CALIFORNIA
High-Speed Rail Authority

2014 Service Planning Methodology

2014 BUSINESS PLAN

SECTION 4 : *Ridership and Revenue Forecasts*

AND *SECTION 5:* *Operations and Maintenance*

California High-Speed Rail System

2014 BUSINESS PLAN

TECHNICAL SUPPORTING DOCUMENT

2014 Service Planning Methodology

April 2014

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1.0 PURPOSE FOR HSR SERVICE PLANS

The development process of the California High-Speed Rail System's (CHSRS) 2014 Business Plan includes a refined operations planning process that was based on the latest ridership forecast data and designed to achieve a balanced service plan reflecting both revenue and non-revenue operations. The plan, which captures service and service costs at an intermediate level of project development, does not yet represent the type of detailed operating plan necessary to provide a commercially driven, investment grade Operating plan.

2.0 SERVICE PLANNING PROCESS

The service planning process used in the Business Plan is formulated to provide service structure, journey time and frequencies that can be used in the Ridership Forecast Model to produce ridership demand forecasts. The ridership demand is then broken down into discrete time periods (peak, off-peak and shoulder peak) and translated into a balanced service plan. The operating plan takes into account the frequencies and stopping patterns that were tested in the ridership model and develops a practical "timetable" for the operating day. The timetables are based on train simulator generated running times modified to reflect an operating "pad" (an industry standard practice to account for day to day operating interruptions) and station dwell time. The service plan is then used to calculate specific outputs such as the number of revenue and non-revenue train runs, train mileage and fleet size for the Operation and Maintenance (O&M) Cost Model. The finished service plan is also the basis for the calculation of feeder bus mileage that is another input for the cost model. The entire process is explained with more detail in this report.

3.0 METHODOLOGY

The Service plans developed for the 2014 Business Plan O&M cost estimate were created in a multi-step process consisting of:

(1) Establishing a service structure and frequency to be used in the ridership model for each of the target years established by the designated project milestone years, 2022, 2027, 2029, and 2040

(2) Calculation of the daily segment volume which is the number of anticipated passengers riding between the adjoining station pairs of the system. This calculation is based on either the ridership model run outputs for the target years or by using the model run outputs and model-calculated annual growth rates for the non-target years as well as assumptions on ramp-up for each phase. These numbers are modified by the application of a peaking factor. The peaking factor is the assumption of what percentage of the daily ridership is boarding during each of the operating day periods. The Peaking Factor Assumptions are listed in Table 1

Table 1 – Assumed Peaking Factor

Period	Peaking Factor	Number of Hours a Day	Percent of Total Daily Traffic
Peak of the Peak	12%	2	24%
Shoulder Peak	10%	2	20%
Off-Peak	4.66%	12	56%

(3) Development of service plans based on the hourly segment volume determined for each year

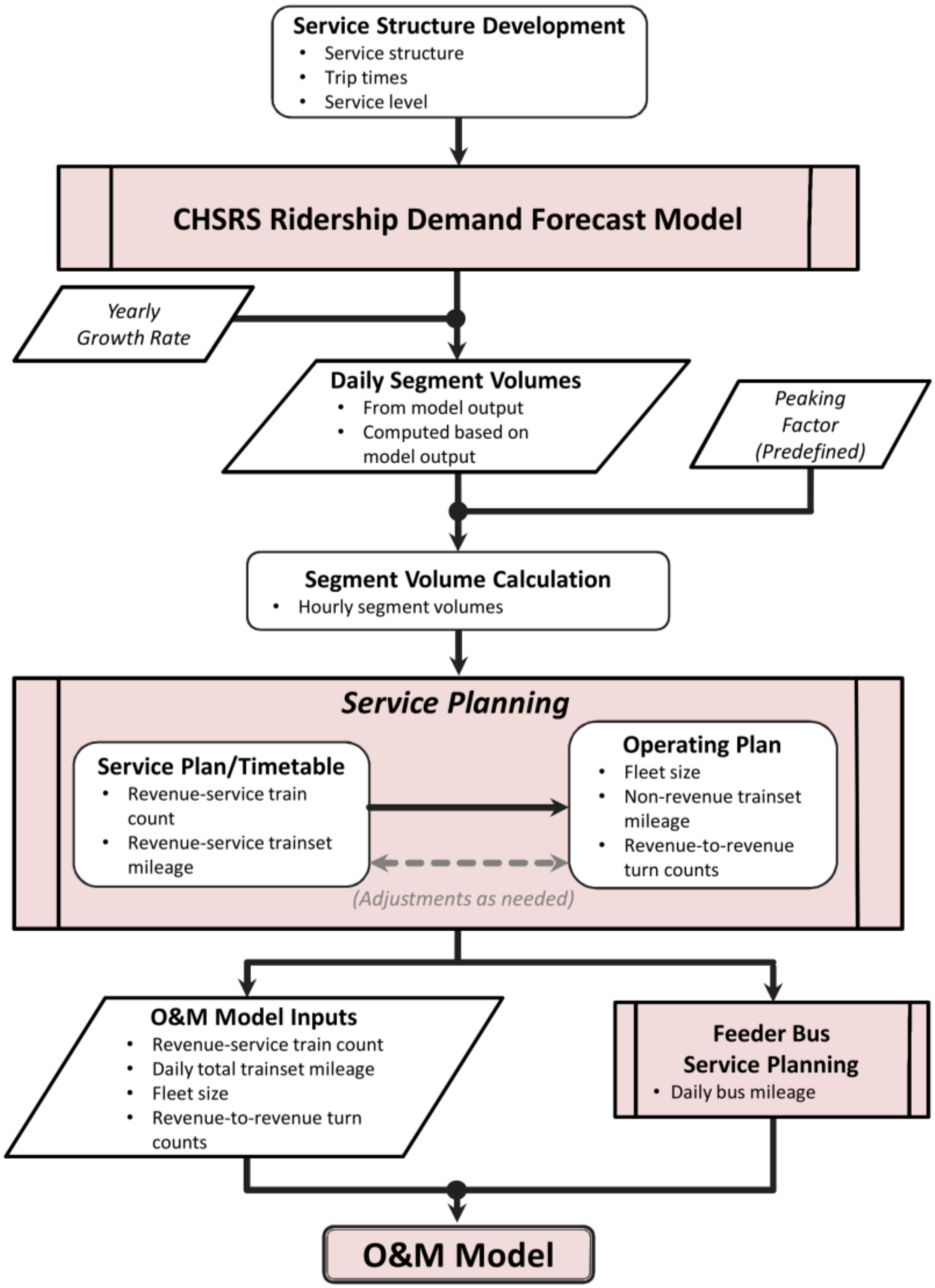
(4) Calculation of the O&M Cost model inputs, :

- Revenue-service train count
- Daily trainset miles
- Fleet size
- Revenue train-to-revenue train turn count

(5) Calculation of the feeder bus service revenue miles

This process is summarized in a flow chart in Figure 1, and details of each of these steps above are summarized in the following subsections.

Figure 1 – Service Planning Process Work Flow



3.2 Service Structure and Service Level for the Ridership Demand Forecast Model

The first step of the service plan development is to create a service structure and service frequencies for the milestone years and phases that the ridership demand forecast model uses.

For 2014 Business Plan, the following ridership milestone and forecast years were selected to allow for more precise forecasts and to better calculate growth rates between the forecast years:

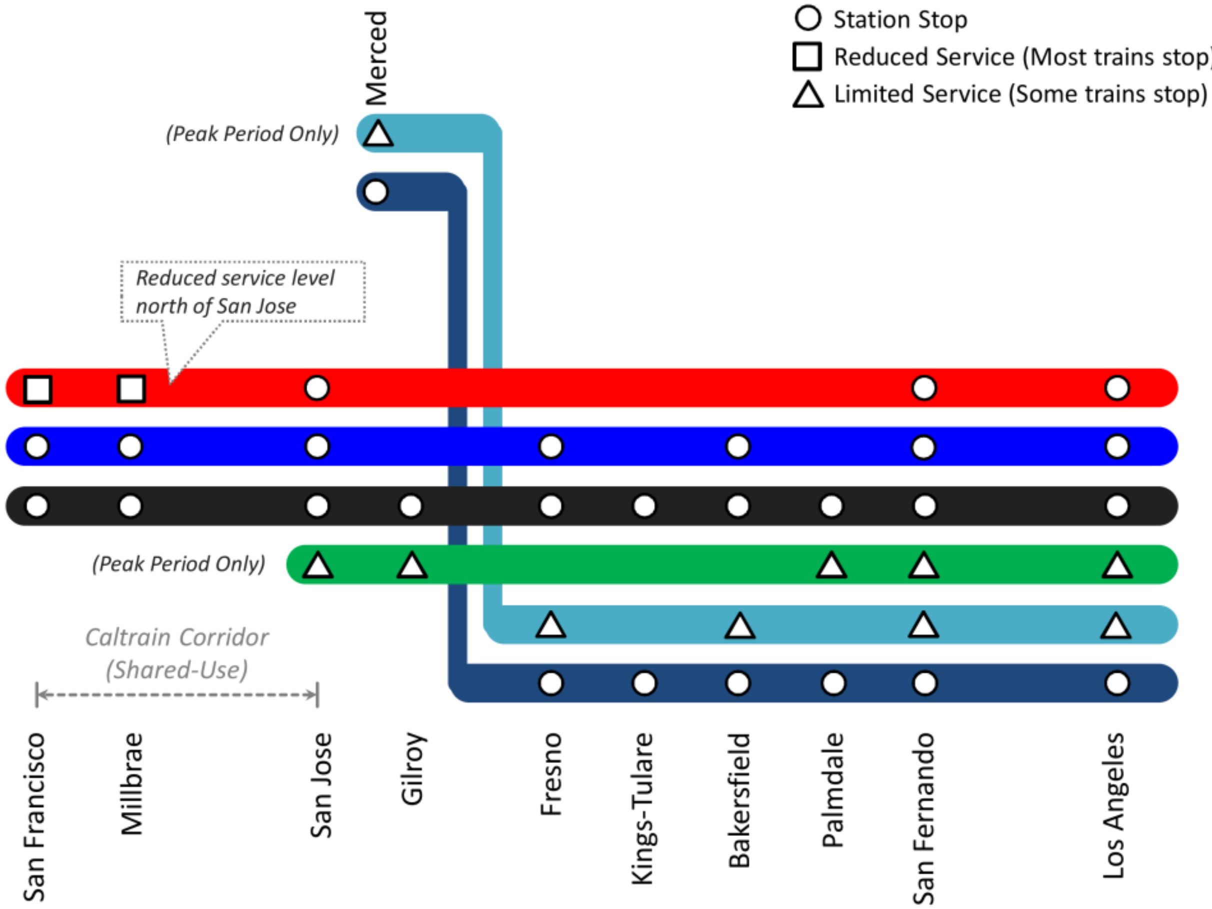
- IOS in 2022 (opening year) and 2027 (Bay to Basin opening year);
- Bay to Basin in 2027 (opening year) and 2029 (Phase 1 Blended opening year);
- Phase 1 Blended in 2029 (opening year) and 2040 (out year)

For each of these target years, a service structure (the combination of stopping patterns normally referred to as local, express and limited stop) and an hourly frequency (the number of trains per hour in each direction) for each stopping pattern in a peak and off-peak hour were prepared for the forecast model run. Anticipated trip time from the origin station to each of the scheduled stops was calculated using a railroad operations simulation model tool, Train Performance Calculations (TPC's) for each stopping pattern in order to devise the ridership model inputs. The TPC tool is part of specialized software package from Berkeley Simulation's RTC application.

The two IOS runs for the 2014 Business Plan used the service frequencies and limited stop service structure from the 2012 Business Plan ridership demand forecast. The ridership demand forecasts for the other target years utilized a modified plan to reflect a more balanced service delivery.

For Bay to Basin and Phase 1 Blended, a new service structure was employed consisting of an all-stop local pattern and variations of limited-stop train patterns. While this requires more precise service planning due to the mid-line overtakes between the slower local train and faster limited-stop trains, it better facilitates the incremental addition of trains during the life-cycle of the program without eliminating passenger travel opportunities to any of the station pairs in the system as depicted in Figure 2.

Figure 2 – Service Structure Assumption for CHSRS 2014 Business Plan: Phase 1 Blended



This type of service structure offers several customer service advantages:

- More frequent express service
- Consistency in the service level at each station throughout the segment and during the service expansion / implementation phases
- Greater operational flexibility for practical application of the commercial service

Although this change in the service structure altered the service frequency of service to some station pairs, it did not affect previous estimates of either ridership or revenue. Inputs regarding the passenger service plans and frequencies for this ridership demand forecast were based on the same service level assumptions used in the 2012 Business Plan and applied to the new service structure.

3.3 Daily Segment Volume

Once the ridership demand forecast model runs were performed, the segment volume, the numbers of anticipated passengers traveling through each of the adjacent station pairs in the system, was derived either directly from the ridership model run output or through calculations made for each future year that O&M cost estimates were calculated.

Since the ridership demand forecast model is capable of calculating the daily segment volume, the model output was used for the daily segment volume for the target years. The daily segment volume for each intermediate year was developed by applying the appropriate growth rate each of the applicable phases predicted in the ridership model and applying the appropriate ramp-up factors as each phase comes online.

3.4 Calculation of the Daily and Hourly Segment Volume

Once the daily segment volume for each of the future years was determined, it was converted into an hourly segment volume. This was accomplished by applying the peaking factor, (the percentage of riders of a given segment into peak hours, shoulder peak hours, and off-peak hours) to the daily segment volume in each segment. The hourly segment volume was determined for each revenue-service hour in each future year that the O&M cost estimate covered.

3.5 Development of High Speed Rail Service Plans

The train schedules were developed through a process consistent with the process utilized to support previous HSR Business Plans.

Service plans for the target years of the ridership forecast model runs were developed based on the hourly frequency and service structure assumptions used for the ridership demand forecast model runs. Using these service assumptions as a template, both peak hour service and off-peak service were applied to the revenue-service hours.

Service plans for the intermediate years were developed using the service plan of the nearest target year and adjusting the service level according to the anticipated hourly segment volume in each intermediate year. However, if the service level is adjusted purely based on the hourly segment volume, the service frequencies could become inconsistent with the ridership forecast assumptions.

The ridership demand forecast model is sensitive to the frequencies and the trip times between station pairs and it is important that there be consistency between the service levels modeled and the service plan itself. Therefore service level adjustments were limited to the following circumstances:

- Additional service is required through organic growth
- When the characteristics of the service change such as when Merced-bound service is extended to San Jose (Bay to Basin)

To develop the service plan, a “static” model using standard calculation software was created for the CHSRS network. This model utilizes train performance calculations taken from prior detailed “dynamic” simulation modeling results to identify the running time of the various types of service and train stopping patterns that are used in the service plans for the CHSRS system. The model generates “stringline” (time-distance) diagrams and tabular outputs describing the timing and scheduled operating performance of every train. It provides a level of detail sufficient to perform “pattern analysis” of the various express, limited stop, and all-stop local services that are envisioned. The objective is to identify a service pattern that achieves the desired level of service at each station while minimizing conflicts between trains and the number of instances of train overtakes. The model provides the ability for trains to be “linked” with subsequent trains and assigned to specific train sets. The resulting trainset equipment cycles form the basis for estimating the size of the required rolling stock fleet.

Early Morning and Late Evening Service

In order to serve all stations with early morning and late evening off peak trains consistent with the ridership forecast assumptions, some trains during this period terminate and start from intermediate stations rather than the end-point stations of the system. In the Phase 1 Blended service plan for instance, the non-stop trains departing from San Francisco to Los Angeles at 0600 would not pass Bakersfield before 0800. This means that intermediate stations would not have any service in the first and the last hours of the revenue-service day and a service gap would be created in a time period when passenger volumes are still anticipated. The addition of short-trip “zone” service addresses the service gap issue and provides the added efficiency of operating revenue trains instead of non-revenue trains to charge and discharge the system.

An example of the service plan developed in this step is presented in Figure 3.

Figure 3 – Example of Service Plan

Southbound

		Train Number:	291001	291002	291003	291004	291005	291006	291007	291008	291009	291010	291011	291012	291013	291014	291015
		Origin:	PMD	PMD	PMD	PMD	BFD	PMD	FNO	PMD	SJC	FNO	MCD	SJC	SFO	SJC	SFT
		Destination:	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU
Code	Station																
SFT	SF - Transbay	dp.															06:00
SFO	Millbrae	dp.													06:01		06:16
SJC	San Jose	dp.									06:00			06:25	06:41	06:37	06:51
GLY	Gilroy	dp.									06:16			↓	↓	06:58	↓
MCD	Merced	dp.									||		06:56	||	||	||	||
FNO	Fresno	dp.							06:30		↓	06:57	07:19	07:15	↓	07:41	↓
KTR	Kings/Tulare	dp.							↓		↓	07:10	07:33	↓	↓	07:55	↓
BFD	Bakersfield	dp.					06:45		07:09		↓	07:41	08:08	07:55	↓	08:26	↓
PMD	Palmdale	dp.	06:15	06:30	06:45	07:00	07:17	07:30	↓	07:50	08:00	08:14	08:46	↓	↓	08:58	↓
SFV	San Fernando Valley	ar.	06:30	06:45	07:00	07:15	07:33	07:45	07:53	08:05	08:16	08:29	09:01	08:38	08:44	09:14	08:56
LAU	Los Angeles	ar.	06:42	06:57	07:12	07:27	07:45	07:57	08:05	08:17	08:28	08:41	09:13	08:50	08:56	09:26	09:08

		Train Number:	291016	291017	291018	291019	291020	291021	291022	291023	291024	291025	291026	291027	291028	291029	291030
		Origin:	SFT	SFT	MCD	SJC	SFT	SJC	SFT	SFT	MCD	SFT	MCD	SJC	SFT	SJC	SFT
		Destination:	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU
Code	Station																
SFT	SF - Transbay	dp.	06:15	06:30			06:45		07:00	07:15		07:30			07:45		08:00
SFO	Millbrae	dp.	06:31	06:46			07:01		07:16	07:31		07:46			08:01		08:16
SJC	San Jose	dp.	07:06	07:21		07:25	07:36	07:42	07:51	08:06		08:21		08:25	08:36	08:42	08:51
GLY	Gilroy	dp.	↓	↓		07:42	07:58	↓	↓	↓		↓		08:42	08:58	↓	↓
MCD	Merced	dp.	||	||	07:53	||	||	||	||	||	08:40	||	08:53	||	||	||	||
FNO	Fresno	dp.	07:57	↓	08:20	↓	08:42	↓	↓	08:57	09:03	↓	09:20	↓	09:42	↓	↓
KTR	Kings/Tulare	dp.	↓	↓	08:34	↓	08:55	↓	↓	↓	↓	↓	09:34	↓	09:55	↓	↓
BFD	Bakersfield	dp.	08:37	↓	09:09	↓	09:26	↓	↓	09:37	09:48	↓	10:09	↓	10:26	↓	↓
PMD	Palmdale	dp.	↓	↓	09:46	09:26	09:59	↓	↓	↓	↓	↓	10:46	10:26	10:59	↓	↓
SFV	San Fernando Valley	ar.	09:20	09:26	10:02	09:41	10:14	09:45	09:56	10:20	10:31	10:26	11:02	10:41	11:14	10:45	10:56
LAU	Los Angeles	ar.	09:32	09:38	10:14	09:53	10:26	09:57	10:08	10:32	10:43	10:38	11:14	10:53	11:26	10:57	11:08

Northbound

		Train Number:	292001	292002	292003	292004	292005	292006	292007	292008	292009	292010	292011	292012	292013	292014	292015
		Origin:	GLY	GLY	GLY	GLY	FNO	FNO	BFD	PMD	SFV	SFV	LAU	LAU	LAU	LAU	LAU
		Destination:	SFT	SFT	SFT	SFT	SFT	SFT	SJC	SFT	SFT	MCD	SFT	SJC	SJC	MCD	SFT
Code	Station																
LAU	Los Angeles	dp.											06:00	06:10	06:17	06:26	06:30
SFV	San Fernando Valley	dp.									06:00	06:08	06:12	06:22	06:29	06:38	06:42
PMD	Palmdale	dp.								06:10	↓	06:31	↓	↓	06:48	↓	↓
BFD	Bakersfield	dp.							06:28	06:44	↓	07:05	↓	↓	↓	07:27	↓
KTR	Kings/Tulare	dp.							↓	07:13	↓	07:35	↓	↓	↓	↓	↓
FNO	Fresno	dp.					06:37	06:52	07:07	07:32	↓	07:52	↓	↓	↓	08:06	↓
MCD	Merced	ar.					||	||	||	||	||	08:16	||	||	||	08:29	||
GLY	Gilroy	dp.	06:16	06:31	06:46	07:01	07:16	07:31	↓	08:16	↓		↓	↓	08:26		↓
SJC	San Jose	dp.	06:34	06:49	07:04	07:19	07:34	07:49	07:58	08:34	08:04		08:19	08:27	08:42		08:49
SFO	Millbrae	ar.	07:07	07:22	07:37	07:52	08:07	08:22		09:08	08:38		08:52				09:22
SFT	SF - Transbay	ar.	07:23	07:38	07:53	08:08	08:23	08:38		09:24	08:54		09:08				09:38

		Train Number:	292016	292017	292018	292019	292020	292021	292022	292023	292024	292025	292026	292027	292028	292029	292030
		Origin:	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU	LAU
		Destination:	SFT	SFT	MCD	SFT	SJC	SJC	MCD	SFT	SFT	SFT	MCD	SFT	SJC	SJC	MCD
Code	Station																
LAU	Los Angeles	dp.	06:35	06:43	06:56	07:00	07:10	07:17	07:26	07:30	07:35	07:43	07:56	08:00	08:10	08:17	08:26
SFV	San Fernando Valley	dp.	06:47	06:55	07:08	07:12	07:22	07:29	07:38	07:42	07:47	07:55	08:08	08:12	08:22	08:29	08:38
PMD	Palmdale	dp.	↓	07:14	07:32	↓	↓	07:48	↓	↓	↓	08:14	08:32	↓	↓	08:48	↓
BFD	Bakersfield	dp.	07:31	07:43	08:06	↓	↓	↓	08:27	↓	08:31	08:43	09:06	↓	↓	↓	09:27
KTR	Kings/Tulare	dp.	↓	08:12	08:35	↓	↓	↓	↓	↓	↓	09:12	09:35	↓	↓	↓	↓
FNO	Fresno	dp.	08:10	08:31	08:53	↓	↓	↓	09:06	↓	09:10	09:31	09:53	↓	↓	↓	10:06
MCD	Merced	ar.	||	||	09:16	||	||	||	09:29	||	||	||	10:16	||	||	||	10:29
GLY	Gilroy	dp.	↓	09:15		↓	↓	09:26		↓	↓	10:15		↓	↓	10:26	
SJC	San Jose	dp.	09:03	09:33		09:19	09:27	09:42		09:49	10:03	10:33		10:19	10:27	10:42	
SFO	Millbrae	ar.	09:37	10:07		09:52				10:22	10:37	11:07		10:52			
SFT	SF - Transbay	ar.	09:53	10:23		10:08				10:38	10:53	11:23		11:08			

3.6 Calculation of O&M Cost Model Inputs

The Service Plans are designed to provide direct inputs for the O&M cost model for:

- Trainset Mileage
- Fleet Size
- Number of Revenue Trains (For Connecting Buses)
- Revenue Train to Revenue Train Turns (Crew numbers)

After the CHSRS service plans were created, all of the equipment was linked to form extended cycles (the planned train schedule assignments for the duration of a service day) to satisfy the terminal requirements (the number of trainsets required to begin revenue service at each terminal station during a calendar day) as well as staging for the morning start-out requirements for each terminal station. These equipment cycles form the basis of the estimate for the total fleet size required by the CHSRS revenue service. These cycles also dictate the daily system-wide trainset mileage that drives the cost input for rolling stock and infrastructure maintenance used in the O&M model.

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 revenue-service movement of the trainsets was derived by adding up all of the revenue-service run mileage included in the service plan. The mileage of the non-revenue movements was added to the revenue-service trainset miles by adding the combined mileage of:

- Non-revenue movements at the beginning of the revenue-service cycle - the distance between a Terminal Station Maintenance Facility (TSMF) 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 revenue-train cycle - the distance between the terminus of the final revenue service of the cycle and one of the TSMFs where the trainset would be stored and maintained for the next revenue-service day

4.0 ASSUMPTIONS

4.1 Infrastructure

- The majority of the CHSRS network is assumed to be exclusive infrastructure separated from any other conventional heavy rail systems, except for the Caltrain corridor between San Francisco and San Jose
- CHSRS passenger stations are assumed to be located at the following locations:
    - San Francisco - Transbay Terminal (SFT)
    - Millbrae (SFO)
    - San Jose Diridon Station (SJC)
    - Gilroy (GLY)
    - Merced (MCD)
    - Fresno (FNO)
    - Kings/Tulare (KTR)
    - Bakersfield (BFD)
    - Palmdale (PMD)
    - San Fernando Valley (SFV)
    - Los Angeles Union Station (LAU)

- Mid-line stations are assumed to be 4-track stations with two center tracks assumed to be main tracks and two outside tracks to be station platform tracks. Station tracks will be siding tracks of approximately 1,410 feet adjacent to the station platform. The switches to allow trains to diverge from the main tracks to the station tracks and are currently designed to handle speeds of 110 MPH. Universal interlockings capable of routing trains to all parts of the station complex must be sited no further than one mile from the turnouts leading to the station tracks.
- The Signal system is assumed to provide a 3-minute minimum signaling headway at 220 MPH, in that 2 trains can operate 3 minutes apart when they are traveling at 220 MPH. It is expected that the timetable headway will maintain minimum 5-minute headway between scheduled trains at intermediate stations.
- TSMFs are assumed to be built as listed in Table 3. **It should be noted here that the location of these facilities are part of the ongoing environmental approval process so are likely to change before they are finalized. They are listed here as assumptions to develop reference points so that non-revenue crew and mileage inputs can be determined for the O&M Cost Model.**

Table 2 – List of Rolling Stock Maintenance Facility Assumed in Service Plan Development

Preliminary Name	Maintenance Capability	Nearby CHSRS Station	Approximate Location	Roll-Out Phase
"Brisbane"	Level II and III	San Francisco – Transbay	Near Bayshore Caltrain Station	Phase 1 Blended
"Morgan Hill-Gilroy"	Level II	San Jose Gilroy	10 miles south of San Jose CHSRS Station	Bay to Basin
"HMF"	Level II – V	Fresno	10 miles south of Fresno CHSRS Station	IOS
"Lancaster-Palmdale"	Level II and III	Palmdale	15 miles north of Palmdale CHSRS Station	IOS (partial; full function required for Bay to Basin service)

4.2 Fleet Specification

- Trainsets with performance characteristics equivalent to the Alstom AGV trainset model were used for the pure run time calculations, and the trip time was based on train performance characteristics described in the trainset specifications and track geometry.
- Trainsets were assumed to be approximately 660 feet in length with 450 passenger seats.
- Each revenue-service train was assumed to be operated in either one trainset or two set configurations based on demand.

4.3 Passenger Service

- The interval of recovery time (scheduled pad) for the CHSRS trains has been established at seven percent of the pure run time as computed by the Train Performance Calculator (TPC) of the Rail Traffic Controller (RTC). RTC is a railroad operations simulation model widely used among railroads in the United States, including the railroad incident/accident investigations by National Transportation Safety Board (NTSB).
- Revenue-service hours of the CHSRS are anticipated to be from 0600 to Midnight (2400), seven days a week; the five-hour period between 0000 and 0500 is allocated to the

maintenance of infrastructure while 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 conceptual schedule features passenger-friendly and operationally-flexible “clockface” patterns with train departures at regular headways and at the same minute after each hour.
- Train schedules consist of two kinds of clockface patterns: one for the peak period and the other for the midday off-peak period.
- There were assumed to be two (2) 2-hour peak periods during the IOS Phase based on demand and two (2) 3-hour peak periods in Bay to Basin Phase and Phase 1 Blended in each revenue service day. The peak hours were increased to accommodate the size of the system and the variety of peak demand times.
- The service during the early morning start-up period and the late evening shut-down period is different from service patterns during other times of the day in order to capture short-distance regional trip demands while offering fast service between terminal stations and intermediate stations.
- Overtakes between faster trains and slower trains occur at intermediate stations in order to allow faster trains to achieve scheduled trip time; no overtakes occur at intermediate stations north of Gilroy..
- Minimum dwell time at intermediate stations is 90 seconds.
- Minimum and desirable layover/turnaround times for a train set between revenue trips at terminal stations are 30 minutes and 40 minutes, respectively.
- Target maximum passenger load on the 8-car train is set at 385 seats, based on the following assumptions:
    - Nominally 85% of the all passenger seats are occupied. This is a target seat occupancy typically assumed in the heavy passenger rail service planning in the United States
    - Seating capacity of 450 on each 8-car trainset, the capacity assumed in the Revised 2012 Business Plan O&M cost forecast

4.4 Fleet Requirements

- All trainsets required for revenue-service operations are assumed to be stored at nearby trainset maintenance facilities, tail tracks at terminal stations, or platform tracks at the passenger stations.
- The total fleet requirement of the system is approximately 10 percent more than the actual number of trainsets required to operate the revenue service in order to provide maintenance spares and revenue service “protect” trains. This is an international industry standard in high-speed passenger rail systems.
- At least two eight car trainsets are assumed to be reserved as “hot standby”. These trainsets are provided to “protect” revenue service during disruptions or unforeseen events.

5.0 FEEDER BUS SERVICE PLANNING

5.1 Introduction

During initial stages of its implementation, the high speed train project would not provide direct high speed train service to some of the major urban areas - such as the San Francisco Bay Area, the Sacramento area, and the Los Angeles Basin area - and the proposed high speed train service would end at Merced and/or San Fernando, creating interim end-of-the-line stations there.

While certain conventional rail connections, - such as Amtrak San Joaquin and Metrolink - would be available between these interim end-of-the-line stations and major urban areas, limited frequency of such connections would not be able to provide connections to/from each high speed train arriving at/leaving from these interim end-of-the-line stations. In order to fill this connectivity gap, the California High Speed Rail System plans to provide feeder bus connections between these interim end-of-the-line stations and the major urban areas during the initial stages of implementation. The exception to this would be the Caltrain service during Bay to Basin Phase, which would provide sufficient connecting service to accommodate demand from the Peninsula.

Feeder bus connections were included in the ridership demand model run specifications. Although the ridership demand model accounts for these feeder bus connections in estimating the ridership for the high speed train system, it does not report the number of passengers that would use the feeder bus connections at each station. Therefore, a set of assumptions and processes were used to estimate the potential revenue that could be generated through these connections, and the level of service required to serve the demand. This report lays out the data inputs, assumptions, and processes used, and the resulting estimates for fare revenue and revenue vehicle miles of service are presented in Table 3.

Table 3 - Estimated Feeder Bus Annual Fare Revenue and Revenue Vehicle Miles

Year	Annual Fare Revenue (in 2012$$)	Annual Revenue Vehicle Miles
2022	2,300,864	4,117,200
2023	3,275,725	4,701,200
2024	4,316,746	6,044,400
2025	5,427,391	8,322,000
2026	6,611,286	8,964,400
2027	3,756,135	3,051,400
2028	4,099,115	3,051,400
2029	3,666,120	3,153,600
2030	4,090,437	3,153,600
2031	4,527,614	3,153,600
2032	4,818,672	3,153,600
2033	5,118,017	3,153,600
2034	5,201,458	3,153,600
2035	5,286,260	3,153,600
2036	5,372,444	3,153,600
2037	5,460,033	3,153,600
2038	5,549,050	3,153,600
2039	5,639,519	3,504,000
2040	5,731,463	3,504,000
2041	5,788,777	3,504,000
2042	5,846,665	3,504,000
2043	5,905,132	3,504,000
2044	5,964,183	3,504,000
2045	6,023,825	4,380,000
2046	6,084,063	4,380,000

Year	Annual Fare Revenue (in 2012$$)	Annual Revenue Vehicle Miles
2047	6,144,904	4,380,000
2048	6,206,353	4,380,000
2049	6,268,416	4,380,000
2050	6,331,100	4,380,000
2051	6,394,411	4,380,000
2052	6,458,355	4,380,000
2053	6,522,939	4,380,000
2054	6,588,168	4,380,000
2055	6,654,050	4,380,000
2056	6,720,591	4,380,000
2057	6,787,796	5,080,800
2058	6,855,674	5,080,800
2059	6,924,231	5,080,800
2060	6,993,473	5,080,800

5.2 Ridership Model Run Specifications

Feeder bus connections were included in the 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 ridership model run specifications for IOS, Bay to Basin, and Phase 1 Blended implementation steps included the following proposed feeder bus connections as summarized in Table 4.

Table 4 – Feeder Bus Connections at Merced and San Fernando

Proposed HST Station Connection Point	Implementation Step		
	IOS	Bay to Basin	Phase 1 Blended
Merced	• Bay Area • Sacramento	• Sacramento	• Sacramento
San Fernando	• Los Angeles Basin	• Los Angeles Basin	-None-

In order to efficiently serve their large geographic areas, both the Bay Area and Los Angeles Basin were provided with more than one feeder bus connection route. The Bay Area was provided two feeder bus routes – one terminating at San Francisco, and the other terminating at San Jose. The Los Angeles Basin area was provided three feeder bus routes – the first one terminating at Los Angeles Union Station, the second one terminating at West Los Angeles, and third one terminating at Santa Anita. Further details for each of these routes are included in the following sections.

5.2.2 Stopping Pattern

Stopping patterns for each connection were determined on the basis of location of major transportation connections and/or size and location of urban areas. Table 5 presents the location of, and the rationale for each bus stop along each feeder bus connection.

Table 5 – Location of Bus Stops

Feeder Bus Connection	Location of Bus Stop	Rational for the Bus Stop
Bay Area (San Francisco)	San Francisco (Ferry Building)	Large urban center with large number of transit connections on the west side of the San Francisco Bay
	Oakland (Jack London Square Amtrak Station)	Large urban center with large number of transit connections on the east side of the San Francisco Bay
	Dublin Pleasanton BART	Medium-sized urban center with end-of-the-line BART station
Bay Area (San Jose)	San Jose (Diridon Station)	Large urban center with large number of transit connections on the south side of the San Francisco Bay
	Gilroy (Caltrain Station)	Medium urban center with transportation connections to the Monterey Bay area
Sacramento	Sacramento (Amtrak Station)	Medium urban center
	Elk Grove (Amtrak Station)	Small urban center with Amtrak service
	Lodi (Amtrak Station)	Small urban center with Amtrak service
	Stockton (Amtrak Station)	Small urban center with Amtrak service
	Modesto (Amtrak Station)	Small urban center with Amtrak service
	Denair/Turlock (Amtrak Station)	Small urban center with Amtrak service
Los Angeles Basin (Los Angeles Union Station)	Burbank Airport	Transportation hub with large number of transit connections on the north side of the Los Angeles Basin
	Los Angeles Union Station	Major transportation hub with large number of transit connections in the core of the Los Angeles Basin
Los Angeles Basin (West Los Angeles)	Van Nuys	Medium urban center on the northwest side of the Los Angeles Basin
	West Los Angeles	Medium urban center on the west side of the Los Angeles Basin
Los Angeles Basin (Santa Anita)	Santa Anita	Medium urban center on east side of the Los Angeles Basin

5.2.3 Run Times

Run times for each feeder bus connection were based on auto travel times between each consecutive bus stop.

5.3 RIDERSHIP

This section presents the process used to estimate the number of passengers that would use the feeder bus connections.

The first step in the process was to identify the regions, as identified in the ridership model, which would be served by each feeder bus connection. The model identifies and reports data outputs for “regions” that largely follow county boundaries. Table 6 shows the constituent counties for the regions defined in the ridership model.

Table 6 – Ridership Model Regions and Constituent Counties

HSR Model Region	Constituent Counties
Association of Monterey Bay Area Governments (AMBAG)	Santa Cruz, Monterey, San Benito
Central Coast	San Luis Obispo, Santa Barbara

HSR Model Region	Constituent Counties
Far North	Mendocino, Lake, Colusa, Glenn, Butte, Sierra Nevada, Plumas, Tehama, Trinity, Humboldt, Shasta, Lassen, Del Norte, Siskiyou, Modoc
Fresno/Madera	Fresno, Madera
Kern	Kern
Merced	Merced
Metropolitan Transportation Commission (MTC)	San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, Marin
Sacramento Area Council of Governments (SACOG)*	Sacramento, El Dorado, Placer Yuba, Sutter, Yolo
San Diego Association of Governments (SanDAG)	San Diego, Imperial
San Joaquin	San Joaquin
South San Joaquin Valley	Kings, Tulare
Southern California Association of Governments (SCAG)	Los Angeles, San Bernardino, Riverside, Orange, Ventura
Stanislaus	Stanislaus
Western Sierra Nevada	Amador, Calaveras, Tuolumne, Mariposa, Alpine, Mono, Inyo

* Does not include Lake Tahoe area

The regions served by the feeder bus connections were identified on the basis of the proposed location of stops for each feeder bus connection. Table 7 lists the ridership model regions served by each feeder bus connection.

Table 7 – Assumed Feeder Bus Destinations Classified in Ridership Model Regions

<table>
<tr><th rowspan="2">Feeder Bus Connection</th><th colspan="3">Implementation Step</th></tr>
<tr><th>IOS</th><th>Bay to Basin</th><th>Phase 1 Blended</th></tr>
<tr><td>Bay Area (San Francisco)</td><td>• MTC</td><td>• None</td><td>• None</td></tr>
<tr><td>Bay Area (San Jose)</td><td>• MTC
• AMBAG</td><td>• None</td><td>• None</td></tr>
<tr><td>Sacramento</td><td>• Far North
• SACOG
• San Joaquin
• Stanislaus</td><td>• Far North
• SACOG
• San Joaquin
• Stanislaus</td><td>• SACOG
• San Joaquin
• Stanislaus</td></tr>
<tr><td>Los Angeles Basin (Los Angeles Union Station)</td><td colspan="3" rowspan="3">SCAG</td></tr>
<tr><td>Los Angeles Basin (West Los Angeles)</td></tr>
<tr><td>Los Angeles Basin (Santa Anita)</td></tr>
</table>

The next step was to estimate what percentage of traffic to/from the regions served would use the feeder bus connections. This percentage value is also referred to as the “mode share” for feeder bus connections. The assumed mode shares and the rationale for each ridership model region served by the feeder bus connections are shown in Table 8.

Table 8 – Assumed Mode Shares for Ridership Model Regions

HSR Model Region Served by Feeder Bus Connection	Implementation Step			Rationale for Assumed Mode Shares
	IOS	Bay to Basin	Phase 1 Blended	
AMBAG	20%	0%	0%	Lack of access to conventional rail connection alternatives, less than 100 mile long trip to Merced, and very low incremental fare for feeder bus connection could lead to a high mode share of 20% during IOS. No feeder bus connection due to direct high-speed rail service at Gilroy during Bay to Basin and Blended Phase 1.
Far North	10%	10%	0%	Auto-dependent characteristics of the area, and a forced transfer to feeder bus connection at Sacramento could constrain the mode share to 10% during IOS and Bay to Basin. No feeder bus connection due to direct high-speed rail service at San Francisco during Phase 1 Blended.
SACOG	20%	10%	10%	Very low incremental fare for feeder bus connection could lead to a high mode share of 20% during IOS. When high-speed rail service is available in the Bay Area, some passengers from Sacramento might prefer using the conventional rail connections between Sacramento and the Bay Area over the feeder bus connection leading to a reduction in the mode share to 10% in Bay to Basin and Phase 1 Blended.
San Joaquin	10%	10%	10%	Auto-dependent characteristics of the area, and relatively short distance to Merced might keep the mode share down at about 10% for all three implementation steps.
Stanislaus	10%	10%	10%	Auto-dependent characteristics of the area, and relatively short distance to Merced might keep the mode share down at about 10% for all three implementation steps.
MTC	20%	0%	0%	Frequent users of transit in the area might prefer the bus connection over driving 100+ miles to Merced, leading to a relatively high mode share of 20% for the IOS. No feeder bus connection due to direct high-speed rail service to Bay Area during Bay to Basin and Phase 1 Blended.
Los Angeles Basin	20%	20%	0%	Frequent users of transit might prefer the bus connection over driving on congested freeways in the area, leading to a relatively high mode share of 20% for the IOS and Bay to Basin. No feeder bus connection due to direct high-speed rail service to Los Angeles Union Station during Phase 1 Blended.

The absolute number of daily passengers that would use the feeder bus connections were calculated by multiplying the mode shares for the feeder bus connections by the total number of annual trips for each region served and dividing by an "annualization factor" of 365.

Since the ridership model reported trips for years 2022, 2027, 2029 and 2040 only, the number of boardings on feeder bus connections for all years between 2022 and 2060 was then calculated though interpolation and extrapolation of the trends of change in systemwide ridership based on the appropriate growth factors found for each phase in the ridership model.

5.4 REVENUE AND FARE

One of the objectives of the ridership model runs was to allow comparison of ridership under various implementation steps with the same set of end-to-end fares. The fares were specified in 2005$$ in the ridership model. In order to escalate the revenue to 2012$$, an escalation factor of 1.1755 - derived based on construction cost indices for 2005 and 2012 as 202.6 and 238.155, respectively - was applied.

The average end-to-end fares for San Francisco Bay Area to Los Angeles Basin area was set at $84.64 in order to be competitive against airline fares in the market. Based on the adopted fare model for high speed rail service, the average fare for Merced-San Fernando trip was set at $82.28. Therefore, the feeder bus connections at the two ends of that high-speed rail service were both set at $1.18 each, such that the total fare for San Francisco Bay Area to Los Angeles Basin area would add up to $84.64.

Similarly, the average end-to-end fares for Sacramento to Los Angeles Basin area was set at $92.86 in order to be competitive against airline fares in the market. Since Merced-San Fernando high-speed rail service was set at $82.28, and San Fernando-Los Angeles Basin feeder bus connection at $1.18, the Merced-Sacramento area feeder bus connection was set at $9.40, such that the total average fare for Sacramento to Los Angeles Basin area would add up to $92.86.

Table 9 presents the incremental fare for using the feeder bus connections, as specified in the ridership model run specifications.

Table 9 – Incremental Fares

Feeder Bus Connection	Incremental Fares (in 2012$$)
AMBAG	$1.18
Far North	$9.40
SACOG	$9.40
San Joaquin	$1.18
Stanislaus	$1.18
MTC	$1.18
Los Angeles Basin	$1.18

The total revenue generated by the feeder bus connections was calculated on the basis of the year-by-year feeder bus connection ridership (derived in the preceding section) and the incremental fares. The revenues, escalated to 2012$$, are included in Table 3.

5.5 SERVICE LEVELS

The feeder bus service levels were determined by the demand for each connection. The high speed rail operations plans include three different service levels corresponding to three different periods during any given day (peak, shoulder peak, and off-peak). The demand for feeder bus connections for these three periods was calculated based on “peaking factors” presented in Table 1.

The absolute demand for the three periods was calculated by multiplying the daily boardings with the relevant peaking factors for each period.

The number of passengers using the feeder bus connections to each high speed rail train was then calculated on the basis of the total number of high speed rail trains serving a station and the demand for each connection serving that station.

The number of feeder bus connections required for each high speed rail train during each period was then calculated on the basis of an assumed capacity of each bus (50 passengers/bus) and an assumed maximum average loading factor (90%).

The total number of feeder bus connections per day was then calculated on the basis of the number of feeder bus connections per high speed train and the total number of daily trains.

The trip length for each feeder bus connection specified in the ridership model runs specifications is presented in Table 10.

Table 10 – Trip Length

High Speed Rail Station	Feeder Bus Connection	Trip Length (in miles)
Merced	Bay Area	140
Merced	Sacramento	120
San Fernando	Los Angeles Basin	20

The total number of annual revenue miles of feeder bus connection service was then calculated by multiplying the trip length with the total number of daily feeder bus connections, number of directions of service (2), and annualization factor (365).

The derived estimates for revenue vehicle miles were then used as input in the operations and maintenance cost model, which then applied the per mile cost to calculate the total operating and maintenance cost for feeder bus connections. Further details for this step are available in the documentation for operating and maintenance cost model.

APPENDIX 1 INPUTS TO O&M COST MODEL

2014 Business Plan Service Plan Input for O&M Model

Item	Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Total Number of Revenue Service Trips	Single Consist Daily Runs	40	44	52	72	76	168	168	233	233	233	233	233	233	229	225	222	218	214	211	209
	Double Consist Daily Runs	0	0	0	0	0	0	0	0	0	0	0	0	0	4	8	11	15	19	22	24
Total Trainset Miles	Daily Single Consist Miles	12,571	13,812	15,774	22,339	23,900	57,380	57,380	92,919	92,919	92,919	92,919	92,919	92,919	91,372	89,851	88,356	86,885	85,439	84,017	83,177
	Daily Double Consist Miles	0	0	0	0	0	0	0	0	0	0	0	0	0	1,547	3,068	4,563	6,034	7,480	8,902	9,742
Number of Revenue to Revenue Service Turns	SF Transbay	0	0	0	0	0	0	0	53	53	53	53	53	53	53	53	53	53	53	53	53
	San Jose	0	0	0	0	0	41	41	5	5	5	5	5	5	5	5	5	5	5	5	5
	Merced	15	16	18	26	27	15	15	13	13	13	13	13	13	13	13	13	13	13	13	13
	San Fernando	15	15	19	27	24	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0
	LA Union Sta.	0	0	0	0	0	0	0	68	68	68	68	68	68	68	68	68	68	68	68	68

Item	Year	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Number of Revenue Service Trips	Single Consist Daily Runs	206	204	202	200	198	196	194	192	191	189	187	185	183	181	179	178	176	174	172
	Double Consist Daily Runs	27	29	31	33	35	37	39	41	42	44	46	48	50	52	54	55	57	59	61
Total Trainset Miles	Daily Single Consist Miles	82,345	81,522	80,706	79,899	79,100	78,309	77,526	76,751	75,983	75,224	74,471	73,727	72,989	72,259	71,537	70,821	70,113	69,412	68,718
	Daily Double Consist Miles	10,574	11,397	12,213	13,020	13,819	14,610	15,393	16,168	16,936	17,695	18,448	19,192	19,930	20,660	21,382	22,098	22,806	23,507	24,201
Number of Revenue to Revenue Service Turns	SF Transbay	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
	San Jose	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Merced	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	San Fernando	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	LA Union Sta.	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68