California High-Speed Rail Project

CALIFORNIA
High-Speed Rail Authority

Estimating High-Speed Train Operating & Maintenance Cost for the CHSRA 2012 Business Plan

April 2012

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The 2012 Business Plan presents a multi-step phased implementation strategy for the statewide high speed rail system. Three possible steps were costed: an initial operating segment (IOS) from Merced to the San Fernando Valley, a Bay Area to Los Angeles Basin step (Bay to Basin), and a Phase 1 Blended from San Francisco, using the existing Caltrain Corridor alignment (with electrification) to San Jose, and then on, to Los Angeles Union Station on dedicated high-speed line. Three different scenarios of operating and maintenance costs, and ridership and revenues were analyzed.

The first section presents the service levels for each step for both the high-speed train (HST) and connecting feeder services (conventional train and dedicated coach services). The second section presents the operating and maintenance (O&M) cost estimating methodology. The third section presents estimated staffing requirements for O&M activities. The fourth section presents the O&M cost estimates resulting from each scenario's assumed schedule of construction and start of service.

1. Service Levels for Implementation Steps

This section describes the service levels assumed for the three implementation steps costed, including both the HST service and the connecting feeder coach and rail services at terminal stations. The service levels were established to meet the forecast demand in each of the years presented. The fifth year of each step's operation is shown, using the schedule of construction depicted in the main Business Plan report, in which the IOS opens in 2022, the Bay to the Basin is put in service in 2027, and Phase 1 Blended starts up in 2029. In order to facilitate comparison among the steps, service levels are also presented for the year 2040; these levels also show how service would grow even if the HST system development did not occur on this schedule.

HST trainset miles were calculated for each service pattern by multiplying its frequency by the length of run, the number of trainsets per train (most are single trainsets), and adding 6% to 11% for non-revenue trainset operation (primarily operations without passengers to and from maintenance facilities for inspection, maintenance, and overnight storage). The extent of non-revenue operations is expressed as a percentage of revenue operations. The sum of all services' trainset miles provided the figures used in Sections 3 and 4 below.

Dedicated feeder coach revenue-service hours were calculated similarly using the number of coaches needed and the length of time each run would take, based on traffic and operating characteristics such as projected levels of congestion and average operating speeds, and travel time estimates from online sources. Revenue service hours then were increased to total service hours using the same percentage as was used to increase each scenario's trainset revenue miles to total trainset miles.

Amtrak, Caltrain, and Metrolink timed connecting service was assumed to be provided by each operator adjusting prior operating schedules at no cost to the HST. Each operator also is assumed to retain the revenue generated on their service by the additional HST passengers.

Initial Operating Segment

The IOS would provide HST service between Merced and a San Fernando Valley station. Amtrak, Metrolink, and dedicated coach services would provide coordinated connections to/from Sacramento, the Bay Area, and other parts of the LA Basin. Service levels assumed for HST and connecting services in year 2026 and 2040, under the "Business Plan Medium" ridership and revenue scenario, are shown in Table 1.

Table 1: IOS South service levels for HST and coordinated coach and rail connections

	Daily Round Trips – 2026				Daily Round Trips - 2040			
HST and Feeder Services	Peak Hours[1]	Shoulder Hours[2]	Off-Peak Hours[3]	Total Daily	Peak Hours[1]	Shoulder Hours[2]	Off-Peak Hours[3]	Total Daily
High Speed Train								
Between San Francisco and San Jose	-	-	-	-	-	-	-	-
Between San Jose and Fresno	-	-	-	-	-	-	-	-
Between Merced and Fresno	6	6	24	**26**	6	6	24	**36**
Between Fresno and Bakersfield	6	6	24	**26**	6	6	24	**36**
Between Bakersfield and Los Angeles	6	6	24	**26**	8	6	24	**38**
Between Los Angeles and Anaheim	-	-	-	-	-	-	-	-
Connections								
At Merced								
Amtrak- Sacramento[4]	1	1	1	**3**	1	1	1	**3**
Amtrak- Oakland[4]	2	2	3	**7**	2	2	3	**7**
Dublin/Pleasanton, Oakland, San Francisco[5]	16	14	36	**66**	18	14	48	**80**
Lodi, Elk Grove, Sacramento	6	6	12	**24**	6	6	24	**36**
Turlock, Modest, Stockton[5]	14	12	36	**62**	14	12	36	**62**
At San Fernando Valley								
Metrolink – LA Union Station[4]	4	4	12	**20**	4	4	12	**20**
Burbank Airport, Van Nuys, West LA, Santa Anita and LA Union Station[5]	60	50	144	**254**	66	54	156	**276**

[1] Two hours each day, one in morning and in afternoon
[2] Two hours each day, one in morning and in afternoon
[3] 12 hours each day
[4] Coordinated schedules assumed
[5] Dedicated Coach service provided by HST

Bay Area to LA Basin (Bay to Basin)

The Bay to Basin step would provide HST service between San Jose and a San Fernando Valley station and between Merced and the San Fernando Valley station. Amtrak, Metrolink, Caltrain, and dedicated coach services would provide coordinated connections to/from Sacramento, and other parts of the LA Basin and the Bay Area. Service levels assumed for HST and connecting services in year 2031 and 2040, under the "Business Plan Medium" ridership and revenue scenario, are shown in Table 2.

Table 2: Bay to Basin service levels for HST and coordinated coach and rail connections

HST and Feeder Services	Daily Round Trips – 2026				Daily Round Trips - 2040			
	Peak Hours[1]	Shoulder Hours[2]	Off-Peak Hours[3]	Total Daily	Peak Hours[1]	Shoulder Hours[2]	Off-Peak Hours[3]	Total Daily
High Speed Train								
Between San Francisco and San Jose	-	-	-	-	-	-	-	-
Between San Jose and Fresno	8	8	24	**40**	8	8	24	**40**
Between Merced and Fresno	4	4	12	**20**	4	4	12	**20**
Between Fresno and Bakersfield	12	10	36	**58**	12	10	36	**58**
Between Bakersfield and Los Angeles	10	8	36	**54**	12	10	36	**58**
Between Los Angeles and Anaheim	-	-	-	-	-	-	-	-
Connections								
At Merced								
Amtrak- Sacramento[4]	1	1	1	**3**	1	1	1	**3**
Amtrak- Oakland[4]	2	2	3	**7**	2	2	3	**7**
Dublin/Pleasanton, Oakland, San Francisco[5]	2	2	12	**16**	2	2	12	**16**
Lodi, Elk Grove, Sacramento	6	4	12	**22**	6	4	12	**22**
Turlock, Modest, Stockton[5]	12	10	36	**58**	12	10	36	**58**
At San Fernando Valley								
Metrolink – LA Union Station[4]	4	4	12	**20**	4	4	12	**20**
Burbank Airport, Van Nuys, West LA, Santa Anita and LA Union Station[5]	98	82	228	**408**	104	86	240	**430**

[1] Two hours each day, one in morning and in afternoon
[2] Two hours each day, one in morning and in afternoon
[3] 12 hours each day
[4] Coordinated schedules assumed
[5] Dedicated Coach service provided by HST

San Francisco & Merced to Los Angeles (Phase 1 Blended)

The Phase 1 Blended step would provide HST service between San Francisco and Los Angeles Union Station. Amtrak and dedicated coach services would provide coordinated connections to/from Sacramento, and other parts of the Bay Area. Service levels assumed for HST and connecting services in year 2033 and 2040, under the "Business Plan Medium" ridership and revenue scenario, are shown in Table 3.

Table 3: Phase 1 Blended service levels for HST and coordinated coach and rail connections

HST and Feeder Services	Daily Round Trips – 2026				Daily Round Trips - 2040			
	Peak Hours[1]	Shoulder Hours[2]	Off-Peak Hours[3]	Total Daily	Peak Hours[1]	Shoulder Hours[2]	Off-Peak Hours[3]	Total Daily
High Speed Train								
Between San Francisco and San Jose	8	8	24	**40**	8	8	24	**40**
Between San Jose and Fresno	10	10	36	**56**	12	10	36	**58**
Between Merced and Fresno	4	4	12	**20**	4	4	12	**20**
Between Fresno and Bakersfield	12	10	36	**58**	12	10	36	**58**
Between Bakersfield and Los Angeles	14	12	36	**62**	14	12	36	**62**
Between Los Angeles and Anaheim	-	-	-	-	-	-	-	-
Connections								
At Merced								
Amtrak- Sacramento[4]	1	1	1	**3**	1	1	1	**3**
Amtrak- Oakland[4]	2	2	3	**7**	2	2	3	**7**
Dublin/Pleasanton, Oakland, San Francisco[5]	2	2	12	**16**	2	2	12	**16**
Lodi, Elk Grove, Sacramento	6	6	24	**36**	6	6	24	**36**
Turlock, Modest, Stockton[5]	12	10	36	**58**	12	10	36	**58**
At San Fernando Valley								
Metrolink – LA Union Station[4]	4	4	12	**20**	4	4	12	**20**
Burbank Airport, Van Nuys, West LA, Santa Anita and LA Union Station[5]	-	-	-	-	-	-	-	-

[1] Two hours each day, one in morning and in afternoon
[2] Two hours each day, one in morning and in afternoon
[3] 12 hours each day
[4] Coordinated schedules assumed
[5] Dedicated Coach service provided by HST

2. Operating & maintenance (O&M) cost estimating methodology

In order to quickly handle a large number of HST service scenarios, a simplified operating and maintenance (O&M) cost model was developed from the more complicated model used in the 2009 Report to the Legislature (2009 Report) and the ongoing project level environmental work (the earlier full model is described in Appendix 5-B of the Draft Merced to Fresno Section Project EIR/EIS[1]). The 2009 O&M costs were benchmarked against recent information from European and Japanese HST experience and from other studies, resulting in somewhat higher estimates than in earlier work in several categories. A method for estimating the O&M cost of inter-city bus services was developed to account for the significant amount of feeder coach service assumed for possible initial operable segments of the HST and extensions. Finally, a methodology was developed to match the HST and feeder service levels more precisely to the forecast ridership.

a) Simplified HST O&M cost model

The simplified O&M cost model combines elements of cost in the 2009 Report that could reasonably vary by changes in a single variable such as train miles or route length. The cost categories of 2009 Report model and the aggregated categories of the simplified model are shown in Table 4, along with the variable that drives each respective cost category.

Table 4 2009 and 2012 model categories

2009 Model		Simplified 2012 Model	
Category	Activity Driver	Category	Activity Driver
Train crew	Train & trainset hours	Train operations & maintenance	Trainset miles
Electric power	Trainset miles & station size		
Trainset maintenance	Trainset miles		
Maintenance of infrastructure	Route miles, capital cost	Same as 2009	Route miles
Stations & train cleaning	Staffed by size & type	Same as 2009	# stations
Sales, marketing, reservations	Staffed by station	Administration & support	% of cost except contingency
Control center	Staff estimate		
Administration	Percent of operations labor		
Insurance	Lump sum	Same as 2009	Lump sum
Contingency	Percent of above	Same as 2009	Percent of above

[1] California High Speed Rail Program Management Team, "HST Operating and Maintenance Cost for Use in EIR/EIS Project Level Analyses". Memorandum to the Central Valley Regional Teams. July 11, 2011. Available on CA HSRA website at:http://208.82.222.137/pdfs/fresno_merced/vol_2/app_5b.pdf

The amount from each of the 2009 Report model categories was re-expressed in the form of the simplified model as shown in Table 5.

Table 5 2009 Report cost by unit and group

	Data from 2009 Report (2009$$)				
	Phase 1 Cost M)	Activity driver unit	Amount	Cost / unit	Cost / unit grouped
Train crew	$ 101.6	TSM	41.6 M	$ 2.36	$ 17.98
Electric power	$ 321.2	TSM		$ 7.45	
Maintenance of equipment	$ 351.8	TSM		$ 8.17	
Maintenance of infrastructure	$ 102.8	RM	520	$200 K	$200 K
Stations & train cleaning	$ 57.4	Station	14	$ 4.1 M	$4.1 M
Administration & support	$ 85.0	% excl. cont.	8%	8%	8%
Insurance	$ 50.0	Lump sum	$50 M	$ 50 M	$50 M
Contingency	$ 53.5	% of above	5%	5%	5%
TSM = Train-set mile; RM = Route mile; K = thousands; M = millions					

b) Benchmarking and updating unit costs for 2012 business plan

While many of the CA HST O&M costs are quite similar to U.S. conventional rail operations and can be reliably estimated from U.S. practices and costs, the cost to maintain high-speed trainsets and dedicated high-speed infrastructure has no close analogy in the U.S. The 2009 Report costs were based on activity levels for the French TGV system, adapted to the planned California operation and U.S. cost levels and labor practices. For the 2012 business plan, these items were compared to results reported for other high speed rail systems in Europe and Japan. European information was drawn from the International Union of Railways (UIC), a worldwide railroad association headquartered in Western Europe[2], published work by Spanish researchers[3], and a feasibility study of HST in Brazil conducted for the Inter-American Development Bank by a British/Chilean engineering and economics consortium.[4] Japanese costs for vehicle maintenance were reported by the Japan Railways Construction, Transport, and Technology

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[2] Union International des Chemins-de-Fer, "High-Speed Rail – Fast Track to Sustainability", Paris, France, 2010, online at http://www.uic.org/IMG/pdf/20101124_uic_brochure_high_speed.pdf

[3] Campos, de Rus, Barron, "Some stylized facts about high-speed rail around the world: an empirical approach", paper presented at 4th Annual Conference on Railroad Industry Structure, Competition and Investment, Universidad Carlos III de Madrid, October, 2006 cited in Halcrow/Sinergia, 2009.
Also similar work in: Campos , Javier, de Rus, Gines and Barron, Ignacio, "A review of HSR experiences around the world", Chapter 1 of "Economic Analysis Of High Speed Rail In Europe", BBVA Foundation, 2007, online at http://mpra.ub.uni-muenchen.de/12397/

[4] Halcrow/Sinergia Consortium, "Brazil TAV Project – Volume 4, Rail Operations and Technology, Part 1: Rail Operations", June, 2009 online at http://www.tavbrasil.gov.br/Documentacao/Ingles/VOL4-OPERATIONS&TECHNOLOGY/OPERATIONS/VOL_4_Pt_1_Operations_Final_Report.pdf

Agency.[5] Additional comparisons of costs were made between published reports of next generation high-speed rail operation project for the Northeast Corridor.

Table 6 shows the 2009 Report unit values for equipment and infrastructure maintenance in relationship to the overseas systems and studies. A comparison is instructive even though there are different categories of cost, and uncertainty from exchange rates and differences in standards of living. The 2009 maintenance of equipment costs for the CA HST, which were based on French TGV experience and include mid-life refurbishment costs, are higher but not out of line with the costs reported for the Japanese system. The UIC figure appears not to include amounts for the mid-life refurbishments of the trainsets, and the Halcrow/Sinergia study costs are factored downwards because of the lower cost of labor in Brazil. Because the CA HST trainsets will operate at higher speeds than those for which costs were reported and run more miles per year, and in order to add some further conservatism, the unit cost was increased 5% to $8.60 per trainset mile.

Table 6 Comparison of 2009 CA HST maintenance costs with overseas HST costs (2009$$)

	CA HST 2009	France	Spain	Japan	UIC Europe	Halcrow /Sinergia
Maintenance of equipment						
(per trainset mile)	$ 8.17	n.a.	n.a.	$7.20	$4.16	$5.75
Maintenance of infrastructure						
Track & systems (per route mile)	--	--	--	n.a.	--	$110,000
Structures (per route mile)	--	--	--	n.a.	--	$90,000
Total (per route mile)	$198,000	$150,000 – 199,000	$177,000	n.a.	$145,000	$200,000

The CA HST maintenance of infrastructure cost, also estimated in 2009 from French TGV line experience, is at the upper end of reported European experience and similar to the Halcrow/Sinergia study cost. Data for maintaining Japan's high speed lines was not uncovered. As a result of this review, the previous cost for infrastructure maintenance was rounded up to $200,000 per mile. The Halcrow/Sinergia study provided support for ramping up the maintenance of infrastructure cost over time to reflect that less maintenance is needed when the line is new, and that in later years it is more expensive as the system matures and replacement time nears. In the current CA HST model, costs start at a third of the average yearly maintenance cost, increase to the 25th year, as a capital renewal program begins to return the assets to new condition. Costs fall as the renewals are completed, and in the 35th year costs reach a cyclical low at two-thirds of the average cost and a new cycle begins.

CA HST energy consumption had been revised since 2009 by more comprehensive electric power load studies, bringing the electricity consumption to roughly 59 kWh per trainset mile including regenerative braking. To this has been added a 7% allowance for station and maintenance facilities electricity consumption. The cost of 17¢ / kWh used in 2009, which had been estimated from LA Metro costs with a three cent premium for "green power" added, was compared to that of the largest electric transit user in the state, the Bay Area Rapid Transit[6]. Their cost of 10.5¢ per kWh was substantially lower, and the

[5] Kikuchi, Kazunari, Japan Railway Construction, Transport and Technology Agency, "About the California High Speed Rail reviews for O & M (California High-Speed Rail O & M Review)", Attachment to e-mail Kikuchi to Hanakura, Yu, Sep. 2, 2011 (translated by Hanakura).

[6] Base Energy Inc. "Energy Efficiency Assessment of Bay Area Rapid Transit (BART) Train Cars". November 2007 online at http://www.bart.gov/docs/BARTenergyreport.pdf

base cost was lowered to the average of the two systems, and the three cent premium added for a total of 15.2 cents per kWh. The combined effect of these two changes was to increase the energy cost to $9.00 per train mile.

The review found no reason to modify the train crew costs, but they were rounded up to $2.40 per trainset mile, from the prior $2.36. The sum of trainset mile related costs - crew, energy, and vehicle maintenance - thus totaled $20 as shown in Table 7.

The remaining cost categories in Table 7 were also reviewed. Administration and support was increased from 8% of all costs except contingency to 10% because the implementation steps are smaller with less activity over which to spread administration and support functions. Station costs were felt to be satisfactory and were not changed. Insurance was lowered to $25 million annually from $50 million after further review of costs for rail passenger service in the U.S. showed that the most expensive cost in 2010 was for the Los Angeles Metrolink system, at approximately $20 million a year. Finally, contingency was increased to 10% from 5% to provide more conservative estimates.

Table 7 2009 and 2012 O&M model costs by category and unit

		2009 Report	2012 Model
	Activity driver unit	Cost / unit (2009$$)	Cost / unit (2009$$)
Train crew, electric power, trainset maintenance	TSM	$17.98	$20.00
Maintenance of infrastructure	RM	$198 K	$200 K
Stations & train cleaning	Station	$ 4.1 M	$4.1 M
Administration & support	% excl. cont.	8%	10%
Insurance	Lump sum	$ 50 M	$25 M
Contingency	% of above	5%	10%
TSM = Train-set mile; RM = Route mile; K = thousands; M = millions			

c) Estimating costs of feeder coach service

The initial operating segment and extensions require tightly coordinated feeder service in order to generate the range of ridership and revenue forecast. Most of this feeder service is envisaged as over-the-road coaches dedicated to the HS service, branded and marketed as an integral part of the HST. Other feeder service is assumed to be provided by Amtrak or Caltrain, also coordinated and co-marketed with the HST, but each operator is assumed to bear its operations cost and keep all revenue related to the segment of the trip made on its trains.

The cost of dedicated feeder coach service was estimated from a review of data and discussions with contract operators. In a recent study by Caltrans, rural intercity bus operations in the State were found to have costs per revenue service hour ranging from $40 to $117 per revenue service hour[7] with very light density service accounting for the upper end. Discussion with one intercity coach industry executive produced an estimate of around $65-$75 per revenue service hour, including the supply of

[7] KFH Group, "California Statewide Rural Intercity Bus Study, Final Draft", Caltrans Division of Mass Transportation, 2007, table 3-9, online at http://www.dot.ca.gov/hq/MassTrans/Docs-Pdfs/5311/Bus-Study/Chapter-3.pdf .

coaches, operation, and establishment / operation of depot and maintenance facilities for a more intense service as would be needed to meet HST trains.[8] For the2011 business plan, a cost of $92 per total (revenue and non-revenue) service hour (including 10% cost contingency) was used.

d) Matching operations frequency with forecast HST ridership

For each year of operations, the capacity of the proposed service was verified and, if necessary, adjusted to ensure sufficient capacity to carry the forecast traffic. This was done by first identifying the segment carrying the maximum traffic on each individual leg of the service, including conventional rail and/or dedicated bus service legs that serve as connections to the high-speed train service. The average daily traffic volumes, provided by the traffic forecasts, were used to compute peak hour traffic volumes based on the hourly service patterns and on the ridership peaking factors identified in the Phase 1 Service Plan as shown in Table 8.

Table 8 Ridership Peaking Factors

Origin-Destination Market	Peak Hour	Peak Shoulder Hour	6 peak hours	10 off-peak hours	Directional Peaking Factors	
					PM Peak South-bound	PM Peak North-bound
Inter-Regional	12%	10%	54%	46%	1.0	1.0
Within MTC Territory	17%	11%	67%	33%	1.2	0.8
Within SCAG Territory	15%	10%	61%	39%	0.9	1.1

Thereafter, the service levels required to carry the forecast hourly traffic were computed based on the capacity, load-factor, and minimum and maximum service level assumptions shown in Table 9. If the minimum service levels were found to have inadequate capacity to carry forecast traffic, the service frequencies were increased until adequate capacity was available. The service frequencies were assumed to be capped at the frequencies used for traffic forecast. If the forecast traffic exceeded the capacity of single trainsets at traffic forecast frequencies, it was assumed that double trainsets would be introduced, as needed.

Table 9 Capacity, Load-factor, and Service Level Assumptions

Mode	Seating Capacity	Maximum Allowed Load Factor
High Speed Train	450 passengers per single trainset	105 percent in peak of the peak and shoulder peak hours, and 90 percent in off peak hours
Dedicated Buses	30 passengers per coach	75 percent

The resulting service frequencies and trainset requirements were then used to compute the O&M costs for each year of operations.

[8] Conversations with Stanley G. Feinsod, Chairman of the Board, MacDonald Transit Associates and Fullington Auto Bus Company, and business development advisor to RATP Dev USA.

3. Staffing Requirements

The staffing requirements for operating the service and maintaining the infrastructure and rolling stock were developed from the operating plan used for the operations and maintenance costing, U.S. and California labor practices and requirements, and overseas HST experience where needed. Staffing was first estimated for the 2009 Report to the Legislature ("Previous Phase 1" in Table 10), based on the following functions and their labor requirements.

1. Operations: operate and dispatch the trains, manage the power supply and train routings, and serve the passengers on-board the trains. Staffing estimate assumed one engineer per train and a four-member crew per trainset (i.e. eight-member crew for a double trainset), and the number of hours worked includes time spent driving and serving on the train, punching in, daily briefings, checking out the train, shut-down at the end of the day, training refreshers, time between trains and similar non-revenue service time.
2. Maintenance of Equipment: cleaning of trains, regular light and heavy maintenance of the trainsets in order to keep the fleet in safe operating condition and available for operations. Staffing estimate is based on two shifts a day for light maintenance throughout the facilities around the state, with additional staff for heavy overhauls at the heavy maintenance facility in the Central Valley.
3. Maintenance of Infrastructure: maintain the physical infrastructure including structures, bridges, buildings, tracks, signaling and communications systems, traction power system. Staffing estimate is based on ratios per mile of track or right of way. More labor-intensive ballasted track was assumed throughout because the extent of slab track on the California high-speed line has not been decided.
4. Passenger Services and Administration/Management: manage passenger services at stations such as ticketing and security, as well as general direction and management of the high speed rail system. Staffing estimate is based on 25 staff per shift for the five largest stations and 17 staff per shift for the remaining stations with three shifts for management and security staff, and two shifts of 10 hours for the remaining staff. Staffing for general management /administration is estimated at 10 percent of sum of all staffing identified above.

The above staffing levels were then applied to the year 2030, business case "high level of ridership and activity for Phase 1 Blended, Bay to Basin, and the initial operating segments steps, through interpolation/extrapolation on the basis of the values of the key driving factors. For the steady state year of 2040, the 2030 estimates were increased proportionally to the growth of ridership at 0.5% a year for the first three categories below; maintenance of infrastructure, which is a function of the length of the HST route, was not increased.

The sum of staffing required for the four labor categories provided the total staffing requirement. The total requirements (rounded-up to the nearest hundred) for steps the IOS, Bay to Basin, and Phase 1 Blended steps under the low and capital cost with constrained construction schedule scenario are as shown in Table 10 below.

Table 10: Driving Factors and Estimates for Staffing Requirements

	Previous Phase 1 (203)	ISO	Bay to Basin	Phase 1 Blended
Driving Factors				
System Length (in miles)	540	300	450	510
Annual Revenue Trainset Miles (in millions)	42.0	8.0	15.4	20.0
Number of Passengers (in millions)	39.20	10.46	19.18	26.36
Staff Requirement				
Maintenance of Equipment	2,100	400	800	1,000
Maintenance of Infrastructure	500	300	500	500
Transportation Operations	1,800	400	700	900
Ancillary Services	600	200	300	500
Total	**5,000**	**1,300**	**2,300**	**2,900**

4. O&M Costs for the 2012 Business Plan Scenarios

Using the methodology and assumptions described above, O&M cost projections were developed for each of the three scenarios consisting of combinations of ridership and revenue, and operations and maintenance cost alternatives. The medium ridership and operating cost scenario provides a base case, and a sensitivity analysis of the low and high cost scenarios reveals the likely fluctuation in O&M cost projections if ridership and demand change.

HIGH, MEDIUM, AND LOW RIDERSHIP, REVENUE, AND OPERATING AND MAINTENANCE COSTS

SERVICE PARAMETERS

	Route Miles	Revenue Service Start	HST Trainset Miles (in millions per year)			Dedicated Coach Hours (in millions per year)		
			High	Medium	Low	High	Medium	Low
IOS	297	2022	9.6	8.9	6.6	0.67	0.52	0.32
Bay to Basin	441	2027	20.0	16.3	12.5	0.41	0.30	0.23
Phase 1 Blended	505	2029	25.3	21.1	16.6	0.31	0.24	0.15

Note: HST Trainset Miles and Dedicated Coach Hours are for Year 2040

HIGH RIDERSHIP, REVENUE, AND O&M COSTS

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050	2055	2060
Ridership (in millions)	-	-	5.1	6.8	8.6	10.5	12.3	16.5	18.1	24.2	26.8	31.8	32.6	33.4	34.3	35.1	36.0
Revenue (in 2010 dollars)	-	-	355	479	605	733	864	1,208	1,331	1,575	1,743	2,070	2,122	2,176	2,231	2,287	2,345
O&M Costs (in 2010 dollars)	100	150	206	253	358	373	387	557	603	680	709	850	888	921	956	929	903
Ops. And Maint. Of Equipment	-	-	90	129	216	228	240	320	353	437	458	550	550	556	587	599	599
Maint. Of Infrastructure	-	-	30	30	30	30	30	44	45	53	56	82	113	134	131	97	75
Stations	-	-	25	25	25	25	25	34	34	46	46	46	46	46	46	46	46
Insurance	-	-	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
General and Administration	-	-	17	21	30	31	32	42	46	56	59	70	73	76	79	77	75
Contingency	-	-	19	23	33	34	35	47	50	62	64	77	81	84	87	84	82
Caltrain Fare Reimbursement	-	-	-	-	-	-	-	45	50	-	-	-	-	-	-	-	-
Start-up Training	100	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

MEDIUM RIDERSHIP, REVENUE, AND O&M COSTS

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050	2055	2060
Ridership (in millions)	-	-	4.0	5.4	6.7	8.1	9.6	12.9	14.2	19.3	21.4	25.7	26.4	27.0	27.7	28.4	29.1
Revenue (in 2010 dollars)	-	-	278	372	467	564	663	941	1,040	1,242	1,380	1,655	1,697	1,740	1,784	1,829	1,875
O&M Costs (in 2010 dollars)	100	150	196	247	258	334	358	480	503	568	627	724	776	802	805	766	778
Ops. And Maint. Of Equipment	-	-	82	124	133	196	216	265	280	344	391	445	457	458	463	464	497
Maint. Of Infrastructure	-	-	30	30	30	30	30	44	45	53	56	82	113	134	131	97	75
Stations	-	-	25	25	25	25	25	34	34	46	46	46	46	46	46	46	46
Insurance	-	-	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
General and Administration	-	-	16	20	21	28	30	37	38	47	52	60	64	66	66	63	64
Contingency	-	-	18	22	23	30	33	41	42	52	57	66	71	73	73	70	71
Caltrain Fare Reimbursement	-	-	-	-	-	-	-	34	38	-	-	-	-	-	-	-	-
Start-up Training	100	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

LOW RIDERSHIP, REVENUE, AND O&M COSTS

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050	2055	2060
Ridership (in millions)	-	-	2.9	3.9	4.8	5.8	6.8	9.3	10.3	14.4	16.1	19.6	20.1	20.6	21.2	21.7	22.2
Revenue (in 2010 dollars)	-	-	200	265	330	395	462	674	748	910	1.019	1,241	1,272	1,304	1,337	1,371	1,405
O&M Costs (in 2010 dollars)	100	150	176	230	238	251	252	411	453	499	518	611	655	705	708	672	656
Ops. And Maint. Of Equipment	-	-	65	110	117	127	128	217	249	287	301	352	356	378	383	386	396
Maint. Of Infrastructure	-	-	30	30	30	30	30	44	45	53	56	82	113	134	131	97	75
Stations	-	-	25	25	25	25	25	34	34	46	46	46	46	46	46	46	46
Insurance	-	-	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
General and Administration	-	-	15	19	20	21	21	32	35	41	43	50	54	58	59	56	54
Contingency	-	-	16	21	22	23	23	35	39	45	47	56	60	64	64	61	60
Caltrain Fare Reimbursement	-	-	-	-	-	-	-	24	26	-	-	-	-	-	-	-	-
Start-up Training	100	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-