership.

5 Although the line-haul time of the flight is about 33% of the total trip, due to restrictions on use of electronics during take off and landing, the productive time is reduced by another 10%.

Table 3.2-7
Total Door-to-Door Peak HST Mode Travel Times (Hours:Minutes)

City Pairs	2020 HST Total Door-to-Door Travel Times
Los Angeles downtown to San Francisco downtown	3:24
Fresno downtown to Los Angeles downtown	2:15
Los Angeles downtown to San Diego downtown	2:21
Burbank (airport) to San Jose downtown [1]	3:07
Sacramento downtown to San Jose downtown [2]	2:16

[1] Time based on the Pacheco Pass representative (base) network alternative. Altamont Pass representative (base) network alternatives 13 minutes longer.

[2] Time based on the Pacheco Pass representative (base) network alternative. Altamont Pass representative (base) network alternatives 34 minutes shorter.

Source: Cambridge Systematics 2007.

Existing conventional rail services are typically not competitive with other modes. For example, while the HST line-haul time (a component of total trip time) between downtown San Francisco and Los Angeles would be just over 2.5 hours, the only existing direct rail service between the Bay Area (Oakland) and Los Angeles (Coast Starlight service) has a line-haul time of more than 12 hours and operates one train daily in each direction. The San Joaquin service between Oakland and Los Angeles takes about 8 hours and 40 minutes but requires transferring to a bus for the Bakersfield to Los Angeles segment of the trip. The HST line-haul time between downtown Los Angeles and downtown San Diego would be about 1 hour and 29 minutes, as compared with current Surfliner line-haul time of 2 hours and 0 minutes to 2 hours and 50 minutes. Caltrans and Amtrak plan to reduce travel times by up to 30% on key intercity routes, such as the Pacific Surfliner and Capitol Corridor services, over the next 20 years; however, the projects required to reach these goals are not yet funded.

Travel Time Effects of the High-Speed Train

Because of its faster line-haul speed, HST would compete with the automobile for shorter distance intercity trips. Because of its shorter terminal processing times, HST would also compete with the airplane for longer distance intercity trips. In the Central Valley, HST would provide shorter travel times than both the highway and air modes for travelers headed to locations near HST stations. The travel time benefits vary considerably between the different HST Network Alternatives depending upon the location and number of HST stations. For example, the Pacheco Pass network alternative that terminates in San Jose would result in an increased total travel time of 25 minutes to downtown San Francisco by auto (transferring to Caltrain commuter rail service would take an additional 69 minutes compared to HST) and/or 26 minutes to Oakland by auto, as compared to Pacheco Pass Alternatives that serve downtown San Francisco and/or Oakland directly. The Altamont Pass Alternative that terminates in Union City would increase total travel times using auto to downtown San Jose by 14 minutes, to San Francisco by 6 minutes, and Oakland by 15 minutes.

Reliability

In its simplest form, *reliability* can be defined as variation in travel time, hour-to-hour and day-to-day for the same trip. Reliability is important for almost any travel need and on any travel mode. Business travelers want to be able to predict how long it will take them to arrive at a meeting, either across town or across the state. Express shippers need to know where packages are at all times and when they will be available for delivery. Vacationers who want to spend as little of their time off as possible traveling to and from their destinations often find themselves making their trips during the most congested days of the year. Reliable travel means fewer late arrivals, improved efficiency, saved time, and reduced frustration.

Travel on most transportation modes is consistent and repetitive, yet at the same time highly variable and unpredictable. This apparent contradiction occurs because travel is consistent and repetitive because peak usage periods occur regularly and can be predicted. The relative size and timing of rush hour is well known in most communities. Simultaneously, travel is variable and unpredictable because, on any given day, unusual circumstances such as a rainstorm or an auto accident can cause serious delays at any time.

The traveling public's experience with variations in travel reliability affects their decisions of how and when to travel, so that they have a reasonable expectation that they will arrive at their destination at a particular time. For example, if a highway is known to have highly variable traffic conditions, a traveler using that route to catch a flight routinely leaves extra time to reach the airport.

Factors Influencing Reliability

Travel time reliability is the direct result of the variable and often unpredictable events that can occur on different travel modes and at any time of day. The traditional way of measuring and reporting travel times experienced by highway users is to consider only average or typical conditions. However, the travel times experienced by users are seldom constant, even for travel on the same facility in the same peak or off-peak time period. Reliability is influenced by several underlying factors that vary over time and that influence the environment in which transportation operates. These factors are listed below.

Incidents

Incidents are events that disrupt normal travel flow, such as obstructions in the travel lanes of highways. Events such as vehicular crashes, mechanical breakdowns, and debris in travel lanes are the most common form of incidents for any mode. On highways, events that occur on the shoulder or roadside can also influence traffic flow by distracting drivers, leading to changes in driver behavior and ultimately to the quality of traffic flow.

Inclement Weather

Inclement weather and related environmental conditions (e.g., rain, fog, snow, ice, and sun glare) can lead to changes in operator behavior, vehicle performance, and operational control requirements that affect traffic flow. Motorists respond to inclement weather by reducing their speeds and increasing their headways. Airport and civil aviation authorities respond by grounding flights or delaying takeoffs and landings. In cases of severe weather, authorities respond by closing roadways and creating vehicle caravans.

Construction

Construction can often reduce the number, width, or availability of travel lanes, rail tracks, and runways. Nearby construction activities can also reduce reliability if operating rules or conditions are changed (e.g., slow orders on rail tracks). Delays caused by work zones have been cited by highway travelers as one of the most frustrating conditions they encounter on trips.

Volume Variation

Volume variation is day-to-day variability in demand that leads to some days with higher travel volumes than others. Different demand volumes superimposed on a system with fixed capacity results in variable, less reliable travel times.

Special Events

Special events, such as concerts, fairs, and sports events, cause localized congestion and disruption in the vicinity of the event that is radically different from typical travel patterns in the region.

Traffic Control Devices and Procedures
Traffic control devices and procedures can lead to intermittent disruption of travel flow through means such as air traffic control, railroad signals and switches, railroad grade crossings, drawbridges, and poorly timed signals.

Base Capacity
Base capacity refers to the physical capacity of a transportation system, such as the number the highway lanes or runways. The interaction of base capacity with the other influences on reliability has an effect on transportation system performance. This effect is caused by the nonlinear relationship between volume and capacity on any mode. When congested conditions are approached, small changes in volume lead to diminished throughput of the transportation system and consequent large changes in delay. Further, facilities with greater base capacity are less vulnerable to disruptions; for example, an incident that blocks a single lane has a greater impact on a highway with two travel lanes than a highway with three travel lanes.

Vehicle Availability and Routing
These can directly affect a traveler's ability to make an on-time trip, particularly on a common carrier, such as airplane and train, or by rental car. End-to-end routing, hubbing,[6] and other strategies to maximize vehicle operation time can affect reliability when a vehicle that is needed in one location first has to complete a trip from a different location. Short layovers, or *pads*, that are scheduled between trips for a given vehicle also affect vehicle availability.

The extent to which these eight factors affect each of the major intercity travel modes, and by extension the HST, is analyzed and compared on a qualitative basis by describing and ranking the extent to which each travel mode is potentially susceptible to each of the eight factors. It is presented in Table 3.2-8 and further detailed below. Because trips are composed of combinations of modal elements (including different modes for trip segments such as station or terminal access), modal rankings have been combined, providing a qualitative understanding of the reliability of each mode.

Table 3.2-8
Modal Reliability

Factor	Relative Susceptibility to Reliability Factors*		
	Air	**Automobile**	**High-Speed Train**
Incidents	**Low** Air travel has very few major incidents and is generally not influenced by incidents on other modes.	**High** Automobile travel can be influenced by minor and major incidents at any location along the roadway and is frequently affected by incidents outside the right-of-way.	**Low** HST has very few major incidents and is generally not influenced by incidents on other modes because the number of grade crossings is minimal or nonexistent.
Inclement weather	**High** A variety of weather conditions anywhere in the country can affect air travel.	**High** A variety of weather conditions can degrade operator ability, make roadways impassible, or damage roadways.	**Low** Trains can operate under virtually any conditions. Guideway is constructed to minimize weather impact.

[6] Hubbing is a reference to the "hub and spoke" operations practice where airlines coordinate a large number of their flights to arrive at a major terminal at the same time to allow passengers to transfer from one plane to the next to complete their trip to their final destination.

Factor	Relative Susceptibility to Reliability Factors*		
	Air	**Automobile**	**High-Speed Train**
Construction	**Low** Most activities scheduled for periods of low airport usage. High-quality construction minimizes routine maintenance needs.	**Moderate** Construction activities (major and minor) are common, but generally occur during warm weather months. Lane closures are often of long-term duration.	**Low** Most activities are scheduled for hours when system is closed. High-quality construction minimizes routine maintenance needs.
Special events	**Low** Special events (e.g., air space closure) are generally rare but can lead to rerouting or airport closure when they do occur.	**Moderate** Special events are common and can create volume fluctuations or short-term lane closures.	**Low** Most special events can be easily accommodated on HST without effect on travel time. Guideway closures are uncommon for this factor.
Traffic control devices or procedures	**Moderate** Reliability strongly influenced by air traffic control rules and capabilities.	**Moderate** Auto travel influenced by traffic signals, railroad crossings, and other devices. Influence depends on level to which devices are optimized.	**Low** HST operates in exclusive, grade-separated right-of-way, minimizing external influences. Double-tracked guideway minimizes switching needs. HST control systems are redundant and highly automated, allowing for a high level of precision in dispatching and control.
Inadequate base capacity	**Moderate** Capacity can be strong influence because of complex procedures for gate usage, taxiing, and takeoffs/ landings. This factor has strong interaction with weather at certain airports.	**High** This is one of the strongest influences on highway reliability, particularly for facilities with three or fewer lanes per direction. Travel time degrades quickly as capacity is approached.	**Low** HST system generally has large capacity reserve. Operations are not allowed to exceed design capacity. Exclusive guideway maintains high level of base capacity at all times.
Volume variation	**Moderate–High** Air travel demand and number of scheduled flights fluctuates broadly from day to day. Aircraft loading and unloading times directly affected by passenger volumes.	**High** Peak-period travel in medium to large urban areas highly influenced by day-to-day or seasonal volume variations. Strong interaction with inadequate base capacity.	**Low** Day-to-day variation in train volumes tends to be low. Passenger volume variation generally does not influence travel times.
Vehicle availability or routing	**High** Airplanes are used multiple times in a given day, and availability can be affected by factors anywhere in the world and with any type of routing system (point-to-point or hub-and-spoke). High capital cost discourages airlines from keeping large reserve fleet.	**Low** Private automobiles are ubiquitous and are widely available for rental in emergency situations. The road and highway network provides alternative routes for most trips.	**Moderate** HST vehicles complete multiple end-to-end trips in a day, potentially affecting availability at specific times and locations; simple routing schemes generally followed.

* *High* indicates that the factor can exert a strong negative influence on travel time reliability for the mode. Conversely, *low* indicates that the factor generally does not play a role in influencing travel time reliability for the mode.

Source: Cambridge Systematics 2003.

Automobile Mode Characteristics

On a day-by-day basis, automobiles tend to be the least reliable of the three modes. Highway travel is highly or moderately susceptible to seven of the eight factors described above. It is only when considering the influence of vehicle availability and routing that automobiles potentially would have a lower susceptibility than other modes.

Recent research provides further evidence on the unreliability of highway travel (Texas Transportation Institute and Cambridge Systematics 2003). This research, which used actual travel time data covering 579 mi (932 km) of freeways in the Los Angeles area, shows that reliability problems exist on highways at all times of the day, all days of the week, and all weeks of the year. This research expressed unreliability in terms of a buffer index, the amount of extra time motorists would need to budget to be certain of arriving on time at their destination 95% of the time. Results showed that a motorist in Los Angeles would need to allow an additional 45 minutes for a typical 1-hour highway trip—fully 75% of normal driving time. Even in midday periods, a traveler would need to budget an additional 30 minutes for the same 1-hour trip, or 50% of the normal time. It is important to note that a buffer does not represent certainty, and on any given day this buffer may or may not be needed.

Air Mode Characteristics

Despite its high average speed, air travel often suffers from reliability problems as a result of several factors. The data in Table 3.2-8 suggest that air travel is moderately or highly susceptible to weather, vehicle availability, volume variation, inadequate base capacity, and traffic control procedures. Air travel is more susceptible than the other two modes to reliability problems arising from weather and vehicle availability. Bad weather and a shortage of aircraft in other states can impact service in California. Air travel reliability is generally not, however, influenced by incidents, construction, or special events.

Airline on-time statistics compiled by the FAA show air travel reliability problems are widespread in California. Airline on-time statistics are available through the Bureau of Transportation Statistics Web site (http://www.bts.gov/ntda/oai). These statistics were reviewed to compare actual versus scheduled flight times for flights departing from Sacramento (SMF), SFO, LAX, and San Diego (SAN) in June 2002.[7] The statistics were analyzed to determine the median scheduled flight time and the 95th percentile actual flight time for flights departing from these four airports.[8] These times and the resulting buffer are shown in Table 3.2-9.[9]

The data in Table 3.2-9 indicate that air travel is generally more reliable than highway travel, as suggested by the smaller buffers (10 to 15% for air travel versus 50 to 75% for highway travel). Nonetheless, the data also show that air travelers at these four airports still need to budget an additional 9 to 18 minutes of in-vehicle travel time to account for unforeseen reliability problems that often arise with air travel.

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[7] Statistics were analyzed for all flights operated by Alaska, America West, American, American Eagle, Delta, Southwest, United, and United Express. These eight airlines account for more than 95% of domestic departures at these four airports. More than 29,000 individual flights were included in the sample.

[8] The 95th percentile was chosen to maintain consistency with the research results reported for the highway mode.

[9] As with the highway mode, the buffer indicates the additional time needed above the average (median) time air travelers would need to budget to arrive on time for their flight with 95% certainty. For air travel, the buffer is expressed as a percentage of the median flight time.

Table 3.2-9
Reliability Statistics for Air Travel in California

Airport	Time (minutes)		Percent Buffer (Delay/Scheduled Flight Time)
	Delay (95th Percentile Travel Time)	Scheduled Flight Duration (Median)	
Sacramento (SMF)	9	85	10.6
San Diego (SAN)	12	90	13.3
San Francisco (SFO)	18	118	15.3
Los Angeles (LAX)	12	110	10.9
Source: Bureau of Transportation Statistics 2002.			

HST has been shown to have a low susceptibility to nearly all of the major factors that affect reliability. It is only on the issue of vehicle availability that HST, like all common carrier modes, has a higher level of susceptibility than highways. Also, HST has the same or lower level of susceptibility on all eight factors compared with air travel or even conventional rail.

Statistics from HST operations in Europe and Asia further confirm the high level of reliability that is inherent with HST. In France, more than 98% of TGV train runs have been completed within 1 min of schedule. In Spain during 2002, 99.8% of AVE runs were completed within 5 min of schedule. In Japan, the JR Central Shinkansen line averaged a 16-second delay per train in 2002. Using the buffer concept that was described for highways and air, these data suggest that HST travelers would likely need to have a schedule buffer less than 1 minutes (less than 1% of scheduled travel time) to account for unforeseen delay and reliability. This in-vehicle travel time buffer is extremely small compared to all other modes.

HST systems have proven worldwide to be far more reliable than conventional U.S. intercity rail services. Several factors account for this reliability.

- Intercity rail service involves mixed operations between conventional intercity passenger services and heavy freight traffic, whereas the HST service would not share tracks with heavy freight services.
- Depending on location and number of operations, the quality of train signal/control/dispatch systems for freight rail systems vary, whereas the HST services would use state-of-the-art automated control systems.
- Most conventional intercity passenger rail routes operate on freight railroads that are dispatched by the host freight railroad. Therefore, dispatching decisions may be based first on the needs of the host railroad, and then on the needs of the passenger train. For example, if a freight train is too long to go into a siding, the dispatcher will have to put the passenger train in the siding to wait until the longer freight train passes. This is just one type of delay for passenger trains using freight railroads.
- Grade crossings are inherently dangerous, providing the opportunity for vehicle and pedestrian collisions and delay due to malfunction of grade-crossing protection equipment. The HST service would be completely double-tracked, fenced, and grade-separated.

  Although detailed statistics were not available, reports on rail operations in California suggest that conventional rail reliability is low (California Department of Transportation 2002). Although Amtrak strives to complete a minimum of 90% of its train runs on time, the most recent data show that the Capitol Corridor is on time about 75% of the time, while intercity service within the LOSSAN corridor is on time about 78% of the time.

Reliability Effects of the HST Alternatives

The HST is likely to provide a greater degree of travel reliability than the No Project Alternative for the following reasons.

- HST would divert significant levels of intercity demand from less reliable modes, particularly highways.
- HST would provide a completely separate transportation system that would have less susceptibility to many factors influencing reliability.
- Highway and air travel reliability would improve because HST would reduce travel demand on highways and air.

The HST alternatives would not be likely to exhibit appreciable differences in system reliability because system capacity and demand would be roughly equivalent. Major design differences (e.g., extent of tunneling) would not make a meaningful difference in reliability, and differences in base travel times on HST would not influence reliability. The reliability of the HST system would not change for the various HST Network Alternatives. However, for HST passengers, adding transfers to other modes and/or longer automobile access/egress trips would have a negative impact on reliability of their total trip.

Sensitivity to Travel Demand Forecasts

As with travel time, reliability is also influenced by the level of travel demand. Other things being equal, reliability is expected to be better on facilities that have lower travel demand (or experience lower V/C ratios) because of the nonlinear relationship between volume and capacity, as mentioned above. Therefore, lower levels of highway or air travel demand with the HST, such as those suggested by the ridership forecasts, would be expected to improve reliability for the highway and air modes. Given the large reliability advantage enjoyed by the HST mode, the HST alternatives would be expected to provide the greatest degree of travel reliability across the range of travel demand scenarios.

<u>Safety</u>

In transportation, three basic characteristics interact to influence the safety of a mode.

- Operator: His or her training, regulation, and experience.
- Vehicle: Its condition, regulation, control systems, and crashworthiness.
- Environment: Weather, guideway type, guideway condition, and terrain.

Each of these characteristics plays a role in the overall safety of the modes, which for this analysis is quantified as the probability of passenger fatality. Injuries are more difficult to compare between modes because they are categorized differently by mode and different injury ratings are used. For instance, automobile injuries are generally related to automobile crashes, while for air, bus, and rail they can include injuries that occur as part of a crash, while boarding/alighting, or in the terminal. The severity of these injuries can vary from scrapes and bruises to life-threatening ones. For the purposes of this analysis, injuries by mode will be discussed but are not measured as a key indicator of safety. This analysis also only considers injuries and fatalities of passengers and does not include employees or other staff.

To assess the relative safety effect of implementing the HST system, analysis has focused on fatalities measured by rate of fatality per 100 million passenger miles traveled. For this analysis the high-end HST ridership forecasts were used because this approach would present the worst case for potential fatalities for all modes and alternatives. The safest mode is the one that has the lowest number of fatalities per 100 million passenger miles traveled (PMT).

Automobile Mode Characteristics

The automobile is unquestionably the most used and the most dangerous of highway, air, and rail modes. The National Highway Traffic Safety Administration estimates that the national motor vehicle fatality rate is 0.80 fatalities per 100 million passenger miles traveled. Nationally in 2000, there were about 6.4 million reported motor vehicle crashes that resulted in 42,000 fatalities and 3.2 million injuries. About 4.2 million crashes involved property damage only (National Highway Traffic Safety Administration 2001). The National Highway Traffic Safety Administration estimates that deaths and injuries resulting from motor vehicle crashes are the leading cause of death for persons between the ages of 4 and 33, while traffic-related fatalities account for more than 90% of all transportation-related fatalities. According to the California Highway Patrol, in 2000 there were 3,331 fatal crashes in California alone (California Highway Patrol 2000). The risk to an individual depends most strongly on the time spent behind the wheel or in the passenger seat. The longer the journey or the more frequently the journey is made, the greater the risk of a crash. Some of the factors that influence auto and highway safety are listed below.

- Operator.
  - Drivers vary in age, experience, ability, and many other factors.
  - Nonprofessional drivers typically operate automobiles.
  - Limited regulatory requirements govern who can operate an automobile and the type of training that is needed, and these requirements vary between states.
- Vehicle.
  - Privately owned vehicles are mechanically not as reliable as the public transportation modes.
  - Maintenance and inspections are not regulated, and are performed by mechanics of varying skill levels.
  - Crashworthiness and roadworthiness varies depending on make and model.
  - Minimum requirements rather than optimum standards dictate safe operating conditions.
- Environment.
  - Highways provide no latitudinal or longitudinal control to individual automobiles.
  - Fixed objects (e.g., trees, light poles, sign posts) are frequently placed within the highway right-of-way.
  - Weather and lighting conditions (wind, rain, fog, snow, ice, darkness, and sun glare) can adversely impact vehicle and driver performance.
  - Traffic control systems that regulate the speed and safe operation of an automobile are limited in influence.
  - Roadway conditions and designs are varied and can include systems based on different design speeds, vehicles, and operating conditions.
  - Drivers are subject to a multitude of potential distractions and interferences.

Air Mode Characteristics

Air travel is a safe mode of travel and in recent years has become even safer with the introduction of improved aircraft and state-of-the-art air traffic control systems. According to the U.S. Department of Transportation (DOT), the likelihood of fatality due to commercial air travel is relatively small (0.02 fatalities per 100 million PMT). According to the University of Michigan Transportation Research Institute, flying a typical nonstop flight is 65 times safer than driving the same distance. Takeoff and landing presents the greatest safety risk during a flight; between 1991 and 2000, 95% of all airline fatalities occurred either during takeoff or landing, and just 5% of fatalities occurred at cruising altitudes (Sivak and Flannagan 2002). Consequently, the risks of flying depend mostly on the number of segments flown and not on the distance flown. Injuries associated with air travel can occur during the process of boarding and alighting, and during flight. Most are relatively minor and include scrapes, bruises, broken bones, and a few serious falls. Some of the factors that influence air travel safety are listed below.

- Operator.
  - Commercial aircraft can only be operated by professional pilots, who are rigorously trained and must update their proficiency regularly.
  - Other airline personnel such as flight attendants are trained to provide immediate assistance in emergency situations.
  - Pilots are subject to drug tests and are regulated by the FAA.
  - Automation of fight operations is well developed and commonly installed.
- Vehicle.
  - Aircraft are regularly maintained to high standards and the FAA regularly inspects these maintenance records.
  - Aircraft themselves are constructed of high-grade metals and, provided they are maintained regularly, can be in active service for decades.
  - All aircraft occupants are required to wear seatbelts during takeoffs and landings, the two procedures that present the greatest safety risk.
  - Air traffic control systems in the United States are standardized and are some of the safest, most reliable systems in the world for controlling commercial aircraft and warning them of potential dangers.
- Environment.
  - One of air travel's greatest weaknesses is its vulnerability to weather. Although most commercial aircraft can fly above or below most storm systems, they often have no choice during takeoffs and landings but to fly through thunderstorms, snow, ice, and fog. Particularly severe weather conditions can ground all aircraft and prevent those in flight from landing.
  - Unexpected turbulence during flight can injure passengers. For this reason, passengers are often required to wear seat restraints and are discouraged from walking or standing during flight.
  - Aircraft have no guideway to provide latitudinal or longitudinal control and therefore run the risk of striking fixed or other flying objects while on the ground or during flight.

High-Speed Train Mode Characteristics

Based on statistics from Europe and Japan, HST is the safest mode of travel.[10] Since 1988, there have been 85 injuries and 14 fatalities[11] reported on all dedicated HST systems in Europe. In Japan's

[10] There are no statistics for HST safety in the United States.

34 years of HST operations, no passenger fatalities have been reported. For the purposes of this analysis and for comparison purposes only, it is assumed that the fatality rate for HST is less than air travel but greater than 0.0, or 0.001 per 100 million PMT. Similar to air travel, the likelihood of injury is associated with boarding and alighting, and during operation, with injuries ranging from minor to severe. The distinguishing reasons for the safety of HST travel relative to air and highway travel are summarized below. The HST mode would be much safer than conventional intercity rail services in California, which operate on freight railroads that have a mix of rail traffic and grade crossings.

- Operator.
  - HST operators would be rigorously trained and tested and would be required to update their qualifications regularly.
  - HST operators would be required to submit to drug tests and would be subject to regulation by the FRA and operating railroads.
  - The train would be completely automated and the train operator would be a failsafe redundant system component that could act in the unlikely case that a system malfunction or other problem occurs.
- Vehicle.
  - The FRA passenger equipment safety standards (49 CFR Part 238) dictate the buff strength or amount of force a train can withstand in a collision, for all passenger equipment. The buff strength is adjusted to the operating and rail traffic conditions and is designed to minimize injuries or fatalities caused by rail crashes.
  - The trains would be completely automated, allowing for centralized command and control of the train system, effectively eliminating the chance of operator error. Much like the BART system in the San Francisco Bay Area, a centralized system would control the operation of the train while the operator would be the physical eyes and ears of the train ensuring passenger safety.
  - Like airplanes, trains and the infrastructure they operate on (tracks, control systems, and electrification systems) would be maintained on a regular schedule. Maintenance records would be subject to inspection by the FRA.
  - Like aircraft, passenger train equipment is built for a long service life. If maintained properly, a modern train car can have a useful life of at least 30 years.
  - HST traffic control and communications systems are state-of-the-art, regulated, and managed during all hours of operation. These systems control the train's speed, schedule, routing, and headway (following distance behind another train). These systems, combined with the operator, have integral redundancy and ensure safety.
- Environment.
  - The HST system would be fully access controlled and grade-separated (including grade crossings), virtually eliminating pedestrian and motor vehicle conflicts.
  - The HST system would be closed to all other rail traffic, greatly reducing the possibility of collision with other trains. An exception is the Caltrain corridor between Gilroy and San Francisco, where the HST would travel at reduced speeds and share the track with express commuter passenger trains.

[11] The worst accident on a dedicated high-speed right-of-way was a derailment in Piacenza, Italy in 1997, which resulted in eight fatalities.

- Inclement weather has only a minimal impact on HST operations. Because it is nearly impossible to read line side signals flashing by at 200 mph (322 kph), HSTs use a cab signaling system that transmits commands directly to the driver. This technology makes high-speed operation possible in darkness, rain, and fog. In Japan, even moderate snowfall does not slow the Shinkansen because of special ice-melting equipment built into the rail bed.
- Unlike aircraft, HST systems are not subject to turbulence. Passengers may sit without seat restraints and may stand and walk comfortably even at maximum speeds and around curves.
- Although HST systems do operate in highly seismic areas, such as Japan, no fatalities have ever occurred as a result of a seismic event. Failsafe technology would stop the trains when an earthquake is detected, and at-grade construction in fault zones would further improve safety.
- The HST system, like other public intercity modes, would be inspected on a regular schedule as required in federal regulations. This regular inspection of both rolling stock and track would ensure the safety of the HST.

The safety characteristics of each mode are summarized in Table 3.2-10. This table shows that for all three safety characteristics, the HST mode has the best safety performance. While air and HST are similar in regard to operator and vehicle characteristics, HST performs better with regard to the environment because the HST mode is capable of operating safely and comfortably in a variety of climatic conditions compared to aircraft, without the need for passenger restraints. The automobile mode fares poorest in terms of safety.

Table 3.2-10
Safety Performance by Mode

	Safety Performance Characteristics		
Mode	**Operator (Training, Regulation, Experience)**	**Vehicle (Condition, Regulation, Control Systems, Crashworthiness)**	**Environment (Weather, Guideway Condition, Terrain)**
Automobile	Poor	Good	Poor
Air	Excellent	Excellent	Poor
HST	Excellent	Excellent	Excellent

Safety Effects of the HST Alternatives

The HST alternatives would provide a safety benefit compared to the No Project Alternative. HST would divert up to 21 million annual intercity highway trips compared to the No Project Alternative, resulting in fewer injuries and fatalities annually. The HST alternatives would have the best overall safety performance, primarily because they divert passengers from the least safe automobile mode to HST, the safest mode. This demand shift combined with the rigorous requirements of HST operators, regular vehicle inspection, maintenance, control systems, crashworthiness, and ability to operate in virtually all weather conditions, make the HST alternatives superior to the No Project Alternative. For the HST Network Alternatives, the safety benefit would vary, depending on the ridership potential of the alternative. The HST Network Alternatives with the highest ridership potential would promote the best overall safety performance.

Connectivity

Connectivity in the study region and the state can be measured qualitatively and quantitatively using the number of modal options that offer competitive transportation services, the availability of intermodal connections, and the frequency of service (number of departures). A greater number of competitive modal options is considered a benefit because it increases the diversity, redundancy, and flexibility of the overall transportation system and provides travelers with greater choices.

- *Modal options* are a measure of the intercity modal diversity of each of the alternatives.
- An *intermodal connection* or facility allows passengers to transfer from one mode to another to complete a trip. A connection can be as simple as a timed connection between a train and a bus or as elaborate as the BART connection to SFO where air, rail, and bus all converge to give multiple transportation options.
- *Frequency* is measured as the number of departures available to travelers in the study region and state. High service frequency benefits travelers because it increases the number of possible connections to different modes and the number of options available for travel to a destination.

Modal Options

The No Project Alternative provides four modal options: automobile, air, intercity rail, and intercity bus. However, intercity travel in California is dominated by automobile and air transportation. The automobile accounts for over 95% of all intercity trips, with air transportation representing more than 3% and conventional rail carrying most of the remaining trips. Although the automobile and air modes compete against one another for the longer-distance intercity trips, such as San Francisco to Los Angeles, the automobile is without rival for many intermediate intercity trips. Table 3.2-11 shows intercity trips by mode between the major metropolitan regions for the proposed HST system. Between the San Francisco Bay Area and the Los Angeles Metropolitan Area, air transportation serves almost 43.4% of the travel market, and the automobile accounts for 56.6%. Air transportation offers fast enough travel times to compete for the long-distance business travel market. Trips between the Central Valley and either the San Francisco Bay Area or the Los Angeles Metropolitan Area are good examples of intermediate intercity trips. For these markets, the automobile serves 97.4% of the travel market, while air transportation serves 1.5% and conventional rail serves about 1.1%.

Table 3.2-11
2005 Intercity Trip Table Summary[a]

	2005 Base Trips		
Market	**Auto**	**Air**	**Conventional Rail**
Los Angeles to Sacramento	3,461,478	1,819,829	-
Los Angeles to San Diego	103,881,859	26,523	3,388,599
Los Angeles to San Francisco	11,186,216	8,562,048	-
Sacramento to San Francisco	49,821,831	7,665	1,860,770
Sacramento to San Diego	95,143	1,099,745	-
San Diego to San Francisco	2,596,853	4,842,881	-
Los Angeles/San Francisco to Valley Cities	83,490,526	1,257,364	922,355
To/From Monterey/Central Coast	118,482,711	177,573	537,584
To/From Far North	109,606,519	1,040,311	327,101
To/From W. Sierra Nevada	75,634,813	1,039,763	67,038
Total	581,985,626	20,094,345	7,136,298

Market	2005 Base Trips		
	Auto	Air	Conventional Rail
[a] Air trips in this table are "local" (or true origin/destination) air trips between metropolitan areas. Connect air trips (which are not destined to a city within the corridor), and their potential for diversion to HST were not forecast in this study. The diversion to HST of connect trips is small in absolute numbers and limited to a few shorter distance intercity markets. [b] Conventional rail trips do not include rail operators that run buses to extend rail service into additional cities because demand for these services is very small. Source: Cambridge Systematics 2007.			

The HST system would provide a new intercity and regional passenger mode of transportation that would improve connectivity to other existing transit modes and airports. HST would bring competitive travel times and frequent and reliable service to the traditional urban centers of the San Francisco Bay Area, Los Angeles Metropolitan Area, Sacramento, and San Diego. It would significantly improve the modal options available in the Central Valley and other areas of the state not well served by public transport (bus, rail, or air) for intercity trips.

Tables 3.2-12 (low end) and 3.2-13 (high end) show intercity trips by mode between the major metropolitan regions in the state projected for 2030 with a statewide HST system. Under the low-end, or base case, assumptions, between the San Francisco Bay Area (MTC region) and the Los Angeles Metropolitan Area (SCAG region), HST is projected to capture at least 41% of the travel market. Air transportation would serve up to 27% of the travel market, the automobile up to 32%, and conventional rail virtually none of the market. For the high-end ridership assumptions, between the San Francisco Bay Area and the Los Angeles Metropolitan Area, HST is projected to capture up to 71% of the travel market, with the automobile as low as 25%, air transportation serving as little as 4%, and conventional rail virtually none of the market. For trips between the Central Valley and either the San Francisco Bay Area or the Los Angeles Metropolitan Area, the automobile would serve 88% of the intercity travel market, while HST would capture 9% for the low-end forecasts (85% automobile trips and 13% HST trips for the high-end forecasts). The HST system would provide similar benefits to other intermediate intercity markets it serves. For longer-distance intercity trips, HST would provide a competitive alternative to driving and flying. For shorter intercity trips, HST would also be an attractive alternative to driving. Between the San Diego and Los Angeles metropolitan regions, HST captures 17% of the market, but this is a large intercity market and results in 22 million HST trips in 2030 (or 28 million HST trips in the high-end scenario).

Table 3.2-12
2030 Intercity Trip Table Summary for the Base Case Scenario

	Auto	Air	Amtrak Rail	HST	Total	Portion
Los Angeles to Sacramento	2,447,325	1,956,035	-	3,314,200	7,717,560	1%
Los Angeles to San Diego	108,245,472	14,609	3,578,088	22,297,219	134,135,388	15%
Los Angeles to San Francisco	6,654,680	5,572,820	-	8,358,500	20,586,000	2%
Sacramento to San Francisco	61,404,194	2,199	4,096,594	2,685,366	68,188,353	8%
Sacramento to San Diego	53,501	1,803,903	-	123,606	1,981,010	0%
San Diego to San Francisco	1,035,505	4,134,720	-	3,422,970	8,593,195	1%
Los Angeles/San Francisco to Valley Cities	120,816,701	2,384,427	1,631,124	12,666,311	137,498,563	15%
Other	198,613,326	496,401	1,218,372	4,247,149	204,575,248	23%
To/From Monterey/ Central Coast	151,777,421	1,616,825	639,414	4,523,086	158,556,746	18%
To/From Far North	115,344,917	1,350,252	339,208	2,654,082	119,688,459	13%
To/From W. Sierra Nevada	34,142,605	313,313	100,691	1,218,470	35,775,079	4%
Total	800,535,647	19,645,504	11,603,491	65,510,959	897,295,601	100%

Table 3.2-13
2030 Intercity Trip Table Summary Sensitivity Analysis Scenario (High-End)

	Auto	Air	Amtrak Rail	HST	Total	Portion
Los Angeles to Sacramento	1,704,185	460,630	-	5,454,195	7,619,010	1%
Los Angeles to San Diego	98,986,175	-	6,439,695	28,173,985	133,599,855	15%
Los Angeles to San Francisco	5,126,790	836,215	-	14,478,090	20,441,095	2%
Sacramento to San Francisco	58,451,465	-	5,407,475	3,378,440	67,237,380	7%
Sacramento to San Diego	72,270	654,810	-	1,095,000	1,822,080	0%
San Diego to San Francisco	601,155	644,955	-	7,186,850	8,432,960	1%
Los Angeles/San Francisco to Valley Cities	114,560,725		2,557,555	18,074,070	135,192,350	15%
Other	195,926,890	293,460	1,738,860	5,865,915	203,825,125	23%
To/From Monterey/Central Coast	148,689,320	255,135	927,830	6,419,985	156,292,270	17%
To/From Far North	111,904,255	547,135	444,570	3,436,475	116,332,435	13%
To/From W. Sierra Nevada	43,574,276	159,147	390,305	2,944,987	47,068,715	5%
Total	779,597,506	3,851,487	17,906,290	96,507,992	897,863,275	100%

Intermodal Connections

The automobile can be used to go virtually anywhere in California. Unlike common carrier transportation modes (air, bus, or rail), the automobile does not require or depend on intermodal connections to get from the trip origin to the trip destination. The flexibility of the automobile mode would be unaffected by the HST.

Scheduled airline service allows a traveler to reach any destination served by commercial airlines in a relatively short travel time. Unlike the automobile, commercial air travel requires intermodal connections to get to the airport and to a final destination. Moreover, airports are predominately located outside major city centers, a considerable distance from the major transit hubs, which are typically downtown. With the exception of the San Francisco and Burbank airports, which are served directly by rail, all airports in California require transfers to automobiles or road-based public transportation.

It is assumed that there would be limited new intermodal connections under the No Project Alternative because a limited number of these improvements are currently planned and programmed.

HST stations would be generally located at existing transportation centers that could serve a wider area through public transit and would enhance intermodal connections in each region. HST stations in the traditional urban cores of the Sacramento area, the San Francisco Bay Area, and Los Angeles area would connect to the heart of the established public transit networks. For example, Los Angeles Union Station (LAUS) is projected to be the most heavily used HST station. LAUS is the transit hub of Los Angeles County and is the primary destination for the Metrolink Commuter rail services, the Los Angeles Metro Red Line, the Pasadena Gold Line, the Amtrak Surfliner service, and the regional bus transit services. The proposed Transbay Transit Center in San Francisco would be located in the heart of San Francisco's financial district and within walking distance of all major downtown hotels, the convention center, and Union Square retail. The Transbay Transit Center would also serve Caltrain commuter rail, all the major bus services to downtown San Francisco, BART, and the extensive San Francisco Municipal Railway (Muni) light-rail system.

The HST could have a profound effect on the Central Valley and on outlying areas that are not well served by other forms of public transportation. The HST would provide convenient and reliable connections to the airports and downtowns of San Francisco and Los Angeles and to Central Valley cities. All of the potential HST station sites in the Central Valley would either be in city centers or at transportation hubs (airports and Amtrak stations).

Frequency

The automobile, by offering unlimited potential frequency and because it can be driven at virtually any time and to virtually any destination, has the highest connectivity of any mode.

Although 17 commercial airports are in the area that would be served by the HST system, the range of city pairs served is considerably narrower because little to no commercial service exists between some of the city pairs. Air travel is market-driven and consequently airlines concentrate their operations on markets that are profitable. The San Francisco Bay Area to Los Angeles Metropolitan Area corridor is the most heavily traveled air corridor in the world. This intercity travel market and the long distance markets to/from Sacramento and to/from San Diego have many daily departures and arrivals. In other regions such as the Central Valley, where demand is lower and the distances shorter, the number of daily flights serving California intercity markets is far more limited.
Table 3.2-14 shows the daily 2005 average air frequencies by airport pair (Cambridge Systematics 2007). While LAX has service to ten airports in California with more than 400 flights per day total, Bakersfield has flights to only four airports in the state and 45 flights per day total. Arcata and Modesto have service to only three airports in the state, and Santa Barbara serves only two airports in California. There is virtually no air service between cities within the Central Valley (Modesto, Bakersfield, Merced, and Fresno).

The HST system would be a new intercity service in the statewide intercity transportation network that would offer a variety of services with different stopping patterns (express, skip-stop, and local services) to serve long-distance, intermediate, and shorter-distance intercity trips. Consequently, HST would increase frequencies for some city pairs that are not well served by air transportation. In addition to the major city pairs, smaller cities in the Central Valley and suburban cities surrounding the major markets would be directly connected with frequent intercity service.

Table 3.2-14
2005 Average Air Frequencies (Flights per Day) by Airport Pair (Each Direction)[a,b]

City	Code	SAN	SNA	LGB	LAX	ONT	BUR	SJC	SFO	OAK	SMF	MRY
San Diego	SAN	-	-	-	-	-	-	-	-	-	-	-
Santa Ana	SNA	-	-	-	-	-	-	-	-	-	-	-
Long Beach	LGB	-	-	-	-	-	-	-	-	-	-	-
Los Angeles	LAX	47	-	-	-	-	-	-	-	-	-	-
Ontario	ONT	-	-	-	-	-	-	-	-	-	-	-
Burbank	BUR	-	-	-	-	-	-	-	-	-	-	-
San Jose	SJC	31	20	-	54	8	9	-	-	-	-	-
San Francisco	SFO	60	35	-	101	22	30	-	-	-	-	-
Oakland	OAK	29	23	7	60	17	16	-	-	-	-	-
Sacramento	SMF	39	14	9	42	18	21	-	15	-	-	-
Palm Springs	PSP	33	-	-	23	-	-	9	20	12	11	-
Oxnard	OXR	-	-	-	-	-	-	-	8	5	8	-
Santa Barbara	SBA	-	-	-	-	-	-	-	14	-	10	-
Bakersfield	BFL	10	17	-	10	-	-	-	-	-	-	8
Fresno	FAT	18	23	-	29	6	14	-	11	-	-	2
Monterey	MRY	-	-	-	25	-	-	3	10	5	4	-
Arcata	ACV	9	7	-	10	-	-	-	-	-	-	-
Modesto	MOD	7	7	-	11	-	-	-	-	-	-	-

[a] Three-digit codes for airports used as the column headings correspond to the airport names in the row headings.

[b] Source: Federal Aviation Administration data from the 10% ticket sample, supplemented with internet queries in August 2006. This includes direct and connecting service for intra-state flights where demand in 2005 is greater than one trip per day (400 annual trips).

The proposed HST system would serve about 20–30 stations (depending on alignment alternative selected). Table 3.2-15 shows the number of daily trains (for each direction) served for each station pair, as assumed for the base case Altamont and Pacheco Pass representative alternatives. This table shows that, compared to air transportation, the addition of HST service would greatly increase the number of trains serving major and intermediate destinations. For example, Fresno and Bakersfield are expected to have service to 25 stations/cities with frequencies of 26 trains daily in each direction. Central Valley cities, such as Merced, Modesto, Stockton, and Visalia as well as additional urban markets in the San Francisco Bay Area and southern California, such as East San Gabriel Valley, Palo Alto/Redwood City, Riverside, Sylmar, and Escondido, would receive frequent service to all HST stations.

Connectivity Effects of the HST Alternatives

The HST alternatives would be a new mode in the state's intercity transportation system. The HST would create a variety of new intermodal connections to local, regional, and intercity modes. The HST would add frequencies to the state's intercity travel network, allowing greater flexibility in travel time and location; however, the HST could result in some decreases in air frequencies in some markets. As compared to the No Project Alternative, the HST alternatives provide the highest level of connectivity in the study region and state, particularly between the Central Valley cities and the city centers of the major metropolitan areas. The level of improvement in connectivity varies among the HST Network Alternatives. The network alternatives that directly serve San Francisco, Oakland, and San Jose would provide the greatest connectivity benefit.

Passenger Cost

Passenger cost is a measure of the relative differences in travel costs between the No Project and HST alternatives. Passenger cost for this analysis means the total cost of the trip, including the cost of traveling to the airport or station, the airplane or train fare, and other associated expenses. Cost is one of the key factors that can influence passenger choice of modes.

There is a range of existing intercity travel options, from relatively inexpensive intercity bus to premium air. For example, the cost of traveling round-trip between Los Angeles and San Francisco (one of the busiest travel corridors in the world) can be as little as $25 for an intercity bus ticket to as much as $350 for a walk-up fare for airline travel. The air travel market particularly features large variations in fares. Sources of these variations include the following factors.

- Time of travel: Peak-period travel tends to be more expensive, and Saturday night stays tend to be less expensive.
- Time of booking: Early bookings tend to be less expensive, while last-minute bookings are more expensive.
- Airport choice: Travel between major destinations such as Los Angeles and San Francisco boasts a variety of options and fares, while travel to or from smaller airports with limited service, such as Fresno and Bakersfield, have greatly limited fare and travel choices.

Passenger cost is quantitatively measured by actual costs to the passenger associated with a typical door-to-door trip. The representative city pairs presented in the travel time discussion earlier in the section are used as a basis to compare the relative differences in cost

Automobile Mode Characteristics

For highway travel, it is assumed that the entire door-to-door trip is made with a private automobile and that there are no ancillary access costs. Automobile travel costs are shown as the total costs per auto. The total costs of operating a vehicle include maintenance, repairs, and taxes, which are shown on a per-auto basis in Table 3.2-16. These costs do not include other costs of owning an auto, such as depreciation, financing, or insurance. The ridership and revenue estimates are based on the perceived costs of making an automobile trip (e.g., fuel and maintenance) and do not include all of the true costs associated with owning and operating a vehicle.

Table 3.2-17 summarizes the costs for making a one-way trip for the representative city pairs. Tolls and parking are included in these estimates. All-day parking in downtown San Francisco or Los Angeles was set at $25. As shown in the table, the door–to-door average perceived one-way cost per person for traveling between representative city pairs by highway range from $40 to $137 for total costs.

Table 3.2-15
2030 High-Speed Train Frequencies (Trains per Day) by Station Pair (Each Direction)

Pacheco Pass

	San Francisco (Transbay)	Millbrae	Redwood City	San Jose	Gilroy	Sacramento	Stockton	Merced	Fresno	Bakersfield	Palmdale	Sylmar	Burbank	Los Angeles Union Station	Norwalk	Anaheim	Irvine	Ontario	Riverside	Temecula	Escondido	University City	San Diego	Morgan Hill	City of Industry
San Francisco (Transbay)																									
Millbrae[1]	54																								
Redwood City	54	54	-																						
San Jose	28	54	54																						
Gilroy	53	53	53	53	-																				
Sacramento	36	18	18	36	18	-																			
Stockton	18	18	18	18	18	47	-																		
Merced	18	18	18	18	18	26	26	-																	
Fresno	36	20	20	36	20	23	23	8	-																
Bakersfield	36	20	20	36	20	23	23	8	55	-															
Palmdale	32	32	32	32	31	20	20	8	30	36	-														
Sylmar	32	32	32	32	31	20	20	8	30	36	54	-													
Burbank	32	32	32	32	31	20	20	8	30	36	54	54	-												
Los Angeles Union Station[1]	28	32	32	28	31	37	29	8	55	61	54	54	54												
Norwalk	3	3	3	3	3	3	3	3	3	3	5	5	5	5	-										
Anaheim	15	5	5	15	6	7	5	6	7	8	7	7	7	22	5	-									

	San Francisco (Transbay)	Millbrae	Redwood City	San Jose	Gilroy	Sacramento	Stockton	Merced	Fresno	Bakersfield	Palmdale	Sylmar	Burbank	Los Angeles Union Station	Norwalk	Anaheim	Irvine	Ontario	Riverside	Temecula	Escondido	University City	San Diego	Morgan Hill	City of Industry
Irvine	15	5	5	15	6	7	5	6	7	8	7	7	7	22	5	22	-								
Ontario	32	27	27	32	27	24	20	8	32	37	47	47	47	58	5	26	26	-							
Riverside	32	27	27	32	27	24	20	8	32	37	47	47	47	58	5	26	26	58	-						
Temecula	32	27	27	32	27	24	20	8	32	37	47	47	47	58	5	26	26	58	58	-					
Escondido	32	27	27	32	27	24	20	8	32	37	47	47	47	58	5	26	26	58	58	58	-				
University City	32	27	27	32	27	24	20	8	32	37	47	47	47	58	5	26	26	58	58	58	58	-			
San Diego	48	27	27	48	27	30	26	8	48	53	47	47	47	80	5	26	26	58	58	58	58	58	-		
Morgan Hill	53	53	53	53	56	18	18	18	22	25	34	34	34	34	3	3	3	31	31	31	31	31	31	-	
City of Industry	32	27	27	32	27	24	20	8	32	37	47	47	47	58	5	26	26	55	55	55	55	55	55	27	-
Modesto (Briggsmore)	18	18	18	18	18	35	35	26	18	18	8	8	8	18	3	6	6	6	6	6	6	6	12	18	6

Altamont Pass

	San Francisco (Transbay) (1)	Millbrae	Redwood City	San Jose	Sacramento	Stockton	Tracy DT	Modesto/SP Downtown	Merced	Fresno	Bakersfield	Palmdale	Sylmar	Burbank	Los Angeles Union Station	Norwalk	Anaheim	Irvine	Ontario	Riverside	Temecula	Escondido	University City	San Diego	Bernel / 680	City of Industry
Millbrae	38																									
Redwood City	38	38																								
San Jose	43	37	37																							
Sacramento	18	14	14	18																						
Stockton	17	14	14	5	49																					
Tracy DT	38	38	38	22	22	16																				
Modesto/SP Downtown	10	10	10	11	17	15	21																			
Merced	10	10	10	11	8	5	21	26																		
Fresno	24	10	10	17	23	23	21	36	26																	
Bakersfield	25	15	15	8	23	23	19	33	22	57																
Palmdale	22	22	22	9	18	20	33	22	22	27	36															
Sylmar	22	22	22	9	18	20	33	22	22	27	36	54														
Burbank	22	22	22	9	18	20	33	22	22	27	36	54	54													
Los Angeles Union Station[1]	14	22	22	13	37	29	33	33	22	57	61	54	54	54												
Norwalk	3	3	3	5	5	3	5	3	3	8	3	5	5	5	5	-										
Anaheim	8	4	4	6	5	4	7	4	3	18	8	7	7	7	22	5	-									
Irvine	8	4	4	6	5	4	7	4	3	18	8	7	7	7	22	5	22	-								
Ontario	18	18	18	12	24	20	26	22	20	23	37	47	47	47	58	5	26	26	-							
Riverside	18	18	18	12	24	20	26	22	20	23	37	47	47	47	58	5	26	26	58	-						
Temecula	18	18	18	12	24	20	26	22	20	23	37	47	47	47	58	5	26	26	58	58	-					

Table 3.2-15. Continued

	San Francisco (Transbay) (1)	Millbrae	Redwood City	San Jose	Sacramento	Stockton	Tracy DT	Modesto/SP Downtown	Merced	Fresno	Bakersfield	Palmdale	Sylmar	Burbank	Los Angeles Union Station	Norwalk	Anaheim	Irvine	Ontario	Riverside	Temecula	Escondido	University City	San Diego	Bernel / 680	City of Industry
Escondido	18	18	18	12	24	20	26	22	20	23	37	47	47	47	58	5	26	26	58	58	58	-				
University City	18	18	18	12	24	20	26	22	20	23	37	47	47	47	58	5	26	26	58	58	58	58	-			
San Diego	28	18	18	18	32	26	26	30	20	39	53	47	47	47	80	5	26	26	58	58	58	58	58	-		
Bernal / 680	31	38	38	41	36	22	66	21	21	41	48	41	41	41	27	6	17	18	44	44	44	44	44	61		
City of Industry	18	18	18	12	24	20	26	22	20	29	37	47	47	47	58	5	26	26	55	55	55	55	55	55	30	-
Warm Springs	25	22	22	14	16	10	22	11	11	11	10	19	19	19	19	7	15	15	19	19	19	19	19	19	28	19

Source: Parsons Brinckerhoff 2007.

[1] The express service between San Francisco and Los Angeles is included in the HSR forecasting model as the primary service for modal choice because the shorter travel times (but longer headways) offer a premium service for this market. As a result, the number of trains represented here is for express service only and does not include the many local trains that offer service between San Francisco (Transbay) and Los Angeles Union Station. For example, this is why there are more trains from Burbank or Riverside to San Francisco.

Table 3.2-16
Auto Ownership and Operating Costs by Category (in 2005 Dollars)

Cost Category	Percent of Cost	Cents per Mile	
		Low-End (Base) Forecast[a]	High-End Forecast[b]
Fuel tax	11	2.3	3.4
Fuel	60	12.0	18.0
Repairs	6	1.1	1.7
Maintenance	14	2.9	4.3
State fees	9	1.7	2.6
Total	100	20.0	30.0

[a] Auto operating cost based on auto operating cost observed in 2005 and increasing with inflation only to 2030 (i.e., no real increase in costs) to represent the base, or low–end, forecasts.
[b] Auto operating cost based on a 50% increase in auto operating cost between 2005 and 2030 to represent the high-end forecasts.
Source: Metropolitan Transportation Commission 2006.

Table 3.2-17
One-Way Door-to-Door Trip Automobile Costs (in 2005 Dollars)′

City Pair	Cost per Trip (dollars)	
	Low-End (Base) Forecast[a]	High-End Forecast[b]
Los Angeles downtown to San Francisco downtown	98	137
Fresno downtown to Los Angeles downtown	58	81
Los Angeles downtown to San Diego downtown	38	50
Burbank (airport) to San Jose downtown	74	108
Sacramento downtown to San Jose downtown	23	34

[a] Auto operating cost based on auto operating cost observed in 2005 and increasing with inflation only to 2030 (i.e., no real increase in costs) to represent the base, or low–end, forecasts. Auto costs include parking, tolls, and auto operating cost.
[b] Auto operating cost based on a 50% increase in auto operating cost between 2005 and 2030 to represent the high-end forecasts. Auto costs include parking, tolls, and auto operating cost.
Source: Cambridge Systematics 2007.

Air Mode Characteristics

The passenger cost of air travel is primarily determined by the available fare. Depending on the airport, airline, time of year, day of the week, and even certain hours of the day, the price of an air ticket can vary greatly. Regions with competing airports or alternative submarkets (i.e., Ontario and Oakland) have more fare, schedule, and airline options compared to airports with limited service (e.g., Fresno and Bakersfield). In California, because most air operations are scheduled to serve longer distance markets, some major airports, such as San Francisco and Los Angeles, have a more limited choice of airlines and fare options for intra-California travel. Airports that provide more limited service, such as Fresno and Bakersfield, typically have only a few flights available per day and typically one or two airlines that serve that market. However, airports like Ontario and Oakland have frequent intra-California flights from a range of airlines at highly competitive fares.

Average total air costs were calculated including access, egress, and airfare costs. The access and egress sum cost ranges from $15 to $31 per trip, including the cost of parking at the airport and tolls needed to drive to the airport. Air trips require at least one other mode to travel from a different location (e.g., home/office) to the airport, which may include public transit (bus or rail), taxi/shuttle, or private auto (may require parking or drop-off). The access and egress costs reported here are costs associated with driving to/from the airport, which are typically higher than the costs for public transit.

A range of airfares are available that depend on time of purchase (e.g., 21-day advance purchase versus same-day fare), duration of visit (e.g., same-day or Saturday night stay), and departure time (e.g., peak versus off-peak). Table 3.2-18 summarizes the average total cost for air travel between city pair destinations for the low-end base (average fares for 2005) and based on the high-end forecast assumptions of a 50% increase in air fares between 2005 and 2030 (in 2005 dollars). No significant differences were found in the observed data between business and nonbusiness travel, so these fares are equal. As shown, airfares vary widely and can range from $153 between Burbank and San Jose to $263 between Sacramento and San Jose for business travel.

Table 3.2-18
Average Air One-Way Door-to-Door
Trip Passenger Costs (in 2005 Dollars)

City Pair	Cost Per Trip (dollars)	
	Low-End (Base) Forecast[a]	High-End Forecast[b]
Los Angeles downtown to San Francisco downtown	133	200
Fresno downtown to Los Angeles downtown	175	263
Los Angeles downtown to San Diego downtown	166	249
Burbank (airport) to San Jose downtown	153	230
Sacramento downtown to San Jose downtown	152	228

[a] Based on high-end revenue and ridership forecasts, which are 50% higher in 2030 than in 2005.
[b] Sample costs include fares, but parking, taxi fares, and other access/egress costs are not included.
Source: Cambridge Systematics 2007.

High-Speed Train Mode Characteristics

Similar to air travel, the primary cost associated with HST travel is the cost of the train ticket. In some locations, such as LAUS and San Francisco Transbay Transit Center, the parking charges are $25 and contribute significantly to the overall cost of the trip. For this analysis, the fare schedule developed from similar assumptions used in the Business Plan were used to compare the representative city pairs (Table 3.2-19). However, based on experience in Asia and Europe, HST fares may vary the way airfares do with the time of year, day of week and duration of stay. New competition may also develop between the different modes that may affect HST fares. The HST could also offer premium and economy services, with corresponding fares, depending on the markets that develop.

As with air travel, both an access fee and an egress fee ranging from $15 to $31 round trip are part of the HST average total costs. HST travel requires at least one mode change to access the nearest

HST station. Because the HST stations are generally located in the city centers, they are assumed to be located closer to larger population and work centers than airports. The HST line-haul travel fare was estimated using the fare schedule presented in the *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study Levels-of-Service Assumptions and Forecast Alternatives Report* (Cambridge Systematics 2007). Interregional and intraregional fares were set using a different set of assumptions to compete more directly with air and commuter rail, respectively.

Table 3.2-19
High-Speed Train One-Way Door-to-Door Trip Passenger Costs (in 2005 Dollars)[a]

City Pairs	Average Total Cost (dollars)
Los Angeles downtown to San Francisco downtown	82
Fresno downtown to Los Angeles downtown	63
Los Angeles downtown to San Diego downtown	43
Burbank (airport) to San Jose downtown	67
Sacramento downtown to San Jose downtown	55

[a] Based on fares plus parking costs, auto operating costs, and tolls paid to access or egress from a train station.
Source: Cambridge Systematics 2007.

Depending on city pair, level of state support for fare subsidies, and competition, intercity passenger rail would be cost-competitive with the HST. On average, given current fares for Amtrak service and the proposed fares for HST, conventional intercity service would cost 4 to 17% less than the HST for the Los Angeles to San Diego and Sacramento to San Jose city pairs listed above, respectively (assuming the same access and egress fees as the HST). These are the only two city pairs with current conventional rail service. Conventional rail would also be considerably less expensive than air, based on the representative city pairs.

Cost Effects of the High-Speed Train Alternatives

The HST alternatives could provide an overall passenger cost savings for all city pairs analyzed. On average, passengers could save from 22% to 87% on the HST, depending on city pair compared with the No Project Alternative. The HST mode is significantly less expensive than the highway mode for long distance travel, is cost-competitive with the highway mode for shorter distance trips between regions, and is always less expensive than the air mode. For all city pairs, the HST provides a price-competitive alternative to existing airline service and the automobile. The passenger costs would not vary noticeably between the HST Alignment Alternatives.

3.2.4 High-Speed Train Network Alternatives and Station Location Options Comparison

Travel conditions do not vary considerably between the different HST Alignment Alternatives. Within each corridor, the HST Alignment Alternatives serve similar potential markets and would have the same infrastructure requirements. HST travel time, connectivity, and passenger costs would vary with the HST Network Alternatives. This section discusses the relative travel condition differences between the HST Network Alternatives and station location options.

The Altamont Pass network alternatives include a potential station at Tracy and the Tri-Valley (at Livermore or Pleasanton) and place Merced on the San Francisco to Los Angeles segment of the HST system, which would result in a higher frequency of service to/from Merced. The Tracy station would serve other nearby Central Valley communities (such as Manteca), and the Tri-Valley station would serve not only the Livermore, Pleasanton, and Dublin area but would also be the nearest station for many cities in Contra Costa County. The Altamont Pass network alternatives would therefore improve travel conditions to these markets.

The Pacheco Pass alignment includes a potential station at Gilroy (or Morgan Hill), and Pacheco Pass network alternatives would have more frequent service to San Jose. The populations that would be served by the Gilroy station would have improved travel conditions (including shorter access times and access costs) with the Pacheco Pass network alternatives. The potential Gilroy/Morgan Hill station would have impact on travel conditions for a large area because, in addition to serving Southern Santa Clara County, it would also be the most accessible station location for serving the Santa Cruz, Monterey/Carmel, and Salinas populations.

The selection of an HST network alternative to serve the Bay Area cities will consider many factors, including the ability to meet the purpose and need of the HST system in the Bay area. This Program EIR/EIS evaluates potential service to the Bay Area along the San Francisco Peninsula and/or potential service along the East Bay. If service to San Francisco, Oakland, and San Jose were pursued, the number of intermodal connections would be greatly increased. However, if only one or two of these cities were directly served by the proposed HST system, service to each of the remaining termini stations would be greatly increased. However, the access times and access costs would increase significantly, and the competitiveness of the new mode on the part or parts of the Bay not served would also be reduced. For example, if the East Bay is not directly served, all trains bound for the Bay Area would terminate in downtown San Francisco and/or San Jose. However, there would be no HST link to directly serve Oakland or the Oakland Airport. Potential HST passengers from much of the East Bay would have to either use the Capitol Corridor, mass transit, or drive to San Francisco, San Jose, or the peninsula to use the HST service.

<u>Potential Station Locations</u>

- For service to downtown San Francisco, the Transbay Transit Center and the 4th and King Station were selected for further evaluation. The 4th and King Station is the existing terminus for the Caltrain commuter rail service. This station site (adjacent to AT&T Park) is well connected to the San Francisco Muni system but stops more than 1 mi short of the financial district of downtown San Francisco and does not connect to BART. The Transbay Transit Center would offer significantly greater connectivity to San Francisco and the greater Bay Area than the existing 4th and King site because of its location in the heart of the downtown San Francisco financial district, where many potential HST passengers could walk to the station. In addition, the Transbay Transit Center would serve as the transit hub for all of the major services to downtown San Francisco, with the advantage of direct connections to BART and San Francisco Muni. The 4th and King Station would have about a 2.5-minute shorter line-haul travel time to San Francisco than the Transbay Transit Center because the trains would travel at relatively slow speeds between 4th and King and the Transbay Transit Center, a distance of 1.2 mi (1.9 km). However, because the Transbay Transit Center would offer greater connectivity to San Francisco and the greater Bay Area than the existing 4th and King site, total travel times to downtown destinations via the Transbay Transit Center are expected to be superior.
- The West Oakland station and the 12th Street/City Center station were selected for further consideration for the Oakland terminus station. Both of these potential stations would directly connect with BART, and both would have good freeway access. The 12th Street/City Center station would have superior connectivity because it is located in the heart of downtown Oakland, where many potential HST passengers could walk to the station. The 12th Street/City Center BART station is also a transfer station, providing greater connectivity to the regional rail transit system.
- A potential station to serve San Mateo County would be located either at Redwood City or Palo Alto. Both would be multimodal stations at existing Caltrain station locations. The Palo Alto

station would be a stop for the Caltrain express services and therefore would have better connectivity to the regional commuter service and to the peninsula. Altamont Pass options to San Francisco via the Dumbarton Crossing could serve only the Redwood City station site.

- A potential station to serve southern Alameda County would be located at Union City, Shinn, or Fremont (Warm Springs). Both Union City and Fremont station location options would offer a high level of connectivity. The Union City station would connect to BART, the Capitol Corridor, and AC Transit, whereas the Fremont (Warm Springs) station would have good access to the I-880 freeway and a future BART extension.
- South Santa Clara County potentially would be served by a station at either Gilroy or Morgan Hill. Both of these two potential stations would be at Caltrain commuter rail station locations. The Gilroy Station is about 10 mi (16 km) south of Morgan Hill and therefore provides better connectivity, travel times, and lower access costs to the Santa Cruz, Monterey/Carmel, and Salinas markets.
- Diridon Station in downtown San Jose would be a multimodal hub maximizing connectivity to downtown San Jose and the Southern Bay Area. Diridon Station would serve Caltrain, ACE Commuter Rail, the Capitol Corridor, Amtrak, VTA buses and light rail, and a possible link to BART. None of the three airport stations would be in the airport terminals, but each would permit easy access by people movers or shuttles (at SFO, BART currently provides a direct connection from the Millbrae Caltrain Station to the SFO international terminal).
- A potential station to serve the Tri-Valley would be located at either Pleasanton or Livermore. The Pleasanton station would be located at the Pleasanton BART Station or at the existing Pleasanton ACE station along Bernal Road (I-680/Bernal Road). The Pleasanton (BART) station would maximize connectivity with the BART, whereas the I-680/Bernal Road location would link to the existing ACE service. Both locations would provide convenient freeway access. A potential station in Livermore would be located on I-580, in downtown Livermore, or at Greenville Road. The Livermore (Downtown) option would provide direct connectivity with ACE commuter service. Each of these options would have good freeway access; however, the Pleasanton station location options are more centrally located in the Tri-Valley and more accessible to Contra Costa County. The Greenville Road station site has the least connectivity and accessibility. As a part of the regional rail planning efforts, the region is investigating the possibility of extending BART Livermore.
- Two potential sites are evaluated to serve Tracy: a potential downtown station and the existing ACE station. The downtown station maximizes connectivity with downtown Tracy, whereas the existing ACE station would provide a multimodal link to the existing commuter rail service. As part of the regional rail planning effort, the region is assuming that if HST were to provide direct service to downtown Tracy, ACE would be moved to this location as well.
- Millbrae (SFO) and Oakland Airport (Coliseum/BART) are two potential airport stations that would have direct connections to local and regional commuter rail services and would minimize potential travel times and costs for HST passengers who would use the trains for access to the airports.
- Two potential station location options are evaluated to serve Modesto: a potential downtown station on the UPRR rail alignment and the existing Amtrak Briggsmore station on the BNSF alignment. The downtown station maximizes connectivity to downtown Modesto and provides convenient access to SR 99, whereas the Amtrak Briggsmore Station is about 5 mi (8 km) east of downtown Modesto. The selection of the alignment between Stockton and Modesto would determine the station site for Modesto.
- To serve Merced, potential station location options are evaluated at downtown Merced along the UPRR alignment and at Castle AFB. The downtown station is located near the city center and transit hub of Merced, has good access to SR 99, and would have the higher level of connectivity of the two locations. The Castle AFB site is about 7 mi (11 km) from downtown Merced but

would provide easy access to the developing University of California, Merced campus via a new highway alignment along Bellevue Avenue.