Chapter 3

Capital Costs

Introduction

Adoption of the blended approach as the preferred implementation strategy is a fundamental shift in the Revised 2012 Business Plan (Revised Plan). Making this shift results in significant changes to previous proposals and capital cost estimates. It translates into projected costs well below the estimates included in the Draft 2012 Business Plan (Draft Plan), completed in November 2011. The reductions are the result of two key changes tied to the blended approach:

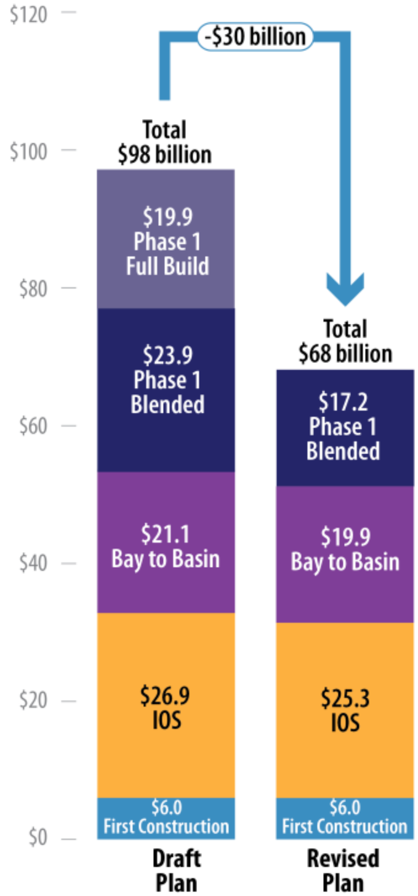
- The Phase 1 Blended option eliminates the need for costly and intrusive new HSR infrastructure in urban areas, reducing the cost of delivering the HSR system called for in Proposition 1A by nearly $30 billion (year-of-expenditure dollars [YOE$]) from the previous Phase 1 Full Build proposal. Completion of the Phase 1 Blended system, as described in Chapter 2, is estimated at $68.4 billion in inflated, YOE dollars, compared to the previous Phase 1 Full Build estimate of $98.1 billion.
- Acceleration of the delivery of improvements in urban areas through early investments and the adjustment of early inflation estimates to align with projections.

Exhibit 3-1 compares the construction cost (YOE$) of the Phase 1 Blended system to the Phase 1 Full Build system and shows how these two key changes yield $30 billion in cost reductions.

This chapter presents updated capital cost estimates for constructing the Phase 1 high-speed rail (HSR) system connecting San Francisco and Merced with Los Angeles and Anaheim through a phased and blended implementation approach. This chapter also describes the Authority's approach to developing these cost estimates and outlines comparisons to international systems and other projects in the United States.

Additional information on the capital cost estimates in this Revised 2012 Business Plan (Revised Plan) is available in *Cost Changes from 2009 Report to 2012 Business Plan Capital Cost Estimates*, which can be accessed at www.cahighspeedrail.ca.gov/business_plan_reports.aspx.

Exhibit 3-1. Phase 1 construction cost comparison—Draft and Revised Business Plan (YOE$)



Assumption	Draft Plan	Revised Plan
Build	**Full Build System** • Dedicated infrastructure *San Francisco to Los Angeles/ Anaheim*	**Blended System** • Dedicated infrastructure *San Jose to Los Angeles* • Shared electrified infrastructure *San Jose to San Francisco* • Upgraded diesel Metrolink corridor *Los Angeles to Anaheim*
Inflation	3% per year staring in 2011	1%—2012 2% per year—2013-2015 3% per year—2016 and beyond

Presentation of capital costs

The capital costs for the high-speed rail system are presented in this chapter in two ways:

- **Constant dollars**—Estimates are initially provided in 2011 dollars to serve as a baseline for conversion to YOE dollars and for comparison with other projects.
- **Year-of-expenditure dollars**—Estimates are then converted into year-of-expenditure dollars by using the baseline 2011 costs and projecting them into the future, using the schedule and implementation approach described in Chapter 2, The Implementation Strategy: Blending, Phasing, Investing in Early Benefits.

A range of costs is associated with each phase of the program because until final environmental approval of all preferred alignments, stations, and maintenance facilities is received, a number of key decisions will remain unresolved. When those decisions are finalized, the final costs also will be determined. For example, for the Central Valley alone, more than 20 alignment options have yet to be finalized, and each option has different costs. To show the range of potential costs, the low cost estimate includes the cumulative lowest cost options, and the high cost estimate includes the cumulative highest cost options, both including environmental mitigation.

This chapter provides the costs for the different steps in the implementation plan (as outlined in Chapter 2, The Implementation Strategy: Blending, Phasing, Investing in Early Benefits) broken out by Federal Railroad Administration (FRA) cost category in 2011 dollars. A contingency of between 10 and 25 percent is included in each cost category to protect against material cost increases, use of different components or parts, and minor quantity changes, depending on the category. A separate and additional "Unallocated Contingency" value of 5 percent also is included as a general reserve to address unanticipated changes. The costs for each step represent a project total at that step and include the cost for constructing prior sections. For example, the Bay-to-Basin estimate includes the cost of the IOS.

Approach and methodology

The following important programmatic considerations directly affect the cost estimates:

- **Program size**—The CHSRP is one of the largest infrastructure programs undertaken in the United States. This program includes installing potentially up to 2,200 miles of rail weighing 276,000 tons; 3.5 million square feet of buildings and facilities; 6,500 miles of electrical wires and cables; and approximately 190 grade separations. A significant portion of the project—approximately 190 miles—may be constructed on elevated structures or in tunnels.
- **Shared benefits and costs**—Consistent with the emphasis on blended systems, many of the improvements included in the cost estimate will benefit other California rail and transit operators as well as the communities through which the system will be constructed. Investments will be made in tracks and systems in joint-use corridors. Communities along the route will see significant investment in new (or replaced) transportation and civil infrastructure, including new grade separations, replacement of existing highway bridges, new transportation stations, and local road improvements to provide access to stations. In addition, transit agencies will experience very significant increases in ridership, and businesses around train stations will benefit from new economic activity. Through the development of cooperative memoranda of understanding and other means, the Authority and its transportation partners are working to develop collaborative funding and cost-sharing strategies. Many costs for these joint-benefit improvements are included in full within the program budget. For example, in the Caltrain corridor between the San Francisco and San Jose corridor, Caltrain and HSR will share the electrified tracks requiring joint investments to enhance the corridor to accommodate additional commuter and HSR service in this heavily traveled corridor. Similarly, investments will be made to upgrade the Southern California Regional Rail Authority (Metrolink) corridors to achieve the blended service and operations described in Chapter 2, The Implementation Strategy: Blending, Phasing, Investing in Early Benefits.

Process overview

In the Caltrain corridor, some joint-benefit costs will be shared.

The development approach for project engineering typically advances in three broad steps:

- Conceptual Engineering (5 percent) provides a comparative basis for evaluating different alignments and developing an order-of-magnitude cost estimate for cost-benefit analysis and budgeting.
- Preliminary Engineering (15 to 30 percent) provides a detailed approximation of project complexity, cost, and construction methodology that reflects actual field conditions and design changes required to mitigate environmental issues and community concerns. Proceeding with the procurement of a design-build contractor at this stage follows standard industry practice for balancing the need for sufficient specificity of preliminary design and the flexibility for innovation in final design and construction. The type and level of cost estimation undertaken by the Authority is in accordance with guidelines from the Association for the Advancement of Cost Engineering (AACE-International) and under those AACE guidelines, are appropriate for bid/tender.[1] A comprehensive report prepared for the U.S. Department of Transportation, the *Design-Build Effectiveness Study* [2] evaluated lessons learned from a variety of design-build projects, including rail, and recommended specific steps for agencies to maximize the benefits of the design-build approach. A key recommendation was that,

  > *Preliminary designs that are incorporated in the RFP [request for proposal] should be no more than 30 percent complete, dropping to lower levels as the size and complexity of the project increases and the contracting agency gains greater experience with this project delivery approach and the use of performance-based specifications.*

- Final Engineering (100 percent) provides the documentation to build the final product.

As the engineering progresses, a proposed project's costs become better defined, allowing for more accuracy. Typically, the most pronounced changes in a design and variations in cost occur between the Conceptual and Preliminary Engineering phases as the project team goes on-site to evaluate specific alignment conditions and environmental impacts and works with the affected communities. The Authority now has advanced beyond this point and is currently undertaking the Preliminary Engineering activities for the program approaching an overall 15 percent design completion, with the design approaching 30 percent for the Central Valley. Thus, at this stage of the project, local conditions, stakeholder requirements, and engineering demands are well understood. Barring major changes in scope or requirements, the level of contingency at this stage—a total of 10 to 25 percent of each construction category—should be sufficient to address reasonably foreseeable increases arising from the normal design process.

The HSR program will be constructed through design-build contracts. Under a traditional design-bid-build project development approach, there is a separate process for completing project design, which is then provided to the construction contractor. Under a typical design-build approach, the public entity provides about 15 percent of the design to the contractor, and a single contractor both completes the design and constructs to those specifications. There are many advantages to this approach, but one of the primary ones is avoiding conflicts between the design and the practical realities that come up during construction. Since a single contractor manages both aspects of project development, costs and risks to the public agency are reduced and the contractor guarantees that the completed project will meet performance criteria established by the public agency.

Development of cost estimate

The cost estimates described and presented in this chapter are based on site-specific route alignments developed during Preliminary Engineering. Although the costs for improvements have been calculated and reviewed, they are nonetheless subject to changes in economic conditions that occur over time and that can affect actual prices—either positively or negatively. The cost estimate is the product of two key items:

- **Quantities**—This is the quantity of materials required to construct the project's key elements from track to stations to trains. The materials quantity depends greatly on the ground conditions where the project will be built—land use and availability, geotechnical conditions, community and stake-holder impacts, and environmental challenges requiring realignment or special designs. These factors are highly site-specific and subject to significant change during the environmental process and as communities participate in key decisions. The FRA defines the categories that must be included in a cost estimate for federally funded rail projects. The major categories are as follows:
  - Track structures and track
  - Stations, terminals, intermodal
  - Site work, right-of-way, and existing improvements
  - Communications and signaling
  - Electric traction
  - Vehicles
  - Professional services
  - Unallocated contingency
  - Finance charges

- **Composite unit prices**—These are the prices associated with the materials. Composite unit prices for complex items, such as stations and electrical substations, may include hundreds of elements, each of which must be separately priced. The prices also must reflect the specific market for each product and material, such as the underlying commodity and labor costs, at the time anticipated for procurement. Composite unit prices for more than 300 separate cost items have been developed for the cost estimates.

The costs and quantities were reviewed by two groups of experts. The regional consultant teams independently reviewed major cost items, such as viaducts, tunnels, embankments, and retaining walls and trenches. In addition, the Authority's program oversight consultant hired a contractor to generate a contractor bid price based on the draft 15-percent design for the Merced-to-Fresno and Fresno-to-Bakersfield sections. Both sets of experts found that costs and quantities fell within a reasonable range.

California added nearly 5 million people between 2000 and 2010, with much of this growth along the project route. In many areas, the alignment has had to be relocated, elevated on bridges, or placed in tunnels to avoid severe community impacts and to navigate through densely populated urban areas.

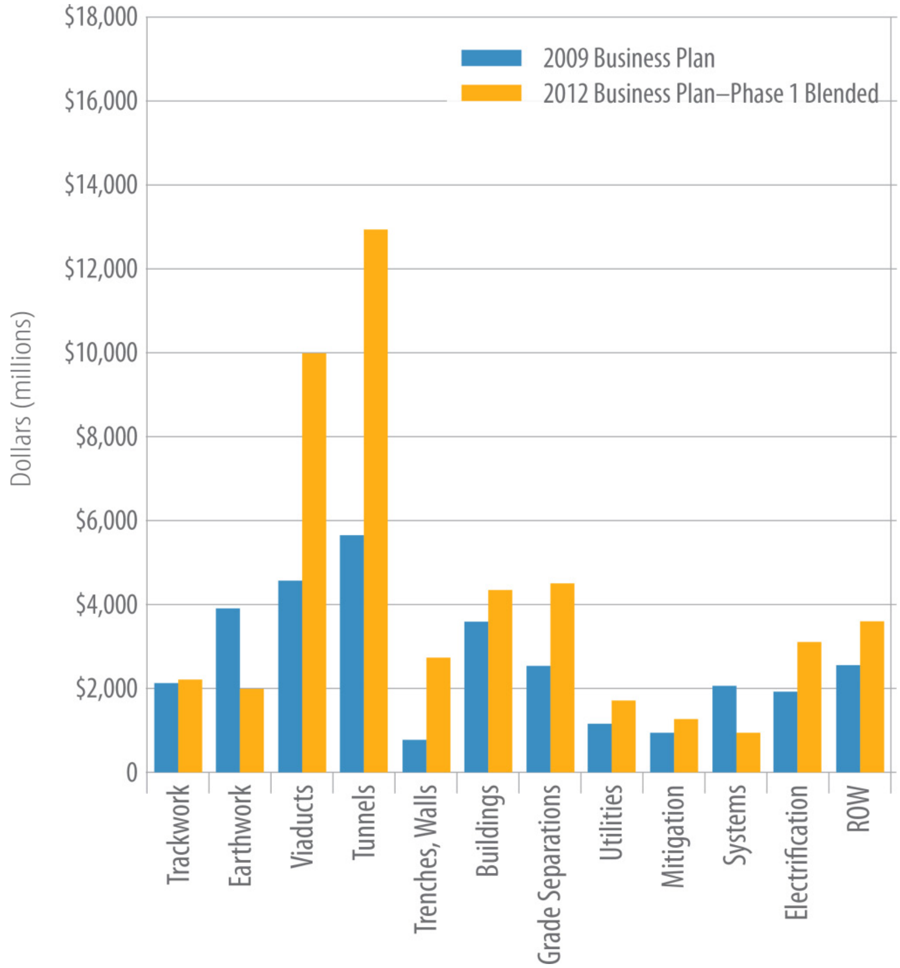
Capital costs in 2011 dollars

The 2009 cost estimates were based on programmatic conceptual design. As noted previously, the cost estimates in this Revised Plan are based on a higher level of preliminary design, which also have been shaped by the changes resulting from the environmental and community review processes. The increased costs in the current estimates are tied to several key factors. Eighty to eighty-five percent of this increase is for additional viaducts, tunnels, embankments, and retaining walls and trenches directly attributable to changes in scope and alignment based on stakeholder input, environmental necessity, and improved knowledge of site conditions; the remaining 15 to 20 percent is attributable to increases in composite unit prices (Exhibit 3-2).

The initial program planning predated much of California's real estate boom in the mid-2000s. Large expanses of vacant or under-utilized property, over which the system would have operated at-grade, have since become bustling communities, suburbs, and roadways. California added nearly 5 million people between 2000 and 2010, with much of this growth along the project route. In many areas, the alignment has had to be relocated, elevated on bridges, or placed in tunnels to avoid severe community impacts and to navigate through densely populated urban areas. In addition, more detailed investigations during Preliminary Engineering have identified challenging geologic and geotechnical conditions, floodplains, and differences in terrain that required realignment of the route or more expensive design approaches.

Taiwan's high-speed rail system operates on elevated structure to accommodate land use.

Exhibit 3-2. Capital cost changes since the 2009 Business Plan



The new development landscape has necessitated adding many miles of elevated structures, tunnels, and other infrastructure. The new designs permit access to major downtown population centers with reduced community impacts and disruption. Approximately 30 to 36 percent of the Phase 1 Blended system may be built on elevated structure or in tunnels, depending on alignment alternatives. The possible length of elevated structures increased from 77 miles in 2009 to between 113 and 140 miles, and tunnels increased from 32 miles to between 44 and 48 miles (with the ranges based on different alternatives still under consideration). Composite unit prices for materials and components also have increased. Some of the increase reflects increased engineering design, providing more detailed material and component specification. Other changes simply reflect increases in the underlying cost of key materials required for HSR infrastructure. Although the recent economic recession has reduced pressure on some prices, the cost for steel, copper, concrete, and other basic commodities has not moderated and is expected to continue to increase because of domestic and international demand, particularly from China.

In summary, the Phase 1 Blended system still connects San Francisco, Los Angeles, and Anaheim via the Central Valley. However, the current system is very different from the one priced in the past because of the changes discussed above.

Initial Operating Section

The IOS is approximately 300 miles long and will permit operation of high-speed rail from Merced to the San Fernando Valley. In addition to constructing the first segment of the IOS between Merced and Bakersfield and extending the tracks to the San Fernando Valley, the IOS includes passenger stations, maintenance and support facilities, traction electrification systems, and train control and communication systems for the entire system, as well as the necessary high-speed trains required for service. Exhibit 3-3 presents construction costs for the IOS broken out by FRA cost category in 2011 dollars.

Exhibit 3-3. Cost to construct IOS—Central Valley to San Fernando Valley (base year fiscal year 2011 dollars)

FRA Standard Cost Categories	Low-cost Option (millions)	High-cost Option (millions)
10—Track structures and track	$14,319	$17,275
Civil (10.04–10.06, 10.08, 10.18)	*$1,470*	*$1,712*
Structures (10.01–10.03, 10.07)	*$11,719*	*$14,298*
Track (10.09, 10.10, 10.14)	*$1,132*	*$1,267*
20—Stations, terminals, intermodal	$618	$618
30—Support facilities: yards, shops, administrative buildings	$433	$433
40—Sitework, right-of-way, land, existing improvements	$4,667	$5,341
Purchase or lease of real estate (40.07)	*$1,461*	*$1,523*
50—Communications and signaling	$518	$559
60—Electric traction	$1,699	$1,830
70—Vehicles	$871	$871
80—Professional services (applies to categories 10–60)	$2,805	$3,309
90—Unallocated contingency	$935	$1,103
100—Finance charges	$0	$0
Total	**$26,865**	**$31,339**

Subtotals for information only

Bay to Basin

The Bay-to-Basin system is approximately 410 miles long and includes construction of a complete HSR system from San Jose and Merced extending south to the San Fernando Valley. This system will allow for blended systems with Caltrain and HSR in San Jose, and with Metrolink and HSR in the San Fernando Valley. Bay to Basin includes all elements of a HSR system: civil infrastructure, passenger stations, maintenance and support facilities, traction electrification systems, and train control and communication systems, as well as the necessary high-speed trains required for service. Exhibit 3-4 presents construction costs for Bay to Basin broken out by FRA cost category in 2011 dollars.

Exhibit 3-4. Cost to construct—Bay to Basin (base year fiscal year 2011 dollars) (includes cost of IOS)

FRA Standard Cost Categories	Low-cost Option (millions)	High-cost Option (millions)
10—Track structures and track	$21,286	$26,716
Civil (10.04–10.06, 10.08, 10.18)	*$2,320*	*$4,353*
Structures (10.01–10.03, 10.07)	*$17,350*	*$20,569*
Track (10.09, 10.10, 10.14)	*$1,618*	*$1,795*
20—Stations, terminals, intermodal	$1,135	$1,137
30—Support facilities: yards, shops, administrative buildings	$471	$468
40—Sitework, right-of-way, land, existing improvements	$7,922	$8,795
Purchase or lease of real estate (40.07)	*$1,914*	*$2,043*
50—Communications and signaling	$692	$749
60—Electric traction	$2,250	$2,434
70—Vehicles	$1,835	$1,835
80—Professional services (applies to categories 10–60)	$4,296	$5,161
90—Unallocated contingency	$1,426	$1,713
100—Finance charges	$0	$0
Total	**$41,313**	**$49,008**

Subtotals for information only

San Francisco to Los Angeles/Anaheim—Phase 1

Implementation of Phase 1 service connecting the San Francisco Transbay Transit Center in the north with the Anaheim Regional Transportation Intermodal Center in the south can occur in increments building off the Bay-to Basin-operating section described above. The Phase 1 Blended system involves constructing an HSR extension to Los Angeles' Union Station, which will provide dedicated high-speed rail infrastructure between Los Angeles and San Jose, and upgraded blended operations in the Caltrain Corridor and in the Metrolink corridor between Los Angeles and Anaheim. Exhibit 3-5 presents construction costs for Phase 1 Blended broken out by FRA cost category in 2011 dollars.

Exhibit 3-5. Cost to construct—Phase 1 Blended (base year fiscal year 2011 dollars) (includes cost of IOS and Bay to Basin)

FRA Standard Cost Categories	Low-cost Option (millions)	High-cost Option (millions)
10—Track structures and track	$23,595	$29,815
Civil (10.04–10.06, 10.08, 10.18)	*$3,069*	*$5,347*
Structures (10.01–10.03, 10.07)	*$18,705*	*$22,422*
Track (10.09, 10.10, 10.14)	*$1,821*	*$2,046*
20—Stations, terminals, intermodal	$3,208	$3,210
30—Support facilities: yards, shops, administrative buildings	$764	$761
40—Sitework, right-of-way, land, existing improvements	$11,938	$13,059
Purchase or lease of real estate (40.07)	*$3,607*	*$3,915*
50—Communications and signaling	$861	$916
60—Electric traction	$2,822	$3,001
70—Vehicles	$3,211	$3,211
80—Professional services (applies to categories 10–60)	$5,256	$6,236
90—Unallocated contingency	$1,788	$2,117
100—Finance charges	$0	$0
Total	**$53,443**	**$62,326**

Subtotals for information only
Figures may not sum due to rounding.

Capital costs in year-of-expenditure dollars

The previous section showed the costs by phase in 2011 dollars. This section converts the 2011 estimates to their year-of-expenditure estimates using the planning schedule in Chapter 2, The Implementation Strategy: Blending, Phasing, Investing in Early Benefits, and assumptions regarding inflation. In this Revised Plan, costs are escalated by applying an inflation rate for each year beyond the baseline. Inflation for 2012 is assumed to be 1 percent; 2013 through 2015 is 2 percent per year; and 3 percent per year is used for 2016 forward. These rates have been estimated based on multiple sources, including the California inflation forecast data provided by the California Department of

Finance, *Engineering News Record* Construction Cost Index historical and forecast indexes, and medium/long-term federal inflation targets.

The planning schedule (Exhibit 3-6) was used to develop year-of-expenditure estimates.

Exhibit 3-6. Construction schedule

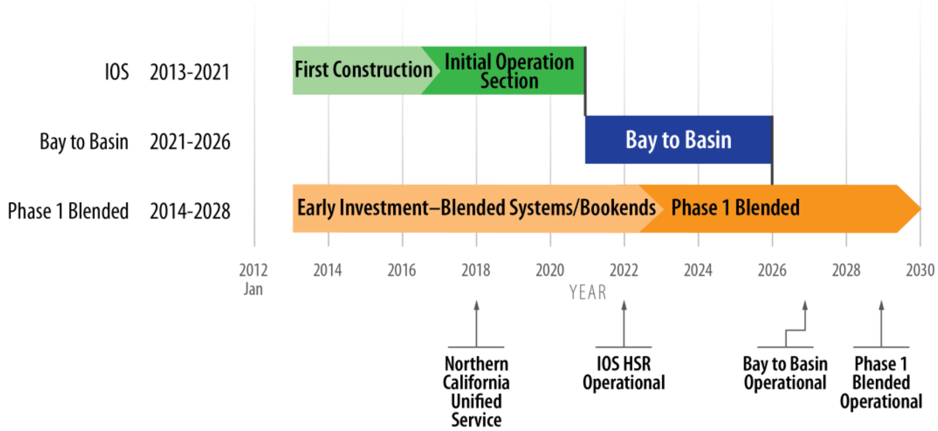


Exhibit 3-7 and Exhibit 3-8 show cost estimates in 2011 and year-of-expenditure dollars for the low-cost options and the high-cost options previously shown in Exhibit 3-3, Exhibit 3-4, and Exhibit 3-5.

Exhibit 3-7. Year-of-expenditure cost for the low-cost options

Section	Incremental Capital Cost (billions 2011$)	Cumulative Capital Cost (billions 2011$)	Completion of Section	Incremental Year-of-Expenditure Capital Cost	Cumulative Year-of-Expenditure Capital Cost
IOS	26.9	26.9	2021	31.3	31.3
Bay to Basin	14.4	41.3	2026	19.9	51.2
Phase 1 Blended	12.1	53.4	2028	17.2	68.4

Exhibit 3-8. Year-of-expenditure cost for the high-cost options

Section	Incremental Capital Cost (billions 2011$)	Cumulative Capital Cost (billions 2011$)	Completion of Section	Incremental Year-of-Expenditure Capital Cost	Cumulative Year-of-Expenditure Capital Cost
IOS	31.3	31.3	2021	36.6	36.6
Bay to Basin	17.7	49.0	2026	24.3	60.9
Phase 1 Blended	13.3	62.3	2028	18.8	79.7

For purposes of financial analysis, the low-cost options are illustrated in the primary tables and the impact of higher costs is shown in the alternative funding scenarios in Chapter 7, Financial Analysis and Funding.

From Union Station, passengers can connect to existing service to reach destinations south and east of Los Angeles.

If a decision is made in the future to construct the Phase 1 Full Build system, this would involve constructing fully dedicated high-speed rail infrastructure between San Jose and San Francisco and between Los Angeles and Anaheim. The projected schedule for completing the Full Build system is 2033, and the total cost is $67.4 billion in 2011 dollars, which would be $91.4 billion in year-of-expenditure dollars. An alternative approach to construction of a Full Build Option on the San Francisco Peninsula was developed and reported in the Draft 2012 Business Plan. It is not under consideration.

Comparing the cost to other high-speed rail systems

To assess the reasonableness of the program's cost estimates, the Authority studied the most recent cost estimates against those of other operational HSR projects. These include worldwide costs evaluated by the World Bank and proposed improvements to the Northeast Corridor proposed by Amtrak. Of note, a cost comparison of different HSR projects only can provide an order of magnitude indication of the current estimate's reasonableness for the CHSRP as every project has its own unique physical, environmental, and policy issues. This is particularly the case with European and Asian HSR programs, built in different political and environmental settings.

International HSR programs

A useful comparison is with a July 2010 report from the World Bank: *High-Speed Rail: The Fast Track to Economic Development?* This report provides lessons for countries considering implementing new high-speed passenger rail service. With respect to construction costs, the report found the following:

> *Experience internationally is that construction and rolling stock capital costs [excluding the purchase or lease of real estate and professional services] . . . typically range from USD [$56–$112 million/mile], depending on the complexity of civil engineering works, the degree of urbanization along the route and required total rolling stock capacity.*[3]

The international cost range can be compared to the costs of the CHSRP implementation steps as described in this Revised Plan. For comparison purposes, the real estate and professional fees have been subtracted from the CHSRP costs, but the costs are shown in 2011 dollars. The construction cost for the IOS will be $75 million to $88 million per mile. For the Bay-to-Basin section, the construction cost will range from $86 million to $102 million per mile. For the Phase 1 Blended system, the construction cost will be $86 million to $100 million per mile. These costs fall within the international HSR cost range.[4]

Amtrak Next Generation (Washington–NYC–Boston)

In September 2010, Amtrak announced its ambitious Next Generation HSR Program for the 460-mile Northeast Corridor (Exhibit 3-9).The program will reduce trip times to less than three hours and 30 minutes for a Washington-to-Boston express train and increase capacity to permit departures every three to five minutes. The FRA has initiated a programmatic environmental impact statement for improvements to the Northeast Corridor. Amtrak recently received funding to begin implementing elements of the upgrade program in New Jersey.

Exhibit 3-9. Amtrak Next Generation

The projected cost for the improvements, prior to any engineering, is $117 billion (including real estate and professional fees) in 2010 dollars. This equates to $254 million per mile. Amtrak's "stair-step" incremental implementation approach assumes that it will take 40 years to construct the full system.[5]

In contrast, the current capital cost estimate for Phase 1 Blended of the CHSRP ($53.4 in 2011$) equates to about $103 million per mile (including real estate and professional fees). The capital cost for the Bay-to-Basin section ($41.3 to $49.0 billion) equates to $100 to $119 million per mile (including real estate and professional fees).

The higher cost per mile of the Next Generation Program reflects the fact that so much of the Northeast Corridor lies in more densely populated urban areas requiring costly tunnels, elevated structures, and expensive property acquisitions. When compared to the cost of California's system, it is comparable to the per-mile costs of the segments that travel through California's dense urban areas.

Comparing the cost to other California transportation investments

California will continue to grow and will continue to need to invest in new infrastructure. With the addition of the equivalent of the population of the State of New York, the level of investment will be in the tens and hundreds of billions if California is to maintain its economic competitiveness and the quality of life that people of the state enjoy.

Several recent reports have identified transportation needs for the state that indicate the level of investment needed in California in the coming decades:

- In October 2011, the California Transportation Commission issued its 2011 *Statewide Needs Assessment Report* that identified $183 billion in capital expansion needs in the state by 2020 (without including high-speed rail). This report can be accessed at www.catc.ca.gov/reports/2012%20Reports/Trans_Needs_Assessment_corrected_01172012.pdf

- The independent, non-partisan *Think Long Committee for California*—which includes such distinguished members as George P. Schultz, Condoleezza Rice, former chair of the Council of Economic Advisors Laura Tyson, and Google Chief Executive Officer (CEO) Eric Schmidt—has cited the state's transportation investment needs at $550 billion over the next *decade*. This report can be accessed at http://berggruen.org/files/thinklong/2011/blueprint_appendix_3_jobs_infrstructure.pdf
- The American Society of Civil Engineers estimated that California needs to invest $365 billion in infrastructure *above* existing funding levels over the next 10 years. This report can be found at www.ascecareportcard.org/.

These numbers provide context for the tremendous needs and investments required to ensure that California's transportation system can accommodate future growth and keep its economy growing.

In preparing this Revised Plan, the Authority did not conduct its own needs assessment for transportation investments. However, a comparison of costs of equivalent capacity provided through different modes of transportation has been prepared. It does not suggest or imply that the equivalent capacity in highways or aviation would be needed and built in the same timeframe; it is a comparison of the costs of doing so. The basis for using a capacity-based comparison lies in the origins of the high-speed rail program. It is different than other infrastructure programs in that the Legislature specifically established the need for the investment and defined it in statute, which was then approved by the voters as Proposition 1A:

> *Cal.S. & H. code § 2704.04. Legislative intent regarding construction of a high-speed train system; use of proceeds of bonds*
>
> *(a) It is the intent of the Legislature by enacting this chapter and of the people of California by approving the bond measure pursuant to this chapter to initiate the construction of a high-speed train system that connects the San Francisco Transbay Terminal to Los Angeles Union Station and Anaheim, and links the state's major population centers, including Sacramento, the San Francisco Bay Area, the Central Valley, Los Angeles, the Inland Empire, Orange County, and San Diego consistent with the authority's certified environmental impact reports of November 2005 and July 9, 2008.*

Construction of the HSR system will provide the state with a given level of capacity for moving people. The actual levels of ridership will vary, much in the way that the capacity of a lane of highway is defined, but the actual usage varies over time. With the need for and the parameters of the system having been established by the Legislature and affirmed by voters, the analysis in this Revised Plan is intended to provide decision-makers with additional context for considering the capital costs of the high speed program, along with an understanding of the cost of providing that same capacity through other modes, and the scale of environmental and social challenges that would be faced in attempting to do so.

For validation, the Authority requested that the California Department of Transportation (Caltrans) calculate the costs of equivalent highway capacity based on guidance from the Authority on the level and location of added capacity. Determination of the appropriate methodology, including assumptions of vehicle occupancy, lane capacity, number of lanes added, and per-mile costs of new lanes, was made by Caltrans. Among other changes, the Caltrans methodology assumes lower vehicle occupancy rates, lower lane volumes, lower cost-per-mile prices based on recent projects, and that lanes would be added in pairs, not individually, as was assumed in the Draft Plan, resulting in an increase in lane miles required. As noted previously, this is not a needs analysis, so Caltrans' estimates do not infer plans to add this specific level of capacity.

The analysis shows that providing equivalent new highway capacity (using the Caltrans methodology) and aviation capacity as that provided by the San Francisco-to-Los Angeles/Anaheim HSR system would cost approximately twice as much as the HSR investment. Building equivalent capacity to Phase 1 Blended through road and airport expansions would cost an estimated $124 billion ($2011) which is equivalent to $158 billion in YOE dollars. Providing the same capacity as the HSR system would require the following: 4,300 new lane-miles of highway, 115 additional gates at California airports , and 4 new airport runways.[6]

In addition, Caltrans estimates that the cost of operating and maintaining the additional highway infrastructure would be $132.8 billion over the next 50 years. Such funding would have to be included in the state budget. Operations and maintenance for high-speed rail will be paid by the operator and funded through system revenues.

Although investment in a balanced, multi-modal transportation clearly is a more cost-effective means of addressing congestion and mobility, this analysis does not calculate or imply a direct correlation between investment in one mode of transportation and avoidance of investment in another. However, such analyses have been made in other cases. For example, Metrolink service in the Los Angeles region has been found to remove the equivalent of one lane of traffic off of Interstate 5 and other highways.[7] Based on Caltrans' estimate of $30 to $50 million per lane-mile for the construction of urban interstate highways, adding a lane for each direction of the full 45-mile length of I-5 in Orange County would cost from $2.7 to $4.5 billion.

End notes

[1] Source: *Professional Practice Guide to Construction Cost Estimating, Third Edition.* Association for the Advancement of Cost Engineering.

[2] *Design Build Effectiveness Study, As Required by TEA-21 Section 1307(f).* Final report prepared for USDOT–Federal Highway Administration. January 2006. (www.fhwa.dot.gov/reports/designbuild/designbuild5.htm)

[3] *Source:* Amos, P., D. Bullock, J. Sondhi. July 2010. *High-Speed Rail: The Fast Track to Economic Development?* The World Bank. www.worldbank.org/research/2010/07/12582340/high-speed-rail-fast-track-economic-development

[4] *Source: Engineering News Record* (ENR). December 27, 2010. "The 2010 4th Quarterly Cost Report." http://enr.construction.com/magazine/2010/1227.asp

[5] *Source:* Amtrak. September 2010. "A Vision for High-Speed Rail in the Northeast Corridor." www.Amtrak.com

[6] *Source:* Parsons Brinckerhoff. October 2011. *Technical Memorandum: Cost of Alternative Modes to High-Speed Rail,* October 2011.

[7] *Cost/Benefit Assessment of Metro's Funding for Metrolink*, prepared for Los Angeles County Metropolitan Transportation Authority (Metro), Final Report, October 4, 2007.