CALIFORNIA High-Speed Rail Authority

SIGNATURE/APPROVAL SHEET

TO: Bill Casey

FROM: Senan Alkhalil

SUBJECT: Approval of 2024 Business Plan Service Planning Methodology

DESCRIPTION OF ENCLOSED DOCUMENT(S): 2024 Business Plan Service Planning Methodology

REVIEWER	REVIEWER'S INTIALS/DATE:	COMMENTS
Signer #1 Name (Print): Bill Casey	Signature on file	
Signer #2 Name (Print): Brian Annis	Signature on file	
Signer #3 Name (Print): Thomas Meinl	Signature on file	
Reviewer #1 Name (Print): Bruce Armistead	Signature on file	
Reviewer #2 Name (Print): Jens Huelsermann	Signature on file	
Author #1 Name (Print): Senan Alkhalil	Signature on file	

California High-Speed Rail Authority

2024 Business Plan

Technical Supporting Document

Service Planning Methodology

Rev 1.0 (Draft)

January 2024

CALIFORNIA
High-Speed Rail Authority

CALIFORNIA High-Speed Rail Authority

Signature/Approval Sheet

TO: Bill Casey

FROM: Senan Alkhalil

SUBJECT: Approval of 2024 Business Plan Service Planning Methodology

DESCRIPTION OF ENCLOSED DOCUMENT(S): 2024 Business Plan Service Planning Methodology

REVIEWER	REVIEWER'S INITIALS/DATE:	COMMENTS
Signer #1 Name (Print): Bill Casey CHSRA Chief Operating Officer	SIGNATURE ON FILE	
Signer #2 Name (Print): Brian Annis CHSRA Chief Financial Officer	SIGNATURE ON FILE	
Signer #3 Name (Print): Thomas Meinl ETO Project Director	SIGNATURE ON FILE	
Reviewer #1 Name (Print): Bruce Armistead CHSRA Chief of Rail Operations	SIGNATURE ON FILE	
Reviewer #2 Name (Print): Jens Huelsermann ETO Lead Planning Rail Advisor	SIGNATURE ON FILE	
Author #1 Name (Print): Senan Alkhalil ETO Senior Consultant Rail Operation	SIGNATURE ON FILE	

TABLE OF CONTENTS

Tables

Figures

ACRONYMS AND ABBREVIATIONS

Abbreviation	Description
AGV	Automotrice à grande vitesse (high-speed electric train built by Alstom)
CRRM	California Rail Ridership Model
CVS	Central Valley Segment, early high-speed rail operation between Merced and Bakersfield
HMF	Heavy Maintenance Facility
HSR	High-speed rail
MPH	Miles per hour
NTSB	National Transportation Safety Board
O&M	Operations and Maintenance
SJJPA	San Joaquin Joint Powers Authority
SJRRC	San Joaquin Regional Rail Commission (SJRRC)
TMF	Trainset Maintenance Facility
TPC	Train Performance Calculations
V2V	Silicon Valley to Central Valley Service (San Francisco to Bakersfield)

1 PURPOSE FOR HIGH-SPEED RAIL SERVICE PLANS

The development process of the California High-Speed Rail Authority 2024 *Business Plan* includes an operations planning framework that was based on the latest ridership forecast data and designed to achieve a balanced service plan providing frequent travel options and limiting the operational effort, including revenue and non-revenue operations. The plan, which captures HSR service and related service costs at an intermediate level of project development, does not yet represent the type of detailed operating plan necessary to provide commercially driven service; this will be developed within the next years. Future commercially driven service offers will consider operational options including the impacts of yield management and other commercial considerations that impact stopping patterns, service frequencies and utilization targets of trains.

The service plans are developed to optimally align with the infrastructure to be provided through the capital cost expenditure plan, updated information for the mixed service corridors between Sales Force Transit Center and Gilroy as well as from Burbank to Anaheim and slotting of trains to accommodate the mixed service operation in these corridors.

Service plans have been developed to cover three phases of project development: Central Valley Segment (Merced to Bakersfield), Silicon Valley to Central Valley Service (San Francisco and Merced to Bakersfield with the full Wye construction option) and Phase 1 (San Francisco and Merced to Anaheim via Los Angeles Union Station and Merced to San Francisco services).

The overall routes and stopping patterns of the service plan were carried over from the 2023 Project Update Report assumptions but updated to reflect revised data to determine slotting of trains in the peninsula and the southern California mixed services corridors as well as to reflect updated travel times of the proposed services.

In addition, for purposes of the ridership modeling, the rail and bus connectivity concept north of Merced was adapted for the Silicon Valley to Central Valley and Phase 1 concepts to account for the connecting services and to match the Central Valley Segment assumptions.

The connectivity concept and the needed service volume will be provided by SJJPA and SJRRC as defined in the Central Valley Segment System Management & Operations Interim Financial Plan[1] and the Central Valley Study Update and Implementation Plan work[2]. This information is not part of the California High-Speed Rail Authority (CHSRA) HSR service planning process, but the service plan and operating concept were added to reflect the newest information available for connecting services.

2 SERVICE PLANNING PROCESS

The service planning process used to prepare the assumptions for the 2024 Business Plan is formulated to provide service structure, journey times, and frequencies that are then used as inputs to the California Rail Ridership Model (CRRM) to produce ridership and revenue forecasts. A practical timetable for the operating day was developed based on estimated hourly service patterns of revenue service trains for peak and off-peak periods.

The timetables are based on run times generated by the Viriato train performance calculator[3], which includes infrastructure-related parameters such as maximum allowable speed and gradients and other physical parameters of the rolling stock. Industry-standard allowances for day-to-day variance in train

[1] CHSRA – Early Train Operator, Central Valley Segment System Management & Operations Interim Financial Plan, June 2020

[2] CHSRA – Early Train Operator, Central Valley Segment Study Update and Implementation Plan, Ongoing

[3] Viriato – Timetable planning software, SMA und Partner AG, Zurich, Switzerland. Viriato is a railroad operations and schedule planning software tool widely used among passenger railroads in the United States and by international operators.

operations – such as weather conditions, fluctuation of train performance due to differences in engineers' handling and minor operating interruptions – are then added to these run times (schedule pad).

The schedule pad allowance was set to 5% of the technically feasible run time on sections where HSR trains operate exclusively and to 10% on mixed service sections to allow for additional disruptions stemming from third-party services and/or coordination hindrances. The timetable also includes further allowances for station dwell times and train turn times.

The Viriato software tool also allows the slotting of trains in mixed service corridors to ensure appropriate train sequencing between the different service categories. For planning purposes, a minimum train sequencing time of 3 minutes is assumed based on the technical design requirements of the train control system to allow for headways of no more than 2 minutes and 45 seconds. This is reduced to 2 minutes for following train services using a diverging or converging junction (e.g. at the blended sections, non-revenue crossing moves and/or where train passing), if required.

The timetable is used to calculate specific outputs, such as the number of revenue and non-revenue train runs, train mileage and fleet size used for the Operations and Maintenance (O&M) Cost Model. The finished timetable is also the basis for the calculation of feeder bus mileage, which is another input for the cost model. The entire process is explained in more detail in this report in chapter 3.3. The timetable does not represent commercially optimized service but rather reflects an illustrative plan that can be used to derive reasonable outputs necessary for ridership, revenue, and O&M cost modeling.

3 METHODOLOGY

The timetables developed for the preparation of the ridership estimates for the 2024 Business Plan were created in a multistep process consisting of:

1. Establishing a service structure and frequency to be used in the demand model for each of the designated demand model project milestone years: 2030, 2040 and 2050.
2. Development of service plans based on the service levels assumed for the demand model run(s) and fleet manipulation.
3. Use of key parameters defining the technical trip times and revenue service schedules and timetable operating assumptions and inputs[4] that include:
    - 20-minute minimum turn time at terminal stations;
    - 2-minute minimum dwell time at stations;
    - 10-minute minimum transfer time between rail and rail or between rail and bus;
    - 3-minute minimum transfer time between bus and bus;
    - Runtime calculation based on trainsets with performance characteristics equivalent to the Alstom Automotrice à Grande Vitesse (AGV) trainset model and train performance characteristics described in the trainset specifications; and
    - All services planned to operate using a single trainset.
4. Calculation of the O&M Cost Model inputs:
    - Revenue service train count;

[4] Assumptions defined in: CHSRA, 2023PUR: Technical Supporting Document Service Planning Methodology June 1, 2018, page 11

- Daily trainset revenue and non-revenue miles and hours;
- Fleet size; and
- Revenue-train to revenue-train turn count.

5. Calculation of the feeder HSR bus service revenue miles and hours.

3.1 Service Structure and Service Level for the CRRM

The first step of developing a service plan is to create a service structure and service frequencies for the milestone years and phases that the demand model uses. As specified earlier, for the *2024 Business Plan*, the following ridership demand model milestone and forecast years were selected to allow the generation of time series of forecasts assuming a fiscally unconstrained implementation:

- Silicon Valley to Central Valley line at 2030, 2040 and 2050 horizons, and
- Phase 1 at 2030, 2040 and 2050 horizons.

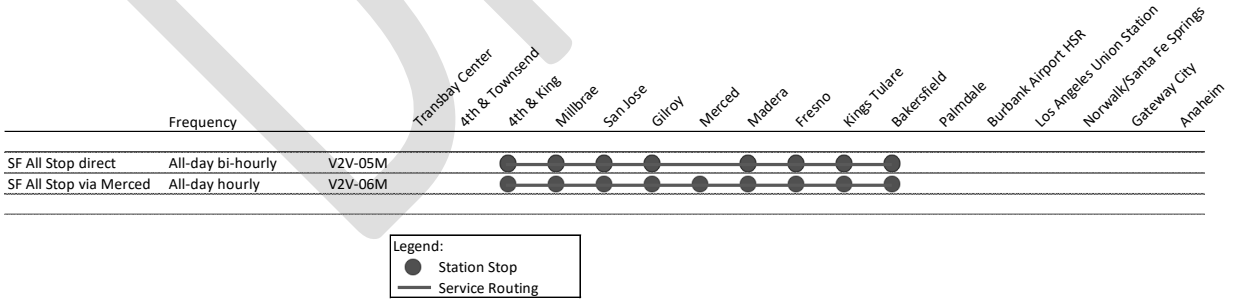
The different services for the two CHSRA operating phases are shown in Figure 3-1 for Valley-to-Valley operation phase and in Figure 3-2 for the Phase 1 operation phase of the high-speed rail system.

A service structure (the combination of stopping patterns normally referred to as Non-Stop, Express, Limited-Stop and All-Stop) and an hourly or bi-hourly frequency (the number of trains per hour in each direction) for each stopping pattern service in peak and off-peak hours were prepared for the forecast model runs.

For each stopping pattern service, anticipated station-to-station run time was calculated after applying schedule pad and dwell time by using the Viriato tool. Then, run times were adjusted, where needed, to allow for proper slotting of trains. As a result, the cumulated station-to-station run time of each stopping pattern reflects the service travel time that is used as a key input for the travel demand model.

As an example, the Silicon Valley to Central Valley service patterns with the full Wye construction option are shown in Figure 3-1, which consists of bi-hourly All-Stop direct train patterns between San Francisco and Bakersfield and consists of hourly All-Stop train pattern between San Francisco and Bakersfield via Merced.

Figure 3-1 Service Structure Assumption for the Silicon Valley to Central Valley Line

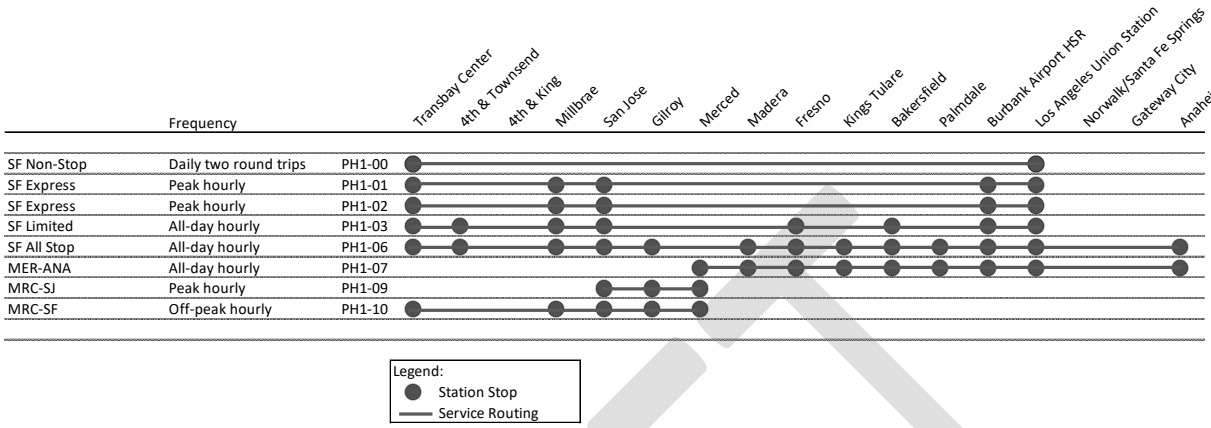


Note: HSR terminal will be moved from “4th & King Station” to “Transbay Center Station” as soon as the Downtown Extension is available.

Figure 3-2 shows the assumed service structure for Phase 1, which consists of Non-Stop, Express, Limited-Stop and All-Stop train pattern services between San Francisco and Los Angeles/Anaheim, consists of All-Stop train pattern service between Merced and Los Angeles/Anaheim and consists of

Limited-Stop train pattern service between Merced and San Jose/San Francisco (alternate Peak/Off-Peak services).

Figure 3-2 Service Structure Assumption for Phase 1



Note: HSR stopping pattern between Los Angeles and Anaheim is subject to confirmation and both "Norwalk/Santa Fe Springs" and "Gateway City" (Fullerton) as a stop are under review.

The service structure illustrated above for Phase 1 offers several customer service advantages:

- Ability to travel between any pair of stations without having to change trains with the exception of trips from Transbay Center, 4th&Townsend and Millbrae to Merced during peak periods (due to slotting limitations of 4 slots per hour and direction on the Peninsula Corridor;
- Mixture of Non-Stop, Express, Limited-Stop and All-Stop services, which offers a diverse range of train services to cover a wide variety of travel needs;
- Consistency in the service level at each station throughout the segment and during the service expansion/implementation phases; and
- Operational flexibility for practical application of the commercial service in future years.

3.2 Development of California High-Speed Rail Service Plans

The train schedules were developed through a process consistent with previous CHSRA Business Plans and 2023 Project Update Report and updated to reflect latest assumptions in preparation of the 2024 Business Plan.

Service plans for the selected years of the demand model (2030, 2040, and 2050) were developed based on the hourly frequency and service structure assumptions. Using these service assumptions as a template, separate peak hour and off-peak hour service plans were developed for the five CRRM time periods shown in Table 3-1.

Table 3-1 Time-of-Day Periods and Operating Hours

Period	Code	Hours	Number of Hours
Weekday AM Peak	AM	06:00 – 10:00	4
Weekday Midday (Off-Peak)	MID	10:00 – 15:00	5
Weekday PM Peak	PM	15:00 – 19:00	4
Weekday Evening (Off-Peak)	OFF	19:00 – 00:00	5
Average Weekend	WKD	06:00 – 00:00	18

The service plans remain consistent for each service scenario for the three horizon years. Therefore, full operating schedules are assumed at the beginning of the Silicon Valley to Central Valley and the Phase 1 operation on day 1 of each service.

The O&M inputs presented in the Appendix "Operations and Maintenance Cost Model Documentation" do not include ramp-up assumptions for operation (100% of service assumed at first day of operation).

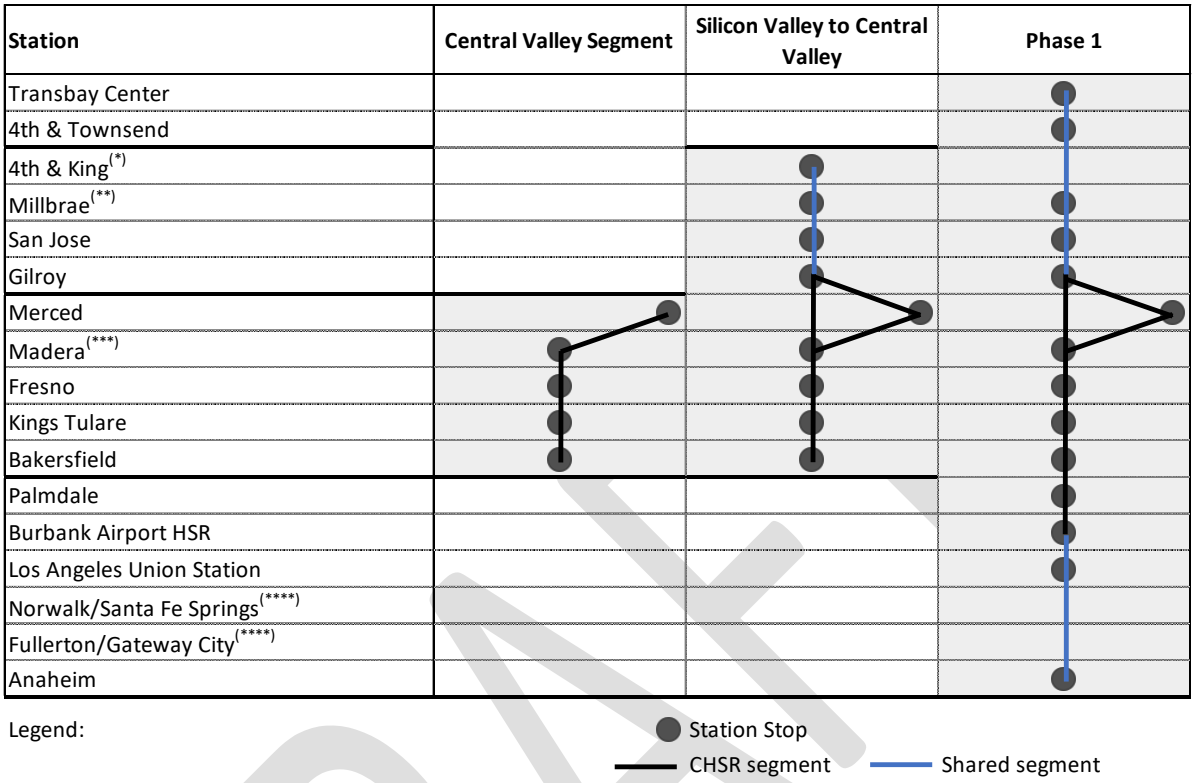
3.2.1 Stopping Patterns

The Silicon Valley to Central Valley service reflects the following:

- Reflection of the CVS early operation between Merced and Bakersfield before Silicon Valley to Central Valley operation commences;
- Early inclusion of Millbrae as a station stop to reflect recent developments in the development of the Millbrae station area planning;
- Addition of the full Wye alignment and the station in Merced in the Silicon Valley to Central Valley service plan; and
- Reflection of the Downtown Extension to Salesforce Transit Center in Phase 1 and Silicon Valley to Central Valley service with a terminus at 4th & King Station for planning purposes.

The Silicon Valley to Central Valley service plan reflects elements from the Phase 1 service plans that are assumed at this earlier stage of operation. The resulting service provides a significant number of train miles that are based on the Silicon Valley to Central Valley services with and without turn in Merced (as shown in Figure 3-3).

Figure 3-3 Stations Served for the *Central Valley Segment,* Silicon Valley to Central Valley and Phase 1 Alternatives



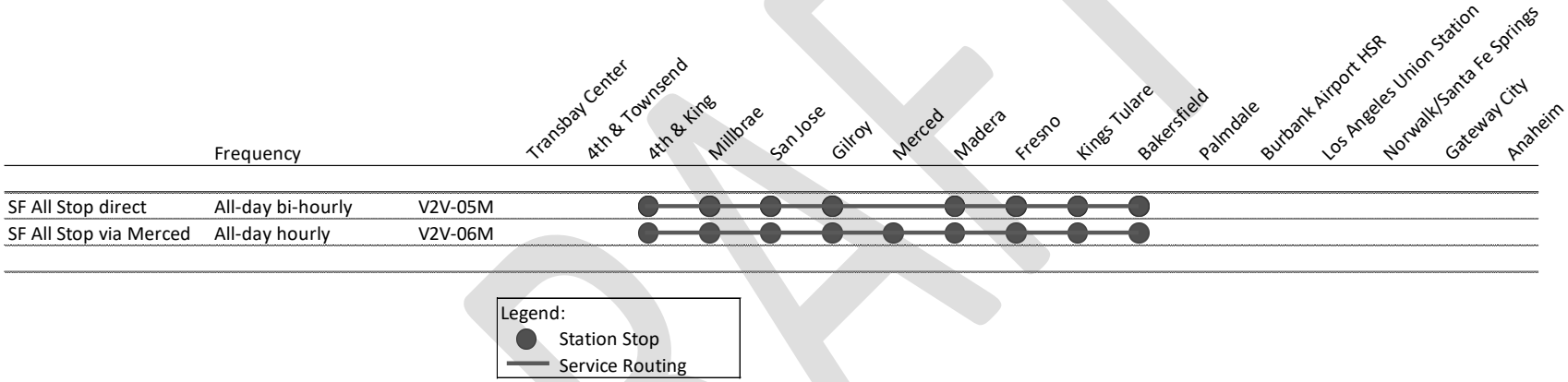
Notes: (*) HSR terminal for V2V will be moved from 4th and King to STC as soon as the Downtown Extension is completed
(**) Millbrae assumed to be operational in Silicon Valley to Central Valley scenario as HSR stop.
(***) CHSR stop in Madera is assumed. The station will be environmentally cleared and funded by local authorities.
(****) In 2024BP there is no stop at both stations. However, a potential stop at Norwalk/Santa Fe Springs and/or at Gateway City (Fullerton) is still under consideration.

The following figures and tables describe the high-speed rail services for the Silicon Valley to Central Valley operation as well as the Phase 1 service. The service plan assumes eight hours of peak operation as well as ten hours of off-peak operation (refer to Table 3-1).

In Silicon Valley to Central Valley (Table 3-4) the San Francisco to Bakersfield via Merced operates at 60-minute headways throughout the operating day. The San Francisco to Bakersfield direct service operates at bi-hourly headways throughout the operating day.

In Phase 1, the service frequencies vary as shown in Table 3-5, with lower frequencies in the off-peak period and reduced service patterns where only five service patterns operate during the off-peak period. In the peak period nine different service patterns with hourly frequencies operate on the Phase 1 system.

Figure 3-4 Stopping Patterns by Line for Silicon Valley to Central Valley Service



Note: HSR services will be moved from 4th and King to STC as soon as the Downtown Extension is completed. HSR service V2V-05M service is peak only service.

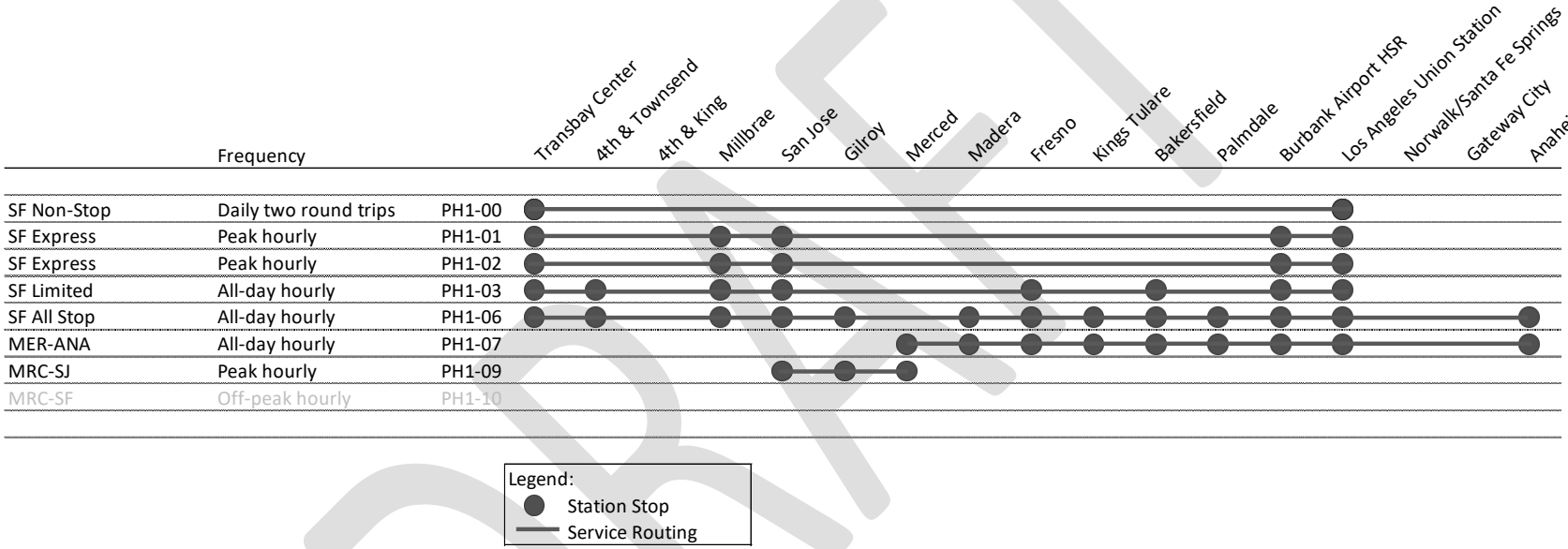
Table 3-2 Service Frequency by Line and Station for Silicon Valley to Central Valley Service

Service Pattern	Southbound	Northbound	Transbay Center	4th & Townsend	4th & King	Millbrae	San Jose	Gilroy	Merced	Madera	Fresno	Kings Tulare	Bakersfield	Palmdale	Burbank Airport HSR	Los Angeles Union Station	Norwalk/Santa Fe Springs	Gateway City	Anaheim
Southbound V2V-05M	9				9	9	9	9		9	9	9	9						
Southbound V2V-06M	16				16	16	16	16	16	16	16	16	16						
Southbound Total Day	25				25	25	25	25	16	25	25	25	25						
Northbound V2V-05M		9			9	9	9	9		9	9	9	9						
Northbound V2V-06M		16			16	16	16	16	16	16	16	16	16						
Northbound Total Day		25			25	25	25	25	16	25	25	25	25						
Total Day (Both Directions)	25	25			50	50	50	50	32	50	50	50	50						
Peak (Both Directions)	14	12			26	26	26	26	17	26	26	26	26						
Off-Peak (Both Directions)	11	13			24	24	24	24	15	24	24	24	24						

Table 3-3 Service Frequency by Station Pair for Silicon Valley to Central Valley Service

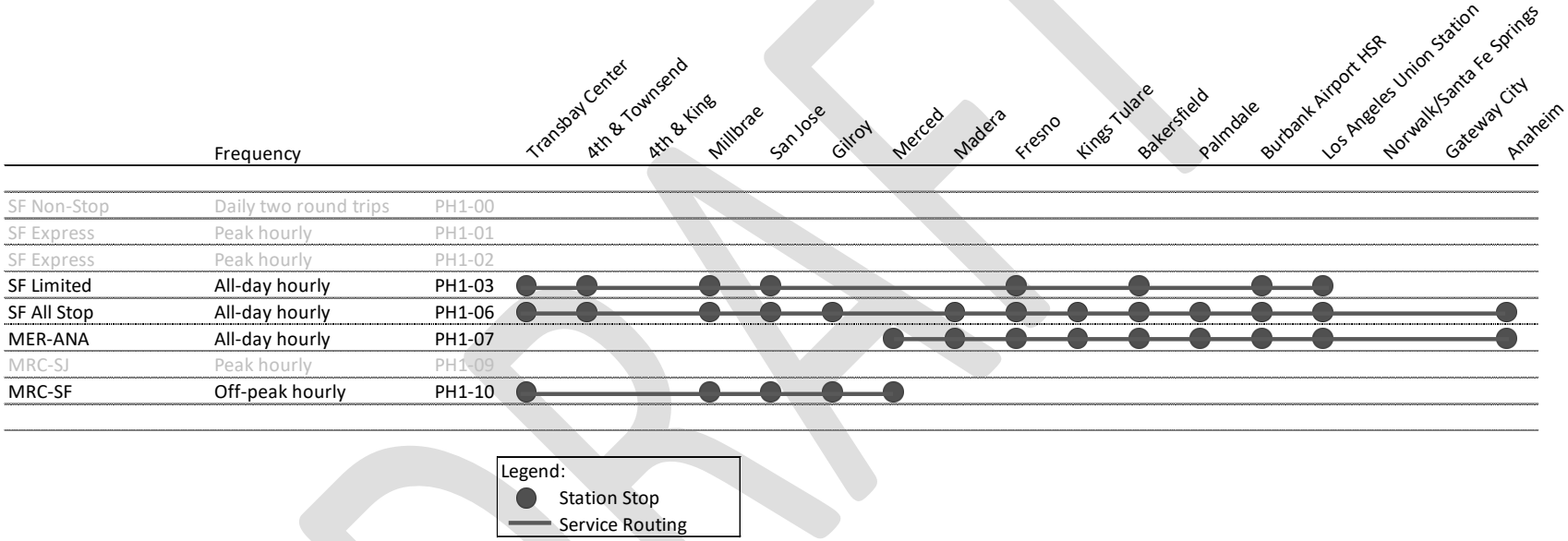
Origin-to-Destination	Transbay Center	4th & Townsend	4th & King	Millbrae	San Jose	Gilroy	Merced	Madera	Fresno	Kings Tulare	Bakersfield	Palmdale	Burbank Airport HSR	Los Angeles Union Station	Norwalk/Santa Fe Springs	Gateway City	Anaheim
Transbay Center																	
4th & Townsend																	
4th & King				25	25	25	16	25	25	25	25						
Millbrae			25		25	25	16	25	25	25	25						
San Jose			25	25		25	16	25	25	25	25						
Gilroy			25	25	25		16	25	25	25	25						
Merced			16	16	16	16		16	16	16	16						
Madera			25	25	25	25	16		25	25	25						
Fresno			25	25	25	25	16	25		25	25						
Kings Tulare			25	25	25	25	16	25	25		25						
Bakersfield			25	25	25	25	16	25	25	25							
Palmdale																	
Burbank Airport HSR																	
Los Angeles Union Station																	
Norwalk/Santa Fe Springs																	
Gateway City																	
Anaheim																	

Figure 3-5 Stopping Patterns by Line for Phase 1 Peak Service



Note: HSR service PH1-10 is off-peak only service.

Figure 3-6 Stopping Patterns by Line for Phase 1 Off-Peak Service



Note: HSR services PH1-00, PH1-01, PH1-02, and PH1-09 are peak only services.

Table 3-4 Service Frequency by Line and Station for Phase 1 Service

Service Pattern	Southbound	Northbound	Transbay Center	4th & Townsend	4th & King	Millbrae	San Jose	Gilroy	Merced	Madera	Fresno	Kings Tulare	Bakersfield	Palmdale	Burbank Airport HSR	Los Angeles Union Station	Norwalk/Santa Fe Springs	Gateway City	Anaheim
Southbound PH1-00	2		2													2			
Southbound PH1-01	8		8			8	8								8	8			
Southbound PH1-02	8		8			8	8								8	8			
Southbound PH1-03	15		15	15		15	15				15		14		14	14			
Southbound PH1-06	16		16	16		16	16	16		16	16	16	16	15	15	15			14
Southbound PH1-07	16								16	16	16	16	16	16	16	16			15
Southbound PH1-09	9						9	9	9										
Southbound PH1-10	8		8			8	8	8	8										
Southbound Total Day	82		57	31		55	64	33	33	32	47	32	46	31	61	63			29
Northbound PH1-00		2	2													2			
Northbound PH1-01		8	8			8	8								8	8			
Northbound PH1-02		8	8			8	8								8	8			
Northbound PH1-03		15	15	15		15	15				15		14		14	14			
Northbound PH1-06		16	16	16		16	16	16		16	16	15	16	15	15	15			14
Northbound PH1-07		16							16	16	16	16	16	16	16	16			15
Northbound PH1-09		9					9	9	9										
Northbound PH1-10		8	8			8	8	8	8										
Northbound Total Day		82	57	31		55	64	33	33	32	47	32	46	31	61	63			29
Total Day (Both Directions)	82	82	114	62		110	128	66	66	64	94	64	92	62	122	126			58
Peak (Both Directions)	49	53	69	35		67	83	34	33	35	52	35	52	35	84	86			35
Off-Peak (Both Directions)	33	29	45	27		43	45	32	33	29	42	29	40	27	38	40			23

Note: Service counts for HSR services PH1-03, PH1-06 and PH1-07 reflect short turns in Fresno, Bakersfield and Los Angeles Union Station with lower train counts south of these stations.

Table 3-5 Service Frequency by Station Pair for Phase 1 Service

Origin-to-Destination	Transbay Center	4th & Townsend	4th & King	Millbrae	San Jose	Gilroy	Merced	Madera	Fresno	Kings Tulare	Bakersfield	Palmdale	Burbank Airport HSR	Los Angeles Union Station	Norwalk/Santa Fe Springs	Gateway City	Anaheim
Transbay Center		31		55	55	24	8	16	31	16	30	15	45	47			14
4th & Townsend	31			31	31	16		16	31	16	30	15	29	29			14
4th & King																	
Millbrae	55	31			55	24	8	16	31	16	30	15	45	45			14
San Jose	55	31		55		33	17	16	31	16	30	15	45	45			14
Gilroy	24	16		24	33		17	16	16	16	16	15	15	15			14
Merced	8			8	17	17		16	16	16	16	16	16	16			15
Madera	16	16		16	16	16	16		32	32	32	31	31	31			29
Fresno	31	31		31	31	16	16	32		32	46	31	45	45			29
Kings Tulare	16	16		16	16	16	16	32	32		32	31	31	31			29
Bakersfield	30	30		30	30	16	16	32	46	32		31	45	45			29
Palmdale	15	15		15	15	15	16	31	31	31	31		31	31			29
Burbank Airport HSR	45	29		45	45	15	16	31	45	31	45	31		61			29
Los Angeles Union Station	47	29		45	45	15	16	31	45	31	45	31	61				29
Norwalk/Santa Fe Springs																	
Gateway City																	
Anaheim	14	14		14	14	14	15	29	29	29	29	29	29	29			

Note: Service counts for HSR services PH1-03, PH1-06 and PH1-07 reflect short turns in Fresno, Bakersfield and Los Angeles Union Station with lower train counts south of these stations.

This page intentionally left blank.

3.3 Calculation of Operations and Maintenance Cost Model Inputs

The service plans are designed to provide direct inputs for the Operations and Maintenance (O&M) Cost Model for:

- Trainset mileage;
- Fleet size;
- Number of revenue trains;
- Crew numbers; and
- Feeder bus miles.

After the service plans were developed, all equipment was linked to form extended cycles[5] to satisfy the terminal requirements,[6] as well as staging for the morning start-out and evening shut-down requirements for each terminal station. These equipment cycles form the basis of the estimate for the total fleet size required by the revenue service. These cycles also dictate the daily system-wide trainset mileage, which affects energy costs as well as rolling stock and infrastructure maintenance costs in the O&M Cost Model.

3.3.1 Trainset Mileage

The daily trainset mileage is computed based on the service plan and the associated equipment cycles created to estimate the fleet size. The mileage of the trainsets was derived by adding up:

- Revenue movements included in the service plan;
- Non-revenue movements at the beginning of the service day—the distance between a train maintenance facility (TMF) or layover location where the trainset was stored overnight and the origin station of the first revenue train of the cycle;
- Non-revenue movements at the end of the service day—the distance between the terminus of the final revenue service of the cycle and the TMF or layover facility where the trainset would be stored and maintained for the next day; and
- Non-revenue movements during the off-peak midday layover —the distance between the terminus of the final revenue service of the peak cycle and the TMF or layover facility where the trainset would be stored for the next off-peak period.

[5] The planned train schedule assignments for the duration of a service day.

[6] The number of trainsets required to begin revenue service at each terminal station during a calendar day.

4 ASSUMPTIONS

The assumptions used in the service planning process are related to infrastructure, fleet parameters, proposed service, and fleet requirements.

4.1 Infrastructure

The northern part of the HSR system between San Francisco and Gilroy will operate on infrastructure shared with Caltrain and its tenants with operating speeds up to 110 MPH.

The central section of the HSR system between Gilroy and Burbank will be dedicated high-speed infrastructure separated from any other rail systems, and trains can reach operating speeds up to 220 MPH on this section.

The southern part of the system, between Burbank and Anaheim, will operate on infrastructure shared with Metrolink, LOSSAN, Amtrak and BNSF, with operating speeds up to 125 MPH.

High-speed rail passenger stations are assumed to be at the following locations:[7]

- San Francisco (Salesforce Transit Center);
- San Francisco (4th & Townsend);
- San Francisco (4th & King);[8]
- Millbrae/SFO;
- San Jose (Diridon Station);
- Gilroy;
- Merced;
- Madera (high-speed rail service assumed to stop; station to be provided by third parties);
- Fresno;
- Kings/Tulare;
- Bakersfield;
- Palmdale;
- Burbank (Airport);
- Los Angeles (Union Station); and
- Anaheim (ARTIC).

Mid-line stations are assumed to be four-track stations with two center through-tracks and two outside platform tracks. These outside platform tracks will be siding tracks of approximately 1,410 feet length and adjacent to the station platform. Universal interlockings capable of routing trains to all parts of the station complex will be provided.

The signal system is assumed to provide a two-minute 45-second minimum signaling headway at 220 MPH.

---

[7] The list of stations shown is not definitive and may be subject to change as the program continues to develop. In 2024BP there is no stop at Norwalk/Santa Fe Springs and/or at Gateway City (Fullerton) stations. However, a potential stop at both stations is under consideration.

[8] San Francisco 4th & King station to be used only until the opening of the Downtown Extension and Salesforce Transit Center station and is considered only in V2V as a station stop for planning purposes. Correspondingly, San Francisco 4th and Townsend station is only assumed a station stop in Phase 1 with the Downtown Extension in operation.

Trainset Maintenance Facilities will be built as listed Table 4-1. Note: the locations of these facilities are part of the ongoing environmental approval process and may change. They are listed here as assumptions to develop reference points to ensure that non-revenue crew and mileage inputs can be determined for the Operations and Maintenance Cost Model.

Table 4-1 List of Rolling Stock Maintenance Facility Assumed in Service Plan Development

Preliminary Name	Roll-Out Phase	Facility type
Bay Area	Silicon Valley to Central Valley	Light Maintenance Facility
Central Valley	Central Valley Segment	Heavy Maintenance Facility
Los Angeles Area	Phase 1	Light Maintenance Facility
Anaheim	Phase 1	Storage Yard with Level I Maintenance activities

Note: The layover facility in Anaheim is considered for layover of trains and will likely have capabilities for minor overnight maintenance of trainsets.

4.2 Fleet Specification

Trainsets with performance characteristics equivalent to the Alstom AGV trainset model were used for the pure run-time calculations. The trip time was based on train performance characteristics described in the trainset specifications and track geometry. Trainsets were assumed to be approximately 672.6 feet (200 meters) in length with 450 passenger seats.

Each revenue-service train was assumed to be operated in one trainset configuration but can be expanded to two trainsets if future demand indicates the need to double the seat capacity. Protect train sets can be used for special service for events or to add capacity for holiday or seasonal increases in demand on given train routes. These details are not part of the base case service planning efforts and will be evaluated as the system is getting closer to implementation.

4.3 Passenger Service

Due to refined CRRM capabilities, separate weekday and weekend day (including holidays) schedules were established. The weekend day schedules are based on off-peak weekday service frequency and stopping patterns.

System revenue-service hours are anticipated to be from 0600 to midnight (0000), seven days per week. The five-hour period between 0000 and 0500 is allocated to the maintenance of infrastructure, and the one-hour period between 0500 and 0600 is allocated for non-revenue movements and other activities required for the morning service start-up.

When possible, the service program features passenger-friendly and operationally flexible “clock face” patterns with train departures at regular headways and at the same minute after each hour. Train schedules consist of two kinds of clock face patterns—one for the peak period and the other for the off-peak period. HSR train schedules also reflect slotting of trains in the Peninsula corridor and south of Burbank Airport HSR Station.

Two 4-hour peak periods are assumed in each revenue service day (morning and afternoon peaks), refer to Table 3-1. The peak hours are meant to accommodate maximum ridership numbers with the limitation of available seats per train. The service during the early morning start-up period and the late evening shut-down period may be different from service patterns during other times of the day to capture short-distance, regional-trip demands while offering optimal service between terminal stations and intermediate stations.

The service planning was further refined to reflect midday service and evening service as well as an all-day weekend service program.

Overtakes between faster trains and slower trains occur at mid-line stations to allow faster trains to achieve scheduled trip time. In some instances, the train being overtaken, or overtaking, may incur additional station dwell time or scheduled trip time to accommodate the overtake at intended locations.

The minimum dwell time at mid-line stations is two minutes. The minimum turnaround time for a trainset between revenue trips at a terminal station is 20 minutes.

4.4 Fleet Requirements

All trainsets required for revenue-service operations are assumed to be stored at nearby Trainset Maintenance Facilities, or on platforms, or tail tracks at mid-line stations.

The total fleet requirement of the system consists of the actual number of trainsets required to operate the revenue service plus a provision of maintenance spares and revenue service “protect” trains following international industry approach in high-speed passenger rail systems.

The adopted approach for this business plan cycle is reasonable and is subject to minor refinement as the project moves closer to implementation. However, change of service plan due to operating parameter changes or change in other system parameters (e.g. O&M, Ridership revenue, BP funding projects, etc.) might be required.

Table 4-2 List of Rolling Stock Set Needs

Operation	Sets for Operation	Protect	Maintenance spare ratio	Spare Ratio	Total
Central Valley Segment	4	1	1	17%	6
Silicon Valley to Central Valley	12	2	3	18%	17
Phase 1	44	6	8	14%	58

Note: Both V2V and Phase 1 service program differs from prior service assumptions and requires a smaller fleet. CVS fleet size shown only for purposes of comparison.

5 FEEDER BUS SERVICE PLANNING

During initial stages of its implementation, the high-speed rail system will not provide high-speed train service to some major urban areas in California, such as the San Francisco Bay Area and the Los Angeles Basin. When Silicon Valley to Central Valley (V2V) service opens, the proposed high-speed rail service would end at San Francisco (4th and King), Merced, and Bakersfield, creating interim terminal stations. To enhance connectivity to/from these interim terminal stations, feeder buses will be implemented. This chapter explains the different feeder bus scenarios.

5.1 Filling the Connectivity Gap

Certain conventional rail connections, such as the San Joaquins and ACE services, connect hourly with the HSR services in Merced. These connecting services also serve regional and local passengers along their routes that do not connect to HSR services.

Due to the improved conventional rail connectivity north of Merced, there will be no dedicated HSR Bus line between Sacramento and Merced in V2V and Phase 1.

For the V2V scenario, it is projected that Bakersfield's link to the Los Angeles Basin will be facilitated by three distinct bus routes, one bus route between Bakersfield and Anaheim operated by CHSRA as HSR Bus and two other bus routes (to Pasadena and Santa Monica) assumed as Intercity Bus. Specialized buses catering to high-speed rail passengers will be introduced.

Service regularity will be enhanced, transitioning from an hourly service plan under CVS to a more frequent timetable comprising both hourly and bi-hourly services. This modification will lead to a comprehensive service program of 25 daily round trips for each of the bus lines. However, this change of bus services at Bakersfield station is tailored exclusively for the duration of the V2V operation, with no extension into the Phase 1 operation envisaged.

Feeder bus connections were included in the California Rail Ridership Model (CRRM) run specifications. The CRRM accounts for these HSR Bus connections in estimating the ridership for the high-speed rail system, and the CRRM forecasts bus revenue based on the number of passengers using the HSR Bus to access and egress the high-speed rail system.

In the Phase 1 scenario, all connections will be provided by the extension of high-speed train services south of Bakersfield for direct links to Palmdale, Burbank, Los Angeles, and Anaheim and connections to the Metrolink and Los Angeles – San Diego – San Luis Obispo (LOSSAN) networks as well as LA Metro rail and bus services.

5.2 California Rail Ridership Model Run Specification

Feeder bus connections were included in the California Rail Ridership Model run specifications for each implementation step. The specifications included stopping patterns, run times and service frequencies for each feeder bus connection.

5.2.1 Feeder Bus Connections

The California Rail Ridership Model run specifications for the Silicon Valley to Central Valley service and Phase 1 implementation steps include the following proposed HSR bus connections as summarized in Table 5-1.

Table 5-1 HSR Bus Connections by Implementation Step

Proposed Connection Point	Silicon Valley to Central Valley	Phase 1
Bakersfield	Bakersfield – Anaheim with 25 RT	None

Three feeder bus routes are envisioned to efficiently serve major population and employment centers around the large geographic area of the Los Angeles Basin:

- The HSR Bus route provides service to the San Fernando Valley along Interstate 5 and to the Los Angeles Basin (terminating in Anaheim);
- The Intercity Bus route provides service to the San Fernando Valley along Interstate 405 and to West Los Angeles (terminating in Santa Monica); and
- The Intercity Bus route provides service to the San Gabriel Valley (terminating in Pasadena).

Further details for each of these routes are included in the following sections.

5.2.2 Stopping Patterns

Stopping patterns for each connection were determined based on the location of major transportation connections and/or the size and location of major population centers or urban areas.

Table 5-2 Location of HSR Bus and Intercity Bus Stops

South of Bakersfield Feeder Bus Connections	Location of Bus Stop
HSR Bus: Bakersfield – Anaheim Line	Bakersfield (High-Speed Rail Station)
HSR Bus: Bakersfield – Anaheim Line	Burbank Airport
HSR Bus: Bakersfield – Anaheim Line	Los Angeles Union Station
HSR Bus: Bakersfield – Anaheim Line	Anaheim (ARTIC)
Intercity Bus: Bakersfield – Santa Monica Line	Bakersfield (High-Speed Rail Station)
Intercity Bus: Bakersfield – Santa Monica Line	Van Nuys
Intercity Bus: Bakersfield – Santa Monica Line	UCLA – Westwood
Intercity Bus: Bakersfield – Santa Monica Line	Expo/Sepulveda
Intercity Bus: Bakersfield – Santa Monica Line	Santa Monica Pier
Intercity Bus: Bakersfield – Pasadena Line	Bakersfield (High-Speed Rail Station)
Intercity Bus: Bakersfield – Pasadena Line	Newhall
Intercity Bus: Bakersfield – Pasadena Line	Pasadena

5.2.3 Run Times

Run times for each feeder bus connection are based on measured travel time using an advanced route optimization software between 5pm-6pm on Tuesday as highway traffic peak period between each stop in both directions via the most direct route. Then the highest average runtime was selected, and a 10% pad was added.

5.3 Ridership

The feeder bus service levels have not been optimized to account for ridership levels projected by the CRRM but are designed to provide timed across-the-platform transfers to all high-speed rail services.

However, based on the service plans that feed the CRRM, forecasts suggest that HSR Bus ridership is significantly higher during the V2V scenario than the capacity of the bus fleet. This is because the V2V segment extends south only to Bakersfield, making feeder buses the best transit option to connect the high-speed trains to Southern California. The CRRM is not capacity constrained, however for Operations and Maintenance Cost calculations, it was assumed that each scheduled departure will include three buses during peak hours, two buses during off-peak hours and one bus on weekends.

As high-speed rail expands in the Phase 1 scenario, feeder bus services are eliminated since travelers to and from the Los Angeles Basin use Metrolink, Pacific Surfliner and other transit services to connect with high-speed rail services at stations in the Los Angeles Basin.

5.4 Revenue and Fares

In the 2024 Business Plan, one objective of the CRRM forecasts is to compare ridership under various implementation steps using the same fare structure for V2V and Phase 1 operations. High-speed rail fares were set to be competitive with airfares, and other travel modes were assumed to maintain overall regional fare levels.

High-speed rail fares in the 2024 Business Plan were revised compared to previous fare assumptions to reflect updated user behavior data, changes to the competitive advantage between travel modes and to incorporate fare differentiation by service type. HSR bus fares were set to be competitive with other modes and remain consistent with previous assumptions. The CRRM assumes a $11.00 HSR Bus fare between Bakersfield and the Los Angeles Basin (fares in June 2018).

Table 5-3 presents the incremental fare for using the HSR bus connections, as specified in the CRRM run specifications.

Table 5-3 HSR Bus Incremental Fares

Bus Origin	Connection to High-Speed Rail	Incremental Fares (in June 2018 dollars)
Los Angeles Basin (Silicon Valley to Central Valley only)	Bakersfield	$11.00

5.5 Bus Service Levels

HSR Bus service levels assumed for the Silicon Valley to Central Valley scenario are set to meet every high-speed train in Bakersfield. Due to the improved conventional rail connectivity north of Merced, there will be no dedicated HSR Bus line between Sacramento and Merced in V2V and Phase 1.

From Bakersfield, each of the three Los Angeles bus lines (one HSR Bus and two Intercity Bus) are timed to meet each high-speed train. In V2V, all three dedicated feeder bus services will operate hourly and bi-hourly with total of 25 round trips per day, whereas in Phase 1 feeder bus services will not operate due to the direct HSR train connections to Los Angeles Basin HSR stations.

As defined earlier, 4th and King station in San Francisco marks the northern interim terminus in the V2V scenario. This station location in San Francisco is well-connected to other transit infrastructure such that feeder bus service is assumed to be unnecessary.

The HSR Bus service plan assumed for the ridership forecast were also used to calculate daily revenue mileage. The total annual revenue miles of HSR Bus service was calculated by multiplying the trip length with the total number of daily HSR Bus connections with an annualization factor of 365 days.

The derived estimates for annual revenue miles were then used as an input in the Operations and Maintenance Cost Model, which applied the per-mile cost to calculate the total operating and

maintenance cost for feeder bus connections. Additional details for this calculation are provided in the Operations and Maintenance Cost Model Technical Supporting Document.

At this stage of the project, non-revenue miles have not been calculated. The calculation of non-revenue miles requires the determination of storage locations and the development of a fleet storage plan. For operations and maintenance cost calculations, a percentage was added to reflect non-revenue miles for HSR Bus services.

APPENDIX A INPUTS TO OPERATIONS AND MAINTENANCE COST MODEL

Table A-1 HSR Service Plan Input for Operations and Maintenance Cost Model for Silicon Valley to Central Valley Line (V2V) and Phase 1 Service for Horizon Years 2030, 2040 and 2050

Item	Type/Station	2030 V2V *	2040 V2V *	2050 V2V *	2030 Phase 1 *	2040 Phase 1 *	2050 Phase 1 *
Daily Total Revenue Service Trips	Weekday	50	50	50	164	164	164
Daily Total Revenue Service Trips	Weekend Day	50	50	50	130	130	130
Annual Trainset Miles	Weekdays	4,395,216	4,395,216	4,395,216	15,311,374	15,311,374	15,311,374
Annual Trainset Miles	Weekend Days	1,920,744	1,920,744	1,920,744	5,164,164	5,164,164	5,164,164
Annual Total Trainset Miles	Total All Days	6,315,960	6,315,960	6,315,960	20,475,538	20,475,538	20,475,538
Daily Service Turns**	SF Transbay	0 / 0	0 / 0	0 / 0	38 / 28	38 / 28	38 / 28
Daily Service Turns**	SF 4th & King	18 / 18	18 / 18	18 / 18	0 / 0	0 / 0	0 / 0
Daily Service Turns**	San José	0 / 0	0 / 0	0 / 0	5 / 0	5 / 0	5 / 0
Daily Service Turns**	Merced	32 / 32	32 / 32	32 / 32	29 / 27	29 / 27	29 / 27
Daily Service Turns**	Bakersfield	20 / 20	20 / 20	20 / 20	0 / 0	0 / 0	0 / 0
Daily Service Turns**	LA Union Station	0 / 0	0 / 0	0 / 0	12 / 12	12 / 12	12 / 12
Daily Service Turns**	Anaheim	0 / 0	0 / 0	0 / 0	21 / 21	21 / 21	21 / 21

Note: *Numbers do not reflect transition between operating phases of the HSR system and show steady state parameters. **Number of revenue-to-revenue service turns, first number for weekdays and second number for weekend days and holidays.

Table A-2 Bus Service Plan Input for Operations and Maintenance Cost Model for Silicon Valley to Central Valley Line (V2V) and Phase 1 Service for Horizon Years 2030, 2040 and 2050

Item	Type/Station	2030 V2V *	2040 V2V *	2050 V2V *	2030 Phase 1 *	2040 Phase 1 *	2050 Phase 1 *
Total Revenue Service Trips	Battery-Powered Bus Daily Runs	50**	50**	50**	-	-	-
Total Bus Miles	Annual Battery Powered Bus Miles	5,379,735	5,379,735	5,379,735	-	-	-
Total Bus Hours***	Annual Battery Powered Bus Hours	133,542.6	133,542.6	133,542.6	-	-	-
Total Bus Equipment needs****	Battery Powered Bus	55	55	55	-	-	-
Daily Service Turns*****	Bakersfield	37	37	37	-	-	-
Daily Service Turns*****	Anaheim	6	6	6	-	-	-

Note: * Numbers do not reflect transition between operating phases of the HSR system and show steady state parameters.

**Total 98 daily trips due to extra peak hour bus service (3 buses per peak hour round trip)

*** Full-charge range is assumed to be 230 miles, but for this analysis, we are imposing an additional 10% buffer on the range, thus capping out the maximum full-charge mileage to 207 miles. Charging is assumed at station and the maximum battery charge time is assumed to be 4 hours.

**** The long turn time due to the required bus charging increases total equipment needs. Comparing with conventional diesel buses, 27 more buses (in total 55 instead of 28) are needed in V2V.

***** Number of Revenue-to-Revenue Service Turns.