CALIFORNIA HIGH-SPEED RAIL EARLY TRAIN OPERATOR

Side-by-Side Study
Quantitative Report, February 8, 2020

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Acronyms and Abbreviations

Term	Definition
ACE	Altamont Corridor Express (San Jose to Stockton rail service)
Amtrak	National Passenger Railroad Corporation
Authority	California High-Speed Rail Authority (CAHSRA)
BN or BNSF	BNSF Railway Company (also known as Burlington Northern and Santa Fe Railway)
Board	California High-Speed Rail Authority Board
CHSRA	California High-Speed Rail Authority
CMF	Metrolink's Central Maintenance Facility
CO_2	Carbon dioxide measured in metric tons to gauge greenhouse gas benefits
CP	Control point (Signal and/or track connection in network)
CTC	Centralized Traffic Control (CTC) signal system
CVS	Central Valley Segment (Merced to Bakersfield), previously referred to as Central Valley Corridor (CVC)
CVC	Central Valley Corridor (Merced to Bakersfield), currently referred to as Central Valley Segment (CVS)
ETO	Early Train Operator
GHG	Greenhouse Gases, shown as metric tons of carbon dioxide (CO2)
HSR	High-Speed Rail
LAUS	Los Angeles Union Station
LA Metro	Los Angeles County Metropolitan Transportation Authority
LCFS	Low Carbon Fuel Standard
LinkUS	Link Union Station (Metro), a project to convert Los Angeles Union Station from a stub-end terminal into a run-through station
LOSSAN	Los Angeles–San Diego-San Luis Obispo Rail Corridor Agency (LOSSAN)
MAS	Maximum authorized speed
Metrolink	Southern California Regional Railroad Authority
MPH	Miles per hour
PenC	Peninsula Corridor (San Francisco to Gilroy)

PMT	Passenger miles traveled
PTC	Positive Train Control (PTC)
SCORE	Southern California Optimized Rail Expansion (SCORE) program
SJJPA	San Joaquin Joint Powers Authority, responsible for administration and management of the San Joaquin Rail Service
SJRRC	San Joaquin Regional Rail Commission, owns and operates and is the policy-making body for the Altamont Corridor Express (ACE®) service
TIRCP	Transit and Intercity Rail Capital Program (Competitive capital grants awarded by the California State Transportation Agency for projects that demonstrate reductions in future greenhouse gas emissions)
TOC	Train operating company
UP or UPRR	Union Pacific Railroad
USD	United States dollars
YOE$ or YOE USD	Year of Expenditure US dollars
ZEV	Zero-emissions vehicle (ZEV) technology

Executive Summary

Previous ETO studies:

The Authority tasked the Early Train Operator (ETO) in 2018 with studying the potential ridership, revenue and operation of an interim service on two different standalone lines, one between Merced and Bakersfield in the Central Valley and the other between San Francisco's 4th Street/King Street Station and Gilroy on the Peninsula.

Central Valley Corridor Study

The study found that Introduction of an early operations HSR service in the Central Valley between Merced and Bakersfield will produce significant value and benefits to communities, public transportation passengers and operators as well as to the State of California.

When connected to the existing state passenger rail network this spine would connect seamlessly at the Merced Station to existing passenger services north to Sacramento via the San Joaquin and Altamont Corridor Express (ACE) rail services and west via ACE and south at Bakersfield Station to Thruway Bus connections into the Los Angeles Basin.

The study showed that high-speed rail service would significantly reduce travel times through the Central Valley, allow for much more frequent service, and generate significantly higher ridership and reduced GHG emissions; while potentially reducing the required level of subsidy for the combined corridor of HSR, ACE and San Joaquin services.

Peninsula Corridor Study

The conclusion for the Peninsula corridor study indicated that early HSR operation in the Peninsula shared corridor as a standalone service does not provide enough ridership benefits and revenue to justify early standalone operation because most of the benefits will be already captured with Caltrain's electrification project and ongoing improvements in the corridor.

Based on the conclusions, CHSRA made a policy recommendation to use USD 4.8 billion in remaining available funding, beyond the USD 15.6 billion associated with meeting the federal and regional commitments, to complete the 171-mile line connecting Merced, Fresno and Bakersfield.

Additional studies requested:

Subsequently, the Board of Directors and the Authority requested that additional studies be performed to help inform its decision-making on adopting an expanded program baseline budget and schedule based on available funds. These studies included:

- **KPMG Business Case Study**: The Board requested that the Authority's financial advisor, KPMG, to develop a Business Case Study for the proposed Merced to Bakersfield interim high-speed rail service. The study evaluated a range of issues including funding and affordability, ridership and revenue forecasts, business model, commercial considerations and socio-economic and other benefits.

- **ETO Side-by-Side Study (This Document)**: The Board requested the ETO to prepare an analysis comparing the impact of the Merced-Bakersfield investment policy recommendation to other comparable early investment options in the San Francisco to Gilroy and the Burbank to Anaheim corridors. This Study evaluated a range of costs and benefits including capital and operating costs, ridership, revenue, GHG reductions and congestion relief. The study was performed in two stages that include a preliminary Qualitative Phase (published October 31, 2019). and a second Quantitative Phase (This report) including the numeric outputs from the different models used.

- **ETO Expanded Central Valley Study**: The Authority also requested the ETO to prepare an expanded Central Valley study in consultation with CalSTA, San Joaquin and ACE Regional services including a more detailed operations plan, an integrated timetable, optimized bus connections as committed in the May 2019 Project Update Report and adjustments to the Business Model to reflect the recommendations of KPMG's Business Case. This study is available on the CHSRA website including updated ridership and revenue forecasts, updated operations and maintenance costs and infrastructure

requirements identified for connecting the ACE and San Joaquin services with the HSR corridor in Merced.

Conclusion from the additional studies:

Together these three studies include the findings that support and reaffirm the Policy Recommendation from the Authority to invest an additional USD4.8 billion in the Merced - Bakersfield line.

Summary of Findings from the Side-by-Side Study

The ETO's Side-by-Side Study concluded that the Merced - Bakersfield line (CVS Scenario 4) yields the greatest benefits compared to the other two corridors related to the following criteria:

(1) Ridership Performance: Measured by the highest increase in Annual Passenger Miles Traveled (PMT);
(2) Congestion Relief: Measured by the greatest reduction in Vehicle Miles Traveled (VMT);
(3) Green House Gas Reduction: Measured by the greatest reduction in metric tons of CO_2;
(4) Operational Expenses: Measured in terms of the highest reduction of required subsidies for operation and maintenance; and
(5) Capital Investment: Measured in terms of the lowest additional investment required.

Summary of Report

Focus of the Side-by-Side Study:

Activities were undertaken to answer two fundamental questions:

- Question 1: How do **benefits of early HSR service** compare in the three corridors (Impact of running HSR trains service in the 3 standalone corridors)
- Question 2: How do **benefits of early HSR investment** compare in the three corridors (Impact of Investing USD 4.8 billon in HSR-eligible infrastructure components to improve regional service without HSR trains service)

Definition of Corridors:

ETO Side-By-Side Study covered three different **standalone** segments of the future California High-Speed Rail System:

- San Francisco/Bay Area (NorCal): Fourth & King Street Station – Gilroy
- Central Valley Segment (CVS): Merced – Bakersfield
- Los Angeles/Anaheim (SoCal): Burbank Airport – Anaheim

It is important to note that the results shown in this study reflect a completely different situation of three standalone corridors compared to the integrated future Silicon Valley to Central Valley Line and Phase 1 when all corridors will be interconnected.

Table ES-1 below shows the comparison of the corridor characteristics, each corridor reflects a specific unique situation of how it will contribute to the future Phase 1 system of the HSR system. The NorCal and SoCal corridors facilitate access to the future termini in urbanized areas whereas the Central Valley provides high-speed connectivity between the three regions.

Due to these unique situations and the different operational characteristics of the corridors, the estimated benefits of early HSR investment differ between the corridors.

Corridor.	Termini	Corridor. Length in Miles (Conn. Services)	Primary Ridership Market	Max. Speed after Invest.	Investment Main Focus	Corridor Situation	Service
NorCal	San Francisco - Gilroy	77 (---)	Regional/ Commuter Rail	up to 110 mph	Capacity Increase	Urban Terminus Area	Shared with Regional Service
CVS	Merced - Bakersfield	171 (~400)	Intercity Long-Distance and Regional/ Commuter Rail	up to 220 mph	Capacity Increase and Travel time improvement	Key Link of HSR System	Dedicated Full HSR Corridor
SoCal	Burbank - Anaheim	44 (~350)	Regional/ Commuter Rail	up to 125 mph	Capacity Increase	Urban Terminus Area	Shared with Regional Service

Table ES-1: Summary of Corridor Characteristics

Scenario Definition and Constraints:

ETO defined four investment scenarios:

- Scenario 1: Today's operation for purpose of data analysis and as a reference point;
- Scenario 2: Committed future regional projects using approved regional funds and HSR committed bookend investments as a baseline for comparison;
- Scenario 3: Assumed additional regional funds paired with early HSR eligible infrastructure investments. This scenario provides an answer to Question 2 (see above - Focus of the Side-by-Side Study) that compares the benefits of early HSR investment in the three corridors. The Scenario 3 impacts measure the Impact of Investing USD 4.8 billion in **HSR-eligible** infrastructure components to improve regional service but without

HSR trains service.

Scenario 3 is not applicable for the Central Valley for two reasons: (1) Any further investment (USD 4.8B) in the corridor will allow the corridor for full high-speed service and (2) the section from Merced to Bakersfield is a dedicated HSR line not shared with the regional services (no concurrent Regional and HSR investments in Merced-Bakersfield same section); and

- Scenario 4: Complete HSR investment to provide full HSR standalone service in each corridor. This scenario provides an answer to Question One above evaluating benefits of early HSR service in the three corridors. The Scenario benefits measure the impact of running HSR service in the three standalone corridors.

Constraints used to define the Scenarios:

Each corridor provides an infinite number of possible infrastructure projects where HSR-eligible funding could be invested depending on the assumed available funds with a large range of benefits form this investment. This challenge combined with the fact that three independent corridors with different characteristics had to be evaluated, ETO limited the study to a reasonable number of alternatives that provide a fair comparison between the three regions and considered the following constraints:

- The HSR-eligible investment that could be diverted is in the order of magnitude of USD 4.8 billion and meaningful investment alternatives of HSR-eligible investment were defined to be used as a threshold to evaluate related benefits;
- HSR-eligible investments require that HSR funds can only be invested in HSR infrastructure within the scope of Phase 1 of HSR program (Aligned with Proposition 1A);
- Additional regional investments are needed to increase regional service and information was used from existing plans and information published and available in the three corridors. This information includes ACE, San Joaquin and Caltrain operations as well as the Metrolink Proposal provided to CHSRA that outlines an early improved service in the Burbank - Anaheim corridor using Zero-Emissions Vehicle (ZEV) technology.

Other information sources:

ETO also used other publicly available financial and ridership information to inform the analyses and to validate the approaches and estimates. ETO was not able to verify the correctness of such information and relied on the information as is and as presented in the various source documents. Ridership and revenue estimates were made using the State Rail Plan model and ETO used existing information and data provided by stakeholders to estimate operating cost for each scenario. Where data was not available for each scenario, ETO prorated operating cost based on assumed train miles and existing public base year information.

Disclaimer:

The scenarios and related costs shown in this report are based on ETO estimates and assumptions solely for the purpose of this study. They do not represent a commitment or a request by regional rail operators or other entities to procure, finance or fund these services.

Corridor Characteristics:

Table ES-1 below shows a comparison of the scenarios and the type of investment that is funded and committed (Scenario 2) and the additional needed regional and HSR-eligible investment to achieve a meaningful infrastructure project into the corridor. Based on these investment scenarios, ETO established service plan scenarios that would be enabled by the investment and modeled the benefits generated by these service plans.

Scenario	Desc.	Model Year	Likely Impl. by	Regional Fleet Invest.	Regional Infrastr. Invest.	HSR Fleet	HSR-Eligible Infrastr. Invest.
NorCal Scenario 1	Existing Service	2028	Existing	---	---	---	---
NorCal Scenario 2	Caltrain Electrification	2028	2022	Initial EMU fleet	Elect. Project (incl. HSR-bookend invest.)	---	Bookends investment provides Infrastructure access rights

Scenario	Desc.	Model Year	Likely Impl. by	Regional Fleet Invest.	Regional Infrastr. Invest.	HSR Fleet	HSR-Eligible Infrastr. Invest.
NorCal Scenario 3	HSR Infrastr. Gilroy - CP Lick	2028	2028	Additional Caltrain EMU fleet expansion for 8 trains per hour and direction	Diridon Station & surrounding rail Infrastr., City-led grade separations	---	HSR Infrastr. Gilroy - CP Lick + Infrastr. Improvements
NorCal Scenario 4	HSR Operation Gilroy - San Francisco	2028	2028	---	---	8 Train sets for standalone HSR operation (6 operation + 1 protect + 1 reserve)	Full HSR Infrastructure including platforms and light maintenance facility
CVS Scenario 2	No-Build, Valley Rail Project	2028	2023	Fleet addition for Valley Rail service	Valley Rail Infrastr.	---	(Under construction but not operational)
CVS Scenario 4	HSR Operation Merced - Bakersfield	2028	2028	---	Connecting loop Merced combined station (ACE, San Joaquin, HSR)	6 Train sets operation	Bakersfield and Merced HSR Extensions
SoCal Scenario 1	Existing Service	2028	Existing	---	---	---	---
SoCal Scenario 2	Partial SCORE Project + Zero-Emission Technology - Regional Investment + HSR Bookends	2028	2026	Metrolink Zero-Emission Vehicle fleet conversion + exp. + LOSSAN fleet exp.	Initial SCORE investment, ZEV maintenance facilities, Link US Phase A	---	---

Scenario	Desc.	Model Year	Likely Impl. by	Regional Fleet Invest.	Regional Infrastr. Invest.	HSR Fleet	HSR-Eligible Infrastr. Invest.
SoCal Scenario 3	HSR Infrastructure Burbank - Fullerton	2028	2033	Additional Metrolink fleet Burbank - Anaheim Corridor	Link US Phase B	---	HSR Infrastructure Burbank Downtown - Fullerton
SoCal Scenario 4	HSR Operation Burbank Airport - Anaheim	2028	2040	---	---	8 Train sets HSR operation	Full HSR Infrastructure with Burbank Airport and Anaheim Stations, HSR platforms, electrification and light maintenance facility (LMF)

Table ES-2: Comparison of Infrastructure and Fleet Investments by Scenario

Measuring the Impact of additional Investment (Change in Benefits)

Each corridor already has an established service with a base ridership, and the purpose of the Side-by-Side Study is to measure the impact of potential additional investments gauging the change against the existing situation.

For this purpose, ETO expressed the benefits as the difference between the Scenarios 3 and 4 (with HSR-eligible investment) versus Scenario 2 that reflects funded and committed regional investment prior to HSR-eligible investment.

Ridership Benefits

Ridership, farebox revenue and passenger miles traveled (PMT) benefits were evaluated using the State Rail Plan Model. The following Figure ES-1, Figure ES-2 and Figure ES-3 show the absolute number of ridership, passenger miles and farebox revenue.

It is important to evaluate the benefits as the increment of benefits between Scenarios, not the absolute value. This increment describes the actual impact of the proposed investment.

While the NorCal and SoCal corridors show the highest absolute numbers, note that the magnitude of the change is higher in all cases in the Central Valley Segment thus indicating that the impact of the investment is highest in this corridor.

The difference between Scenario 1 and Scenario 2 reflects the impact of the completion of the regional funded investment of ongoing improvements. The difference between Scenario 2 and 3 reflects the impact of HSR-eligible investments and additional regional investment to operate additional regional service on the improved infrastructure, but no HSR trains service.

The difference between Scenario 3 and 4 reflects the impact of the complete HSR investment with HSR trains service in addition to the improved regional service in Scenario 3.

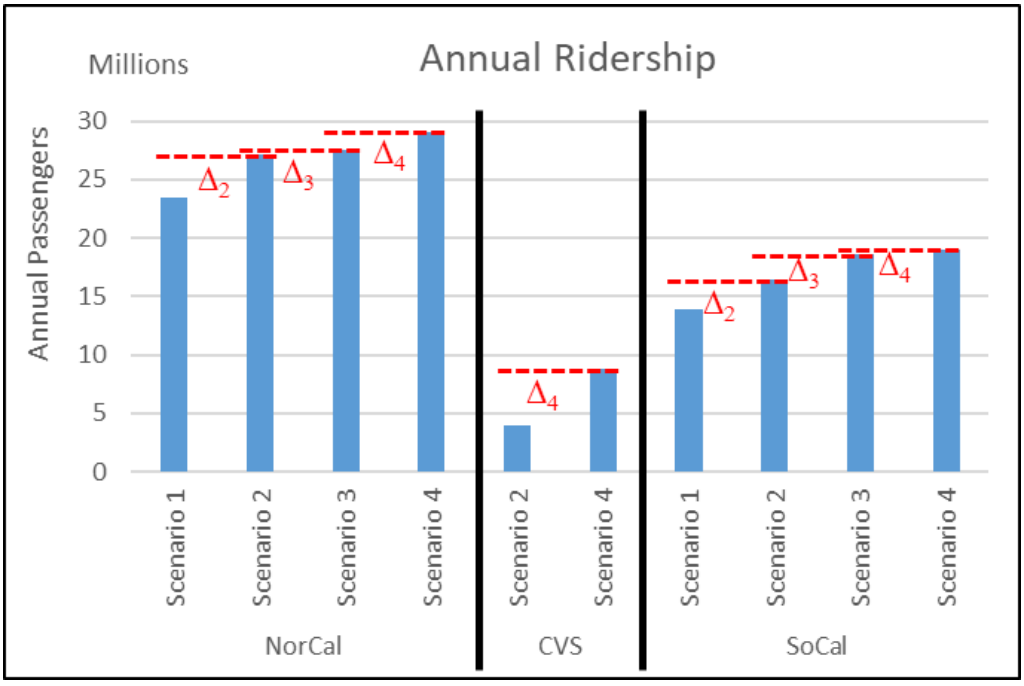


Figure ES-1: Total Annual Ridership Estimates by Scenario

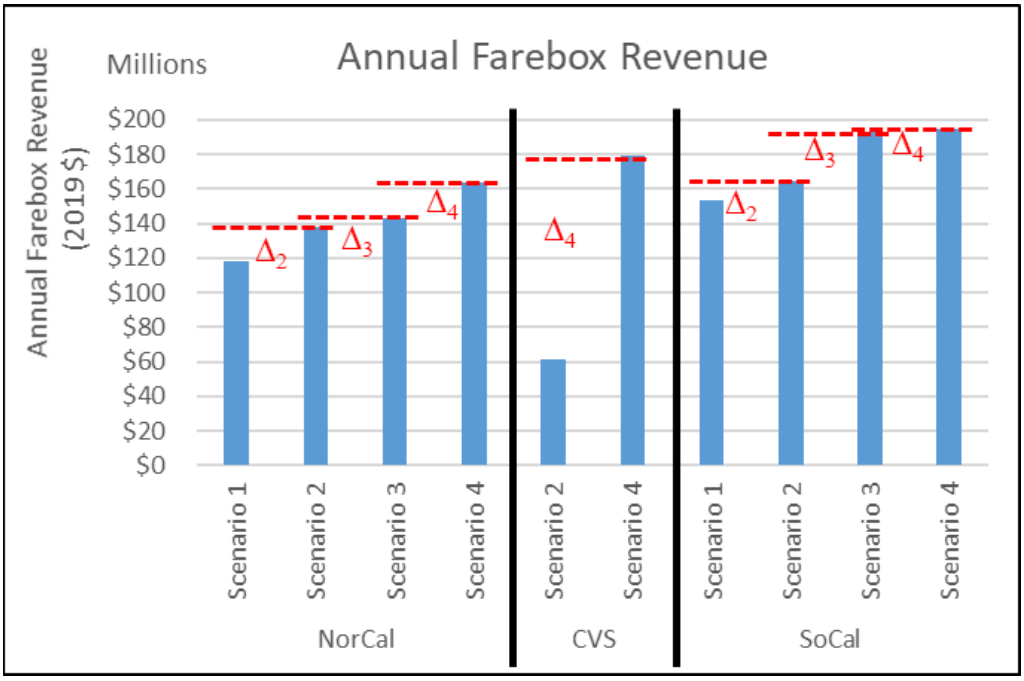


Figure ES-2: Total Annual Revenue Estimates by Scenario

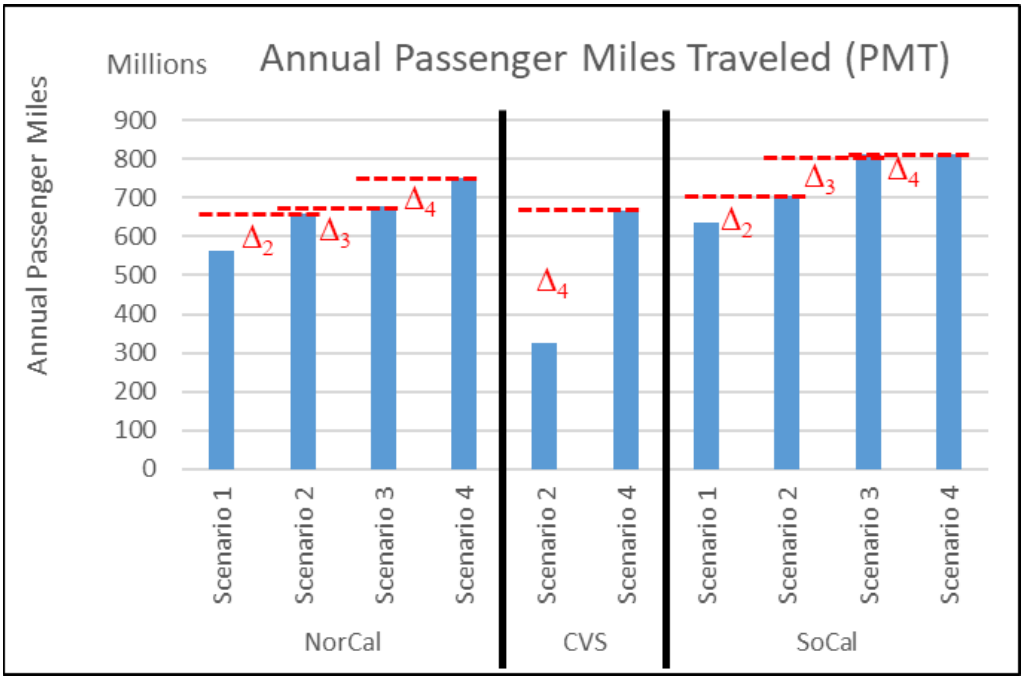


Figure ES-3: Total Passenger Miles Traveled (PMT) Estimates by Scenario

To facilitate an easy comparison of the three ridership parameters among the three corridors, the following Figure ES-4, Figure ES-5 and Figure ES-6 show the incremental ridership, revenue and passenger miles traveled compared to the completion of Scenario 2.

The CVS Scenario 4 provides the highest increase in both percentage and net increase of ridership and revenue benefits. This includes the amount of passenger miles traveled which is an industry typical indicator of transportation performance and combines the number of passengers and the distance traveled by these passengers.

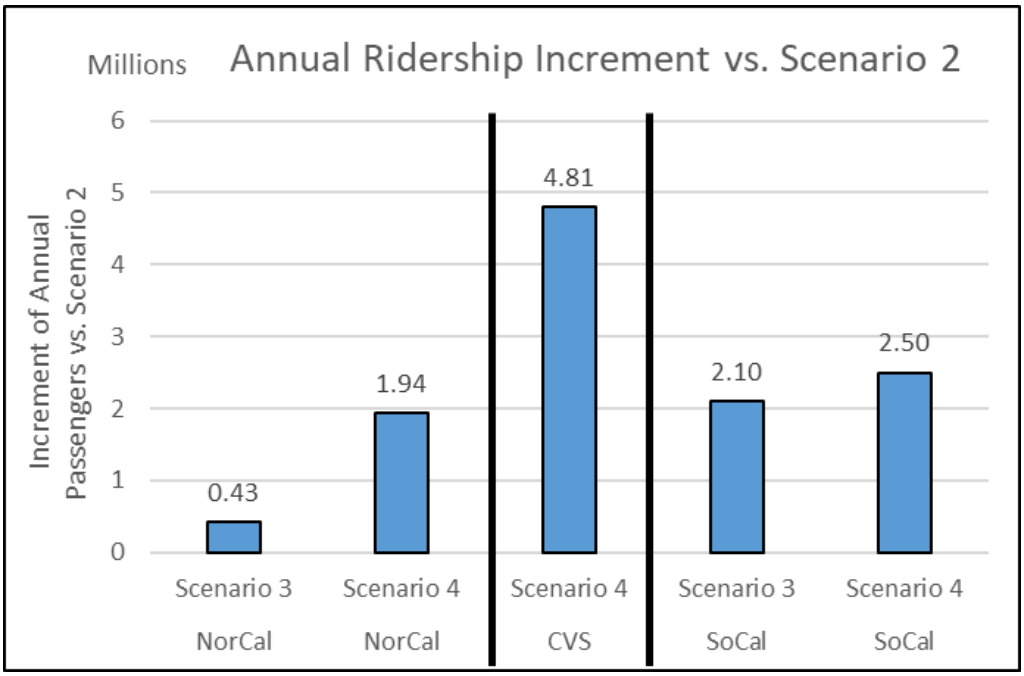


Figure ES-4: Change in Annual Ridership vs. Scenario 2

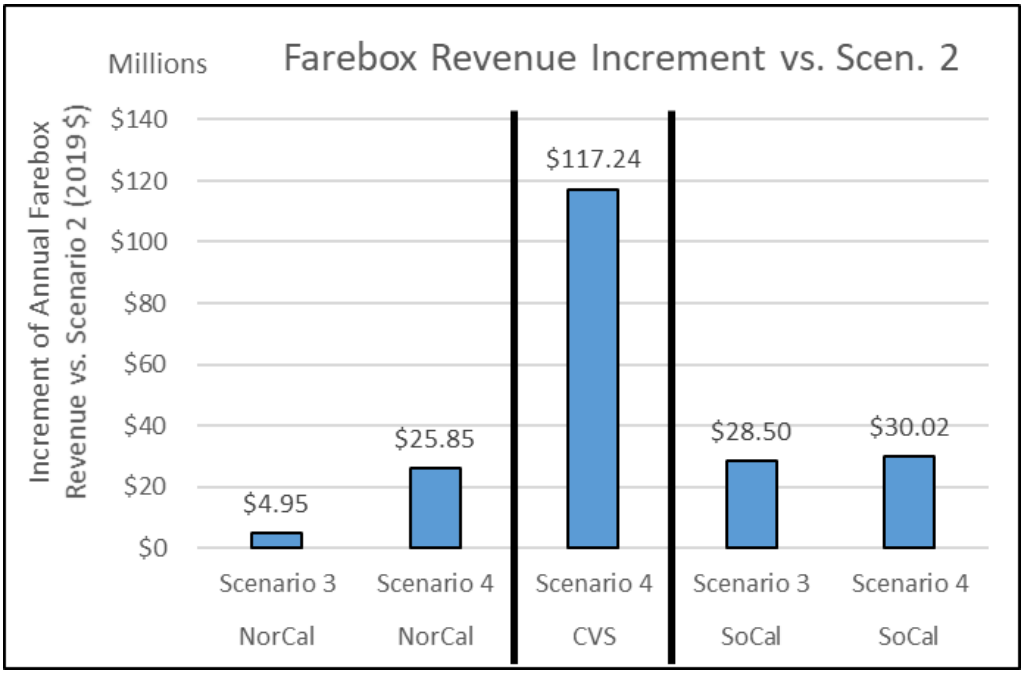


Figure ES-5: Change in Annual Revenue vs. Scenario 2

Congestion Relief Benefits

CVS generates the highest passenger miles (Figure ES-6) traveled in the system. Since VMT is linked to PMT, the resultant reduction in highway travel is highest in the Central Valley segment.

Congestion benefits are measured by reduction in vehicle miles traveled. The CVS Scenario 4 provides the highest reduction in VMT (Figure ES-7).

The data also shows that the CVS investment has the highest efficiency between the additional service offered and the additional demand generated with this offer.

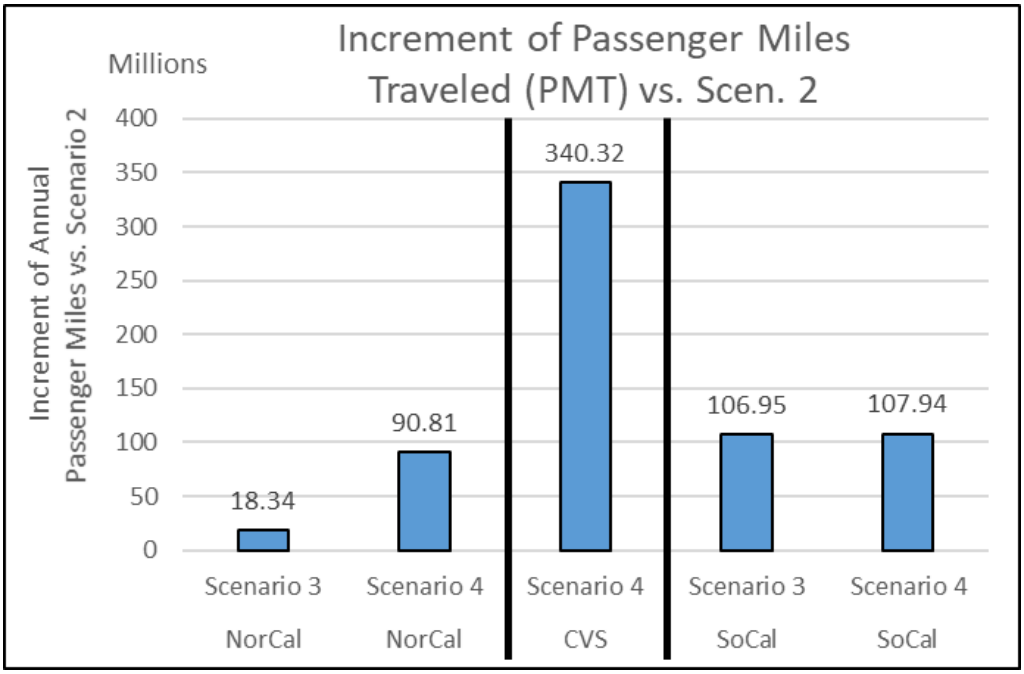


Figure ES-6: Change in Annual Passenger Miles Traveled (PMT) vs. Scenario 2

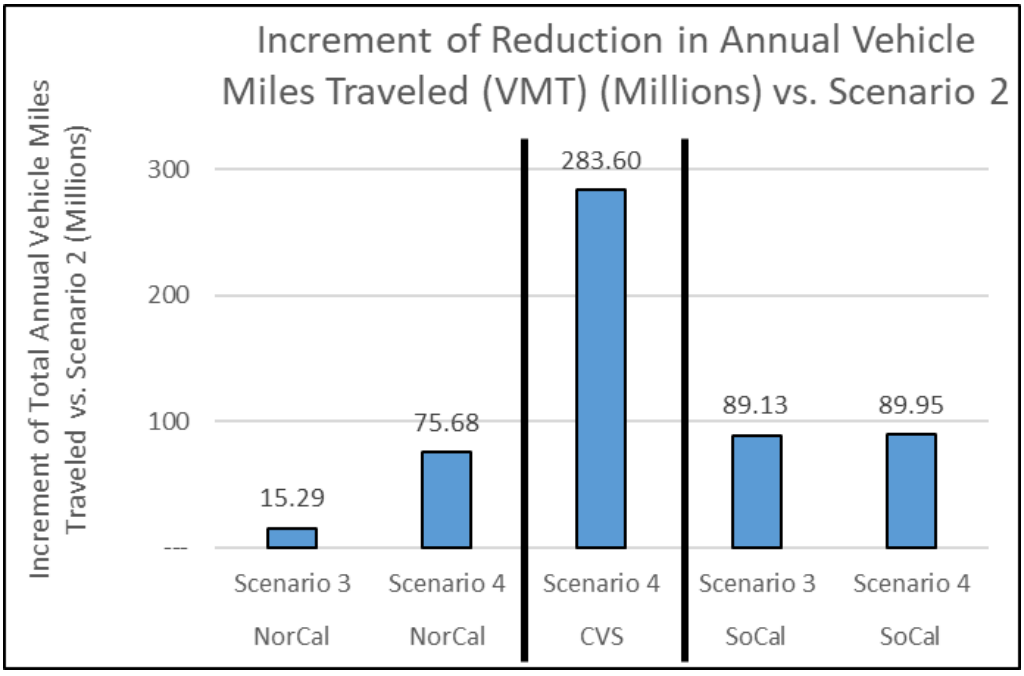
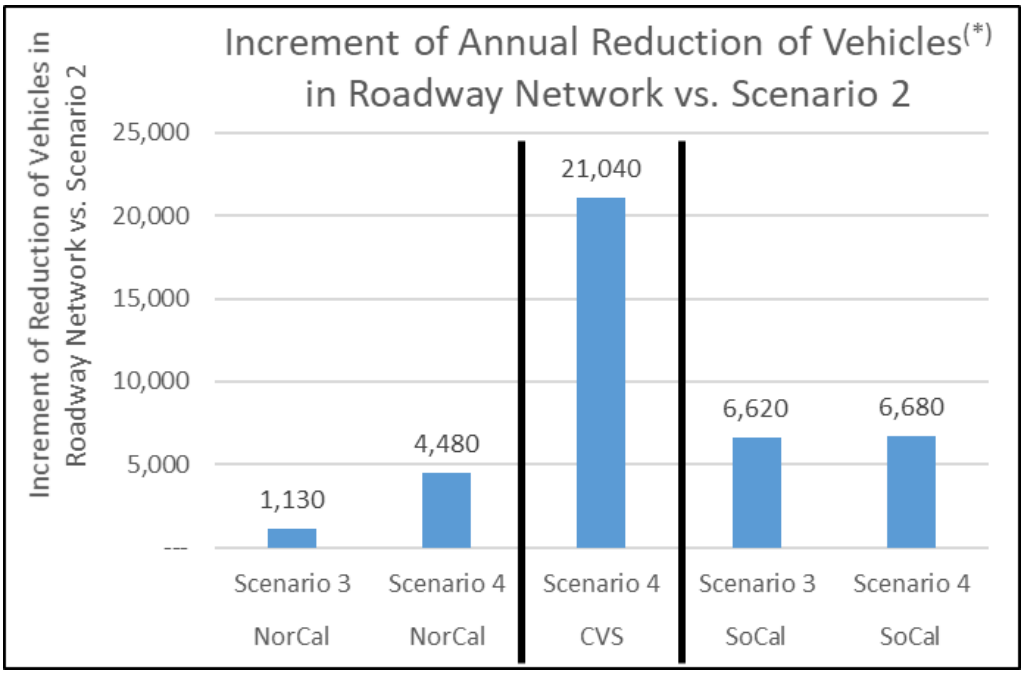


Figure ES-7: Change in Vehicle Miles Traveled (VMT) vs. Scenario 2

The annual reduction of vehicle miles can also be expressed as a reduction of vehicles using the roadway network by dividing the annual VMT reductions by the average mileage driven per car per year. The resultant equivalent reduction of vehicles is depicted in Figure ES-8 below. CVS Scenario 4 shows the highest reduction of 21,000 vehicles per year not using the roadway system due to the reduced VMT versus Scenario 2.



Note: (*) Assumes an average mileage per car of 13,476 miles per year.[1]

Figure ES-8: Change in Annual Congestion Benefits in Reduced Number of Vehicles using Roadway Network versus Scenario 2

Greenhouse Gas (GHG) Benefits

The GHG benefits for each scenario are evaluated based on the TIRCP ARB model that estimates changes in GHG benefits based on rail service mileage and reduction in vehicle miles traveled.

[1] FHWA, Average miles driven per year per driver: https://www.fhwa.dot.gov/ohim/onh00/bar8.htm

This method was applied to all three corridors and shows the highest amount of reduced Carbon Dioxide (CO2) emissions in the CVS Scenario 4 (Figure ES-9) due to the linkage to the VMT reductions and the highest ridership benefits.

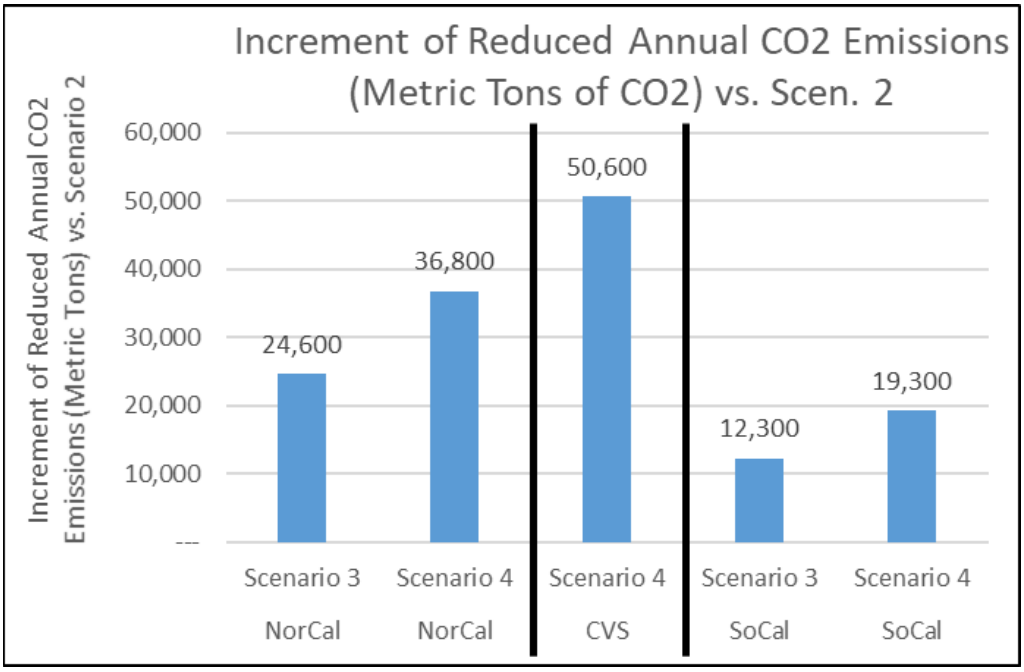


Figure ES-9: Change in Annual Greenhouse Gas (GHG) Benefits

Operations and Maintenance Cost and Subsidy Requirements

For each one of the scenarios ETO estimated annual operations and maintenance costs for the regional rail services as well as for the proposed standalone HSR service in each corridor. The regional rail service operations and maintenance costs are based on input from the Caltrain business plan, information from the regional rail operators in the Central Valley as well as public information for the Pacific Surfliner and Metrolink.

In Northern California the data was used to prorate cost based on the scenario definitions.

In CVS the data for regional rail was specifically provided to ETO in addition to the ETO's calculation of the annual operations and maintenance costs for the HSR section Merced – Bakersfield.

In Southern California the data for the existing service was prorated for the scenarios according to train mileage. This approach was chosen since there was no available comparable business plan data for the Metrolink system.

In all three corridors the HSR operating costs were developed using a bottom-up approach to estimate the infrastructure maintenance costs, the rolling stock operations and maintenance costs and the actual cost to operate HSR service. This process assumed that the assets owned by HSR would be leased to a subsidiary of the public entity operating currently in each corridor and that these entities would be performing the operation of a standalone HSR service.

Figure ES-10 below shows a comparison of the estimated annual farebox revenues, other annual revenue less low carbon fuel standard (LCFS) credits, the operating and maintenance costs as well as the resultant subsidy requirement for each scenario and corridor (all data in 2019 USD).

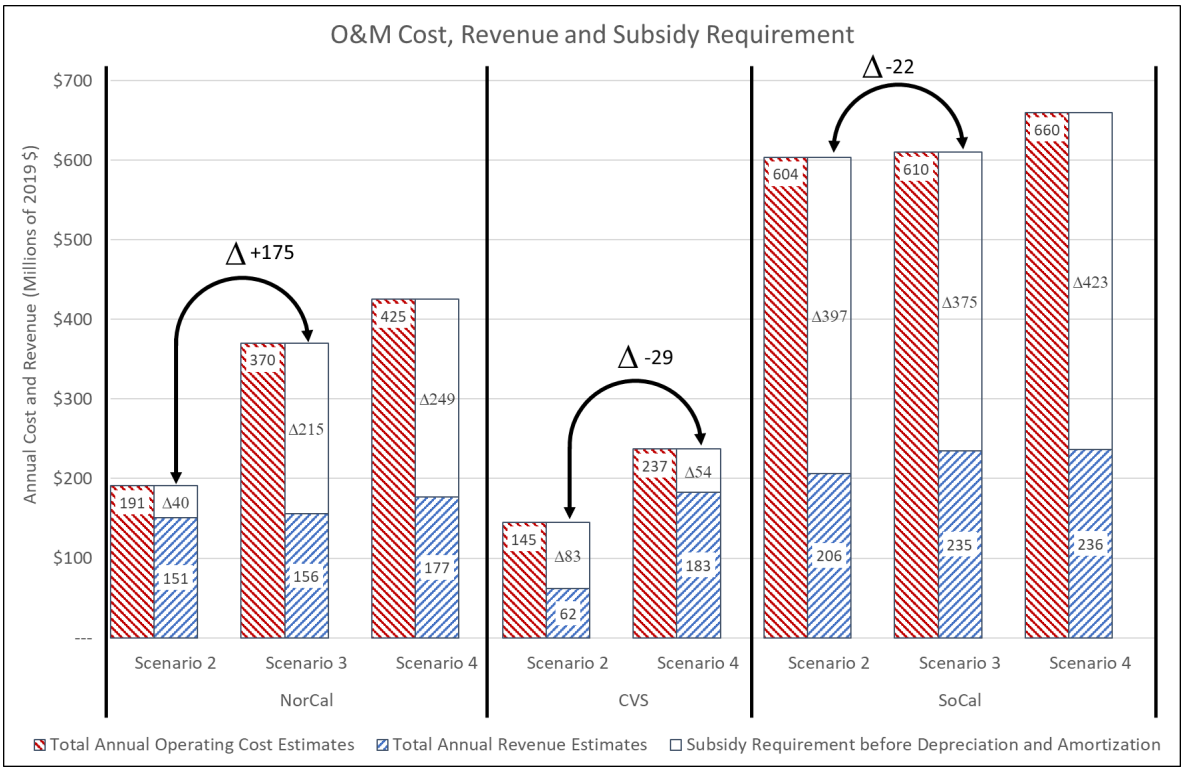


Figure ES-10: Change in Annual Operations and Maintenance Cost, Revenue and Potential Subsidy Requirements

Only the CVS Scenario 4 and CVS provides the highest reduction in annual subsidy requirement of 28.76 million dollars without the consideration of Low Carbon Fuel Standard (LCFS) credits that would account for an additional 12.7 million dollars in revenue.

the CVS Scenario 4 is the only alternative that provides significant benefits from the increase in service while reducing subsidy requirements.

Important Note:

The scenarios and related costs shown in this report are based on ETO estimates and assumptions are used solely for the purpose of this study, they do not represent a commitment or a request by regional rail operators or other entities to procure, finance or fund these services.

Capital Cost and Funding

ETO compiled available information from the Caltrain business plan, SJRRC and SJJPA, Metrolink and the Authority to summarize needed capital investment to achieve the proposed scenarios in each of the corridors. Figure ES-11 below shows a comparison of the needed investment versus Scenario 2, the amount of currently funded and committed investment as well as the increment in funding requirements that are not yet available to complete the investment. Scenario 2 in SoCal assumes a conversion of the system to zero emissions vehicle (ZEV) technology and requires 5.1 billion dollars to achieve this conversion. While Scenario 2 in NorCal and in CVS are currently fully funded, the proposed conversion to ZEV technology in SoCal is currently unfunded.

The summary for the HSR investment uses the lower boundary of investment totals from the range of cost estimates provided by the Authority in NorCal and SoCal. These estimates are lower than the originally provided estimates in the Qualitative Report since each set of numbers is based on a different construction scope. For purposes of this side-by-side comparison the lower range of cost estimates was used to reflect a more conservative cost estimate. These estimates for HSR-eligible investment needs could be subject to change as more refined plans are developed.

For CVS the investment totals for HSR service remain constant as shown in the project update report and include 15.6 billion dollars for the completion of the Madera to Poplar Avenue segment and an incremental 4.8 billion dollars to complete the extensions to Merced and Bakersfield and to purchase HSR rolling stock.

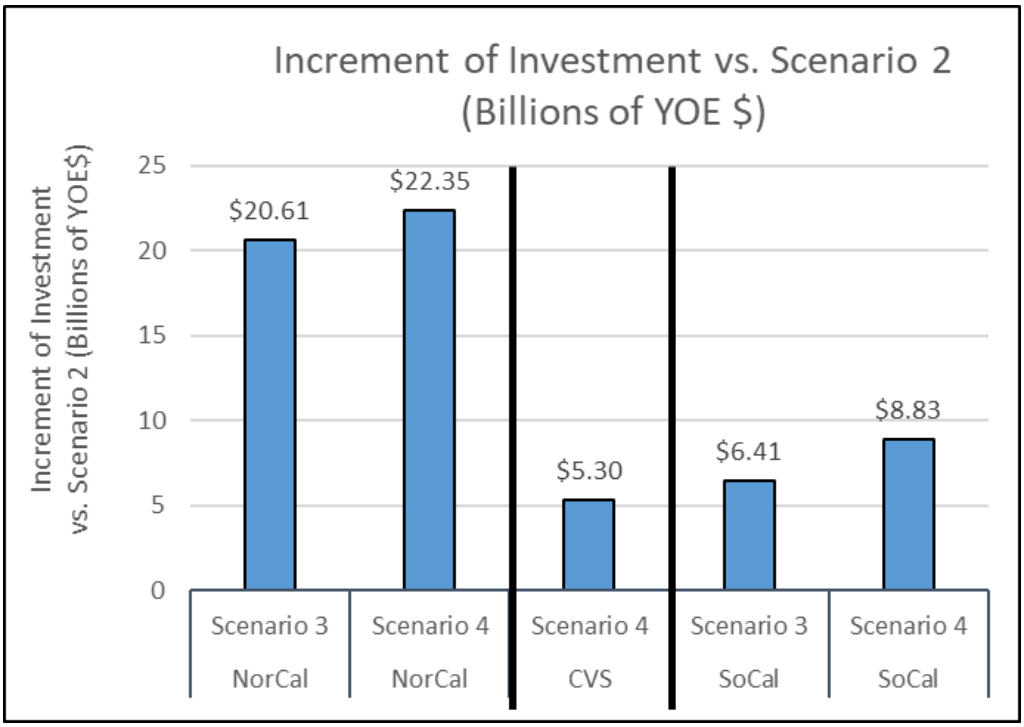


Figure ES-11: Investment and Funding Increment vs. Scenario 2 by Corridor (Billions of YOE USD)

The resultant total investment needs of regional and HSR-eligible investments are shown in Figure ES-12. CVS Scenario 4 requires the lowest system total investment of 5.3 billion dollars, which includes the additional regional investment of 0.5 billion dollars to achieve the highest benefits of early HSR investment and allows high-speed rail operation. In NorCal and SoCal significant regional and local funding is needed to in addition to the HSR investment. At this point it is unclear if such significant regional funding can be provided to achieve the benefits from early HSR investment.

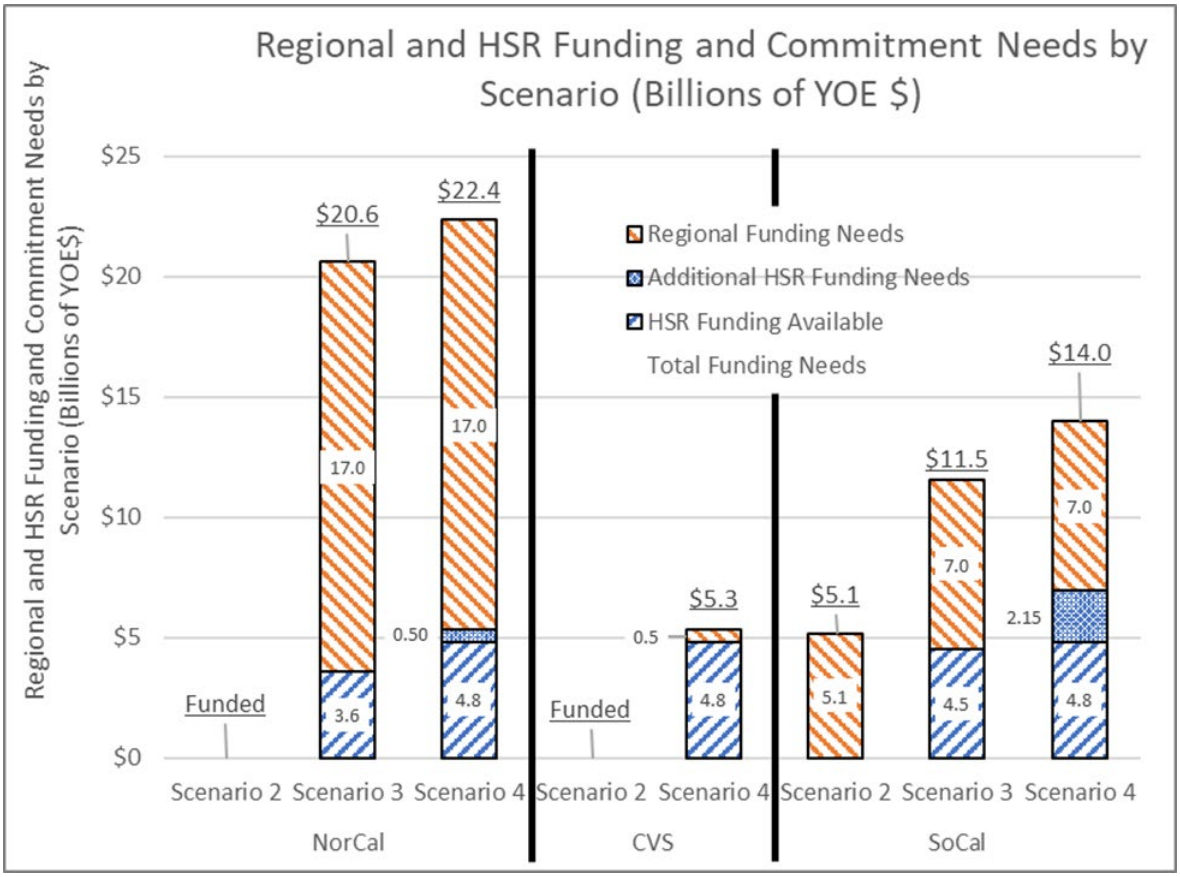


Figure ES-12: Funded Versus Unfunded Investment vs. Scenario 2 by Corridor (Billions of YOE USD)

Conclusions

The quantitative analysis of the scenarios in the three corridors and summary of benefits leads to the following conclusions:

- From the HSR-program perspective, only Scenario 4 in CVS enables high-speed rail operation and provides higher benefits as compared to the other corridors.
- From the operations and maintenance cost perspective, the Central Valley Segment offers the highest reduction in subsidy requirement. All other corridors will potentially require an increased subsidy to cover the additional cost for improved service.

- From the perspective of the investment needs (CapEx), benefits from early HSR investments can be realized only with considerable additional regional investment in NorCal and SoCal. CVS requires a moderate investment of up to 0.5 billion dollars of regional commitment to implement the proposed service plan.
- Considering the environmental impacts, CVS Scenario 4 offers the highest environmental benefits increase and provides the highest congestion reduction benefits due to significant VMT reductions.

Answers to Two Key Questions

Based on the analytical output, the study's two key questions can be answered as follows:

- **Question 1:**
  How do benefits of early HSR service compare in the three corridors?

  Only the CVS corridor offers significant benefits from true HSR operation. In the NorCal and SoCal corridors early HSR operation does not provide major ridership benefits of HSR service due to corridor limitations and the focus of the investment on needed capacity increases. Significant HSR benefits only materialize when both corridors are connected to the statewide HSR system.

- **Question 2:**
  How do benefits of early HSR investment compare in the three corridors?

  HSR eligible investment in the NorCal and SoCal corridors enables significant capacity improvements in each corridor to prepare for future HSR operation but also requires large regional investments to provide benefits from increased regional service.

  Increases in rail passenger demand depend on both the capacity and travel time improvements among other factors. The ridership benefits are only incremental in the NorCal and SoCal corridors as compared to the Central Valley due to the following inherent differences in the corridors:

i Investments in the NorCal and the SoCal corridors will improve capacity significantly but show only minor improvements for regional travelers in travel time (approximately 6-12 minutes); and

ii In the CVS corridor the investment not on only will more than double the capacity but reduce the travel time by more than 90 minutes.

The following chapters describe in detail the methodology, the assumptions for the analysis, the benefits and parameters as well as the conclusions drawn from the quantitative analysis.

1 Introduction and Background

1.1 Board Request

Prior to initiation of the Side-by-Side Study, ETO worked on the following two financial analysis studies to compare the benefits of early HSR investment that were published with the project update report in May 2019:

- The Central Valley Corridor Study
- The Peninsula Corridor Study

The studies concluded that HSR investment in the Central Valley will generate significant value and provide travel time savings and ridership benefits. The conclusion for the Peninsula corridor study indicated that early HSR operation in the Peninsula as a standalone service does not provide enough ridership benefits and revenue to justify early standalone operation.

In May 2019 the High-Speed Rail Authority Board (Board) ask the ETO to compare options for potential early service investments in three high-speed rail corridors. ETO was specifically tasked by the Authority to provide a Side-by-Side Study that covers early HSR investment in three different segments of the future California High-Speed Rail System:

- San Francisco/Bay Area (NorCal): 4th & King Street Station – Gilroy
- Central Valley Segment (CVS): Merced – Bakersfield
- Los Angeles/Anaheim (SoCal): Burbank Airport – Anaheim

This requested study needs to answer two fundamental questions:

- Question 1: How do benefits of early HSR service compare in the three corridors?
- Question 2: How do benefits of early HSR investment compare in the three corridors?

The study was performed in two stages that include an early preliminary Qualitative Phase and a second Quantitative Phase. This report builds on data and the report of the Qualitative Phase

(published October 31, 2019) and summarizes the Quantitative Phase of the work undertaken.

This effort also relies on information that is part of the already completed CVC and PenC studies from May 1, 2019 as well as the updated CVS study published February 8, 2020.

Furthermore, the analysis was also informed by Caltrain's Business Plan information as well as a Metrolink Proposal provided to ETO that outlines an early improved service in the Burbank - Anaheim corridor using Zero-Emissions Vehicle (ZEV) technology. ETO also used other publicly available financial and ridership information to inform the analyses and to validate the approaches and estimates. ETO was not able to verify the correctness of such information and relied on the information as is and as presented in the various source documents.

Based on the study scope, Figure 1-1 ETO has completed Stage 2 tasks for each corridor and scenario including ridership and revenue modeling using the State Rail Plan model, estimation of operations and maintenance cost (OpEx), estimation of investment needs (CapEx) and the available funding for each scenario. The analysis includes also the estimation of GHG benefits and congestion relief as well as other opportunities including completion dates, opportunities for private sector investment and local matching funds.

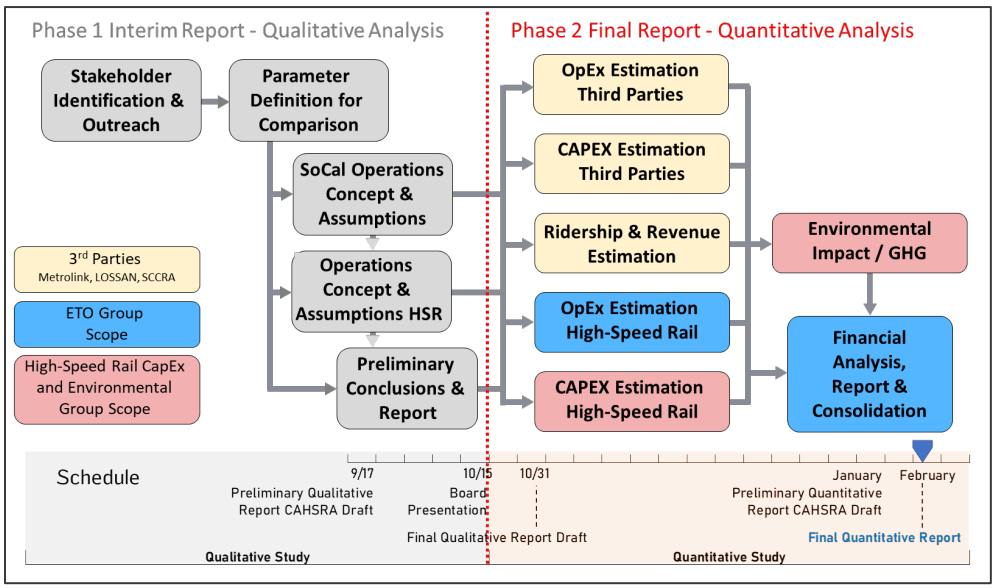


Figure 1-1: Side-by-Side Study Scope

This report as well as a separate presentation to the Authority's Board summarize the work performed as well as the summary of the analyses and conclusions.

1.1.1 Investment Scenarios in the Study Corridors

ETO defined four investment Scenarios in the Northern California (NorCal) and Southern California (SoCal) corridors:

- Scenario 1: Today's operation for purpose of data analysis and as a reference point;
- Scenario 2: Committed future regional projects using approved non-HSR funds and HSR bookend investments as a baseline for comparison;
- Scenario 3: Additional regional funds paired with early HSR infrastructure investments to provide an answer to Question 2 for the comparison of the benefits of early HSR investment in the three corridors; and
- Scenario 4: Complete HSR investment to provide full HSR standalone service in each corridor to provide an answer to question one for the comparison of benefits of early HSR service in the three corridors.

Each of the study corridors reflects varying and incremental investment by the region, the state, others and the High-Speed Rail Authority. ETO consulted with Stakeholders such as SJRRC, SJJPA, LOSSAN, Metrolink, LA Metro, Caltrain and CalSTA to consider additional information and further refine scenario assumptions prior to the quantitative phase of the study.

The following Table 1-1 shows the comparison of the corridor characteristics that are facilitated by the proposed HSR-eligible investment in the three corridors. Each corridor reflects a specific unique situation of how it will contribute to the future Phase 1 system of the HSR system. The NorCal and SoCal corridors facilitate access to the future termini in urbanized areas whereas the CVS segment provides a key link of the future system with high-speed access to the Central Valley. Due to these unique situations and the different operational characteristics of the corridors, the estimated benefits of early HSR investment differ between the corridors.

Corr.	Termini	Termini: Primary Connect. Services	End-to-End Corridor Length in Miles (Conn. Services)	Primary Ridership Market	Maximum Speed after Invest.	Invest. Focus	Corr. Situation	Service
NorCal	San Francisco – Gilroy	Local Transit Only	77 (---)	Regional and Commuter Rail Demand	up to 110 mph	Capacity Increase & Optimize Train Throughput	Leading into Urban Terminus Area	Mixed with Regional Service
CVS	Merced - Bakersfield	Buses to Los Angeles Basin, ACE, San Joaquins, Thruway Buses	171 (~400-420)	Intercity Long-Distance Passengers and Regional Rail Demand	up to 220 mph	Provide High-Speed Service	Key Link of HSR System	Dedicated HSR Corridor
SoCal	Burbank – Anaheim	Pacific Surfliner, Metrolink Lines	44 (~350)	Regional and Commuter Rail Demand	up to 110/125 mph	Capacity Increase & Optimize Train Throughput	Leading into Urban Terminus Area	Mixed with Regional Service

Table 1-1: Summary of Corridor Characteristics

Scenario 2 in each corridor reflects the committed and ongoing investment in each of the corridors. Scenario 3 builds on Scenario 2 and reflects HSR investment that prepares the Phase 1 system as well as regional investment to provide benefits from the HSR investment e.g. additional rolling stock to add service on the improved infrastructure. Scenario 4 builds on Scenario 3 and includes investment that enables standalone HSR operation in each corridor.

Table 1-2 below summarizes the needed investment differentiated by HSR-eligible investment and regional investment. HSR eligible investment is defined as infrastructure and rolling stock cost that can be funded with HSR funding and that represent an early investment to work to towards the Phase 1 HSR system.

Corridor	Scenario	Desc.	Model Year	Likely Imple-mented	Regional Fleet Invest.	Regional Infrastr. Invest.	HSR Fleet	HSR Eligible Infrastr. Invest.
NorCal	Scenario 1	Existing Service	2028	Existing	---	---	---	---
NorCal	Scenario 2	Caltrain Electrification - Regional Investment + HSR Bookends	2028	2022	Caltrain Electrification Project with initial EMU fleet	Caltrain Electrification Project (Incl. HSR bookend investment)	---	---
NorCal	Scenario 3	HSR Infrastructure Gilroy - CP Lick	2028	2028	Additional Caltrain EMU fleet expansion for 8 trains per hour and direction	Diridon Station and surrounding rail infras., City-led grade separations	---	HSR Infrastructure Gilroy - CP Lick + infrastructure improvements
NorCal	Scenario 4	HSR Operation Gilroy - San Francisco	2028	2028	---	---	8 Trainsets for standalone HSR operation (6 operation + 1 protect + 1 reserve)	Full HSR Infrastructure including platforms and light maintenance facility
CVS	Scenario 2	No-Build, Valley Rail Project	2029	2023	Fleet addition for Valley Rail service	Valley Rail infras.	---	HSR section Madera - Poplar Avenue (Under construction but not operational)

Corridor	Scenario	Desc.	Model Year	Likely Imple-mented	Regional Fleet Invest.	Regional Infrastr. Invest.	HSR Fleet	HSR Eligible Infrastr. Invest.
CVS	Scenario 4	HSR Operation Merced - Bakersfield	2029	2028	Fleet addition for connecting service	MITC Connector for San Joaquin service	6 Trainsets for standalone HSR operation (4 operation + 1 protect + 1 reserve)	Bakersfield and Merced HSR Extensions
SoCal	Scenario 1	Existing Service	2028	Existing	---	---	---	---
SoCal	Scenario 2	Partial SCORE Project + Zero-Emission Technology - Regional Investment + HSR Bookends	2028	2026	Metrolink Zero-Emission Vehicle fleet conversion + expansion + LOSSAN fleet expansion	Initial SCORE investment, ZEV maint. facilities, Link US Phase A	---	---
SoCal	Scenario 3	HSR Infrastructure Burbank - Fullerton	2028	2033	Additional Metrolink fleet Burbank - Anaheim Corridor	Link US Phase B	---	HSR Infrastructure Burbank Downtown - Fullerton
SoCal	Scenario 4	HSR Operation Burbank Airport - Anaheim	2028	2040	---	---	8 Trainsets for standalone HSR operation (6 operation + 1 protect + 1 reserve)	Full HSR Infrastructure with Burbank Airport and Anaheim Stations, HSR platforms, elec. and light maint. facility (LMF)

Table 1-2: Comparison of Investment Needs by Scenario

1.1.2 Quantitative Evaluation of Metrics for each Scenario

The study considers the following parameters to measure the benefits of each scenario as requested by the board:

- Ridership and revenue estimates including passenger miles traveled (PMT);
- Operations and maintenance costs (OpEx);
- Investment needs by scenario (CapEx) and committed funding;
- Benefits from reduction of greenhouse gas (GHG) emissions;
- Congestion relief shown as rail passenger miles traveled (PMT), vehicle miles travelled (VMT) reduction and reduction of automobiles travelling in the network; and
- Near term benefits including completion dates, early benefits, the potential for private investment and local matching funding.

1.2 Recap of the Qualitative Report Observations

The qualitative report provided the following observations and derived next steps for the quantitative analysis:

1. The SoCal High-Speed Rail investment can only be maximized if additional regional investment (beyond currently funded expansions) is made to improve the regional rail network outside of the Burbank – Anaheim corridor. At this point in time the ETO has not been able to identify such committed investments or their availability. ETO will review and consider a planning scenario that was provided by Metrolink as Basis for Scenario 3 and 4 and utilize related information where possible in the quantitative phase of the project.

2. The NorCal corridor requires a regional investment level in addition to the High-Speed Rail investment that is currently not available beyond the electrification project to maximize the benefits of the early High-Speed Rail investment. The Caltrain Business Plan is under development and highlights these funding requirements for various growth scenarios. ETO is working with Caltrain to obtain data that reflects the Moderate Growth Caltrain Business Plan data and incorporate that information for Scenarios 2, 3 and 4.

3. Depending on where High-Speed Rail investment priorities are set, extensive opportunity cost can occur in the Central Valley Segment if capital is shifted between corridors and lead to partial investment in the corridors. This cost is related to construction cost increases if the completion of the Merced and Bakersfield extensions is significantly delayed, additional throw-away cost to connect the Madera – Poplar Avenue section back to the freight railroad alignments to enable non-HSR service on the infrastructure and for adaptation of signal systems for this operation as well as the proportionally higher maintenance cost for the asset without utilizing the benefits of the High-Speed infrastructure.

4. The incremental ridership benefits of the SoCal High-Speed Rail investment (Scenario 3 and 4 investment focused on Burbank - Anaheim) appear to be limited compared to the Scenario 2 where a significant regional network-wide investment provides high impacts for the entire SoCal network outside of the Burbank – Anaheim corridor.

5. From the Authority's perspective maximizing benefits of early High-Speed Rail investments in the SoCal and NorCal corridors generates additional capital needs that complement the already committed High-Speed Rail projects (bookend investment) to cover the additional infrastructure and the High-Speed Rail rolling stock cost in the NorCal and SoCal corridors.

6. There may be regional benefits that would accrue from additional regional service in both NorCal and SoCal, but the substantial benefits of High-Speed Rail service accrue only in longer segments when connections to the Central Valley are in place where travel time advantages are much larger.

After completion of the Qualitative Report, ETO was able to obtain additional information from Caltrain, Metrolink and Authority regarding capital expenditures and related information to further inform the quantitative phase of the study.

1.3 Stakeholder Input and Interaction

For the NorCal scenarios ETO received information that was developed for the Caltrain business

plan and that describes the capital needs for the future expansion of the Caltrain system as well as related ridership benefits, operations cost, revenue and GHG benefits. ETO participated in an in person meeting as well as in phone calls to discuss the available information and how it would complement the Side-by-Side Study.

For the CVS corridor further analysis was performed to update the CVS financial study based on refined information from the regional rail operators. The data and assumptions were coordinated and discussed with SJRRC and SJJPA and are basis for the updated study report. A full discussion of these data assumptions is documented in the updated CVS Report.

In the SoCal corridor ETO received a document from Metrolink that outlines a proposal to operate improved rail service between Burbank and Anaheim after HSR-eligible investment is made in Corridor. The document includes capital expenditures for zero-emissions vehicle (ZEV) technology as well as the needed improvements of maintenance facilities. Based on this new information, ETO assumed a conversion of the Metrolink system to this new technology in Scenario 2 already to allow the inclusion of GHG benefits in this region after completion of the regional investment.

Further coordination with the Authority resulted in updated information of the needed capital expenditures in the NorCal and SoCal corridors to prepare the corridors for HSR operation (Scenario 3) as well as for providing standalone HSR operation in these Corridors (Scenario 4). This new capital expenditures information in combination with the information provided in the qualitative report shows ranges of capital cost for Scenario 3 and 4 in the NorCal and SoCal corridors. While the estimates from the qualitative report were based on scope that is derived from the environmental review of the corridors, the estimates for the quantitative report are based on estimates that are derived for the 2020 business plan which includes a reduced scope of investment. Both sets provide a range of needed investment and in order to be conservative, the needed investment estimates for the quantitative analysis use the lower range of each HSR-eligible investment in NorCal and SoCal. In the CVS corridor the capital expenditures remain identical to the estimates provided in the project update report in May 2019.

The continued interaction with stakeholders from each of the corridors enabled a transparent analysis and provided further insights that informed this Side-by-Side Study.

1.4 Analysis Approach and Methodology

The Side-by-Side Study uses the parameters discussed above to evaluate scenarios in each of the corridors using a methodology that is consistent across the three corridors and allows for transparency in the comparison of the benefits and cost. The following sections lay out how ETO analyzed each of the parameters and which tools were used for the analytical process.

1.4.1 Ridership Estimation

The State Rail Plan Demand Model was used to estimate future ridership, passenger miles traveled and revenue information to allow a comparison across the three corridors since the model is designed to estimate ridership and revenue for rail corridors across California.

In each of the three study corridors the model was established using existing service plan information and validated against existing ridership information. After this initial step future year demand matrices were developed for the 2028 / 2029 forecast horizons based on an interpolation of the base year and the 2040 model horizon year demand data sets. For each of the corridors the proposed service plans in each of the scenarios were programmed into the model framework and ridership estimates were performed for a no-build (existing service in Scenario 1) as well as for the various investment scenarios. The model output provides average weekday ridership information and the resultant revenue estimates were calculated using the assumed fare levels in each corridor. The revenue assumes existing regional rail fares for regional services and are expressed in 2019 Dollars. The model also provides a summary of passenger miles traveled (PMT) for an average weekday.

Annual numbers we were derived from the average weekday numbers by multiplying the daily numbers with annualization factors that reflect the existing ratio of weekday versus annual ridership and revenue numbers in each corridor. The estimates do not reflect deductions for ramp-up since the study only compares point estimates (one horizon year).

1.4.2 Operations and Maintenance Cost Estimates

The operations and maintenance costs for regional rail services were derived based on input from the regional rail operators and publicly available financial information and scaled based on train miles provided in each of the scenarios. In general, ETO assumed that existing cost structures of regional rail services remain in place and that future rail services will be performed in a similar fashion as compared to today's operation.

In NorCal the O&M costs are based on estimates that were developed for the Caltrain Business Plan by Caltrain and these estimates were carried into the Side-by-Side Study for the regional service. The data shows efficiencies in operation with increase in train miles and the Side-by-Side Study reflects these efficiencies.

For the CVS corridor both SJJPA and SJRRC provided operations cost estimates for Scenario 2 and Scenario 4 based on existing cost structures but assuming efficiencies in overhead cost that can be materialized with a universal operator concept. A detailed cost estimation process is shown in the updated CVS Study.

For the SoCal corridor only existing operations and maintenance cost information was readily available for the Side-by-Side Study. The cost was prorated with the increase in train miles and assumes existing cost structures since no detailed business plan information for the SoCal corridor was available for use in the Side-by-Side Study. The introduction of zero-emissions vehicle (ZEV) technology was assumed to be cost-neutral for the per mile operation and maintenance cost since there likely will be cost savings for fuel but potentially higher maintenance costs for the advanced technology. Since ETO was not able to obtain related estimates the assumption of constant per-mile cost was used for the SoCal study. ETO utilized efficiency assumptions from the NorCal corridor and applied those to the SoCal scenarios to enable a transparent comparison of cost assuming similar efficiencies in the SoCal scenarios. The resultant cost estimates need to be considered high-level estimates, a detailed operating plan and cost estimation process and business plan would be required to provide refined numbers.

The HSR operation and maintenance costs were derived with a bottom-up approach in the CVS

corridor for both the infrastructure as well as the rolling stock. For the NorCal and SoCal corridors the cost was then prorated based on the service miles for rolling stock and based on centerline miles for infrastructure using the CVS information.

An identical business model for the HSR standalone operation was assumed for each of the corridors in Scenario 4 to operate the standalone HSR service. This business model assumes a lease agreement with the regional rail provider for Authority owned infrastructure and rolling stock.

1.4.3 Capital Cost and Funding Requirements

The capital cost estimates are based on information provided by Caltrain, SJRRC, SJJPA, Metrolink, the Authority and other publicly available information describing infrastructure investment in the three corridors. This information also provides insights into the available and committed funding of these investments and allows to show the share of funding available versus funding needed to establish each scenario. ETO relied on this information to derive a summary of committed investment and funding needs for the Side-by-Side Study but did not perform a review of capital costs or further analysis to refine the capital cost requirements. Some of the information appears to be high-level in nature and is likely subject to change once more refined planning and engineering studies are performed.

Since completion of the qualitative report ETO was able to obtain further information on the HSR eligible investment for the NorCal and SoCal corridors. While the qualitative report relied on estimates that are based on the scope of the environmental review in each of the corridors the more recent estimates use a refined construction scope that is basis of the Authority's 2020 business plan. These new estimates provide a lower range of investment needs and the quantitative report uses this lower range of cost estimates in lieu of the higher estimates shown in the qualitative report.

Section 9 includes a detailed comparison of these cost ranges and highlights the variability of these cost estimates based on the assumed midpoint of construction due to inflationary adjustments. All capital expenditure and funding numbers are shown in year-of-expenditure (YOE) dollars.

1.4.4 Evaluation of Greenhouse Gas (GHG) Benefits

GHG benefits were derived using the TIRCP GHG Analysis Tool[2] and are based on information for each scenario describing the type of train miles provided as well as the reduction in vehicle miles traveled.

This Quantification Methodology and accompanying TIRCP Calculator Tool was developed for the California State Transportation Agency (CalSTA) Transit and Intercity Rail Capital Program (TIRCP) to provide methods for estimating the GHG emission reductions and air pollutant emission co-benefits of each proposed project by component.

This methodology uses calculations to estimate the reduction in passenger (auto) vehicle miles traveled (VMT) and associated GHG emission reductions based on specific transportation characteristics of proposed projects. These calculations are based on the "Methods to Find the Cost Effectiveness of Funding Air Quality Projects for Evaluating Motor Vehicle Registration Fee Projects and Congestion Mitigation and Air Quality Improvement Projects" (CMAQ Methods) and CARB-developed emission factors.

TIRCP applicants use this methodology to estimate and report the total project GHG emission reductions (in metric tons (MT) of carbon dioxide equivalents (CO2e) as well as the total project GHG emission reductions per dollar of GGRF funds requested.

The process was applied to all three corridors and scenarios and therefore allows a transparent and consistent analysis of the GHG benefits of each scenario. For purposes of comparison the reductions of metric tons of carbon dioxide (CO_2) were used for analyzing the impacts of each scenario on GHG emissions.

[2] Source: California Air Resources Board, Quantification Methodology for the California State Transportation Agency Transit and Intercity Rail Capital Program: https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/calsta_tircp_finalqm_18-19.pdf

1.4.5 Estimation of Congestion Relief Benefits

Congestion relief benefits were measured by:

- Annual estimate of the reduction in vehicle miles traveled for each scenario; and
- Annual reduction of vehicles traveling in each corridor.

The reduction in VMT values were derived from the change in rail passenger miles traveled (PMT) assuming an average occupancy of 1.2 per vehicle.

The reduced number of vehicles per year using the roadway network was calculated by dividing the VMT reductions by the average distance driven per vehicle per year (Assumes an average mileage per car of 13,476 miles per year[3]).

1.4.6 Identification of Other Opportunities

Other opportunities of each investment where described in a qualitative way and include early benefits of the HSR-eligible investment, the potential completion dates of HSR investment and how such investment could be sequenced with committed and funded regional and local investment in each corridor, potential for private sector investment and the availability of local matching funds.

1.4.7 Comparison of Scenarios

To gauge the effectiveness of HSR-eligible investment, ETO expressed the benefits as the difference of Scenarios 3 and 4 versus Scenario 2 that reflects funded and committed regional investment prior to HSR-eligible investment. It is assumed that Scenario 2 investment by the regions will be in place prior to any HSR-eligible investment and therefore benefits from such HSR

[3] Federal Highway Administration (FHWA), 13,476 miles driven per year per driver: https://www.fhwa.dot.gov/ohim/onh00/bar8.htm

investment have to be measured against Scenario 2 benefits.

The following chapters describe in detail the definition of the scenarios, the underlying service plans, operations and maintenance costs, investment needs and funding as well as the ridership and revenue, GHG and congestion benefits and other opportunities for each scenario.

2 Infrastructure and Operating Scenario Definition

2.1 NorCal Corridor

The overall situation of the NorCal corridor reflects the difference in ownership of the infrastructure north and south of Control Point (CP) Lick. The sections north of CP Lick are owned by Caltrain whereas the section South of CP link to Gilroy is part of the HSR-eligible investment and will be owned by the Authority. In order to have a consistent approach between the different corridors it is assumed for the NorCal corridor that during a standalone operation of HSR service Caltrain will lease the infrastructure from the authority as well as the rolling stock to operate a standalone HSR service. The underlying business model is shown in the following Figure 2-1 and Table 2-1 describes the roles and responsibilities of each party in the corridor.

The following three Scenarios were analyzed in the ridership analysis of the original PenC study:

- No-Build with existing service of 5 peak hour Caltrain diesel trains per direction (Scenario 1 of the Side-by-Side Study)
- Partial High-Speed Rail eligible investment enabling full electric operation and 8 peak hour electric Caltrain trains per direction (Scenario 3 of the Side-by-Side Study)
- Full High-Speed Rail eligible investment enabling full electric operation and 8 peak hour electric Caltrain trains per direction plus 2 HSR trains per hour and direction (Scenario 4 of the Side-by-Side Study)

In order to provide a comparison between the NorCal and SoCal corridors, ETO added a fourth scenario that reflects only the committed regional investment for the Caltrain Electrification. This scenario enables 4 electric and 2 diesel trains per hour and direction in the peak hour (Scenario 2 of the Side-by-Side Study).

Scenarios 1, 3 and 4 are based on the PenC study output to perform the side-by-side comparison and Scenario 2 benefits are based on the Caltrain business plan output for that scenario. ETO has been working with Caltrain stakeholders to obtain and summarize the relevant data. The cost calculations have been revised from the original PenC study to assume the new HSR commercial assumptions to enable a side-by-side comparison with the CVS corridor.

2.1.1 NorCal Scenario 4 - HSR Train Operations

Infrastructure Assumptions and Stations

The HSR service is assumed as a standalone service between Gilroy and San Francisco since the connection to the Central Valley will not be available prior to implementation of the Silicon Valley to Central Valley Project. It is assumed that the HSR-eligible investment will be made to enable HSR service and to enable maintenance of the HSR rolling stock in the Brisbane light maintenance facility (LMF).

The HSR service will stop in the Gilroy, San Jose Millbrae and 4th & King stations as shown in Figure 2-1 below.

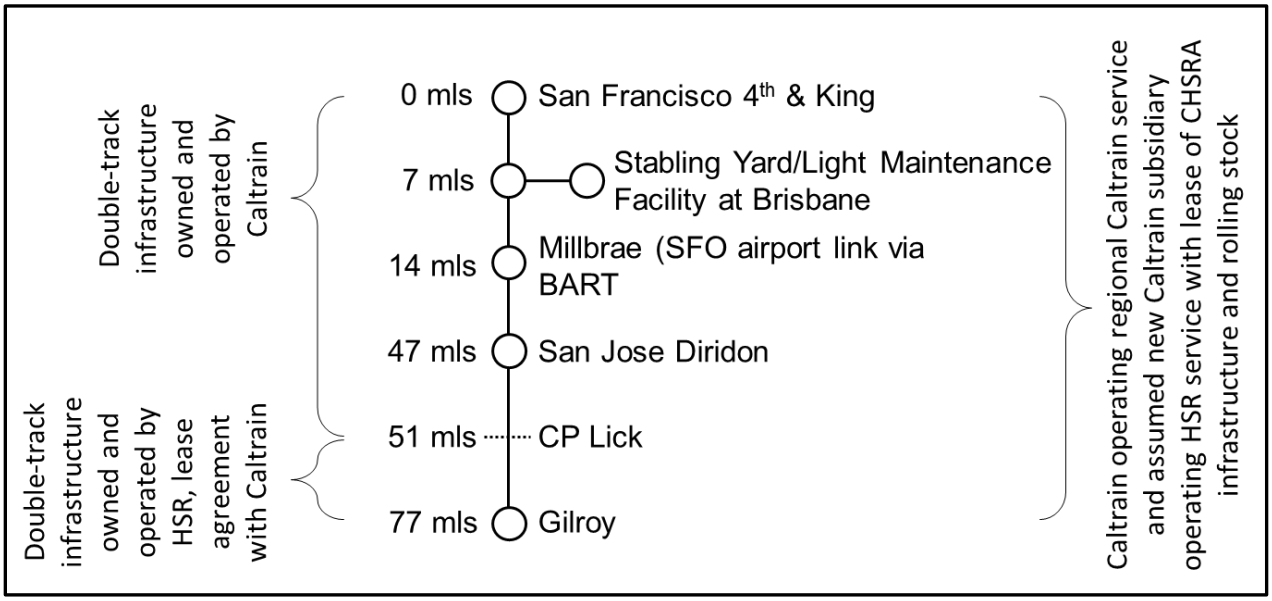


Figure 2-1: HSR Infrastructure and Stations in SoCal

Commercial Structure of Standalone HSR Operations

In order to provide a comparable business model for standalone HSR operation in the NorCal corridor, the proposed CVS commercial arrangement was transferred to an application in the Caltrain corridor as shown in Figure 2-2 below.

Caltrain is assumed to have a subsidiary that operates the HSR operation and can realize similar savings in overhead and operational cost as calculated in the CVS corridor. The track & systems and rolling stock suppliers would be providing the services to the Authority which would pass through the cost to the Caltrain subsidiary operating the trains.

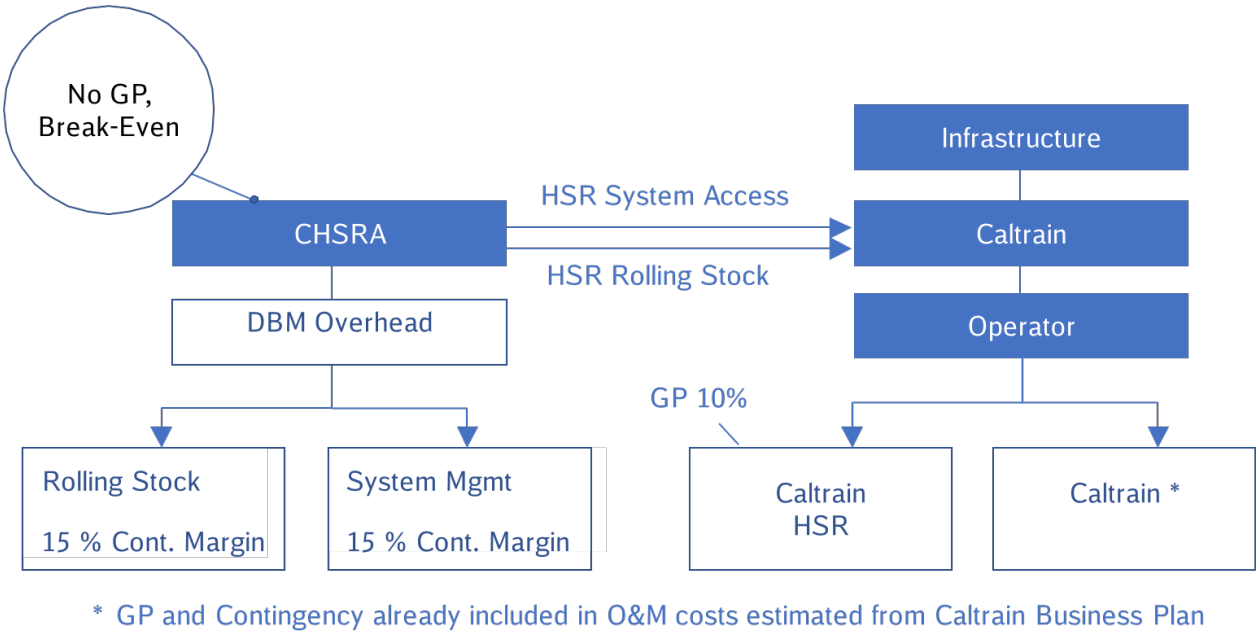


Figure 2-2: Commercial Model for HSR Services in NorCal

Operations Tasks and Responsible Parties for Standalone HSR Operation in NorCal

Based on the commercial structure shown above for the NorCal HSR operation, Table 2-1 below describes the resultant responsibilities of the rail infrastructure owner Caltrain (San Francisco to CP Lick), HSR rolling stock provider, HSR track and systems provider, CHSRA and Caltrain as public entity procuring rail operations services.

Operational Task	CHSRA	Caltrain	T&S Supplier	RS Supplier
Infrastructure Management overhead	✓ (CHSRA section)	✓ (Caltrain section)		

Operational Task	CHSRA	Caltrain	T&S Supplier	RS Supplier
Maintenance of Track & Systems		✓ (Caltrain section)	✓ (CHSRA section)	
Maintenance of HSR RS				✓
Maintenance of civil structures		✓ (Caltrain section)	✓ (CHSRA section)	
OCC		✓		
TOC Management		✓		
Operations		✓		
Fare Collection		✓		
HMF facility				✓
Station maintenance		✓ (Caltrain section)	✓ (CHSRA section)	
Station operations and Facilities		✓		
Marketing & Branding		✓		
Security & Policing	✓ (CHSRA section)	✓ (Caltrain section)		
EHS	✓ (CHSRA section)	✓ (Caltrain section)		
Insurance	✓ (CHSRA section)	✓ (Caltrain section)		

Table 2-1: Stakeholder Assignment of Operational Tasks in NorCal

The cost analysis uses the assumed commercial model for Scenario 4 in the cost calculation and compares the resultant changes against Scenario 2 that assumes a continued operation within existing commercial agreements.

2.2 CVS Corridor

The CVS Corridor Study uses two scenarios to evaluate the HSR operation in the Central Valley:

Scenario 2 is the baseline and assumes the completion of the Valley Rail Project[4] that provides two new daily round-trips for the Amtrak San Joaquins service to better connect San Joaquin Valley travelers with the Sacramento Area, and an extension of Altamont Corridor Express (ACE) between Sacramento and Merced which builds upon ACE funding from Senate Bill (SB) 132; and

Scenario 4 includes the completion of the Merced to Bakersfield Segment of the High-Speed Rail system, an optimized ACE and San Joaquin rail service north of Merced and optimized bus connectivity that allow a seamless journey and ensure that passengers transferring from and to the HSR rail service have coordinated transfer opportunities.

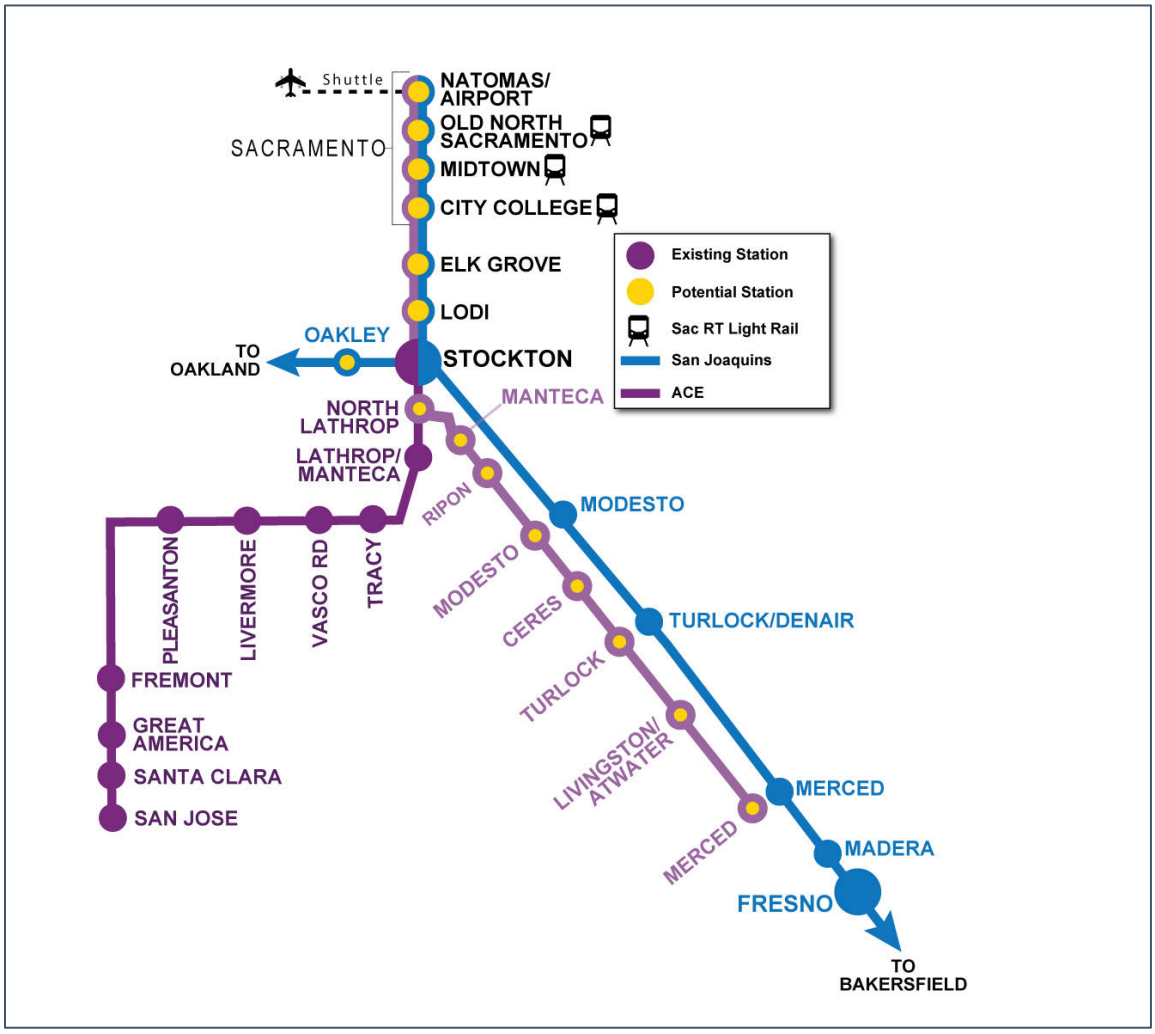
In both scenarios the modeling assumed that trips can be made on buses without the need to connect to a rail service[5] to reflect the recent changes based on Senate Bill No. 742.

2.2.1 Scenario 2 – No-Build with Valley Rail Improvements

Scenario 2 shown in Figure 2-3 assumes the completion of the Valley Rail Project that is funded and will provide ACE train service toward Ceres and Merced, extend and reroute San Joaquin services to reach Natomas north of Sacramento and allow for additional train service between Merced – Stockton and Natomas.

[4] San Joaquin Joint Powers Authority (SJJPA), Valley Rail
Source: https://sjjpa.com/valley-rail/

[5] SB-742 Intercity passenger rail services: motor carrier transportation of passengers.
Source: http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200SB742



Source: SJJPA, https://sjjpa.com/valley-rail/

Figure 2-3: CVS Service Patterns for Scenario 2

2.2.2 Scenario 4 - HSR Train Operations

Infrastructure Assumptions

The service concept for the High-Speed Rail services through the Central Valley Segment (CVS) plans for one high-speed train per hour per direction and builds on the completion of the Valley Rail Project (Scenario 2).

The scenario assumes the following improved connectivity with HSR service as well as improvements that benefit riders that travel north of Merced:

- All high-speed trains are scheduled according to a clock face timetable, in which departures and arrivals occur at the same minute of each hour;
- At the northern terminus of the interim high-speed rail service at Merced, the schedule provides for conveniently timed transfers between high-speed trains and corresponding San Joaquin and Altamont Corridor Express (ACE) trains, as well as for buses supported by cross-platform transfers;
- At the southern terminus of the high-speed rail in Bakersfield (BFD) the schedule provides for conveniently timed transfers between high-speed trains and intercity coach buses.

Figure 2-4 below shows the CVS mileage and stations where HSR service will operate. Madera station will be environmentally cleared and built by others but is assumed as a station stop in the HSR service.

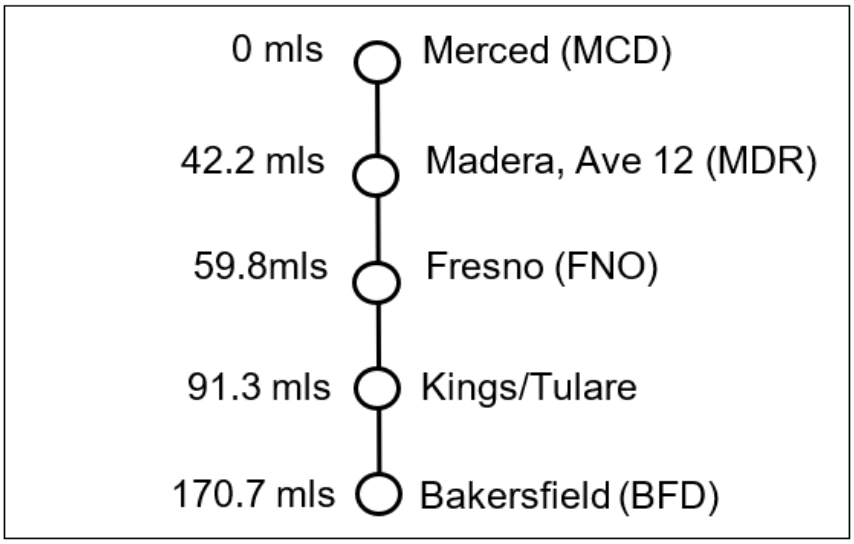


Figure 2-4: CVS HSR Segment Mileage and Stations

Figure 2-5 below depicts a sketch of the Merced Intermodal Transit Center (MITC) Connection between the BNSF Stockton subdivision and the UP Fresno subdivision (“The Loop”).

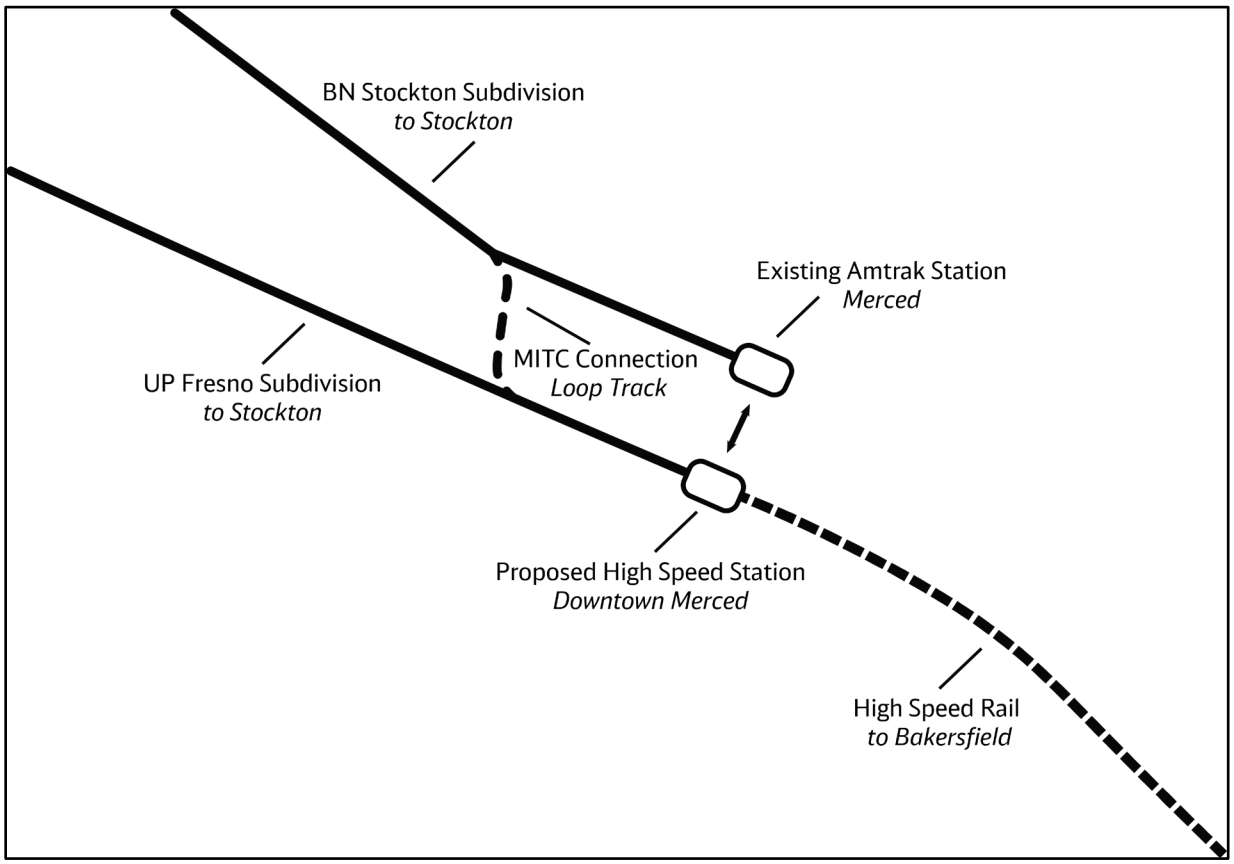


Figure 2-5: Schematic Sketch of MITC Connection Between BNSF Stockton Subdivision and UP Fresno Subdivision ("The Loop")

The revenue service for HSR and the Connecting ACE, San Joaquin and Bus services extend over approximately 19 hours per day for seven days per week. For maintenance purposes of infrastructure and rolling stock, nightly operations-free time slots of approximately five hours are scheduled. The Heavy Maintenance Facility (HMF) for the rolling stock maintenance is assumed to be located in the area south of Fresno.

Stations

The 170.7-mile travel corridor between the northern terminus, Merced, and the southern terminus, Bakersfield, will have regular intermediate stops at Madera (Madera station will be environmentally cleared and funded by others), Fresno and Kings/Tulare. It is assumed that the Merced HSR station (also known as Merced Intermodal Station) will bring conventional trains

(San Joaquins, Altamont Corridor Express ACE) and high-speed trains together at one platform as to allow for easy cross-platform transfer.

To make this possible, San Joaquins and ACE trains approaching Merced from the north will switch from the BNSF tracks (Stockton Subdivision) to an alignment parallel to UP tracks (Fresno Subdivision) through cross-over tracks or “The Loop”, also referred to as the MITC connection (see Figure 2-5). This connection is located in an industrial area and will follow existing tracks and service will therefore not end at today’s Amtrak station but instead will terminate at the future Merced High-Speed Rail Station.

Currently, a new at-grade HSR station is environmentally cleared for the site between G Street and Martin Luther King, Jr. Street. This is the basis for the projected operations and maintenance cost calculations. However, latest discussions between CHSRA and the City of Merced propose an elevated HSR station between R Street and O Street, where HSR and San Joaquins trains meet cross-platform. ACE trains are assumed to arrive and depart at-grade.

Access to Stations and Transfer Between Trains and Trains/Buses

The CVS HSR station infrastructure is assumed to support convenient transfers between train to train (short cross-platform transfer) or train to bus to keep transfer times short and the overall travel experience attractive.

Connectivity

Customer satisfaction and an economically successful operation of the high-speed rail system are central success factors. To achieve these, a high degree of connectivity and the creation of consistent and integrated travel chains throughout California comprising clock face timetables, both for the high-speed trains and the corresponding rail and bus feeder services, are a must. All high-speed trains will be connected as follows:

- At Merced, the northern terminus, train connectivity is provided from/to:
  - San Jose (1x ACE)
  - Oakland (5x San Joaquin)

- Sacramento – Natomas (6x San Joaquins; 3x ACE Northbound and 5x ACE Southbound)

In hours where train schedules have gaps in service a parallel bus service with identical stopping patterns will guarantee connectivity to travelers to reach destinations outside of the HSR service area. This bus service complementing the rail service will allow a transformational increase in service frequency also for travelers on segments north of Merced.

The assumed future ACE and San Joaquins with the intermediate stations are shown in Figure 2-6 below and are further discussed in the CVS Study report including details regarding additional bus connections assumed at the Merced station and the southern terminal in Bakersfield.

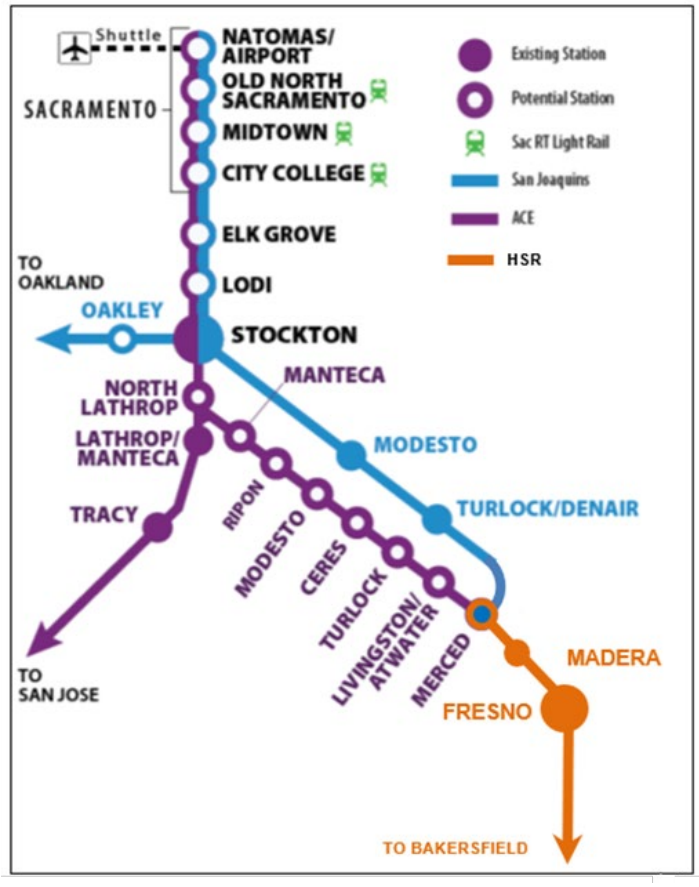


Figure 2-6: Scenario 4 Connectivity of CVS HSR Services with San Joaquins and Altamont Corridor Express (ACE) at Merced Station.

Business Model HSR Operations

Based on CHSRA's current view of the commercial structure for early HSR services implementation, the CVS Study provides pre-operations and operations financial projections. CHSRA will charge System Access Fees and Rolling Stock rental fees to the SJRRC, who will procure a universal operator as the train operating company (TOC) for early services in the Central Valley until such time as V2V operations are ready for service to be operated by CHSRA. In the meantime, the TOC will be responsible for HSR train operations, ACE and San Joaquins train operations and bus connections.

The TOC will be responsible in total for the associated O&M costs, bus costs and the System Access Fees and Rolling Stock rental fees, which will be charged by CHSRA. The resulting high-level commercial structure for the Central Valley is illustrated below in Figure 2-7.

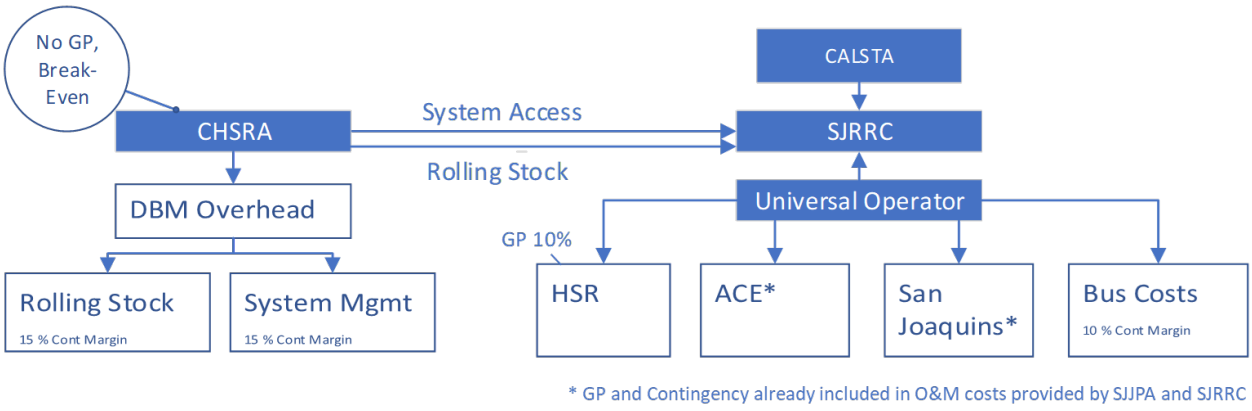


Figure 2-7: Commercial Model for HSR Services in CVS

Operations Tasks and Responsible Parties

Based on the commercial structure shown above, Table 2-2 describes the resultant responsibilities of the rail infrastructure owners north of Merced (BNSF and UP), HSR rolling stock provider, HSR track and systems provider, CHSRA and the SJRRC and SJJPA as public entity procuring rail operations services.

The cost analysis uses the assumed commercial model for Scenario 4 in the cost calculation and compares the resultant changes against Scenario 2 that assumes a continued operation within existing commercial agreements.

Operational Task	CHSRA	San Joaquin +ACE+HSR Universal Operator	UP	BNSF	CHSRA T&S Supplier	CHSRA RS Supplier
Infrastructure Management Overhead	✓ (CHSRA section)		✓ (UP sections)	✓ (BNSF sections)		
Track & Systems Maint.			✓ (UP sections)	✓ (BNSF sections)	✓ (CHSRA section)	
HSR RS Maint.						✓
Civil Structure Maint.			✓ (UP sections)	✓ (BNSF sections)	✓ (CHSRA section)	
OCC HSR/Existing			✓ (UP sections)	✓ (BNSF sections)	✓ (CHSRA section)	
TOC HSR Management		✓				
Operations		✓ (Regional and HSR)				
Fare Collection		✓ (Regional and HSR)				
HMF facility HSR						✓
Station Maint. Trackside					✓ (CHSRA section)	
Station Operations and Facilities		✓				
Marketing & Branding		✓ (Regional and HSR service)				
Security & Policing	✓ (CHSRA section)	✓ (Regional sections)	✓ (UP sections)	✓ (BNSF sections)		
EHS		✓				

Operational Task	CHSRA	San Joaquin +ACE+HSR Universal Operator	UP	BNSF	CHSRA T&S Supplier	CHSRA RS Supplier
Insurance	✓ (CHSRA section)	✓ (Metrolink sections)	✓ (UP sections)	✓ (BNSF sections)		

Table 2-2: Assignment of CVS Operational Tasks by Stakeholder

2.3 SoCal Corridor

The infrastructure in the SoCal corridor (Burbank to Anaheim) is owned by the Counties as well as by BNSF. The section of the proposed HSR infrastructure from Burbank Airport HSR Station to Burbank Downtown (CP Allen) and the new HSR infrastructure in Anaheim as well as the proposed LMF are part of the HSR-eligible investment and are assumed to be owned by the Authority after completion of the investment. The remaining sections with HSR-eligible investment from CP Allen to Los Angeles Union Station and from Union Station to Fullerton will require HSR investment but will continued to be operated by the Counties or BNSF.

In order to have a consistent approach between the different corridors it is assumed for the SoCal corridor that during a standalone operation of HSR service Metrolink will lease the infrastructure from the authority as well as the rolling stock to operate a standalone HSR service. LOSSAN will continue to operate under the existing arrangements the Pacific Surfliner service over the improved corridor infrastructure.

2.3.1 SoCal Scenario 4 - HSR Train Operations

Infrastructure Assumptions and Stations

The HSR service is assumed as a standalone service between the Burbank Airport HSR Station and Anaheim since the connection to the Central Valley will not be available prior to implementation of Phase 1 of the HSR system. It is assumed that the HSR-eligible investment will be made to enable HSR service and to enable maintenance of the HSR rolling stock in dedicated HSR light maintenance facility (LMF) south of Union Station. The HSR service will stop in Burbank Airport, Los Angeles Union Station, Fullerton and Anaheim Figure 2-8.

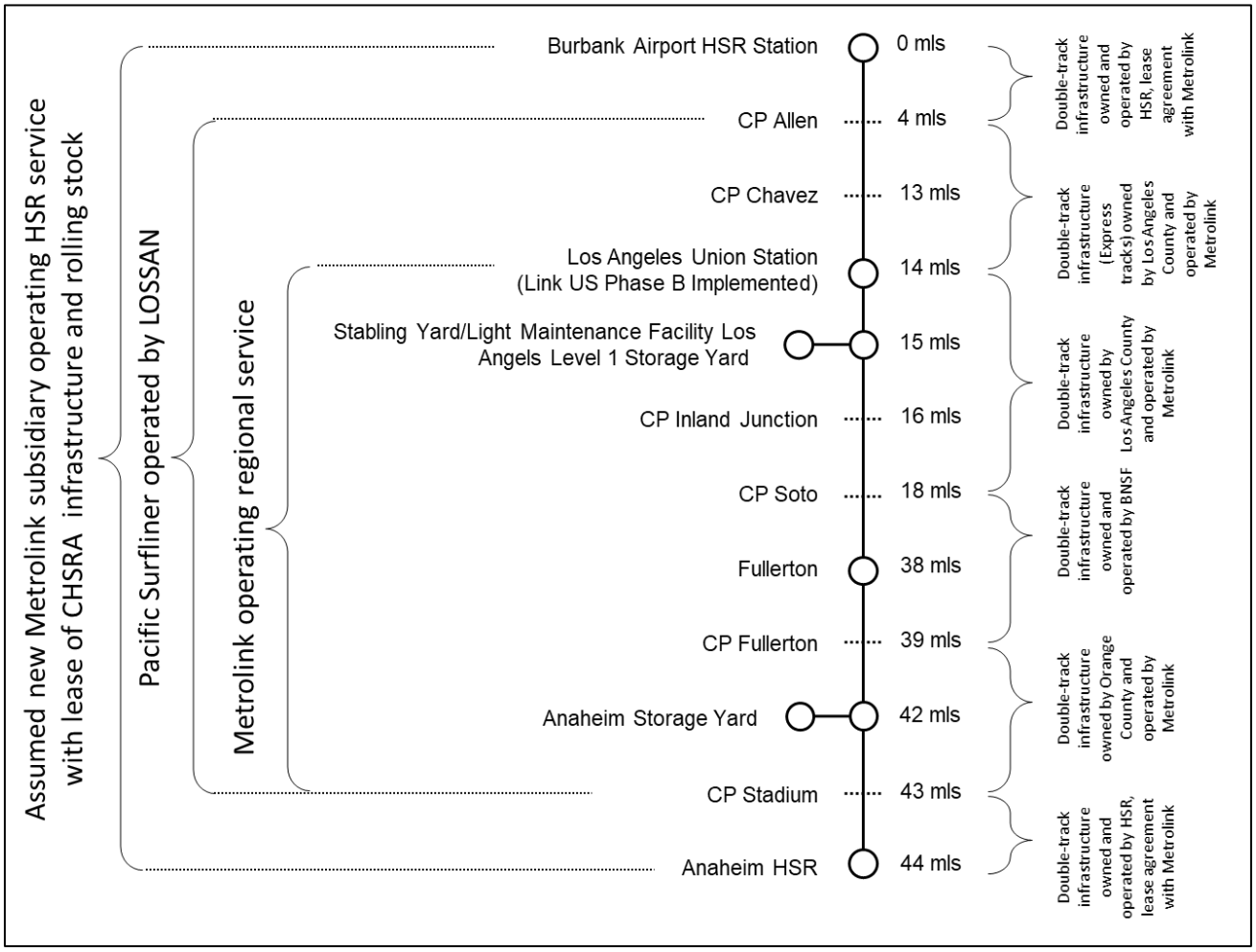


Figure 2-8: HSR Infrastructure and Stations in SoCal

Commercial Structure of Standalone HSR Operations

In order to provide a comparable business model for standalone HSR operation in the NorCal corridor, the proposed CVS commercial arrangement was transferred to an application in the SoCal corridor Figure 2-9. Metrolink is assumed to have a subsidiary that operates the HSR operation and can realize similar savings in overhead and operational cost as calculated in the CVS corridor. The track & systems and rolling stock suppliers would be providing the services to the Authority for the infrastructure sections owned by the Authority and the rolling stock which would then pass through the cost to the Metrolink subsidiary operating the HSR trains.

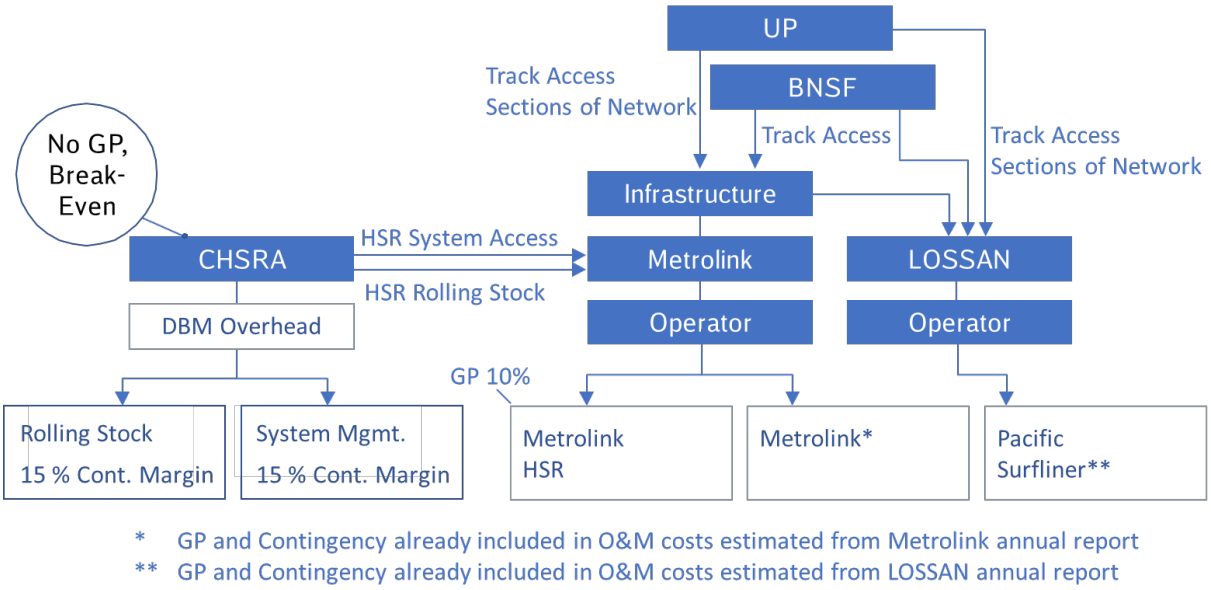


Figure 2-9: Commercial Model for HSR Services in SoCal

Operations Tasks and Responsible Parties for standalone HSR Operation in SoCal

Based on the commercial structure shown above for the SoCal HSR operation, Table 2-3 describes the resultant responsibilities of the rail infrastructure owned by the Counties/Metrolink and BNSF, the HSR rolling stock provider, the HSR track and systems provider, CHSRA, and Metrolink and LOSSAN as public entities procuring rail operations services.

Operational Task	CHSRA	Metrolink	LOSSAN	BNSF	CHSRA T&S Supplier	CHSRA RS Supplier
Infrastructure Management overhead	✓ (CHSRA sections)	✓ (Metrolink sections)		✓ (BNSF sections)		
Maintenance of Track & Systems		✓ (Metrolink sections)		✓ (BNSF sections)	✓ (CHSRA sections)	
Maintenance of HSR RS						✓

Operational Task	CHSRA	Metrolink	LOSSAN	BNSF	CHSRA T&S Supplier	CHSRA RS Supplier
Maintenance of civil structures		✓ (Metrolink sections)		✓ (BNSF sections)	✓ (CHSRA sections)	
OCC HSR		✓				
TOC HSR Management		✓				
Operations		✓ (Metrolink and HSR)	✓ (Pacific Surfliner)			
Fare Collection		✓ (Metrolink and HSR)	✓ (Pacific Surfliner)			
HMF facility HSR						✓
Station maintenance		✓ (Metrolink sections)			✓ (CHSRA sections)	
Station operations and Facilities		✓				
Marketing & Branding		✓ (Metrolink and HSR service)	✓ (Pacific Surfliner service)			
Security & Policing	✓ (CHSRA sections)	✓ (Metrolink sections)		✓ (BNSF sections)		
Environment (E), Health (H) and Safety (S) (EHS)		✓				
Insurance	✓ (CHSRA sections)	✓ (Metrolink sections)		✓ (BNSF sections)		

Table 2-3: Assignment of Operational Task in SoCal by Stakeholder

3 Service Plans

3.1 NorCal Scenarios

The service plans for the NorCal Scenarios for the regional Caltrain service are based on existing service (Scenario 1), service after completion of electrification (Scenario 2), higher frequency regional rail service reflecting the Moderate Growth Scenario of the Caltrain Business Plan[6] (Scenario 3) and HSR standalone operation (Scenario 4) in addition to the improved regional service in Scenario 3.

The service plan parameters are derived from the Caltrain Business Plan effort and adapted to match the Side-by-Side Study scenario assumptions regarding implementation horizons and the demand modeling horizon (2028). While the Caltrain business plan assumes implementation of the Downtown Extension (DTX) to the Transbay Terminal by 2033 prior to development of the moderate growth scenario, the Side-by-Side Study does not assume this extension and therefore the data set obtained from the Caltrain business plan team was adjusted to reflect this difference.

Figure 3-1 through Figure 3-4 describe the peak period stopping patterns and the type of propulsion used for each service scenario. Scenarios 3 and 4 assume a fully electrified operation of regional Caltrain service and Scenario 4 includes HSR standalone service in addition to the regional service increase.

The overall daily regional train mileage for each scenario is derived from the Caltrain business plan information as well as the related operations and maintenance cost for each scenario.

[6] Peninsula Corridor Joint Powers Board, Choosing a Long Range Vision: https://caltrain2040.org/wp-content/uploads/2019.10.03_JPB_Final_Caltrain-Business-Plan.pdf

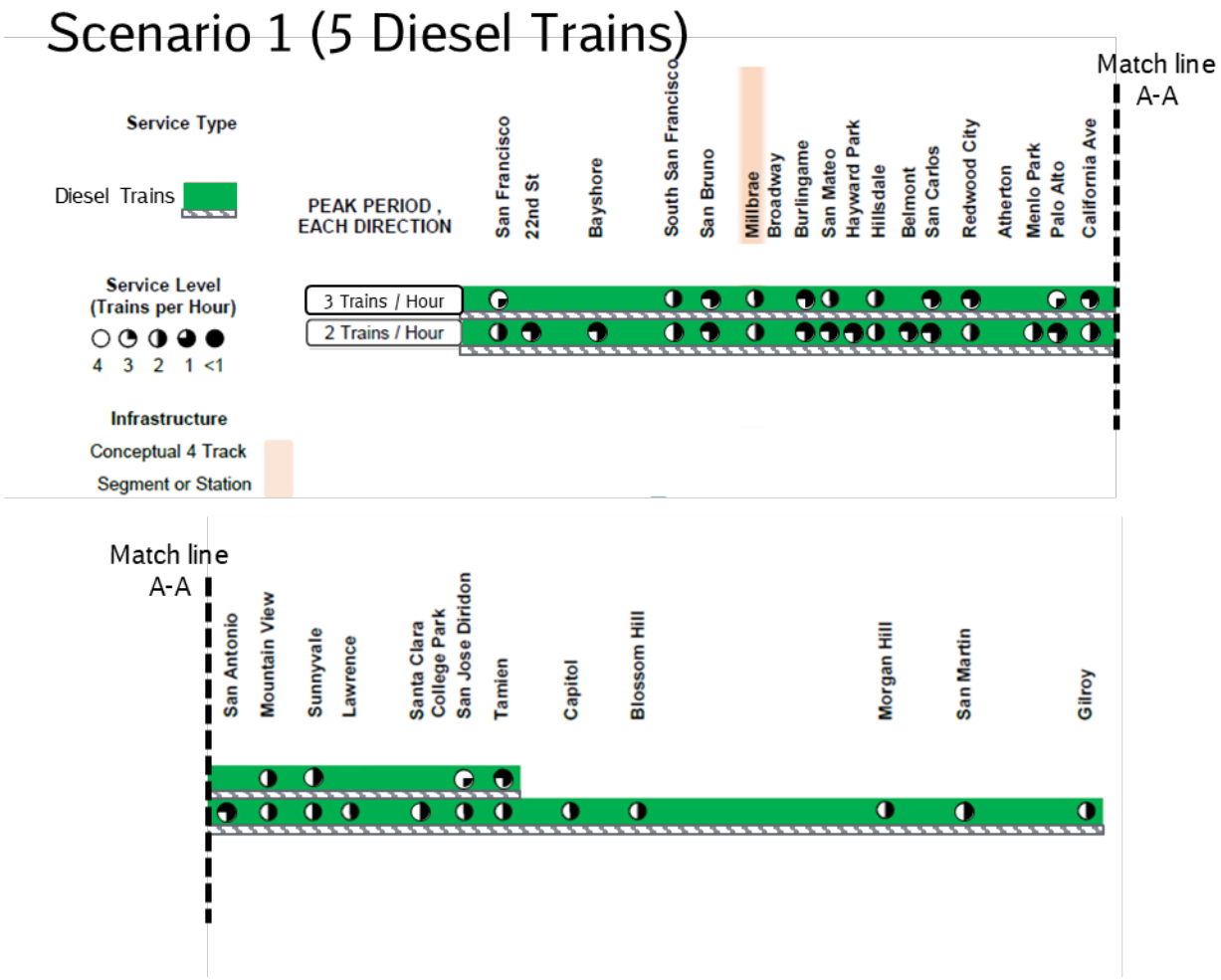


Figure 3-1: NorCal Service Patterns for Scenario 1

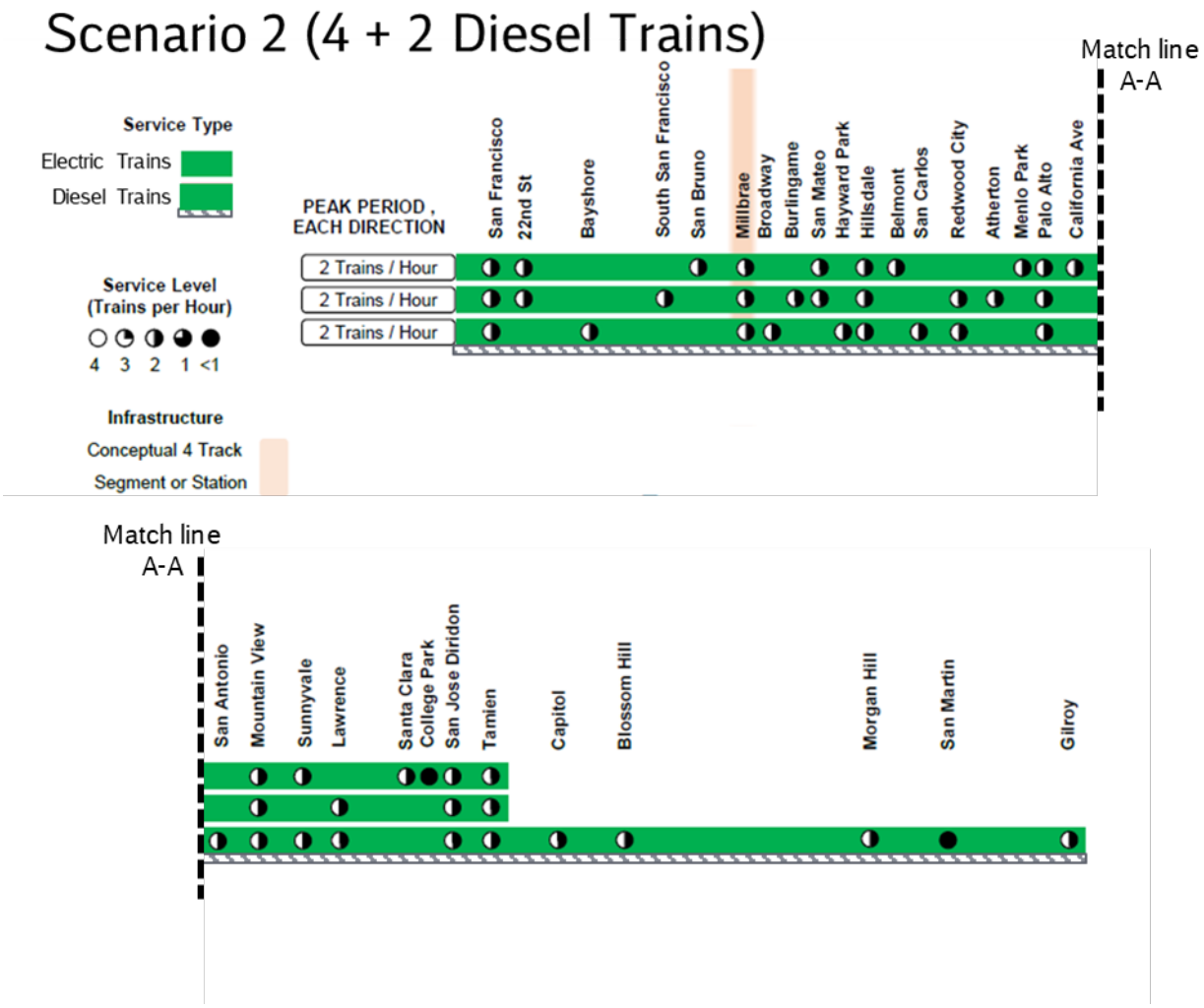


Figure 3-2: NorCal Service Patterns for Scenario 2

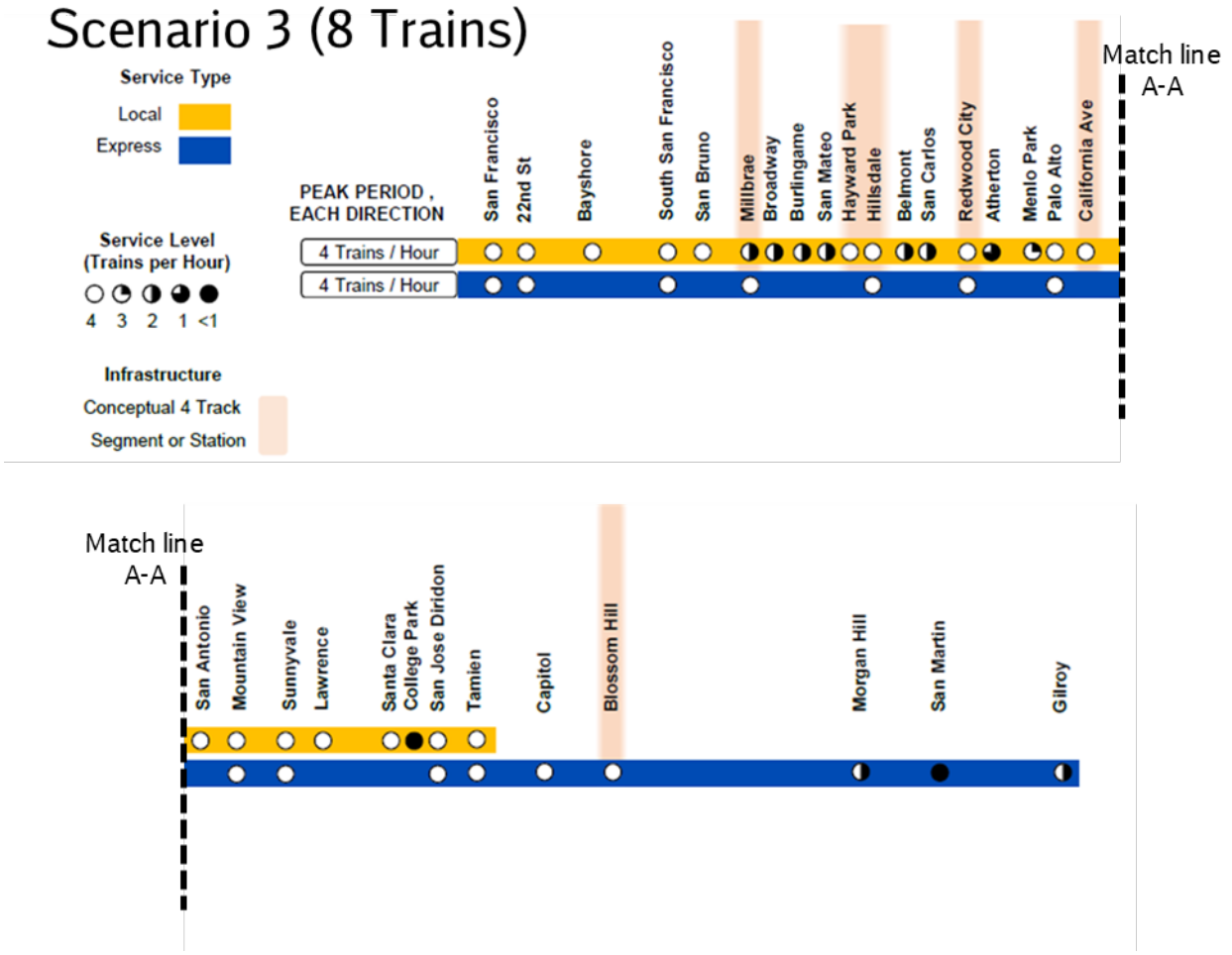
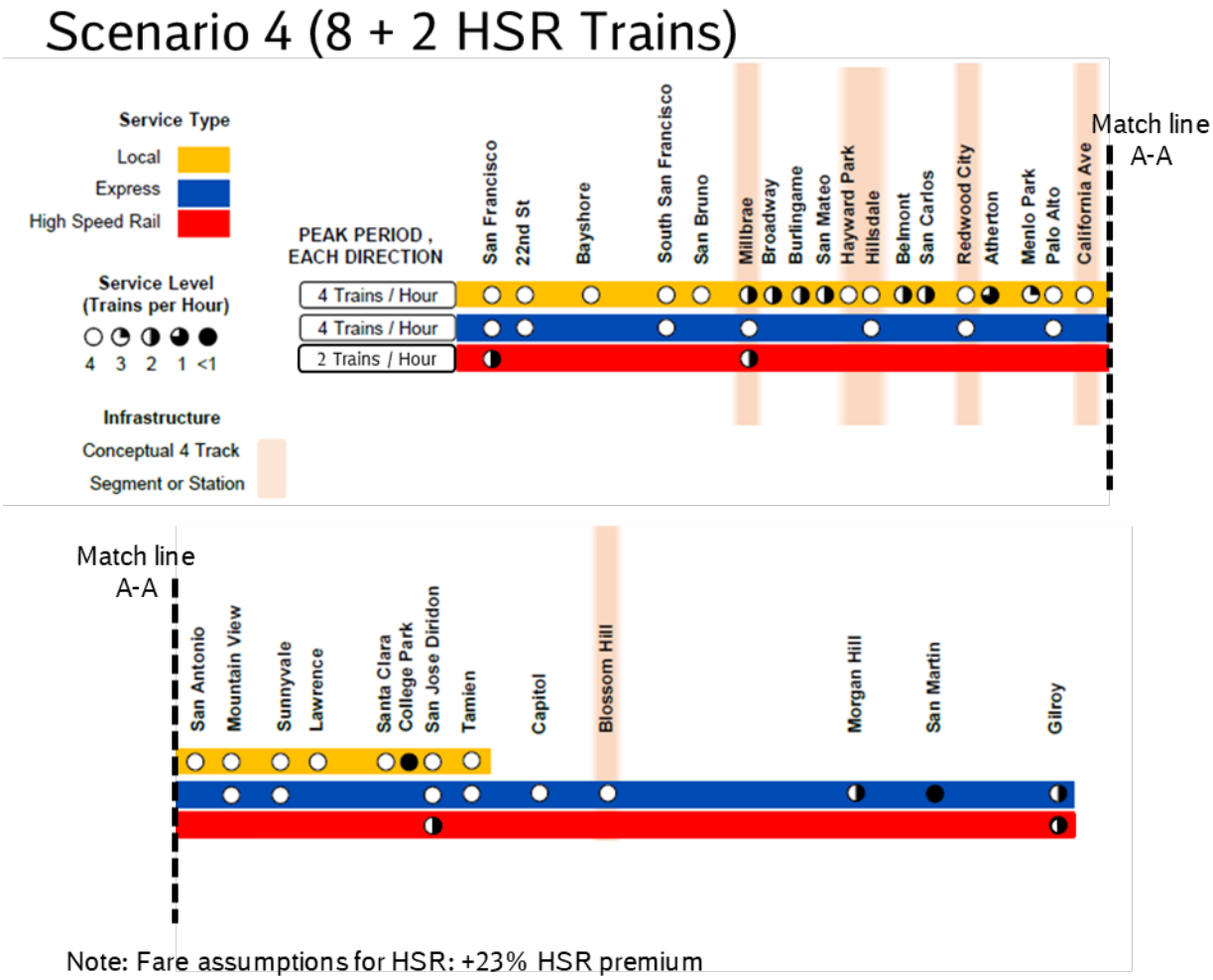


Figure 3-3: NorCal Service Patterns for Scenario 3



Note: Fare assumptions for HSR: +23% HSR premium

- PenC Coach class fares shall be calculated at Caltrain fare plus a premium of 10%;
- Business/First class fares shall be calculated at the PenC coach class fare plus a premium of 75%;
- An 80% /20% split of coach versus business users. Weighted surcharge is therefore 23% on top of Caltrain cash fare.

Figure 3-4: NorCal Service Patterns for Scenario 4

3.2 CVS Scenarios

3.2.1 Scenario 2 Service

Scenario 2 assumes the Valley Rail Project completed and increased train frequencies on the San Joaquin and the ACE rail service. Table 3-1 below illustrates the changes in services between the Existing service, Scenario 2 (No HSR) and Scenario 4 (With HSR service).

City Pairs	2017 NB (Current Service)	2029 Scenario 2 (Valley Rail Project)	2029 Scenario 4 (with HSR)
Merced-Sacramento via San Joaquin	0	2	6
Sacramento – Bakersfield via San Joaquin	2	3	0
Oakland – Merced via San Joaquin	5 (to Bakersfield)	4 (to Bakersfield)	5 (to Merced)
Sacramento Natomas – Merced via ACE	-	1Rail + 3Rail/Bus (Bus Merced-Ceres)*	Northbound: 3Rail; Southbound: 5Rail**
San Jose – Merced via ACE	-	1	1

Note: (*) Assumes 253 service days per year, (**) assumes 365 service days per year.

Table 3-1: ACE and San Joaquins Train Service to/through Merced

3.2.2 Scenario 4 Service Requirements

Regional Rail Service

With implementation of the HSR investment in CVS and the regional investment, the improved infrastructure will allow the following integrated services at the Merced HSR terminal:

- 5 San Joaquins round trips between Merced-Oakland.
- 2 San Joaquins round trips between Merced-Sac Valley Station via UP Fresno Sub.
- 4 San Joaquins round trips between Merced-Natomas via UP Sacramento Sub.

- 3 ACE Northbound trains between Merced-Natomas via UP Sacramento Sub.
- 5 ACE Southbound trains between Natomas-Merced.
- 1 ACE round trip between Merced-San Jose.

This totals 15 ACE/San Joaquins northbound trains connecting to HSR and 17 total ACE/San Joaquins southbound trains connecting to HSR (1 San Joaquins and 1 ACE Southbound trains both meet the same HSR connecting train at Merced).

HSR Service

The following timetables provide comprehensive information on all high-speed trains. The timetable is uniform across all 365 days per year. All high-speed trains start from and terminate in the Stabling Yard. The following Figure 3-5 shows the stringline chart for the high-speed rail services between Merced and Bakersfield.

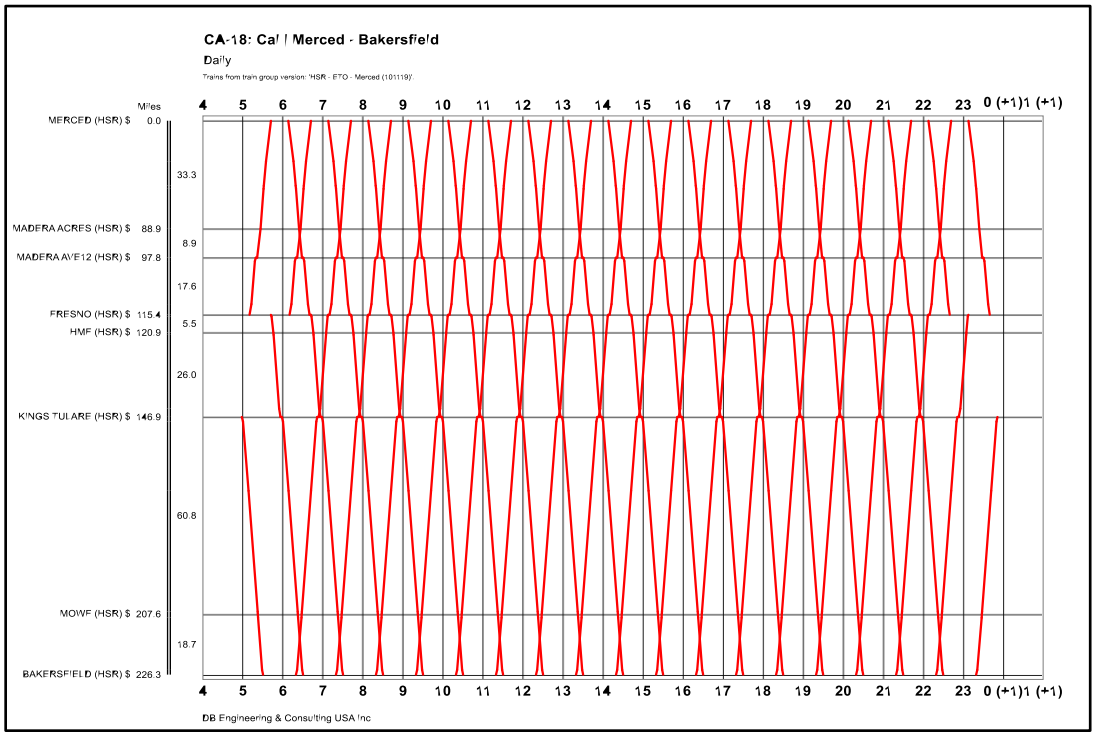


Figure 3-5: Stringline Chart of HSR Services Between Merced and Bakersfield

HSR Rolling Stock Requirement

Operating one train per hour per direction on the CVS HSR corridor will require six HSR trainsets:

- Four operational trains
- One train for operational reserve
- One train for maintenance

The capital cost for the rolling stock is included in the capital cost for the Merced and Bakersfield HSR extensions.

Train Miles

ETO summarized the annual train miles for the ACE, San Joaquin and bus services as well as for the HSR operation and used cost data from SJRRC and SJJPA to estimate the cost of the regional rail services. The HSR operations and maintenance cost was determined with a bottom-up calculation approach by the ETO

Bus Services

As part of the continued effort to develop an integrated service concept for CVS, the ETO has worked closely with SJRRC to create a working model for the bus connection network to optimize connectivity between HSR rail services and major markets in the state of California. The buses north of Merced will supplement conventional rail operations, while the buses south of Bakersfield will be the only transfer mode from HSR to the Southern California markets during the CVS operation.

With additional bus connections to the assumed train connections north of Merced, it is assumed there will be a service of 18 daily round trips between Merced and San Jose, 18 daily round trips between Merced and Oakland via Dublin-Pleasanton BART as well as 18 daily round trips between Merced and Sacramento. For Southern California, the developed bus connection network represents a focus on the Los Angeles market with the goal of offering a seamless journey to West Los Angeles, LA Union Station via Burbank and Pasadena/San Bernardino.

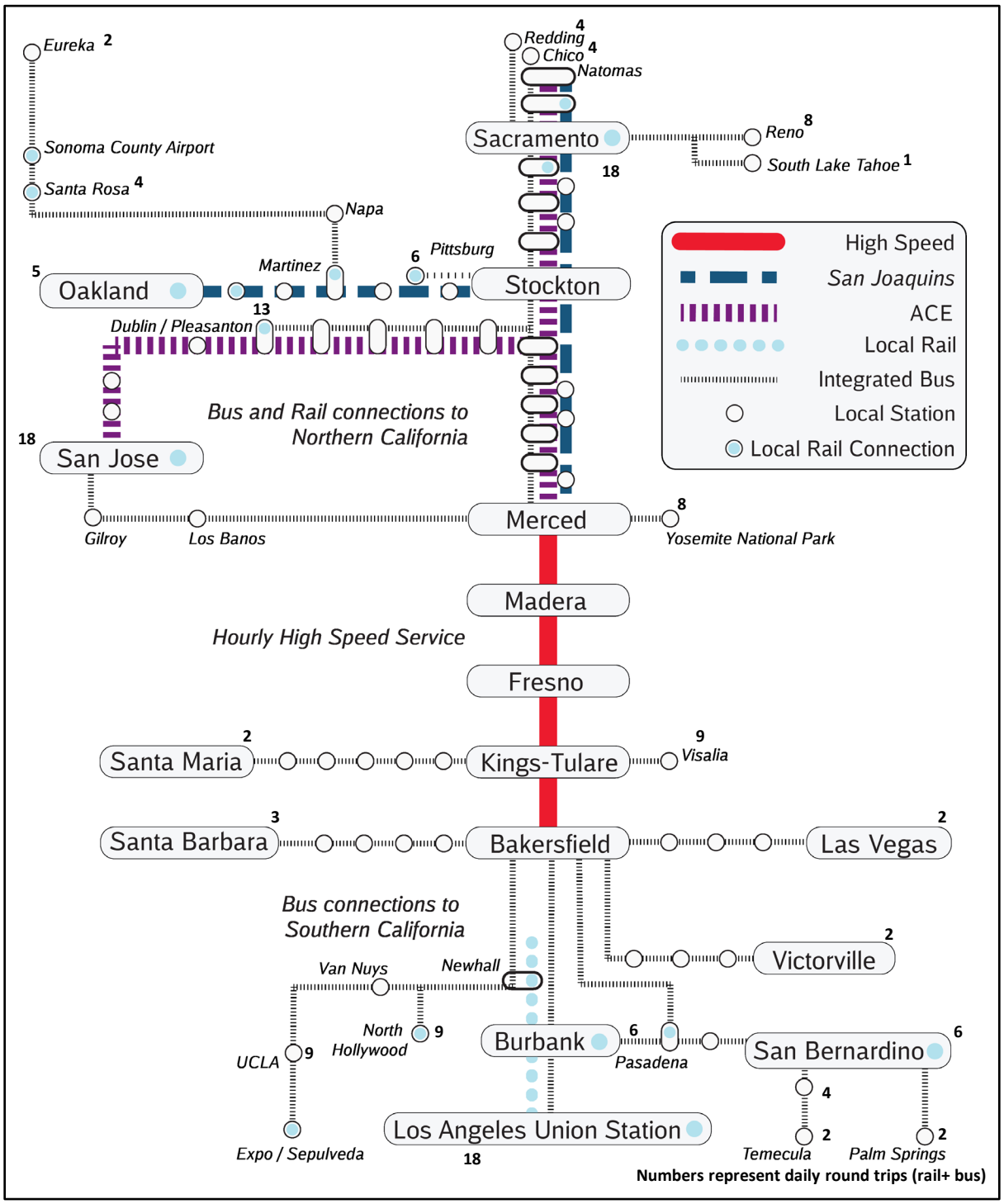


Figure 3-6: Central Valley Service Integration with Rail and Bus Connections to HSR

Connecting Bus services Northern California

Bus connections to HSR services at Merced:

- San Jose via Gilroy, Los Banos (17 PDPD)
- Dublin/Pleasanton BART (13 PDPD) for transfer to Oakland/San Francisco area
- Sacramento-Natomas (9 PDPD[7] [8])
- Yosemite National Park (8 PDPD) - An increment in bus services is assumed compared to today's services

Bus services from and to Sacramento

- Chico (4 PDPD)
- Redding (4 PDPD)
- Reno (8 PDPD) - An increment in bus services is assumed compared to today's services
- South Lake Tahoe (one PDPD)

Additional Bus Services

- Bus shuttle service is assumed between Stockton and Pittsburg/Bay Pt. to connect to BART
- Bus services from Martinez (San Joaquins) to Santa Rosa (4 PDPD) and to Eureka (2 PDPD)

Connecting Bus Services Southern California

Bus connections from and to HSR services at Bakersfield

- Los Angeles Union Station via Burbank Airport (18 PDPD)

[7] 5 of 9 connections have a transfer at Stockton from Oakland-bound San Joaquins trains
[8] 1 of 9 connections has a transfer at Manteca from San Jose-bound ACE train

- Newhall (18 PDPD) to connect to Metrolink and future additional train connections. From Newhall the buses will to continue to:
    - Expo Sepulveda via Van Nuys and Westwood-UCLA to connect to Expo Line (9 PDPD)
    - North Hollywood to connect to Metro Red Line (9 PDPD)
- Pasadena to connect to LA Metro Gold Line during peak period (6PDPD). These buses will continue to:
    - San Bernardino (6 PDPD) and to Riverdale (4 PDPD)/Temecula (2 PDPD) and Palm Springs (2 PDPD)
- Santa Barbara via Fillmore, Santa Paula, Oxnard, Ventura, Carpinteria as currently provided (3 PDPD)
- Victorville via Tehachapi, Mojave, Lancaster, Palmdale, Littlerock as currently provided (3 PDPD)
- Las Vegas via Barstow (2 PDPD)

Bus Connections to HSR at Kings/Tulare:

- Santa Maria via Lemoore, Kettleman City, Paso Robles, Atascaedro, San Luis Obispo, Groover Beach as currently provided (2 PDPD)
- Visalia (9 PDPD). An increment in bus services is assumed compared to today's services between Hanford and Visalia.

Additional Bus Services

- Bus shuttle service will be assumed from Burbank as additional service for the Pasadena area during off-peak period (6 PDPD)

These improved connections were also assumed in the travel demand modeling process and in the cost modeling to reflect ridership impacts and related cost increases.

3.3 SoCal Scenarios

ETO defined in discussions with stakeholders the following four scenarios and service plans:

- Scenario 1 (Figure 3-7) reflects the existing service plan (2017) and represents a reference point for the demand modeling at the future 2028 horizon to reflect a do-nothing situation. This scenario uses the existing infrastructure on the Southern California Metrolink and LOSSAN network. Service levels are the existing services in effect in 2019 with LAUS to Fullerton train counts at 84 passenger trains per day (Total of both directions).

- Scenario 2 (Figure 3-8) assumes additional infrastructure improvements to the network through the SCORE program and other TIRCP-funded projects. In this scenario a half-hourly peak-period service is assumed on all Metrolink lines except the Riverside Line. Service frequencies would be hourly or less during the off-peak periods. The scenario assumes the opening of two run-through tracks at LAUS as part of the Link US Program (Phase A) and 110 passenger trains per day (Total of both directions) are operating between LAUS and Fullerton.

- Scenario 3 (Figure 3-9) assumes that all high-speed rail infrastructure without Burbank Airport station or Anaheim station, no catenary or light maintenance facility, but without any HSR service on the corridor. In this scenario HSR investment provides significant capacity increases in the Burbank-LAUS–Fullerton sections and allows for increased regional service with upwards of 15-minute service headways in the study area of the SoCal corridor Burbank-LAUS-Anaheim. This scenario assumes additional run-through tracks at LAUS (Link US Phase B) to facilitate additional run-through service using the additional approach track capacity. In this scenario there are upwards of 140 trains per day operating in the section between LAUS to Fullerton.

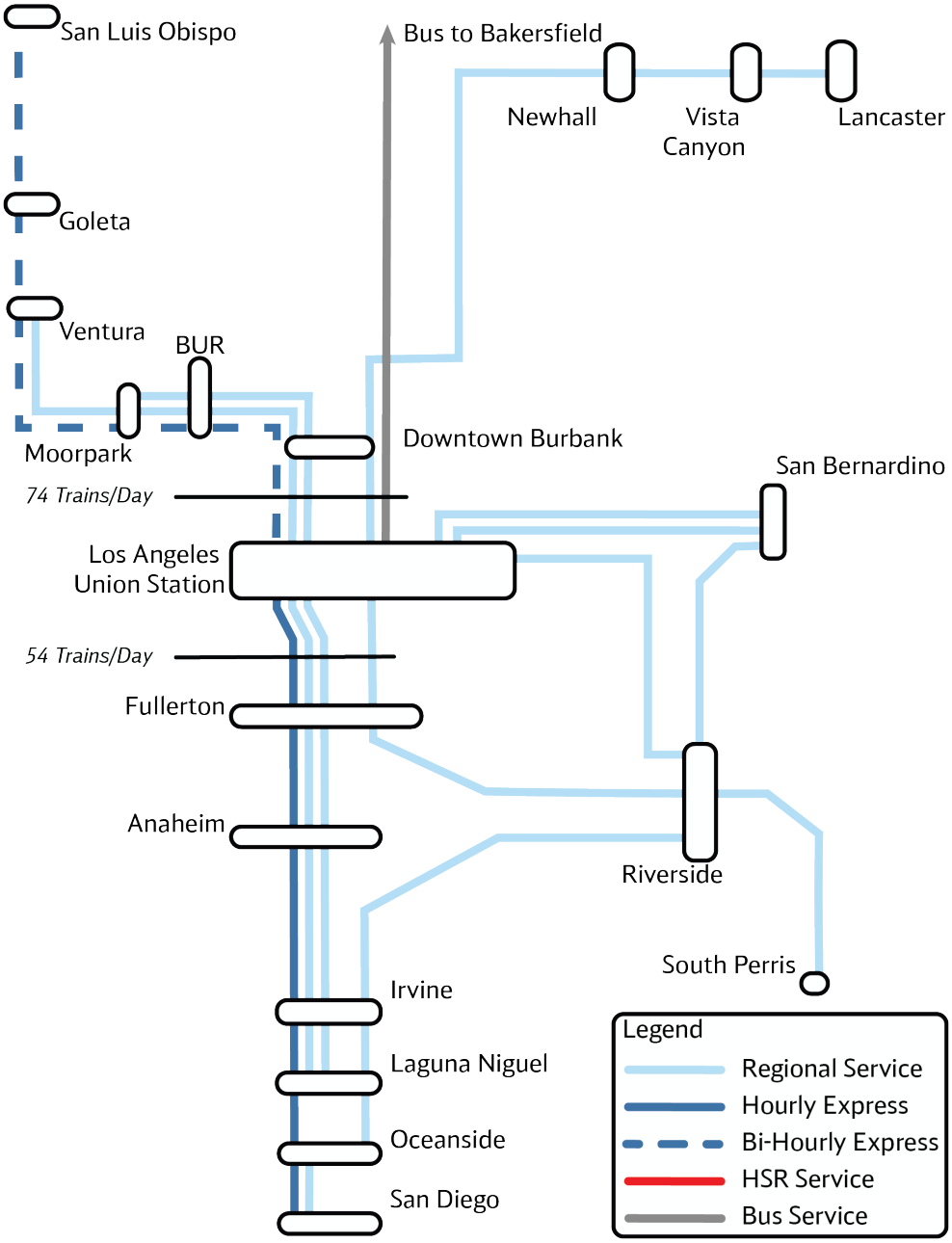
- Scenario 4 includes HSR service with 52 HSR trains per day in addition to the Scenario 3 service providing two trains per hour and per direction between Burbank Airport, LAUS, Fullerton and Anaheim (Figure 3-10). Additional HSR investment in this scenario includes the Burbank Airport station, the Anaheim HSR station improvements, overheard catenary to allow for operation of electric HSR equipment, high-level HSR platforms and a light

maintenance facility (LMF). In this scenario there would be 7 trains per hour in the study area of Burbank-LAUS-Anaheim with 192 trains operating between LAUS and Fullerton.

Table 3-2 below shows a comparison of the key differences of the four scenarios including the infrastructure assumptions, throughput in the Los Angeles – Fullerton section, levels of LAUS build-out as well as the service improvements.

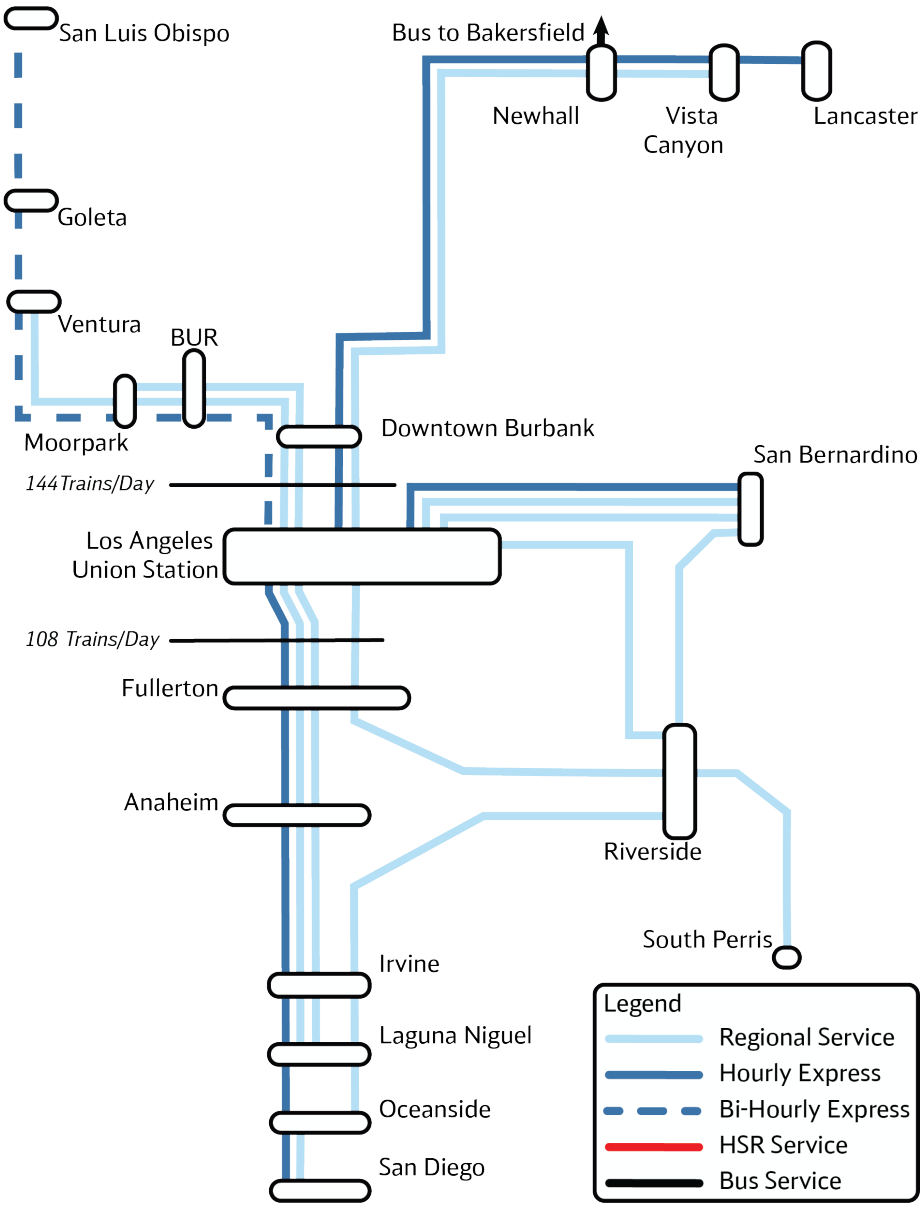
Scenario 1	Scenario 2	Scenario 3	Scenario 4
SoCal Baseline (2017)	SoCal Non-High-Speed Investment	SoCal High-Speed Investment (no HSR Service)	SoCal All High-Speed Investment (with HSR Service)
Existing infrastructure	SCORE TIRCP + Limited Additional Projects	HSR infrastructure (Burbank – Anaheim)	HSR service (Burbank -Anaheim)
LA–Fullerton: up to 84 trains / day	LA–Fullerton: up to 110 trains/day	LA–Fullerton: up to 140 trains / day	LA–Fullerton: up to 140 + 52 HSR trains / day
Existing LA Union Station	2 run-through tracks at LA Union Station	8/9 run-through tracks at LA Union Station	8/9 run-through tracks at LA Union Station
Existing service levels	Half-hourly peak regional service with express overlays	HSR investment allows for increased regional service	HSR between Burbank and Anaheim

Table 3-2: Service and Infrastructure Parameters of SoCal Scenarios



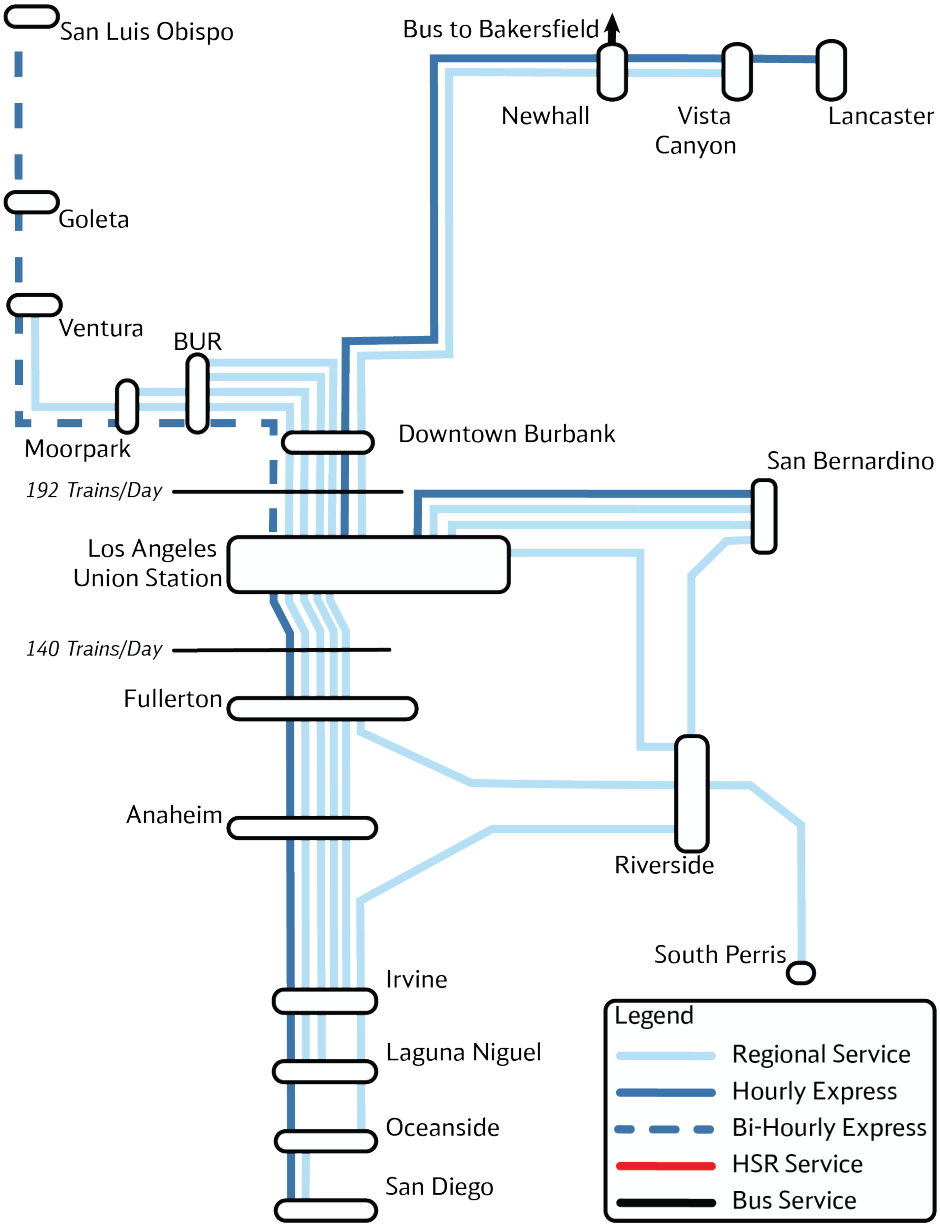
Note: Each line represents existing peak service corridors.

Figure 3-7: SoCal Scenario 1 Service (Existing)



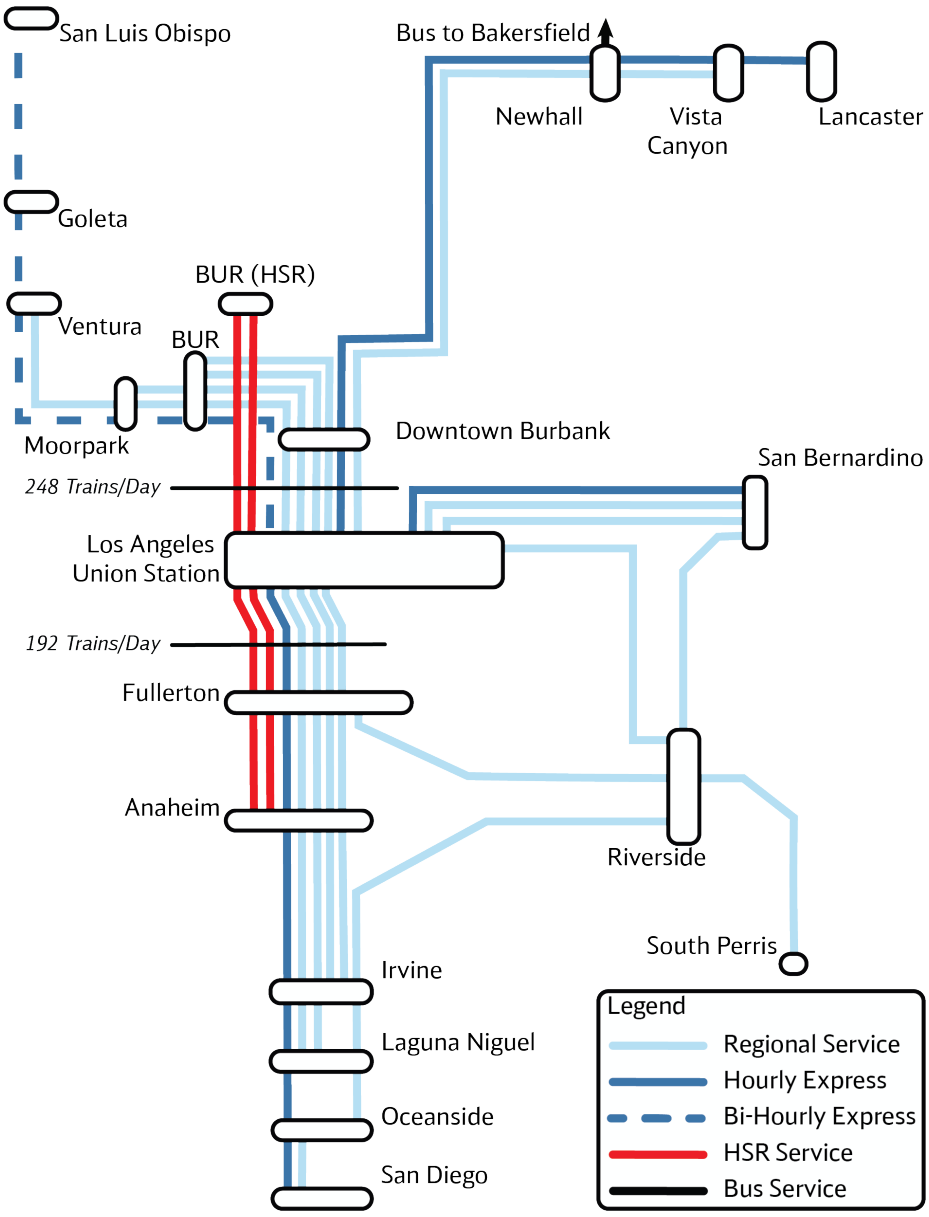
Note: Each line represents a generalization of peak service conditions (exceptions apply) .

Figure 3-8: SoCal Scenario 2 Service (Partial SCORE Implementation and Phase A of Link US)



Note: Each line represents a generalization of peak service conditions (exceptions apply) .

Figure 3-9: SoCal Scenario 3 Service (Initial HSR investment and Phase B of Link US)



Note: Each line represents a generalization of peak service conditions (exceptions apply) .

Figure 3-10: SoCal Scenario 4 Service (Full HSR investment and standalone HSR operation)

3.3.1 Corridor Throughput

Based on the service plan for each scenario ETO has derived a comparison of throughput capacity in the peak hour by direction in the trunk section of the SoCal corridor. Table 3-3 below shows the comparison of the number of trains per direction per hour assumed in each of the scenarios with regional or High-Speed Rail eligible investment. The data is shown for peak period and off-peak by direction.

Service Zone	Scenario 2 Peak	Scenario 2 Off Peak	Scenario 3 Peak	Scenario 3 Off Peak	Scenario 4 Peak	Scenario 4 Off Peak
Burbank to LA Union Station Express Trains	2 Express	1 Express	2 Express	1 Express	2 Express	1 Express
Burbank to LA Union Station Regional Trains	4 Regional	3 Regional	6 Regional	3 Regional	6 Regional	3 Regional
Burbank to LA Union Station HSR Trains					2 High-Speed	1 High-Speed
Burbank to LA Union Station Total Trains	6	4	8	4	10	5
LA Union Station to Fullerton Express Trains	1 Express	1 Express	1 Express	1 Express	1 Express	1 Express
LA Union Station to Fullerton Regional Trains	3 Regional	2 Regional	5 Regional	3 Regional	5 Regional	3 Regional
LA Union Station to Fullerton HSR Trains					2 High-Speed	1 High-Speed
LA Union Station to Fullerton Total Trains	4	3	6	4	8	5
Fullerton to Anaheim Express Trains	1 Express	1 Express	1 Express	1 Express	1 Express	1 Express
Fullerton to Anaheim Regional Trains	2 Regional	1 Regional	4 Regional	2 Regional	4 Regional	2 Regional

Service Zone	Scenario 2 Peak	Scenario 2 Off Peak	Scenario 3 Peak	Scenario 3 Off Peak	Scenario 4 Peak	Scenario 4 Off Peak
Fullerton to Anaheim HSR Trains					2 High-Speed	1 High-Speed
Fullerton to Anaheim Total Trains	3	2	5	3	7	4

Table 3-3: Comparison of Hourly Train Throughput in the SoCal Corridor

4 Ridership, Passenger Miles and Farebox Revenue Estimates

As outlined in the Methodology Section 1.4 of this report, ETO used the State Rail Plan demand-modeling framework to evaluate the ridership and revenue and passenger miles travelled (PMT) in each of the corridors and for each of the scenarios.

The model was run first for existing conditions for the base year and validated against existing count information. This step assured that the model represents reasonably well the existing conditions. The model was subsequently applied to the future year Scenarios in each of the corridors and reflects the specific service plan improvements.

In order to evaluate the impacts of the HSR-eligible investment in each of the corridors it is imperative to compare the differences of Scenarios 3 and 4 (HSR investment) against Scenario 2 that reflects the completion of regional committed and funded investments. While corridors might show high absolute numbers of ridership performance even in the baseline, the measurement of the performance versus the needed investment needs to be made based on the difference of investment versus Scenario 2.

The following sections provide both the absolute as well as the difference values to allow for a transparent review of the impacts of the HSR-eligible investment.

4.1 Annual Ridership, Revenue and Passenger Milles Travelled

The absolute annual estimates for revenue, ridership and passenger miles traveled are shown in the following Table 4-1. The ridership model provides average weekday data that was expanded to annual values using the existing relationships between weekday and annual data sets.

The following sections in this study describe the incremental impacts of the HSR-eligible and parallel regional investment in Scenarios 3 and 4 versus Scenario 2 that includes completion of committed regional projects.

Year	Description	Service	Annual Ridership (Millions) (*)	Annual Revenue (Millions of USD)	Annual Passenger Miles (Millions)
2028	NorCal **Scenario 1**	**Caltrain**	**23.5**	**118.4**	**564.4**
2028	NorCal **Scenario 2**	**Caltrain**	**27.1**	**138.0**	**660.4**
2028	NorCal **Scenario 3**	**Caltrain**	**27.6**	**142.9**	**678.8**
2028	NorCal Scenario 4	Caltrain	27.3	140.9	666.0
2028	NorCal Scenario 4	HSR	1.7	22.9	85.2
2028	NorCal **Scenario 4**	**Total**	**29.1**	**163.8**	**751.3**
2029	CVS Scenario 2	San Joaquin	1.8 unlinked	33.1	208.1
2029	CVS Scenario 2	ACE	2.2 unlinked	14.6	88.6
2029	CVS Scenario 2	Bus	0.9 unlinked	13.9	29.5
2029	CVS **Scenario 2**	**Total**	**4.0 linked**	**61.6**	**326.1**
2029	CVS Scenario 4	San Joaquin	3.1 unlinked	62.4	133.6
2029	CVS Scenario 4	ACE	4.6 unlinked	45.3	188.6
2029	CVS Scenario 4	Bus	2.1 unlinked	33.3	132.2
2029	CVS Scenario 4	HSR	2.0 unlinked	37.8	212.0
2029	CVS **Scenario 4**	**Total**	**8.8 linked**	**178.8**	**666.4**
2028	SoCal Scenario 1	LOSSAN	2.6	73.1	240.3
2028	SoCal Scenario 1	Metrolink	11.3	80.2	394.8
2028	SoCal **Scenario 1**	**Total**	**13.9**	**153.3**	**635.2**
2028	SoCal Scenario 2	LOSSAN	2.4	66.5	219.1
2028	SoCal Scenario 2	Metrolink	14.1	97.9	485.2
2028	SoCal **Scenario 2**	**Total**	**16.5**	**164.4**	**704.3**
2028	SoCal Scenario 3	LOSSAN	3.0	85.4	283.2
2028	SoCal Scenario 3	Metrolink	15.5	107.5	528.0
2028	SoCal **Scenario 3**	**Total**	**18.6**	**192.9**	**811.2**
2028	SoCal Scenario 4	LOSSAN	2.8	79.1	266.2
2028	SoCal Scenario 4	Metrolink	15.3	107.0	524.9

Year	Description	Service	Annual Ridership (Millions) (*)	Annual Revenue (Millions of USD)	Annual Passenger Miles (Millions)
2028	SoCal Scenario 4	HSR	0.9	8.4	21.1
2028	SoCal **Scenario 4**	**Total**	**19.0**	**194.4**	**812.2**

Notes: (*) In CVS the data by service represents unlinked trips, the totals are shown as systemwide linked trips. A linked trip that uses for example two systems is shown as two unlinked trips. Totals of unlinked trips therefore do not add to total of linked trips. Numbers by service in NorCal and SoCal are shown as linked trips but might not add exactly to system totals due to rounding.

Table 4-1: Annual Ridership Summary by Scenario

4.2 Incremental Annual Ridership Benefits

The CVS Scenario 4 provides the highest increase in both percentage and net increase of ridership benefits versus Scenario 2 of 4.8 million additional annual ridership (Figure 4-1), USD 117 million additional revenue (Figure 4-2) and 340 million annual passenger miles traveled (Figure 4-3). The significant ridership benefits are related to large travel time reductions (over 90 minutes for end-to-end trips on HSR, significant increases in service frequency for all travelers (from up to 7 roundtrips to up to 18 roundtrips) and an integrated connectivity concept with coordinated schedules in the CVS corridor.

In the NorCal corridor the HSR investment allows for additional capacity but doesn't provide further travel time benefits in Scenario 3. Scenario 4 with HSR operation provides moderate travel time benefits and additional frequency for HSR users only. Due to the length of the corridor the related service benefits are limited and therefore the ridership reaction is limited as well.

The SoCal ridership impact is slightly higher than the NorCal corridor since the relative frequency improvements that the HSR investment enables in SoCal are higher than in the NorCal corridor due to a lower base service in SoCal Scenario 2.

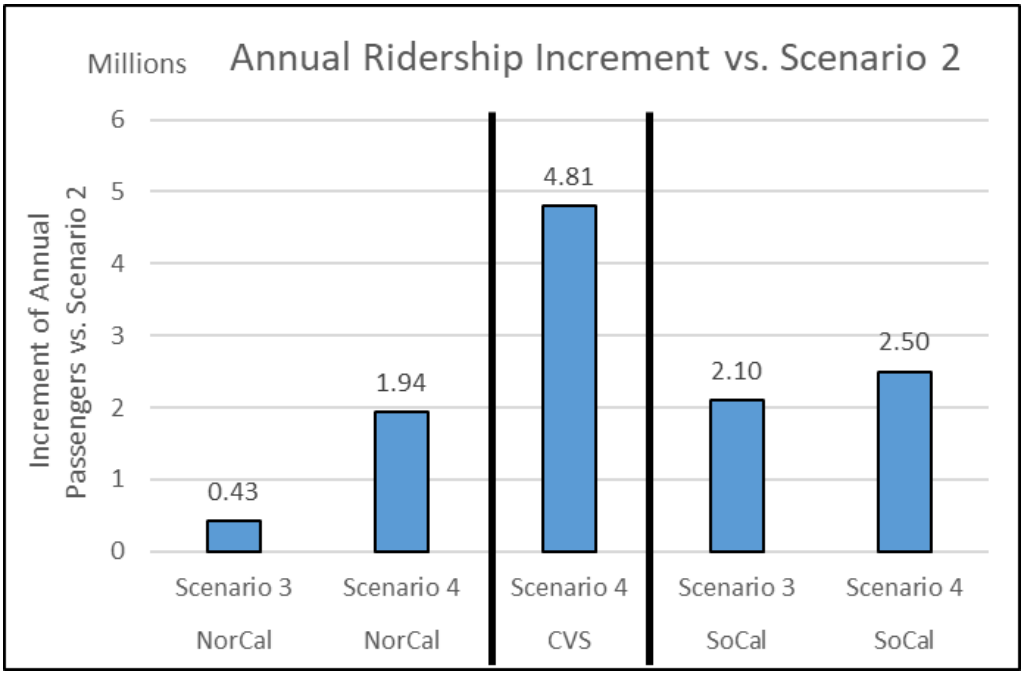


Figure 4-1: Change in Annual Ridership vs. Scenario 2

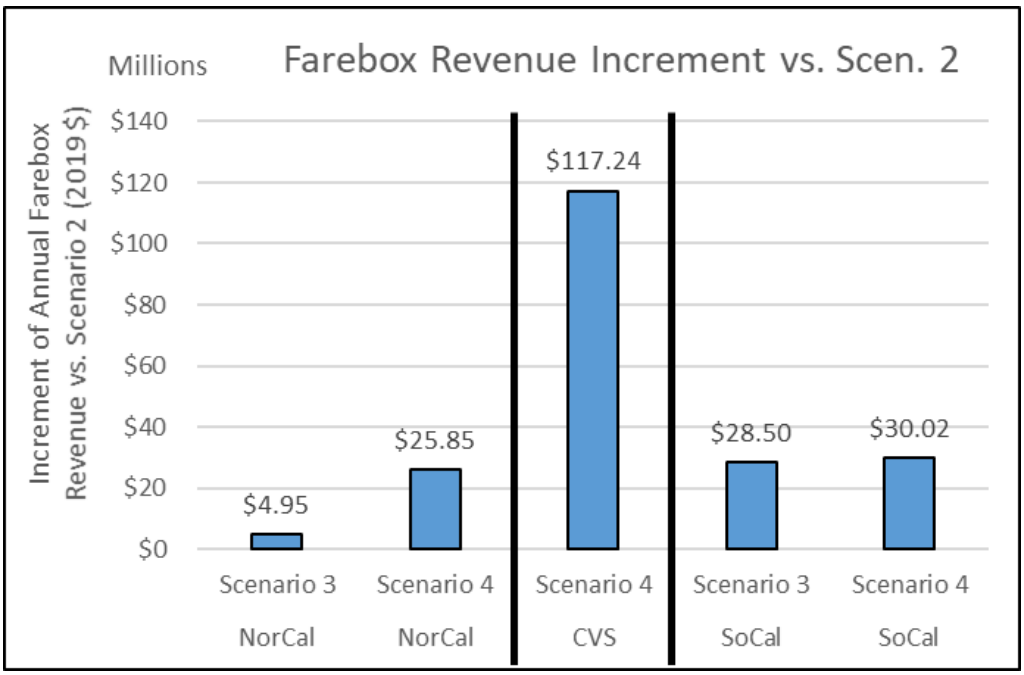


Figure 4-2: Change in Annual Revenue vs. Scenario 2

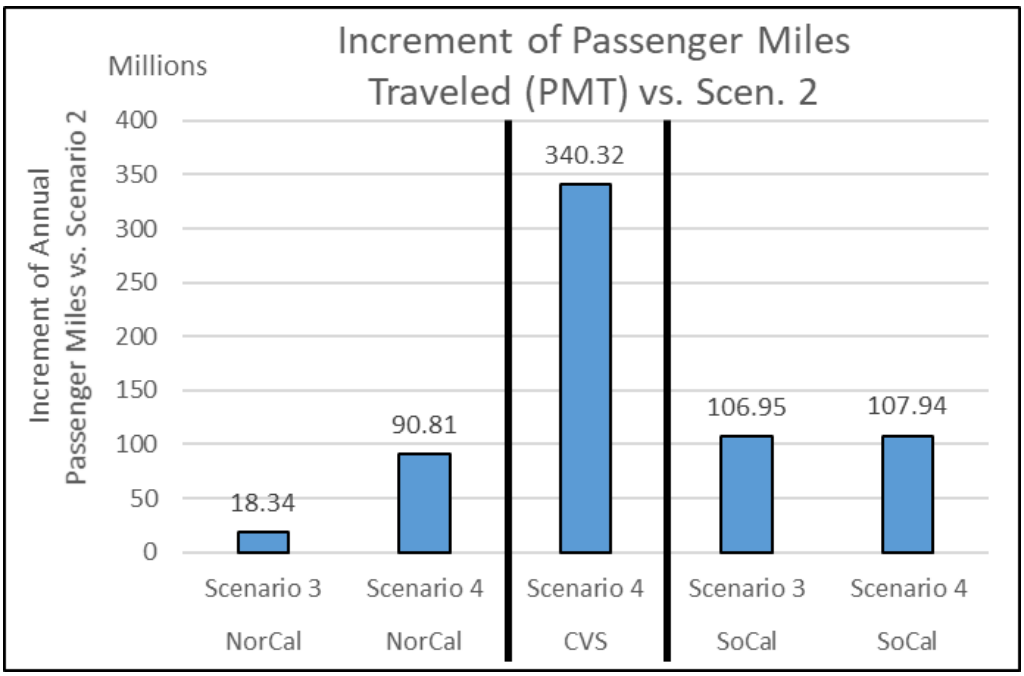


Figure 4-3: Change in Annual Passenger Miles Traveled (PMT) vs. Scenario 2

4.3 Summary of Ridership Performance

The ridership benefits of the investment are determined by the corridor-specific service improvements and the distinctively different travel markets that each of the corridor serves.

The following Table 4-2 summarizes the average distance per trip as well as the average revenue per passenger mile. The trip lengths in CVS are significantly longer than in the NorCal and SoCal corridors since the CVS service serves long-distance intercity rail passengers whereas the NorCal and SoCal corridors operate in shorter regional and commuter rail markets.

The Pacific Surfliner in SoCal also serves the long-distance intercity rail passengers but the overall market for this service is much smaller than the Metrolink market and the Anaheim – Burbank corridor investments do not provide significant benefits for Pacific Surfliner intercity passenger rail riders. The average distance travelled per passenger on the HSR service in the CVS is significantly higher in the CVS than in either the NorCal or SoCal corridor. This is an indicator that HSR operation only provides significant benefits in the CVS Scenario 4.

Year	Description	Service	Average Trip Length in Miles	Average Revenue Per Passenger Mile in USD
2028	**NorCal Scenario 1**	**Caltrain**	**24.0**	**0.210**
2028	**NorCal Scenario 2**	**Caltrain**	**24.3**	**0.209**
2028	**NorCal Scenario 3**	**Caltrain**	**24.6**	**0.211**
2028	NorCal Scenario 4	Caltrain	24.4	0.212
2028	NorCal Scenario 4	HSR	49.2	0.269
2028	**NorCal Scenario 4**	**Total**	**25.8**	**0.218**
2029	CVS Scenario 2	San Joaquin	117.0	0.159
2029	CVS Scenario 2	ACE	40.0	0.165
2029	CVS Scenario 2	Bus	32.0	0.470
2029	**CVS Scenario 2**	**Total**	**82.2**	**0.189**
2029	CVS Scenario 4	San Joaquin	43.0	0.290
2029	CVS Scenario 4	ACE	41.0	0.240
2029	CVS Scenario 4	Bus	63.0	0.252
2029	CVS Scenario 4	HSR	103.0	0.290
2029	**CVS Scenario 4**	**Total**	**75.9**	**0.268**
2028	SoCal Scenario 1	LOSSAN	92.3	0.304
2028	SoCal Scenario 1	Metrolink	34.9	0.203
2028	**SoCal Scenario 1**	**Total**	**45.6**	**0.241**
2028	SoCal Scenario 2	LOSSAN	90.7	0.304
2028	SoCal Scenario 2	Metrolink	34.5	0.202
2028	**SoCal Scenario 2**	**Total**	**42.7**	**0.233**
2028	SoCal Scenario 3	LOSSAN	93.0	0.301
2028	SoCal Scenario 3	Metrolink	34.0	0.204
2028	**SoCal Scenario 3**	**Total**	**43.7**	**0.238**
2028	SoCal Scenario 4	LOSSAN	96.6	0.297
2028	SoCal Scenario 4	Metrolink	34.3	0.204
2028	SoCal Scenario 4	HSR	23.5	0.397
2028	**SoCal Scenario 4**	**Total**	**42.8**	**0.239**

Table 4-2: Average Trip Length and Average Revenue by Passenger Mile by Scenario

5 Greenhouse Gas Benefits

The greenhouse gas (GHG) benefits were evaluated using the TIRCP GHG Analysis Tool and are based on information for each scenario describing the type of train miles provided as well as the reduction in auto vehicle miles traveled (VMT). The rail service was differentiated by type of equipment and propulsion system to reflect the GHG emissions change on both the supply side (train miles) and the demand side (passenger miles diverted to rail). The net difference by scenario is shown as reductions in metric tons of carbon dioxide (CO_2).

This Quantification Methodology and accompanying TIRCP Calculator Tool was developed for the California State Transportation Agency (CalSTA) Transit and Intercity Rail Capital Program (TIRCP) to provide methods for estimating the GHG emission reductions and air pollutant emission co-benefits of each proposed project by component.

5.1 Changes in Rail Service and Vehicle Miles Traveled

Based on the increase in passenger miles travelled (PMT) in each scenario, equivalent reductions in vehicle miles traveled (VMT) were derived by dividing the passenger miles by 1.2 to reflect the average vehicle occupancy. Table 5-1 below shows both parameters as well as the incremental change of PMT and VMT versus Scenario 2. This increment shows the impacts of the HSR-eligible investment on passenger travel performance. The following Figure 5-1 shows the difference in train miles as an indicator in the change of the supply of travel options, Figure 5-2 shows the change in passenger miles traveled versus Scenario 2 and Figure 5-3 shows the corresponding reduction in vehicle miles travelled.

Corridor	Scenario	Total Annual Train Miles (Millions)	Increase in Annual PMT vs. Scenario 2 (Millions)	Annual Passenger Miles Travelled (PMT) (Millions)	Increase in Annual PMT vs. Scenario 2 (Millions)	Reduction in Annual Vehicle Miles (Millions)	Reduction in Annual Vehicle Miles vs. Scenario 2 (Millions)
NorCal	Scenario 1	1.39	---	564.41	---	-470.34	---
NorCal	Scenario 2	2.24	---	660.44	---	-550.36	---
NorCal	Scenario 3	6.32	4.08	678.78	18.34	-565.65	-15.29
NorCal	Scenario 4	8.34	6.10	751.25	90.81	-626.04	-75.68
CVS	Scenario 2	7.11	---	326.13	---	-271.77	---
CVS	Scenario 4	14.67	7.55	666.44	340.32	-555.37	-283.60
SoCal	Scenario 1	4.69	---	635.17	---	-529.31	---
SoCal	Scenario 2	8.54	3.85	704.28	---	-586.90	---
SoCal	Scenario 3	9.40	4.70	811.24	106.95	-676.03	-89.13
SoCal	Scenario 4	10.23	5.54	812.23	107.94	-676.86	-89.95

Table 5-1: Annual Train Miles, Passenger Miles and Reduction of Vehicle Miles by Scenario

Based on the data, CVS provides the highest systemwide increase in train miles (Service offered) and also the highest increment in passenger miles (Demand). The increase also shows the best effectiveness of the addition of train miles with the higher than proportional increase in PMT.

The proportional increase in PMT is linked to the VMT that represents the congestion relief (VMT reduction) that is discussed in the next chapter. The highest efficiency between the additional offer (train miles) and the additional demand occurs in CVS Scenario 4 since this is the only scenario that benefits from true high-speed travel time savings and frequency increases.

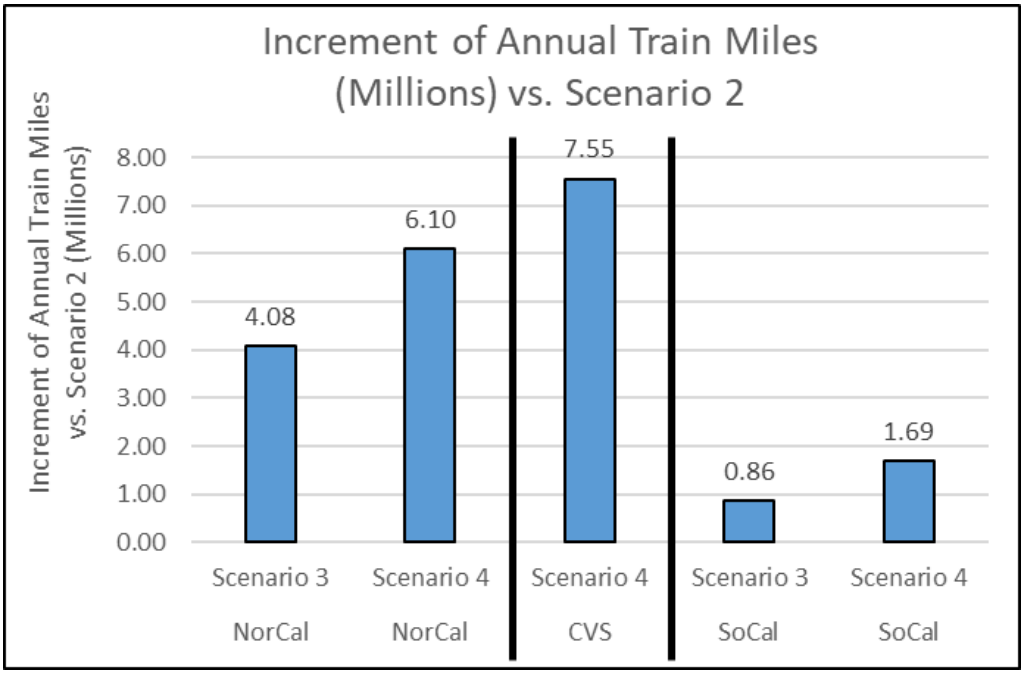


Figure 5-1: Increment of Annual Train Miles vs. Scenario 2

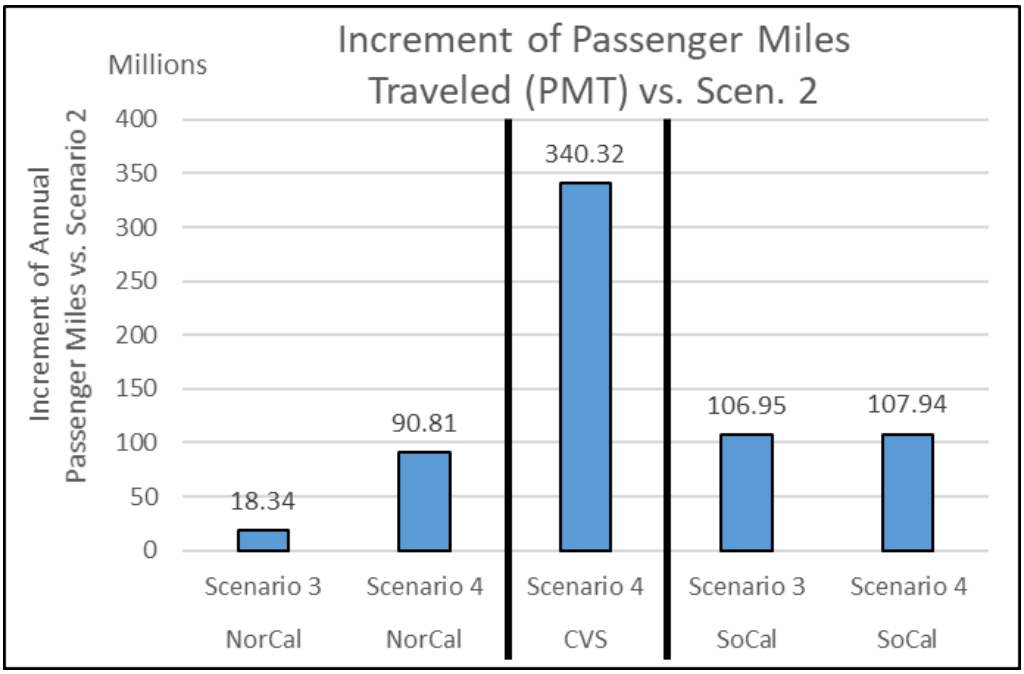


Figure 5-2: Increment of Annual Passenger Miles Traveled (PMT) vs. Scenario 2

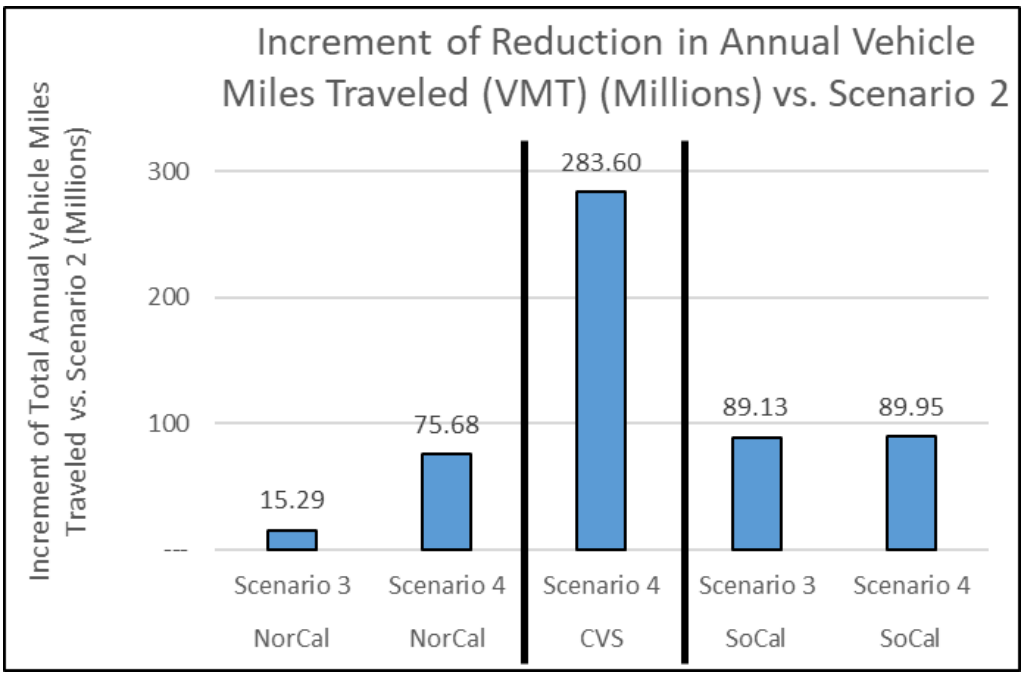


Figure 5-3: Increment of Reduction in Annual Vehicle Miles Traveled (VMT) vs. Scenario 2

5.2 Service Supply Miles and Propulsion Systems

In addition to the reduction of the auto vehicle miles it is necessary to quantify the change in service miles to determine the net difference in GHG emissions according to the ARB TIRCP calculation tool. The following tables describe the annual service miles by rolling stock type and what kind of propulsion system is proposed for these services. It is assumed that the proposed zero-emissions vehicle technology in SoCal is a true zero-emissions approach that is equivalent to using renewable electric energy.

Year	Scen.	Serv.	Total Annual Train Miles (Millions)	D1 BL5 set miles Diesel loco with 5 coaches	D1 BL6 set miles Diesel loco with 6 coaches	D1 BL7 set miles Diesel loco with 7 coaches	EMU BL6 set miles 6-car EMU (**)	EMU BL7 set miles 7-car EMU (**)	EMU BL8 set miles 8-car EMU (**)	EMU BL10 set miles 10-car EMU (**)	HSR Electric Train-Set 8-car EMU (*)
2028	**Scen.1**	**Caltrain**	**1.39**	**1.01**	**0.38**	**---**	**---**	**---**	**---**	**---**	**---**
2028	**Scen.2**	**Caltrain**	**2.24**	**---**	**0.05**	**0.05**	**---**	**2.13**	**---**	**---**	**---**
2028	**Scen.3**	**Caltrain**	**6.32**	**---**	**---**	**---**	**4.75**	**---**	**---**	**1.56**	**---**
2028	Scen.4	Caltrain	**6.32**	---	---	---	4.75	---	---	1.56	---
2028	Scen.4	HSR	**2.02**	---	---	---	---	---	---	---	2.02
2028	**Scen.4**	**Total**	**8.34**	**---**	**---**	**---**	**4.75**	**---**	**---**	**1.56**	**2.02**

Notes: (*) Assume full renewable electric energy mix for HSR operation.

(**) Caltrain has not yet stated the type of electricity sources past electrification.

The GHG analysis assumes typical average Bay Area electricity source mix.

Table 5-2: NorCal Annual Train Miles by Equipment and Propulsion Type

Year	Scenario	Service	Total Annual Train/ Bus Miles (Millions)	San Joaquin Diesel loco with 5 coaches	ACE Diesel loco with 6 coaches	Bus Connections Coach Bus (**)	HSR Electric Trainset 8-car EMU (*)
2029	Scenario 2	San Joaquin	1.57	1.57	---	---	---
2029	Scenario 2	ACE	0.21	---	0.21	---	---
2029	Scenario 2	Bus	5.34	---	---	5.34	---
2029	**Scenario 2**	**Total**	**7.11**	**1.57**	**0.21**	**5.34**	**---**
2029	Scenario 4	San Joaquin	1.05	1.05	---	---	---
2029	Scenario 4	ACE	0.55	---	0.55	---	---
2029	Scenario 4	Bus	10.86	---	---	10.86	---
2029	Scenario 4	HSR	2.22	---	---	---	2.22
2029	**Scenario 4**	**Total**	**14.67**	**1.05**	**0.55**	**10.86**	**2.22**

Notes: (*) Assume full renewable electric energy mix for HSR operation.

(**) Assumes bus operation with electric buses full renewable electric energy mix.

Table 5-3: CVS Annual Train and Bus Miles (Millions) by Equipment and Propulsion Type

Year	Description	Service	Total Annual Train Miles (Millions)	Metrolink Diesel loco with 5 coaches	Metrolink ZEV with 5 coaches (**)	LOSSAN Diesel loco with 6 coaches	HSR Electric Trainset 8-car EMU (*)
2028	Scenario 1	LOSSAN	1.73	---	---	1.73	---
2028	Scenario 1	Metrolink	2.96	2.96	---	---	---
2028	**Scenario 1**	**Total**	**4.69**	**2.96**	**---**	**1.73**	**---**
2028	Scenario 2	LOSSAN	2.61	---	---	2.61	---
2028	Scenario 2	Metrolink	5.93	---	5.93	---	---
2028	**Scenario 2**	**Total**	**8.54**	**---**	**5.93**	**2.61**	**---**
2028	Scenario 3	LOSSAN	2.61	---	---	2.61	---
2028	Scenario 3	Metrolink	6.79	---	6.79	---	---
2028	**Scenario 3**	**Total**	**9.40**	**---**	**6.79**	**2.61**	**---**
2028	Scenario 4	LOSSAN	2.61	---	---	2.61	---
2028	Scenario 4	Metrolink	6.79	---	6.79	---	---
2028	Scenario 4	HSR	0.84	---	---	---	0.84
2028	**Scenario 4**	**Total**	**10.23**	**---**	**6.79**	**2.61**	**0.84**

Notes: (*) Assume full renewable electric energy mix for HSR operation.

(**) Metrolink proposes to convert the entire fleet to Zero-Emissions Vehicles (ZEV) based on battery or hydrogen technology. The GHG analysis assumes electric operation with renewable energy.

Table 5-4: SoCal Annual Train Miles (Millions) by Equipment and Propulsion Type

5.3 GHG Benefits from Reduced Carbon Dioxide Emissions

Based on the auto VMT reductions and the train service mileage using the TIRCP ARB Calculator the emissions reductions were calculated for each of the corridors and scenarios and are shown as annual savings of metric tons of carbon dioxide in Table 5-5 below.

The following Figure 5-4 shows the resultant net difference versus Scenario 2 as annual savings of CO_2 and CVS Scenario 2 shows the highest annual reductions of 50,600 metric tons of CO_2 versus Scenario 2. As discussed earlier the main component of the reduction is due to the significant reduction of vehicle miles in CVS Scenario 4.

Corridor	Year	Scenario	Total Annual Train Miles (Millions)	Increment Vs. Scenario 2 (Millions)	Reduction of Annual Vehicle Miles Traveled (Millions)	Increment Vs. Scenario 2 (Millions)	Annual GHG Savings (Metric Tons CO2)	Increment Vs. Scenario 2 (Metric Tons CO2)
NorCal	2028	Scenario 1	1.39		0.00		---	---
NorCal	2028	Scenario 2	2.24		0.71		13,500	---
NorCal	2028	Scenario 3	6.32	4.08	4.10	3.40	38,200	24,600
NorCal	2028	Scenario 4	8.34	6.10	5.79	5.08	50,400	36,800
CVS	2029	Scenario 2	7.11		0.00		46,200	---
CVS	2029	Scenario 4	14.67	7.55	6.30	6.30	96,800	50,600
SoCal	2028	Scenario 1	4.69		0.00		---	---
SoCal	2028	Scenario 2	8.54		3.21		122,700	---
SoCal	2028	Scenario 3	9.40	0.86	3.92	0.71	135,000	12,300
SoCal	2028	Scenario 4	10.23	1.69	4.62	1.41	142,000	19,300

Table 5-5: Annual Train Miles, VMT Reductions and GHG Benefits by Scenario

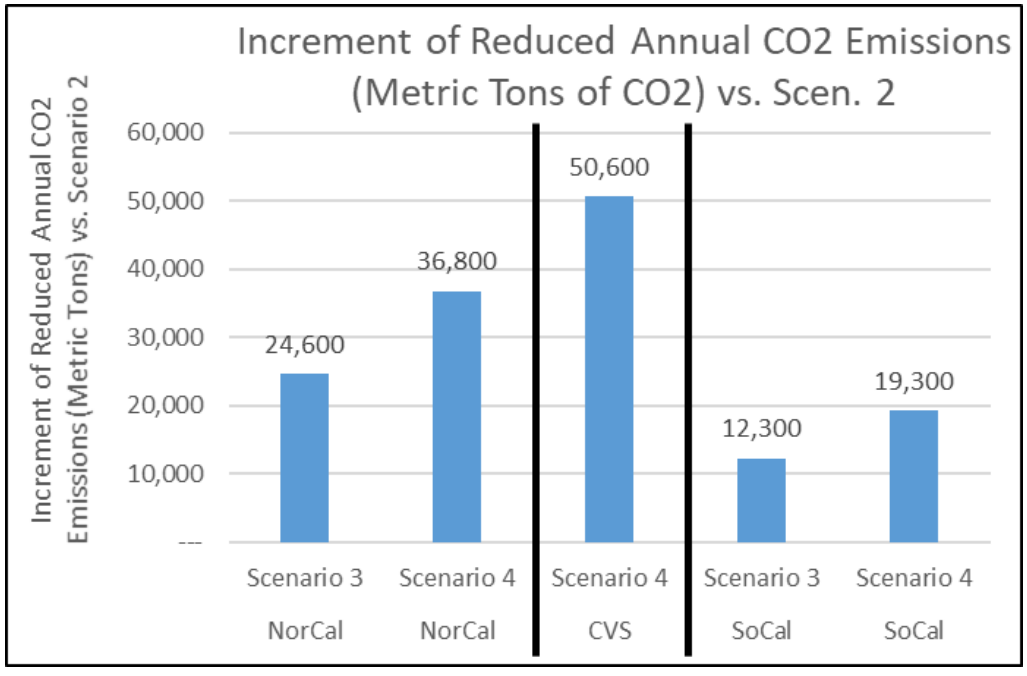


Figure 5-4: Reduction in Annual Greenhouse Gas (GHG) Emissions versus Scenario 2

6 Congestion Relief Benefits

Congestion relief was evaluated with three measures:

- Reduction in annual vehicle miles traveled (network-wide benefit); and
- Reduction in equivalent cars traveling in the roadway network (network-wide benefit).

The following chapters describe the resultant congestion relief benefits of the HSR-eligible investment expressed as differences versus Scenario 2.

6.1 Vehicle Miles Traveled (VMT)

The CVS Scenario 4 shows the highest vehicle miles reductions of 283 million miles per year as seen in Figure 6-1 below. The SoCal corridor shows about 90 million miles reduced and the NorCal corridor provides 76 million miles of reduced VMT versus Scenario 2. The high value in the central valley is caused by both the significant increase in ridership as well as the much longer travel distances of passengers as compared to the SoCal and NorCal corridors. These criteria show a network-wide view of the congestion relief benefits.

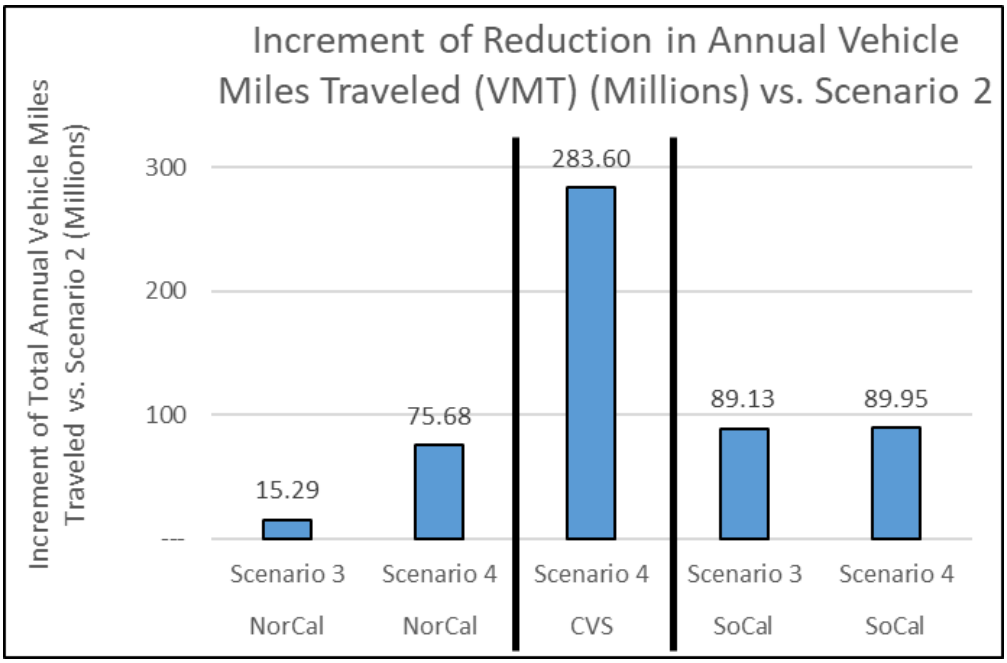
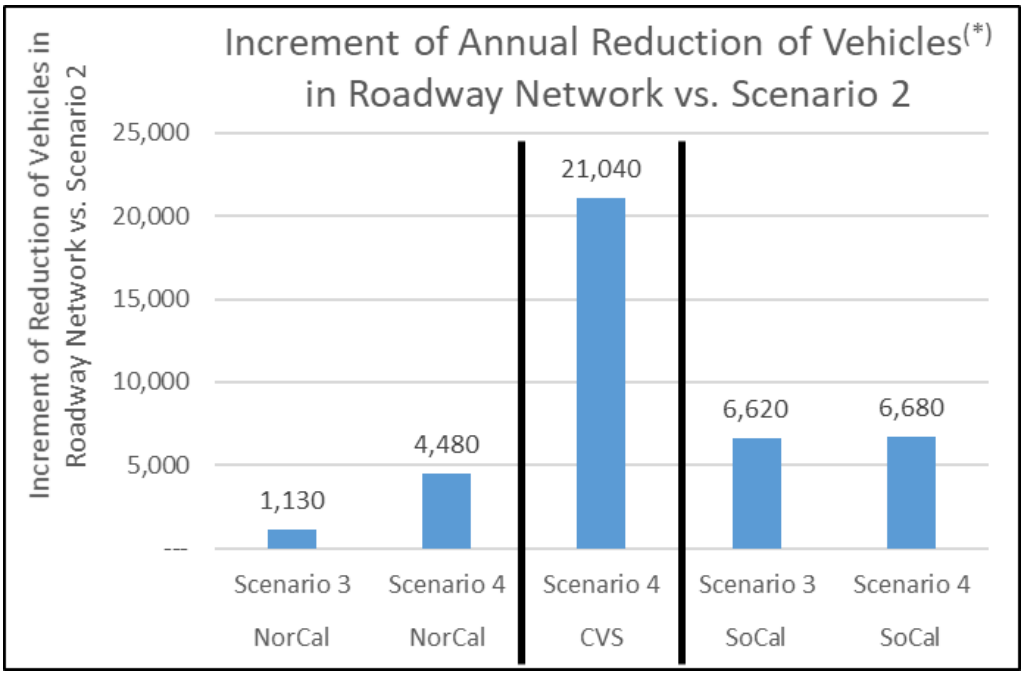


Figure 6-1: Reduction in Annual Vehicle Miles Traveled (VMT) vs. Scenario 2

6.2 Reduction of Number of Vehicles in Roadway System

In order to provide more understandable criteria for the VMT reduction, ETO provided a summary of the equivalent reduction of the number of vehicles travelling in the roadway network as shown in Figure 6-2 below. This parameter was derived by dividing the annual VMT reduction (expressed as difference versus Scenario 2) by the average mileage driven per driver (based on FHWA data 13,476 miles per year[9]). The resultant annual number of cars would not be driving in the network since passengers are diverted to rail services. Since the parameter is directly proportional to the VMT CVS also shows the highest reductions of 21,000 cars per year. These criteria show a network-wide view of the congestion relief benefits.



Note: (*) Assumes an average mileage per car of 13,476 miles per year.

Figure 6-2: Reduction in Annual Vehicles traveling in Roadway Network vs. Scenario 2

[9] Federal Highway Administration (FHWA), 13,476 miles driven per year per driver: https://www.fhwa.dot.gov/ohim/onh00/bar8.htm

7 Other Benefits

7.1 Near-Term Benefits of HSR Investment

One of the criteria to be developed by the scope of the Side-by-Side Study are early benefits of HSR-eligible investment if this investment spent in each of the corridors. The following paragraphs describe these early benefits for each corridor separately and given the needed investments for each scenario (see Section 9 below), it is evident the benefits can only be achieved in one corridor since the available funding is not sufficient to cover investment in two corridors let alone all three corridors.

NorCal

In NorCal the early HSR investment would complement a significant local investment and provide infrastructure for full electric operation of Caltrain to Gilroy (NorCal Scenario 3) with related GHG benefits. The HSR-eligible investment will prepare the corridor for future HSR operation, improve throughput capacity and increase train throughput above 6 trains per hour to at least 8 trains per hour and direction during the peak. The early operation of HSR service shows very limited benefits at a high operating cost and needs additional HSR investment but would add 2 additional trains per hour and direction.

Early investment could help advance planned other improvements in the corridor including the Diridon Station improvements, city-led grade separations and the Downtown Extension (DTX) in San Francisco to the Transbay Terminal. There are however significant funding needs by regional and local partners needed to implement these improvements and the HSR-eligible investment is only a small share of the overall total cost in the NorCal corridor[10].

[10] Caltrain Business Plan, Peninsula Corridor Joint Powers Board, Choosing a Long Range Vision, pages 52 through 56: https://caltrain2040.org/wp-content/uploads/Caltrain-BP-Service-Vision-Presentation.pdf

CVS

The HSR investment in the Central Valley Segment will establish full high-speed rail operation on 171 miles of the network and will help to gain valuable HSR operational experience at speeds of up to 220 mph. None of the other corridors can provide this build-up of know-how since the SoCal and NorCal standalone services would be operating in mixed service corridors within speed limits of conventional rail services (110 mph in NorCal and 110/125 mph in SoCal).

From a passenger's perspective the HSR service will result in significant reductions in travel times (100 minutes between Bakersfield and Merced, 90 minutes for connecting passengers) and significantly improve service frequency from currently 7 train pairs that are limited by the freight railroad capacity to 18 train pairs including connecting service.

This improvement in service will enable a transformation with state-wide implications. The end-to-end distance of the HSR service and the connecting corridors is in the range of 400 plus miles and will provide statewide connectivity.

Due to this long extend of where benefits will materialize the CVS Scenario 4 shows the highest VMT reductions and GHG benefits that are crucial to improving the air quality in the Central Valley. The continued investment will also help to maintain the economic benefits of the ongoing HSR investment in an area that relies on economic development form the construction spending and the future operation of the HSR services.

SoCal

The benefits of early HSR investment in SoCal are related to preparing the corridor for future HSR operation, it significantly improves track capacity and increases train throughput above current levels. In Scenario 3 the daily throughput would increase from currently 84 trains per day to up to 140 trains per day. With HSR standalone operation that throughput would increase to 192 trains.

The HSR investment would enable a connection to Link US Phase B and utilize the higher station capacity with additional service. The full added capacity however would only be utilized after the connection to the HSR system in Phase 1 is implemented.

In the section between Los Angeles Union Station and Fullerton the HSR investment will allow the separation of passenger trains from freight trains between CP Soto and Fullerton and increase operational flexibility and increase reliability for either service since two separate freight and passenger tracks are established. Phase B of Union Station is currently not funded, so a timely parallel investment by the regional partners is necessary to achieve the benefits from the HSR investment.

7.2 Estimated Completion Dates

Based on the ongoing regional improvements in each of the corridors, the proposed completion of the investments of Scenario 2 in each of the corridors and the expected HSR investment volume the following estimated implementation timeframes are expected:

- NorCal: HSR investment after electrification is completed – implemented by 2028
- CVS: HSR implementation Merced – Bakersfield completed November 2028
- SoCal: HSR investment after SCORE initial investment is completed – HSR investment completed in Phases by 2033 (Scenario 3) and by 2040 (Scenario 4). Sequential implementation assumed due to consideration that investment is implemented while operating the regional rail system in the corridor.

The following Figure 7-1 shows a graphical representation of the implementation time lines and the sequencing of the investment. The midpoint of construction was used for NorCal and SoCal HSR investment to provide year-of-expenditure (YOE) capital cost estimates.

The demand modeling assumes the same 2028/2029 horizon to make the ridership estimates comparable between the different corridors. It is important to note that the implementation for certain scenarios will likely not be completed until much later than the 2028/2029 horizon.

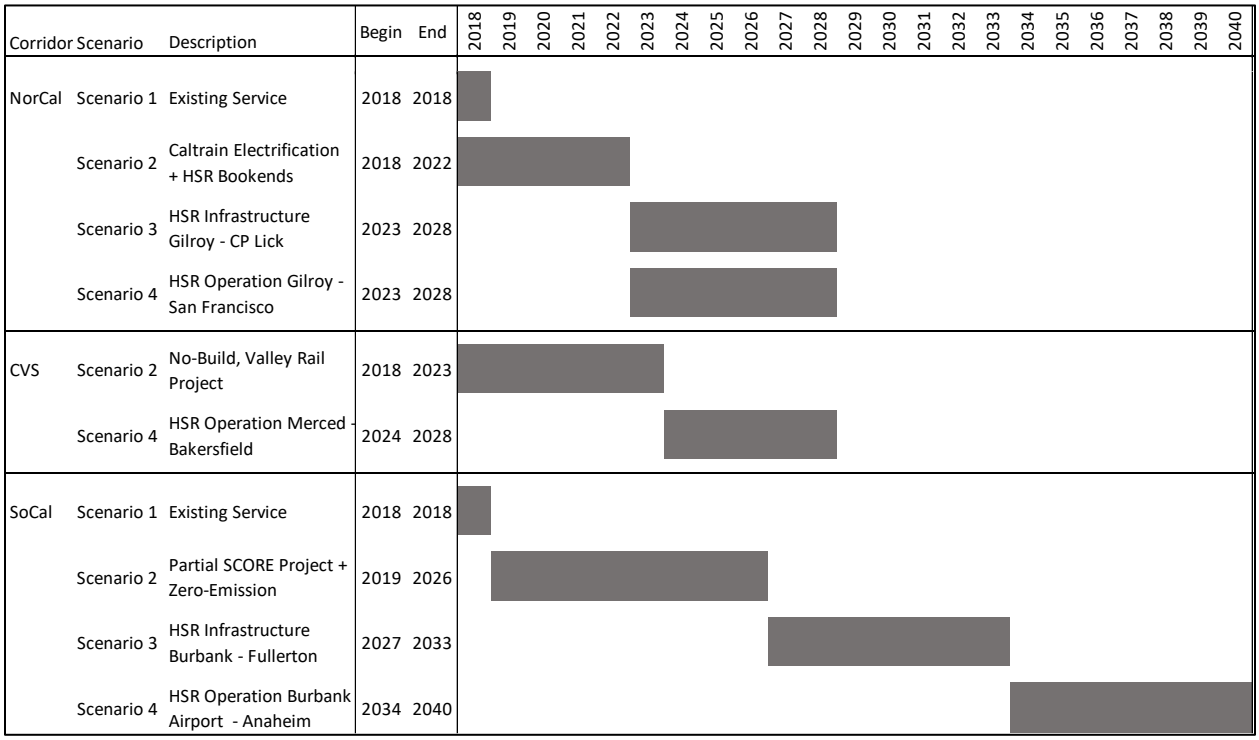


Figure 7-1: Estimated Implementation Schedule of Regional and HSR Investment

7.3 Potential for Private Investment

For development of large infrastructure projects, generally private sector investment is either made in parallel to developing the infrastructure project outside of the actual project (e.g. transit-oriented development or real estate development over or alongside the rail corridor) or in the process of the corridor development where a private sector entity might provide funding (public-private partnership (PPP) project) to develop the corridor and the public sector gets compensated in form of availability payments or via another financial structure of such a development project. A third way can be private sector interests in developing a rail corridor to provide benefits to that private entity that could co-sponsor the development of the corridor. However, at completion of this study ETO is not aware of concrete plans or commitments by private sector entities to sponsor or co-fund any improvements related to an HSR investment in any of the three corridors.

NorCal

In the NorCal corridor the proposed Diridon Station improvements that would coincide with the HSR investment could include private sector investment that would develop property around the station. Such investment could foster future travel demand due to increase employment and housing opportunities around the station but would typically not provide direct funding to the rail corridor.

A similar situation would occur when the Transbay Terminal / Downtown Extension is developed where such future improvements to connectivity could trigger private investment. This extension is not assumed in study due to the implementation horizon that is beyond the initial HSR investment in the NorCal corridor.

The Millbrae Station could have a component of private sector development as well. Especially the proximity to the Airport in San Francisco could increase the potential of such an investment. Similar to the Diridon Station, such investment could increase future travel demand due to an increase in employment and housing opportunities, but the private partner would not provide direct funding to the rail corridor.

CVS

In the CVS corridor private sector investment could be made around station-area development but is likely to occur after the operation of HSR service has started since the densities around the future HSR stations in this corridor are much lower than the ones in the urbanized SoCal and NorCal corridors.

SoCal

Similar to the NorCal corridor Link US Phase B could include private sector investment in the SoCal corridor in form of an overbuild development in conjunction with the development of Union Station. The SoCal region is working frequently with alternative delivery methods for infrastructure projects and therefore such a regional investment project could trigger private sector involvement in form of a PPP project.

HSR investment in the Burbank Airport Station and Anaheim Station could initiate further private sector investment around the station to take advantage of the added connectivity and related potential opportunities for private investment. However, at the point of completion of this report no concrete plans or intentions have been made public for any of the corridors.

7.4 Potential for Local Matching Funds

Based on publicly available information and discussions with stakeholders, the following matching funding opportunities were identified.

NorCal

The Caltrain Business Plan assumes city-led grade separations with an estimated cost of USD 6.8 billion. These improvements will likely occur over time to mitigate the increased closure times of rail crossings with an increase train frequency. There will also be local funds needed contributing to the Diridon Station improvements.

CVS

After implementation of HSR service, station-area development related efforts and further integration of transit operations could trigger local investment. In Scenario 4 SJRRC/SJJPA anticipate further contributions towards an integrated rail system. The exact funding amounts and sources of funding still need to be determined.

SoCal

In the SoCal corridor station-area development and integration could trigger local investment in the corridor to optimize transit connections and other land-side station access improvements. Metrolink proposed conversion of the system to zero-emissions vehicle (ZEV) technology (Scenario 2) that will likely require additional local funding as well as the completion of Phase B of the Link US project.

In order to maximize benefits in the entire Metrolink network after the HSR investment between Burbank and Anaheim it is necessary to invest into the branches to increase track capacity and

frequency in these sections. While such improvements were not included in Scenarios 3 or 4, local co-funding would be needed to implement such further improvements.

ETO is not aware of specific funding agreements and commitments from local partners at completion of the study in any of the corridors beyond of the funded and committed projects assumed in Scenario 2 of this study.

8 Operations and Maintenance Cost

The operations and maintenance (O&M) costs for each scenario are calculated separately for the regional rail service as well as the standalone HSR service (Scenario 4) in each of the study corridors. The estimates for regional services are based on either readily available information from the Caltrain business plan, input provided by SJRRC and SJJPA as well as published information from annual reports of Metrolink and LOSSAN rail operations.

The CVS study used a bottom-up approach to calculate operations and maintenance costs for the HSR infrastructure, the HSR rolling stock and the operation of HSR services. This data set was used to estimate similar costs in the NorCal and SoCal corridors prorated based on train miles for operational O&M cost and centerline track miles for infrastructure O&M cost.

8.1 O&M Cost NorCal Scenarios

The operations and maintenance costs by scenario in the NorCal corridor reflect the data from the Caltrain Business Plan. Scenario 3 also includes the lease fees the Authority would charge to Caltrain for using the new electrified section from CP Lick to Gilroy. This cost will be charged to cover the track & systems maintenance contract expenses and was calculated based on the CVS approach and prorated with the centerline miles between CP Lick and Gilroy. In Scenario 4 the HSR O&M cost also includes the operations and maintenance cost for the HSR rolling stock while the operation is assumed to be carried out by Caltrain taking on the role of the operator for such a standalone HSR service. This assumption mirrors the commercial model that is assumed in the CVS corridor.

8.2 O&M Cost CVS Scenarios

In the CVS corridor the Side-by-Side Study utilized the estimates that were derived from the updated Central Valley segment study. A detailed description of the datasets and methodology to derive these cost estimates can be found in Chapter 3 of the Updated CVS Report.

The O&M cost for the CVS Scenario 2 assumes the implementation of the Valley Rail Project and related service assumptions and improvements. The cost data was provided by SJRRC and

SJJPA. The cost for the initial operation of HSR between Merced in Bakersfield in Scenario 4 was calculated by the ETO with a bottom-up approach. The cost for the optimized connecting rail and bus services of the ACE and San Joaquin rail services was provided by SJRRC and SJJPA and ETO respectively. The overall cost estimates for Scenario 4 reflect a 30% efficiency gain in overhead costs due to a consolidated operation of three different services and related savings in administrative costs and expected operational efficiencies.

8.3 O&M Cost SoCal Scenarios

The service plans outlined in Section 3.3 above were used as a basis to determine rolling stock requirements for the Metrolink and LOSSAN services. In lieu of detailed services plans, which were not available for each scenario, current Metrolink and LOSSAN operating figures were used as a basis to derive rolling stock needs in Scenarios 2, 3, and 4.

The existing annual train miles for the Metrolink System in Scenario 1 were sourced from Exhibit 3.1a of the Southern California Regional Rail Authority (SCRRA) Fiscal Year 2019-2020 Budget adopted June 28, 2019[11].

Train count information for Metrolink in Scenario 1 was sourced from the Metrolink Timetable Effective April 8, 2019 and in effect on all lines within the Metrolink system[12].

Trainset counts for each line were sourced from the Metrolink crew and equipment cycle sheets effective April 8, 2019. Metrolink equipment does not solely operate on one line within the system. We calculated values for each line based on the amount of consists needed to operate the service levels only on the one line and without intermixing with other Metrolink services. The total number

[11] Southern California Regional Rail Authority (SCRRA), Fiscal Year 2019-20 Proposed Budget (Including Forecast for FY2020-21 thru FY2023-24), Source: https://metrolinktrains.com/globalassets/about/board/for-posting---fy2019-20-budget-book.pdf

[12] Source: https://metrolinktrains.com/globalassets/schedules/singles_mlk_lft_alllines_19_10_14.pdf

of consists in Scenario 1 is equal to the 40 daily consists Metrolink had in service in the April 8, 2019 consist sheet.

These figures do not include equipment in maintenance facilities for planned and unplanned mechanical inspection, nor does it include additional equipment kept in reserve to aid in unplanned service interruptions.

8.3.1 Equipment Needs

Using the weekday train miles, and the number of consists used to provide service an “Average Miles Per Consist” figure was derived that indicated the number of revenue miles a train consist would be active on a given service day. Due to the varying length, trip time, and service levels on each line in the Metrolink system, this number was calculated on a line by line basis. This average was used subsequently applied in Scenarios 2, 3, and 4 to calculate the equipment requirements for the increased service levels on each line in the Metrolink system.

Currently most Metrolink services operate during the peak travel periods of the morning and evening rush hours. As a result, significant portions of the Metrolink fleet is idle during the day between these service periods. Scenarios 2, 3, 4 envision elevated service levels that would offer more all-day service levels on most Metrolink lines. However, no assumptions were made on the opportunities for increased utilization of equipment in these scenarios. Rolling stock needs are based on the average train miles per consist from Scenario 1 and reflect peak period requirements.

While there may be opportunities for higher equipment utilization, it would require more detailed analysis and service planning that is outside of the scope of this study. To reflect these efficiencies from a cost perspective, ETO applied the same efficiencies that Caltrain highlights in their Business Plan to the SoCal Scenarios 2, 3 and 4. This approach was chosen since no detailed data was available from the operators for the SoCal operating Scenarios 2, 3 and 4.

Calculations for Pacific Surfliner services (LOSSAN) were based on the Amtrak train schedule in effect October 14, 2019[13]. Due to differing service levels north and south of Los Angeles Union Station, train counts and consist needs are broken out between North and South. The same methodology for developing an average daily train mile per consist.

Each Metrolink consist was assumed to consist of one locomotive and five unpowered coach cars. Each LOSSAN consist was assumed to consist of one locomotive and six unpowered coach cars. No assumptions were made for cars providing food service on LOSSAN services.

Additional rolling stock is necessary to allow for periodic planned and unplanning maintenance activities and to protect service. An assumption of 10% spare equipment ratio was used for both Metrolink and LOSSAN services.

The SoCal cost estimates for operation and maintenance are based on existing published information and are prorated by train miles for each scenario. The assumed conversion of the entire Metrolink service in Scenario 2 to zero-emissions vehicle (ZEV) technology is assumed to be cost-neutral from a unit cost perspective as compared to today's diesel operations. As discussed above ETO assumed similar efficiency gains in Scenarios 2, 3 and 4 as compared to Caltrain's cost estimates in the NorCal corridor to enable a transparent comparison.

8.4 O&M Cost Summary

The following Table 8-1 shows a comparison of the annual operations and maintenance costs for regional services in each of the corridors and scenarios as well as the O&M cost for HSR infrastructure and operation. All values are calculated in 2019 Dollars and are based on the information available at completion of this report and the cost estimation process escribed above.

[13] Source: https://www.pacificsurfliner.com/globalassets/pdfs/schedules/2019-pacific-surfliner-schedule-10october.pdf/

Corridor	Scenario	Total Annual Train Miles (Millions)	Regional Rail Annual Operating Cost Estimates (Millions 2019 USD)	HSR Operating Cost Estimates (Millions 2019 USD)	Total Annual Operating Cost Estimates (Millions 2019 USD)
NorCal	Scenario 1	1.39	136.73	---	136.73
NorCal	Scenario 2	2.24	190.87	---	190.87
NorCal	Scenario 3	6.32	366.68	3.72	370.40
NorCal	Scenario 4	8.34	366.68	58.51	425.19
CVS	Scenario 2	7.11	144.80	---	144.80
CVS	Scenario 4	14.67	132.34	104.72	237.06
SoCal	Scenario 1	4.69	386.57	---	386.57
SoCal	Scenario 2	8.54	603.70	---	603.70
SoCal	Scenario 3	9.40	610.08	---	610.08
SoCal	Scenario 4	10.23	610.08	49.50	659.58

Table 8-1: Summary of Service Miles and O&M Cost for Regional and HSR Service

The total annual O&M cost was then compared against the annual farebox revenue and the ancillary revenue for each scenario and a subsidy requirement is derived for each scenario. The resultant subsidy requirements are shown in Table 8-2. CVS provides the highest reduction in subsidy requirements – USD 28.76 million without consideration of Low Carbon Fuel Standard (LCFS) credits which could further reduce the subsidy by USD 12.7 million. The following Figure 8-1 shows the corresponding graphical representation of the O&M cost, fare box and ancillary revenue and subsidy requirement by scenario.

Corridor	Scenario	Total Annual Operating Cost Estimates (Millions 2019 USD)	Annual Farebox Revenue Estimates (Millions 2019 USD)	Annual Other Revenue (Less LCFS Credits) (Millions 2019 USD)	Estimated Farebox Recovery Ratio (Percent)	Subsidy Requirement before Depreciation and Amortization (Millions 2019 USD)
NorCal	Scenario 1	136.73	118.43	12.71	87%	-5.58
NorCal	Scenario 2	190.87	137.95	12.71	72%	-40.20
NorCal	Scenario 3	370.40	142.90	12.71	39%	-214.79

Corridor	Scenario	Total Annual Operating Cost Estimates (Millions 2019 USD)	Annual Farebox Revenue Estimates (Millions 2019 USD)	Annual Other Revenue (Less LCFS Credits) (Millions 2019 USD)	Estimated Farebox Recovery Ratio (Percent)	Subsidy Requirement before Depreciation and Amortization (Millions 2019 USD)
NorCal	Scenario 4	425.19	163.80	12.71	39%	-248.68
CVS	Scenario 2	144.80	61.59	---	43%	-83.21
CVS	Scenario 4	237.06	178.83	3.77	75%	-54.45
SoCal	Scenario 1	386.57	153.32	41.98	40%	-191.26
SoCal	Scenario 2	603.70	164.43	41.98	27%	-397.29
SoCal	Scenario 3	610.08	192.94	41.98	32%	-375.16
SoCal	Scenario 4	659.58	194.45	41.98	29%	-423.15

Table 8-2: Annual O&M Cost, Revenues, Farebox Recovery Ratio and Subsidy Requirements

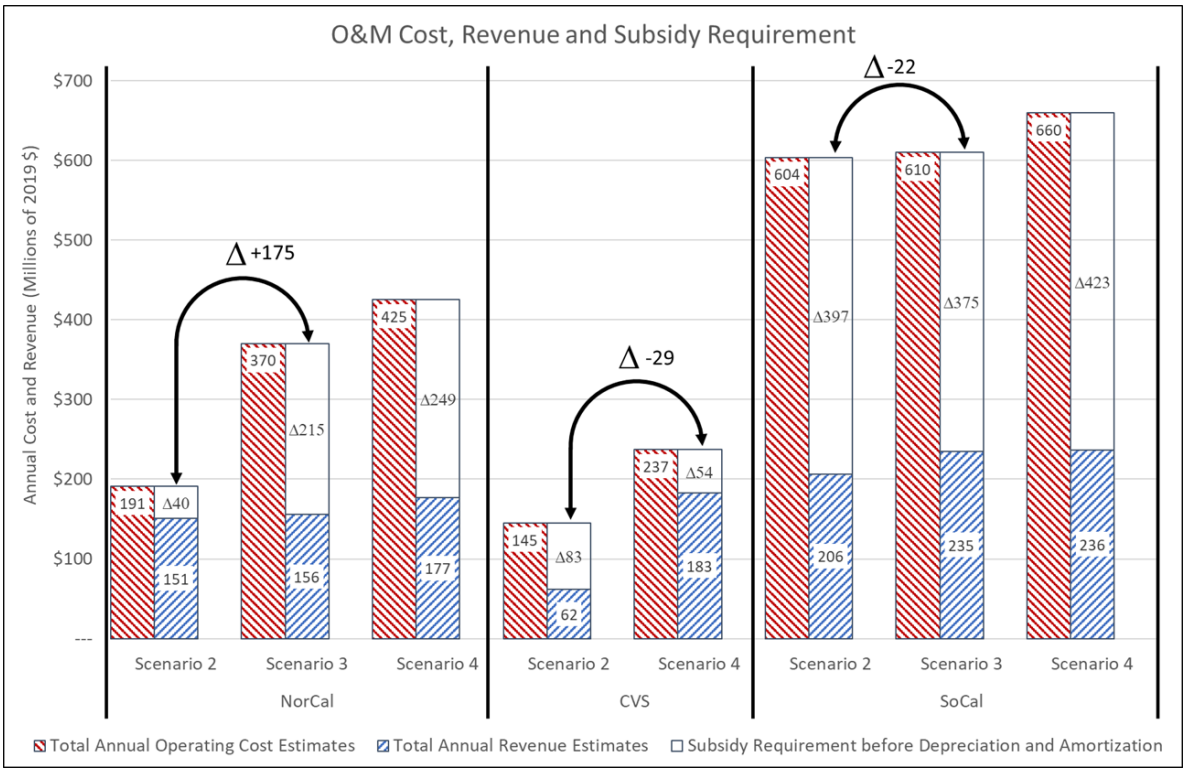


Figure 8-1: O&M Cost, Revenue and Subsidy Requirement by Scenario

In NorCal and SoCal the added service will likely require significant increases in annual subsidies in either corridor. The Caltrain Business Plan draws a similar conclusion, no similar information was available for the SoCal system.

Table 8-3 shows the changes of the subsidy requirements versus Scenario 2. Only CVS Scenario 4 and SoCal Scenario 3 show a reduction of subsidy needs versus Scenario 2 with CVS Scenario 4 enabling the highest potential reduction after the HSR investment.

Corridor	Scenario	Subsidy Requirement before Depreciation and Amortization (Millions 2019 USD)	Incremental Change of Subsidy Requirement vs. Scenario 2 (Millions 2019 USD)	Incremental Change of Subsidy Requirement vs. Existing (Millions 2019 USD)
NorCal	Scenario 1	-5.58		-20.31
NorCal	Scenario 2	-40.20	---	14.31
NorCal	Scenario 3	-214.79	-174.59	188.90
NorCal	Scenario 4	-248.68	-208.47	222.79
CVS	Scenario 2	-83.21	---	13.11
CVS	Scenario 4	-54.45	28.76	-15.65
SoCal	Scenario 1	-191.26		8.68
SoCal	Scenario 2	-397.29	---	214.71
SoCal	Scenario 3	-375.16	22.13	192.58
SoCal	Scenario 4	-423.15	-25.86	240.57

Table 8-3: Change of Subsidy Requirements vs. Scenario 2

9 Investment Needs and Funding

The investment needs and the available funding data is based on publicly available information, the Caltrain Business Plan information, estimates and summaries provided by SJRRC and SJJPA as well as information for the TIRCP funding of the initial Southern California Optimized Rail Expansion (SCORE) program and information for the Link US program.

Since completion of the qualitative report ETO was able to obtain further information on the HSR eligible investment for the NorCal and SoCal corridors. While the qualitative report relied on estimates that are based on the scope of the environmental review in each of the corridors the more recent estimates use a refined construction scope that is basis of the Authority's 2020 business plan. These new estimates provide a lower range of investment needs and the quantitative report uses this lower range of cost estimates in lieu of the higher estimates shown in the qualitative report.

The following Figure 9-1 and Figure 9-3 compare the lower and higher cost ranges as well as the impact of the change in completion schedule on year-of-expenditure (YOE) Values. Depending on the duration of construction the CapEx values can vary significantly. For purpose of the comparison ETO used the lower new data sets to be conservative in these assumptions for HSR investment needs to achieve the benefits.

9.1 Investment Needs NorCal Scenarios

Table 9-1 below shows the comparison of the Regional and the HSR-eligible investment, the funded and committed dollars and additional funding needs to complete each Scenario. The electrification of the Caltrain corridor between San Jose and San Francisco is fully funded.

Scenario 3 is only 10% funded and requires USD 3.6 billion in HSR funding and USD 17 billion of regional and local funding to achieve the benefits.

Scenario 4 requires additional USD 1.7 billion HSR funding to operate HSR service with a total of USD 5.3 billion funding that exceeds the USD 4.8 billion of available HSR funding by USD 0.5 billion in case the CVS funding is diverted to the corridor.

Type of Cost	Scenario 2	Scenario 3	Scenario 4
Regional	2.34	19.39	19.39
HSR	---	3.56	5.30
Total	2.34	22.95	24.69
Regional Funded and Committed (*)	2.34	2.34	2.34
HSR Funded and Committed	---	---	---
Total Funded and Committed	2.34	2.34	2.34
Regional Funding Needs	---	17.05	17.05
HSR Funding Needs	---	3.56	5.30
Total Funding Needs	---	20.61	22.35
Share of Funded and Committed	100%	10%	9%

Note: (*) Includes CHSRA Bookend Investments of USD 713 million for Caltrain Electrification and USD 84 million for 25th Avenue Grade Separation.

Table 9-1: NorCal Investment, Committed Funding and Additional Funding Needs (Billions of YOE USD)

Figure 9-1 below depicts the upper and lower range of HSR CapEx in NorCal and the change of these values depending on the midpoint of construction. The lower cost points were used for analysis and comparison between the corridors.

The resultant HSR investment in Scenario 3 is USD 3.6 billion and USD 4.7 billion in Scenario 4. The qualitative report showed USD 4.1 billion and USD 7.2 billion, respectively.

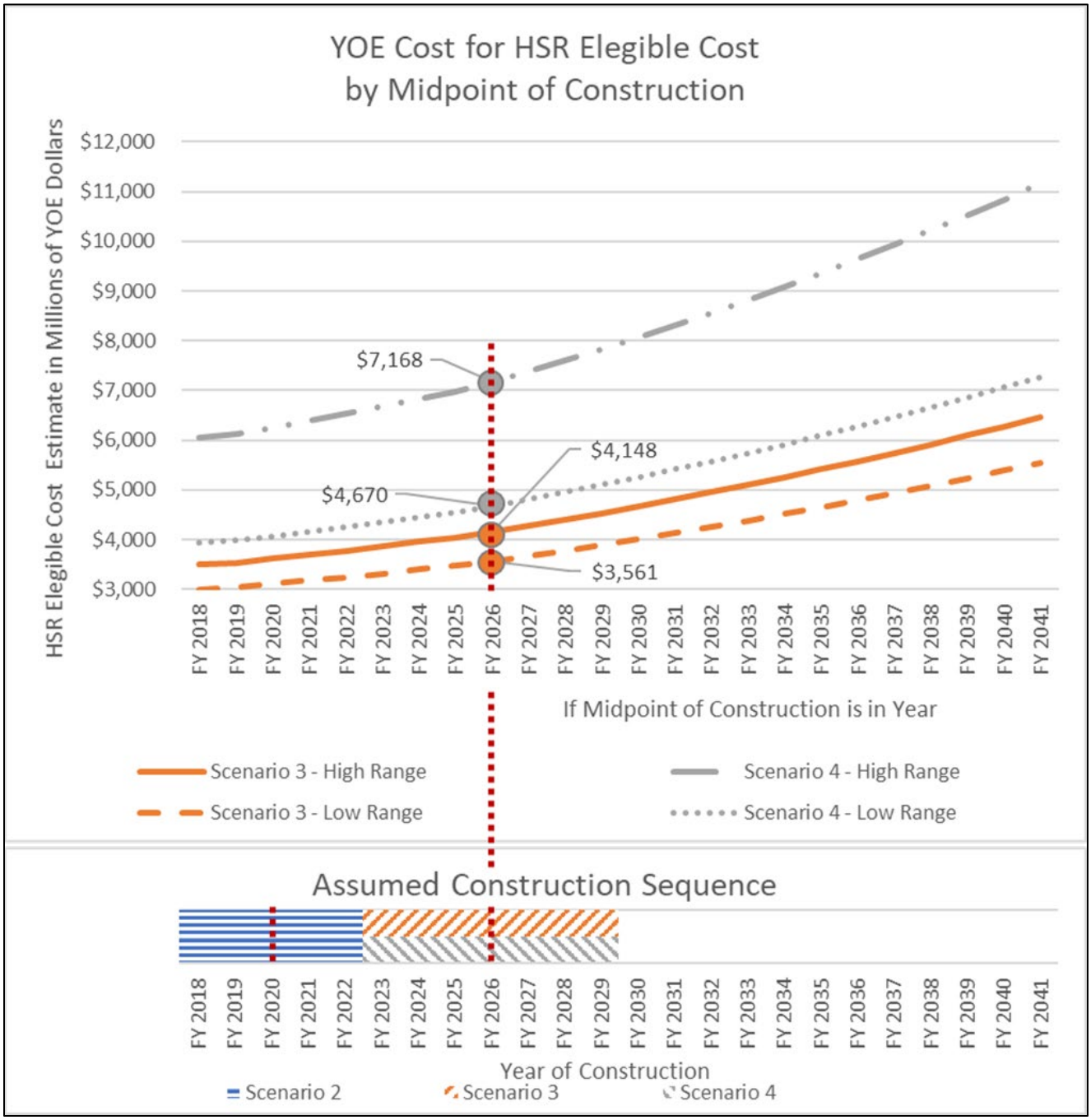
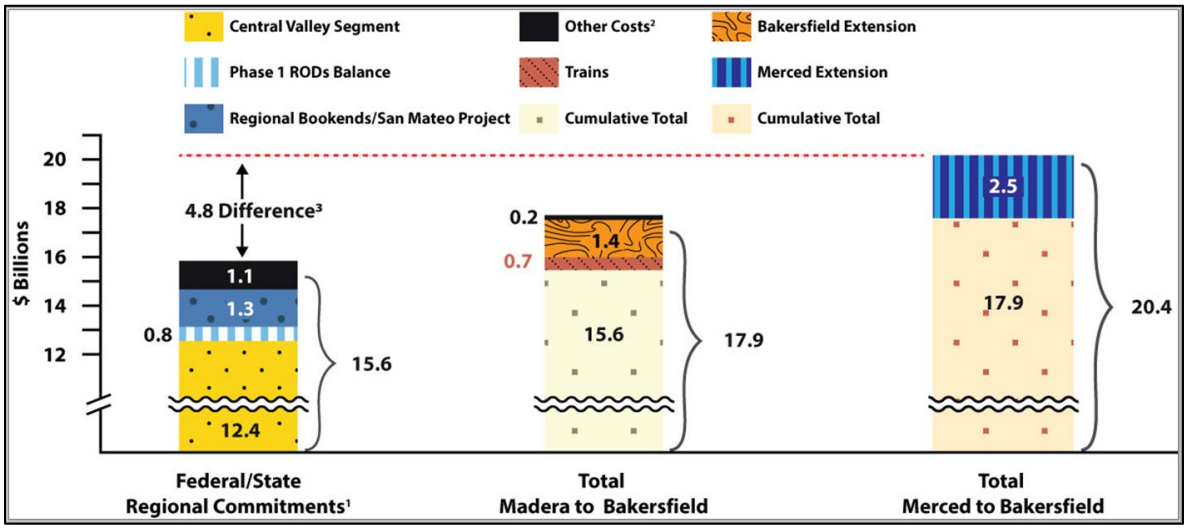


Figure 9-1: NorCal Ranges of HSR-Eligible Investment and Variability by Mid-Point of Construction (Millions of USD)

9.2 Investment Needs CVS Scenarios

HSR Investment in CVS

Based on the Project Update Report from May 2019, the capital cost for the Central Valley Segment between Madera and Poplar Avenue is estimated at USD 15.6 billion in year of expenditure (YOE) Dollars and has been approved by the Authority Board of Directors. The total investment to complete the extensions to Merced and Bakersfield as well as to purchase the High-Speed Rail rolling stock is estimated at USD 20.4 billion as illustrated in Figure 9-2 below.



Notes:

Federal/State/Regional Commitments – These include completion of the Federal grant agreements to complete all Phase 1 Environmental Documents and 119 miles of civil and structural rail infrastructure from Madera to Poplar; completion of state and regional projects including SB 1029 Bookend projects (Caltrain Electrification Project, Rosecrans/ Marquardt Grade Separation and Link US) and the regional San Mateo Grade Crossing project.

Other Costs – Other costs include program support costs and historical Phase 2 expenditures.

Based on P70 estimates, potential for change with P100 estimates and due to FY 10 lawsuit (USD 926 million)

Source: California High-Speed Rail Authority, Delivering High-Speed Rail to Californians, Project Update Report to the California State Legislature, May 2019

Figure 9-2: Central Valley Segment HSR Investment Summary (Billions of USD)

Implications of Partial CVS Investment

If investment is prioritized in other sections of the future High-Speed Rail network, significant benefits are lost in the Central Valley since the Madera – Poplar Avenue corridor will not provide the benefits of a High-Speed Rail service.

It will likely resemble a slightly improved service over the existing San Joaquin service with similar frequency and only moderately higher operating speeds since the existing slot limitations on the freight railroads north and south of the Madera – Poplar Avenue sections still limit the service to 7 train pairs per day. In addition opportunity costs are likely to occur due to the partial investment in the Central Valley without corresponding benefits since the Authority will lose the opportunity to showcase a High-Speed Rail corridor, later completion of the Merced and Bakersfield extensions will incur cost increases and the infrastructure maintenance cost for a Diesel train based service will be proportionally higher due to the higher maintenance standards for a high-speed rail line as compared to a conventional diesel-based operation at lower speeds.

The diesel operation will also require throw-away investments to facilitate a diesel train-based service. These throw-away investments include:

- Adaptation of the signal system for non-High-Speed Rail rolling stock;
- Connecting tracks between the High-Speed Rail alignment and freight rail tracks in Madera and at Poplar Avenue; and
- Modifications to station platforms on the High-Speed Rail alignment to accommodate Diesel hauled rolling stock.

The limited use of High-Speed Rail infrastructure in the Central Valley by San Joaquin trains will resemble the current situation with only minor improvements and will create high operational expenses for a then-underutilized infrastructure asset. There also will be very limited or minimal environmental improvements since the service will not change considerably from today's service. ETO did not analyze such a partial completion scenario in the side-by-side comparison but the decision-making process for setting investment priorities will need to consider these implications.

The study summarized the costs and benefits of a full investment in the Central Valley Corridor after completion of the CVS study.

Investment Needs in CVS

In CVS Scenario 2 that reflects implementation of the Valley Rail Project is fully funded at roughly USD 1 billion. Scenario 4 requires USD 4.8 billion for completion of the HSR extensions to Merced and Bakersfield and up to USD 0.5 billion of additional regional funds are needed to achieve connectivity in addition to the benefits of the HSR operation in the CVS corridor. The resultant share of funded and committed investment is 76% of the total amount in Scenario 4 (USD 16.6 billon funded and committed of USD 21.9 billion total investment).

Type of Cost	Scenario 2	Scenario 3	Scenario 4
Regional	1.00	---	1.50
HSR	15.60	---	20.40
Total	16.60	---	21.90
Regional Funded and Committed	1.00	---	1.00
HSR Funded and Committed (*)	15.60	---	15.60
Total Funded and Committed	16.60	---	16.60
Regional Funding Needs	---	---	0.50
HSR Funding Needs	---	---	4.80
Total Funding Needs	---	---	5.30
Share of Funded and Committed	100%	---	76%

Note: (*) Includes HSR funds for Madera - Poplar Avenue USD 15.6 billion.

Table 9-2: CVS Investment, committed Funding and additional Funding Needs (Billions of USD)

9.3 Investment Needs SoCal Scenarios

Scenario 2 in SoCal Table 9-3 assumes the conversion to zero-emissions vehicle (ZEV) technology and the related cost were estimated based on data provided by Metrolink for a

conversion of the existing fleet. Scenario requires more rolling stock due to expanded service and the investment needs reflect that increased fleet size.

The infrastructure and the new technology fleet requires USD 5 billion that are currently unfunded. The implementation of the Initial SCORE project and of Phase A of Link US are funded at USD 1.83 billion. Scenario 2 is therefore only 26% funded.

Type of Cost	Scenario 2	Scenario 3	Scenario 4
Regional	6.96	8.84	8.84
HSR	---	4.53	6.95
Total	6.96	13.37	15.80
Regional Funded and Committed (*)	1.83	1.83	1.83
HSR Funded and Committed	---	---	---
Total Funded and Committed	1.83	1.83	1.83
Regional Funding Needs (**)	5.14	7.02	7.02
HSR Funding Needs	---	4.53	6.95
Total Funding Needs	5.14	11.55	13.97
Share of Funded and Committed	26%	14%	12%

Notes:

(*) Includes CHSRA Bookend Investments of USD 77 million for Rosecrans Marquardt Grade Separation and USD 423 million for Link US (Phase A Run Through Tracks).

(**) Reflects conversion of Metrolink fleet to ZEV technology and cost for related adaptation of maintenance facilities.

Table 9-3: SoCal Investment, committed Funding and additional Funding Needs (Billions of USD)

Scenario 3 requires additional USD 1.9 billion regional and USD 4.5 billion HSR funding and Scenario 4 requires an additional USD 2.4 billion HSR investment over Scenario 3 to operate HSR service. Overall committed funding currently covers only 14% of Scenario 3 and 12% of Scenario 4 capital expenditures. The Scenario 4 HSR investment exceeds the USD 4.8 billion funding in case the CVS funding is diverted to the SoCal region.

Figure 9-3 below depicts the upper and lower range of HSR CapEx in SoCal and the change of these values depending on the midpoint of construction. The lower cost points were used for analysis and comparison between the corridors. The resultant HSR investment in Scenario 3 is USD 4.5 billion and USD 6.3 billion in Scenario 4. The qualitative report showed USD 6.8 billion and USD 12.4 billion, respectively.

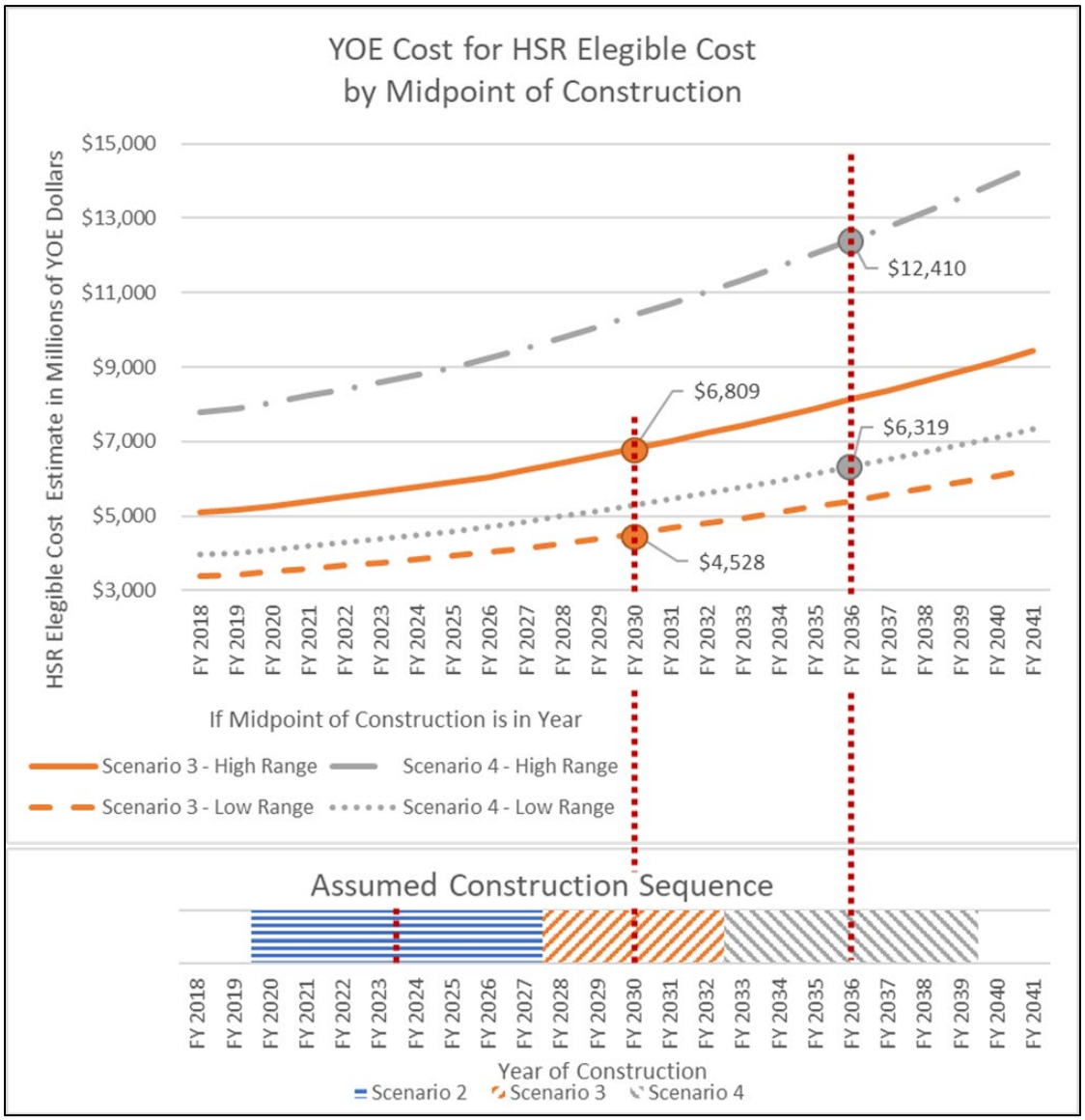


Figure 9-3: SoCal Ranges of HSR-Eligible Investment and Variability by Mid-Point of Construction (Millions of USD)

9.4 Summary of Investment Needs, Available and Committed Funding and Funding Gaps

Figure 9-4 below shows the increment of investment versus Scenario 2. CVS Scenario 4 requires the least total additional investment including HSR funds to achieve the benefits from the HSR investment.

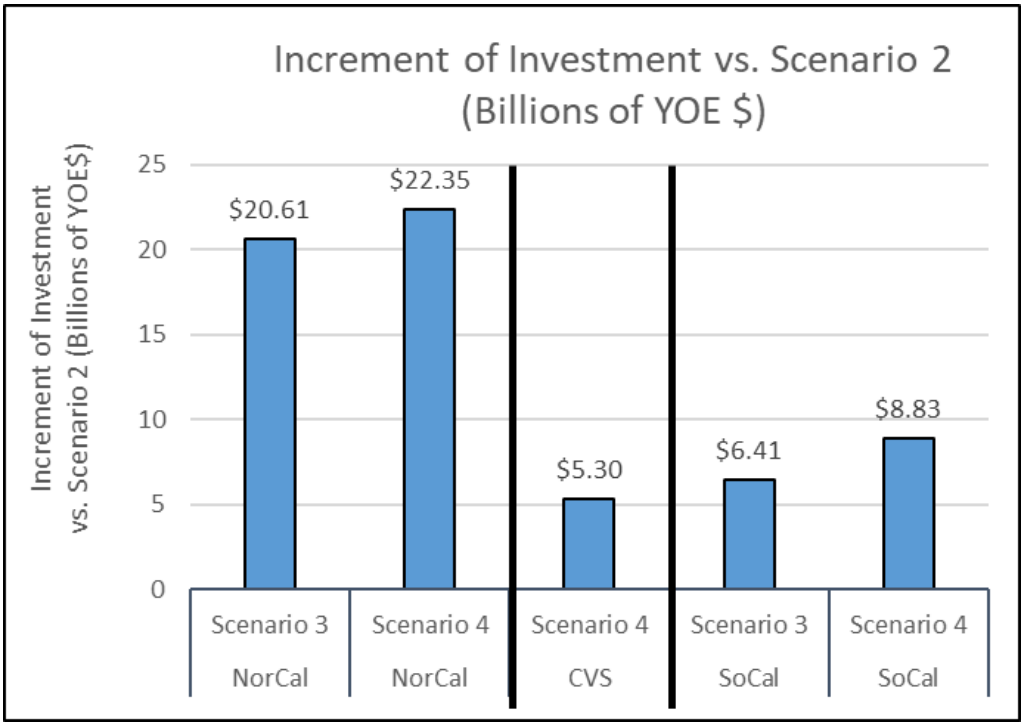


Figure 9-4: Increment of Investment vs. Scenario 2 in billions of YOE USD vs. Scenario 2

The CVS corridor has currently the highest committed funding available that consists of USD 15.6 billion for the Madera to Poplar Avenue section and USD 1 billion for the Valley Rail Project. NorCal has USD 2.3 billion funding for the electrification project and SoCal USD 1.8 Billion for the initial SCORE investment and Phase A of the Link US project (Figure 9-5). The values in NorCal and SoCal include the Bookend Funding provided by the Authority to both corridors.

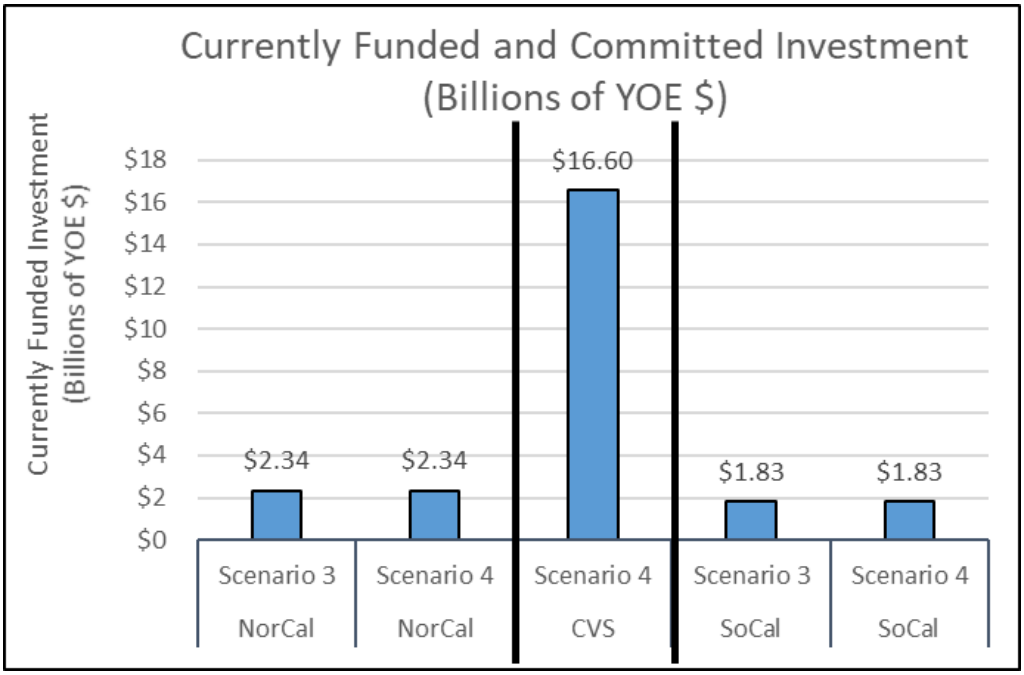


Figure 9-5: Currently Funded and Committed Investment in Billions of YOE USD vs. Scenario 2

Figure 9-6 shows a summary of the additional needed total funding as increment over Scenario 2 differentiated by regional funding needs and HSR funding of 4.8 billion that is not committed and further HSR funding needs.

In NorCal a total of 20 to 22 billion are needed to get the Caltrain corridor to a fully electrified and high-capacity rail corridor. The required HSR investment ranges from USD 3.6 billion (Scenario 3) to USD 5.3 billion (Scenario 4).

The CVS corridor requires USD 4.8 billion of HSR investment and up to USD 0.5 billion of regional investment to complete Scenario 4.

In SoCal the ZEV conversion in Scenario 2 is unfunded and requires USD 5.1 billion in regional funding. Scenario 3 requires a total of USD 11.6 billion with USD 4.5 billion of HSR funding needs and Scenario 4 requires USD 14 billion total funding with USD 6.9 billion of HSR funding exceeding the available USD 4.8 billion available funds by USD 2.2 billion.

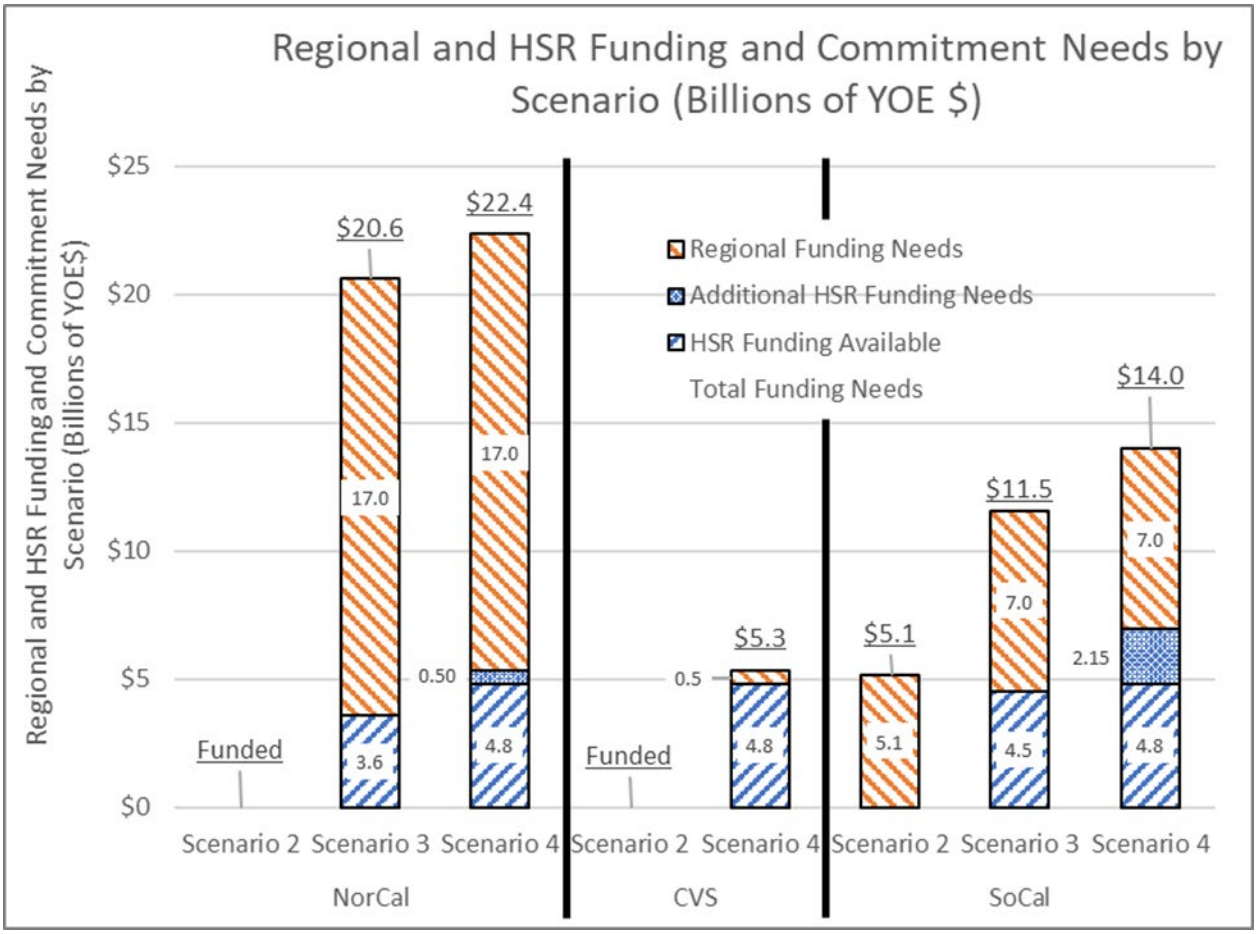


Figure 9-6: Regional and HSR Funding and Commitment Needs in Billions of YOE USD

The share of investment that is currently funded and where funding is committed is shown in the following Figure 9-7. CVS Scenario 4 has the highest share of committed funding not considering the USD 4.8 billion in HSR funding that is not committed yet to the project.

The share of the funded investment in NorCal and SoCal Scenarios 3 and 4 with HSR investment range from about 10% to 14%. Significant additional local and regional funding commitments are needed to achieve the full corridor benefits with HSR the investment in both corridors.

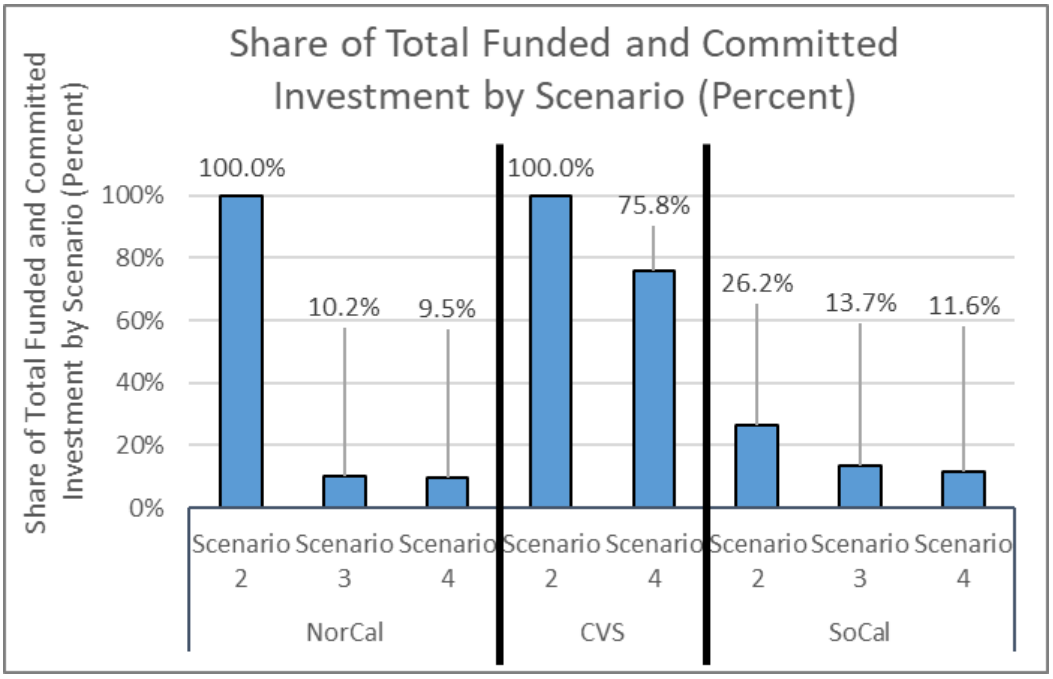


Figure 9-7: Share of Total Funded and Committed Investment by Scenario

10 Summary and Conclusions

The following paragraphs summarize the results of the analysis and draw the conclusions from the side-by-side comparison of the three study corridors and the different investment scenarios.

10.1 Side-by-Side Comparison of Benefits and Costs

Figure 10-1 below summarizes the various parameters that were analyzed for each Scenario including ridership and revenue benefits, CapEx and OpEx, Congestion Relief and GHG benefits.

CVS Scenario 4 assumes completion of the Merced – Bakersfield HSR infrastructure and HSR operation in the corridor. This scenario requires the least additional regional investment to implement the high-speed rail service and shows the highest share of committed total funding.

This scenario also provides the highest ridership and revenue benefits, the highest reduction in GHG emissions and the most congestion relief benefits due to a much higher amount of VMT reduction as compared to the NorCal or SoCal scenarios with HSR investment. It also eliminates the highest number of equivalent cars driving in the roadway network.

CVS Scenario 4 provides the potential to reduce operating subsidies versus Scenario 2 by almost USD 29 million per year. SoCal Scenario 3 also provides a subsidy reduction of USD 22 million per year. All other scenarios result in an increase in annual O&M cost versus Scenario 2.

Overall the CVS HSR investment provides the most benefits with the least investment needs and lowest operating cost.

The scenarios and related cost shown in this report are based on ETO estimates and do not represent a commitment by regional rail operators or other entities to finance or fund these services. Further planning has to be undertaken and commercial agreements have to be developed to allow for such commitments.

Corridor	Scenario	Change in Regional CapEx (Billions of YOE$) vs. Scenario 2	Change in HSR-Eligible CapEx (Billions of YOE$) vs. Scenario 2	Change in Total CapEx (Billions of YOE$) vs. Scenario 2	Share of Funded Investment
NorCal	Scenario 3	17.05	3.56	20.61	10.2%
NorCal	Scenario 4	17.05	5.30	22.35	9.5%
CVS	Scenario 4	0.50	4.80	5.30	75.8%
SoCal	Scenario 3	1.88	4.53	6.41	13.7%
SoCal	Scenario 4	1.88	6.95	8.83	11.6%

Corridor	Scenario	Change in Annual Ridership (Millions) vs. Scenario 2	Change in Annual Passenger Miles Travelled (PMT) (Millions) vs. Scenario 2	Change in Annual GHG Benefits vs. Scenario 2 (Metric Tons of CO2)
NorCal	Scenario 3	0.43	18.34	24,626
NorCal	Scenario 4	1.94	90.81	36,849
CVS	Scenario 4	4.81	340.32	50,641
SoCal	Scenario 3	2.10	106.95	12,304
SoCal	Scenario 4	2.50	107.94	19,259

Corridor	Scenario	Change in Congestion Relief - Reduction in Annual Vehicle Miles (Millions) vs. No-Build vs. Scenario 2	Change in Difference in Equivalent Number of Cars Taken Off the Road Network vs. Scenario 2
NorCal	Scenario 3	15.29	1,130
NorCal	Scenario 4	75.68	5,610
CVS	Scenario 4	283.60	21,040
SoCal	Scenario 3	89.13	6,620
SoCal	Scenario 4	89.95	6,680

Corridor	Scenario	Change in Annual Farebox Revenue (Millions 2019$) vs. Scenario 2	Change in Annual Operating Cost (Millions 2019$) vs. Scenario 2	Change in Annual Subsidy Estimate (Millions 2019$) vs. Scenario 2
NorCal	Scenario 3	4.95	179.53	174.59
NorCal	Scenario 4	25.85	234.32	208.47
CVS	Scenario 4	117.24	92.25	-28.76
SoCal	Scenario 3	28.50	6.38	-22.13
SoCal	Scenario 4	30.02	55.88	25.86

Figure 10-1: Summary of Analysis Output by Scenario

10.2 Conclusions

The quantitative analysis of the scenarios in the three corridors and the summary of benefits leads to the following conclusions:

- From the HSR-program perspective, only Scenario 4 in CVS enables high-speed rail operation and provides higher benefits as compared to the other corridors.
- From the operations and maintenance cost perspective, the Central Valley Segment offers the highest reduction in subsidy requirement. All other corridors will potentially require an increased subsidy to cover the additional cost for improved service.
- From the perspective of the investment needs (CapEx), benefits from early HSR investments can be realized only with considerable additional regional investment in NorCal and SoCal. CVS requires a moderate investment of up to 0.5 billion dollars of regional commitment to implement the proposed service plan.
- Considering the environmental impacts, CVS Scenario 4 offers the highest environmental benefits increase and provides the highest congestion reduction benefits due to significant VMT reductions.

10.3 Answers to Two Key Questions

Based on the analytical output, the study's two key questions can be answered as follows:

- **Question 1:**
  How do benefits of early HSR service compare in the three corridors?

  Only the CVS corridor offers significant benefits from true HSR operation. In the NorCal and SoCal corridors early HSR operation does not provide major ridership benefits of HSR service due to corridor limitations and the focus of the investment on needed capacity increases. Significant HSR benefits only materialize when both corridors are connected to the statewide HSR system.

- **Question 2:**
  How do benefits of early HSR investment compare in the three corridors?

  i) HSR eligible investment in the NorCal and SoCal corridors enables significant capacity improvements in each corridor to prepare for future HSR operation but also requires large regional investments to provide benefits from increased regional service.

  ii) Increases in rail passenger demand depend on both the capacity and travel time improvements among other factors. The ridership benefits are only incremental in the NorCal and SoCal corridors as compared to the Central Valley due to the following inherent differences in the corridors:

  iii) Investments in the NorCal and the SoCal corridors will improve capacity significantly but show only minor improvements for regional travelers in travel time (approximately 6-12 minutes); and

  iv) In the CVS corridor the investment not on only will more than double the capacity but reduce the travel time by more than 90 minutes.

The following chapters describe in detail the methodology, the assumptions for the analysis, the benefits and parameters as well as the conclusions drawn from the quantitative analysis.

Disclaimer:

The scenarios and related costs shown in this report are based on ETO estimates and assumptions solely for the purpose of this study. They do not represent a commitment or a request by regional rail operators or other entities to procure, finance or fund these services.