4 COSTS AND OPERATIONS

4.1 INTRODUCTION

This chapter summarizes the estimated capital and operations and maintenance (O&M) costs for the Modal and High-Speed Train (HST) Alternatives evaluated in this Program EIR/EIS. To be consistent with the definition of the HST Alternative (see Chapter 2, *Alternatives)*, the capital and O&M costs associated with the HST Alternative comprise the costs associated with only the alignment and station options that most closely reflect the "highest return on investment system" as presented in the California High Speed Rail Authority's (Authority's) final business plan (Business Plan) (California High Speed Rail Authority 2000). The O&M costs for the HST Alternative were developed based on an operations plan and network simulation model that represents the physical characteristics of the proposed HST alignment options and the performance of the proposed HST equipment.

4.2 CAPITAL COSTS

Capital costs were estimated for both the Modal and HST Alternatives in 2003 dollars. The costs are associated with infrastructure improvements defined for each alternative and do not include the costs associated with the No Project Alternative. The programmed and funded improvements included under the No Project Alternative are assumed to have been implemented by 2020 for both the Modal and HST Alternatives.

4.2.1 Modal Alternative

The total capital costs associated with the Modal Alternative include both the highway and aviation components as presented in Table 4.2-1. As described in Chapter 2, the modal improvements were defined to serve the representative (high-end) ridership demand.

Table 4.2-1
Total Cost for Modal Alternative

Improvement	Cost
Highway Component	$66,000,000,000
Aviation Component	$16,000,000,000
Total Cost	$82,000,000,000

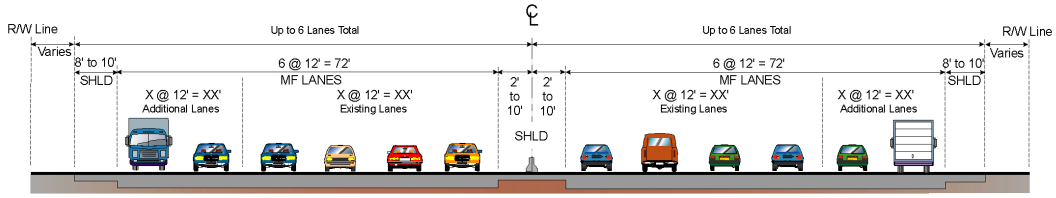
A. HIGHWAY COMPONENT

Capital costs were estimated for the highway component of the Modal Alternative based on planning-level cost estimates prepared for freeway widening and interchange improvement projects in urban areas in California. The unit material costs were compiled based on recent California Department of Transportation (Caltrans) construction cost information from various improvement projects throughout the state.

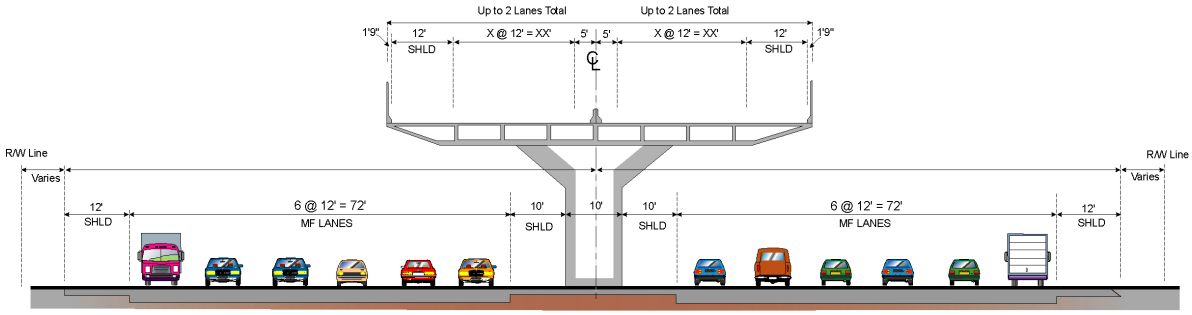
The hypothetical highway improvements include a number of additional lanes that varies per highway corridor. These improvements (additional lanes) are assumed to be in specific corridors for the Modal Alternative, but they could be made to other parallel highways/roads in some cases. The Modal Alternative improvements were compared to the number of lanes that would exist with the No Project Alternative on each route segment to determine whether the improvement would be

described as a widening or a new facility. The additional lanes would widen the existing facility up to a total of 12 lanes, as shown on Figure 4.2-1, a typical cross-section of a highway widening. Beyond 12 total lanes, additional lanes are defined as a separate facility. For this analysis, it is assumed that separate facilities in urban areas would be placed on elevated structures above existing facilities because of right-of-way constraints. The vast majority of Modal Alternative improvements would be widenings rather than separate facilities.

Figure 4.2-1
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)

The total capital costs for the highway component of the Modal Alternative and a description of each of the highway cost elements are presented in Appendix 4-A. The unit costs associated with each cost element are also presented in Appendix 4-A.

B. AVIATION COMPONENT

For the aviation component of the Modal Alternative, hypothetical capacity improvements (terminal gates, runways, and other associated improvements) were identified at representative airports. Specific constraints at each representative airport were considered and improvements were assigned on a case-by-case basis. Assumptions regarding the assignment of new gates and runways to specific airports are described in Chapter 2. For estimation of capital costs, the terminal gates and associated capacity improvements are represented in terms of additional passenger terminal area, rights-of-way (additional physical footprint), parking spaces (on/off site), and primary lanes of access road.

The estimated costs for the Modal Alternative aviation component are based on recent cost information for other airport improvements in California and around the United States (Parsons Brinckerhoff 2003). The aviation component costs are for runways, gates, access roads, demolition/clearing, utility relocation, and right-of-way. Other improvements (e.g., aprons, taxiways, passenger facilities, parking) are included based on planning-level assumptions regarding their size, extent, or placement. Descriptions of each cost element, specific cost assumptions, associated unit

costs, and sources for the aviation component of the Modal Alternative are presented in Appendix 4-B. The total capital costs for the aviation component are also presented by region in Appendix 4-B.

4.2.2 High-Speed Train Alternative

Capital costs were estimated for all of the proposed HST alignment and station options evaluated in this Program EIR/EIS. Because of the variations in alignment and station options being considered in the Program EIR/EIS process, there is potentially a wide range of capital costs associated with a complete statewide system. For a system of alignment and station options similar to the "highest return on investment system," as presented in the Business Plan, the costs could range from $33 to $37 billion. This is more than the estimated costs for a complete statewide system in the Business Plan; at least $2 billion of the cost increase over the previous estimate in the Business Plan is due to inflation.[1] Other differences result from the different alignment (horizontal and vertical) and station configurations being evaluated that were not considered in the Business Plan. The proposed alignment and station configuration options and design assumptions would be reviewed at the project level to identify cost savings through application of value engineering practices.

The capital costs are representative of all aspects of implementation of a proposed HST system, including construction, right-of-way, environmental mitigation, and design and management services. The construction costs include procurement and installation of line infrastructure (tracks, bridges, tunnels, grade separations, and power distribution); facilities (passenger stations, storage and maintenance facilities); systems (communications, train control); and removal or relocation of existing infrastructure (utilities, rail tracks). The right-of-way costs include the estimated costs to acquire properties needed for construction of the HST infrastructure. The environmental mitigation costs include a rough estimate of the proportion of capital cost required for mitigating environmental impacts, based on similar completed highway and rail line construction projects. No specific mitigation costs are identified at this program level of review. As with the Modal Alternative, the HST infrastructure and facilities costs account for the materials necessary to accommodate the representative (high-end) ridership forecasts. Other implementation costs are estimated in terms of add-on percentages to construction costs to account for agency costs associated with administration of the program (design, environmental review, and management). The estimated total capital costs for each of the HST alignment and station options are presented in Appendix 4-C.

A. UNIT COST ESTIMATES

The capital costs have been categorized into discrete cost elements. In general, the capital costs were estimated by determining the appropriate unit costs for the identified cost elements and the cost element quantities from conceptual HST alignment and station option plans prepared for each region. Each cost element is defined in Appendix 4-C, along with the methods, assumptions, and unit cost applied in each case. Many of the cost elements were reviewed by HST owners and operators as part of the peer review of the corridor evaluation study commissioned by the Authority (DE-Consult Deutsche Eisenbahn-Consulting GmbH 2000). The unit costs and assumptions were also reviewed as part of the alignment and station screening for this evaluation. Application of these unit costs and assumptions is consistent with past studies for the HST and provides sufficient detail for the comparison of alignment and station options at this program level.

[1] This reflects an 8.36% increase in construction costs from early 2000 to September 2003, based on *Engineering News Record Construction Cost Index*.

B. ADJUSTMENTS TO UNIT COSTS

The unit costs were adjusted to account for inflation from 2000 to February 2003, based on the *Engineering News Record Construction Cost Index Report*. The revised unit costs are based on the unit costs developed for the Business Plan.

Adjustments were also made to the tunneling unit costs, based on the tunneling conference held in December 2001. This technical tunneling conference was held to address issues associated with the tunneling proposed for the statewide HST system. The conference was attended by seven representatives of major tunneling contractors, nine specialized tunneling consulting engineers, two geologists/geotechnical engineers, Authority staff, and representatives of the program management and regional study consultant teams. The conference reviewed past assumptions and requirements, construction methods, and cost estimating. The conference focused on gaining insights and input regarding feasibility, construction methods, and cost assumptions associated with the proposed tunneling. As a result of the conference and subsequent research and analysis, the Authority revised the tunneling-related unit costs applied in the Authority's previous studies to reflect changes in design and construction assumptions (e.g., advance rates and tunnel lining).

4.3 OPERATIONS AND MAINTENANCE COSTS

O&M costs were developed for the both the Modal and HST Alternatives. These costs are assumed to be in addition to the costs of the No Project Alternative. Therefore, only the incremental cost to operate and maintain the additional highway and airport improvements under the Modal Alternative, and the incremental cost to operate and maintain the HST Alternative were estimated.

4.3.1 Modal Alternative

Annual O&M costs for the Modal Alternative were calculated based on estimated costs of material and labor required to maintain and operate the hypothetical highway and airport improvements proposed under the Modal Alternative.

A. HIGHWAYS

An average cost per lane mi per year was calculated based on the costs of materials and labor required to maintain a highway lane mi over a 40-year lifecycle. The annual cost of maintaining the 2,970 lane mi [4,780 km] of the highway component of the Modal Alternative would be $135.6 million. The amount represents what it would cost a contractor to perform the work, and reflect typical California costs. California Highway Patrol and other emergency response costs and administrative overhead (Caltrans) are not included in this analysis. A detailed breakdown of the highway maintenance costs can be found in Appendix 4-D.

B. AIRPORTS

O&M costs were estimated for airport improvements in each of the five study regions. Annual O&M costs associated with these airports are based on the actual O&M costs for airports in each region, as reported in their annual financial statements. Average or representative unit costs were estimated and applied to each airport that was part of the study. This was done to keep the airport operations and maintenance costs uniform throughout the state.

The unit costs for airfield runway expansion projects were derived from the reported O&M costs of the airports divided by the number of linear feet for the existing runways. This O&M cost per linear foot of runway was then applied to the linear feet of each runway added under the Modal Alternative. The unit costs for the terminal expansion (e.g., new gates) projects were derived from the annual

terminal O&M costs divided by the number of terminal aircraft gates for each of the airports. This cost per gate was then applied to the gate expansion plans for each airport.

The cost of operating and maintaining aircraft, marketing and reservations, and propulsion fuel are not part of this O&M calculation. It is assumed that the number of aircraft operations would be the same under the No Project, Modal, and HST Alternatives.

The Modal Alternative would require 42,000 linear ft (12,802 linear km) of runway and 91 gates to accommodate the representative demand. The annual O&M costs for the runways and gates would be $19.2 million and $46.5 million, respectively, or a total of $65.7 million per year. A detailed breakdown of the annual operating costs is found in Appendix 4-E.

4.3.2 High-Speed Train Alternative

The annual O&M costs of the HST Alternative are based on system indicators, including operating speed, travel time, station configuration, maintenance and storage facility, and operating schedule. All of these system indicators are outputs of the California high-speed rail simulation model as documented in the operations report. (Parsons Brinckerhoff 2003.)

A. OPERATING SPEEDS

For the HST system, higher operating speeds (150–220 mph [241–354 kph]) are proposed for areas where the alignment is less constrained, and lower operating speeds (less than 125 mph [201 kph]) are proposed in the more heavily developed areas. Local and semi-express services would not necessarily reach the maximum speeds on a given segment. Figures 4.3-1 and 4.3-2 show the maximum speeds that could be attained on the various alignment options of the proposed HST system.

B. TRAVEL TIMES

Table 4.3-1 shows the optimal express trip times between the city pairs considered in the Business Plan. These times represent the estimated travel times between city pairs without interference from other trains or stops at intermediate stations.

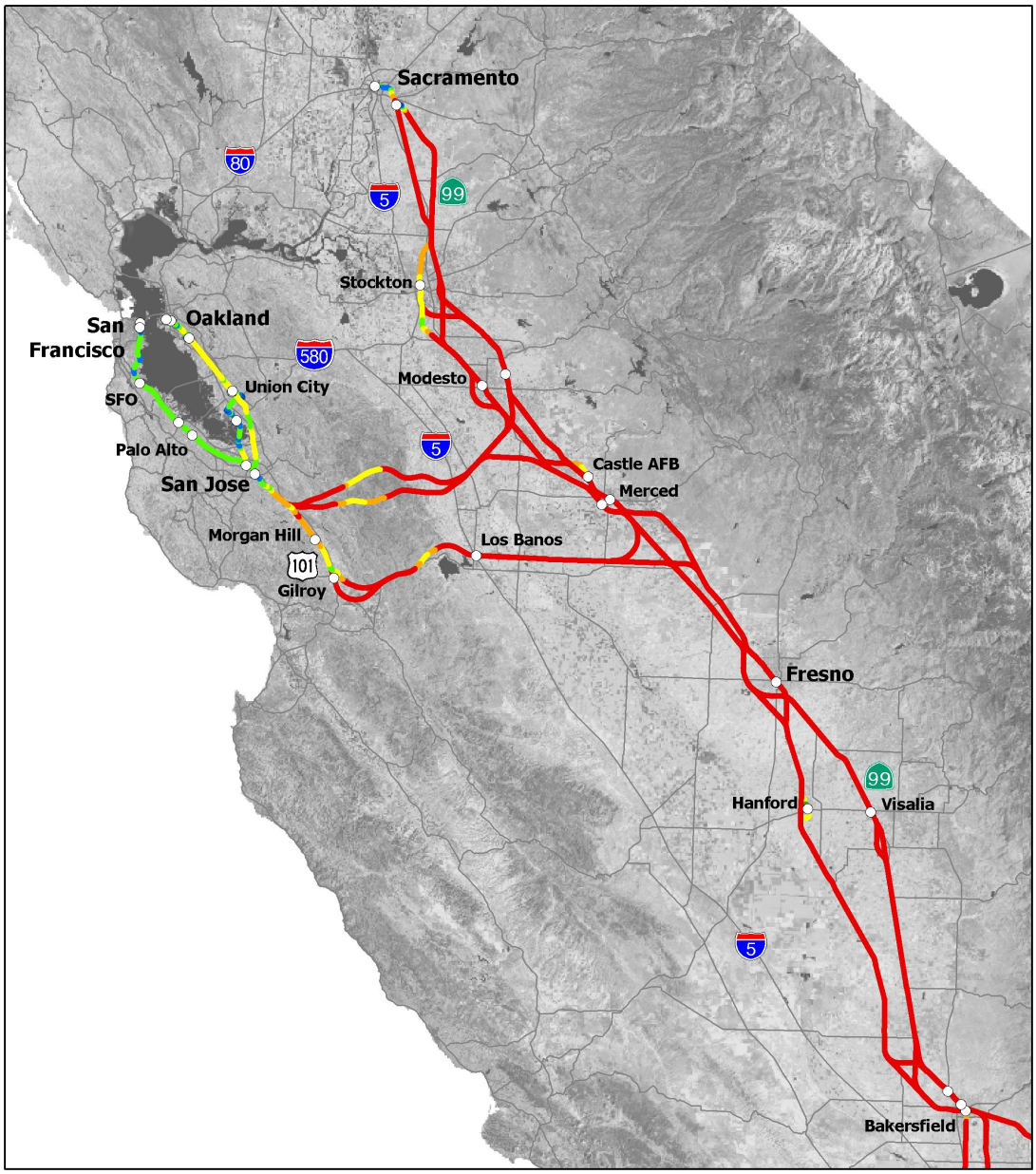
Table 4.3-1
Optimal Express Trip Times between City Pairs (220 mph [350 kph] maximum speed)

	Travel Time (Hrs:Min)							
	Los Angeles	San Francisco	San Jose	San Diego	Sacramento	Fresno	Bakersfield	Riverside
Los Angeles	N/A	2:25	1:56	1:06	2:00	1:12	0:41	0:30
San Francisco	2:25	N/A	0:30	3:30	1:27	1:18	1:47	2:55
San Jose	1:56	0:30	N/A	3:02	0:50	0:49	1:19	2:26
San Diego	1:06	3:30	3:02	N/A	3:07	2:19	1:49	0:39
Sacramento	2:00	1:27	0:50	3:07	N/A	0:53	1:23	2:30
Fresno	1:12	1:18	0:49	2:19	0:53	N/A	0:35	1:42
Bakersfield	0:41	1:47	1:19	1:49	1:23	0:35	N/A	1:12
Riverside	0:30	2:55	2:26	0:39	2:30	1:42	1:12	N/A

N/A = not available.

Note: Travel times based on I-5 alignment option between Los Angeles and Bakersfied (add 10 minutes for the Antelope Valley option) and the Qualcomm alignment option in San Diego (add 7 minutes for the Miramar Road or Carroll Canyon alignment options).

Figure 4.3-1
Maximum Operating Speeds for Express Service on Proposed HST System
Northern California



September 23, 2003

California High Speed Train Program EIR/EIS

Legend

Speed Ranges

MPH	KPH
0 - 31	0 - 50
31 - 62	50 - 100
62 - 93	100 - 150
93 - 124	150 - 200
124 - 155	200 - 250
155 - 186	250 - 300
186 - 217	300 - 350

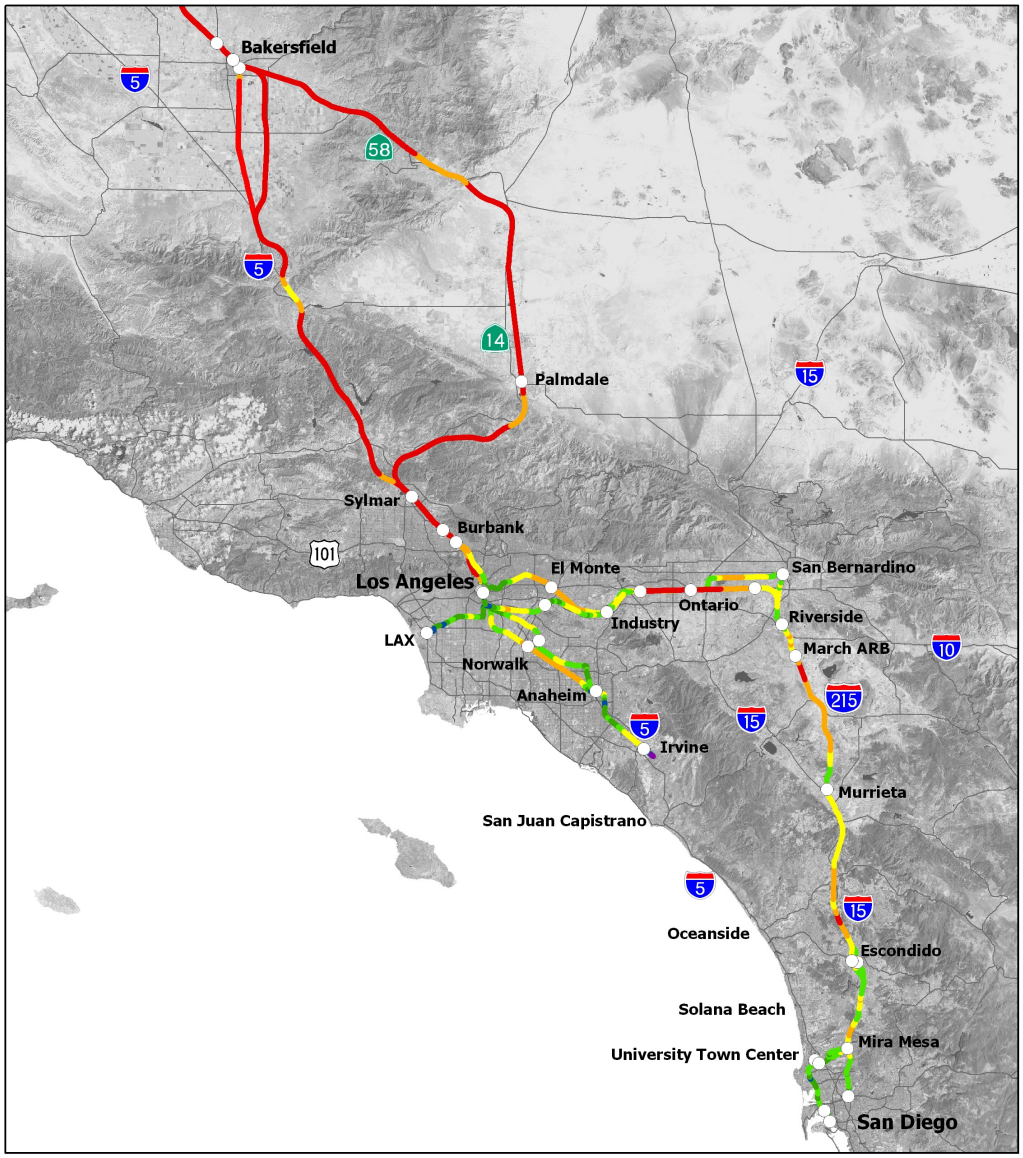
10 0 10 Miles

10 0 10 Kilometers

CALIFORNIA HIGH SPEED RAIL AUTHORITY

Express Trip Time
Train Service Speeds
Northern California

Figure 4.3-2
Maximum Operating Speeds for Express Service on Proposed HST System
Southern California



May 24, 2005

California High Speed Train Program EIR/EIS

10 5 0 10 20 Miles

10 5 0 10 20 Kilometers

CALIFORNIA HIGH SPEED RAIL AUTHORITY

Legend

Speed Ranges

MPH	KPH
0 - 31	0 - 50
31 - 62	50 - 100
62 - 93	100 - 150
93 - 124	150 - 200
124 - 155	200 - 250
155 - 186	250 - 300
186 - 217	300 - 350

Express Trip Time
Train Service Speeds
Southern California

C. STATIONS

There are two general station types for the proposed HST system: terminal and intermediate (line) stations. Intermediate stations would have four tracks, with two through-tracks for express service.

D. MAINTENANCE FACILITIES AND STORAGE YARDS

The train sets used for the HST system would need to be maintained at several points along the HST corridor. To estimate maintenance costs it was assumed that the system would have four maintenance facilities. Three of these facilities would be the primary locations for cleaning, servicing, inspecting, and maintaining the vehicles, as well as storing the trains overnight. A fourth facility would serve as a heavy maintenance facility. In addition to these maintenance facilities, each of the terminal stations would have some light maintenance and cleaning capabilities.

E. CONCEPTUAL OPERATING SCHEDULE

The service levels tested in the system network simulation model were 86 trains per day in each direction (i.e., north and south) (172 total), assuming 650 and 1,175 seats per train for the low- and high-end ridership forecasts, respectively. The service type and stopping patterns are summarized below.

- Express (20 trains per day in each direction): Trains running from Sacramento, San Jose, or San Francisco to Los Angeles and San Diego with one intermediate stop between origin and destination.
- Semi-Express (21 trains per day in each direction): Trains running between similar endpoints as the express, with a limited number of intermediate stops.
- Suburban-Express (20 trains per day in each direction): Trains running express between major metropolitan regions, but stopping frequently within these regions.
- Local (21 trains per day in each direction): Trains stopping at all intermediate stops, with potential for skipping stops to improve service depending on demand.
- Regional (4 trains per day in each direction): Trains running local that begin or end in the Central Valley, operating mostly during commute hours.

F. OPERATIONS AND MAINTENANCE ANNUAL COSTS

The HST projected annual O&M costs are based on the train miles resulting from the simulation model described above and the unit costs developed for the HST corridor evaluation study. A cost estimation method and unit costs were developed for the previous corridor evaluation study to provide an order of magnitude cost estimate for HST service. This method was peer reviewed by the operators of several HST systems, as discussed above in Section 4.2.2.A, and found to be adequate for this level of analysis. The same method has been applied in this analysis with updated estimates of total train miles from the simulation model to provide a cost estimate for the "highest return on investment system" from the Business Plan. The number of train miles for the proposed HST system is 81,622 per weekday, or 27,049,531 per year. For comparison with the Modal Alternative (specifically the aviation component), the HST O&M costs do not include costs for train operations, maintenance of the fleet of train sets, propulsion fuel (electricity), or the marketing and reservations for the service. Table 4.3-2 summarizes those costs.

Table 4.3-2
Annual Costs of Operating and Maintaining HST Infrastructure

Item	Dollars per Train Mile (2003 $)	Annual Cost (millions 2003 $)
Station Services	0.54	14.6
Insurance	1.32	35.7
General Support	0.95	25.7
Maintenance of Way	2.83	76.5
Total per Year [1,2,3]		152.5

[1] Total cost is based on 253 weekdays and 112 weekend days. The weekend level of service (i.e., number of trains) is 70% of a typical weekday level of service.
[2] Includes inflation (adjustment of 8.36% from 2000 figures) and additional train miles accounting for train placement (i.e., to and from the overnight storage location) and maintenance activities.
[3] Numbers are subject to rounding.

Source: Parsons Brinckerhoff 2003

Other costs associated with operating a HST train system as used in the Business Plan include train operations, equipment maintenance, marketing and reservations, and propulsion power (electricity). These HST fleet O&M costs are shown on a per-train-mi basis in Table 4.3-3.

Table 4.3-3
Annual Costs of Operating and Maintaining an HST System

Item	Annual Dollars per Train Mile (2003 $)	Annual Costs (millions 2003 $)
Train Operations	6.59	178.2
Equipment Maintenance	7.73	208.9
Marketing and Reservations	1.39	37.5
Power	4.66	126.1

Source: Parsons Brinckerhoff 2003

4.3.3 Operating Cost Comparison of the Alternatives

Table 4.3-4 summarizes the estimated annual O&M costs of the proposed Modal and HST Alternatives. The incremental O&M costs of the Modal Alternative infrastructure would be 32% higher than the O&M costs of the HST Alternative infrastructure. This analysis is based on estimated costs only and does not take into account the costs associated with potential financing mechanisms for any of the alternatives (e.g., bonds and bond financing).

Table 4.3-4
Annual Operating Costs (Millions of 2003 Dollars)[1]

Alternative	Airports[2]	Highways[3]	HST[4]	Total
Modal	$65.7	$135.6	N/A	$201.3
HST	N/A	N/A	$152.5	$152.5

N/A = not available.

1 Incremental costs in addition to the costs associated with the No Project Alternative.

2 Based on American Association of Airport Executive Annual Airport Financial Reporting Statements, 2002. Airport operating cost information is for the following airports: Oakland, San Jose, Sacramento, Fresno, Burbank, Ontario, Long Beach, and San Diego.

3 Highway costs were calculated on a per-freeway-mi basis. The costs are based on industry standard costs for replacing PCC (67% of highway lane mi) and AC (33% of highway lane mi) sections. Costs do not include ancillary costs of operating roadways, such as highway patrol and other incident response costs.

4 HST projected annual O&M costs based on train miles resulting from the simulation model described above and the unit costs developed for the HST corridor evaluation study. Costs from the evaluation study were adjusted for inflation by a factor of 8.36% to make them 2003 dollars. Costs do not include the costs from train operations, maintenance of fleet of train sets, propulsion fuel (electricity), or marketing and reservations for the service.