between Los Angeles and San Francisco is 10 hrs and 5 min. Even with full implementation of planned improvements, the travel time can only be reduced to 8 hrs and 30 min (Amtrak 2000),[6] and the service would still require transferring to buses to travel between Emeryville and San Francisco and between Bakersfield and Los Angeles.

2.5.2 Modal Alternative Carried Forward

As discussed in the previous section, a single mode (highway, aviation, or conventional passenger rail) would not effectively serve the various trip lengths and purposes of intercity trips. In addition, a single mode would not meet the fundamental purpose and need and objectives of the proposed HST system in terms of reliability, safety, and serving intercity travel demand. Further, intercity rail and commercial bus service do not provide a competitive option to serve the representative demand that the Modal Alternative is designed to capture (potential high-speed rail trips).

The Authority and the FRA have therefore developed a modal alternative that is a hybrid of future transportation improvement options in both the highway and aviation modes of intercity travel. It is assumed that the total representative demand would be split evenly between highway and air trips, based on the mode split estimated in the forecasts for intercity trips (58 million) and the direct assignment of the long-distance commute trips (10 million) to the highway mode. Hypothetical capacity improvements to the highway and aviation system were identified based on the forecast proportions of the representative intercity travel demand in each of these modes. These highway and aviation improvements represent an equivalent level of capacity to meet the representative demand. The highway and aviation components of the Modal Alternative are described below.

Transportation demand management options, like congestion management, were not considered as part of this alternative, since the effect of such options on the statewide intercity travel demand cannot be quantified at this level of study.

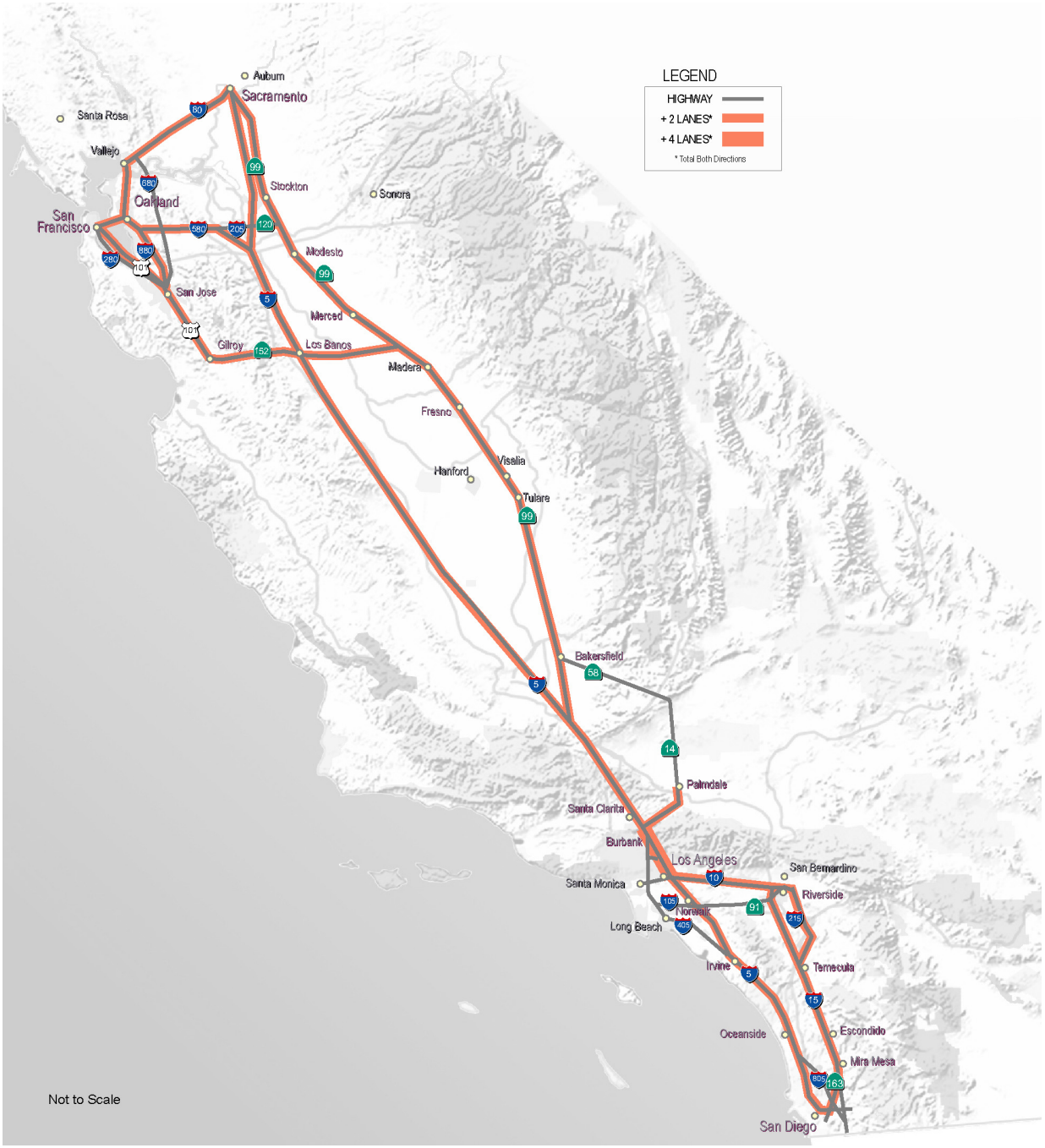
A. HIGHWAY COMPONENT

Level of Improvement

The highway component of the Modal Alternative consists of over 2,900 lane mi (4,667 km) of highway capacity added to the No Project highway network. Figure 2.5-1 presents the hypothetical improvements identified to serve the highway portion of the forecasted intercity travel demand. These capacity improvements are represented in numbers of lanes for broad segments of highway corridors. The hypothetical improvements reflect an equivalent level of capacity (as defined below under *Improvement Definition*) to serve the portion of the representative demand that would use highways, which is assumed to be 50% of the 68 million total annual trips in the representative demand or 34 million trips (24 million intercity and 10 million long-distance commute trips). This is the volume of highway trips expected to be diverted to a proposed HST system. To limit potential environmental impacts, the capacity improvements focused on expanding existing highways instead of creating new transportation corridors. Although the land area for widening existing facilities by one or two lanes would be similar to that required for the creation of new highways, widening existing highways would avoid many incompatibility and severance impacts, which could be considerable in both urban communities and rural settings such as farmlands and open spaces. In addition, few new transportation facilities are being planned by local, regional, and state agencies in the intercity corridors identified. For the limited cases where new facilities are being planned (e.g., SR-65 in the Central Valley), there is insufficient information available regarding the location and definition of the facility to adequately quantify potential impacts.

[6] Existing connecting bus travel times were used between Los Angeles and Bakersfield (2 hrs and 45 min with transfer time) and Emeryville to San Francisco (40 min with transfer time).

Figure 2.5-1
Highway Improvement Component of Modal Alternative



In cases where highway facilities for the No Project Alternative have been built to their operational limit (typically in dense urban areas), this analysis assumed that additional lanes would be placed over the existing facility on an aerial structure. Although this configuration would introduce more potential for visual impacts, total impacts would be considerably less than those that would result from introducing an entirely new corridor in a congested urban area. By developing this alternative the Authority and the FRA do not in any way recommend, endorse, or suggest that these improvements could or should be implemented on a specific highway or highway segment. Nor is it assumed that a proposed HST system would negate the potential need to expand highways in the state.

Improvement Definition

The *equivalent level of capacity* is the number of additional lanes that would be added to the highway corridor to serve the allocated highway portion of the representative demand, which is 34 million trips. These improvements are assumed to be in a specific corridor for the purposes of this analysis, but the improvements could also be made to parallel facilities in some cases. A detailed description of the highway improvement option methodology is found in Appendix 2-F.

Table 2.5-1 compares the additional lanes with the number of lanes that would exist in the No Project Alternative on each route segment to determine whether the improvement is defined as *widening* or a *new facility*. The additional lanes represent widening of the existing facility up to a total of 12 lanes, as shown in Figure 2.5-2, a typical cross-section of a highway widening. Beyond 12 total lanes, additional lanes are defined as a separate facility. Separate facilities in urban areas would be placed over the existing facility (elevated configuration of some lanes, up to two per direction) because of right-of-way constraints.

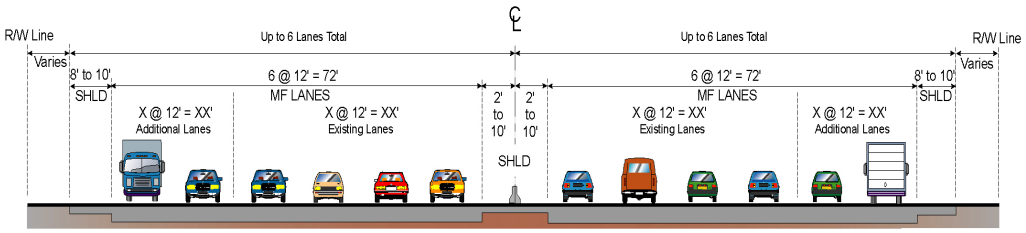
Associated Improvements

Additional improvements such as interchanges, bridge widenings, etc., would be needed in support of the added lanes. These associated improvements are defined in general terms based on engineering standards regarding size, extent, and placement.

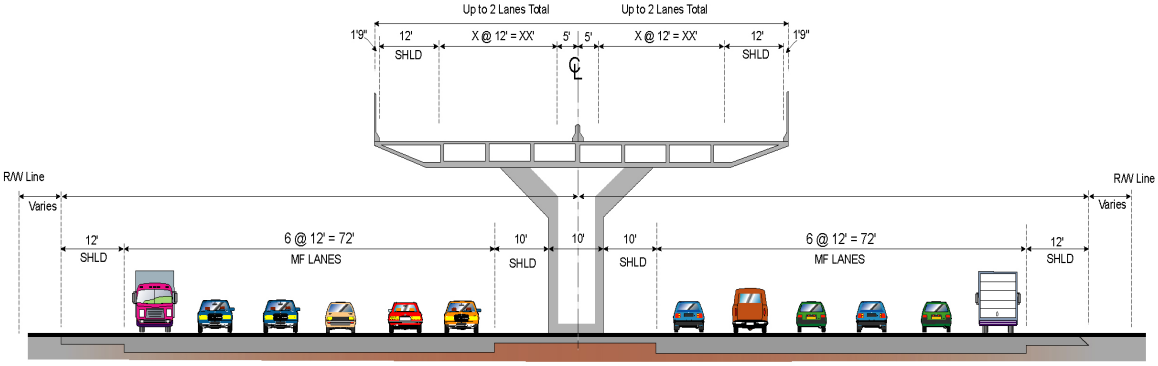
Table 2.5-1
Definition of Highway Improvements

Highway Corridor	Segment (From–To)	No. of Additional Lanes[a] (Total–Both Directions)	No. of Existing Lanes (Total–Both Directions)	Type of Improvement
Bay Area to Merced				
US-101	SFO	2	8	Widening
US-101	SFO to Redwood City	2	8	Widening
US-101	Redwood City to I-880	2	8	Widening
I-880	US-101 to San Jose	2	8	Widening
US-101	San Jose to Gilroy	2	6	Widening
US-101	Gilroy to SR-152	2	4	Widening
SR-152	US-101 to I-5	2	2	Widening
SR-152	I-5 to SR-99	2	4	Widening
I-80	San Francisco to I-880	2	10	[b]
I-80	I-880 to I-5 (Sacramento)	2	8	Widening
I-880	I-80 to I-238	2	8	Widening
I-580	I-880 to I-5 (via I-238)	2	8	Widening
I-880	I-238 to Fremont/Newark	2	8	Widening

FIGURE 2.5-2
Typical Highway Improvement Cross-Sections



Modal Alternative Highway Widening Cross-Section
(Up to 6 Lanes Per Direction)



Modal Alternative Separate Highway Facility
(Up to 2 Lanes Per Direction)

Highway Corridor	Segment (From–To)	No. of Additional Lanes[a] (Total–Both Directions)	No. of Existing Lanes (Total–Both Directions)	Type of Improvement
I-880	Fremont/Newark to US-101	2	6	Widening
Sacramento to Bakersfield				
I-5	I-80 to Stockton	2	6	Widening
I-5	Stockton to I-580/SR-120	2	6	Widening
I-5	I-580/SR-120 to SR-152	2	4	Widening
I-5	SR-152 to SR-99	2	4	Widening
SR-99	I-5 to SR-58	2	6	Widening
SR-99	Sacramento to SR-120	2	4	Widening
SR-99	SR-120 to Modesto	2	6	Widening
SR-99	Modesto to Merced	2	4	Widening
SR-99	Merced to SR-152	2	4	Widening
SR-99	SR-152 to Fresno	2	4	Widening
SR-99	Fresno to Tulare/Visalia	2	6	Widening
SR-99	Tulare/Visalia to SR-58	2	4	Widening
Bakersfield to Los Angeles				
I-5	SR-99 to SR-14	2	8	Widening
I-5	SR-14 to I-405	4	10	Separate facility
I-5	I-405 to Burbank	4	8	Widening
I-5	Burbank to Los Angeles Union Station (LAUS)	4	8	Widening
SR-58/14	SR-99 to Palmdale	0	4	Widening
SR-14	Palmdale to I-5	2	4	Widening
Los Angeles to San Diego via Orange County				
I-5	LAUS to I-10	4	8	Widening
I-5	I-10 to Norwalk	2	6	Widening
I-5	Norwalk to Anaheim	2	6	Widening
I-5	Anaheim to Irvine	2	10	Widening
I-5	Irvine to I-405	2	10	Widening
I-5	I-405 to SR-78	2	8	Widening
I-5	SR-78 to University Town Center (UTC)	2	8	Widening
I-5/I-8	UTC to San Diego Airport	2	8	Widening
I-8	SR-163 to I-5	2	8	Widening
Los Angeles to San Diego via Inland Empire				
I-10	I-5 to East San Gabriel Valley	2	10	Widening
I-10	East San Gabriel Airport to Ontario Airport	2	8	Widening
I-10	Ontario Airport to I-15	2	8	Widening
I-10	I-15 to I-215	2	8	Widening

Highway Corridor	Segment (From–To)	No. of Additional Lanes[a] (Total–Both Directions)	No. of Existing Lanes (Total–Both Directions)	Type of Improvement
I-15	I-10 to I-215	2	8	Widening
I-215	Riverside to I-15	2	4	Widening
I-215	I-10 to Riverside	2	6	Widening
I-15	I-215 to Temecula	2	10	Widening
I-15	Temecula to Escondido	2	8	Widening
I-15	Escondido to Mira Mesa	2	10	Widening
I-15	Mira Mesa to SR-163	2	10	Widening
SR-163	I-15 to I-8	2	8	Widening

[a] Represents the number of through lanes needed in addition to the total number of lanes in the No Project highway network to serve the representative demand.

[b] No additional or separate facility assumed. Additional demand is assumed to utilize the existing bridge, spreading the peak period congestion.

Source: Caltrans Highway Logs 2001

B. AVIATION COMPONENT

Level of Improvement

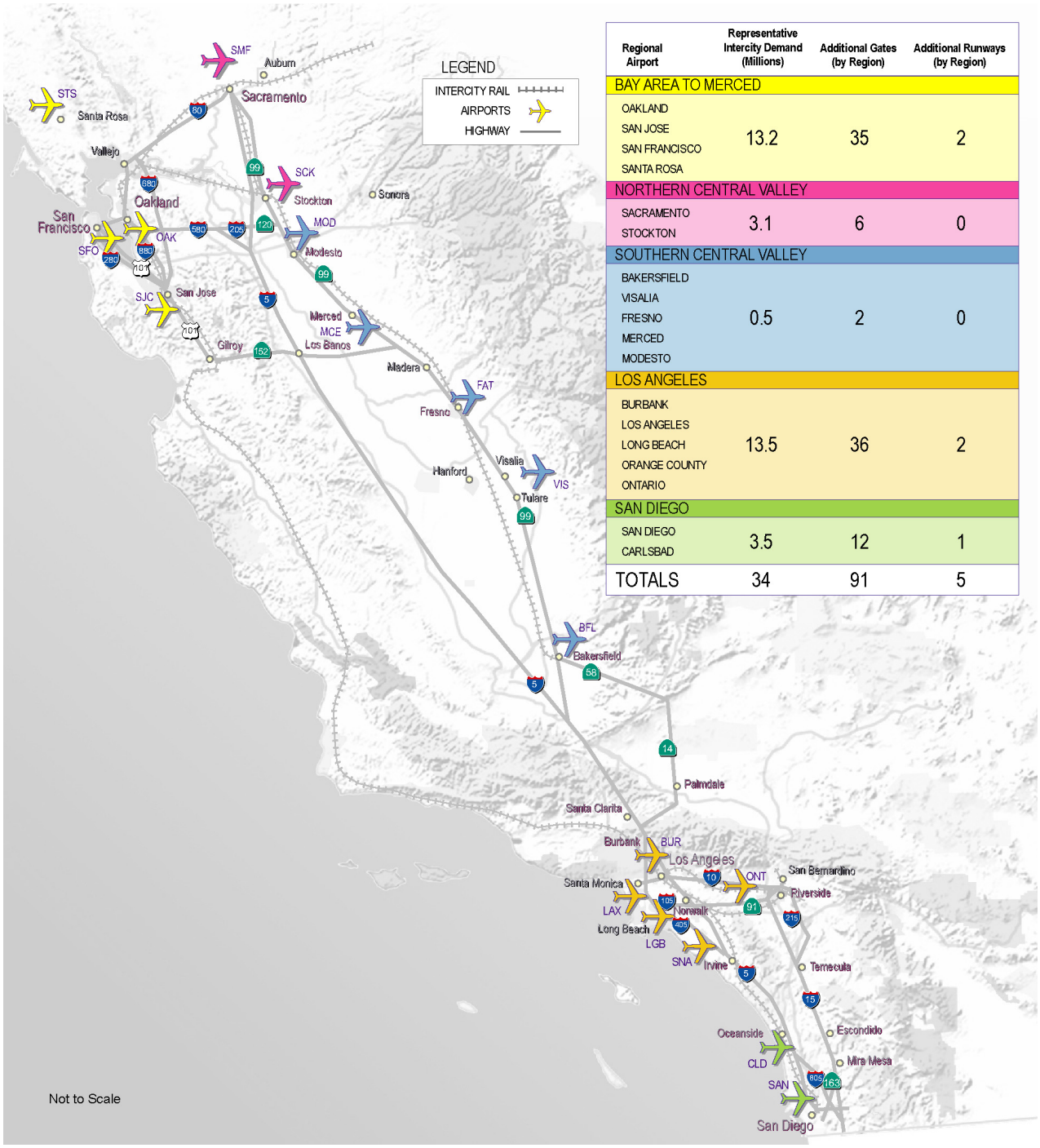
The remaining 50%, or approximately 34 million of the 68 million total intercity trips (representative demand), has been allocated to air as the preferred mode of travel. This is the volume of air trips expected to be diverted to a proposed HST system. This portion of the demand was then assigned to each region, based on the regional distribution of trips as forecasted (based on the *Independent Ridership and Passenger Revenue Projections for High Speed Rail Alternatives in California, Draft Final Report*, (Charles River Associates 2000). Hypothetical improvements (terminal gates, runways, and other associated improvements) were identified at individual airports within each region to accommodate this demand and assess the potential for environmental impact. The level of improvement required is the net capacity increase over the No Project Alternative to serve only intra-California trips, based on the existing proportions of intrastate versus out-of-state flight statistics. By developing this alternative the Authority and the FRA do not in any way recommend, endorse, or suggest that these improvements could or should be implemented at a specific airport. Nor is it assumed that a proposed HST system would negate the potential need to expand airports in the state.

The regional level of improvement (over and above the No Project Alternative) to accommodate representative intercity demand is summarized in Figure 2.5-3 and Table 2.5-2. Of the 18 airports in the study area, eight representative airports were identified to accommodate the additional improvements for the assessment of potential environmental impacts. To avoid the highly speculative nature of locating new airports, it is assumed that improvements would only occur at airports where there is currently existing intercity commercial airline passenger service.

Regional assumptions developed to identify which airports would accommodate the representative improvements are summarized below.

Bay Area: Future local/regional trips would shift from San Francisco International Airport to Oakland International Airport and the airport in San Jose to maintain sufficient capacity for long haul and international trips. Consistent with this strategy, it is assumed that all of the regional representative air demand and aircraft operations for the Bay Area would be accommodated at

Figure 2.5-3
Aviation Improvement Component of Modal Alternative



Regional Airport	Representative Intercity Demand (Millions)	Additional Gates (by Region)	Additional Runways (by Region)
BAY AREA TO MERCED			
OAKLAND SAN JOSE SAN FRANCISCO SANTA ROSA	13.2	35	2
NORTHERN CENTRAL VALLEY			
SACRAMENTO STOCKTON	3.1	6	0
SOUTHERN CENTRAL VALLEY			
BAKERSFIELD VISALIA FRESNO MERCED MODESTO	0.5	2	0
LOS ANGELES			
BURBANK LOS ANGELES LONG BEACH ORANGE COUNTY ONTARIO	13.5	36	2
SAN DIEGO			
SAN DIEGO CARLSBAD	3.5	12	1
TOTALS	34	91	5

Oakland or San Jose. This assumption is consistent with one of the proposed strategies identified in the Metropolitan Transportation Commission's *Regional Airport System Plan* (Metropolitan Transportation Commission 2000). This is also consistent with the current trend of air carriers choosing to shift regional air service to other airports in the region in the face of increasing capacity constraints at San Francisco International. San Francisco and Oakland airports are currently considering expansion.

Southern San Joaquin Valley: Fresno is the geographical and population center of the region, and the Fresno airport could accommodate all regional representative air demand and aircraft operations.

Table 2.5-2
Definition of Aviation Improvements

Regional Airport	Representative Intercity Demand (Millions)	Additional Gates (by Region)	Additional Runways (by Region)	Annual Passengers (Millions)	Number of Runways	Number of Gates
Bay Area to Merced						
Oakland	13.2	35	2	11.4	3	24
San Jose				13.1	3	31
San Francisco				33.9	4	117
Santa Rosa				0.08	2	1
Northern Central Valley						
Sacramento	3.1	6	0	7.5	2	30
Stockton				n/a	2	6
Southern Central Valley						
Bakersfield	0.5	2	0	1.4	2	12
Visalia				0.3	2	7
Fresno				0.01	1	1
Merced				0.03	2	1
Modesto				0.1	1	1
Los Angeles						
Burbank	13.5	36	2	4.7	2	14
Los Angeles				61.6	4	140
Long Beach				7.3	2	14
Orange County				6.7	2	26
Ontario				0.6	5	9
San Diego						
San Diego	3.5	12	1	15.1	1	41
Carlsbad				0.1	1	1
Totals	**34**	**91**	**5**	**163.9**	**41**	**476**
Source: Airport Master Plans						

Northern San Joaquin/Sacramento Valley: Regional representative intercity demand could be accommodated at a single airport, and Sacramento is currently planning an expansion and associated improvements.

Los Angeles Basin: It is assumed that air carriers would choose to shift regional service to other satellite airports in the face of increasing capacity constraints for long haul and international flights at LAX. While LAX may continue to provide regional service, it is assumed that all of the regional representative air demand and aircraft operations for the Los Angeles region would be accommodated at Ontario, Burbank, and Long Beach. The southern California Area Government's *Regional Aviation Plan for the 2001 Regional Transportation Plan* (Southern California Area Governments 2001) suggests that Ontario is expected to absorb the majority of passengers that are expected to shift to other airports in the region as LAX becomes increasingly capacity constrained. The City of Los Angeles and the FAA are preparing an EIR/EIS for a proposed master plan of improvements for LAX, including some runway reconfiguration of the existing four parallel runway system. Additionally, it was assumed that other needed regional improvements would be located at Burbank and Long Beach because of their proximity to central Los Angeles. (Even though Burbank and Long Beach airports have considerable noise abatement, land use, and other operating constraints, improvements are considered for planning purposes only and to estimate potential impacts.) Long Beach Airport currently has flight limitations (related to noise) that effectively limit passenger capacity to 3 million to 3.5 million annually. John Wayne/Orange County Airport was not considered because of specific limitations (annual passenger cap, curfew, gate limits) that restrict the capacity of the airport (Southern California Area Governments 2001).

San Diego: It is assumed that all of the regional representative intercity demand would be accommodated at SAN. The San Diego airport is expected to reach its projected physical capacity of 337,000 annual operations and 24.4 million annual passengers between 2020 and 2025. The San Diego Association of Governments and the San Diego Coast Regional Airport Authority are developing an air transportation action program to determine if Lindbergh Field can be combined with or replaced by another airport site to meet long-term passenger and cargo demand (FAA communication 11-18-02). According to the *2020 Regional Transportation Plan*, future landside and airside improvements will be located at San Diego until another site becomes available. At present, no other sites have been identified (San Diego Association of Governments 2000).

It is estimated that the Modal Alternative would require 91 additional airport terminal passenger gates and five additional runways at airports throughout the study area. Figure 2.5-3 summarizes the required improvements by region.

Improvement Definition

Aviation improvements (gates and runways) were quantified by region and assigned to existing facilities, unless specific constraints or policies prohibit expansion. Specific constraints at each airport facility were considered and capacity improvements were assigned to airports on a case-by-case basis. The current assumptions regarding the assignment of new gates and runways to specific airports are described above. For the environmental analyses, these facilities are represented in terms of additional right-of-way (physical footprint on- and off-site), additional parking spaces (on- and off-site), and additional primary lanes of access road. A detailed discussion of the methodology for determining aviation improvements is found in Appendix 2-G.

Associated Improvements

Other improvements such as taxiways, passenger facilities, additional lanes of secondary (service) access roadway, etc., would be needed in support of the new gates and runways. These associated improvements are defined in general terms based on engineering standards regarding size, extent, or placement.

2.6 HIGH-SPEED TRAIN ALTERNATIVE

The HST Alternative represents the proposed action and was developed by considering a range of potential HST technologies, corridors, and alignment and station options within the corridors. Informed by previous studies and the scoping process, the Authority and the FRA evaluated potential HST corridors and defined those that best met the project purpose, which is to provide a reliable mode of travel that links the major metropolitan areas of the state and delivers predictable and consistent travel times. A further objective is, in a manner sensitive to and protective of California's unique natural resources, to provide an interface with commercial airports, mass transit, and the highway network and to relieve the capacity constraints of the existing transportation system as intercity travel demand increases in California. Through the screening process, reasonable and feasible technology, alignment, and station options were identified for analysis in this Program EIR/EIS. The general HST corridors and study regions are shown in Figure 2.1-1.

2.6.1 Travel Times and Frequency of Service

Independent ridership and revenue forecasts (Charles River Associates) prepared for the Business Plan show that competitive travel times and frequent service are essential to attract travelers to an HST system. For the HST Alternative to be economically feasible, operating speeds over 200 mph (322 kph), high frequencies of service, and efficient operations are necessary. For this fundamental reason, the Authority and the FRA carried forward the criteria that the proposed HST system would operate at speeds of up to about 220 mph (350 kph) and developed a conceptual service plan (Section 2.6.2), that makes the HST system highly competitive with travel by air or auto. It is important to note that maximum speeds cannot be achieved on many portions of the proposed system, particularly the heavily constrained urban areas (Figure 2.6-1). Express travel between downtown San Francisco and downtown Los Angeles could be accomplished in just 2.5 hrs. The trip between downtown Los Angeles and San Diego would take a little over an hour. Table 2.6-1 shows additional samples of express travel times between cities.

Table 2.6-1
Express Travel Times

TRAVEL TIMES (HOURS:MINUTES)	Los Angeles	San Francisco	San Jose	San Diego	Sacramento	Fresno	Bakersfield	Riverside
Los Angeles	-	2:30	2:02	1:00	2:09	1:19	0:47	0:29
San Francisco	2:30	-	0:31	3:29	1:40	1:15	1:47	2:58
San Jose	2:02	0:31	-	3:00	1:12	0:46	1:18	2:29
San Diego	1:00	3:29	3:00	-	3:07	2:17	1:46	0:34
Sacramento	2:09	1:40	1:12	3:07	-	0:53	1:25	2:36
Fresno	1:19	1:15	0:46	2:17	0:53	-	0:35	1:46
Bakersfield	0:47	1:47	1:18	1:46	1:25	0:35	-	1:15
Riverside	0:29	2:58	2:29	0:34	2:36	1:46	1:15	-

Figure 2.6-1
Average Operating Speed on High-Speed Train System[1]

[1] Based on "Highest Return on Investment" system from the Final Business Plan, 2000.

The Business Plan described a representative system of corridors and stations, and used the system in developing ridership forecasts, cost estimates, an assessment of potential environmental impacts, performance characteristics, and funding scenarios. The representative system is referred to in the Business Plan as the "highest return on investment route" and is incorporated into the range of corridors being studied for the HST Alternative.[7] The ridership forecast for the highest return on investment route has been used as the *representative demand* for defining the intercity travel need for the HST and Modal Alternatives.

The projected HST travel times account for alignment, train performance characteristics, acceleration and deceleration capabilities, and passenger comfort criteria. HST system operators and manufacturers of HST equipment were consulted in the development of the travel times and design criteria for the proposed HST system.

2.6.2 Conceptual Service Plan

To satisfy the travel time, service quality, and ridership goals (representative demand) developed for the Business Plan, and accounting for the general characteristics of the corridors considered, a conceptual service plan was developed that would provide a wide variety of service options. A mix of express, semi-express, local, and regional trains would serve both intercity passengers and long-distance commuters. In order for HST service to be economically viable, the plan provides frequent and efficient operations.

In 2020, a total of 86 weekday trains in each direction would be provided to serve the statewide intercity travel market. Sixty-four of the trains would run between northern and southern California, and the remaining 22 trains would serve shorter distance markets. The basic service pattern provides most passenger service between 6 a.m. and 8 p.m., with a few trains starting or finishing trips beyond these hours. Eighty-six trains per day could be a highly frequent operation; however, as shown below, when divided into 5 levels of service the frequency is greatly reduced. Frequencies would be further reduced in order to serve multiple end points. For example, for HST service between northern and southern California through the Central Valley, some trains would go to the Bay Area, and others to Sacramento. Therefore, while there could be 12 local trains, only a portion of these would serve each endpoint. The following five types of intercity trains are planned.

- Express (20 trains per day): Trains running between Sacramento, San Jose, or San Francisco and Los Angeles or San Diego without intermediate stops.
- Semi-Express (12 trains per day): Trains running between Sacramento, San Jose, or San Francisco and Los Angeles and San Diego with intermediate stops at major Central Valley cities such as Modesto, Fresno, and Bakersfield.
- Suburban-Express (20 trains per day): Trains running between northern and southern California and locally within the major metropolitan areas (i.e., the San Francisco Bay Area and the Los Angeles area) at the beginning and end of the trip without intermediate stops in the Central Valley.
- Local (12 trains per day): Trains stopping at all stations. Some of these local trains might ultimately be operated as a "skip stop" or semi-express service, where trains would stop at only a portion of the possible stations on a specific line, to improve the service and better match patterns of demand.
- Regional (22 trains per day): Sacramento to San Francisco service and early morning service from the Central Valley to San Francisco or Los Angeles/San Diego.

[7] The route defined by the Business Plan is approximately 700 mi (1,127 km) long and serves the major metropolitan areas of California, including San Francisco, Sacramento, the Central Valley, Los Angeles, and San Diego.

2.6.2a Safety and Security

The safe operation of the HST system would be of the utmost importance. To this end, the HST Alternative is described as a fully grade separated and fully access-controlled guideway with intrusion monitoring systems. This means that the HST infrastructure (e.g., mainline tracks and maintenance and storage facilities) would be designed to prevent access by unauthorized vehicles, persons, animals, and objects. The capital cost estimates include allowances for appropriate barriers (fences and walls), state-of-the-art communication, access-control, and monitoring and detection systems. All aspects of the HST system would conform to the latest Federal requirements regarding transportation security as developed and implemented.

The HST trainsets (train cars) would be pressure sealed to maintain passenger comfort regardless of aerodynamic changes along the line. The description of the HST Alternative in the Final Program EIR/EIS has been updated to include this provision.

2.6.2b Electrification

Please see Section 3.5 Energy of the Program EIR/EIS, which provides an overview of the potential operation and construction impacts associated with the use of energy, including electrical energy, for the existing conditions and the No Project, Modal and HST Alternatives. The energy analysis concluded that the HST Alternative would have a net energy benefit as compared to the No Project Alternative, but would result in an increase in electric power demand. The Draft Program EIR/EIS assessed the total energy that would be needed from California's electricity grid to power and to operate the proposed HST system from its commencement (a portion of the system) to full implementation. The HST alternative does not include the construction of a separate power source. The analysis concluded that sufficient electricity is expected to be available to power the proposed HST, as segments are constructed and begin operating, since power generation is expected to grow to meet increased demand in the state and the power needs of the proposed HST system represent a small part of that overall increase in demand. It is beyond the scope of this Program EIR/EIS to analyze all the potential additions that may be made to the state's power general system to serve increased electricity demand in California over time.

For the purposes of identifying potential impacts and costs in the Draft Program EIR/EIS, the HST power supply system was defined in the Engineering Criteria report, which was included in the Draft Program EIR/EIS by reference. The power supply would consist of a 2x25KV overhead catenary system for all electrified portions of the statewide system. Supply stations would be required at approximately 30-mile intervals. Based on the estimated power needs of this system, these stations would need to be approximately 20,000 square feet (200′ X 100′). Switching stations would be required at approximately 15-mile intervals. These stations would need to be approximately 7,500 square feet (150′ X 50′). Paralleling (booster) stations would be required at approximately 71/2-mile intervals. These stations would need to be approximately 5,000 square feet (100′ X 50′). Each station includes a control house that would need approximately 800 square feet (40′ X 20′). These facilities are not sited as part of this Program EIR/EIS. However, the facilities defined fall well within the potentially affected environment areas defined for the Program level EIR/EIS study. Facility placement, sizing, and spacing would be determined during subsequent project level environmental review.

Appendix 4-C describes the unit costs and assumptions for electrification items (substations, cable trenches, electrical equipment, catenary poles, wires, power feeders and returns, transformers, etc.). Costs for the transmission lines from the local utility source to the substation are included in the energy costs, which are a part of the HST system operation and maintenance costs.

2.6.3 Potential for Freight Service

The proposed HST system could be used to carry small packages, parcels, letters, or any other freight that would not exceed typical passenger loads. This service could be provided either in specialized

freight cars on passenger trains or on dedicated lightweight freight trains. In either case, the lightweight freight vehicles would be required to have the same performance characteristics as the passenger equipment. This type of freight could be accommodated without adjustment to the passenger operational plan or modification to the passenger stations and therefore was included in the funding scenario described in the Business Plan.

A high-speed freight service might also be provided on specialized, medium-weight freight trains. This specialized freight equipment would have limited axle loads (19 metric tons compared to the conventional freight standard of 27 metric tons per axle), would operate at speeds of up to 125 mph (200 kph), and would be scheduled at night to avoid conflict with passenger or maintenance operations. A medium-weight freight service could carry high-value or time-sensitive goods such as electronic equipment and perishable items. Although such a service would not interfere with passenger operations, it would require loading and unloading facilities separate from the passenger stations. Additional pick-up and distribution networks for this type of freight might also be required. While the Authority recognizes the potential for overnight medium-weight freight service on the proposed high-speed tracks, it has not been included in this analysis. Discussions with potential high-speed freight operators could be initiated as part of subsequent project development with appropriate analysis.

2.6.4 Performance Criteria

The Authority and the FRA defined performance criteria for the HST Alternative that would meet the purpose of and need for a proposed HST system, using information gathered in previous feasibility and corridor evaluation studies. To meet the travel time and service quality goals, the proposed statewide HST system would be capable of speeds in excess of 200 mph (320 kph) on fully grade-separated tracks with state-of-the-art safety, signaling, and automated train control systems. These performance criteria are summarized in Table 2.6-2.

Table 2.6-2
HST Performance Criteria

Category	Criteria
System Design Criteria[8]	Electric propulsion system. Fully grade-separated guideway. Fully access-controlled guideway with intrusion monitoring systems. Track geometry must maintain passenger comfort criteria (smoothness of ride, lateral acceleration less than 0.1 g).
System Capabilities	All-weather/all-season operation. Capable of sustained vertical gradient of 3.5% without considerable degradation in performance. Capable of operating parcel and special freight service as a secondary use. Capable of safe, comfortable, and efficient operation at speeds over 200 mph. Capable of maintaining operations at 3-minute headways. Capable of traveling from San Francisco to Los Angeles in approximately 2.5 hrs. Equipped with high-capacity and redundant communications systems capable of supporting fully automatic train control.
System Capacity	Fully dual track mainline with off-line station stopping tracks. Capable of accommodating a wide range of passenger demand (up to 26,000 passengers per hour per direction).

[8] Engineering Criteria, January 2004

Category	Criteria
	Capable of accommodating normal maintenance activities without disruption to daily operations.
Level of Service	Capable of accommodating a wide range of service types (express, semi-express/limited stop, and local).

2.6.5 Description of High-Speed Train Technology Groups

Four primary technology groups were considered in the development of the HST Alternative. Because of the need for early implementation, other less developed technologies (those not currently in operation or not ready for implementation) were not considered. The groups are classified by their speed (both currently obtainable speeds as well as targeted speeds that may result from further research and development) and by similar design characteristics. The four technologies—very high speed steel-wheel-on-steel-rail, magnetic levitation, high speed steel-wheel-on-steel-rail, and non-electrified steel-wheel-on-steel-rail—are described below.

A. VERY HIGH-SPEED STEEL-WHEEL-ON-STEEL-RAIL (ELECTRIFIED)

The very high-speed (VHS) group includes trains capable of maximum operating speeds near 220 mph (350 kph) using steel-wheel-on-steel-rail technology (Figure 2.6-2). To operate at high speeds, a dedicated, fully grade-separated right-of-way is necessary with more stringent alignment requirements than those needed for lower speed lines. However, it would be possible to integrate VHS systems into existing conventional rail lines in the congested urban areas with resolution of potential equipment and operating compatibility issues by the FRA and the California Public Utilities Commission. All VHS systems currently in operation use electric propulsion with overhead catenary. These include the Train à Grande Vitesse (TGV) in France, the Shinkansen in Japan, and the InterCity Express (ICE) in Germany.

B. MAGNETIC LEVITATION

The magnetic levitation (maglev) group uses either attractive or repulsive magnetic forces and electric propulsion to lift and move the train along a guideway (Figure 2.6-2). Current systems under development are designed for maximum operating speeds above that of VHS technology. The FRA's Maglev Deployment Program supports development of a system capable of operating speeds of 240 mph (385 kph) for the future implementation of a maglev demonstration project in this country. Magnetic levitation allows the vehicles to hover or float a short distance above the guideway, thereby eliminating friction and rolling resistance. Because of the unique dedicated guideway required, it would not be possible to share track with conventional steel wheel systems, although right-of-way could be shared.

C. HIGH-SPEED STEEL-WHEEL-ON-STEEL-RAIL

The high-speed (HS) group is basically an improvement of traditional railroad passenger technology that has been designed to operate at speeds of 100 to 150 mph (160 to 240 kph) on existing rail infrastructure. This category of technology includes "tilt" technology, which allows for higher operating speeds over geometrically constrained alignments (e.g., where a sharp curve radii restricts train speeds). Systems in this category use electric power sources. Amtrak's Acela service from Boston to New York City and to Washington, D.C., is an example of this technology.

D. NON-ELECTRIFIED STEEL-WHEEL-ON-STEEL-RAIL (CONVENTIONAL)

This technology group includes existing diesel locomotive intercity train equipment (e.g., Amtrak). Speeds of up to 100-150 mph (160 to 240 kph) are possible for this type of HST technology.

Figure 2.6-2 VHS and Maglev Technology Examples

VHS Train (ICE)

Maglev (Transrapid)

2.6.6 High-Speed Train Technology Options Considered and Rejected

A. STEEL-WHEEL-ON-STEEL-RAIL AT LOWER SPEED (BELOW 200 MPH)

The Authority's enabling legislation, Senate Bill (SB) 1420 (chaptered 9/24/96, Chapter 796, Statute of 1996), defines *high-speed rail* as "intercity passenger rail service that utilizes an alignment and technology that makes it capable of sustained speeds of 200 mph (320 kph) or greater."

Previously, the California Intercity High-Speed Rail Commission investigated three types of HST technology: HS, VHS, and maglev. The comparison of HS and VHS provided a basis for the recommended maximum speeds.

The lower ridership forecasts (based on the investment-grade analysis as described in Chapter 1) showed that sustaining high maximum operating speeds had a major impact on potential travel times and potential ridership and revenue for the system. The Commission's study showed that minimum express travel times between San Francisco and Los Angeles would be 3 hrs and 24 min for the HS technology, as compared to 2 hrs and 42 min for the VHS technology. Faster travel times afforded by the VHS technology would result in 3.7 million more riders and $151 million more annual revenue than the HS technology for the 2015 projections (Charles River Associates 1996). However, capital costs for the HS and VHS systems would be about the same. California's existing rail corridors have not been substantially improved, and shared use of the existing freight facilities was not considered feasible.[9] Both technologies would require the same fully grade-separated infrastructure that could not share tracks with standard U.S. freight operations, and both would require new alignments through mountain passes in both northern and southern California (Parsons Brinckerhoff 1995).

Based on this analysis, the Commission directed staff to focus the technical studies on the VHS and maglev technologies. This direction is consistent with foreign HST experience, the experience of the northeast corridor (Boston-New York-Washington, D.C.), and HST studies done elsewhere in the U.S., which show that to compete with air transportation and generate high ridership and revenue, the intercity HST travel times between the major transportation markets must be below 3 hrs.

B. MAGNETIC LEVITATION TECHNOLOGY AND STEEL-WHEEL-ON-STEEL-RAIL ELECTRIFIED, FULLY DEDICATED SERVICE

While a completely dedicated train technology using a separate track/guideway would be required on the majority of the proposed system, requiring such separation everywhere in the system would prohibit direct HST service to certain heavily constrained terminus sections (i.e., San Francisco Peninsula from San Jose to San Francisco, and the existing [LOSSAN] rail corridor between Los Angeles Union Station [LAUS] and Orange County). Because of extensive urban development and severely constrained right-of-way, HST service in these terminus sections would need to share physical infrastructure (tracks) with existing passenger rail services in existing or slightly modified corridors. Sharing track with existing passenger rail services on these heavily constrained corridors would allow for direct HST service without passenger transfer. However, the HST system would need to be compatible with the other trains sharing the tracks.[10] Maglev technology requires separate and distinct guideway configurations that would preclude the sharing of rail infrastructure.

[9] Current FRA safety requirements for rolling stock (trainsets) preclude the use of non-compliant rolling stock (such as off-the-shelf European equipment, which is constructed to different structural design standards) unless otherwise waived. In addition to the regulatory aspects, there are other issues associated with the potential operation of existing freight services with HST passenger services. High freight car axle loads and relatively low speed freight operations would compromise HST operating efficiency, maintenance standards/tolerances, and strict safety requirements. Conventional freight trains also require different track geometry for superelevation and have different clearance requirements.

[10] Current FRA safety requirements for rolling stock preclude the use of non-compliant rolling stock (such as off-the-shelf European equipment, which is constructed to different structural design standards) unless otherwise waived.

For example, on the San Francisco Peninsula, sharing track with Caltrain express services would be the only practical alternative for providing a direct link to San Francisco. Because of the lack of sufficient right-of-way along the Peninsula, dedicated (exclusive guideway) alignments would require tall elevated structures along Caltrain or U.S. Highway 101 (US-101) rights-of-way and extensive purchases of additional right-of-way. The aerial portions of such an alignment would introduce a major new infrastructure element along the Caltrain corridor that would have visual impacts (intrusion/shade/shadow) on the adjacent land uses, including residential areas along this alignment. For a Caltrain exclusive guideway alignment option, the introduction of an elevated structure (for the high-speed tracks and stations) would also have adverse impacts on the suburban town centers along the Caltrain corridor (San Mateo, San Carlos, Redwood City, Menlo Park, Palo Alto, and Mountain View). Although the structure would generally be in a commercial area in these centers, it would represent a physical barrier for land use and urban design. The installation of an exclusive guideway alignment would present major construction issues, involving the construction of an aerial guideway adjacent to and above active existing transportation facilities, while maintaining rail traffic. In San Francisco, major new tunnel construction, in addition to that already proposed for the extension of Caltrain services into the Transbay Terminal, would be required, and would similarly present major construction and cost issues.

In contrast, by taking advantage of the existing rail infrastructure, a shared-use configuration would be mostly at grade. Shared-use options would be less costly and would result in fewer environmental impacts. In addition, for these alignment options improved regional commuter service—electrified, fully grade-separated, with additional tracks and fencing—would help mitigate the impacts of additional rail service along the Peninsula. Shared-use improvements in this corridor would potentially result in safety and service improvements for Peninsula commuters and potentially improve automobile traffic flow at rail crossings and reduce noise impacts, since a grade-separated system could eliminate trains blowing warning horns throughout the alignment. Shared-use options would provide the opportunity for a partnership with the San Mateo County Transit District (SamTrans), the owner of the right-of-way, and operator of the Caltrain service, and would provide the opportunity to incrementally improve a portion of the network. While SamTrans has indicated support for the general concept of a proposed HST system sharing tracks with Caltrain service, it has also commented that a dedicated (exclusive guideway) high-speed rail service along its existing right-of-way would be infeasible, because there would not be enough space for both types of services to operate separately.

Improvements to these heavily constrained urban corridors would be most effectively implemented in an incremental manner to maintain existing services, allow for corresponding improvements to the existing services, limit construction impacts, and reduce immediate funding needs. By contrast, infrastructure for completely dedicated (separate track) steel-wheel-on-steel-rail or maglev technology would not lend itself to incremental improvement.

In summary, these two systems—maglev and steel-wheel-on-steel-rail electrified fully dedicated service—would not allow for direct HST service to major intercity travel markets and therefore would not meet the purpose of and need and objectives for the proposed project.

2.6.7 High-Speed Train Technology Option Carried Forward

STEEL-WHEEL-ON-STEEL-RAIL ELECTRIFIED, POTENTIAL FOR SHARED SERVICE

This type of HST technology includes steel-wheel-on-steel-rail trains capable of meeting the Authority's performance criteria (as summarized previously in Table 2.6-2) that would be able to share tracks at reduced speeds with other compatible services. All existing systems with this very high-speed capability use electric propulsion. This state-of-the-art, high-speed, steel-wheel-on-steel-rail technology would operate in the majority of the statewide system in dedicated (exclusive track) configuration. However, where the construction of new separate HST infrastructure would be

infeasible, shared track operations would use improved rail infrastructure and electrical propulsion. Potential shared-use corridors would be limited to sections of the statewide system with extensive urban constraints. Shared-use corridors would meet the following general criteria in addition to the performance criteria.

- Uniform control/signal system.
- Four tracks at stations (to allow for through/express services and local stopping patterns).
- May require three to four mainline tracks (depending on capacity requirements of HST and other services).
- Physical or temporal separation from conventional freight traffic.

Using this technology, the proposed system would be constructed with consistent dual tracking in a variety of construction sections (e.g., at grade, elevated structure, tunnel), as appropriate for the constraints of each specific section. These typical construction sections are illustrated in Figures 2.6-3, 2.6-4, and 2.6-5.

2.6.8 Previously Considered Alternative Corridor Options Reconsidered and Rejected

The following HST Alternative corridor options were evaluated and eliminated from further consideration during the alternatives screening process based on the consideration of available information, primarily data from previous studies. The detailed technical results and descriptions of public involvement activities and findings that support the elimination of these conceptual alternatives are provided in previously completed reports referenced herein. These previous studies, as described above in Section 2.3.1 (*Background*), incorporated system objectives, analysis methods, and evaluation criteria similar to those used in this Program EIR/EIS. The previous studies applied GIS databases and analysis methods that have been refined, updated, and applied in this Program EIR/EIS.

Appendix 2-H provides tables summarizing the comparison of alternative HST corridors. These tables present screening criteria used to evaluate corridor options and distinguish between the options carried forward and those eliminated from further consideration. The tables highlight the primary considerations for elimination. Tables 2-H-2 and 2-H-3 in Appendix 2-H present some of the options evaluated in the previous studies. The reasons for elimination of each of the corridor options evaluated in the previous studies are categorically summarized below in Table 2.6-3 and further described in the subsections that follow.

Table 2.6-3
Review of Previous Studies of High-Speed Train Alternatives:
Corridor Options Considered but Eliminated

	Reason for Elimination						
Corridor	**Construction**	**Incompatibility**	**Right-of-Way**	**Connectivity/ Accessibility**	**Revenue/ Ridership**	**Environment**	**Environmental Concerns**
Los Angeles to San Francisco Bay only				P	P		
Coastal Corridor (San Jose to Los Angeles)	S				P	S	Natural resources along coast, cultural, visual, geology, property displacement

Figure 2.6-3
At-Grade Section

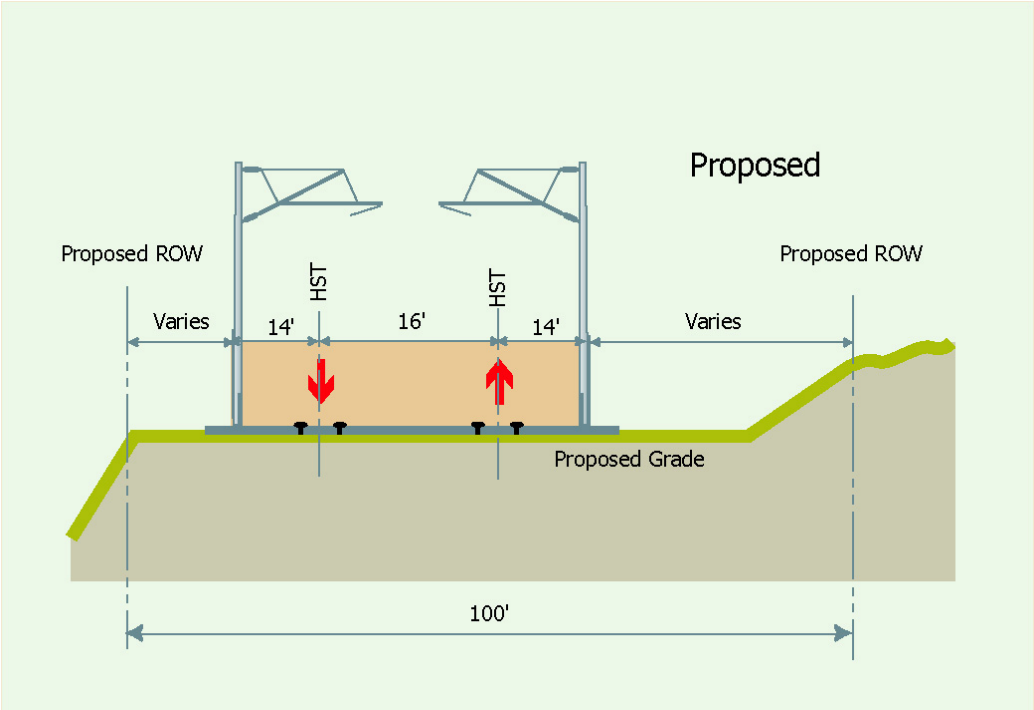


Figure 2.6-4
Elevated Structure

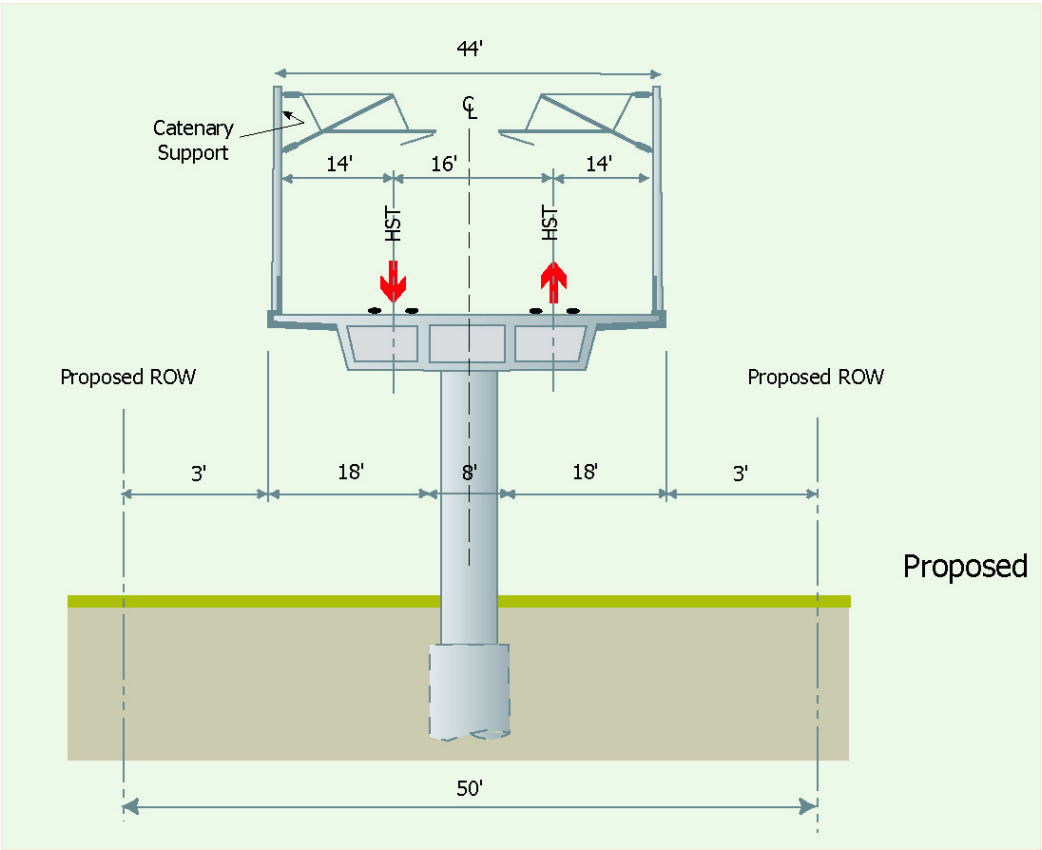
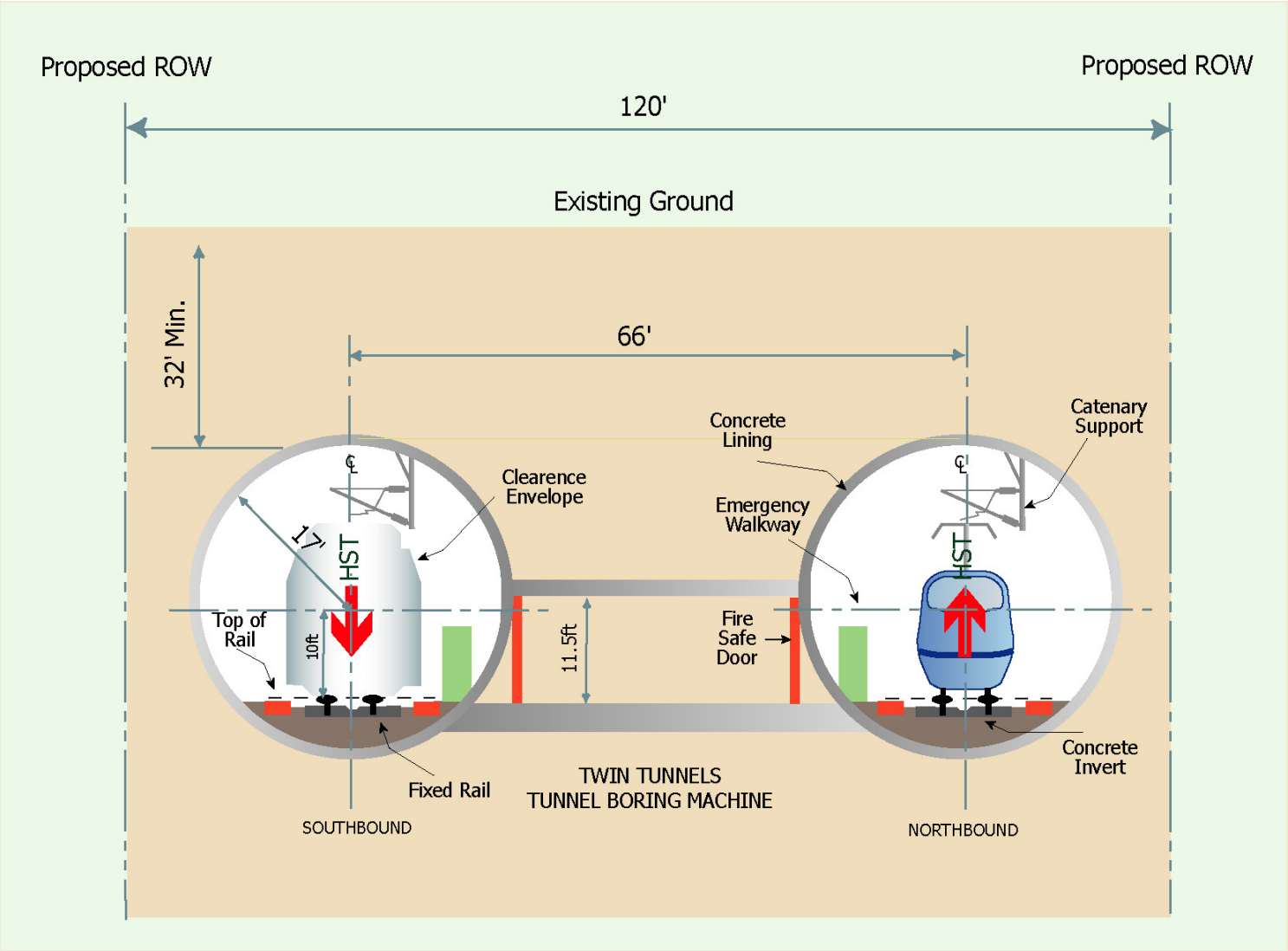


Figure 2.6-5
Twin Tunnels



Corridor	Reason for Elimination						
	Construction	Incompatibility	Right-of-Way	Connectivity/ Accessibility	Revenue/ Ridership	Environment	Environmental Concerns
I-5 Corridor (Sacramento to Bakersfield)		S		P	P		
Capitol Rail Corridor (Sacramento to Oakland)				P	P		
Panoche Pass (Central Valley to Bay Area)	S			P	P		
LAX as LA Terminus	S			P	P		
LOSSAN Corridor dedicated high-speed service	P		P			P	Natural resources, coastal habitats and communities, wetlands/lagoons, visual, geology, biology
Extension to San Diego from East Mission Valley	P		P			P	Land use, property displacement
Peñasquitos Canyon (I-15 to I-5)						P	Natural resources, parkland, open space, wetlands preserve, biology
Definitions:							
Reason: Primary (P) and Secondary (S) reasons for elimination.							
Construction: Engineering and construction complexity, initial and/or recurring costs that would render the project impracticable and logistical constraints.							
Environment: High potential for considerable impacts to natural resources, including waters, streams, floodplains, wetlands, and habitat of threatened or endangered species that would fail to meet project objectives.							
Incompatibility: Incompatibility with current or planned local land use as defined in local plans that would fail to meet project objectives.							
Right-of-Way: Lack of available rights-of-way or extensive right-of-way needs would result in high acquisition costs and/or delays that would render the project impracticable.							
Connectivity/Accessibility: Limited connectivity with other transportation modes (aviation, highway and/or transit systems) would impair the service quality, could reduce ridership of the HST system, and would fail to meet the project purpose.							
Ridership/Revenue: The corridor would result in longer trip times and/or have suboptimal operating characteristics and would have low ridership and revenue and would fail to meet the project purpose.							

For many of the corridor options described below, impracticability[11] (cost, constructability issues, technical constraints, and right-of-way constraints) or inability to meet basic project objectives and purpose and need (ridership potential, connectivity and accessibility, compatibility with existing or planned development, and severe operational constraints) is the prominent elimination factor. Inability to avoid or substantially reduce environmental impacts and other environmental considerations are primary factors in the elimination of the Peñasquitos Canyon extension to San Diego from East Mission Valley option and the dedicated high-speed service option along the coast between Los Angeles and San Diego. Environmental considerations also contribute to the factors supporting the elimination of the coastal corridor between San Jose and Los Angeles.

[11] Impracticability constraints are listed under the Clean Water Act Section 404. For this document, options considered "impracticable" were also considered "infeasible" under CEQA guidelines.

A. LOS ANGELES TO SAN FRANCISCO BAY ONLY

The Commission's 1993 enabling legislation, Senate Concurrent Resolution 6 (SCR-6) states that "by the year 2020, high-speed ground transportation service [should] be operating between Sacramento, the San Francisco Bay Area, the Los Angeles area, the San Bernardino/Riverside area, Orange County, and San Diego." An HST system serving these metropolitan areas and the Central Valley would be available to well over 90% of the state's population. The Commission recommended that the initial HST system link California's major transportation markets, limiting the necessary feasibility studies to the markets defined by SCR-6.

The SCR-6 legislation further states that "a Los Angeles to San Francisco Bay Area High-Speed Corridor [should] be the first corridor developed." The Commission identified several alternatives for phasing a proposed statewide HST network, including Sacramento to the Bay Area or Los Angeles to San Diego, as the first phases of the system. While the Commission deferred phasing decisions to later stages of project development, it recommended ruling out consideration of a San Francisco Bay Area to Los Angeles system that would not include links to Sacramento and San Diego (California Intercity High Speed Rail Commission 1996). Capital costs would be increased by more than 40%, and operational and maintenance costs would be increased by more than 30% with the addition of links to Sacramento and San Diego. However, the addition of these markets would have a positive impact on the forecasted ridership and revenue for the system. A statewide network that would include Sacramento and San Diego would increase ridership by nearly 90% and revenues by 86%. As a result, the Commission recommended that the HST system encompass California's major metropolitan areas: Sacramento, the San Francisco Bay Area, Los Angeles, and San Diego. The Los Angeles to San Francisco Bay only option was eliminated from further consideration because it would not serve all the markets recommended by the Commission and it would have only slightly over one half of the ridership of a system that included these markets.

B. COASTAL CORRIDOR (SAN JOSE TO LOS ANGELES)

Phase 1 of the Commission's feasibility studies comprised an initial broad-scale review of major corridor alternatives between the San Francisco Bay Area and Los Angeles (the coastal, I-5 and SR-99 corridors) to identify those with the greatest potential for HST service (Figure 2.6-6). This initial review concluded that the coastal corridor had the least potential for HST service at maximum speeds exceeding 150 mph (240 kph). Coastal corridor travel times between Los Angeles and the San Francisco Bay Area would be considerably longer than either the SR-99 or I-5 corridors. Travel times for coastal corridor alignments ranged from 3 hrs and 25 min to 4 hrs and 30 min for non-stop express VHS service (very high-speed steel-wheel-on-steel-rail service with maximum speeds up to 217 mph or 350 kph) between San Francisco and Los Angeles. Travel times for the I-5 and SR-99 corridors ranged from 2 hrs and 23 min to 2 hrs and 47 min between San Francisco and Los Angeles.

The longer travel times for the coastal corridor alignments were due to challenging and sensitive geography, particularly along the coast between San Luis Obispo and Los Angeles, which resulted in a longer route. With considerably longer travel times, this corridor had ridership projections 24% to 46% below the shortest I-5 corridor option. The coastal corridor also had the highest projected capital costs due to environmental constraints and the length of the route. The coastal corridor costs were estimated to be about 22% higher than the I-5 corridor and 12% higher than the SR-99 corridor. The coastal corridor was found to have the highest potential impacts on cultural resources, visual impacts, property displacement, as well as the most steep slopes, but lower potential impacts on threatened and endangered species and water resources than some inland corridor options.[12]

[12] These findings were adopted by the Commission in May 1995 and the analysis was summarized in the Commission's "Definition and Ranking of Potential Alignments" report dated September 15, 1995.