THE CALTRAIN CORRIDOR VISION PLAN

Appendix A

Rail: Existing Conditions and Vision Plan Methodology

Appendix A describes today's Caltrain rail system and service. It also explains the assumptions and methodology used to develop the Caltrain Corridor Vision Plan recommendations for future rail service in the corridor.

1. Caltrain Today

The following existing conditions form what this study assumes to the baseline conditions that the Vision Plan elements are built upon. This information and the assumptions were based on what was available in 2016.

1.1 Physical Infrastructure

The Caltrain Corridor is an approximately 48-mile rail corridor between the San Francisco 4th and King Station and San Jose Diridon Station. Between San Francisco and CP (Control Point) Coast[1], a short distance north of the Santa Clara station, the corridor is owned and controlled by the Peninsula Corridor Joint Powers Board (i.e., Caltrain). Between CP Coast and Diridon Station, the corridor is a portion of Union Pacific Railroad's (UP's) Coast Subdivision (i.e., its rail line from Oakland to San Luis Obispo). The entire right-of-way and all main tracks in this section are owned by Caltrain, with the exception of Main Track 1, which is owned and maintained by UP[2].

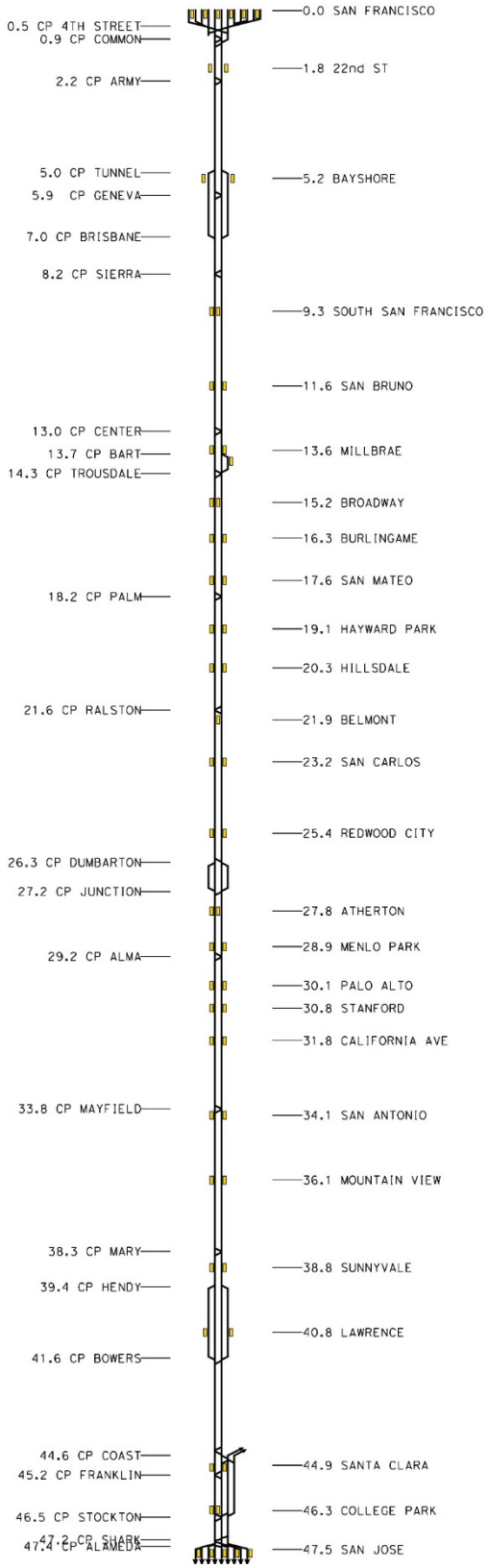
Caltrain owns all stations in the corridor, all of which it received from the California Department of Transportation (Caltrans) in 1993[3]. The corridor is primarily a two main track corridor. Major track infrastructure components and stations are shown in Figure 1. At eight locations, the corridor includes main tracks or sidings other than two main tracks, also shown in Figure 1. Figure 2 lists some of the other important facilities for railroad operations and Figure 3 describes the stations.

[1] A Control Point is a location in a Centralized Traffic Control (CTC) railroad network with signals and turnouts directly controlled by dispatchers. On the Caltrain corridor, "control point" is generally synonymous with "interlocking."

[2] *Right-Of-Way Maps*. Peninsula Corridor Joint Powers Board, 2007.

[3] *Caltrain Design Criteria*. Peninsula Corridor Joint Powers Board, 2011.

Figure 1. Corridor Rail Track and Station Configuration



Stations along the corridor and their key operational characteristics are identified in Figure 2.

Figure 2. Corridor Rail Special Facilities

Begin*	End*	Facility	Notes
San Francisco (MP 0.2)	CP 4th Street (MP 0.5)	San Francisco station tracks	12 tracks and one pocket track
CP Tunnel (MP 5.0)	CP Brisbane (MP 7.0)	Four main tracks	Outside main tracks routinely used during peak hours by Limited trains to be overtaken by Baby Bullet trains
CP BART (MP 13.7)	CP Trousdale (MP 14.3)	"Millbrae Controlled Siding" (within Millbrae station)	Infrequently used for storing disabled trains
CP Dumbarton (MP 26.3)	CP Junction (MP 27.2)	Two controlled siding tracks ("West Controlled Siding" and "East Controlled Siding")	
CP Hendy (MP 39.4)	CP Bowers (MP 41.6)	Four main tracks	Outside main tracks routinely used during peak hours by Limited trains to be overtaken by Baby Bullet trains
CP Coast (MP 44.6)	CP Stockton (MP 46.5)	Four main tracks	
CP Stockton (MP 46.5)	CP Alameda (MP 47.4)	Three main tracks	
CP Alameda (MP 47.4)	San Jose station	San Jose station tracks	Nine stations tracks

* Railroads typically identify locations along a linear railroad corridor according to its milepost (MP) location, i.e., how many miles a given location on the corridor is from a reference location. On the Peninsula corridor, milepost zero is in San Francisco and milepost values increase south along the corridor.

Figure 3. Corridor Rail Stations

Station	Track Configuration	Platform Configuration	Notes
San Francisco (4th and King)	12 station tracks	6 island platforms	Terminal station
22nd St	2 tracks	2 side platforms	
Bayshore	4 tracks	2 side platforms	Express trains use center tracks
South San Francisco	2 tracks	Side platform + small island platform	"Hold-out rule" in effect[4]
San Bruno	2 tracks	2 side platforms	
Millbrae	2 tracks + siding	3 side platforms	Separate platform provided for siding track
Broadway	2 tracks	Side platform + small island platform	"Hold-out rule" in effect; Currently only served by trains on weekends
Burlingame	2 tracks	2 side platforms	
San Mateo	2 tracks	2 side platforms	
Hayward Park	2 tracks	2 side platforms	
Hillsdale	2 tracks	2 side platforms	
Belmont	2 tracks	Center platform	
San Carlos	2 tracks	2 side platforms	
Redwood City	2 tracks	2 side platforms	
Atherton	2 tracks	2 side platforms	"Hold-out rule" in effect; Currently only served by trains on weekends
Menlo Park	2 tracks	2 side platforms	
Palo Alto	2 tracks	2 side platforms	
Stanford	2 tracks	2 side platforms	Used for Stanford home football games only (typically on specific Saturdays)
California Ave	2 tracks	2 side platforms	
San Antonio	2 tracks	2 side platforms	
Mountain View	2 tracks	2 side platforms	
Sunnyvale	2 tracks	2 side platforms	
Lawrence	4 tracks	2 side platforms	Express trains use center tracks
Santa Clara	2 tracks	Side platform + island platform	Also serves Amtrak Capitol Corridor and Altamont Corridor Express (ACE).
College Park	4 tracks	Side platform + small island platform	"Hold-out rule" in effect
San Jose Diridon	9 tracks	Side platform + 4 island platforms	Also serves Capitol Corridor and Altamont Corridor Express (ACE), and Amtrak Coast Starlight.

The entire corridor is operated with Centralized Traffic Control (CTC), whereby authority for trains to occupy track in the corridor is issued by a dispatcher to trains via wayside signals. The existing signalling system generally features three-block, four-aspect controls lines, meaning that two trains must be separated by three signal blocks (each about 4,000 to 5,000 feet long) to experience green

[4] At stations where passengers must cross an active track in order to board and alight from trains, a "station hold-out rule" is in effect. At these stations, the engineers of two trains approaching the station must coordinate via radio so that only one train is in the station at a time (i.e., one train will "hold out-" side of the station.)

("clear") signal aspects. Between interlockings[5], the system has automatic signals along the side of the track that cannot be controlled by the dispatcher and respond automatically to track occupancy status ahead on the corridor.

Most of the corridor is configured to allow a maximum operating speed of 79 miles per hour. In certain locations, however, the horizontal geometry of the tracks requires a lower maximum operating speed. (For example, immediately north of the San Bruno station, the maximum operating speed is 60 miles per hour.)

1.2 Caltrain Today: Demand and Supply

Transit agencies operate vehicles on routes that have a specific transit capacity – a value that the transit agency measures as being 100% full. "Line capacity" (expressed in terms of "passengers per hour") is a function of the capacity of each individual vehicle (bus or trains) and the frequency of vehicles operating on the route. This is shown in the equation below:

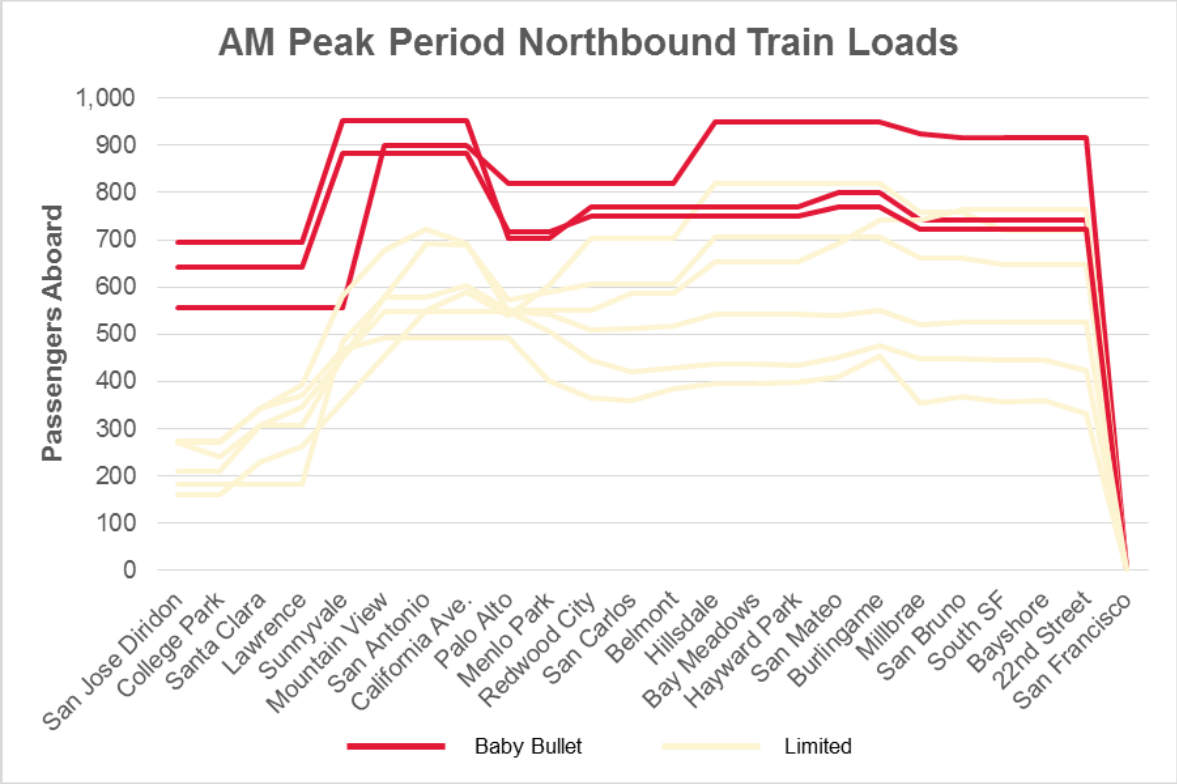
$$\frac{Passengers}{Hour} = \frac{Passengers}{Train} \times \frac{Trains}{Hour}$$

Most transit vehicles make intermediate stops between the route's terminus points, with passengers boarding and exiting at each intermediate stop. Along the route each vehicle/train has a location of "peak loading," which is when the number of passengers aboard reaches a maximum value for capacity. The amount of passengers at this peak loading point and the remaining transit capacity above this existing peak loading determines whether vehicles are at, above, or below capacity. Peak loadings at or above capacity are an indication of whether vehicles at particular times have the ability of to accommodate new passengers (picking up new passengers at intermediate stops).

As an example, the Figure 4 shows the average passenger loading for each AM peak period northbound train during its run from San Jose Diridon station to San Francisco station. In this case, each train has a location of peak loading generally near Mountain View or San Mateo.

[5] On the Caltrain corridor, "interlocking" is generally synonymous with "control point," i.e., a location in a Centralized Traffic Control (CTC) railroad network with signals and turnouts directly controlled by dispatchers.

Figure 4. AM Peak Period Northbound Train Load



Transit agencies commonly cite "ridership" as a key performance metric, which is often shared with the public as a measure of how well the agency or a particular transit service is performing. (Ridership is functionally identical to "boardings," which Caltrain uses). Ridership best identifies a total number of tickets sold but does not represent how passengers consume transit capacity, specifically where passengers get on trains and how long they remain on a train. This is important because ridership alone cannot determine if the transit service is operating at or above capacity. Capacity is measured for how the full the trains are at every point along the route, and train peak loadings better shows how well the service is accommodating passenger demand and whether additional trips can be service. For example, a passenger riding a train for ten stops consumes more capacity than does a passenger riding the train for a single stop.

1.2.1 Caltrain Today: Service Structure

Today, Caltrain operates a weekday schedule with 92 trains per day (46 northbound and 46 southbound). Service operates every day. Weekday service generally operates from 4:30 AM until 1:30 AM. Trains are each operated as one of three designated service classes:

- **Local-** Train makes all station stops (23 station stops)
- **Limited-** Train makes approximately half of the total station stops (11-18 station stops)
- **Baby Bullet-** Train makes, at most, six of the total station stops

Each of the above service classes are operated throughout the day generally according to the following schedule:

	Trains per Hour per Direction, by Service			
Time Period	**TOTAL**	**Local**	**Limited**	**Baby Bullet**
Early Morning (4 AM – 6 AM)	1	1	-	-
AM Peak Period (6 AM – 9 AM)	5	-	3	2
Mid-Day (9 AM – 4 PM)	1	1	0	0
PM Peak Period (4 PM – 7 PM)	5	-	3	2
Late Night (7 PM – 1 AM)	1	1	-	-

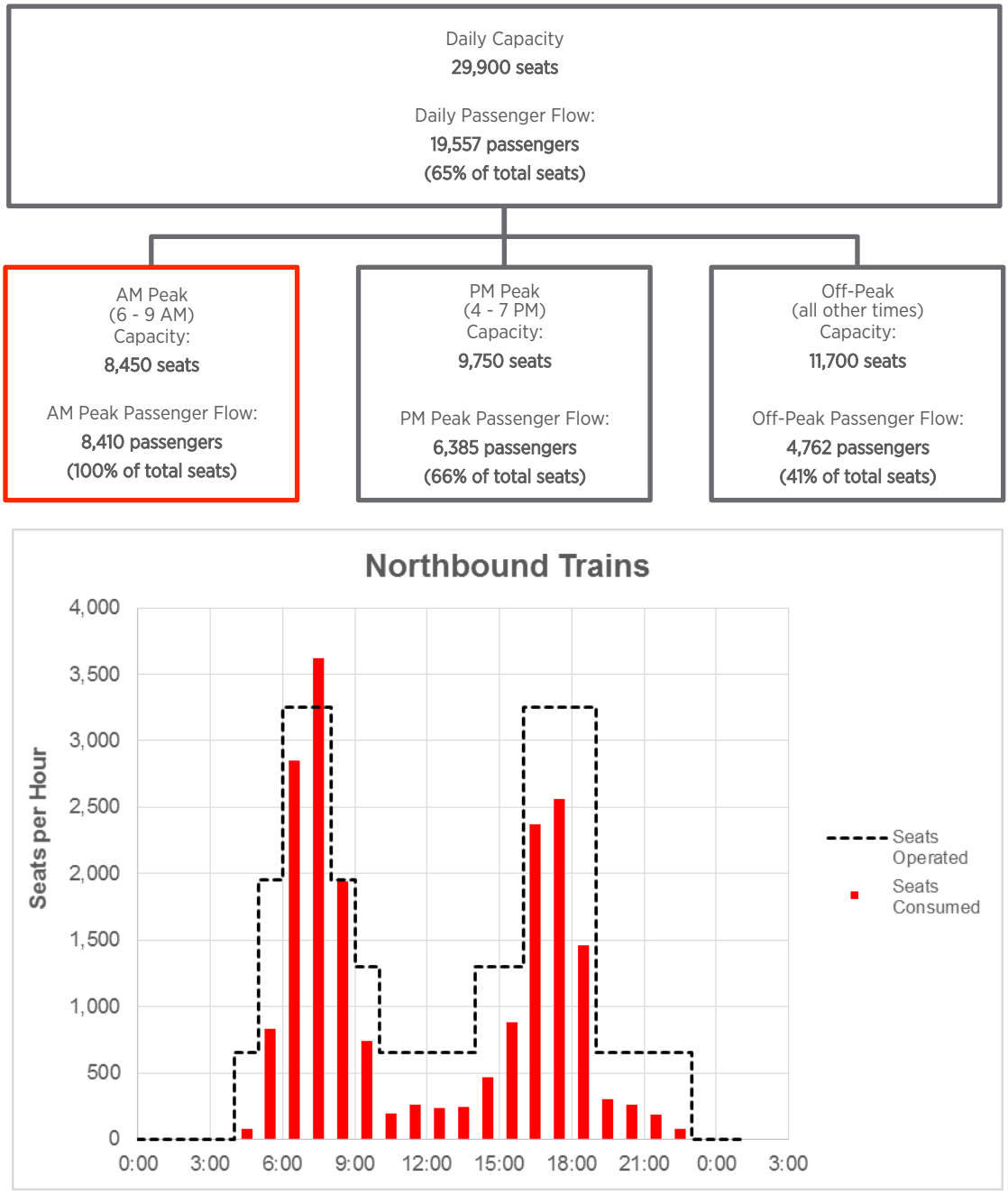
In off-peak periods, Caltrain generally operates one local train per hour (in each direction). During the peak periods, Caltrain currently operates five trains per hour (in each direction): two Baby Bullet trains and three Limited trains per hour (one Limited-Stop train and two Zone Limited[6] trains).

[6] A zone limited train operates as a local train in portions of the corridor (making all stops within a particular "zone") and as an express in the rest of the corridor, making few or no intermediate station stops.

1.2.2 Caltrain Today: Capacity Used

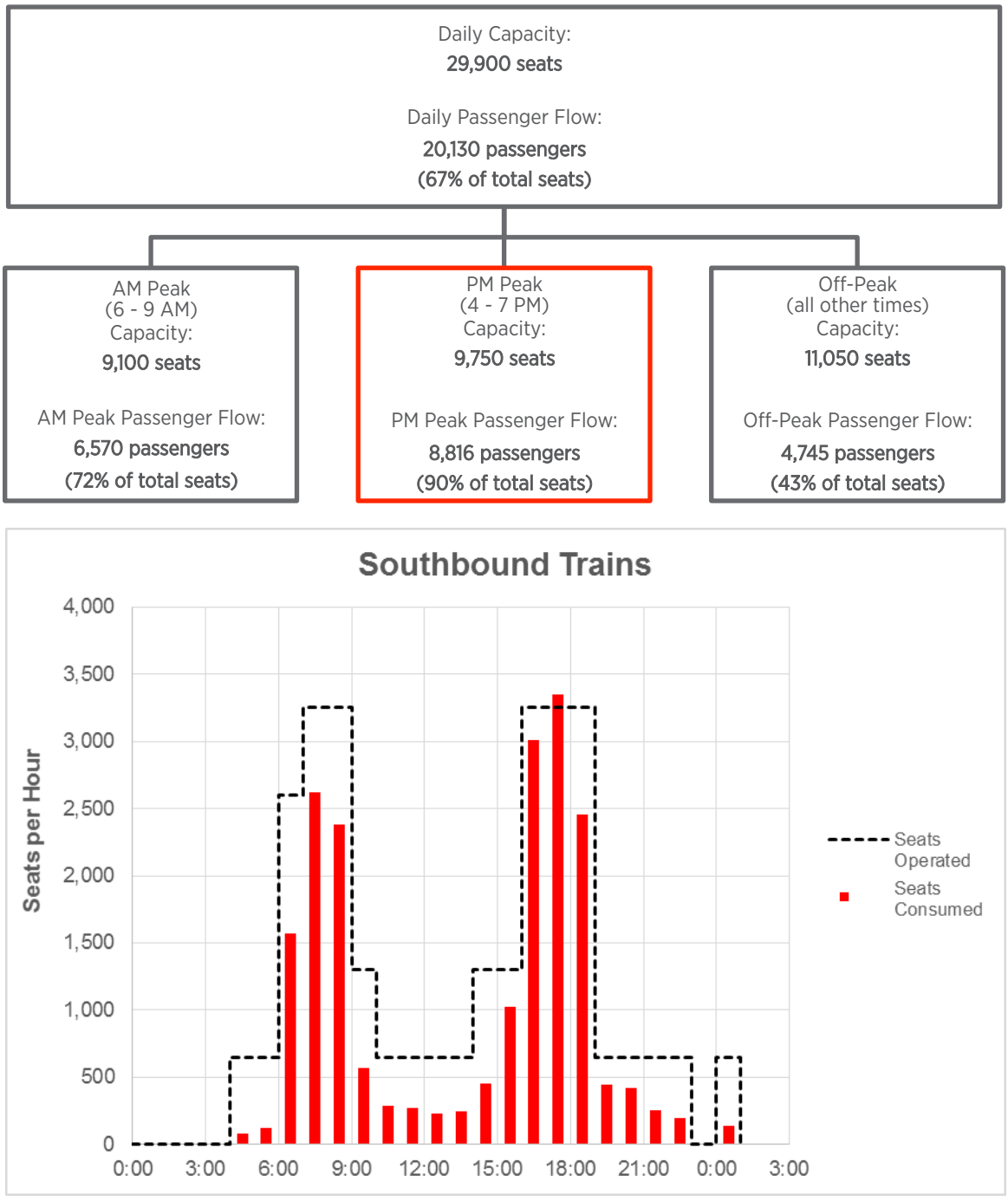
Based on the peak period service schedule described above, only 65% of Caltrain capacity in the northbound direction is used on a daily weekday basis, as shown in Figure 5, using 2016 boardings data.

Figure 5. Northbound Capacity Used



In the southbound direction, 67% of daily capacity is consumed as shown in Figure 6.

Figure 6. Southbound Capacity Used



Today, many Caltrain peak-period trains experience crowding conditions. While trains are generally oversubscribed (or nearly so) in both directions during both peak periods, trains are especially busy in the traditional Peninsula commute directions (i.e., northbound AM, southbound PM). In the traditional commute directions, 90-100 percent of transit capacity is consumed. In the directions opposite the traditional commute directions, only approximately 70 percent of transit capacity is consumed.

During the off-peak periods, however, there is ample seating capacity available - only approximately 40 percent of transit capacity is consumed. As a result, if daily capacity and daily passenger flows alone are considered, it would appear that there is ample transit capacity throughout the day. (This is a result of the "averaging" effect of combining the widely differing characteristics of the peak and off-peak periods). Taking a daily average (including both peak and off-peak periods), approximately 70 percent of total transit capacity is consumed.

During the peak periods, Caltrain operates five times as much service as it does during the off-peak periods. However, passenger demand is twelve times greater during peak periods than it is during off-peak periods.

2. Vision Plan: Rail Assumptions and Methodology

The Caltrain Corridor Vision Plan looks at potential strategies for corridor service above and beyond what is analyzed and identified in the 2013 Caltrain/High-Speed Rail Blended Operations Analysis (an analysis of how high-speed rail and Caltrain could both operate service on the peninsula rail corridor). This study consulted a number of published documents to understand future planning efforts related to projects including Caltrain Electrification, Caltrain Modernization 2.0 (CalMod 2.0), and High-Speed Rail. Only published documents and information provided by Caltrain were used to inform the assumptions regarding future conditions. Sources include:

- *Technical Memorandum TM 2.1.2 Alignment Design Standards for High-Speed Train Operation*. California High-Speed Rail Authority, 2009
- *Caltrain Design Criteria – Signals*. Peninsula Corridor Joint Powers Board, 2011.
- *Caltrain / California HSR Blended Operations Analysis.* Peninsula Corridor Joint Powers Board, 2012.
- *Caltrain / HSR Blended Grade Crossing and Traffic Analysis*. Peninsula Corridor Joint Powers Board, 2013.
- *Caltrain/HSR Blended Service Plan Operations Consideration Analysis*. Peninsula Corridor Joint Powers Board, 2013.
- *Caltrain SRTP FY 2015-2024*]
- *Peninsula Corridor Electrification Project Final Environmental Impact Report*. Peninsula Corridor Joint Powers Board, 2015.
- *Request for Proposal for Procurement of Bi-Level Electric Multiple Units (EMU) Vehicles*, Peninsula Corridor Joint Powers Board, 2015.
- *Draft 2016 Business Plan*. California High-Speed Rail Authority, 2016.

From the above documents, the following key milestones are identified for the Caltrain corridor:
- **2020**- Peninsula Corridor Electrification Project (PCEP) completed
- **2024**- Caltrain Modernization 2.0 (CalMod 2.0) completed [*Caltrain SRTP FY 2015-2024*]
- **2025**- California High-Speed Rail Project "Silicon Valley – Central Valley" operational (San Francisco – Bakersfield)
- **2029**- California High-Speed Rail Project "Phase 1" operational (San Francisco – Anaheim)

2.1 Vision Plan Rail Operations Assumptions and Methodology

The Vision Plan proposes an incremental approach to increasing rail frequency and seats offered on the corridor, building from what is planned today after electrification. The Vision Plan does not prescribe one particular schedule. Rather, we have explored prototypical operating scenarios that would be attractive to cities throughout the corridor and would balance the needs of different types of users and trips. In particular, all options offer both express services and local services – emphasizing both quality and access. Variations of the prototypical operating scenarios include having fewer stations, adding more peak-hour service or turning some trains back sooner instead of having them complete the whole route. Additionally, in the interim period before high-speed rail service begins, Caltrain could operate high-speed-like service (limited stops, high speeds) to grow the market for future high-speed service.

2.2 Study Corridor Extents

Analysis was conducted for a corridor from the proposed Transbay Transit Center to San Jose Diridon station. All Caltrain and HSR trains are assumed to operate the full length of the corridor from Transbay Terminal to San Jose (except as specifically identified in the Peninsula Local / Silicon Valley Express alternative).

The Blended Operations Analysis assumed high-speed rail trains would use dedicated track from Santa Clara to San Jose Diridon station and use dedicated platforms at San Jose Diridon. Capacity constraints associated with San Jose Diridon station were therefore not considered in this analysis (and/or assumed to be less limiting than overall corridor capacity constraints). Capacity constraints at Diridon station can more easily and less expensively be addressed that can corridor capacity constraints (with the addition, for example, of improved interlocking trackwork or new station platforms).

Broadway and Atherton stations are not served by any trains in this analysis. This is consistent with prototypical timetables used in the Blended Operations Analysis.

2.3 Caltrain Modernization (CalMod) and Peninsula Corridor Electrification Project (PCEP)

Caltrain is in the process of delivering the Peninsula Corridor Electrification Project (PCEP), which will feature several key improvements to the corridor:

- Corridor electrification, including a new electrically-powered Electric Multiple Unit (EMU) rail vehicle fleet and 130-140 track miles of overhead contact system (OCS) infrastructure between San Francisco and San Jose's Tamien station to distribute electric power to the electric vehicles
- Advanced signaling system, including CBOSS PTC (Communication-Based Overlay Signal System Positive Train Control), which will bring federally mandated safety benefits and performance enhancements to the Caltrain corridor.

The advanced signaling system is expected to be operational in 2016. Corridor electrification is expected to be completed by 2020.

2.4 Caltrain Modernization 2.0 (CalMod 2.0)

Following the completion of the Caltrain Modernization (CalMod) project, Caltrain intends to deliver a set of major improvements to the Caltrain corridor collectively known as Caltrain Modernization 2.0 (CalMod 2.0). These improvements will include:

- Complete conversion of fleet from diesel to Electric Multiple Unit (EMU)
- Reconstruction of platforms to accommodate level board and 8-car trains
- Elimination of grade crossings (through grade separation projects and street closures)

2.5 California High-Speed Rail

High-speed rail is assumed to serve three stations in the study corridor:

- San Francisco (Transbay Transit Center)
- Millbrae
- San Jose Diridon

A mid-Peninsula station was at one time considered for inclusion between Millbrae and San Jose (in Redwood City or Palo Alto). This has been eliminated from immediate high-speed rail project plans but may be considered again in future phases of the project.

The high-speed rail project is expected to be delivered in phases:

- Silicon Valley to Central Valley (San Jose – near Bakersfield, 2025)
- San Francisco to Bakersfield (if funding becomes available, this may occur in place of the preceding phase, 2025)
- Phase 1 (San Francisco – Los Angeles / Anaheim, 2029)

On the study corridor, the following high speed-rail service levels are anticipated with each phase of project development:

Figure 7. Planned Corridor High-Speed Rail Service Levels

HSR Development Phase	HSR Train Frequency (trains per hour)	
	Peak	Off-Peak
Silicon Valley – Central Valley, 2025	0	0
San Francisco – Bakersfield, 2025	2	1
Phase 1, 2029	4	4

2.6 Caltrain/High-Speed Rail Blended Operations Analysis

Original concepts for the California High-Speed Rail project called for a four-track corridor between San Francisco and San Jose to allow a large level of flexibility in accommodating both planned Caltrain services and high-speed rail services. However, a four-track corridor was determined to have significant

impacts on communities adjacent to the Caltrain rail corridor. The Blended Operations Analysis study (2012) was consequently conducted with the goal of identifying means of accommodating both Caltrain and high-speed rail services with infrastructure requirements short of a completely four-track corridor.

The Blended Operations Analysis concluded that, *without the construction of new major overtake facilities*, the corridor could support peak period service levels of six Caltrain trains per hour and two high-speed rail trains per hour.

With the construction of a overtake facility, approximately six to nine miles in length, the corridor could support peak period service levels of six Caltrain trains per hour and four high-speed rail trains per hour. The Blended Operations Analysis conceptually analyzed potential overtake facility locations; in that study, and its 2013 update, the "Full Midline Overtake" option showed the greatest potential to reliably serve Caltrain and high-speed trains with the minimum amount of new track infrastructure.

The 2012 study considered a Caltrain corridor from San Francisco 4th/King station to San Jose Diridon station (i.e. the operational implications of the proposed Downtown Extension [DTX] project to the Transbay Transit Center were not directly considered). The DTX project was partially addressed in a 2013 update to the 2012 study (*Caltrain/HSR Blended Service Plan Operations Consideration Analysis).*

2.7 Downtown Rail Extension (DTX) and Transbay Transit Center

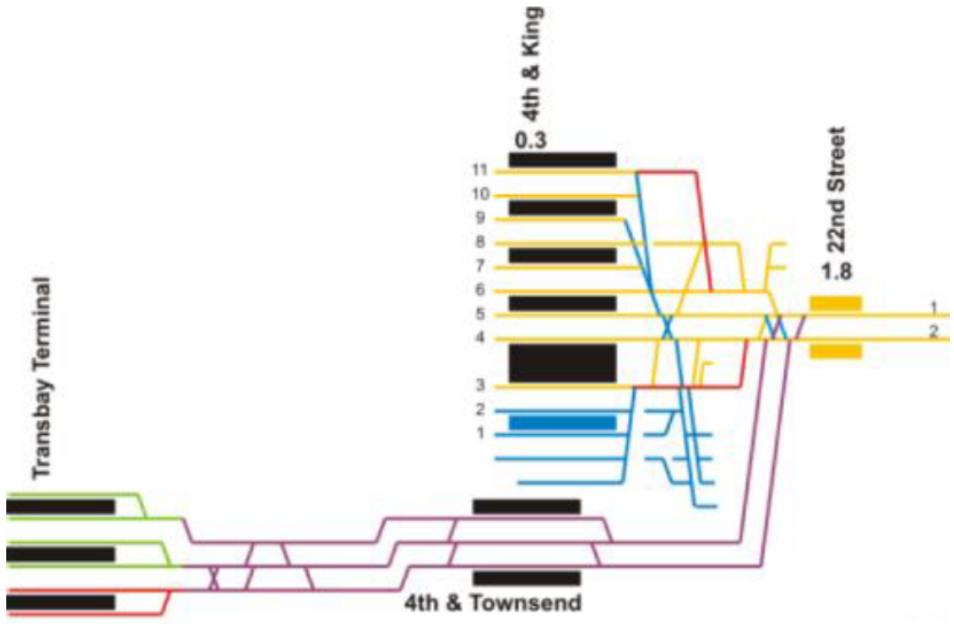
It is ultimately planned for the rail corridor to be extended from the existing northern terminus at 4th/King Station to the Transbay Transit Center. The Transbay Transit Center is planned to have six tracks. Three island platforms would each serve two tracks. The 2013 *Caltrain/HSR Blended Service Plan Operations Consideration Analysis* suggests the track configuration of this extension and station could potentially give this new terminal a lower train capacity than the rest of the corridor at large. This could be potentially mitigated by originating and terminating *some* trains at 4th/King in the future, rather than running *all* trains all through to the Transbay Transit Center. This will reduce the attractiveness of the overall corridor to passengers.

The 2013 Caltrain/HSR Blended Service Plan Operations Consideration Analysis outlines service assumptions to date and may change as the DTX concept is further developed.

- The 4th/King station is retained as a terminus station; a new 4th/Townsend station is constructed to serve Caltrain trains traveling to/from the Transbay Transit Center.
- In the peak period, two peak period Caltrain trips per hour serve 4th/Townsend and Transbay Transit Center.
- In the peak period, four Caltrain trips per hour serve 4th/King.
- In the peak period, four HSR trips per hour serve Transbay Transit Center (without stopping at 4th/Townsend).
- Of the three Transbay Transit Center platforms, two are assumed to be dedicated for HSR trains and one is assumed to be dedicated for Caltrain trains. (Put differently, four tracks are dedicated for HSR trains and two for Caltrain.)
- Factors that influence the number of through trains to Transbay Transit Center include:
    - Train turnaround time (how quickly Caltrain trains can be turned around to southbound service. The minimum turnaround time assumption has not been published nor documented in publicly available documents)

- Platform assignments (finalizing the platform assignments between HSR and Caltrain, and if Caltrain and HSR platforms can be shared)

Figure 8. Downtown Extension (DTX) Schematic Track Diagram[7]



From the assumed train frequencies above, a service throughput and turnaround can be estimated for each station track:

Figure 9. Transbay Transit Center Capacity Analysis

	Caltrain	HSR
Service to TTC	2 trains/hour	4 trains/hour
Station Tracks	2	4
Service per Station Track	1 train/hour	1 train/hour
Average Train Turnaround Time	1 hour	1 hour

For the scenario tested in the 2013 blended operations analysis, it was assumed that each station track only serves (on average) one train per hour. There is no publicly available documentation available to determine if additional trains can be accommodated, although the blended operations assumption appears to be conservative; i.e., trains should be able to be turned around in significantly less time than one hour.

For the purposes of this study, under more aggressive assumptions (similar to other industry examples), an increased train capacity of the Transbay Transit Center can be estimated:

[7] Caltrain/HSR Blended Service Plan Operations Consideration Analysis. Peninsula Corridor Joint Powers Board, 2013.

Figure 10. Transbay Transit Center Capacity Analysis- Study Assumptions

Service	Caltrain	HSR
Average Train Turnaround Time	20 minutes	30 minutes
Service per Station Track	3 trains/hour	2 trains/hour
Station Tracks	2	4
Service to TTC	6 trains/hour	8 trains/hour

Under the above assumptions, estimated capacity of the Transbay Transit Center is greatly increased. However, this ignores the capacity of the interlocking at the "throat" of the Transbay Transit Center, which may or may not constrain overall station capacity (i.e., the interlocking itself potentially may not be able to deliver trains to/from the station platforms as quickly as the platforms themselves can turnaround trains). In addition, it may be possible to reassign platforms amongst Caltrain and HSR trains to better match service levels or to allow any train to serve any platform.

Importantly, many components of the Downtown Extension are effectively fixed at this point in time. These components include:

- Number of Transbay Transit Center platforms and tracks
- Geometry of northwestern portion of station "throat"

Many components of the Downtown Extension can still be revised to optimize overall operations:

- Number of Transbay Transit Center platforms and tracks assigned to each service (Caltrain and HSR)
- Station "throat" interlocking trackwork layout
- Interlocking trackwork layout where Downtown Extension interfaces with existing approach to 4th/King station.
- Number and configuration of tracks between existing 4th/King approach and Downtown Transit Center.

Many of the underlying assumptions can also be expected to change due to the ongoing San Francisco *Railyard Alternatives and I-280 Boulevard Feasibility Study*, which may dramatically reconfigure rail and roadway infrastructure within the vicinity of the existing 4th/King station.

2.8 Future Vehicle Fleet

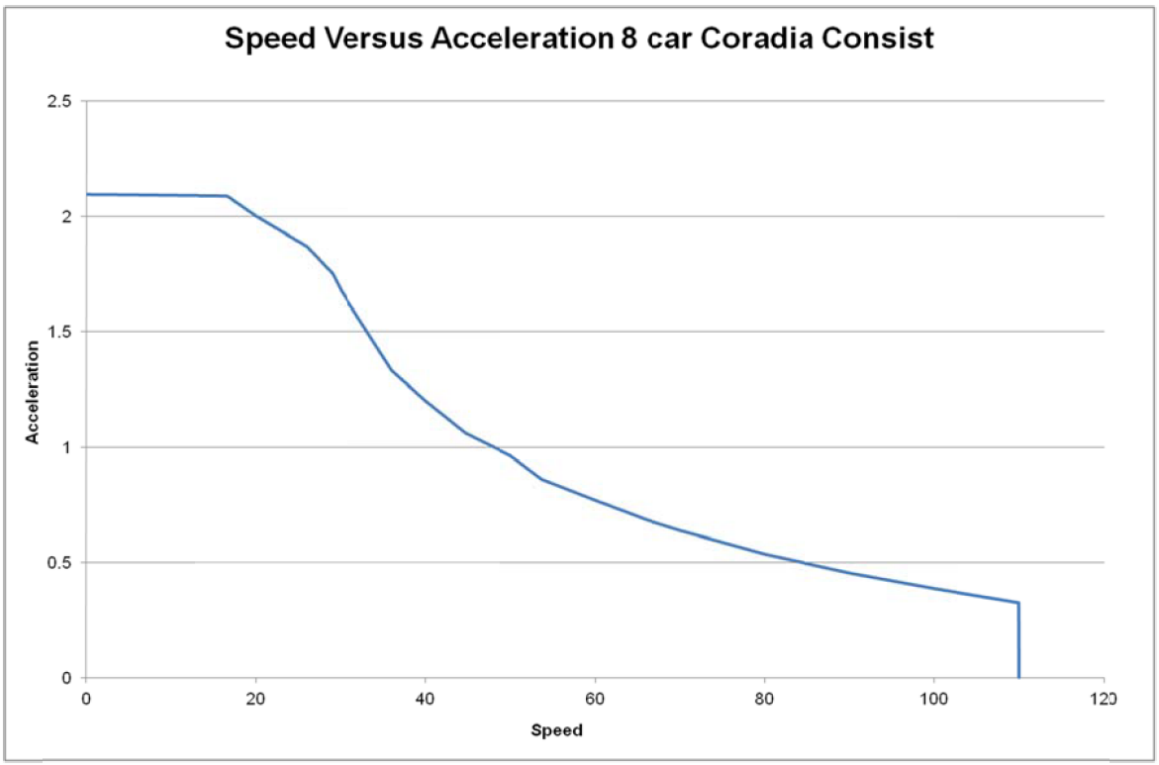
2.8.1 Performance Characteristics: Caltrain

Caltrain and HSR average acceleration, deceleration, top speed, and dwell times were estimated by calibrating against services with known stopping patterns (local, skip-stop, and HSR express) and corresponding run times given in the Blended Operations Analysis report. The run times in the Blended Service Analysis are, in turn, based on prototypical specifications for existing EMU vehicles, as identified in the Blended Service Analysis.

Figure 11. Acceleration/Deceleration for Simulated Caltrain EMU

Phase	Acceleration / Deceleration (mph per second)
Initial Acceleration (0 to 19 mph)	2.1
Acceleration (higher velocities)	Declines from 2.1 mph/s with increasing speeds. See Figure 12 below.
Deceleration for Station Stops	1.8
Deceleration for Signal (Stop or Stop & Proceed)	1.2
Deceleration for Civil Speed Enforcement	1.2

Figure 12. Speed vs. Acceleration for Simulated Caltrain EMU[8]



[8] Caltrain / California HSR Blended Operations Analysis. Peninsula Corridor Joint Powers Board, 2012.

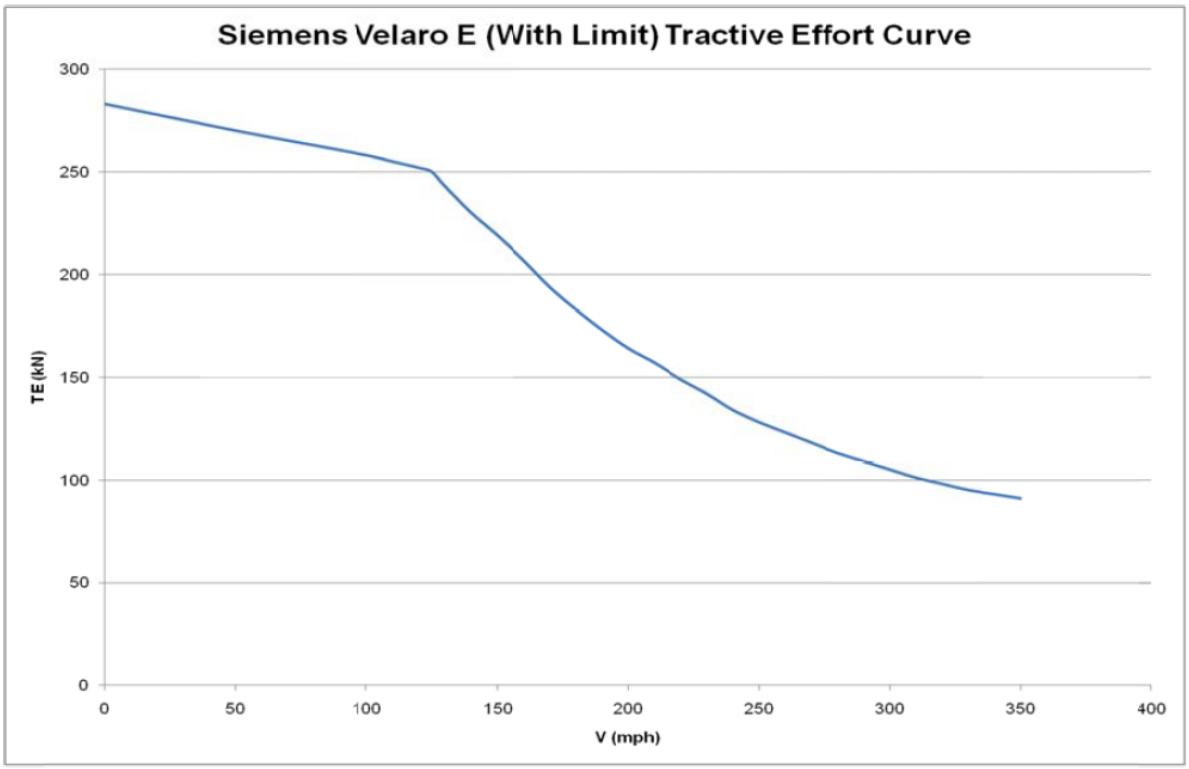
2.8.2 Performance Characteristics: High-Speed Rail

Caltrain and HSR average acceleration, deceleration, top speed, and dwell times were estimated by calibrating against services with known stopping patterns (local, skip-stop, and HSR "express") and corresponding run times given in the Blended Operations Analysis report. The run times in the Blended Service Analysis are, in turn, based on prototypical specifications for existing Siemens Velaro E vehicles, as identified in the Blended Service Analysis.

Figure 13. Acceleration/Deceleration for Siemens Velaro E High-Speed Trainset

Phase	Acceleration / Deceleration (mph per second)
Initial Acceleration (0 to 19 mph)	1.05
Acceleration (higher velocities)	Declines from 1.05 mph/s with increasing speeds. See Figure 14 below.
Deceleration for Station Stops	1.5
Deceleration for Signal (Stop or Stop & Proceed)	1.2
Deceleration for Civil Speed Enforcement	1.2

Figure 14. Siemens Velaro E High-Speed Trainset Tractive Effort Curve[9]



[9] Caltrain / California HSR Blended Operations Analysis. Peninsula Corridor Joint Powers Board, 2012.

2.8.3 Corridor Run Times

The Blended Corridor Analysis provided corridor run times for trains operating with specific service patterns. In this analysis, the average performance parameters were calibrated to match run times outlined in the Blended Corridor Analysis (shown in Figure 15). These times are travel times from 4th/King station to Diridon station.

Figure 15. Corridor Run Times, by Stop Pattern, As Reported by the Blended Service Analysis

Stop Pattern	Corridor End-to-End Run Time (minutes)
Caltrain Local	73
Caltrain Skip-Stop A	60
High-Speed Rail	43

The overall performance of Caltrain and HSR trains on the corridor is representative of electric-multiple unit (EMU) vehicles operating with a maximum speed of 79 miles/hour. The Blended Operations Analysis considered three combinations of allowable maximum speeds for Caltrain and HSR, but scenarios where both trains are operating with a maximum speed of 79 miles/hour will result in the greatest overall train capacity (because all trains will be operating at the most similar speeds in that case).

2.8.4 Future Passenger and Bike Capacity

The following "policy" passenger capacity was assumed for each Caltrain vehicle type (counting both seats and an allowable number of standees per car):

Figure 16. Caltrain Vehicle Passenger Capacity[10]

Vehicle Type	Capacity (passengers per car)
Caltrain Existing Fleet (a mix of Bombardier and Gallery cars)	130
Caltrain EMU Fleet	112

Based on discussions with the California High-Speed Rail Authority, an approximate passenger capacity of 1,000 passengers per train was also assumed.

Today, a typical 5-car Caltrain train has capacity for between 72 and 80 bicycles aboard.[11] Put differently, Caltrain has an approximately 9:1 seats to bicycle capacity ratio.

[10] EMU Procurement- Seats/Standees/Bikes/Bathroom. Peninsula Corridor Joint Powers Board, May 28, 2015.

[11] Ibid.

During peak periods, high levels of crowding occur on many trains. Many passengers who attempt to board Caltrain trains with bicycles at these times are denied entry due to insufficient available space (i.e., are "bumped").

In its Request for Proposals (RFP) for train manufacturers for its proposed EMU fleet, Caltrain specified a seats-to-bikes ratio of 8:1.[12]

The above passenger capacity numbers were used to calculate the passenger capacity totals for the long-term scenarios developed for this study, which did not account for bicycle capacity.

2.9 Future Train Control and Signalling

CBOSS PTC (Communication-Based Overlay Signal System Positive Train Control) is assumed to be in place on the corridor in the future. CBOSS PTC, to be implemented by 2015, brings federally mandated safety benefits and performance enhancements to the Caltrain corridor. PTC is associated with the safety enhancements related to collision prevention, civil speed restrictions, and roadway worker protection zones. CBOSS is associated with the attributes of the system related to improved performance and capacity enhancement.

CBOSS PTC allows for a minimum train headway of 3 minutes 16 seconds (based on the unimpeded minimum supportable headway for all-stops trains identified in the Blended Operations Analysis). The Blended Operations Analysis report specifically identified this minimum headway to be attainable for two trains operating on the same "local" stopping pattern.

With the existing infrastructure, (diesel-powered) vehicles, and signaling system, the minimum supportable train headway on the Caltrain is generally:[13]

- 5 minutes between two trains operating on an "express" stopping pattern (i.e., making no station stops between San Francisco and San Jose)
- 6 minutes between two trains operation on the same "local" stopping pattern (i.e., making all station stops between San Francisco and San Jose)

[12] Peninsula Corridor Electrification Program Request for Proposal for Procurement of Bi-Level Electric Multiple Units (EMU) Vehicles, Peninsula Corridor Joint Powers Board, August, 2015.

[13] Caltrain Design Criteria – Signals. Peninsula Corridor Joint Powers Board, 2011.

2.10 High-Speed Rail Overtake Requirements

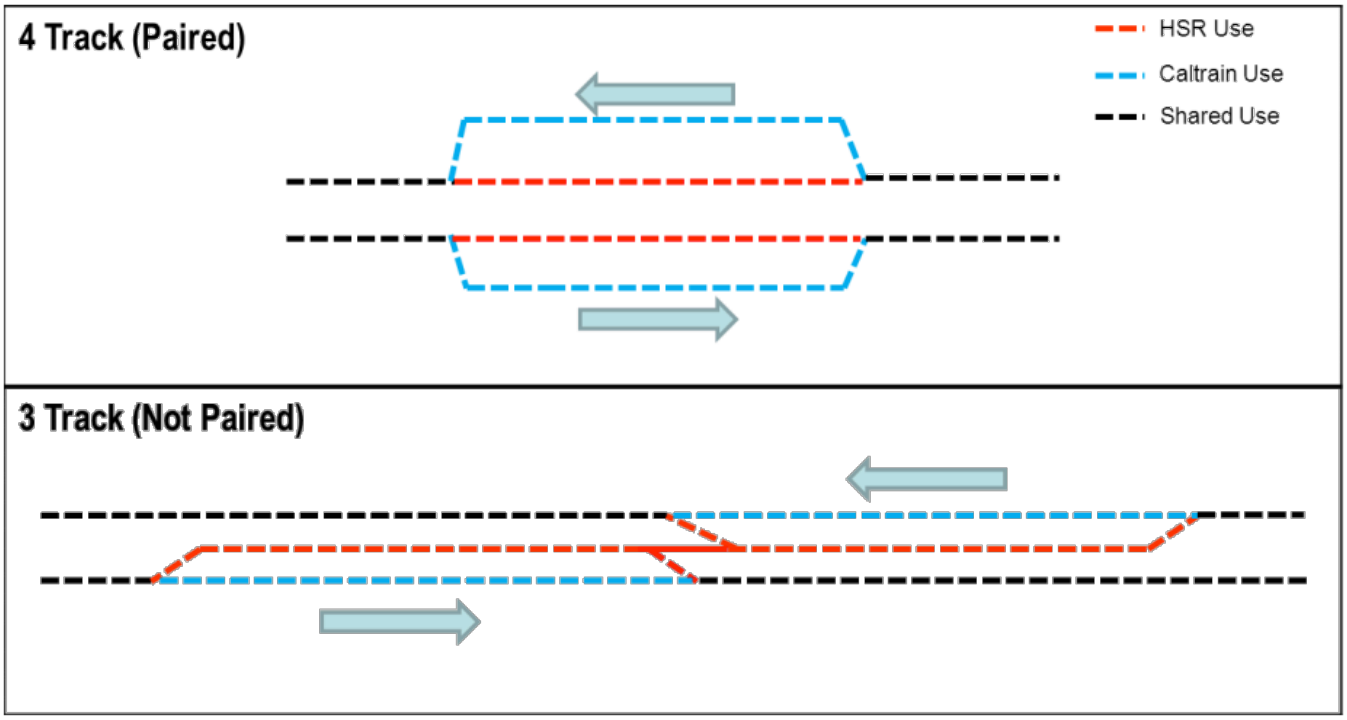
The Blended Operations Analysis indicates that Caltrain and high-speed rail can operate together, without substantial additional rail infrastructure, for a combinations of frequencies up to 6 Caltrain trains/hour and 2 High-Speed Rail trains/hour.

The above combination of services is feasible without additional rail infrastructure but not necessarily desirable. Specifically, it forces an "uneven" Caltrain timetable, whereby three Caltrain trains depart from each terminal station within 10 minutes and then 20 minutes pass before the next group of Caltrain trains can depart.

For more "even" Caltrain timetables or greater capacity for Caltrain or high-speed rail trains, "overtake track" must be constructed along the corridor. Overtake tracks allow fast trains to overtake slow trains along the corridor.

Overtake tracks for the two opposite directions of travel can either be constructed in the same locations on the corridor ("paired," resulting in four-track corridor segments) or in different locations (resulting in, at most, three-track corridor segments). The four-track approach reduces the length of the corridor impacted by new track construction but requires the width of a four-track cross-section. The three-track approach reduces the maximum corridor cross-section to three tracks but brings construction impacts (including station reconstructions) to a greater length of the corridor. Example configurations of overtake facilities are shown in Figure 17.

Figure 17. Overtake Track Configurations[14]



In this analysis, overtake facilities were sized such that the faster train could overtake the slower train without delaying either train (i.e., for "delay-free" overtakes).

[14] Caltrain/HSR Blended Service Plan Operations Consideration Analysis. Peninsula Corridor Joint Powers Board, 2013.

The Blended Operations Analysis required seven minute advantage for an overtake to be completed:

- 3 minute following move headway (slow train ahead of fast train)
- 30 second route reestablishment time at overtake diverging interlocking
- 30 second route reestablishment time at overtake merging interlocking
- 3 minute following move headway (fast train ahead of slow train)

There required passing track length for a delay-free overtake was typically approximately 10 miles. For greater detail on specific overtake requirements, see the findings for specific alternatives in the following sections.

2.11 Grade Separations

Between San Francisco and San Jose, there are 40 existing at-grade rail crossings on the peninsula rail line. Grade separations (specifically highway-rail) are not required for operation of any of the studied service scenarios.[15] However, several of the alternatives call for train frequencies significantly greater than existing conditions and service plans that have been formally analyzed to-date[16]; greater impacts to local street circulation could be expected at at-grade crossings.

Caltrain / HSR Blended Grade Crossing and Traffic Analysis considered the impacts of service plans identified in the Blended Operations Analysis study on local street operations near Caltrain grade crossings. Specifically, four service plans were tested:

- Existing conditions: five Caltrain trains per hour, no high-speed rail ("5/0")
- Six Caltrain trains per hour, no high-speed rail ("6/0")
- Six Caltrain trains per hour, two high-speed rail trains per hour ("6/2")
- Six Caltrain trains per hour, four high-speed rail trains per hour ("6/4")

Key findings from the study were:

- Improved grade crossing and train control technology (included as part of Caltrain's new CBOSS system) will bring new efficiencies in grade crossing operation. Specifically, grade crossings near stations will no longer see "double gate action" when a train stops at a station in advance of a grade crossing.
- Increasing Caltrain service from five trains per hour (with current crossing and train control technology) to six trains per hour (with improved crossing and train control technology) has a negligible impact on overall "gate down time."

[15] A legal need for grade separations would only be triggered by trains operating faster than 110 mi/hr (when "an approved barrier system" must be provided at at-grade crossings) and by trains operating faster than 125 mi/hr (when at-grade crossings at outright prohibited).

[16] The Caltrain Electrification EIR studies a service plan with six Caltrain and four high-speed rail trains per hour, for a total of 10 trains per hour.

- Increasing train service further does not necessarily increase overall gate down time across the corridor. Some grade crossings see increased gate down time while others see decreased gate down time.
    - In the "6/2" scenario, nine to ten grade crossings experience reduced gate down time compared to existing conditions while all others experience increased gate down time.
    - In the "6/4" scenario, three to five grade crossings experience reduced gate down time compared to existing conditions while all others experience increased gate down time. In this case, the addition of passing tracks improved the performance of several grade crossings because, in some cases, two, three, or sometimes even four, trains could pass through a grade crossing all at once.
- Gate down times at any specific grade crossing, and consequently traffic performance, will be highly sensitive to the exact timetables used by Caltrain and HSR services.

New and reconstructed stations identified in the study are assumed, however, to include grade-separated crossings to/from platforms for passengers.

2.12 Other Train Services on the Corridor

Caltrain is expected to continue sharing tracks with other current (and proposed) rail services in the future.

Between San Francisco and CP Coast (Santa Clara)

- Union Pacific freight trains
- Proposed: Dumbarton Corridor service (San Francisco – Dumbarton)
- Proposed: Coast Daylight intercity rail service (Los Angeles – San Francisco)

Between CP Coast and Diridon Station

- Capitol Corridor
- Altamont Corridor Express (ACE)
- Amtrak Coast Starlight
- Union Pacific freight trains
- Proposed: Coast Daylight intercity rail service (Los Angeles – San Francisco)

3. Vision Plan: Rail Operating Scenarios Considered

The following operating scenarios were evaluated for electrified Caltrain service from the Transbay Transit Center to Diridon, together with four high-speed rail trains. Each one tests a different approach to operating Caltrain and High-speed rail trains together.

This sketch analysis shows that adding tracks increases the number of trains that can operate per hour (for example, the baby bullet/skip stop) and that a simpler schedule, with fewer service types, also increases the number of trains that can operate per hour (for example, the all stops scenario). While removing stops was only explored in one scenario, it has benefits in every scenario because it not only reduces time spent stopped, it enables trains to achieve higher speeds before slowing down again to stop.

Several of these scenarios assume there are four tracks, which is not likely to be possible in the foreseeable future. State legislation may be required in order to add four-track segments, which are required to be grade-separated according to Caltrain's design standards.[17] (discussed on page 28 of the Caltrain Corridor Vision Plan). For that reason, the scenario presented on page 35 of the Caltrain Corridor Vision Plan shows an incremental process of adding capacity and schedule improvement.

Scenarios were tested both for short-term operations and for long-term (vision) operations. Service plans were tested that would be feasible with the existing diesel-powered vehicle fleet, track infrastructure, and train control and signaling.

[17] See Caltrain Design Criteria: http://www.caltrain.com/assets/_engineering/engineering-standards-2/criteria/CHAPTER7.pdf. "Caltrain does not have and does not allow at-grade crossings where there are four (4) tracks (passing tracks)." FRA guidelines also discourage grade at-crossings where there are three or more tracks See https://www.fra.dot.gov/eLib/Details/L03536 (page 5).

Figure 18. Rail Operation Scenarios Considered[18]

Service Plan Evaluated ***Peak hour capacity***	**Description**	**Peak Period Service (trains per hour per direction)**	**Corridor End-to-End Travel Time (fastest Caltrain service in minutes)**	**Approximate Capital Cost[19]**
Baby Bullet / Skip-Stop (4-track system) *10,750 passengers per hour*	Specific train services are completely segregated between the pairs of tracks (i.e., the two pairs of tracks are operationally independent). On one set of tracks, a pair of "A-B Skip-Stop" Caltrain services together serve all of the stations on the corridor. On the second pair of tracks, "Baby Bullet" Caltrain trains make a limited set of station stops and share the tracks with HSR trains. This scenario assumes that the Baby Bullet trains will make up to six intermediate stops (between San Jose and San Francisco), for a total travel time of 57 minutes.	4 Baby Bullet 4 Skip-Stop "A" 4 Skip-Stop "B"	57	$ 900 M - 1.6 B
"45-Minute Baby Bullet" (4-track system) *10,750 passengers per hour*	Identical to the "Baby Bullet / Skip-Stop alternative, except that in order to attain a 45 minute end to end travel time between San Jose and San Francisco (Transbay Terminal), no more than one intermediate stop can be made on the Baby Bullet. This alternative features a completely four-track corridor between San Francisco and San Jose. In this scenario, specific train services are completely segregated between the pairs of tracks (i.e., the two pairs of tracks are operationally independent). On one set of tracks, a pair of "A-B Skip-Stop" Caltrain services together serve all of the stations on the corridor. On the second pair of tracks, "Baby Bullet" Caltrain trains make a limited set of station stops and share the tracks with HSR trains.	4 Baby Bullet 4 Skip-Stop "A" 4 Skip-Stop "B"	45	$ 900 M - 1.6 B

[18] For cost assumptions, see Appendix B.

[19] Includes level boarding costs with HSR implementation.

All Stops, Fewer Stations (4-track system) *10,750 passengers per hour*	In this scenario, specific train services are completely segregated between the pairs of tracks (i.e., the two pairs of tracks are operationally independent). This alternative features a single class of Caltrain train service, with each serving the same reduced set of intermediate stations, striking a balance between corridor end-to-end travel time and station coverage (Optionally, four additional "Baby Bullet" Caltrain trains can also be overlaid to also operate on the "fast"/"HSR" tracks, to operate a total of 16 Caltrain trains per hour). HSR would operate on its own set of independent tracks. Fewer stops is a benefit to running times on all operating scenarios, not just this one.	12 trains	72	$ 1.9 - 2.6 B
All Baby Bullet (2-track system) *8,100 passengers per hour*	A two-track corridor between San Francisco and San Jose with four-track covering large portions of the corridor. In this scenario, Caltrain and HSR services are operationally dependent and must be closely coordinated because of the need for HSR trains to overtake Caltrain trains within the limits of the overtake facilities. Caltrain trains all operate as one of three classes of Baby Bullet. Each class of Baby Bullet train operates as a local trains (making all stops) within a third of the total corridor and as an express train (making few or no stops) in the other two-thirds of the corridor. HSR trains also operate on the corridor.	3 Baby Bullet "A" 3 Baby Bullet "B" 3 Baby Bullet "C"	62	$ 1.4 - 2.2 B
Skip-Stop (2-track system) *7,200 passengers per hour*	A two-track corridor between San Francisco and San Jose with four-track overtake facilities covering large portions of the corridor. In this scenario, Caltrain and HSR services are operationally dependent and must be closely coordinated because of the need for HSR trains to overtake Caltrain trains within the limits of the overtake facilities. A pair of "A-B Skip-Stop" Caltrain services together serve all of the stations on the corridor. HSR trains also operate on the corridor.	4 Skip-Stop "A" 4 Skip-Stop "B"	67	$ 1.1 - 1.7 B

Peninsula Local/ Silicon Valley Express (2-track system) *7,200 passengers per hour*	A two-track corridor between San Francisco and San Jose with four-track overtake facilities covering large portions of the corridor. In this scenario, Caltrain and HSR services are operationally dependent and must be closely coordinated because of the need for HSR trains to overtake Caltrain trains within the limits of the overtake facilities. Two Caltrain services serve the corridor: a "Peninsula Local" service making all stops between San Francisco and Redwood City and a "Silicon Valley Express" service making limited stops between San Francisco and Redwood City and making all stops between Redwood City and San Jose. HSR trains also operate on the corridor.	4 Peninsula Local 4 Silicon Valley Express	69	$ 1.0 – 1.5 B
Skip-Stop, New Bayshore Alignment (Expansion Project) *7,200 passengers per hour*	A two-track corridor between San Francisco and San Jose with four-track overtake facilities covering large portions of the corridor. Also includes a new "Bayshore Alignment." In this scenario, Caltrain and HSR services are operationally dependent and must be closely coordinated because of the need for HSR trains to overtake Caltrain trains within the limits of the overtake facilities. A pair of "A-B Skip-Stop" Caltrain services together serve all of the stations on the corridor. In the southern portion of the corridor, one of the two Caltrain services continues to operate on the existing Caltrain corridor; the other Caltrain service and HSR trains operate over the new Bayshore branch.	4 Skip-Stop "A" 4 Skip-Stop "B"	70	$ 4 – 7 B

3.1 Short-Term Operations (Pre-Electrification)

Today, Caltrain operates five trains per hour in the peak period (two Baby Bullets and three Limited trains per hour). Several alternatives were tested to see if the more trains could be operated within the existing service framework, retaining many of the strengths of the existing schedule (i.e., multiple fast trains per hour [Baby Bullets] and complete local coverage of stations accommodated by Limited-Limited transfers) and requiring no new rail infrastructure. The most promising option (Three Limited + Three Baby Bullet) that balances the above-mentioned strengths is described below.

3.1.1 Three Limited + Three Baby Bullet Service

This alternative allows for six trains per hour (three Limiteds and three Baby Bullets). As in today's peak period service, Baby Bullets can be operated, with each making approximately five intermediate station stops between San Francisco and San Jose. (The exact Baby Bullet station stops is unimportant to the overall service plan. Given that three Baby Bullets could operate each hour, each could serve a different set of station stops, as do current Baby Bullet trains.) Each Limited train would operate as a "zone local" service making all station stops within a specific "zone" of the corridor (north, mid, or south) and only makes stops at key transfer stations elsewhere on the corridor.

Key benefits of this service plan include:

- An increase in Baby Bullet service (from two trains/hour to three trains/hour)
- Increased overall speeds for Limited trains (each train would see reduced end-to-end corridor travel times)
- Complete connectivity between all stations for "local" trips, i.e., trips between every station pair can be completed by transferring between Limited trains at designated transfer stations.

Figure 19. "Three Limited + Three Baby Bullet" Prototypical Stop Pattern

Station	Limited A	Limited B	Limited C	Baby Bullet
San Francisco (4th / King)	●	●	●	●
22nd St			●	●
Bayshore			●	
South San Francisco			●	
San Bruno			●	
Millbrae	●	●	●	●
Burlingame			●	
San Mateo			●	
Hayward Park		●	●	
Hillsdale		●		
Belmont		●		
San Carlos		●		
Redwood City		●		●
Menlo Park		●		
Palo Alto		●		●
California Ave	●	●	●	
San Antonio	●			
Mountain View	●			●
Sunnyvale	●			
Lawrence	●			
Santa Clara	●			
College Park	●			
San Jose Diridon	●	●	●	●

3.1.2 Other Short-Term Options

Many of the long-term options presented in the following section have the potential to be implemented in the short-term, but not to the full extent. A discussion is needed to understand priorities around speed, travel time, station coverage, and capacity to develop new short-term options. This study did not analyze how the long-term service scenarios might perform in the short-term.

3.2 Long-Term (Electrified) Operations

Service plans were tested that would be feasible with the EMU vehicle fleet and expanded corridor track infrastructure (including significant overtake track facilities).

3.2.1 Baby Bullet / Skip-Stop (4-track)

This alternative features a completely four-track corridor between San Francisco and San Jose. In this scenario, specific train services are completely segregated between the pairs of tracks (i.e., the two pairs of tracks are operationally independent).

On one set of tracks, a pair of "A-B Skip-Stop" Caltrain services together serve all of the stations on the corridor. On the second pair of tracks, "Baby Bullet" Caltrain trains make a limited set of station stops and share the tracks with HSR trains. This scenario assumes that the Baby Bullet trains will make up to six intermediate stops (between San Jose and San Francisco), for a total travel time of 57 minutes.

Figure 20. "Baby Bullet / Skip-Stop" Track Assignment

"Slow" Tracks	"Fast" Tracks
4 Skip-Stop "A" Caltrain trains/hour	4 Baby Bullet Caltrain trains/hour
4 Skip-Stop "B" Caltrain trains/hour	4 HSR trains/hour

- Train capacity: **12 Caltrain trains/hour** (per direction)
- Passenger capacity: **10,750 passengers/hour (per direction)**

  156,000 passengers/day (per direction, assuming reduced off-peak schedule)
- SF-to-SJ travel time: **67 minutes (A/B Skip-Stop)**

  57 minutes (Baby Bullet)

Figure 21. "Baby Bullet / Skip-Stop" Prototypical Stop Pattern

Station	Skip-Stop A	Skip-Stop B	Baby Bullet[20]
San Francisco (Transbay Transit Center)	●	●	●
San Francisco (4th / King)	●	●	●
22nd St	●		
Bayshore		●	
South San Francisco	●		
San Bruno		●	
Millbrae	●	●	●
Burlingame	●		
San Mateo		●	●
Hayward Park	●		
Hillsdale		●	
Belmont	●		
San Carlos		●	
Redwood City	●		●
Menlo Park		●	
Palo Alto	●	●	●
California Ave		●	
San Antonio	●		
Mountain View	●	●	●
Sunnyvale	●		
Lawrence		●	
Santa Clara	●		
College Park		●	
San Jose Diridon	●	●	●

[20] The stations shown under the Baby Bullet service are for visual reference only. The exact stations served does not influence the travel time or speed within the scenario

3.2.2 45-Minute Baby Bullet / Skip-Stop (4-track)

This alternative is identical to the "Baby Bullet / Skip-Stop alternative, except that in order to attain a 45 minute end to end travel time between San Jose and San Francisco (Transbay Terminal), no more than one intermediate stop can be made on the Baby Bullet.

This alternative features a completely four-track corridor between San Francisco and San Jose. In this scenario, specific train services are completely segregated between the pairs of tracks (i.e., the two pairs of tracks are operationally independent).

On one set of tracks, a pair of "A-B Skip-Stop" Caltrain services together serve all of the stations on the corridor. On the second pair of tracks, "Baby Bullet" Caltrain trains make a limited set of station stops and share the tracks with HSR trains.

Figure 22. "45-Minute Baby Bullet / Skip-Stop" Track Assignment

"Slow" Tracks	"Fast" Tracks
4 Skip-Stop "A" Caltrain trains/hour	4 Baby Bullet Caltrain trains/hour
4 Skip-Stop "B" Caltrain trains/hour	4 HSR trains/hour

- Train capacity: **12 Caltrain trains/hour** (per direction)
- Passenger capacity: **10,750 passengers/hour** (per direction)

  156,000 passengers/day (per direction, assuming reduced off-peak schedule)
- SF-to-SJ travel time: **67 minutes (A/B Skip-Stop)**

  45 minutes (Baby Bullet)

Compared to the "Baby Bullet / Skip-Stop" alternative, the "45 Minute Baby Bullet/Skip Stop" alternative, the number of stations that will be served by a Baby Bullet will be no more than four. This assumes that the four Baby Bullet trains per hour will each make a different intermediate stop from one another.

Figure 23. "Baby Bullet / Skip-Stop" Prototypical Stop Pattern

Station	Skip-Stop A	Skip-Stop B	Baby Bullet[21]
San Francisco (Transbay Transit Center)	●	●	●
San Francisco (4th / King)	●	●	
22nd St	●		
Bayshore		●	
South San Francisco	●		
San Bruno		●	
Millbrae	●	●	
Burlingame	●		
San Mateo		●	●*
Hayward Park	●		
Hillsdale		●	
Belmont	●		
San Carlos		●	
Redwood City	●		
Menlo Park		●	
Palo Alto	●	●	
California Ave		●	
San Antonio	●		
Mountain View	●	●	
Sunnyvale	●		
Lawrence		●	
Santa Clara	●		
College Park		●	
San Jose Diridon	●	●	●

[21] The stations shown under the Baby Bullet service are for visual reference only. The exact stations served does not influence the travel time or speed within the scenario

3.2.3 All Stops, Fewer Stations

This alternative features a completely four-track corridor between San Francisco and San Jose. In this scenario, specific train services are completely segregated between the pairs of tracks (i.e., the two pairs of tracks are operationally independent).

This alternative features a single class of Caltrain train service, with each serving the same reduced set of intermediate stations, striking a balance between corridor end-to-end travel time and station coverage (Optionally, four additional "Baby Bullet" Caltrain trains can also be overlaid to also operate on the "fast"/"HSR" tracks, to operate a total of 13 Caltrain trains per hour).

High Speed Rail service would operate on its own set of independent tracks.

Figure 24. "All Stops, Fewer Stations" Track Assignment

"Slow" Tracks	"Fast" Tracks
12 Caltrain trains/hour	4 HSR trains/hour

- Train capacity: **12 Caltrain trains/hour**
- Passenger capacity: **10,750 passengers/hour** (per direction)

  156,000 passengers/day (per direction, assuming reduced off-peak schedule)
- SF-to-SJ travel time: **72 minutes**

Figure 25. "All Stops, Fewer Stations" Prototypical Stop Pattern

Station	Caltrain
San Francisco (Transbay Transit Center)	●
San Francisco (4th / King)	●
22nd St	●
Bayshore	No Service
South San Francisco	●
San Bruno	●
Millbrae	●
Burlingame	No Service
San Mateo	●
Hayward Park	●
Hillsdale	●
Belmont	No Service
San Carlos	●
Redwood City	●
Menlo Park	●
Palo Alto	●
California Ave	●
San Antonio	No Service
Mountain View	●
Sunnyvale	●
Lawrence	No Service
Santa Clara	●
College Park	No Service
San Jose Diridon	●

3.2.4 All Baby Bullet

This alternative features a completely four-track corridor between San Francisco and San Jose. In this scenario, specific train services are completely segregated between the pairs of tracks (i.e., the two pairs of tracks are operationally independent).

On one set of tracks, three "Baby Bullet" Caltrain services together serve all of the stations on the corridor. Each Caltrain service operates as a "zone local" service making all station stops within a specific "zone" of the corridor (north, mid, or south) and only makes stops at key transfer stations elsewhere on the corridor. On the second pair of tracks, HSR trains operate.

(Optionally, four additional "Baby Bullet" Caltrain trains can also be overlaid to also operate on the "fast"/"HSR" tracks, to operate a total of 13 Caltrain trains per hour.)

Figure 26. "All Baby Bullet" Track Assignment

Caltrain Tracks	HSR Tracks
3 Baby Bullet "A" Caltrain trains/hour	4 HSR trains/hour
3 Baby Bullet "B" Caltrain trains/hour	
3 Baby Bullet "C" Caltrain trains/hour	

- Train capacity: **9 Caltrain trains/hour** (per direction)
- Passenger capacity: **8,100 passengers/hour** (per direction)

  140,000 passengers/day (per direction, assuming reduced off-peak schedule)
- SF-to-SJ travel time: **62 minutes**

Figure 27. "All Baby Bullet" Prototypical Stop Pattern

Station	Baby Bullet A	Baby Bullet B	Baby Bullet C
San Francisco (Transbay Transit Center)	●	●	●
San Francisco (4th / King)	●	●	●
22nd St			●
Bayshore			●
South San Francisco			●
San Bruno			●
Millbrae	●	●	●
Burlingame			●
San Mateo			●
Hayward Park		●	
Hillsdale		●	
Belmont		●	
San Carlos		●	
Redwood City		●	
Menlo Park		●	
Palo Alto		●	
California Ave	●	●	●
San Antonio	●		
Mountain View	●		
Sunnyvale	●		
Lawrence	●		
Santa Clara	●		
College Park	●		
San Jose Diridon	●	●	●

3.2.5 Skip-Stop

This alternative features a two-track corridor between San Francisco and San Jose with four-track overtake facilities covering large portions of the corridor. In this scenario, Caltrain and HSR services are operationally dependent and must be closely coordinated because of the need for HSR trains to overtake Caltrain trains within the limits of the overtake facilities.

A pair of "A-B Skip-Stop" Caltrain services together serve all of the stations on the corridor. HSR trains also operate on the corridor.

- Train capacity: **8 Caltrain trains/hour** (per direction)
- Passenger capacity: **7,200 passengers/hour** (per direction)

  134,000 passengers/day (per direction, assuming reduced off-peak schedule)
- SF-to-SJ travel time: **67 minutes**

Figure 28. "Skip-Stop" Prototypical Stop Pattern

Station	Skip-Stop A	Skip-Stop B
San Francisco (Transbay Transit Center)	●	●
San Francisco (4th / King)	●	●
22nd St	●	
Bayshore		●
South San Francisco	●	
San Bruno		●
Millbrae	●	●
Burlingame	●	
San Mateo		●
Hayward Park	●	
Hillsdale		●
Belmont	●	
San Carlos		●
Redwood City	●	
Menlo Park		●
Palo Alto	●	●
California Ave		●
San Antonio	●	
Mountain View	●	●
Sunnyvale	●	
Lawrence		●
Santa Clara	●	
College Park		●
San Jose Diridon	●	●

3.2.6 Peninsula Local / Silicon Valley Express

This alternative features a two-track corridor between San Francisco and San Jose with four-track overtake facilities covering large portions of the corridor. In this scenario, Caltrain and HSR services are operationally dependent and must be closely coordinated because of the need for HSR trains to overtake Caltrain trains within the limits of the overtake facilities.

Two Caltrain services serve the corridor: a "Peninsula Local" service making all stops between San Francisco and Redwood City and a "Silicon Valley Express" service making limited stops between San Francisco and Redwood City and making all stops between Redwood City and San Jose. HSR trains also operate on the corridor.

- Train capacity: **8 Caltrain trains/hour** (per direction)
- Passenger capacity: **7,200 passengers/hour** (per direction)

  134,000 passengers/day (per direction, assuming reduced off-peak schedule)
- SF-to-SJ travel time: **69 minutes**

Figure 29. "Skip-Stop" Prototypical Stop Pattern

Station	Peninsula Local	Silicon Valley Express
San Francisco (Transbay Transit Center)	●	●
San Francisco (4th / King)	●	●
22nd St	●	
Bayshore	●	
South San Francisco	●	
San Bruno	●	
Millbrae	●	●
Burlingame	●	
San Mateo	●	
Hayward Park	●	
Hillsdale	●	●
Belmont	●	
San Carlos	●	
Redwood City	●	●
Menlo Park		●
Palo Alto		●
California Ave		●
San Antonio		●
Mountain View		●
Sunnyvale		●
Lawrence		●
Santa Clara		●
College Park		●
San Jose Diridon		●

3.2.7 Skip-Stop, New Bayshore Alignment (Expansion Project)

This alternative features a two-track corridor between San Francisco and San Jose with four-track overtake facilities covering large portions of the corridor. Further, this alternative includes a new "Bayshore Alignment." In this scenario, Caltrain and HSR services are operationally dependent and must be closely coordinated because of the need for HSR trains to overtake Caltrain trains within the limits of the overtake facilities.

A pair of "A-B Skip-Stop" Caltrain services together serve all of the stations on the corridor. In the southern portion of the corridor, one of the two Caltrain services continues to operate on the existing Caltrain corridor; the other Caltrain service and HSR trains operate over the new Bayshore branch.

- Train capacity: **8 Caltrain trains/hour** (per direction)
- Passenger capacity: **7,200 passengers/hour** (per direction)

  134,000 passengers/day (per direction, assuming reduced off-peak schedule)
- SF-to-SJ travel time: **70 minutes**

Figure 30. "Skip-Stop, New Bayshore Branch" Prototypical Stop Pattern

Station	Skip-Stop A	Skip-Stop B
San Francisco (Transbay Transit Center)	●	●
San Francisco (4th / King)	●	●
22nd St	●	
Bayshore		●
South San Francisco	●	
San Bruno		●
Millbrae	●	●
Burlingame	●	
San Mateo		●
Hayward Park	●	
Hillsdale		●
Belmont	●	
San Carlos		●
Redwood City	●	
Menlo Park	●	
Palo Alto	●	
California Ave	●	
San Antonio	●	
Mountain View	●	
Sunnyvale	●	
Lawrence	●	
Bayfront (Menlo Park)		●
East Palo Alto		●
North Bayshore		●
Moffett		●
Great America Pkwy		●
Santa Clara	●	●
College Park		●
San Jose Diridon	●	●