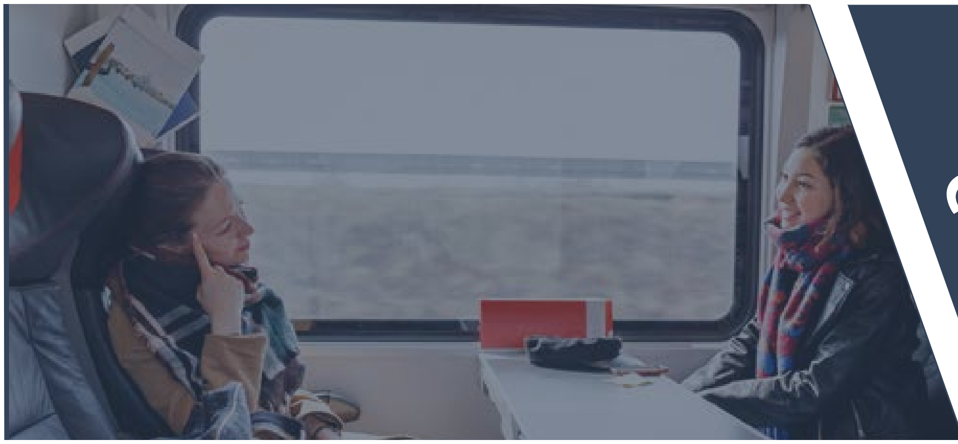
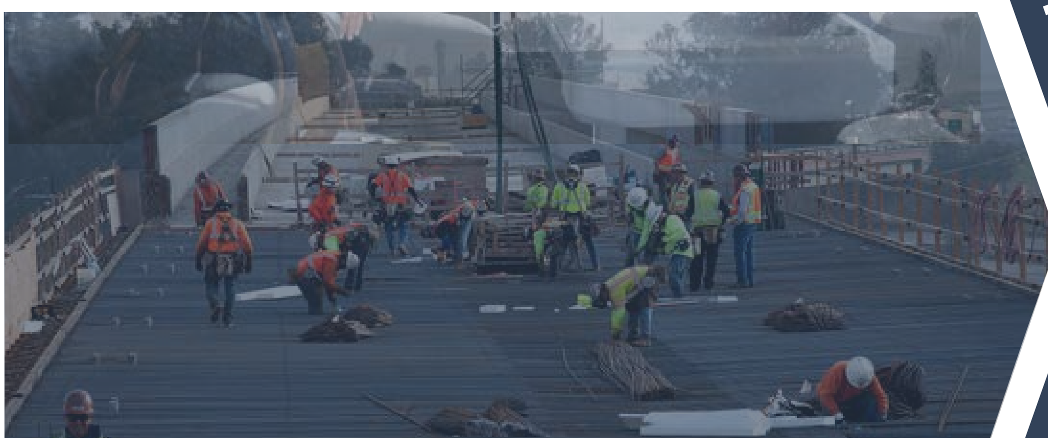
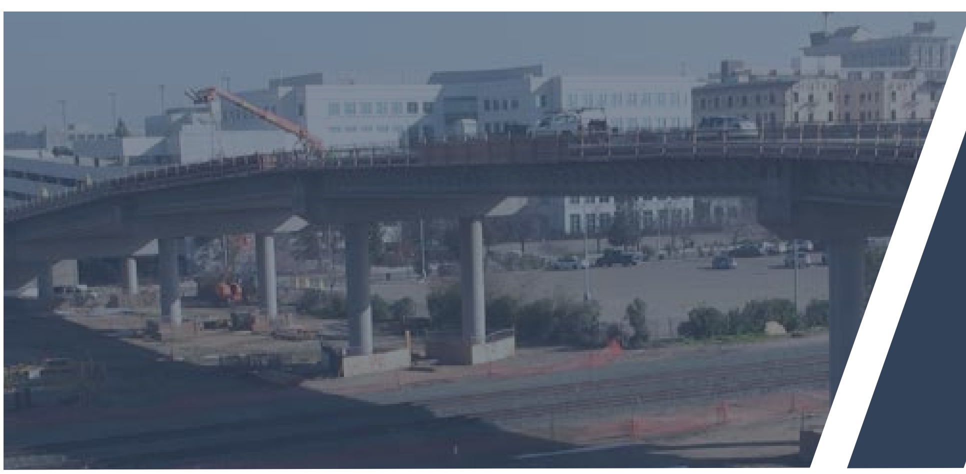
DRAFT REVISED 2018 Business Plan: Technical Supporting Document

Service Planning Methodology

June 1, 2018







CONNECTING CALIFORNIA

EXPANDING ECONOMY

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CALIFORNIA High-Speed Rail Authority

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CALIFORNIA High-Speed Rail Authority

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To: Joseph Hedges
From: Matt Henley
Description of Enclosed Document(s): 2018 Business Plan Service Planning Methodology

REVIEWER INFORMATION		
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ACRONYMS AND ABBREVIATIONS

AGV	Automotrice à grande vitesse (high-speed electric train built by Alstom)
HMF	Heavy Maintenance Facility
MPH	Miles per Hour
NTSB	National Transportation Safety Board
O&M	Operations and Maintenance
TMF	Trainset Maintenance Facility

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1 PURPOSE FOR HIGH-SPEED RAIL SERVICE PLANS

The development process of the California High-Speed Rail *2018 Business Plan* includes an operations planning framework 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 commercially driven service.

The service plans developed are aligned with the infrastructure to be provided through the capital cost expenditure plan and the service plans aim to optimize utility of the provided infrastructure.

2 SERVICE PLANNING PROCESS

The service planning process used in the *2018 Business Plan* is formulated to provide service structure, journey time, and frequencies that can be used in the Travel Demand Forecast Model to produce ridership demand and revenue forecasts. A practical "timetable" for the operating day is developed based on estimated hourly service patterns of revenue service trains for "peak" and "off peak" periods. The timetables are based on generated running times by a train simulator with industry-standard allowances for day to day variance in train operations, such as weather conditions, fluctuation of the train performance due to difference in ~~motormen's~~ engineer's handling, and minor operating interruptions. Station dwell times are also accounted for in the "timetable". 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 Operations 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. 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 Operations and Maintenance cost modeling.

3 METHODOLOGY

The service plans developed for the *2018 Business Plan* Operations and Maintenance cost estimate were created in a multi-step process consisting of:

1. Establishing a service structure and frequency to be used in the Travel Demand Forecast Model for each of the designated project milestone years, 2029, 2033, and 2040
2. Development of service plans based on the service levels assumed for the Travel Demand Forecast Model run(s) and fleet manipulation
3. Calculation of the Operations and Maintenance Cost Model inputs:
    - Revenue service train count
    - Daily trainset miles
    - Fleet size
    - Revenue train-to-revenue train turn count
4. Calculation of the feeder bus service revenue miles

3.1 Service Structure and Service Level for the Travel Demand Forecast Model

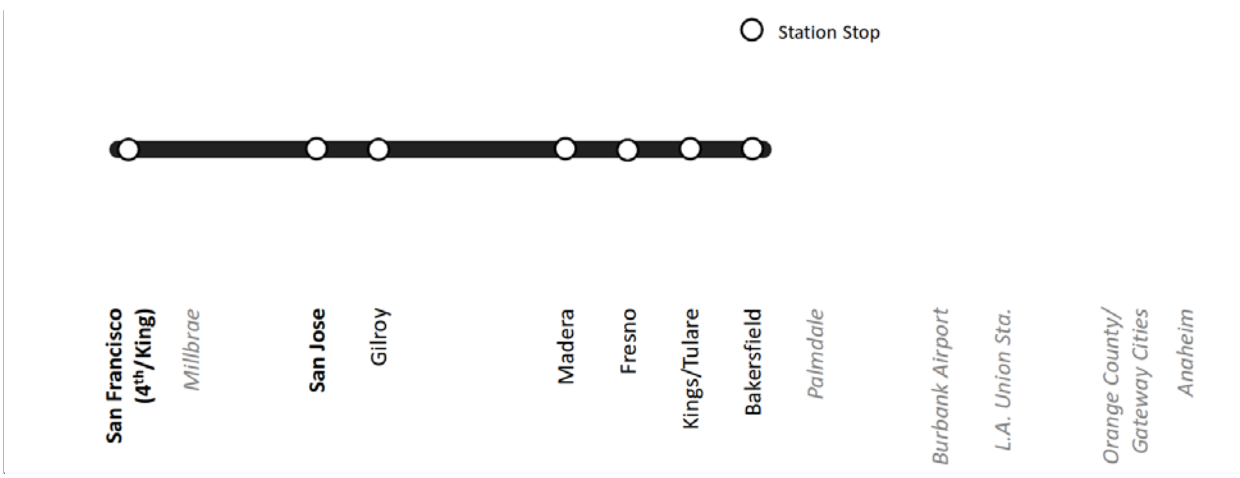
The first step of the service plan development is to create a service structure and service frequencies for the milestone years and phases that the Travel Demand Forecast Model uses.

For the *2018 Business Plan*, the following ridership milestone and forecast years were selected to allow for more precise forecasts:

- Silicon Valley to Central Valley line (San Francisco to Bakersfield) in 2029
- Phase 1 (San Francisco/Merced to Los Angeles/Anaheim) in 2033 and 2040 (out-year)

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 peak and off-peak hours were prepared for the forecast model runs. The service structure pivots from the hourly service patterns assumed in the service planning work done for the *2016 Business Plan*. Anticipated service travel time~~Anticipated trip time~~ from the origin station to each of the scheduled stops for each stopping pattern was calculated using a railroad operations simulation model tool, Train Performance Calculations.[1] These service travel times~~trip travel times~~ are a key input for the Travel Demand Forecast Model. The Train Performance Calculation tool is part of specialized software package from Berkeley Simulation's Rail Traffic Controller application.

As an example, the Silicon Valley to Central Valley service patterns are shown in Figure 1. Figure 2 shows the assumed service structure for Phase 1, which consists of an all-stop local pattern and variations of limited-stop train patterns. These patterns are similar to the Phase 1 service structure assumed in the *2016 Business Plan* but include improved service to Merced and stops at Madera for interchange with Amtrak San Joaquin services.



[PDH1][HY2]

Figure 1 Service Structure Assumption for the California High-Speed Rail *2018 Business Plan*: Silicon Valley to Central Valley Line

[1] Service travel time means the time that it takes a fully operational in-service train, with no operating restrictions, to transition a fully operational section of track, also known as pure run time.

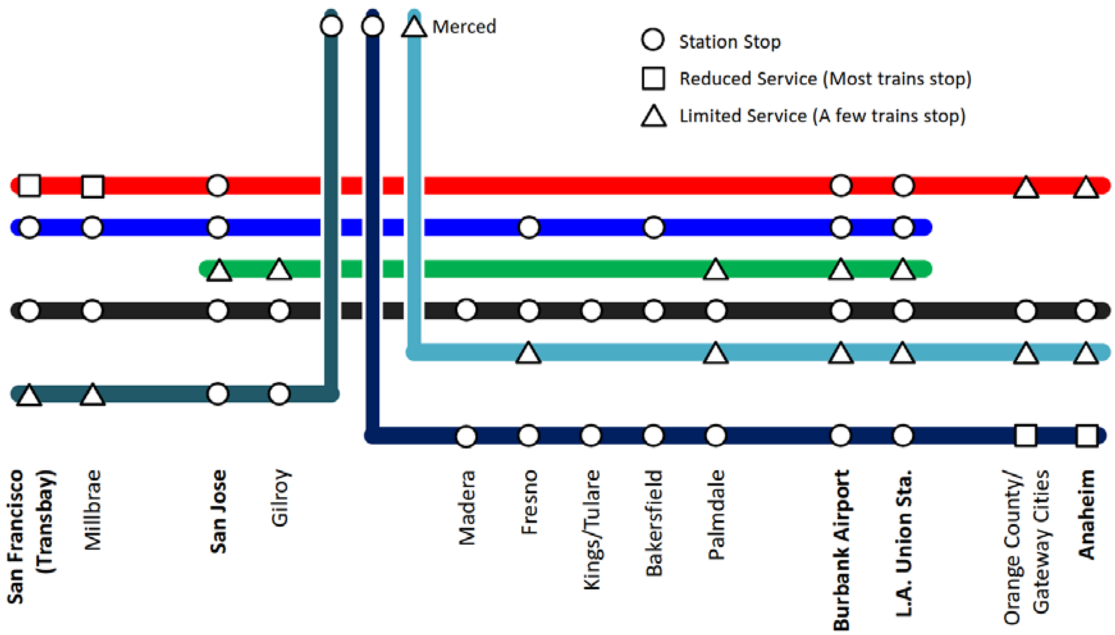


Figure 2 Service Structure Assumption for the California High-Speed Rail *2018 Business Plan*: Phase 1

The service structure illustrated above offers several customer service advantages:

- Ability to travel between any pair of stations without having to change trains as required by Proposition 1A
- Mixture of express service, limited-stop service, and all-stop local service offers a diverse menu of train services to cover a wide variety travel needs
- Consistency in the service level at each station throughout the segment and during the service expansion / implementation phases
- Operational flexibility for practical application of the commercial service

3.2 Development of California High-Speed Rail Service Plans

The train schedules were developed through a process consistent with previous California High-Speed Rail Business Plans.

Service plans for the milestone years of the Travel Demand Forecast Model runs were developed based on the hourly frequency and service structure assumptions used in the model. Using these service assumptions as a template, separate peak hour and off-peak hour service plans were developed.

Service plans for the intermediate years reflect the service plans from the previous “milestone” year. For example, the 2029 service plan exists until the system expands to Phase 1 in 2033. The Phase 1 service plan remains consistent from 2033 and beyond. Ramp-up factors, as documented in the Operations and Maintenance Technical Supporting Document and the *2018 Business Plan*, are applied to these service plans to simulate the gradual start-up of high-speed rail service levels. The Operations and Maintenance inputs presented in the appendix reflect the Operations and Maintenance ramp-up assumptions.

3.2.1 Early Morning and Late Evening Service

To serve all stations with early morning and late evening off peak trains, some trains during this period terminate and start from intermediate stations rather than the end-point stations of the system. In the Phase 1 service plan for instance, the non-stop trains departing from Northern California to Southern California at 0600 would not pass Bakersfield before 0800. Without short-trip "zone" service, intermediate stations would not receive service in the first and last hours of the revenue-service day. This would create a service gap, i.e., a time period where passengers would use the system but there is no service. The addition of zone service addresses the service gap issue while providing several operational benefits, including:

- Reduction of the trainsets that needs to be stored at the TMFs near Downtown San Francisco and Downtown Los Angeles overnight, which could potentially allow reduction of the train layup capacity in areas where the availability of the large parcels suitable for the TMFs is limited compared to other parts of the state.
- Increased efficiency of operating revenue trains instead of non-revenue trains to charge and discharge the system.

Zone service remains part of the overall service plan and is considered when deriving inputs for the Operations and Maintenance cost model (outlined in Section 3.3), such as trainset miles, train turns and bus miles. However, the Travel Demand Forecasting Model does not consider zone service in its forecasts to maintain simplicity. By considering Operations and Maintenance impact, but not ridership and revenue impact, forecasting remains conservative.

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

Southbound

StaCode	Station												
	Train Number:	401001	401003	401005	401007	401009	401011	401013	401015	401017	401019	401021	401023
	Origin:	PMD	PMD	PMD	PMD	PMD	BFD	BFD	FNO	PMD	SJC	MCD	SJC
	Origin Dp. Time:	06:00:00	06:20:00	06:35:00	06:50:00	07:05:00	06:45:00	07:00:00	06:41:00	07:54:00	06:00:00	06:36:00	06:11:00
	Destination:	ANA	ANA	LAU	ANA	ANA	ANA	LAU	LAU	ANA	LAU	ANA	MCD
	Dest. Ar. Time:	07:26:30	07:50:15	07:14:15	08:21:15	08:36:15	08:54:00	08:16:30	08:23:00	09:25:15	08:38:30	09:48:15	07:05:00
SFT	S.F. - Transbay dp.												
SFO	Millbrae dp.												
SJC	San Jose dp.										06:00		06:11
GLY	Gilroy dp.										06:23		06:39
MCD	Merced ar.										‖		07:05
MCD	Merced dp.										‖	06:36	
MDR	Madera dp.										↓	↓	
FNO	Fresno dp.								06:41		↓	07:10	
KTR	Kings/Tulare dp.								↓		↓	↓	
BFD	Bakersfield dp.						06:45	07:00	07:19		↓	07:52	
PMD	Palmdale dp.	06:00	06:20	06:35	06:50	07:05	07:21	07:36	↓	07:54	07:58	↓	
BUR	Burbank dp.	06:22	06:43	06:58	07:13	07:28	07:46	08:00	08:08	08:17	08:22	08:38	
LAU	Los Angeles dp.	06:39	07:01	07:14	07:32	07:47	08:05	08:16	08:23	08:36	08:38	08:57	
FUL	Fullerton dp.	07:20	07:43		08:14	08:29	08:47			09:18		09:41	
ANA	Anaheim ar.	07:26	07:50		08:21	08:36	08:54			09:25		09:48	

StaCode	Station												
	Train Number:	401025	401027	401029	401031	401033	401035	401037	401039	401041	401043	401045	401047
	Origin:	SJC	SJC	FNO	PMD	SFO	SFT	MCD	SFT	SJC	SFT	SFT	SFT
	Origin Dp. Time:	06:15:00	06:24:00	07:20:00	08:30:00	06:06:00	06:00:00	07:21:00	06:15:00	07:09:00	06:30:00	06:45:00	07:00:00
	Destination:	LAU	ANA	ANA	LAU	LAU	LAU	ANA	ANA	MCD	ANA	LAU	LAU
	Dest. Ar. Time:	08:44:30	11:08:00	10:20:30	09:09:45	08:48:30	09:33:00	11:23:00	11:42:30	08:03:30	10:33:15	09:53:30	10:33:00
SFT	S.F. - Transbay dp.						06:00		06:15		06:30	06:45	07:00
SFO	Millbrae dp.					06:06	06:21		06:36		06:51	07:06	07:21
SJC	San Jose dp.	06:15	06:24			06:27	06:43		06:58	07:09	07:13	07:28	07:43
GLY	Gilroy dp.	↓	06:52			↓	↓		07:24	07:37	↓	↓	↓
MCD	Merced ar.	‖	‖			‖	‖		‖	08:03	‖	‖	‖
MCD	Merced dp.	‖	‖			‖	‖	07:21	‖		‖	‖	‖
MDR	Madera dp.	↓	07:26			↓	↓	07:42	07:59		↓	↓	↓
FNO	Fresno dp.	↓	07:52	07:20		↓	07:38	08:07	08:27		↓	↓	08:38
KTR	Kings/Tulare dp.	↓	08:17	07:39		↓	↓	08:34	08:52		↓	↓	↓
BFD	Bakersfield dp.	↓	08:55	08:12		↓	08:19	09:12	09:29		↓	↓	09:19
PMD	Palmdale dp.	↓	09:38	08:49	08:30	↓	↓	09:49	10:11		↓	↓	↓
BUR	Burbank dp.	08:28	10:01	09:12	08:53	08:32	09:16	10:13	10:34		09:23	09:37	10:16
LAU	Los Angeles dp.	08:44	10:19	09:32	09:09	08:48	09:33	10:32	10:54		09:42	09:53	10:33
FUL	Fullerton dp.		11:01	10:14				11:16	11:36		10:26		
ANA	Anaheim ar.		11:08	10:20				11:23	11:42		10:33		

StaCode	Station											
	Train Number:	401049	401051	401053	401055	401057	401059	401061	401063	401065	401067	401069
	Origin:	MCD	SJC	SFT	SFT	SJC	SFT	SFT	MCD	SJC	SFT	SFT
	Origin Dp. Time:	08:21:00	07:51:00	07:15:00	07:30:00	08:24:00	07:45:00	08:00:00	09:21:00	08:51:00	08:15:00	08:30:00
	Destination:	ANA	LAU	ANA	LAU	MCD	LAU	LAU	ANA	LAU	ANA	LAU
	Dest. Ar. Time:	12:23:00	10:36:00	12:42:30	10:38:30	09:21:30	10:53:30	11:33:00	13:23:00	11:36:00	13:42:30	11:38:30
SFT	S.F. - Transbay dp.			07:15	07:30		07:45	08:00			08:15	08:30
SFO	Millbrae dp.			07:36	07:51		08:06	08:21			08:36	08:51
SJC	San Jose dp.		07:51	07:58	08:13	08:24	08:28	08:43		08:51	08:58	09:13
GLY	Gilroy dp.		08:16	08:24	↓	08:55	↓	↓		09:16	09:24	↓
MCD	Merced ar.		‖	‖	‖	09:21	‖	‖		‖	‖	‖
MCD	Merced dp.	08:21	‖	‖	‖		‖	‖	09:21	‖	‖	‖
MDR	Madera dp.	08:42	↓	08:59	↓		↓	↓	09:42	↓	09:59	↓
FNO	Fresno dp.	09:07	↓	09:27	↓		↓	09:38	10:07	↓	10:27	↓
KTR	Kings/Tulare dp.	09:34	↓	09:52	↓		↓	↓	10:34	↓	10:52	↓
BFD	Bakersfield dp.	10:12	↓	10:29	↓		↓	10:19	11:12	↓	11:29	↓
PMD	Palmdale dp.	10:49	09:56	11:11	↓		↓	↓	11:49	10:56	12:11	↓
BUR	Burbank dp.	11:13	10:19	11:34	10:22		10:37	11:16	12:13	11:19	12:34	11:22
LAU	Los Angeles dp.	11:32	10:36	11:54	10:38		10:53	11:33	12:32	11:36	12:54	11:38
FUL	Fullerton dp.	12:16		12:36					13:16		13:36	
ANA	Anaheim ar.	12:23		12:42					13:23		13:42	

Northbound

StaCode	Station												
	Train Number:	402002	402004	402006	402008	402010	402012	402014	402016	402018	402020	402022	402024
	Origin:	GLY	GLY	GLY	GLY	FNO	MCD	FNO	BFD	PMD	BUR	MCD	BUR
	Origin Dp. Time:	06:16:00	06:31:45	06:46:45	07:01:45	06:40:00	06:59:00	06:55:00	06:30:00	06:07:00	06:00:00	07:32:00	06:05:00
	Destination:	SFT	SFT	SFT	SFT	SFT	SFT	SJC	SJC	SFT	SFT	SJC	MCD
	Dest. Ar. Time:	07:30:00	07:45:45	08:00:45	08:15:45	08:30:00	08:44:30	08:07:15	08:48:15	09:59:45	09:00:00	08:31:00	08:51:30
ANA	Anaheim dp.												
FUL	Fullerton dp.												
LAU	Los Angeles dp.												
BUR	Burbank dp.										06:00		06:05
PMD	Palmdale dp.									06:07	↓		06:30
BFD	Bakersfield dp.								06:30	06:48	↓		07:09
KTR	Kings/Tulare dp.								07:11	07:29	↓		07:47
FNO	Fresno dp.					06:40		06:55	07:36	07:49	↓		08:11
MDR	Madera dp.					06:58		07:15	07:56	08:17	↓		08:36
MCD	Merced ar.					‖		‖	‖	‖	‖		08:51
MCD	Merced dp.					‖	06:59	‖	‖	‖	‖	07:32	
GLY	Gilroy dp.	06:16	06:31	06:46	07:01	↓	07:32	07:44	08:25	08:47	↓	08:08	
SJC	San Jose dp.	06:41	06:57	07:12	07:27	07:43	07:57	08:07	08:48	09:12	08:12	08:31	
SFO	Millbrae dp.	07:05	07:21	07:36	07:51	08:06	08:21			09:36	08:36		
SFT	S.F. - Transbay ar.	07:30	07:45	08:00	08:15	08:30	08:44			09:59	09:00		

StaCode	Station												
	Train Number:	402026	402028	402030	402032	402034	402036	402038	402040	402042	402044	402046	402048
	Origin:	FNO	LAU	LAU	MCD	LAU	LAU	LAU	ANA	ANA	LAU	ANA	MCD
	Origin Dp. Time:	07:20:00	06:00:00	06:15:00	08:00:15	06:26:00	06:30:00	06:35:00	06:00:00	06:13:00	06:54:00	06:28:00	09:00:15
	Destination:	SFT	SFT	SFT	SJC	SJC	SFT	SJC	MCD	SFT	SFT	SFT	SJC
	Dest. Ar. Time:	09:31:15	09:14:45	11:00:15	08:59:15	08:51:30	09:44:45	09:19:15	10:00:45	10:14:45	10:29:45	12:00:15	09:59:15
ANA	Anaheim dp.								06:00	06:13		06:28	
FUL	Fullerton dp.								06:09	06:21		06:36	
LAU	Los Angeles dp.		06:00	06:15		06:26	06:30	06:35	06:47	07:00	06:54	07:15	
BUR	Burbank dp.		06:17	06:32		06:42	06:47	06:52	07:04	07:17	07:11	07:32	
PMD	Palmdale dp.		↓	07:07		↓	↓	07:18	07:37	↓	↓	08:07	
BFD	Bakersfield dp.		↓	07:49		↓	↓	↓	08:16	↓	08:02	08:49	
KTR	Kings/Tulare dp.		↓	08:31		↓	↓	↓	08:57	↓	↓	09:31	
FNO	Fresno dp.	07:20	↓	08:51		↓	↓	↓	09:25	↓	08:42	09:51	
MDR	Madera dp.	07:47	↓	09:15		↓	↓	↓	09:46	↓	↓	10:15	
MCD	Merced ar.	‖	‖	‖		‖	‖	‖	10:00	‖	‖	‖	
MCD	Merced dp.	‖	‖	‖	08:00	‖	‖	‖		‖	‖	‖	09:00
GLY	Gilroy dp.	08:17	↓	09:49	08:36	↓	↓	08:56		↓	↓	10:49	09:36
SJC	San Jose dp.	08:42	08:27	10:13	08:59	08:51	08:57	09:19		09:27	09:42	11:13	09:59
SFO	Millbrae dp.	09:06	08:51	10:37			09:21			09:51	10:06	11:37	
SFT	S.F. - Transbay ar.	09:31	09:14	11:00			09:44			10:14	10:29	12:00	

StaCode	Station											
	Train Number:	402050	402052	402054	402056	402058	402060	402062	402064	402066	402068	402070
	Origin:	LAU	LAU	LAU	ANA	LAU	LAU	ANA	MCD	LAU	LAU	ANA
	Origin Dp. Time:	07:26:00	07:30:00	07:35:00	07:00:00	07:54:00	08:00:00	07:28:00	10:00:00	08:26:00	08:30:00	08:00:00
	Destination:	SJC	SFT	SJC	MCD	SFT	SFT	SFT	SJC	SJC	SFT	MCD
	Dest. Ar. Time:	09:50:30	10:44:45	10:19:15	11:00:45	11:29:45	11:14:45	13:00:15	11:00:00	10:50:30	11:44:45	12:00:45
ANA	Anaheim dp.				07:00			07:28				08:00
FUL	Fullerton dp.				07:09			07:36				08:09
LAU	Los Angeles dp.	07:26	07:30	07:35	07:47	07:54	08:00	08:15		08:26	08:30	08:47
BUR	Burbank dp.	07:42	07:47	07:52	08:04	08:11	08:17	08:32		08:42	08:47	09:04
PMD	Palmdale dp.	↓	↓	08:18	08:37	↓	↓	09:07		↓	↓	09:37
BFD	Bakersfield dp.	↓	↓	↓	09:16	09:02	↓	09:49		↓	↓	10:16
KTR	Kings/Tulare dp.	↓	↓	↓	09:57	↓	↓	10:31		↓	↓	10:57
FNO	Fresno dp.	↓	↓	↓	10:25	09:42	↓	10:51		↓	↓	11:25
MDR	Madera dp.	↓	↓	↓	10:46	↓	↓	11:15		↓	↓	11:46
MCD	Merced ar.	‖	‖	‖	11:00	‖	‖	‖		‖	‖	12:00
MCD	Merced dp.	‖	‖	‖		‖	‖	‖	10:00	‖	‖	
GLY	Gilroy dp.	↓	↓	09:56		↓	↓	11:49	10:36	↓	↓	
SJC	San Jose dp.	09:50	09:57	10:19		10:42	10:27	12:13	11:00	10:50	10:57	
SFO	Millbrae dp.		10:21			11:06	10:51	12:37			11:21	
SFT	S.F. - Transbay ar.		10:44			11:29	11:14	13:00			11:44	

Figure 3 Example of Service Plan (Phase 1, Year 2040)

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3.3 Calculation of Operations and Maintenance Cost Model Inputs

The service plans are designed to provide direct inputs for the Operations and Maintenance Cost Model for:

- Trainset Mileage
- Fleet Size
- Number of Revenue Trains (for Connecting Buses)
- Revenue Train to Revenue Train Turns (Crew Numbers)
- Feeder Bus Miles

After the service plans were developed, all the equipment was linked to form extended cycles[2] to satisfy the terminal requirements[3] 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 revenue service. These cycles also dictate the daily system-wide trainset mileage, which impacts energy costs as well as rolling stock and infrastructure maintenance costs in the Operations and Maintenance 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 revenue-service movement of the trainsets was derived by adding up all 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 TMF 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 TMFs where the trainset would be stored and maintained for the next revenue-service day.

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

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

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4 ASSUMPTIONS

4.1 Infrastructure

- The northern part of the system between San Francisco and Gilroy will operate on infrastructure shared with Caltrain and their tenants with operating speeds up to 110 MPH in the Phase 1 system
- The central section of the system between Gilroy and Burbank will be dedicated high-speed infrastructure separated from any other conventional heavy rail systems with operating speeds up to 220 MPH
- The southern part of the system, between Burbank and Anaheim, will operate on infrastructure shared with Metrolink, Amtrak and BNSF with operating speeds up to 125 MPH
- High-speed rail passenger stations are assumed to be located at the following locations[4]:
    - San Francisco Transbay Transit Center
    - San Francisco 4th & King[5]
    - Millbrae
    - San Jose Diridon Station
    - Gilroy
    - Merced
    - Madera (interim rail interchange only)
    - Fresno
    - Kings/Tulare
    - Bakersfield
    - Palmdale
    - Burbank Airport
    - Los Angeles Union Station
    - Gateway Cities/Orange County[6]
    - Anaheim
- Mid-line stations are assumed to be 4-track stations with two center through tracks and two outside platform tracks. Station tracks will be siding tracks of approximately 1,410 feet adjacent to the station platform. Universal interlockings capable of routing trains to all parts of the station complex will be provided.

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[4] The list of stations shown is not definitive and may be subject to change as the program continues to develop. This list enables Ridership and Revenue forecasting, Operations and Maintenance forecasting, and Lifecycle Cost forecasting. The final set of stations operated on the network will meet the Prop 1A requirements.

[5] The San Francisco 4th & King station is assumed in the Silicon Valley to Central Valley (San Francisco to Bakersfield) scenario only; San Francisco Transbay Terminal is assumed for Phase 1.

[6] For timing purposes, Fullerton has been used in this analysis.

- The signal system is assumed to provide a 2 minute 45 second minimum signaling headway at 220 MPH.
- Trainset Maintenance Facilities will be built as listed in Table 1. It should be noted here that the locations of these facilities are part of the ongoing environmental approval process and 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 Operations and Maintenance Cost Model.

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

Preliminary Name	Maintenance Capability	Roll-Out Phase
Bay Area	Level III	Silicon Valley to Central Valley
Central Valley HMF	Level V	Silicon Valley to Central Valley
Gilroy	Level I (stabling only)	Silicon Valley to Central Valley
Los Angeles Area	Level III	Phase 1
Anaheim	Level I (stabling only)	Phase 1

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 timeservice travel 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 trainset configurations based on demand.

4.3 Passenger Service

- Pure run times have been computed by the Train Performance Calculator in Rail Traffic Controller[7]. For a non-stop run between San Francisco and Los Angeles Union Station the pure run time meets the Proposition 1A requirement for this time to not exceed 2 hours 40 minutes.
- To allow for minor variances associated with the daily operation of train services a The interval of recovery time, (scheduledknown as pad is applied to the pure run times.) for the high-speed rail trains has been established at ten percent of the pure run time as computed by the Train Performance Calculator in Rail Traffic Controller. On the newly constructed, dedicated high-speed sections a pad of 5% is applied; on sections where high-speed services share the track with other train operators a pad of 10% is applied. Rail Traffic Controller is a railroad operations simulation model widely used among railroads in the United States and by the National Transportation Safety Board (NTSB).
- System revenue-service hours are anticipated to be from 0600 to Midnight (0000), seven days a week; the five-hour period between 0000 and 0500 is allocated to the maintenance of

[7] Rail Traffic Controller is a railroad operations simulation model widely used among railroads in the United States and by the National Transportation Safety Board (NTSB).

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 “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.
- There were assumed to be two ~~(2)~~ 3-hour peak periods in each revenue service day. The peak hours are meant 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 may be different from service patterns during other times of the day ~~in order to~~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~~to allow faster trains to achieve scheduled service travel time~~trip time~~. In some instances, the train being overtaken or overtaking may incur additional station dwell time or scheduled service travel time~~trip time~~ to accommodate the overtake at intended locations.
- Minimum dwell time at intermediate stations is ~~180 seconds (three minutes) for Silicon Valley to Central Valley service and 120 seconds (~~two minutes~~)~~ ~~during Phase 1~~except at Los Angeles Union station where a dwell of five minutes is applied for through services.
- Minimum ~~and desirable layover/~~turnaround time~~s~~ for a train set between revenue trips at a terminal station~~s~~ ~~are~~ 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 platform or tail tracks at intermediate 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~~to provide maintenance spares and revenue service “protect” trains. This is an international industry standard in high-speed passenger rail systems.
- It is anticipated that service plans will continue to be developed in conjunction with the early train operator and that this will impact fleet sizes. The adopted approach for this business plan cycle should be considered reasonable and conservative.

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5 FEEDER BUS SERVICE PLANNING

5.1 Introduction

During initial stages of its implementation, the high-speed rail system would not provide direct high-~~-~~speed train service to some of the major urban areas - such as the Sacramento area and the Los Angeles Basin area. When the Silicon Valley to Central Valley line opens, the proposed high-speed train service would end at 4th & King in San Francisco and at Bakersfield creating interim end-of-the-line stations. While certain conventional rail connections, such as the Amtrak San Joaquin Service, ~~–~~would be available between the opening of the Silicon Valley to Central Valley line segment and major urban areas, the 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 fact, there are currently minimal transit options between Bakersfield and the Los Angeles Basin area. ~~In order to~~To fill this connectivity gap, the high-speed rail service will be supplemented with feeder bus connections between the opening of the Silicon Valley to Central Valley line segment and certain major urban areas during the initial stages of implementation.

Feeder bus connections were included in the Travel Demand Forecast Model run specifications. The Travel Demand Forecast Model accounts for these feeder bus connections in estimating the ridership for the high-speed rail system; it also forecasts bus revenue based on the number of passengers using the feeder bus to access and egress the high-speed rail system. Table 2 presents feeder bus revenue by forecast year and the number of bus revenue miles. It is important to note that the feeder bus service levels have also not yet been optimized.

Table 2 Estimated Feeder Bus Annual Fare Revenue and Revenue Vehicle Miles[8]

Year	Bus Revenue in ~~June Dec~~June 2017	Bus Revenue Vehicle Miles
2029	$~~7,019~~6,930,000~~296,000~~	5,955,000
2033	$~~20136,000~~199,000	1,925,000
2040	$~~516~~453~~9~~,000	2,300,000

Note: All dollar figures presented are in June $2017. The 2018 Business Plan escalates these to December $2017 for consistency with Capital and Lifecycle costs.

The significant drop in feeder bus revenue when the Phase 1 system opens is due to a reduction in the feeder bus service offered. Given the minimal service frequencies of the San Joaquin Amtrak trains between Sacramento and Fresno and the absence of transit connecting the Bakersfield and the Los Angeles Basin, there are few transit options available that connect to the Silicon Valley to Central Valley line. As a result, before the high-speed rail system expands to Phase 1 a feeder bus will run frequently enough to meet each high-speed rail train in Madera and in Bakersfield. Phase 1 feeder bus service is reduced as the system extends its reach; additional information on the feeder bus connections can be found in the sections below.

[8] Bus Revenue and Bus Revenue Vehicle Miles presented here are “ramped-up” to account for the gradual increase in service after the opening year. For the full details of the ramp-up assumptions, see the Forecast Chapter of the *2018 Business Plan* and the Operations and Maintenance Cost Model Technical Documentation.

5.2 Travel Demand Forecast Model Run Specification

Feeder bus connections were included in the Travel Demand Forecast 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 Travel Demand Forecast Model run specifications for the Silicon Valley to Central Valley line and Phase 1 implementation steps include the following proposed feeder bus connections as summarized in Table 3.

Table 3 Feeder Bus Connections

Proposed High-Speed Rail Station Connection Point	Implementation Step	
	Silicon Valley to Central Valley	Phase 1
Madera ~~High-Speed Rail~~interim rail interchange (~~Silicon~~ Valley to ~~Central~~ Valley line) Merced High-Speed Rail (Phase 1)	Sacramento	Sacramento
Bakersfield High-Speed Rail	Los Angeles Basin	None

To efficiently serve major population and employment centers around the large geographic area of the Los Angeles Basin, more than one feeder bus connection route was assumed. The Los Angeles Basin area was provided with three feeder bus routes – the first one provides service to the San Fernando Valley along Interstate 5 and to Central Los Angeles (terminating at Los Angeles Union Station), the second one provides service to the San Fernando Valley along Interstate 405 and to the Westside (terminating in West Los Angeles), and third one provides service to the San Gabriel Valley (terminating in 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 based on the location of major transportation connections and/or the size and location of major population centers or urban areas.

Table 4 Location of Mid-Line Bus Stops

Feeder Bus Connection	Location of Bus Stop
Sacramento	▪ Sacramento (Amtrak Station) ▪ Elk Grove (Amtrak Thruway bus stop) ▪ Lodi (Amtrak Station) ▪ Stockton (Amtrak Station) ▪ Modesto (Amtrak Station) ▪ Denair/Turlock (Amtrak Station) ▪ Merced (High-Speed Rail Station) ▪ Madera (~~High Speed~~Interim Rail ~~Station~~Interchange)
Los Angeles Basin (Los Angeles Union Station)	▪ Burbank Airport ▪ Los Angeles Union Station
Los Angeles Basin (West Los Angeles)	▪ Van Nuys ▪ West Los Angeles
Los Angeles Basin (Santa Anita)	▪ Santa Anita

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

The feeder bus service levels have not been optimized to account for ridership levels projected by the Travel Demand Forecast Model. However, based on the service plans that feed the Travel Demand Forecast Model, forecasts suggest that ridership is significantly higher during the Silicon Valley to Central Valley line phase. This is because the Silicon Valley to Central Valley line opening segment connects only with limited Amtrak San Joaquin service in the north and extends only as far south as Bakersfield, making the high-speed rail feeder bus the best transit option to connect the high-speed trains to Southern California.

As high-speed rail expands to the Phase 1 system in 2033, feeder bus ridership drops significantly as the Los Angeles basin is well served by high-speed rail either directly or through connections with Metrolink or LA Metro rail services.

5.4 Revenue and Fare

In the *2018 Business Plan*, one of the objectives of the Travel Demand Forecast Model runs was to allow comparison of ridership under various implementation steps with the same set of end-to-end fares. High-speed rail fares were set to be competitive with airfares and other modes of travel were assumed to maintain overall fare levels between regions.

High-speed rail fares in the *2018 Business Plan* utilize a generally consistent approach with the *2016 Business Plan* and remain competitive with airfares in the market. Indexed to ~~June December~~June 2017, the model assumes that an average fare from San Francisco to Los Angeles is $93. Similarly, feeder bus fares were set to be competitive with other modes of and remain consistent with the *2016 Business Plan* assumptions. The Travel Demand Forecast Model assumes a $10.36 feeder bus fare between Sacramento and Madera/Merced and $1.29 for connections at the mid-line bus stops (all dollars indexed to ~~June December~~June 2017). The bus fares for the Bakersfield area to Los Angeles Basin connection are assumed to be $12.95 in the *2018 Business Plan*, consistent with fares listed for the Amtrak Thruway bus between Bakersfield and Los Angeles for the existing Amtrak San Joaquin service.

Table 5 presents the incremental fare for using the feeder bus connections, as specified in the Travel Demand Forecast Model run specifications.

Table 5 Incremental Fares

Bus Origin	Connection High-Speed Rail Station or Interchange	Incremental Fares (in ~~June~~ June~~Dec~~ 2017 $)
Los Angeles Basin (Silicon Valley to Central Valley only)	Bakersfield (Silicon Valley to Central line)	$12.95
Sacramento Area	Madera (Silicon Valley to Central Valley line) Merced (Phase 1)	$10.36
Stockton/Modesto/Denair/Merced	Madera (Silicon Valley to Central Valley line) Merced (Phase 1)	$1.29

5.5 Service Levels

Feeder bus service levels assumed for the Silicon Valley to Central Valley line opening phase in 2029 are set to meet every high-speed train in Madera and Bakersfield. Except for the San Joaquin Amtrak trains in Madera, few transit options exist that connect the Silicon Valley to Central Valley line ~~segment~~ from the Sacramento area in Northern California, and only the Amtrak Thruway bus connects current San Joaquin service between Bakersfield and the Los Angeles Basin area in Southern California.

As defined earlier, the 4th and King station in San Francisco marks the northern interim terminal in the Silicon Valley to Central Valley line segment. This station in downtown San Francisco is close enough to other transit infrastructure that feeder bus service is assumed not to be necessary. The Amtrak San Joaquin conventional rail service connects the Sacramento area to the Central Valley and is a logical transit option to connect to the Silicon Valley to Central Valley line at Madera. However, Amtrak San Joaquin service is limited and feeder bus service is assumed to meet high-speed trains at Madera as an alternate option.

Bakersfield currently has very limited transit connection options to Southern California. Potential riders from the Los Angeles Basin area that want to access high-speed rail by transit will rely on feeder bus connections to meet high-speed trains at the Bakersfield station until the high-speed rail system expands to Southern California. As a result, each of the three Los Angeles feeder bus lines runs frequently enough to meet each high-speed train at the Bakersfield station.

Phase 1 feeder bus service levels are reduced significantly and service assumptions remain generally consistent with the 2016 Business Plan. As the Phase 1 system extends to Palmdale, Burbank, and further south, Metrolink will connect the Los Angeles Basin to several high-speed rail stations. As a result, the Los Angeles Basin feeder bus is removed from the Travel Demand Forecast Model in Phase 1. Feeder bus service is continued in the Sacramento area during Phase 1 to connect the region to the Merced terminal in the Central Valley.

In the *2018 Business Plan*, the service levels assumed in the ridership forecast were also used to calculate daily revenue bus mileage. 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, an annualization factor (365), and a factor to account for roundtrip service (2).

The derived estimates for revenue vehicle 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 step are available in the Operations and Maintenance Cost Model Technical Supporting Document.

Appendix A INPUTS TO OPERATIONS AND MAINTENANCE COST MODEL

Table 6 *2018 Business Plan* Service Plan Input for Operations and Maintenance Cost Model (Silicon Valley to Central Valley Line through Phase 1)

Item	Year	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Number of Revenue Service Trips	Single Consist Daily Runs	30	32	34	35	214	223	232	242	255	255	255	255	255	255	255	255
	Double Consist Daily Runs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Trainset Miles	Annual Single Consist Miles	3,789,394	3,975,772	4,177,930	4,380,088	27,209,112	28,399,393	29,599,367	30,799,342	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020
	Annual Double Consist Miles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Revenue to Revenue Service Turns	SF Transbay	0	0	0	0	48	50	52	54	57	57	57	57	57	57	57	57
	SF 4th & King	8	8	8	9	0	0	0	0	0	0	0	0	0	0	0	0
	San Jose	0	0	0	0	18	18	19	20	21	21	21	21	21	21	21	21
	Merced	0	0	0	0	23	24	26	27	28	28	28	28	28	28	28	28
	Bakersfield	8	9	9	10	0	0	0	0	0	0	0	0	0	0	0	0
	LA Union Sta.	0	0	0	0	27	28	29	30	32	32	32	32	32	32	32	32
	Anaheim	0	0	0	0	31	32	34	35	37	37	37	37	37	37	37	37

Item	Year	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	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255
	Double Consist Daily Runs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Trainset Miles	Annual Single Consist Miles	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020	32,466,020
	Annual Double Consist Miles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Revenue to Revenue Service Turns	SF Transbay	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57
	SF 4th & King	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	San Jose	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	Merced	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
	Bakersfield	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	LA Union Sta.	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
	Anaheim	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37

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