California High-Speed Rail Authority

2020 Business Plan

Technical Supporting Document

Operations and Maintenance Cost Model Documentation

Rev 0.4 (Draft)

May 2020

CALIFORNIA High-Speed Rail Authority

Prepared by

for the Authority

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CALIFORNIA High-Speed Rail Authority

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DESCRIPTION OF ENCLOSED DOCUMENT(S): 2020 Business Plan Operations & Maintenance Cost Model Documentation

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ACRONYMS AND ABBREVIATIONS

Abbreviation	Description
ATO	Automatic Train Operation
CDL	Commercial Driver License
CDO	Chief Digitization Officer
CEO	Chief Executive Officer
CEQA	California Environmental Quality Act
CHRO	Chief Human Resources Officer
CPM	Cost per thousand impressions
CRM	Customer relationship management
ETO	Early Train Operator
FRA	Federal Railroad Administration
FTE	Full-time employee
GSA	General Services Administration
GSM-R	Global System for Mobile Communications-Railway
GWh	Gigawatt hour
HMF	Heavy Maintenance Facility
HVAC	Heating, ventilation and air conditioning
IGP	Industrial General Permit
IIPP	Injury and Illness Prevention Plan
kWh	Kilowatt hour
LGV	Lignes à Grande Vitesse
LMF	Light Maintenance Facility
MOE	Maintenance of Equipment
MOI	Maintenance of Infrastructure
MOW	Maintenance of Way
NEPA	National Environmental Policy Act
O&M	Operations and Maintenance
OBP	Office of Planning Budgeting
OCC	Operations Control Center
OCS	Overhead Catenary System
OTT	Over the top
PFAL	Project Finance Advisory Ltd.
PG&E	Pacific Gas & Electric
PTC	Positive Train Control
ROW	Right of Way
RWQCB	Regional Water Quality Control Board
SUV	Sport Utility Vehicle
SWPPP	Storm Water Pollution Prevention Plan
TOC	Train Operating Company
tphpd	Trains per hour per direction

1 INTRODUCTION AND EXECUTIVE SUMMARY

The California High-Speed Rail Authority (Authority) is responsible for planning, designing, building and operation of the first high-speed rail system in the nation. By the California Public Utilities Code section 185033 as amended by Assembly Bill (AB) 528, this technical memorandum supports the content of the Business Plan requirement. California high-speed rail will connect the mega-regions of the state, contribute to economic development and a cleaner environment, create jobs and preserve agricultural and protected lands. By December 2033, the system will run from San Francisco to the Los Angeles basin in under three hours at speeds capable of over 200 miles per hour. The system will eventually extend to Sacramento and San Diego, totaling 800 miles with up to 24 stations.

This Technical Supporting Document outlines the assumptions and inputs for the California High-Speed Rail System Operations and Maintenance Cost Model. The model is designed to help test the system's ability to meet the requirements of Proposition 1A to operate without a subsidy. The model is based on the current level of available system detail and assumptions surrounding the system operations.

In 2019, there was a transition in responsibility from Planning and Delivery Group to Operations for selected supporting documents of the Business Plan. As a result, via the Authority 17-20 contract, the Early Train Operator (ETO) has assumed the responsibility of reviewing and updating the Operations and Maintenance Cost Model and Technical Supporting Document. The ETO brings international high-speed rail experience in operations and maintenance planning, development and delivery.

Since the release of the *2018 Business Plan*, the direction of the California High-Speed Rail Project has changed. Given the funding constraints and current political challenges, newly elected California Governor Gavin Newsom made the executive decision to focus on opening an interim service in the Central Valley, to initiate high-speed service in California as soon as possible. This provides Californians with mobility, economic and environmental benefits in the least amount of time.

This building-block approach is a way to "live within our means," as explained in the 2019 Project Update Report, which would lead to the opening of early service between Merced and Bakersfield in the Central Valley by the end of 2028. This interim service would be followed by the Silicon Valley to Central Valley Service in December 2031, and Phase 1 shortly thereafter in December 2033 (according to the assumptions used for this cost model).

1.1 Clarifications on the Operations and Maintenance Cost Model Scope

The *2018 Business Plan* includes the stages of Silicon Valley to Central Valley and Phase 1, while the 2019 Project Update Report included the concept of Central Valley early service between Merced and Bakersfield. The operations, maintenance and revenues for the Central Valley early service were studied by the ETO and presented in an independent document, *Central Valley and Peninsula Corridors Operations Financial Plan Study* in support of the Project Update Report.

Three stages or "building blocks" are identified for high-speed rail operations:

1. Central Valley early service—Merced to Bakersfield (operations and maintenance costs covered in the ETO *Central Valley Segment System Management & Operations Interim Financial Plan*)
2. Silicon Valley to Central Valley—San Francisco to Bakersfield (covered in this document)
3. Phase 1—San Francisco to Anaheim (covered in this document)

Given the changes in the program, the ETO team performed a full review of the operations and maintenance cost model methodology, assumptions, cost line items and inputs for each of the sections. In addition, the team has made several enhancements to the financial model that was used to forecast costs based on DB's experience in high-speed rail operations.

The following major enhancements to the model were made in comparison to the *2018 Business Plan*:

- Incorporated updated costs for a full-service marketing and branding department;
- Updated the revenue collection costs including costs to operate and maintain the fare collection infrastructure;
- Reflected a maintenance and operations costs approach based on realistic maintenance response times with service levels in line with the updated service plan;
- Incorporated costs for a likely scenario of Track access fees in the shared corridors; and
- Adjusted and increased the ramp up of the operations and maintenance costs for Silicon Valley to Central Valley and Phase 1 considering that an early service will be in place in the Central Valley several years before these phases.

While several cost items were added to the model, refinements to cost items were implemented, such as:

- Reflection of the policing and security strategy of the system;
- An updated (yet conservative) approach to the ramp-up scenarios for both ridership and revenue, considering that the early Central Valley service will reduce the ramp up of the subsequent phases; and
- New approaches to staffing.

These updates result in revised costs that both increase and decrease the cost of operations and maintenance (O&M) in their respective categories and lead to a positive outlook for the system, similar to the *2018 Business Plan*.

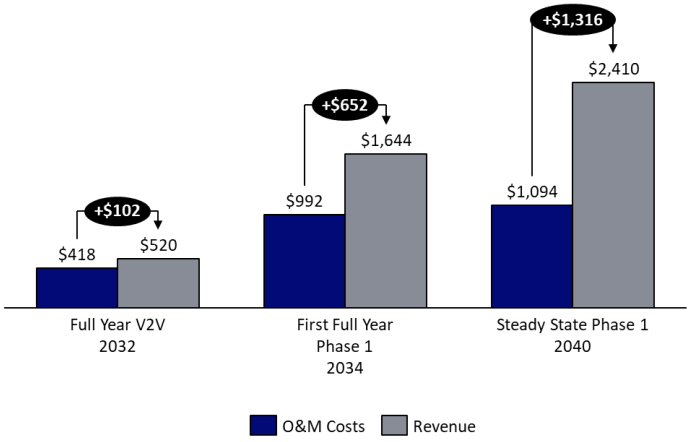
The O&M model forecasts in the first full year of operations for Silicon Valley to Central Valley in 2032 (start of operations in December 2031):

- An associated operations and maintenance cost of $418 million; and
- A net revenue of $520 million.

This leads to a system net positive cashflow of $102 million in the first full year of operations (without the consideration of ancillary revenues).

The following figure shows the cashflow (operations expenditures vs. revenue) for selected stages.

Figure 1 Operations and Maintenance Costs vs. Net Revenue (in June 2019 dollars)



1.2 Further Refinements and Next Steps

The current O&M model reflects a service plan for a two-leg wye south of Merced. This includes the following high-speed service sections in the Silicon Valley to Central Valley stage:

- San Francisco to Bakersfield (two trains per hour per direction (tphpd) in the peak, one tphpd in the off-peak)
- Merced to Bakersfield (one tphpd all day)

The results from our cost model led to a net positive cashflow of $102 million (2019 dollars) running the two-leg wye scenario in year one of Silicon Valley to Central Valley operations (see Figure 1). This level of service provides more benefits to the community in terms of train frequency, travel time, and connections compared to the Silicon Valley to Central Valley service plan from the *2018 Business Plan*.

After performing an analysis with the ridership and cost model forecasts on various scenarios, the ETO identified that there was potential optimization in postponing the number of train services (Specifically the San Francisco to Merced service) in the initial years of Silicon Valley to Central Valley operations. After further analyzing the model results, the two-leg wye scenario provided the most significant cost benefits, including:

- An increase in the overall financial net result. The two-leg wye scenario showed a slight decrease of revenue (due to the slight decrease in service), but a significant saving of operations and maintenance costs.
- An increase in savings in capital investment expenditure, achieved by reducing the number of trainsets as well as the capital expenditure reductions of postponing building the additional infrastructure for the north leg of the wye until a more developed stage of the project.

The ETO, in consultation with the Authority, will continue to refine the study and make additional refinements to the financial model, including fare policy, track access fees and additional information available in the near future from the procurement process of the track, systems and rolling stock.

The model used for this *2020 Business Plan* builds on the model used for the *2018 Business Plan* and has the same model structure and base. However, the updated model takes into account changes recommended by ETO subject matter experts both as they relate to values in the cost model as well as the modeling process.

Following the release of the *2020 Business Plan*, a consolidated model will be developed that includes the three building blocks of implementation, namely the Central Valley segment, Silicon Valley to Central Valley and Phase 1. Currently, the Central Valley Study uses a separate cost model developed by DB Engineering & Consulting which also supported the Project Update Report in May 2019.

Both models include the following categories of operations and maintenance costs: train operations, dispatching, maintenance of rolling stock, maintenance of infrastructure, station operations and train/station cleaning, police and security, commercial, general and administrative. Each section summarizes assumptions for staffing, shifts, material and tool costs and other expenses (such as subcontractor costs) around which conceptual operating strategies are developed. The model does not attempt to optimize the operations to reduce costs but reflects an average and achievable operating scenario that could be further improved by the future operator. The proposed consolidated model will incorporate all of the relevant cost and revenue aspects from the Authority's perspective for all three building blocks.

2 PURPOSE OF THE MODEL

The Operations and Maintenance Cost Model, similar to the model used for the *2018 Business Plan*, aims to test different operating scenarios, ridership, service and commercial options. Specifically, the model helps test whether these different scenarios would follow Proposition 1A as to the system's ability to operate without an operating subsidy. For this purpose, the results of this model should be compared with the revenue forecasts for each year. The model also provides estimates of the total employees needed to run the system.

Note: All dollar figures presented in this document are base year as of June 2019. The *2020 Business Plan* escalates these figures to 2019 dollars for consistency with base year Capital and Lifecycle costs.

3 UPDATES TO THE MODEL SINCE THE 2018 BUSINESS PLAN

The *2020 Business Plan* Operations and Maintenance Cost Model is based on the structure and foundation of the *2018 Business Plan* Operations and Maintenance Cost Model but with a variety of updates and modifications. The 2018 Operations and Maintenance model was developed according to U.S. Department of Transportation Inspector General specifications and deemed to be robust by external high-speed rail subject matter experts, such as the Peer Review Group. The key assumption and structural model upgrades are documented in this section. Minor adjustments, such as cost escalation of wages, are embedded in the body of the Technical Supporting Document.

For the *2020 Business Plan*, the Authority has commissioned the responsibilities of the biennial update to the Early Train Operator, DB Engineering & Consulting (DB E&C USA Inc.). For core areas, subject matter experts have checked the assumptions for plausibility and have done a new assessment taking into account current technologies, regulations and processes.

3.1 Model Start Year and Phasing

The present Business Plan 2020 assumes that the starting point will be postponed by 3 years to the end of 2031. This reflects the current plans for the program. The following table shows the segments and the corresponding phasing.

Table 1 Segment and Phasing of BP 2018 Versus BP 2020

Step	Operating Segment	BP 2018	BP 2020
Silicon Valley to Central Valley	San Francisco 4th & King to Bakersfield	2029-2032	2032*-2033
Phase 1	San Francisco Transbay/Merced to Los Angeles/Anaheim	From 2033	From 2034*

*It is assumed that operation starts in December of the previous year.

3.2 Ramp Up Factor

The *2018 Business Plan* model previously assumed one eight-year ramp up series for the Silicon Valley to Central Valley Line and Phase 1 periods, beginning in 2029 and fully ramped up by 2037. In contrast, the *2020 Business Plan* assumes that operation will be full in year 1. The reason for the change in the assumptions is that railroad will already operate on a large part of the line before Silicon Valley to Central Valley is put into operation. Table 2 captures the new ramp-up series assumed in the model.

Table 2 Ramp-Up Factors Used in *2020 Business Plan* Operations and Maintenance Model

Year	Phase	BP 2018	BP 2020
2029	Silicon Valley to Central Valley	70%	-
2030	Silicon Valley to Central Valley	73.75%	-
2031	Silicon Valley to Central Valley	77.5%	-
2032	Silicon Valley to Central Valley	81.25%	100%*
2033	Silicon Valley to Central Valley	-	100%
2033	Phase 1	85%	-
2034	Phase 1	88.75%	100%*
2035	Phase 1	92.5%	100%
2036	Phase 1	96.25%	100%
2037	Phase 1	100%	100%
2038	Phase 1	100%	100%

*It is assumed that operation starts in December of the previous year.

3.3 Unit Prices and Labor Cost Growth

The *2020 Business Plan* unit prices and salaries were escalated, where applicable, from June 2017 dollars to June 2019 dollars using the California Consumer Price Index-All Urban Consumers series.[1] The index produces a compound annual growth rate of 3.50 percent between 2017 and 2019.

3.4 Personnel Calculation

The personnel calculation was adjusted for the areas of Operations, Maintenance of Rolling Stock and Maintenance of Infrastructure. For Operations, the *2018 Business Plan* approach, which used the roundtrip per crew shift factor, was replaced in the *2020 Business Plan* by a time-based personnel calculation. Similarly, Protect trains have already been considered in Valley-to-Valley phase. The reason for this is that smooth and punctual operation must already be ensured in this phase. Due to the existence of numerous railway crossings, no vehicles from old stock are available and to ensure an acceptable reaction time protect trains are indispensable. The function of Road Manager has been included to ensure the supervision and quality assurance of train operations and to supplement train crews and the operational emergency management.

The Maintenance of Rolling Stock related personnel was changed from a facility-based approach in the *2018 Business Plan* to a time-based calculation. For every task related to Maintenance of Rolling Stock is evaluated, how much time is needed to execute the task and in what rhythm the task has to be carried out. Based on the total hours is calculated what number of personnel needed. This approach allows a more specific determination of the required personnel, which also depends on the number of train sets maintained. In BP 2018, a constant number per facility was assumed, regardless of the number of trains.

The Maintenance of Infrastructure costs were updated to align with the revised service plan and based on a response time of 90 minutes. The approach in the *2018 Business Plan* to assume coverage of every maintenance activity with Authority personnel was replaced by using subcontractors for services, where appropriate. Additionally, a part of blended sections was taken out of consideration. This applies to the following routes:

- Silicon Valley to Central Valley: San Francisco to Gilroy, thereof
    - Owned by Caltrain: San Francisco to CP Lick
    - Authority owned: CP Lick to Gilroy
- Phase 1 (in addition):
    - Owned by Metrolink: Burbank to Anaheim

It is assumed that the maintenance costs for the blended sections, which are not owned by California High-Speed Rail Authority, is covered by track access charges, which has to be paid by the Authority to the owner of the assets. Conversely, the Authority will be paid track access charges from Caltrain for using the Authority's assets from CP Lick to Gilroy.

3.5 Energy Costs

The *2018 Business Plan* assumed an energy unit cost of $0.1163 per kilowatt-hour (kWh) (in 2017 dollars). This estimate was based on Pacific Gas & Electric (PG&E) transmission voltage rates available in the E-20 tariff, which is applicable to services to customers demanding over 1000 kW[2]. The *2020*

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[1] California Consumer Price Index. California Department of Industrial Relations. Accessed September 2017. <https://www.dir.ca.gov/OPRL/CPI/EntireCCPI.PDF>

[2] https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_E-20.pdf

Business Plan assumes the identical tariff and includes an updated energy unit cost of $0.1312 per kilowatt-hour (kWh) (in 2019 dollars). Compared to the *2018 Business Plan*, the *2020 Business Plan* also includes the costs for ancillary energy consumption for heating, ventilation and air conditioning (HVAC). The energy unit cost is based on Phase 1 system demand. The Silicon Valley to Central Valley phase was not discretely modeled. Please read Section 5.3 for additional information on assumptions for energy unit cost and energy usage, Section 7.3.1 for additional information on energy usage in maintenance facilities, and Section 9.5.3.1 for more on station energy usage.

3.6 County Population projections

Updates to population figures were made in the *2020 Business Plan* Operations and Maintenance Cost Model, based on forecasts by county developed by California Economic Forecast, Moody Analytics, and California Department of Finance and Traffic Analysis Zone-level forecasts from respective MPOs. The county population forecasts impact the advertising costs in the Operations and Maintenance Model. Please read Section 11.1 for additional information on marketing assumptions and Appendix E— for detailed county population forecasts.

3.7 Insurance

Currently, the Highspeed Rail Authority is evaluating the overall insurance strategy. In the present Business Plan 2020 it is assumed, that the Authority is responsible for taking out insurance policies. Given advances in system design since the *2018 Business* Plan and the resulting updated driver factors, Marsh, a global leader in insurance broking and risk management, provided updated coverage rates, which depend on ridership, revenues and asset values. Insurance rates from Marsh reflect insurers' risk factors at the time of the production of the *2020 Business Plan* and may change in future years as the high-speed rail system design and concept of operations advances to a higher level of completion. Marsh's insurance estimates include fixed and variable components depending on the type of coverage. Please see Section 13 for additional information on insurance assumptions.

3.8 All Other Model Assumptions and Inputs

All other model assumptions and inputs from the *2018 Business Plan* Operations and Maintenance Cost Model were reviewed by subject matter experts and found to be consistent with the current concept of operations for the California High-Speed Rail System. These validated inputs were re-used for the *2020 Business Plan* Operations and Maintenance Cost Model, and where necessary, California Consumer Price Index escalation was used to escalate unit cost amounts from 2017 dollars into 2019 dollars (see Section 4).

Three new, separate sections for Marketing, Revenue Collection and Environmental, Health and Safety are included.

This Technical Supporting Document captures only the assumptions for the Operations and Maintenance costs (which covers operations and routine maintenance). For Lifecycle costs (rehabilitation and replacement), please see the 50-Year Lifecycle Capital Cost Model Technical Supporting Document.

4 UNIVERSAL ASSUMPTIONS

The model aims to present a realistic scenario for operation of the high-speed rail system. The scenario aims to be technically sound based on conventional rail practice in the US and applicable adjustments for high-speed rail service from around the world. For the medium (base) cost scenario, the following assumptions are applicable across all categories of costs/personnel.

Table 3 System Implementation Phasing from the *2020 Business Plan*

Step	End Points	Anticipated Year Opening
Silicon Valley to Central Valley	San Francisco 4th & King to Bakersfield	2032*
Phase 1	San Francisco Transbay/Merced to Los Angeles/Anaheim	2034*

*It is assumed that operation starts in December of the previous year.

1. The model assumes the phasing as proposed in the *2020 Business Plan*, which appears in Table 3 above.
2. The length of the system, the stations that are assumed to be operating, and other system details are based on the system, service and implementation assumptions outlined in the *2020 Business Plan* and Technical Supporting Document: Service Planning Methodology. This information builds on the system assumptions used in the development of the *2018 Business Plan,* but includes some key differences, specifically the additional service to Merced.
3. Unit cost assumptions from the *2018 Business Plan* California High-Speed Rail System Operations and Maintenance Model being used again in the *2020 Business Plan* California High-Speed Rail System Operations and Maintenance Model were escalated to June 2019 dollars from June 2017 dollars using the California Consumer Price Index Annual Series – All Urban Consumers. The escalation rate assumed between 2017 and 2019 on an annual basis is approximately 3.5 percent.
4. Fringe rates are applicable to all positions except contracted positions.
5. Fringe rates were extracted from the Brotherhood of Locomotive Engineers and Trainmen document valid for 2019. With the addition of costs for the Federal Employers Liability Act[3], they are as follows:
    - $19,031.88 for the health, vision, dental and retiree health plans
    - 5.50 percent of wage up to $17,787 for Railroad Unemployment Insurance Act benefits
    - 13.1 percent of wage up to $98,700 for Railroad Retirement Tier 2
    - 6.2 percent of wage up to $132,900 for Railroad Retirement Tier 1
    - 7.45 percent of wage with no limit (1.45 percent for Medicare and 6 percent for Federal Employers Liability Act compensation)
6. The model conservatively assumes that the system workload will be filled by an equivalent number of FTEs and that no employee will need to work overtime and be paid at overtime rates. It is acknowledged that this is not the most efficient way to operate and that a private operator can

[3] Brotherhood of Locomotive Engineers and Trainmen. Fringe Benefits 201. Nov. 2016. <https://www.ble-t.org/pdf/Fringe-Benefits-2019.pdf>

improve its labor costs by using overtime for short additional labor needs instead of using higher levels of personnel as currently assumed in the model. Where appropriate, subcontractors were also used for specific tasks.

7. General and administrative personnel are assumed to be an additional 10 percent of the total workforce (including supervisors, managers and engineers). In addition, a contingency of 21 percent was allocated as a buffer, same as in Business Plan 2018.
8. Of the 365 days in the year, employees will be unavailable to work on some days. To calculate the number of staff, every employee was assumed to work 1,794 hours per year. This number of hours takes into account an average of 40 hours per week, as well as holidays, sickness and training.
9. Generally, the time-based calculation applies to non-contract positions.
10. The same number of trains, and therefore the same number of crews, will operate every day. Crews will work a 40-hour workweek. To cover absence times (holiday, sickness, training) it is assumed, that one Full-time Equivalent works 1,794 hours per year.
11. Wages were gathered from existing railroad and transit properties and were provided by different subject matter experts.
12. Compared to the *2018 Business Plan*, the costs for shared facilities (i.e., the Caltrain corridor, Metrolink guideway and others) were calculated to reflect track access charges. In order not to anticipate any assumptions about a track access pricing in California the approach is to use a fee from a railway system, which is characterized by the following characteristics:
    - Openly accessible system for every provider
    - Non-discriminatory access to the infrastructure to all possible operators
    - Management of prices is supervised by a higher authority
    - Transparency with regard to pricing system and processes[4]

To meet these specifications, the established system in Germany with its transparent pricing appears suitable for these purposes. In the relevant sections only a speed up to 110 mph is possible due to the mixed traffic with slower regional trains of Caltrain respectively Metrolink. Therefore, a rate of 5.23 Euro per kilometer is assumed that is valid on Regional speed sections for Highspeed Rail.

The following categorization of stations is used in the *2020 Business Plan*; although, in certain cases, this categorization may deviate.

a. Level A – Final system terminal stations:
    - Silicon Valley to Central Valley: Not applicable
    - Phase 1: Los Angeles Union Station, San Francisco Transbay Center
b. Level B – Interim terminal stations or major stations
    - Silicon Valley to Central Valley: San Francisco 4th & King, Bakersfield, Fresno, Merced, San Jose
    - Phase 1: Anaheim, Bakersfield, Burbank, Fresno, Merced, San Jose
c. Level C – Intermediate and smaller stations
    - All other stations

[4] https://fahrweg.dbnetze.com/resource/blob/2080364/e90531f8dc75aecd2007d9c3875fef50/track_access_charges_2019-data.pdf

5 TRAIN OPERATIONS COST

The Train Operations portion of the model consists of personnel, electrical and other costs directly involved in the operation of the trainsets.

5.1 Related Personnel

For the purpose of the Operations and Maintenance model, personnel in the calculation of the train operations cost are considered to be on-board train crews consisting of train engineers, conductors and assistant conductors. On-board service attendants, with possible functions like customer service or on-board service, are not considered.

Additionally, the protect trains are crewed with train engineers, conductors and assistant conductors.

Road managers function as supervisors, are in charge of the quality of daily train operations and supervise the train personnel.

5.2 Assumptions and Model Inputs

5.2.1 Primary Drivers

The main driver to optimize the use of the existing workforce is matching personnel shifts with train shifts—throughout all timetabling and personnel and asset planning processes. The employees' working time should be used in the best possible manner. The main assumption is a yearly availability of 1,794 hours for all operational personnel. The total time of train operations in hours divided by the individual working time per each position—moderated by a certain percentage of inefficiency of matching employees' and trains' shifts—results in the number of required employees.

All federal, state and other relevant guidelines will be taken into account.

5.2.2 General Assumptions

The following specific assumptions have been made:

1. On-board service personnel are not considered in the headcount. For example, one to two on-board service attendants per train offer on-board refreshment services from coffee carts and in restaurant cars. These on-board services may be outsourced to a subsidiary of the Train Operating Company (TOC) or to a third party. In both cases, the outsourced entity would benefit from a steady stream of clients and the marketing efforts of the TOC.
2. All trainsets are considered to be single trainsets. No double trainsets are taken into account.
3. It is intended that—whenever possible—train crews start and finish at the same location, i.e., the same stabling yards located at the Heavy Maintenance Facility (HMF) or at the Light Maintenance Facility/ies (LMF) or the station platform near the HMF or the LMF, in particular, when a regular crew change takes place during the day. In the latter case, or when the timetable or operational reasons require to deviate from the general rule "start point = end point," the minibuses will help reduce the inconvenience to train crews.
4. Road managers constitute the hierarchic level between the operational train personnel and the train operations director and represent a professional profile which includes several supervisory functions (such as road foreman[5]). This key position represents onsite leadership, communicates between staff levels above and below and takes on overall responsibility for the operational

[5] In charge of supervising the engineers

quality of daily train services, the disposition of traincrews as well as the operational emergency management.

5.2.3 Personnel Headcount

The following on-board personnel are assumed for each type of crew:

- For a **single-consist trainset**: one train engineer, one conductor, two assistant conductors (Table 4).
- **Protect train:** one train engineer, one conductor and one assistant conductor (Table 5). These trains are manned during commercial service hours.
- The number of **road managers** depends on the number of personnel to be supervised and the complexity of the train operations in the respective track section (Table 6). Note that the first road manager, as an intermediate level between road manager and train operations director, is not considered in the following calculation:
    - **Supervision of up to 100 employees**: The number of road managers increases proportionally, comprising 10 percent of the employees. In this range, the workload of the road manager is considered to be 50 percent leadership/supervision and 50 percent administration.
    - **Supervision of 100 or more employees:** The efforts for administration increase proportionally at 50 percent for leadership/supervision, but only at 25 percent for administration, as administrative synergies will become more effective. This leads to a road manager's quota of 7.5 percent starting with the 101st employee.

The following tables summarize the information discussed above for each type of on-board crew member.

Table 4 Headcount[6] per Single Trainset in Commercial Service Including Empty Trips

Position	Silicon Valley to Central Valley	Phase 1
Number of Trainsets to Cover the Service Plan	17	66
Train Engineers	17 trains × [1 Position ø13.4hrs[7] ≈ 2.7 FTE] x 1.15 = 53 FTE	66 trains × [1 Position ø12.8hrs ≈ 2.6 FTE] x 1.15 = 197 FTE
Conductor	17 trains × [1 Position ø13.4hrs ≈ 2.7 FTE] x 1.15 = 53 FTE	66 trains × [1 Position ø12.8hrs ≈ 2.6 FTE] x 1.15 = 197 FTE
Assistant Conductor (2 per train)	17 trains × [2 Positions ø13.4hrs ≈ 5.4 FTE] x 1.15 = 107 FTE	66 trains × [2 Position ø12.8hrs ≈ 2.6 FTE] x 1.15 = 394 FTE
Total	**213**	**788**

[6] 15% mark-up factor for inevitable inefficiencies in crew shift planning of commercial trains.

[7] The percentage is equivalent to the average service hours of one trainset.

Table 5 Headcount per Protect Train, Crewed During Commercial Service Hours

Position	Silicon Valley to Central Valley	Phase 1
Number of Protect Trainsets During Commercial Service Hours*	2	6
Train Engineers	2 trains × [1 Position ø18 hrs ≈ 3.7 FTE] = 7.4 FTE	6 trains × [1 Position ø18 hrs ≈ 3.7 FTE] = 22.2 FTE
Conductor	2 trains × [1 Position ø18 hrs ≈ 3.7 FTE] = 7.4 FTE	6 trains × [1 Position ø18 hrs ≈ 3.7 FTE] = 22.2 FTE
Assistant Conductor (1 per train)	2 trains × [1 Position ø18 hrs ≈ 3.7 FTE] = 7.4 FTE	6 trains × [1 Position ø18 hrs ≈ 3.7 FTE] = 22.2 FTE
Total	**22**	**67**

*The staffing for the Protect trains is a conservative approach, with the maximum number of people required. Due to the flexibility between Protect trains and maintenance trains—and more trains in maintenance, the number could also be lower.

Table 6 Headcount for Management Train Operations

Position	Silicon Valley to Central Valley	Phase 1
Train Operations Director	1 position 8 hours	1 position 8 hours
Road Manager	26	69
Total	**27**	**70**

5.3 Energy Costs for Traction Power

Energy costs are based on the usage of energy for the movement of trains. The Authority has committed to using 100 percent renewable energy, so energy unit costs are based on the cost of renewables.

5.3.1 Energy Cost Calculation

For the determination of the traction power consumption, the following parameters are used:

- The unit cost of the industrial “E-20” tariff of PG&E, the utility with the widest distribution along the California High-Speed Rail tracks.
- The calculative average power consumption per mile of an eight-car high-speed trainset with 130 persons on board.
- The mileage of all trainsets in operation per day multiplied respectively per year.

To determine the average power consumption (kwh per mile) of the trainsets, extensive consumption studies under different conditions have been undertaken. Energetic recoveries during train deceleration into the network will not be reimbursed by PG&E.

5.3.2 Energy Usage

Energy usage is based on the following:

- The preliminary timetable concepts for the different stopping patterns with a total yearly mileage, including deadhead miles, of 7,683,615 miles in Silicon Valley to Central Valley and 29,940,950 miles in Phase 1.

- The calculative and experience-based traction power consumption of approximately 37 kWh per trainset mile (with 130 persons on board).

Conservative annual estimates of energy usage were calculated to total:

- 305 GWh for Silicon Valley to Central Valley with 17 trainsets being operational
- 1,184 GWh for Phase 1 with 66 trains being operational

5.4 Equipment, Other Costs

Each member of the on-board crew will require a uniform. The uniform allowance is based on the uniform costs from the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 and escalated to 2019 dollars.[8] Uniform costs are estimated at $326 per employee per year.

Mainly the road managers will require a small number of Non-Rail Vehicles, particularly when rail service is not an option, to be flexible in the fulfilment of their tasks as supervisors, quality assurers and incident responders.

The vehicle fleet will consist of the following types:

- 4WD Ext. Cab Pick Up/Sport Utility Vehicle (SUV):
  - 15 (Silicon Valley to Central Valley)
  - 40 (Phase 1)
- Minibus (for crew transport):
  - 2 (Silicon Valley to Central Valley)
  - 2 (Phase 1)

The vehicles are located in the HMF and LMF(s), or temporarily wherever needed for the task to be fulfilled.

The road manager will incur office supply costs, which are assumed to be $457 per year per employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013–2014 (escalated to 2019 dollars). Cell phones are assumed for every employee with an estimated allowance of $756 per year per employee based on the U.S. General Services Administration Cost Per Person Model (escalated to 2019 dollars).[9] In addition, the Global System for Mobile Communications-Railway (GSM-R) is assumed with a similar cost level as for cell phones. The assumption is that there is one GSM-R device per trainset.

By the use of minibuses, it is assumed that no travel expenses will arise.

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[8] SFMTA. SFMTA Operating Budget for FY 2013-2014. October 14, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>

[9] U.S. General Services Administration. Cost Per Person Model V2.0. October 14, 2013. <http://www.gsa.gov/portal/content/105134>

6 DISPATCHING AND CONTROL COSTS

The Dispatching and Control portion of the Operations and Maintenance model consists of the personnel and costs directly related to directing and controlling train operations, which includes the Planning Department.

6.1 Related Personnel

Dispatching personnel for train operations, including control of the Supervisory Control and Data Acquisition for the Overhead Catenary Line, located in the Operations Control Center (OCC) at the Heavy Maintenance Facility (HMF) or at stabling yard interlocking units in the HMF and the Light Maintenance Facility/ies (LMF) is clearly separated from other control personnel dealing with maintenance-related duties and therefore being allocated to the respective maintenance chapters herein.

6.2 Assumptions and Model Inputs

6.2.1 Primary Drivers

A high degree of automation and reliability in the transfer of control commands, both electronic or digital interlocking systems, allow for long main line distances to be dispatched from one OCC, which will most likely be located in the HMF/main stabling yard area.

The two (Silicon Valley to Central Valley) and three (Phase 1) stabling yards, situated at the HMF and the LMF(s), however, will be dispatched independently from the main line. The local interlocking units installed do not dispose of full signal protection of the turnouts. The depot dispatchers' workplaces will be located near to the yard and shunting tracks.

Infrastructure maintenance facilities, hosting the yellow plant, do not dispose of internal interlocking systems. Their access to the mainline will be dispatched from the OCC.

6.2.2 General Assumptions

The OCC will be run all day in three shifts, the stabling yard interlocking units in two to three shifts (LMF) or three shifts (HMF), according to the needs of the train movements.

Blended services: With the Authority's services reaching San Francisco during the Silicon Valley to Central Valley phase and therefore using Caltrain's tracks between San Jose (CP Lick) and San Francisco, it would be beneficial to have a presence in Caltrain's OCC located in Menlo Park. This would promote good communication and cooperation between the parties and represent the Authority's interests regarding Caltrain's dispatching decisions. Dispatching rules such as how train movements are prioritized must be agreed on and documented between the railroad organizations.

6.2.3 Personnel Headcount

Trains are being dispatched:

- On the mainline, controlled by the line dispatchers of the OCC; and
- In the stabling yards, controlled by the depot dispatchers locally situated in HMF and LMFs.

Furthermore, regular and construction timetables have to be created in the Planning Department for high-speed trains and for intermodal exchange between high-speed trains and other transportation providers, such as conventional trains or buses, to create seamless transportation chains. Operational data will be aggregated and evaluated by the performance and data manager as to identify the need for improvement and increase efficiency.

Table 7 shows the staffing for the OCC and the Planning Department under different system phases.

Table 7 Operations Control Center and Planning Headcount by System Phase

Position	Silicon Valley to Central Valley	Phase 1
Operation Control Director[10]	1 position 8 hrs = 1 FTE	1 position 8 hrs = 1 FTE
Chief Line Dispatcher[11]	[1 position 24 hrs ≈ 4.9 FTE] = 5 FTE	[1 position 24 hrs ≈ 4.9 FTE] = 5 FTE
Line Dispatcher[12]	[2 positions 24 hrs ≈ 9.8 FTE] = 10 FTE	[3 positions 24 hrs ≈ 14.6 FTE] = 15 FTE
Depot Dispatcher, One Yard Master	[2 × 2 positions 24 hrs ≈ 19.5 FTE] = 20 FTE	[3 × 2 positions 24 hrs ≈ 29.3 FTE] = 30 FTE
Information Controller	[1 position 18 hrs ≈ 3.7 FTE] = 4 FTE	[1 position 18 hrs ≈ 3.7 FTE] = 4 FTE
Planning Director[10]	1 position 8 hrs = 1 FTE	1 position 8 hrs = 1 FTE
Scheduler (regular/construction)[10]	1 position 8 hrs = 1 FTE	2 position 8 hrs = 2 FTE
Performance and Data Manager[10]	1 position 8 hrs = 1 FTE	1 position 8 hrs = 1 FTE
Total	**43**	**59**

6.3 Equipment, Other Costs

The dispatching department will require 2 non-revenue vehicles at the OCC for supervisors to respond to incidents and get between locations on occasions when rail service is not an option. The purchase price of $40,000 for the vehicles is assumed to be lease-based and includes insurance, maintenance and fuel costs.

All dispatch personnel will incur office supply costs and will require cell phones. The office supplies are assumed to be $457 per year per dispatch employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013–2014 (escalated to 2019 dollars). The cell phone allowance is estimated at $756 per year based on the U.S. General Services Administration Cost Per Person Model (escalated to 2019 dollars). [13] In addition, GSM-R and landline communication is assumed with a similar cost level as for cell phones. The assumption is, that there is one GSM-R and landline device per workstation.

[10] These positions do not work in shifts.

[11] In the function of "Deputy Director Operation Control"

[12] Train Dispatcher

[13] U.S. General Services Administration. Cost Per Person Model V2.0. 14 October, 2013. <http://www.gsa.gov/portal/content/105134>

7 MAINTENANCE OF ROLLING STOCK COSTS

The Maintenance of Rolling Stock portion of the model consists of personnel and other costs required for maintaining trains. The model assumes a warranty period for major work that will be handled by the rolling stock manufacturer of three years (with two of those years before revenue train operations start).

7.1 Related Personnel

Personnel in the rolling stock maintenance department are divided into the following categories:

1. Technicians (Mechanical and Electrical)
2. Supervisors
3. Laborers
4. Storehouse Employees

7.2 Assumptions and Model Inputs

7.2.1 Inspections

1. Regulatory inspections are guided by the Code of Federal Regulations and the Federal Railroad Administration. The Authority is currently discussing the use of new train inspection technologies with federal stakeholders; however, pending any future changes in federal guidance, the following rolling stock assumptions have been utilized in the *2020 Business Plan*.
2. Each maintenance facility will perform regulatory inspections and testing at the required intervals to maintain FRA compliance. Additionally, the manufacturer's recommended tasks, cleaning and servicing of trainset facilities and Rolling Stock will take place.
3. Staffing at each facility will be based on the number of trainsets being serviced at the facilities as established in the Key Metrics for Service Specification starting location requirements, the frequency of the required inspection and testing, and the effort needed to perform each task. Assumptions are based on current state of the art technologies and regulations with the likelihood that advances in inspection and testing techniques as well as changes to regulations will occur prior to implementation. The number of staff in Table 8 on the next page is assumed for each facility.
4. Assumptions for occurrence of inspections:
    - Daily, 321 inspections per year per trainset
    - Monthly, 12 inspections per year per trainset
    - 92 days, 4 inspections per year per trainset
5. Material costs for these inspections (escalated to 2019 dollars):[14]
    - Daily, $272 per inspection
    - Monthly, $2,594 per inspection
    - 92 days, $5,000 per inspection

[14] Costs based on the Taiwan High-Speed Rail Corporation Model of Maintenance Practices.

6. Corrective maintenance consists of identifying a defect, determining the root cause, taking corrective action and preventive measures. Corrective maintenance is performed in response to defects:
    - Identified during inspections and servicing by maintenance personnel;
    - Reported in service by operating crews; and
    - Transmitted through the rolling stock onboard health monitoring systems.

It is assumed corrective maintenance will be performed once a year per trainset at a material costs of $160,838.

Wheel truing may occur as part of the Rolling Stock Maintenance Plan when the wheel profile is measured during scheduled maintenance intervals by precision equipment and is found to be out of the tolerances of the optimal wheel profile. Wheel truing will take place when conditions of a wheel approach the recommended defect limits of the Rolling Stock Maintenance Plan and prior to reaching FRA condition limits. The depth of the cut to renew the profile drives the number of times that a wheel can be reprofiled and contributes to its life span. Wheel truing is assumed to occur every 300,000 miles at material costs of $100 per service.

Table 8 Maintenance Facility Periodic Inspection Staffing

Inspection Staffing	Silicon Valley to Central Valley	Phase 1
HMF	• 7 Supervisors • 31 Technicians • 3 Laborers • 4 Storehouse Employees	• 8 Supervisors • 55 Technicians • 6 Laborers • 6 Storehouse Employees
Bay Area	• 7 Supervisors • 16 Technicians • 3 Laborers • 4 Storehouse Employees	• 8 Supervisors • 50 Technicians • 6 Laborers • 6 Storehouse Employees
Los Angeles Area	N/A	• 8 Supervisors • 66 Technicians • 6 Laborers • 6 Storehouse Employees

7.2.2 Overhauls

1. Bogie inspection and overhauls as well as general inspections and overhauls are driven by the mileage of the trainsets. Bogie inspection and overhauls are performed at 600,000-mile intervals and general inspections and overhauls are performed at 1,200,000 mile intervals.
2. With the projected annual miles per trainset of 384,181 for Silicon Valley to Central Valley and 415,847 for Phase 1 service, the corresponding scheduling for both operating periods would cycle at approximately 18 months for the bogie inspection and overhaul, and 36 months for the general inspection and overhaul. Additionally, it is assumed that any FRA-required brake overhauls will be included in the general overhaul and that wheel changeouts will also coincide with the general overhaul schedule.

3. Overhauls take place at the HMF, and with the projected frequencies it is critical that the HMF is designed and equipped to support a workload of frequent and numerous overhauls of trainsets including the removal, replacement and renewal of bogies and other undercar equipment, roof-mounted equipment such as HVAC units and pantographs, and doors as well as other interior and exterior systems and appointments. Additionally, capital spares of bogies, brake components, HVAC units and other systems or components must be sufficient to provide an adequate float of materials to support the overhauls by allowing renewed Rolling Stock to be swapped out with removed equipment, rather than removing, overhauling and reinstalling. This approach reduces out-of-service time and facility resource bottlenecks.
4. To establish the beginning overhaul cycles that meet the requirements of the overhaul mileage intervals, overhauls will need to be started early for the first cycle. It is too early at this point to determine the exact starting point, but it can be expected that the initial cycle would begin somewhere in the range of 350,000 to 450,000 miles. This ramp up would require overhaul staff hiring to begin prior to allow for training.
5. Wheel changeout: Although it is difficult to provide an accurate projection of wheel wear patterns until dynamic testing is performed on the high-speed rail system with the actual trainsets, it is assumed for this cost model that the high-speed train rail-to-wheel interfaces will provide a range of 1,200,000 miles before approaching their condemning limit and requiring changeout.
6. The additional staffing required to support the overhaul works appears in Table 9 on the next page.
7. Trainsets are anticipated to be delivered with pre-installed wireless internet/Wi-Fi equipment. Maintenance for this equipment will take place during the overhaul process and is included in the existing cost of trainset overhauls. Connection charges for this equipment are estimated to be $5,129 per trainset per year based on operational data from the Northern Indiana Commuter Transportation District.
8. Materials for overhauls include:
    - Bogie/truck inspections cost $147,726 per inspection (escalated to 2019 dollars)[15]
    - Overhaul general inspections cost $1,023,617 per inspection (escalated to 2019 dollars)[16]
    - Wheel change outs cost $174,480 per trainset (escalated to 2019 dollars)[17]
9. It was assumed that the Authority's maintenance facilities are water consumption neutral, due to rain harvesting and gray water recycling technologies. Thus, train maintenance water consumption is reflected in the Operations and Maintenance Cost Model's Maintenance of Rolling Stock cost forecasts.

[15] Costs based on the Taiwan High-Speed Rail Corporation overhaul records

[16] Ibid.

[17] Ibid.

Table 9 Maintenance Facility Periodic Overhaul Staffing

Overhaul Staffing	Silicon Valley to Central Valley	Phase 1
Bogie Inspection and Overhaul	• 2 Supervisors • 17 Technicians • 1 Laborer • 2 Storehouse Employees	• 8 Supervisors • 60 Technicians • 6 Laborers • 6 Storehouse Employees
General Inspection and Overhaul	• 2 Supervisors • 10 Technicians • 1 Laborer • 1 Storehouse Employee	• 4 Supervisors • 34 Technicians • 2 Laborers • 2 Storehouse Employees

7.3 Utilities

7.3.1 Energy Usage

Maintenance facility energy usage is estimated at 27 kWh per square foot based on the average of Santa Clara Valley Transportation Authority's Guadalupe Facility (25 kWh per square foot) and Utah Transit Authority's Jordan River Facility (29 kWh per square foot).[18] Energy unit cost for maintenance facilities is assumed to be the same as presented in Section 3.5, though facilities will be supported by local service providers.

7.3.2 Water and Sewer

Maintenance facility water and sewer costs are estimated at $0.205 per year per square foot and $0.182 per year per square foot, respectively. These are based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013–2014 (escalated to 2019 dollars).[19]

7.3.3 Facility Size

The number and level of maintenance facilities planned for the system drive some of the Maintenance of Rolling Stock staffing needs. The size of these facilities also drives their energy usage. The levels of maintenance facilities explain the set of functions that they can perform. Typically, a facility will be able to perform functions up to a certain level (including all lower-level functions). The functions are described as follows.[20]

1. Level 1: In-Service Monitoring
2. Level 2: Examination
3. Level 3: Periodic Inspections
4. Level 4: Overhauls
5. Level 5: Modifications and Major Repair

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[18] VTA Guadalupe Facility energy consumption provided by VTA on 26 Nov. 2012. UTA Jordan River Facility energy consumption provided by UTA on 27 Nov. 2012.

[19] SFMTA. *SFMTA Operating Budget for FY 2013-2014*. 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>

[20] *Concept of Operations*. California High-Speed Train Project. May 4th, 2012.

The facilities planned at each stage of the program are as follows.

Table 10 Maintenance Facilities and Levels by Phase

Facility	Silicon Valley to Central Valley	Phase 1
Level 5: HMF	On	On
Level 3: Los Angeles Area	Off	On
Level 3: Bay Area	On	On

The facilities have the following buildings and sizes, which are used to calculate the approximate energy consumption for these facilities.

Table 11 Heavy Maintenance Facility Buildings and Sizes

Heavy Maintenance Facility Building Function	Size (square feet)
Support & Administration Building	283,800
Maintenance Building	101,900
Wheel True Building	54,600
MOW Building	40,050
Car Wash Building	58,200
Paint & Body Shop Building	54,600
Service & Inspection Building	134,650
Total (square feet)	**727,800**

Table 12 Light Maintenance Facility Buildings and Sizes

Light Maintenance Facility Building Function	Bay Area Size (square feet)	LA Area Size (square feet)
Support & Administration Building	127,960	127,960
Maintenance Building	45,935	45,935
Wheel True Building	24,610	24,610
MOW Building	18,050	18,050
Car Wash Building	26,250	26,250
Service & Inspection Building	60,700	60,700
Total (square feet)	**303,505**	**303,505**

Note: Facility sizes are preliminary and subject to change.

7.4 Equipment, Other Costs

Each member of the Maintenance of Rolling Stock staff will require a **uniform**. The uniform allowance is based on the uniform costs from the San Francisco Municipal Transportation Agency Operating Budget

for FY 2013–2014 (escalated to 2019 dollars).[21] Uniform costs are estimated at $326 per employee per year.

Maintenance of Rolling Stock personnel will require a small number of **non-rail vehicles** to move people and materials between various locations in the facilities and between facilities. The vehicle fleet will consist of 1 car for each maintenance facility. The vehicles are priced based on a rate of $19,024 per car per year, which includes a lease rate and fuel, maintenance and insurance costs. (escalated to 2019 dollars). Additionally, there will be two stake body trucks at the HMF. The stake body trucks are priced with a rate of $31,637, which includes lease rate, maintenance, fuel and insurance costs (escalated to 2019 dollars). The Operations and Maintenance model includes a conservative allocated contingency rate of 25 percent placed on leased vehicles to account for other acquisition models which may be utilized by the eventual operator.

Consistent with the Maintenance of Infrastructure assumptions below**, tools** and other consumables are assumed to be 5 percent of the total labor cost.

Supervisors will incur **office supply** costs and will require **cell phones**. The office supplies are assumed to be $457 per year per supervisor based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013–2014 (escalated to 2019 dollars).[22] The cell phone allowance is estimated at $756 per year per supervisor based on the U.S. General Services Administration Cost Per Person Model (escalated to 2019 dollars).[23]

Maintenance of Rolling Stock facilities will require some Information Technology/software functionality. Based on the General Services Administration (GSA) per person cost model (escalated to 2019 dollars), the Information Technology costs are estimated at $5,816 per user profile. It is assumed that at each maintenance facility supervisors, storehouse employees and inspections technicians have a user profile. In addition, an allocated contingency rate of 18 percent was assumed to account for additional specialty systems which may be implemented by the eventual operator.

One of the many anticipated amenities to be offered on-board California High-Speed Rail System trains is wireless internet (Wi-Fi) service. A module was built into the Operations and Maintenance Cost Model to account for Wi-Fi service and connectivity costs. The following assumptions are behind the Wi-Fi forecasts:

1. The cost of maintaining Wi-Fi equipment is included in the recurring trainset Maintenance of Rolling Stock overhaul costs.
2. Wi-Fi equipment will be pre-installed in the frame of each trainset delivered.
3. Wi-Fi will be a free amenity offered to California High-Speed Rail passengers.
4. The monthly cost of Wi-Fi service per train car is approximately $53.42 (2019 dollars). This estimate is based on Internet connection charges the Northern Indiana Commuter Transportation

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[21] SFMTA. *SFMTA Operating Budget for FY 2013–2014*. 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf.>

[22] SFMTA. *SFMTA Operating Budget for FY 2013–2014*. 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf.>

[23] U.S. General Services Administration. *Cost Per Person Model V2.0*. 14 October, 2013. <http://www.gsa.gov/portal/content/105134>

District has paid for in a trial of Wi-Fi service on its commuter rail line between Chicago Millennium Station and South Bend International Airport.[24]

5. Each California High-Speed Rail trainset would include eight train cars, all with active Wi-Fi equipment that incurs the monthly Wi-Fi service charge. Therefore, the annual Wi-Fi charge per trainset is $5,129.
6. Wi-Fi service is categorized as a Maintenance of Rolling Stock expense in the Operations and Maintenance model. As with other Maintenance of Rolling Stock trainset expenditures, an allocated contingency rate of 23 percent is applied on top of annual Wi-Fi expenditures. Please see Section 14.2 for more information on allocated contingency rates.

7.5 Cost Rationalization for Bogie Inspection and Overhaul General Inspections

The average number of miles travelled by each trainset is assumed to be the total trainset miles for that year divided by the number of trainsets in the fleet at that time. However, if each trainset's actual usage is assumed to be the system-wide average, then the bogie inspection and overhaul general inspection costs would have very large swings between years, as each batch of trainsets all get the work done together. This would be an unrealistic scenario, as actual operating practice would plan the overhauls and operations in a way that would have roughly the same amount of work to be done each year by running some trainsets more than others.

At this time, it would be impractical to attempt to plan the Rolling Stock manipulation to this level of detail. Instead, the model assumes that the operations will successfully rationalize the bogie inspection and overhaul general inspection schedules. The model uses a seven-year rolling average for all but the first and last three years of the model after the end of the warranty period.

For the first three years, the model calculates the total expected expenditure in the first half of the model timeframe and compares it to the costs not included in the rolling averages. The difference is then allocated to the first three years, assuming a ramp-up with 1/6 of the difference in the first year, 1/3 in the second year and 1/2 in the third year. For the last three years of the model, the difference between the total expenditure and the rolling average total is split evenly between the last three years.

This method creates a more accurate and realistic cost profile while maintaining the total costs over the model's estimating period. However, this method does result in Maintenance of Rolling Stock costs varying year to year as a result of the trainset delivery schedule for the project, with each group of trains introduced into revenue service subject to inspection work at set cycles over the modeling period. However, this variance (with peaks and troughs) is mitigated with the cost rationalization methodology applied to Maintenance of Rolling Stock costs in the model. For a simplified example of how the rationalization is applied, see Appendix D Maintenance of Rolling Stock Cost Rationalization Example.

[24] "Wi-Fi being tested on some South Shore Trains." The Times of Northwest Indiana. 27 August 2015. <http://www.nwitimes.com/business/local/wi-fi-being-tested-on-some-south-shore-train-cars/article_59cd5a45-49a6-5919-8c15-b30f66ae038b.htm>l

8 MAINTENANCE OF INFRASTRUCTURE

The Maintenance of Infrastructure portion of the model includes the personnel, materials, tools and equipment required to maintain the tracks, systems, structures and facilities. It is assumed that most Maintenance of Infrastructure activities will occur during one tour at night and that daytime Maintenance of Infrastructure staffing will respond to incidents.

8.1 Related Operating Personnel

Personnel for the Maintenance of Infrastructure are divided into the following units:

1. Track and Systems
2. Structures
3. Facilities (stations and rolling stock maintenance facilities)

8.2 Assumptions and Model Inputs

8.2.1 Duties and Responsibilities of Maintenance of Infrastructure Units

The description and duties and responsibilities of the Maintenance of Infrastructure units are as follows:

1. **Track and Systems**—This group is responsible for performing all preventative and corrective maintenance activities required for Track, Signal, Communications, Overhead Catenary System and Electric Traction.
2. **Structures**—This group is responsible for all preventative and corrective maintenance activities required for civil structures including bridges, tunnels, culverts, drainage systems, etc.
3. **Facilities**—This group is responsible for all train maintenance facilities (HMF and LMFs), Maintenance of Way (MOW) facilities and train stations. This encompasses all aspects including but not limited to janitorial services, lighting, HVAC, plumbing and roadways.

8.2.2 Pricing Assumptions

The maintenance staffing is based on a series of assumptions. These assumptions may impact the estimate if they change as the design and construction periods progress.

8.2.2.1 Operations

The Revenue Service Period will be 18 hours per day from 6 a.m. to 12 a.m. The Maintenance Period or Non-Revenue Service Period will be 6 hours per day from 12 a.m. to 6 a.m. These periods will remain the same every day for the entire year.

8.2.2.2 Maintenance

Systems personnel will handle both train control and communications systems with single personnel. There will not be separate train control and communications personnel. During revenue hours, personnel will only respond to incidents, and repairs will happen after the revenue service period has ended for the day unless all train traffic has been stopped.

- Visual track inspections will not be required. A track geometry system will be installed on a revenue service train.
- A mechanic will be assigned to each track crew during the non-revenue hours.
- Employees will work a minimum of 8 hours per day.
- Major rehabilitation work has not been included.
- Support for adjacent and/or third-party work requiring protection from the Overhead Catenary System (OCS) and/or Track has not been included.

- There will be access to the right of way from adjacent roadways.
- Welders will work in two-person crews.

8.2.2.3 Assets—Silicon Valley to Central Valley

- All track is direct fixation.
- Fencing will be installed on both sides of the track for the entire distance.
- Approximate track miles are 570 for CP Lick to Bakersfield.
- There will be two MOW facilities plus the HMF for a total of three maintenance bases.
- MOW facilities will have track connections and sidings for storage of equipment and accessing the mainline. The MOW facilities will be located near mainline crossovers to allow access to both mainlines.
- The stations to be maintained are Gilroy, Merced, Madera*, Fresno, Kings-Tulare and Bakersfield. Square footages to be maintained are based on the following table.

Table 13 Silicon Valley to Central Valley Station Areas to Be Maintained

Station Name	Track Side Square Feet	Land Side Square Feet	Total Facility Area
Gilroy	88,648	65,421	154,069
Merced	41,924	49,076	91,000
Madera*	59,124	0	59,124
Fresno	41,924	53,834	95,758
Kings/Tulare	41,924	0	41,924
Bakersfield	41,924	38,740	80,664

*Environmentally cleared and funded by others.

- Approximately 15 percent of the track will be built on structures, in a trench or a tunnel.
- There will be WiFi along the entire system.
- The signal system will include Positive Train Control (PTC) and Automatic Train Operation (ATO).
- The track alignment does not include any tight curves that will require more frequent rail replacement.
- Traction power substations and communications and signal houses will be place at regular intervals along the alignment.
- Communications and Signal houses will be combined.
- HMF and LMF in the San Francisco area will be operational.

8.2.2.4 Assets—Phase 1

- All track is direct fixation.
- Fencing will be installed on both sides of the track for the entire distance.
- Approximate track miles are 810 for CP Lick to Burbank.
- There will be three MOW facilities plus the HMF for a total of four maintenance bases.
- MOW facilities will have track connections and sidings for storage of equipment and accessing the mainline. The MOW facilities will be located near mainline crossovers to allow access to both mainlines.
- The stations to be maintained are Gilroy, Merced, Madera*, Fresno, Kings-Tulare, Bakersfield, Palmdale and Burbank. Square footages to be maintained are based on the following table.

Table 14 Phase 1 Station Areas to Be Maintained

Station Name	Track Side Square Feet	Land Side Square Feet	Total Facility Area
Gilroy	88,648	65,421	154,069
Merced	41,924	49,076	91,000
Madera*	59,124	0	59,124
Fresno	41,924	53,834	95,758
Kings/Tulare	41,924	0	41,924
Bakersfield	41,924	38,740	80,664
Palmdale	41,924	43,482	85,406
Burbank	41,924	43,007	84,931

*Environmentally cleared and funded by others.

- Approximately 15 percent of the track will be built on structures, in a trench or a tunnel.
- There will be WiFi along the entire system.
- The signal system will include PTC and ATO.
- The track alignment does not include any tight curves that will require more frequent rail replacement.
- Traction power substations and communications and signal houses will be place at regular intervals along the alignment.
- Communications and Signal houses will be combined.
- HMF and LMF in the San Francisco area and the Los Angeles area will be operational.

8.2.3 Personnel Headcount

The following personnel are required. All full-time equivalent positions are based on 1,794 hours of work to account for 10 holidays, 15 days of vacation on average, 6 sick/personal days, and 4.75 days of training. The staffing calculations for Silicon Valley to Central Valley and Phase 1 follow the following principles:

Revenue Service Period staffing calculations: Staffing levels during the Revenue Service Period were established to provide for 1 to 1.5 hours of response time to an incident.

Maintenance Period staffing calculations: The following staffing levels are based on the performance of required preventative maintenance tasks and availability to perform corrective maintenance tasks as necessary. Personnel were dispersed through the three (Silicon Valley to Central Valley) and four (Phase 1) maintenance bases to reduce travel time due to limited maintenance time.

Table 15 Silicon Valley to Central Valley Full-time Personnel

Position	Division	Total	Revenue Hours	Non-Revenue Hours	Overtime %*
Chief Engineer	Engineering	1	1		
Deputy Chief Engineer	Engineering	1	1		
Administrative Assistant	Engineering	2	2		
Stores Manager	Track & Systems	1	1		
Stores Clerk	Track & Systems	1	1		
Stores Handling	Track & Systems	3	1	2	
Procurement Specialist	Track & Systems	1	1		
Track Manager	Track & Systems	2	1	1	
Track Engineer	Track & Systems	2	2		
Track Supervisor	Track & Systems	3	1	2	
Track Inspector/Foreman	Track & Systems	13	8	5	15%
Track Laborer	Track & Systems	10		10	15%
Equipment Operator	Track & Systems	12	2	10	15%
Welder	Track & Systems	6		6	15%
Mechanic	Track & Systems	8	3	5	15%
Systems Manager	Track & Systems	2	1	1	
Systems Inspector	Track & Systems	8	4	4	15%
Systems Tech.	Track & Systems	26	11	15	15%
Systems Tech. (San Jose to Gilroy Monday-Friday)	Track & Systems	6	6	0	15%
Systems Tech. (San Jose to Gilroy Weekends)	Track & Systems	2	2	0	15%
Systems Engineer	Track & Systems	8	4	4	
Power/OCS Manager	Track & Systems	2	1	1	
OCS Supervisor	Track & Systems	2		2	
Power/OCS Inspector/Foreman	Track & Systems	5		5	15%
Power Techs	Track & Systems	10		10	
OCS Tech.	Track & Systems	21	11	10	15%
OCS Tech. (CDL License)	Track & Systems	5		5	15%
Structures Manager	Structures	1	1		
Structures Engineer	Structures	2	1	1	
Bridge Inspector	Structures	4		4	
Structures Foreman	Structures	3		3	15%

Position	Division	Total	Revenue Hours	Non-Revenue Hours	Overtime %*
Structures Laborer	Structures	5		5	15%
Facilities Manager	Facilities	1	1		
Asst. Facility Manager	Facilities	2	1	1	
Facilities Foreman (HMF & LMF)	Facilities	6	4	2	15%
Facilities Technician (HMF & LMF)	Facilities	7	4	3	15%
Facilities Foreman (Stations)	Facilities	9	9		15%
Facilities Technician (Stations)	Facilities	9	9		15%
Train Engineer		1			
Train Conductor		1			
Total		214			

*Overtime translated into 35 FTE in the O&M calculation.

8.2.3.1 Silicon Valley to Central Valley Staffing Calculations During the Revenue Service Period

The staffing of certain positions is based on the following calculations:

- Track and Systems
  - Track Inspector
    - 1 person x 18 hours x 365 days X 2 maintenance bases
    - This provides approximately 1.5 hours of response time to an incident.
    - 13,140
    - 8 FTEs
  - Systems Maintainer
    - 1 person x 18 hours x 365 days X 3 maintenance bases
    - This provides for approximately 1 hour of response time to an incident.
    - 19,710 hours
    - 11 FTEs
  - Systems Inspectors
    - 1 per 4 Systems Maintainers
    - 4 FTEs
  - OCS Technician
    - 1 person x 18 hours x 365 days X 3 bases
    - This provides for approximately 1 hour of response time to an incident.
    - 19,710 hours
    - 11 FTEs
- Structures
  - No hourly personnel during revenue service period.
- Facilities
  - Heavy Maintenance Facility
    - Facilities Foreman
      - 1 person x 16 hours per day X 224 days
      - 3,584 hours
      - 2 FTEs

        - Facilities Technician
            - 1 person x 16 hours per day X 224 days
            - 3,584 hours
            - 2 FTEs
    - Light Maintenance Facility
        - Facilities Foreman
            - 1 person x 16 hours per day X 224 days x 1 bases
            - 3,584 hours
            - 2 FTEs
        - Facilities Technician
            - 1 person x 16 hours per day X 224 days x 1 bases
            - 3,584 hours
            - 2 FTEs
- Stations—Merced, Gilroy, Fresno and Bakersfield will have 1 person on duty during the Revenue Service Period with overlap to allow for exchanging of information and tasks.
    - Facilities Foreman
        - 1 person x 10 hours per day X 365 days x 4 stations
        - 14,600 hours
        - 9 FTEs
    - Facilities Technician
        - 1 person x 10 hours per day X 365 days x 4 stations
        - 14,600 hours
        - 9 FTEs

8.2.3.2 Silicon Valley to Central Valley Staffing Calculations During the Maintenance Period

- Track and Systems
    - Track
        - Track—Crew of 1 Foreman, 2 Operators, and 2 Laborers operating from each base
            - Track Foreman
                - 1 x 8 hours x 365 days x 3 maintenance bases
                - 8,760 hours
                - 5 FTEs
            - Operator
                - 2 x 8 hours x 365 days x 3 maintenance bases
                - 17,520 hours
                - 10 FTEs
            - Track Laborer
                - 2 x 8 hours x 365 days x 3 maintenance bases
                - 17,520 hours
                - 10 FTEs
        - Welders—Crews of 2 Welders operating from each base
            - 2 people x 8 hours x 224 days x 3 maintenance bases
            - 10,752 hours
            - 6 FTEs
    - Systems—Systems Maintainer working as individuals or a team depending on the work to be performed

        - Systems Maintainer
            - 3 people x 8 hours x 365 days x 3 bases.
            - 26,280 hours
            - 15 FTEs
        - Systems Inspectors
            - 1 Inspector per 4 Signal Maintainers
            - 4 FTEs
    - OCS—Crews of 1 Foreman and 3 Technicians; 1 of the Technicians will have a commercial truck driver's license.
        - OCS Inspector/Foreman
            - 1 person x 8 hours x 365 days x 3 bases
            - 8,760 hours
            - 5 FTEs
        - OCS Technicians
            - 2 people x 8 hours x 365 days x 3 bases
            - 17,520 hours
            - 10 FTEs
        - OCS Technician-Commercial Driver's License
            - 1 person x 8 hours x 365 days x 3 bases
            - 8,760 hours
            - 5 FTEs
    - Electric Transmission
        - Power Technicians
        - 2 persons x 8 hours x 365 days x 3 bases
        - 17,520 hours
        - 10 FTEs
- Structures—Crews of 1 Foreman and 2 Laborers working from 2 bases
    - Structures Foreman
        - 1 person x 8 hours x 365 days x 1.5 bases
        - 4,8380
        - 3 FTEs
    - Structures Laborers
        - 2 people x 8 hours x 365 days x 2 bases
        - 8,760 hours
        - 5 FTEs
- Facilities
    - Heavy Maintenance Facility
        - Facilities Foreman
            - 1 person x 8 hours per day X 224 days
            - 1,792 hours
            - 1 FTE
        - Facilities Technician
            - 2 persons x 8 hours per day X 224 days
            - 1,792 hours
            - 2 FTE
    - Light Maintenance Facility
        - Facilities Foreman

        - 1 person x 8 hours per day X 224 days x 1 bases
        - 1,792 hours
        - 1 FTEs
    - Facilities Technician
        - 1 person x 8 hours per day X 224 days x 1 bases
        - 1,792 hours
        - 1 FTEs
- Stations—No personnel on duty during the Maintenance Period

Table 16 Phase 1 Full-time Personnel

Position	Division	Total	Revenue Hours	Non-Revenue Hours	Overtime %*
Chief Engineer	Engineering	1	1		
Deputy Chief Engineer	Engineering	1	1		
Administrative Assistant	Engineering	2	2		
Stores Manager	Track & Systems	1	1		
Stores Clerk	Track & Systems	1	1		
Stores Handling	Track & Systems	3	1	2	
Procurement Specialist	Track & Systems	1	1		
Track Manager	Track & Systems	2	1	1	
Track Engineer	Track & Systems	2	2		
Track Supervisor	Track & Systems	3	1	2	
Track Inspector/ Foreman	Track & Systems	15	8	7	15%
Track Laborer	Track & Systems	14		14	15%
Equipment Operator	Track & Systems	18	4	14	15%
Welder	Track & Systems	8	0	8	15%
Mechanic	Track & Systems	11	4	7	15%
Systems Manager	Track & Systems	3	1	2	
Systems Inspector	Track & Systems	10	5	5	15%
Systems Tech.	Track & Systems	35	15	20	15%
Systems Tech. (San Jose to Gilroy Monday-Friday)	Track & Systems	6	6	0	15%
Systems Tech. (San Jose to Gilroy Weekends)	Track & Systems	2	2	0	15%
Systems Engineer	Track & Systems	8	4	4	
Power/OCS Manager	Track & Systems	2	1	1	
OCS Supervisor	Track & Systems	2		2	
Power/OCS Inspector/Foreman	Track & Systems	7		7	15%

Position	Division	Total	Revenue Hours	Non-Revenue Hours	Overtime %*
Power Techs	Track & Systems	10		10	
OCS Tech.	Track & Systems	29	15	14	15%
OCS Tech. (CDL License)	Track & Systems	7		7	15%
Structures Manager	Structures	1	1		
Structures Engineer	Structures	2	1	1	
Bridge Inspector	Structures	4		4	
Structures Foreman	Structures	5		5	15%
Structures Laborer	Structures	10		10	15%
Facilities Manager	Facilities	1	1		
Asst. Facility Manager	Facilities	2	1	1	
Facilities Foreman (HMF & LMF)	Facilities	9	6	3	15%
Facilities Technician (HMF & LMF)	Facilities	9	6	3	15%
Facilities Foreman (Stations)	Facilities	13	13		15%
Facilities Technician (Stations)	Facilities	13	13		15%
Train Engineer		1			
Train Conductor		1			
Total		275			

*Overtime translated into 45 FTE in the O&M calculation

8.2.3.3 Phase 1 Staffing Calculations During the Revenue Service Period

The staffing of certain positions is based on the following calculations:

- Track and Systems
  - Track Inspector
    - 1 person x 18 hours x 365 days X 2 maintenance bases
    - This provides approximately 1.5 hours of response time to an incident.
    - 13,140
    - 8 FTEs
  - Systems Maintainer
    - 1 person x 18 hours x 365 days X 4 maintenance bases
    - This provides for approximately 1 hour of response time to an incident.
    - 26,280 hours
    - 15 FTEs
  - Systems Inspectors
    - 1 per 4 Systems Maintainers
    - 4 FTEs
  - OCS Technician
    - 1 person x 18 hours x 365 days X 4 bases
    - This provides for approximately 1 hour of response time to an incident.
    - 26,280 hours
    - 15 FTEs

- Structures
  - No hourly personnel during revenue service period.
- Facilities
  - Heavy Maintenance Facility
    - Facilities Foreman
      - 1 person x 16 hours per day X 224 days
      - 3,584 hours
      - 2 FTEs
    - Facilities Technician
      - 1 person x 16 hours per day X 224 days
      - 3,584 hours
      - 2 FTEs
  - Light Maintenance Facility
    - Facilities Foreman
      - 1 person x 16 hours per day X 224 days x 2 bases
      - 7,168 hours
      - 4 FTEs
    - Facilities Technician
      - 1 person x 16 hours per day X 224 days x 2 bases
      - 7,168 hours
      - 4 FTEs
- Stations—Merced, Gilroy, Fresno, Bakersfield, Palmdale and Burbank will have 1 person on duty during the Revenue Service Period with overlap to allow for exchanging of information and tasks.
  - Facilities Foreman
    - 1 person x 10 hours per day X 365 days x 6 stations
    - 21,900 hours
    - 13 FTEs
  - Facilities Technician
    - 1 person x 10 hours per day X 365 days x 6 stations
    - 21,900 hours
    - 13 FTEs

8.2.3.4 Phase 1 Staffing Calculations During the Maintenance Period

- Track and Systems
  - Track
    - Track—Crew of 1 Foreman, 2 Operators, and 2 Laborers operating from each base
      - Track Foreman
        - 1 x 8 hours x 365 days x 4 maintenance bases
        - 11,680 hours
        - 7 FTEs
      - Operator
        - 2 x 8 hours x 365 days x 4 maintenance bases
        - 23,360 hours
        - 14 FTEs
      - Track Laborer
        - 2 x 8 hours x 365 days x 4 maintenance bases
        - 23,360 hours

            - 14 FTEs
        - Welders—Crews of 2 Welders operating from each base
            - 2 people x 8 hours x 224 days x 4 maintenance bases
            - 3,584 hours
            - 8 FTEs
    - Systems—Systems Maintainer working as individuals or a team depending on the work to be performed
        - Systems Maintainer
            - 3 people x 8 hours x 365 days x 4 bases.
            - 35,040 hours
            - 20 FTEs
        - Systems Inspectors
            - 1 Inspector per 4 Signal Maintainers
            - 5 FTEs
    - OCS—Crews of 1 Foreman and 3 Technicians; 1 of the Technicians will have a commercial truck driver's license.
        - OCS Inspector/Foreman
            - 1 person x 8 hours x 365 x 4 bases
            - 11,680 hours
            - 7 FTEs
        - OCS Technicians
            - 2 people x 8 hours x 365 days x 4 bases
            - 23,360 hours
            - 14 FTEs
        - OCS Technician-Commercial Driver's License
            - 1 person x 8 hours x 365 days x 4 bases
            - 11,680 hours
            - 7 FTEs
    - Electric Transmission
        - Power Technicians
        - 2 person x 8 hours x 365 days x 3 bases
        - 17,520 hours
        - 10 FTEs
- Structures—Crews of 1 Foreman and 2 Laborers working from 2 bases
    - Structures Foreman
        - 1 person x 8 hours x 365 days x 2 bases
        - 5,840
        - 4 FTEs
    - Structures Laborers
        - 2 people x 8 hours x 365 days x 2 bases
        - 11,680 hours
        - 7 FTEs
- Facilities
    - Heavy Maintenance Facility
        - Facilities Foreman
            - 1 person x 8 hours per day X 224 days
            - 1,792 hours
            - 1 FTE

        - Facilities Technician
            - 1 person x 8 hours per day X 224 days
            - 1,792 hours
            - 1 FTE
    - Light Maintenance Facility
        - Facilities Foreman
            - 1 person x 8 hours per day X 224 days x 2 bases
            - 3,584 hours
            - 2 FTEs
        - Facilities Technician
            - 1 person x 8 hours per day X 224 days x 2 bases
            - 3,584 hours
            - 2 FTEs
- Stations—No personnel on duty during the Maintenance Period

8.2.4 Materials and Other Costs

1. Based on the Union Internationale des Chemins de fer's International Benchmarking of Track Cost, materials for Maintenance of Infrastructure are estimated as 15 percent of the total Maintenance of Infrastructure labor cost.[25]
2. An additional 5 percent of the total labor cost is assumed for miscellaneous tools, uniforms and so forth.

8.2.5 Maintenance Vehicles

The Maintenance of Infrastructure teams will also need to have both rubber tire and on-track vehicles. All vehicles are assumed to be leased based on the following table. Lease costs are calculated based on a 5 percent annual interest rate with the term coinciding with the life expectancy of the vehicle. A per gallon fuel rate of $4.25 was utilized for both gas and diesel vehicles. Annual maintenance was estimated based on a percentage of the purchase price ranging from 1 percent to 5 percent. The table below provides the details by vehicle.

Table 17 Silicon Valley to Central Valley and Phase 1 Non-revenue Vehicles and Equipment

Division	Description	Model	Type	Silicon Valley to Central Valley	Phase 1
Facilities	Stake Body Truck		Vehicle	1	1
Facilities	Pick-up Truck-Extended cab	F-150	Vehicle	7	10
CS	4X4 HR Crew Cab Truck	F-250	Vehicle	3	5
CS	Bridge Inspection Truck-HR		Equipment	2	2
CS	Pick-up Truck-Extended cab	F-150	Vehicle	3	3
CS	Vacuum Truck-HR		Equipment	1	2
T&S	4X4 HR Crew Cab Truck	F-250	Vehicle	4	4
T&S	Backhoe-HR		Equipment	2	2

[25] International Union of Railways (UIC). International Benchmarking of Track Cost. 2001. 13 Nov. 2012. <http://www.arema.org/files/library/2001_Conference_Proceedings/00026.pdf>

Division	Description	Model	Type	Silicon Valley to Central Valley	Phase 1
T&S	Bucket Loader		Equipment	2	2
T&S	Bucket Truck-OCS		Equipment	4	4
T&S	Catenary Car		Equipment	1	1
T&S	Excavator-HR		Equipment	2	2
T&S	Flat Cars		Equipment	3	3
T&S	Fuel & Lube Truck		Equipment	1	1
T&S	Hi-Rail Inspection Truck	F-250	Vehicle	4	9
T&S	Inspection Car		Equipment	1	1
T&S	Locomotive		Equipment	1	1
T&S	Logging Truck-HR		Equipment	3	4
T&S	Lowboy trailer		Vehicle	2	2
T&S	Pick-up Truck-Extended cab	F-150	Vehicle	17	0
T&S	Pick-up Truck-Extended cab		Vehicle	0	31
T&S	Rail Dollies		Equipment	2	2
T&S	Rail Puller		Equipment	2	2
T&S	Speedswing		Equipment	2	2
T&S	Stake Body Truck		Vehicle	1	2
T&S	Swivel Dump-HR		Equipment	4	4
T&S	Tractor trailer		Vehicle	2	2
T&S	Utility Trucks-Mechanic		Vehicle	3	4
T&S	Utility Trucks-Power		Vehicle	3	4
T&S	Utility Trucks-Signal		Vehicle	11	15
T&S	Utility Trucks-Signal Crew		Vehicle	3	4
T&S	Water Tank		Equipment	2	2
T&S	Welders Truck		Vehicle	3	4
			TOTAL	102	137

The calculation base is described in Appendix A.

8.3 Subcontracted Service

Subcontractors will be utilized for to perform some maintenance activities including but not limited to the below list:

- Rail grinding
- Vegetation spraying along the right of way

- Janitorial
- Landscaping
- HVAC
- Elevator
- Fire alarm and suppression
- Plumbing
- Electrical in stations and facilities

Table 18 Silicon Valley to Central Valley and Phase 1 Subcontractor Service Costs

Task	Department	Unit	Unit Cost	Silicon Valley to Central Valley Units	Silicon Valley to Central Valley Costs	Phase 1 Units	Phase 1 Costs
Rail Grinding	Track	Track Mile	$7,000	570	$3,990,000	818	$5,726,000
Weed Spraying	Track	Track Mile	$500	570	$285,000	818	$409,000
Janitorial-Stations	Facilities	Sq. Ft	$4.74	522,539	$2,476,835	692,876	$3,284,232
Roads-Stations	Facilities	Sq. Ft	$0.4550	522,539	$237,755	692,876	$315,259
Landscaping-Stations	Facilities	Sq. Ft	$0.1512	522,539	$79,008	692,876	$104,763
General Maintenance Services-Stations	Facilities	Sq. Ft	$3.50	522,539	$1,828,887	692,876	$2,425,066
Janitorial-HMF & LMF	Facilities	Sq. Ft	$1.86	472,995	$879,771	618,510	$1,150,429
Road-HMF & LMF	Facilities	Sq. Ft	$0.4550	472,995	$215,213	618,510	$281,422
Landscaping-HMF & LMF	Facilities	Sq. Ft	$0.1512	472,995	$71,517	618,510	$93,519
General Maintenance Services-HMF & LMF	Facilities	Sq. Ft	$4.27	472,995	$2,019,689	618,510	$2,641,038
On-board Train Cleaning	Facilities	Sq. Ft	$4.74	144,000	$682,560	144,000	$682,560
Janitorial-Maintenance of Infrastructure (MOI) Bases	Structures	Sq. Ft	$1.86	30,000	$55,800	40,000	$74,400
General Maintenance Services-MOI Bases	Structures	Sq. Ft	$4.27	30,000	$128,100	40,000	$170,800

These estimates are based on information from the International Facility Management Association.

8.4 Equipment, Other Costs

Each member of the Maintenance of Infrastructure staff will require a uniform. The uniform allowance is based on the uniform costs from the San Francisco Municipal Transportation Agency Operating Budget

for FY 2013-2014 (escalated to 2019 dollars).[26] Uniform costs are estimated at $326 per employee per year. This does not apply to the management.

Maintenance of Infrastructure personnel will require cell phones. The cell phone allowance is estimated at $756 per year per employee based on the U.S. General Services Administration Cost Per Person Model (escalated to 2019 dollars)[27] and applies to 210 employees for Silicon Valley to Central Valley and 262 for Phase 1.

The same number of employees is assumed to require information technology/software functionality. Based on the GSA per person cost model (escalated to 2019 dollars), the information technology costs are estimated at $5,816 per user profile. In addition, an allocated cost contingency of 18 percent was assumed to account for additional specialty systems which may be implemented by the eventual system operator.

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[26] SFMTA. *SFMTA Operating Budget for FY 2013–2014*. 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf.>

[27] U.S. General Services Administration. Cost Per Person Model V2.0. 14 October, 2013. <http://www.gsa.gov/portal/content/105134>

9 STATION OPERATIONS AND TRAIN AND STATION CLEANING

The Station Operations portion of the model consists of personnel and costs directly involved in the operation of passenger stations. Costs for train cleaning at stations, along with yards, is also included in this section.

9.1 Background

Station elements are constructed over time and consist of trackside station elements, landside elements, commercial development and blended service corridor planning principles.

9.1.1 Trackside Station Elements

These components will be constructed as part of Track and Systems and represent the minimum elements required to operate as an unstaffed stop, including:

- Pedestrian and vehicular access
- Unstaffed ticketing and fare control
- Platform and canopy
- Platform access concourse and vertical circulation
- Security
- Facility maintenance

9.1.2 Landside Station Elements

As ridership grows, these elements provide staffed operational spaces required to operate the system, including:

- Passenger waiting concourses
- Restrooms
- Staffed ticketing and information
- Train crew support
- Train grooming and maintenance
- Train food service
- Station operations
- Track and systems operator spaces

9.1.3 Commercial Development

While all passenger amenity spaces (such as retail and foodservice facilities) may not be provided on the first day of California High-Speed Rail revenue operations, local stakeholders may choose to enhance the sites by providing commercial development or provisions for temporary and flexible activities, such as civic events and food trucks. Other commercial development not related to passenger rail services may also be provided as part of larger station area planning activities.

9.1.4 Blended Service Corridor Planning Principles

The Authority will operate on blended service corridors from Transbay to Gilroy and Los Angeles Union Station to Anaheim (except the track from Fullerton to Anaheim), and service agreements will be needed with each operator to define scope of responsibility and costs for access. The Authority has developed and outlined the following core planning principles to guide the development of these service agreements:

- The Authority is a tenant at blended service corridor stations.
    - Blended service corridor station operators will provide:
        - Station operations including station control, staff areas (restrooms, breakrooms, and locker rooms)
        - Station maintenance

        - Station infrastructure—including mechanical, electrical, plumbing, fire protection and communications systems
        - Station security and police
        - Passenger functions: Restrooms, wellness rooms, vendor spaces
        - Track and Systems operations
        - Platforms: dedicated platforms to meet Authority-level boarding requirements
        - Platform access concourse common spaces (concourses, stairs, elevators, escalators, ramps, etc.)
        - Track and Systems spaces on the platform for electrical/communications equipment
        - Platform maintenance rooms
        - Space for Authority-required functions such as train cleaning/grooming, crew, maintenance and commissary
- The Authority will provide equipment and staff for its ticketing and fare control and communications.
    - Design criteria includes:
        - Station facility elements that are designed and constructed to the blended service corridor operators' design criteria and should accommodate Authority space requirements.
        - Track and System elements that are designed and constructed to the blended service corridor operators' design criteria and Authority operational requirements, e.g., train envelope, power, track geometry, etc.

9.2 Stations Types

In Chapter 4, Universal Assumptions, assumption 13 describes the assignment of stations to different station categories. The categories can be described as follows.

9.2.1 Terminal (End-of-Line) Stations (Level A)

Because trains dwell on terminal station platforms for a longer time than at intermediate stations, these end-of-line facilities provide additional ancillary facilities related to the servicing of trains before turning back. At shared stations, these ancillary facilities and systems may be California High-Speed Rail-dedicated or shared with other rail operators, such as Caltrain, Metrolink or Amtrak. Terminal station activities may include provisioning onboard food service, light interior cleaning of the train, trash removal, train crew changeover and light mechanical maintenance and inspection.

9.2.2 Key Intermediate Stations with Turnback Service (Level B)

Key intermediate stations with turnback service may have more extensive access to connecting feeder services or a higher level of ridership than regular intermediate stations, but less than that of terminal stations. During the early stages of the system phase-in, some trains may originate and terminate at these stations to optimize utilization of the train fleet. At shared stations, these ancillary facilities and systems may be California High-Speed Rail-dedicated or shared with other rail operators.

9.2.3 Temporary Terminal Stations (Level B)

During the initial operating phases of the program, some future intermediate stations function as temporary terminal stations. At shared stations, these ancillary facilities may be California High-Speed Rail-dedicated or shared with other rail operators. Temporary terminal station activities may include provisioning onboard food service, light interior cleaning of the train, trash removal, train crew changeover, and light mechanical maintenance and inspection.

9.2.4 Intermediate Stations (Level C)

Basic California High-Speed Rail stations not functioning as end-of-line or other terminal-type facilities are considered intermediate stations. For security and safety reasons, such as to reduce excessive passenger congestion, long-term waiting by passengers is encouraged and facilitated in the concourse area rather than on platforms.

9.3 Related Personnel

Station personnel include ticket agents and passenger assistance representatives.

Station maintenance and cleaning will be outsourced to subcontractors. In addition, the cost of personnel for cleaning train cars is included in this section. The cost of police and security for stations and trains is covered in Section 10.

9.4 Assumptions and Model Inputs

The following assumptions apply to station operation and cleaning, train cleaning staff and station energy usage.

9.4.1 Station Operations and Cleaning

9.4.1.1 Primary Drivers

The primary driver affecting escalation of station personnel headcount are assumed to be the number of stations in the system and station ridership in each phase. Stations fall under the following classifications.

Table 19 Station Levels and Descriptions

High-Speed Rail Station	Station Type	Silicon Valley to Central Valley	Phase 1
SF Transbay	Terminal		Contribution
SF 4th & Townend	Intermediate		Contribution
SF 4th & King	Terminal (Interim)	Trackside	
Millbrae	Intermediate	Trackside	
San Jose	Intermediate	Trackside	
Gilroy	Intermediate	Trackside	Landside
Merced	Intermediate	Trackside	Landside
Madera*	Stop		
Fresno	Intermediate	Landside	
Kings/Tulare	Intermediate	Trackside	
Bakersfield	Intermediate	Trackside (Interim)	Trackside & Landside
Palmdale	Intermediate		Trackside & Landside
Burbank	Intermediate		Trackside & Landside
LA Union Station	Terminal		Contribution
Fullerton	Intermediate		Trackside
Anaheim	Terminal		Trackside

*Madera is environmentally cleared and funded by others.

The staffing is based on the following classification:

Group I: SF Transbay, LA Union Station

Group II: Landside, depending on the respective phase

Group III: Trackside, depending on the respective phase

Madera is environmentally cleared and funded by others and therefore considered as a Group III station.

9.4.1.2 General Assumptions

1. Station personnel consist of ticket clerks/customer service representatives. The primary function of a ticket clerk/customer service representative is to:
    - Give general information about connections, schedule, etc.
    - Assist people with buying tickets.
    - Assist people in need of help to get on the train.

    Though each station will have automated ticket vending machines, ticket clerks/customer service representatives are expected to provide in-person assistance to customers for a variety of needs. As with most of the operations, this is contingent on the delivery model chosen for the program and the ultimate operator of the system. Given the current concept of operations for the program, it is expected that ticket clerks/customer service representatives will be available at stations to provide a high-level of service consistent with the business class experience envisioned for the system. It is possible that the eventual operator chooses to use more ticket-vending machines than assumed in the model. The station staffing is driven by the role of the stations on the system. Group I and Group II stations have more staffing than Group III stations.
2. Stations may be open for customer operations for up to 18 hours. It is assumed that customer service representatives will be staffed at the stations during those 18 hours.
    - Group I stations will be staffed with four customer service representatives during peak hours (off-peak: three).
    - Group II stations will be staffed with three customer service representatives during peak hours (off-peak: two).
    - Group III stations will be staffed with two customer service representatives during peak hours (off-peak: one).
3. All stations that have passengers going through them will also require cleaning personnel. This service is contracted out to a third party and depends on the size of each station. Only high-speed rail stations are considered in these costs.

9.4.1.3 Personnel Headcount

Customer service staff according to group are listed in assumption 2 above. In addition to those customer service representatives, it is assumed that a manager for passenger services will oversee a pool of station assistants in the field. When Phase 1 starts, an additional manager will be considered.

9.5 Train Cleaning Staff

9.5.1 Primary Drivers

1. Trains going from revenue service to revenue service will generally be cleaned in the stations where they are being turned.

2. Trains going from revenue service to deadhead or from deadhead to revenue service will be cleaned at the maintenance facilities.

9.5.2 Personnel Headcount

Stations where revenue service begins and terminates will have the following train cleaning staffing:

1. Station-based train cleaning teams will consist of 10 people. However, these teams can be split into half-teams when necessary.
2. The number of teams that will be used to clean trains will be one team per 15 trains being turned from revenue to revenue service in the station rounded to the nearest half-team with no cleaning staff if three or fewer trains will be turned.
3. For example, with two trains being turned in a station[28], no cleaning teams will be required; with 10 trains being turned, there will be one full team; and with 20 trains being turned, there will be one full team and one half team.

Table 20 Maintenance Yard Cleaning Staffing Tour

Teams and Tour at Maintenance Facilities	Silicon Valley to Central Valley	Phase 1
HMF	2 teams over 3 shifts	3 teams over 3 shifts
Bay Area	2 teams over 2 shifts	3 teams over 3 shifts
Los Angeles Area	N/A	3 teams over 3 shifts

9.5.3 Utilities

9.5.3.1 Energy Usage

Table 21 on the next page summarizes the total building area of each station as currently planned. These stations are generally in their conceptual levels of design and will continue to change as the design advances through coordination with local municipalities and agencies. These figures are used to calculate the projected energy cost for stations. Station energy usage is assumed to be 14.3 kWh per square foot, based on the Energy Information Agency's average for retail buildings.[29]

[28] It is assumed that in cases where there is no cleaning staff at a station, the on-board staff and/or the station staff will do basic cleaning before returning the train to revenue service and a more thorough cleaning will be performed at the yard.

[29] Energy Information Agency. Commercial Building Energy Consumption Survey. 2003. <http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html> Accessed 10 Dec. 2012.

Table 21 Station Building Areas During Silicon Valley to Central Valley and Phase 1 (subject to change as design advances)[30]

Station	Total Building Area (square feet)
San Francisco Transbay (incl. Caltrain)*	118,945
San Francisco 4th & Townsend**	55,518
San Francisco 4th & King***	47,983
Merced	91,000
Millbrae	32,041
San Jose	118,833
Gilroy	154,069
Madera****	59,124
Fresno	95,758
Kings/Tulare	41,924
Bakersfield	80,664
Palmdale	85,406
Burbank	84,931
LA Union Station	84,966
Fullerton	51,889
Anaheim	86,932

*San Francisco Transbay will only be a Phase 1 station.
**San Francisco 4th and Townsend will only be a Phase 1 station.
***San Francisco 4th and King will only be a station for the Silicon Valley to Central Valley phase.
****Environmentally cleared and funded by others.

9.5.3.2 Water and Sewer

Station water and sewer costs are estimated at $0.205 per year per square foot and $0.187 per year per square foot, respectively. These are based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2019 dollars).[31]

9.6 Equipment, Other Costs

9.6.1 Uniforms

Each member of the station staff will require a uniform. The uniform allowance is based on the uniform costs from the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014.[32] Uniform costs are estimated at $326 per employee per year (escalated to 2019 dollars).

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[30] The model includes the ability to add the other stations under consideration for the system including infill stations such as Mid-Peninsula and Phase 2 stations, but all of those stations are currently turned off.

[31] SFMTA. SFMTA *Operating Budget for FY 2013–2014*. 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>

[32] SFMTA. *SFMTA Operating Budget for FY 2013–2014*. 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>

9.6.2 Vehicles

Station personnel will require a small number of non-rail vehicles to move supervisors and other personnel around, as necessary. The vehicle fleet will consist of one pick-up truck-extended cab at each high-speed rail station. The price is outlined in the assumptions register and includes the lease rate, fuel costs, maintenance costs and costs for licensing and insurance. The Operations and Maintenance model includes a conservative allocated cost contingency rate of 25 percent placed on leased vehicles to account for other acquisition models which may be utilized by the eventual operator.

9.6.3 Supplies and Cell Phones

Station personnel will incur office supply costs and will require cell phones. The office supplies are assumed to be $457 per year per employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2019 dollars).[33] The cell phone allowance is estimated at $756 per year per employee based on the U.S. General Services Administration Cost Per Person Model (escalated to 2019 dollars).[34] [35] Cleaning personnel will require cleaning supplies. The cleaning supplies are priced at $83 per year per employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2019 dollars).

9.6.4 Information Technology/Software

Each station will require some information technology/software functionality. Based on the GSA per person cost model, the information technology costs are estimated at $5,816 per user profile (escalated to 2019 dollars). It is assumed that each station will have two user profiles, and each terminal will have four user profiles. In addition, an allocated cost contingency of 18 percent was assumed to account for additional specialty systems which may be implemented by the eventual operator.

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[33] SFMTA. *SFMTA Operating Budget for FY 2013–2014*. 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>

[34] U.S. General Services Administration. *Cost Per Person Model V2.0*. 14 October, 2013. <http://www.gsa.gov/portal/content/105134>

[35] SFMTA. S*FMTA Operating Budget for FY 2013–2014.* 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>

10 POLICE AND SECURITY POSITIONS

This section provides a background, the positions, assumptions and headcount analysis for police and security functions.

10.1 Primary Drivers

1. The planned number of facilities and passenger stations for each segment and the total route miles of the system.
2. The planned size and function of the stations (Group I, II and III).
3. Supervisory requirements for a workforce of various sizes.

10.2 General Assumptions

Under the current model, all **policing** for the California High-Speed Rail System (train and infrastructure) will be provided by the California Highway Patrol funded through a legislative budgetary action.

However, the California High-Speed Rail Authority will be responsible for the **security** portion across Silicon Valley to Central Valley and Phase 1, executed by unsworn officers.

Thus, only **unsworn officers** are included in the current model.

- An **Unsworn Officer** or **Security Guard** is a trained security person in the employ of a certified security firm/contractor. Unsworn officers will be positioned at each station, equipment maintenance facility and maintenance of infrastructure base.
- Unsworn Officers/Security Guards are assumed to be employed under agreements with private security firms. However, for current modeling purposes, the costs are estimated to be consistent with the rest of the model as non-contracted positions but using the appropriate rates from those organizations.
- Many separate security contracts will need to be negotiated for each station under each phase.

10.3 Personnel Headcount

The following assumptions are applied to security staff:

- The required full-time equivalents are depending on the location and the classification of the station in the system. The following full-time equivalents are assumed:
    - Group I station: 12
    - Group II/III station: 7.5
    - Maintenance of Rolling Stock/Maintenance of Infrastructure facility: 6

10.4 Equipment, Other Costs

The security functions will require significant amounts of equipment for their operations. The equipment needs and drivers for the unsworn officers, including command staff, are as follows:

- Personal equipment
- All-terrain vehicles, including fuel and disposables

11 COMMERCIAL COSTS AND FUNCTIONS

The commercial costs portion of the model consists of the costs and functions to market the Authority's high-speed rail services, the revenue collected from those who use these services as well as environmental, health and safety cost considerations.

11.1 Marketing, Revenue Collection and Environmental, Health and Safety

The marketing budget that the marketing and branding department spends to increase ridership includes advertising costs. Revenue collection describes the assumed approach related to ticket sales and the associated costs. Other commercial costs address the obligations related to environment as well as ensure the health and safety of riders and staff.

11.1.1 Marketing and Branding Department

For the purpose of the *2020 Business Plan,* the following assumptions for marketing and branding were made:

- Primary marketing and branding staff will have a central location for the entire system:
  - Silicon Valley to Central Valley (San Francisco to Bakersfield starting December 2031)
  - Phase 1 (San Francisco to Los Angeles to Anaheim starting December 2033)
- Staffing will need to be in place six months to approximately a year before service begins to develop the launch campaign and develop awareness and demand for the service.
- Station assistants are assumed to be available at all stations 18 hours, seven days per week.
- A full-service advertising agency will be engaged to develop an advertising campaign and to plan and place media. Other out-sourced services include research, loyalty program support agency, on-call graphic designer, public relations/crisis communications agency and call center support.
- System investments include customer relationship management (CRM) and website programming, support and analytics.

Local outreach subcontractors will be engaged to help drive up demand, located in the Central Valley and Bay Area during the Silicon Valley to Central Valley phase and located in the Los Angeles area during Phase 1.

11.1.1.1 Marketing and Branding Development

Marketing and branding (M&B) is essential to overall ridership and revenue success. This program will build excitement, anticipation, interest and intent to try rail services.

The Train Operating Company's early, customer-centric approach is assumed to be subcontracted with an accomplished California-based marketing firm to conduct market research that helps identify the most effective messaging and visuals as a compelling brand identity to be created for California High-Speed Rail. It will define the key elements for the brand in close cooperation with the Authority, including developing an inspiring product name that triggers positive emotions, is related to local roots and resonates with different cultures across California. The TOC and the M&B firm will test a variety of options among target audiences to ensure creation of a truly inspiring brand.

The TOC will subsequently need to develop an aggressive marketing and public information campaign to build interest and educate people about California High-Speed Rail. They will include fully integrated media strategies that reach individual audience segments through paid, earned and social media with targeted messages that resonate with their lifestyle, interests and needs.

The following types of functions are assumed to be performed by the TOC:

- Marketing and communications
- Customer service, in-person at a station and via phone through a Customer Call Center as described in the organization chart and list of assumptions
- Management of customer accounts and profiles by an enterprise CRM system
- Fare pricing, promotions, sales, analytics and related e-commerce integration with website, mobile app, etc.

11.1.1.2 Cost Drivers

In accordance with marketing and branding concept described above, M&B costs comprise recurrent cost components related to:

- **Advertising agency service contract:** integrated marketing campaign and paid media advertising
- **Customer Call Center:** passenger assistance with ticketing, schedule/trip planning, refunds
- **Loyalty program**
- **PR/crisis communications firm service contract**
- **Web and mobile integration and analytics support:** customer account management (CRM) licensing agreements—the account management interfaces with the revenue collection function.

In line with the scope of this budget, upfront fixed costs related to realization of customer account management/CRM platform, customer call center and website and customer facing app are excluded, as these are assumed to have been put in place and paid for on commencement of full stand-alone revenue service.

11.1.2 Advertising

Advertising costs are based on the number of people that the advertising campaign is trying to reach and the number of impressions required for the campaign to have an impact. This is expressed as a cost per 1,000 impressions, or CPM. People generally need to see an ad multiple times to be influenced by it; this concept is called the effective frequency of advertising, and it generally ranges from three to five times, depending on the campaign, product or service, target audience, media channels, etc.

When the operator of California High-Speed Rail plans an advertising campaign, the Authority targets specific market segments and populations based on current market conditions, research, strategy, budget and geographic priorities at the time of execution. For the purposes of this cost model, we have assessed two geographic scenarios for the first two phases:

1. Silicon Valley to Central Valley (San Francisco to Bakersfield)
2. Phase 1: (San Francisco to Los Angeles)

The geographic coverage for each phase includes the following markets.

Table 22 Geographic Coverage by Phase

Silicon Valley to Central Valley	Phase 1
Bakersfield	Bakersfield
Fresno	Fresno
Modesto	Modesto
Sacramento	Sacramento
Stockton	Stockton
Visalia	Visalia
Monterey/Salinas/Santa Cruz	Monterey/Salinas/Santa Cruz
San Francisco/Oakland/San Jose	San Francisco/Oakland/San Jose
San Luis Obispo	San Luis Obispo
Santa Barbara	Santa Barbara
Santa Maria-Lompoc	Santa Maria-Lompoc
	Los Angeles/Orange County
	Oxnard/Ventura
	Riverside/San Bernardino

For the purposes of the cost calculation, the model assumes that the campaign will reach every person in a select number of counties in California. It also assumes that no advertising will take place in other states. The counties that will be targeted by each phase are as follows:

Silicon Valley to Central Valley: Alameda, Contra Costa, Fresno, Kern, Kings, Los Angeles, Madera, Marin, Mariposa, Merced, Monterey, Sacramento, San Benito, San Francisco, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Stanislaus, Tulare, Ventura

Phase 1 (in addition to the aforementioned counties): Orange, Riverside, San Bernardino

Costs are estimated with a primary audience of adults aged 18+ assuming sufficient budget to execute a combination of local mass media channels, including TV, radio, outdoor and digital (display, mobile, over the top (OTT)[36], social media and video). The impression allocation for this estimation is as follows.

[36] OTT covers a wide range of content delivered through applications and third-party services (Hulu, Amazon Prime, etc.). Over-the-top content can be accessed directly through an Internet-connected platform such as a PC, laptop, tablet, smartphone, and other web enabled devices (smart TVs, Apple TV, Roku, etc.).

Table 23 Media Channel Impression Allocations

Media Channel	% of Impressions
Local TV	25%
Radio	20%
Outdoor	40%
Digital (including display, mobile, OTT, social media and video)	15%

Based on the above impression allocation and average media cost estimates for 2019-2020, the effective CPM (in June 2019 $) is $22.96 for the Silicon Valley to Central Valley Phase and $27.16 for Phase 1.

Table 24 Estimated CPM

Geography	Phase	Target Audience	Estimated CPM
San Francisco to Bakersfield	Silicon Valley to Central Valley	Adults 18+	$22.96
San Francisco to Los Angeles/Anaheim	Phase 1	Adults 18+	$27.16

This estimate is higher than previous Business Plan CPM estimates for several reasons, including:

- The updated cost estimate takes into account newer digital media tactics, like digital video and OTT video streaming services accessible through various devices and services not as widely used at the time of the original estimate and not considered in that cost analysis.
- The original cost estimate was based on national advertising costs which are considerably lower than local and regional media CPMs, especially for broadcast media, because of the smaller audience size in local markets.

11.1.3 Revenue Collection

The *2020 Business Plan* includes several assumptions for a comprehensive revenue collection system. In the past, only credit card costs were considered, whereas the entire system's costs are now being accounted for.

In addition to customer convenience and travel experience, the following key goals are assumed:

- **Payment integration** so that travellers can easily plan and make a trip using multiple mobility services with a single transaction, identify price options and book trips across various connecting services, including high-speed rail.
- **Data security and identity protection** to consider current and upcoming consumer privacy laws and regulations. On January 1, 2020, California will witness significant changes to its privacy laws. The California Consumer Privacy Act grants consumers the right to know what information companies have about them—and to have that information deleted. To ensure electronic identification for tickets, a code on a mobile device or a chip in a credit card can be used.
- **Multiple payment options** to address the needs of riders who rely on cash.
- **State of the art technology**, which is the most advanced in terms of software and technological infrastructure.

- **Minimizing the high cost of collecting revenues** is an important consideration. The cost reductions include specification development, implementing a full-scope software, refinements to hardware and information technology infrastructure, as well as system monitoring and analytics.

To implement these core objectives, the system must not have characteristics such as metal barriers or conventional ticket vending machines at stations. To enable individuals to make cash payments, partnerships can be established with retailers or other financial service institutions. Instead of having staffed ticket windows at stations to assist customers with tickets, customer service assistance is assumed (see Section 9 on stations) to ensure customers receive information and assistance with boarding.

A cost of 5 percent based on the revenue is assumed in the *2020 Business Plan* to enable such a system. This estimate includes cost categories such as transaction fees; ticketing as a service implementation fees; system update and maintenance fees; and payment fees to the financial service provider.

11.1.4 Environmental, Health and Safety

11.1.4.1 Environmental Considerations

Assuming all required plans are developed prior to the start of operations, the Environmental Department will be responsible for performing and/or implementing the following items:

Aboveground Storage Tank Permitting

Obtain permits, implement plans, develop training modules, document inspections and certifications. This includes development of an associated Spill Prevention, Control and Countermeasure plan.

Storm Water/Wastewater Quality Compliance

Ensure compliance with regulations governing equipment service documentation, training, wastewater, facility water, Storm Water Pollution Prevention Plan (SWPPP), Industrial General Permit (IGP) and National Pollutant Discharge Elimination System permitting. The Environmental Technician will provide regular inspections, as required by the SWPPP and IGP. The Environmental Manager will consult with each affected Regional Water Quality Control Board (RWQCB) through which the alignment passes, including the:

- San Francisco RWQCB
- Central Coast RWQCB
- Central Valley RWQCB
- Lahontan RWQCB
- Los Angeles RWQCB
- Santa Ana RWQCB

Air Pollution Compliance

Obtain permits, schedule inspections and certify portable equipment for the Phase 1 corridor. It is assumed that all heavy equipment, such as cranes, will be Tier 3 or above. The Environmental Officer will work closely with the Vehicle Maintenance Officer to ensure that all vehicles are maintained in accordance with conditions of the permits per the following district requirements:

- Bay Area Air Quality Management District
- Monterey Bay Air Resources District
- San Joaquin Valley Air Pollution Control District
- Eastern Kern Air Pollution Control District

- Antelope Valley Air Quality Management District
- South Coast Air Quality Management District

California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) Post-Construction Requirements

Develop and perform employee training, implement the weed control plan as per Final CEQA/NEPA mitigation measures and biological permits. The Environmental Officer will act as Weed Management Officer during the operations period.

Hazardous Materials Management

Obtain permits, write performance reports, train personnel, perform inspections and prepare shipping manifests. In addition, the community right-to-know in the Emergency Planning and Community Right-to-Know Act, Superfund Amendments and Reauthorization Act Title III requires an Emergency Response Report, a Hazardous Materials Business Plan and a Chemical Inventory, all of which will be developed by the Environmental Officer. Hazardous Materials/Hazardous Waste Permits will likely be required at each Operations and Maintenance Facility. The Environmental Manager will manage permits and plan compliance with the associated jurisdictional Certified Unified Public Agency for the following as described:

- San Francisco: San Francisco Department of Public Health – EH Branch
- San Jose: County of Santa Clara Hazardous Materials Compliance Division
- Gilroy: County of Santa Clara Hazardous Materials Compliance Division
- Merced: Merced County Environmental Health
- Fresno: Fresno County Department of Public Health
- Bakersfield: Kern County Environmental Health Services Department
- Palmdale: Los Angeles County Fire Department
- San Fernando Valley: Los Angeles County Fire Department
- Los Angeles: Los Angeles County Fire Department

Sustainability Management

Implement plans as required by the FRA and the State of California; provide monthly and annual sustainability reports.

11.1.4.2 Health and Safety

The following elements are considered in the field of health and safety.

Injury and Illness Prevention Plan

Develop an Injury and Illness Prevention Plan (IIPP) which includes:

- Responsibility
- Compliance
- Communication
- Hazard assessment
- Accident/exposure investigation
- Hazard correction
- Training and instruction
- Record keeping

An effective IIPP must fully involve all employees, supervisors and management, identify specific workplace hazards, correct said hazards in an appropriate and timely manner and provide effective training. The plan must be reviewed annually.

Heat Illness Prevention Plan

Develop a Heat Illness Prevention Plan that applies to all outdoor places of employment, including emergency response procedures. The plan must be reviewed annually.

Valley Fever Control Measures

Implement Valley fever control measures in coordination with the county public health officer. Plan requirements include:

- Training for recognizing symptoms of illness and minimizing exposure;
- Providing washing facilities;
- Providing vehicles with enclosed, air-conditioned cabs; and
- Making respiratory protection masks with particulate filters available to workers.

Emergency Preparedness Plan

Develop an Emergency Preparedness Plan that is available online for all emergency responders. The plan must be distributed every three years or when plans change and include:

- Procedures for initial and on-board notification to the control center.
- Informing passengers and indicating corrective countermeasures. The control center notifies emergency responders, adjacent rail modes of transportation, and appropriate railroad officials

Fire Safety

Annually, develop written procedures for inspection, testing and maintenance of systems and equipment.

Emergency Action Plan

Develop and implement an Emergency Action Plan. The plan must be reviewed annually or when plans change and should include procedures for:

- Emergency evacuation;
- Employees who remain to operate critical plant operations before they evacuate;
- Accounting for all employees;
- Employees performing rescue or medical duties;
- The preferred means of reporting fires and other emergencies; and
- Names or regular job titles and contact information for persons/departments who must be contacted for further information about duties under the plan.

An alarm system that complies with Article 165 must also be established.

Radiofrequency Radiation Exposure Limits and Electric System

Report maximum permissible levels for whole and partial body exposure to electromagnetic energy. Document safety standards and train personnel for proper operation, maintenance, repair and inspections of electrical systems.

Health and Safety Labor

Develop health and safety plans and ensure that the plans are implemented as required. Plans should include:

- Training procedures for employees working in various departments; and

- Information to direct health and safety personnel.

11.1.4.3 Cost Drivers

The major cost drivers associated with environmental compliance are labor, environmental permits and third-party inspection requirements.

11.2 Bus Costs

The Operations and Maintenance costs include costs for the Authority's own buses. Considering the state of California's regulation to transition to all-electric public buses by 2040[37], recent developments in the public transit sector with agencies successfully implementing electric bus fleets and the assumed future advancements in the storage capacity of the batteries used in electric buses, the ETO assumed a fully electric bus fleet for the Business Plan. These buses are used to ensure complete coverage of the system. The following bus services are assumed.

For Silicon Valley to Central Valley and Phase 1, an hourly bus service northbound from Merced to Sacramento is assumed. A connection to the high-speed rail service is provided in Merced.

Additionally, for Silicon Valley to Central Valley a southbound service is assumed. Three bus connections from Bakersfield are assumed, with a connection to the high-speed rail trains. Each of the three bus lines runs every half hour to LA Union Station, West LA and Santa Anita.

Due to shortage of data for electric bus fleets, to determine bus costs per mile, the ETO compiled various costs collected from Amtrak's thruway services in California. Based on the fiscal year 2018 cost, bus costs per mile range from $2.50 to $3.51 (in 2018 dollars). This results in a weighted average of $3.45. The escalation to June 2019 dollar values results in a cost rate of $3.52.

The data from Amtrak's thruway buses is shown in Appendix F Amtrak Thruway Connections.

The number of bus miles is determined by the service plan for the system as well as connecting bus services that are expected to be offered. Deadhead miles are added to the revenue miles to reach total bus miles. Caltrans Division of Rail provided the deadhead percentage for a representative medium-distance bus route (Sacramento to Reno and Sparks, NV) of 15.3 percent[38]. This percentage is assumed to be applicable to the planned bus connections to the high-speed rail system and is applied uniformly for each year. More information on bus miles can be found in the Service Planning Methodology Technical Supporting Document.

11.3 Operator Profit

It is currently assumed that operator profit will be calculated and evaluated separately during the contracting process. One of the key rationales for contracting is the reduced cost that can be achieved by the contractor (after taking profit into account). As such, it is not currently included in the model, as contracting decisions have not been finalized.

11.4 Tax Liability

It is currently assumed that tax liabilities will be calculated and evaluated separately. As such, tax liability is not currently included in the model.

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[37] https://ww2.arb.ca.gov/news/california-transitioning-all-electric-public-bus-fleet-2040

[38] https://www.apta.com/wp-content/uploads/Resources/resources/statistics/Documents/FactBook/2018-APTA-Fact-Book.pdf

12 GENERAL ADMINISTRATION AND EXECUTIVE MANAGEMENT

The executive and corporate organization is comprised of senior level personnel and experienced support staff who lead and direct the organization at the command and policy level. The organization's chief executive officer (CEO, President or Executive Director) chairs this group, and its members oversee the major departments and their functions. The positions described in this section are illustrative of the major functions that comprise management. However, the number of personnel required to fill these functions is calculated as a percentage of the total personnel employed at the system.

12.1 Related Personnel

The Executive and Corporate Organization are comprised of several organizational levels. The top level consists of the CEO—the top officer of the organization. The CEO reports to a senior board of appointed individuals and is responsible for the highest level of decision-making and policy setting.

The executive/corporate functions of a railroad organization immediately below the Chief Executive Officer are generally divided into the following areas of responsibility and are represented by the titles which accompany them. The examples below illustrate management positions typically used in other organizations. Note that although these positions are most often considered senior within the organization, such organization placement is dependent upon the "corporate organization" philosophy. They are included here for the purpose of illustrating a typical corporate structure and providing an example of the functions required at the senior level.

1. The **Chief Operating Officer** is responsible for the railroad's primary operating functions: the operation of trains and transportation of customers, the maintenance and repair of the rolling stock, the maintenance and repair of infrastructure, the selling of tickets and the customer services provided in the passenger station. These areas are directed and managed by department heads, reporting to the Vice President of Operations.
2. The **Chief Environmental Health and Safety Officer** is responsible for corporate safety policies and procedures, for directing regulatory requirements and managing safety data and reporting, and overseeing the effectiveness of the departmental safety programs.
3. The **Chief Legal Officer** is responsible for representing the railroad in general legal matters and litigation as determined by the General Counsel. Such matters commonly relate to corporate law, liability and claims, contracts, labor law, insurance and so forth.
4. The **Chief Financial Officer** is responsible for the development of the budget, payroll, general accounting, accounts payable, revenue accounting, and pertinent financial policies and procedures for the organization. The position manages financial forecasting and reporting, bookkeeping, and other corporate finance responsibilities as necessary.
5. The **Chief Human Resources Officer** (CHRO) is responsible for developing and managing the primary HR policies and procedures, functions of recruiting and hiring, personnel administration and records management, diversity management, and benefits administration. In addition, the CHRO is responsible for preparing and managing labor agreements for conducting labor negotiations, managing disputes, and providing direction to departments that are affected by labor contracts and practices. This role often falls under Human Resources.
6. The **Chief Procurement Officer** directs and manages the development of contracts for material and services needed by the organization.
7. The **Chief Digitalization Officer** (CDO) is responsible for developing the corporate strategy, policies, and procedures on information systems based upon the technology needs of the organization. Other activities include the purchase, development, installation, and maintenance of

the information systems. Additionally, the CDO is responsible for the digitalization and system integration of commercial and operational services.

8. Other positions, including Internal Auditing, may be elevated to the corporate level as a way to maintain direct linkage to the chief executive and preserve the priority of the function.

12.2 Assumptions and Model Inputs

The following assumptions are made concerning the executive and corporate level of the organization:

1. The total headcount for management and administration of the system is assumed to be 10 percent of the total of the other departments, the so-called blue collar workers. The calculated number (subtotal) forms the basis for distributing the number among the different levels.
2. Executive positions are estimated to comprise 5 percent of this subtotal and are assumed to be compensated at senior executive rates.
3. Senior manager positions below executives are estimated to comprise 10 percent of the subtotal and are assumed to be compensated at a rate 25 percent below executive rates.
4. Mid-managers are estimated to comprise 25 percent of the subtotal and are assumed to be compensated at a manager's/supervisor's rate.
5. Administration and other lower level corporate staff are estimated to comprise 60 percent of the subtotal and will be compensated accordingly.
6. The allocation of positions with general and administrative staffing is based on a comparison with other railroad properties in the U.S. and high-speed rail systems abroad.

12.3 Equipment, Other Costs

General and administrative personnel will require a number of non-rail vehicles. The vehicle fleet is assumed to be 16 cars in the Silicon Valley to Central Valley phase and in Phase 1. The cars are priced based on a standard SUV lease rate which includes fuel costs, maintenance and insurance with a rate of $21,290 per car (escalated to 2019 dollars). In addition, a conservative cost contingency rate of 25 percent is assumed and calculated on leased vehicles to account for other acquisition models which may be utilized by the eventual operator.

All general and administrative personnel will incur office supply costs, and the managers will require cell phones. The office supplies are assumed to be $457 per year per general and administrative employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2019 dollars).[39] The cell phone allowance is estimated at $756 per year per manager (general and administrative employees at the mid-management level or higher) based on the U.S. General Services Administration Cost Per Person Model (escalated to 2019 dollars).[40] [41]

Each general and administrative employee will require Information Technology/software functionality. Based on the GSA per person cost model, Information Technology costs are estimated at $5,816 per user profile (escalated to 2019 dollars). It is assumed that each general and administrative employee will

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[39] SFMTA. *SFMTA Operating Budget for FY 2013–2014*. 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>

[40] U.S. General Services Administration. *Cost Per Person Model V2.0*. 14 October, 2013. <http://www.gsa.gov/portal/content/105134>

[41] SFMTA. S*FMTA Operating Budget for FY 2013–2014.* 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>

have a user profile. In addition, the Operations and Maintenance model assumes a conservative cost contingency rate of 18 percent placed on leased vehicles to account for additional specialty systems which may be implemented by the eventual operator.

It is assumed that the managers will incur some amount of travel expenses per year. The costs are estimated at $1,163 per year for mid-managers, $3,490 per year for senior managers and $11,632 per year for executive managers. These estimates are based on figures established in prior business plans and escalated to 2019 dollars using Consumer Price Index escalation.

13 INSURANCE

Currently, the Highspeed Rail Authority is evaluating the overall insurance strategy. In the present Business Plan 2020 it is assumed, that the Authority is responsible for taking out insurance policies. Marsh, a global leader in insurance broking and risk management, provided updated coverage rates for the *2020 Business Plan*, which are based on ridership, revenues and asset values. The general insurance costs provided by Marsh are broken down into six categories, as described in the following table.

Table 25 Insurance Costs

Insurance Type	Self-Insured Retentions/ Deductible	Insurance Coverage Limits	Descriptions
General and Rail Liability	$1.0M	$350M	Provides coverage for injury and damage caused by the Authority's operations, or occurring on the Authority's property. Commercial general liability insurance premiums for operations with significant rail exposure are determined through an analysis of many factors including passenger count, fare revenue, miles of rail, speed and number of trains, number of "at grade" crossings, and whether the track utilized is single or double, shared with others or dedicated.
Real and Personal Property	$1.0M to $2.5M	$1.0B	Provides coverage for structures, buildings, property within structures and other improvements in the event of damage. Includes base coverage for fire, water damage and earthquakes.
Rolling Stock Property	$1.0M to $2.5M	$1.0B	Provides coverage for rolling stock and trainset property in the event of damage.
Business Interruption	$1.0M	$100M	Provides coverage for loss of net profits and continuing expenses in circumstances where insured physical damage to insured property forces to suspend high-speed rail operations, or where passengers or employees cannot gain access to the premises.
Track & Infrastructure Assets	$2.5M	$1.0B	Provides additional coverage for track and infrastructure assets, such as catenary, bridges and tunnels, in the event of insured loss or damage.
Earthquake and Flood	$1.0M	$100M	Provides additional coverage for insured high-speed rail property and assets in the event of flooding, earthquakes as defined in the policy. .

Marsh's insurance estimates are applicable on an annual basis and include fixed and variable components depending on the type of coverage, as described in the following table.

Table 26 Fixed and Variable Insurance Rates

Insurance Type	Variable Rate (2019 $)	Variable Rate Description	Insurance Costs 2040 Phase 1 (2019 $)
General and Rail Liability	$0.24	Per Passenger	$9.4M
Real and Personal Property	$1.20	Per $1,000 of Insurable Value	$3.9M
Rolling Stock Property	$2.00	Per $1,000 of Insurable Value	$7.8M
Business Interruption	$1.80	Per $1,000 of Revenue	$4.3M
Track & Infrastructure Assets	$0.24	Per $1,000 of Insurable Value	$7.4M
Earthquake and Flood	N/A	Fixed rate of $6.0M	$6.0M

Insurance rates from Marsh reflect risk factors at the time of the production of the *2020 Business Plan* and may change in future years as the high-speed rail system design and concept of operations advances to a higher level of completion.

14 CONTINGENCY

The model contains two sets of contingencies: unallocated contingency to account for unknowns that may arise in the operations and maintenance of the system and allocated contingency to account for known risks, uncertainties and unknowns associated with individual cost categories. The contingency percentages that were applied followed the guidance from the Department of Transportation Inspector General's report for systems at intermediate stages of development and amount to a total of 20 to 30 percent total contingency, based on the various cost items.

14.1 Unallocated Contingency

Unallocated contingency is set at 5 percent of all cost items before consideration of allocated contingency. This is the same as the unallocated contingency applied in the lifecycle cost estimate and is deemed sufficient to account for unknowns and unexpected costs that may come up.

14.2 Allocated Contingency

The allocated contingency percentages used in the *2020 Business Plan* Operations and Maintenance Cost Model assume the same ones used in *2018 Business Plan* Operations and Maintenance Cost Model. Although, higher quality information is now available for each cost category, and as a result, confidence ratings have most likely increased since the *2018 Business Plan*, it is proposed to maintain a level of conservatism. (However, to remain consistent with the *2018 Business Plan* and to maintain a level of conservatism in the allocated contingency assumptions, allocated contingency percentages remain the same.)

Table 27 Allocated Contingency Percentages by Cost Category

Cost Category	Allocated Contingency Percentage (%)
Labor	
Maintenance of Equipment	20.00
Maintenance of Infrastructure	22.50
On-board Staff (including Road Manager and protect crews)	21.25
Dispatching	16.25
Train Cleaning and Station Maintenance Staff	18.75
Stations	22.50
Police and Security	18.33
General and Administrative Staff	21.25
Materials, Tools and Other Direct Costs	
Maintenance of Infrastructure Materials (including stations)	22.50
Maintenance of Infrastructure Tools, Uniforms, etc.	20.63
Maintenance of Infrastructure Vehicles	25.00
Vehicles Besides Maintenance of Infrastructure and Police and Security	21.67
Police and Security Vehicles	20.00

Cost Category	Allocated Contingency Percentage (%)
Police and Security Equipment	20.00
Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.) for Every Department	18.33
Maintenance of Equipment Tools, Uniforms, Etc.	20.63
Maintenance of Equipment Regulatory Inspections	21.25
Maintenance of Equipment General Overhauls and Bogie Inspections	22.50
Utilities	
Train Operations Energy	19.38
Stations and Maintenance Facilities Energy	22.50
Stations and Maintenance Facility Water and Sewer	24.17
Other Costs	
Bus Costs	23.13
Advertising	21.67
Revenue Collection	20.00
Marketing & Branding, Incl. Advertising and Call Center	21.67
Insurance	18.33

15 OPERATIONS STARTUP AND COMMISSIONING

15.1 Rolling Stock Procurement

Table 28 below describes a possible delivery schedule for rolling stock. It is based on three considerations: an April 29, 2009 memorandum titled California High-Speed Train Project Trainset Procurement which finds that based on outreach to potential vendors it is reasonable to assume delivery of up to 10 train sets in one year; the service plans for the Silicon Valley to Central Valley Line and Phase 1; and, the rate of ridership growth projected in the *2020 Business Plan*.[42] This delivery schedule may be modified at the time of purchase based on vendor input and capital considerations.

Table 28 Potential Rolling Stock Commissioning Schedule

Delivered and Accepted By	System Development Step	San Francisco-Anaheim Incremental	San Francisco-Anaheim Total
2031	Silicon Valley to Central Valley	—	10
2032	Silicon Valley to Central Valley	10	20
2033	Phase 1	30*	50
2034	Phase 1	10	60
2035	Phase 1	7	67
2036	Phase 1	5	72
2037	Phase 1	—	72

*Excess trainsets beyond 10 in these years to be delivered before Phase 1 and are assumed to be placed in service after Phase 1 commences.

15.2 Testing and Commissioning

Testing and commissioning costs are currently not addressed in the model, because the model only looks at operating costs after the start of revenue service. Testing and commissioning costs are accounted for in the capital cost estimate.

15.3 System Resiliency

In the rare event of a stranded train or an emergency, it is assumed that train rescue could be managed by the existing high-speed rail fleet, due to available standby trains stationed throughout the system.

[42] California High-Speed Train Project, Train Procurement. PMT Memo. April 29, 2009.

16 MONTE CARLO RISK ANALYSIS

Monte Carlo simulations are part of a broad class of computational algorithms that rely on repeated random samplings from a range of variable inputs to determine the probability of different cost, schedule, revenue or other outcomes. Monte Carlo simulations are used in a variety of ways for the California High-Speed Rail Program to determine possible cost, schedule or revenue outcomes when uncertainty and risk are incorporated into the underlying models. Consistent with the *2018 Business Plan*, the *2020 Business Plan* utilized a top-down reference class analysis based on comparable rail projects around the globe to evaluate risks to the Operations and Maintenance forecasts for the California High-Speed Rail Program.

Another possible way Monte Carlo methods are used is as part of a "bottom-up" analysis, replacing point-estimates with probability distributions and incorporating risks into the baseline cost estimate, schedule or revenue projection to calculate possible cost, schedule, revenue or other outcomes. Single values or point estimates for inputs such as activity durations or line item costs are replaced with probability distributions or ranges of possible cost or durations to account for the inherent uncertainty surrounding any particular point-estimate. For example, the 45 days a planned activity in a schedule is expected to take is replaced with a duration range, such as taking between 40 and 60 days.

The possibility of unplanned activities or unexpected costs (risks) may also be included as inputs. Risk "events," that may or may not happen, may be added according to the assigned probability of occurrence, each having a defined impact range such as days of delay or additional costs. The algorithm selects ("samples") a value from the range that has been given to that input, records it, goes on to the next activity or line-item, selects a value from its distribution, records it and continues to do so for every input to the model. When it runs into a risk, it will "roll the dice" to determine if the risk has happened on this particular run and if so, select from the range of possible impacts to determine its effect, just as with other inputs. If the risk has a high probability of occurring, then on most runs the risk will happen and will impact the final result. If it is low, then on most runs, it will not. In other words, the dice are loaded based on what initial probability was assigned to the risk.

Once it has sampled from every input distribution and risk, completing one run or iteration, it calculates the result—in the case of a cost estimate, simply adding up all the different individual amounts for each line-item and risk event that happened on that particular iteration—simulating one possible outcome. Then the algorithm repeats this process to obtain another possible outcome. The algorithm will repeat this process thousands of times, depending on how complicated the underlying model and inputs are, until it is "satisfied" that a full range of possible outcomes and associated probabilities has been determined. These probabilities—how likely a particular cost, completion date or revenue projection is—are a key differentiator between the results of Monte Carlo simulation techniques and the results of traditional "what-if" or scenario analysis which typically do not provide any guidance as to how likely (or not) a particular outcome is, such as how likely it is that a project will finish on time or on budget.

16.1 Utilizing a Top-down Vs. Bottom-up Analysis

In the *2020 Business Plan*, Monte Carlo simulations were employed as part of a top-down or reference-class analysis. While reference class analysis cannot provide the granularity of a traditional bottom-up approach that is most useful from an internal management standpoint, the results of the reference-class analysis are based on actual project outcomes and are not dependent on the quality or comprehensiveness of internal risk identification or assessment efforts. In a top-down analysis, the algorithm works much the same way and is used for the same purposes, but instead of individual schedule activities or costs, it uses actual outcomes from similar projects to determine the probability of certain outcomes, for example, that a particular revenue projection will be met or costs will be below a certain target.

The results of a traditional or bottom-up risk analysis approach are typically captured in a risk register. As recommended in Department of Transportation Inspector General guidance and elsewhere, the risk register is eminently useful for systematizing and documenting the identification, assessment and mitigation of individual risks. For this reason, it is a key tool in California High-Speed Rail System risk management efforts as described in the Authority's Risk Management Plan. The risk register and underlying bottom-up approach does, however, have potentially significant limitations with regards to the accurate quantification of risk exposure, which also contributes to the decision to use a top-down approach. Chief of these is that the degree to which such an effort captures the actual risk exposure is dependent on the ability of participants to comprehensively identify and then accurately quantify the impact of said risks.

To a greater or lesser extent, a bottom-up analysis is also affected by certain modeling decisions such as the correlation between individual risks—the actualization of some affects the likelihood and impact of others, sometimes making them more likely and/or expensive, sometimes less. For the vast majority of project risks, there is no objective means for determining the appropriate correlation factor. Additionally, to be complete, this methodology also requires a determination of the dollar value of any identified schedule impacts, which in turn requires a significant amount of foresight regarding not just what risk may strike a project but also when. The extent to which these activities are carried out by project personnel and/or stakeholders also introduces the potential for optimism bias. For business planning purposes, as opposed to internal tracking and risk management purposes, the key objective for the analysis was and is to develop an accurate, objective measure of the risk exposure as measured by the potential variance between actual (eventual) and estimated costs together with the probability of a given variance. Given the relative weaknesses of a bottom-up approach for such a determination, the Operations and Maintenance risk analysis employs a reference-class methodology for Operations and Maintenance cost risk quantification.

In reference-class analysis, the algorithm is given a set of outcomes from other, similar projects and then uses these in a Monte Carlo simulation to, in a sense, work backwards to determine a probability distribution that would lead to the given set of outcomes. From this resulting distribution, we can determine how likely a particular outcome is for this project based on the outcomes of other similar projects. This is akin to asking a number of people who live in your town how long it takes them to drive to another town. From this sample, you could develop a general idea of what is a reasonable amount of time to allot for your trip and what is not. The Monte Carlo simulation simply allows for much more specific predictions, e.g., there is a 75 percent chance that your trip will take between 41 and 57 minutes or there is a 2 percent chance that your trip will take longer than 80 minutes.

For the Operations and Maintenance risk analysis, the Authority identified the six reference projects in Table 29.

Table 29 Reference Project Cost Variances from Plan

System	O&M Variance from Plan
Sprinter	-1%
FrontRunner	1%
LGV Rhone-Alpes	4%
LGV-Nord	6%
Music City Star	27%
Réseau Express Régional E	34%

Based on these results, the Authority parameterized a risk exposure curve as follows:

1. Minimum: Medium cost scenario with unallocated contingency only.
2. Most Likely: Medium cost scenario with full contingency.
3. Maximum: Medium cost scenario with full contingency + 34 percent.

The Minimum (best case scenario) was set as the medium cost scenario plus unallocated contingency only. Unallocated contingency was equivalent to 5 percent of the baseline cost; all allocated contingency was removed. The Most Likely cost parameter for the risk curve was taken to be equivalent to the medium cost scenario with full contingency—allocated and unallocated. As in the *2018 Business Plan*, the Maximum is based on the worst reference case scenario, or the largest cost overrun as a percentage of the original cost estimate, and is set at 34 percent above the medium cost scenario with full contingency.

The above parameterization provides a reasonable, well-supported assessment of the potential risk exposure for Operations and Maintenance costs. However, if there is a bias, a number of factors suggest that the parameterization is more likely to overstate potential costs rather than understate them. In particular:

- The Operations and Maintenance Cost Model is not yet optimized due to the fact that the system is not yet 100 percent designed. As more factors are defined, the easier it will be to think about efficiency measures.
- Based on the 2018 Operations and Maintenance Cost Model and associated assumptions, the ETO and related subject matter experts reviewed the cost estimates. With regard to the approach for different cost categories, changes were made in the calculation of different cost items for the *2020 Business Plan*. One significant change in service expansion was due to the inclusion of the service to Merced already in the Silicon Valley to Central Valley phase.
- The Lignes à Grande Vitesse (LGV) Rhone-Alps and LGV Nord reference cases show 4 percent and 6 percent cost overruns, respectively, and are the two most on-point cases in the reference set, as they are both high-speed rail systems.[43] Nevertheless, the Maximum parameter was set based on the worst case in the reference set, a 34 percent cost overrun on the Réseau Express Régional E system.

These parameters were input to a Monte Carlo simulation(s), and individual simulations were run for each year of each phase, Silicon Valley to Central Valley (San Francisco to Bakersfield), and Phase 1 increment (San Francisco to los Angeles/Anaheim) as well as for each year of All (combining Silicon Valley to Central Valley and Phase 1), based on the risk-adjusted cost estimates for those years and phases. The Minimum, Most Likely and Maximum scenarios were derived from the reference class parameters listed above.

The risk analysis was applied to the cost of each phase incrementally by using the same parameterization independently on Silicon Valley to Central Valley line costs, (incremental) Phase 1 costs, and All (total) costs for each year. Within each phase, correlation factors were applied between years under the assumption that costs, whether high or low, had some year to year momentum; in other words, if costs in a particular year fell on the high side of the distribution one year, they were more likely to be high the following year on that particular iteration. A positive correlation of 0.50 was assumed for each year within the Silicon Valley to Central Valley line phase and Phase 1. During the significant expansion in operations

[43] Even these, relatively minor, cost overrun percentages may overstate actual cost overruns.

from the Silicon Valley to Central Valley line to Phase 1 during the transition between years 2033 and 2034, the year-to-year relationship for costs is assumed to be significantly weaker, though still positive. Correlation rates used in the risk analysis are summarized below.

Table 30 Correlation Rates Used for *2018 Business Plan* Risk Analysis

Category	Years 2030, 2033, 2035 and Beyond	Year 2034 (transition year between San Francisco–Bakersfield and Phase 1 increment)
Correlation Rate	+0.50	+ 0.16

17 BREAKEVEN ANALYSIS

To help evaluate operational viability, a breakeven analysis was performed using a Monte Carlo risk analysis. The analysis determined a probability for fare box revenues to be equal to or greater than Operations and Maintenance costs. The analysis used the same revenue and Operations and Maintenance cost models discussed in the *2020 Business Plan* and in this Technical Supporting Document. In addition, the analysis assumed a 0.50 positive correlation factor between fare box revenue and Operations and Maintenance costs. This assumption was made to account for the possibility that if revenues were to be higher or lower than expected, there would be corresponding changes to service, resulting in similar movement in Operations and Maintenance costs. The results provide a probability distribution pairing different profit or loss outcomes with their likelihood, which allows the Authority to determine the probability of system revenues equaling or exceeding Operations and Maintenance costs.

Given the multi-year nature of the planned operating contract, the breakeven projections and the expertise of a private sector operator, the Authority fully anticipates that the ramp-up period cash flows can be well-managed through contractual payment structures and short-term working capital and that the system will not require an operating subsidy.

Table 31 presents the results of the breakeven analysis during (i) the Silicon Valley to Central Valley line opening year; (ii) the Phase 1 opening year; and (iii) Year 2040 of operations for Phase 1. Consistent with new high-speed rail systems around the world, the first year of operations on the Silicon Valley to Central Valley line is expected to be the most sensitive to operating costs as operations commence and early ridership begins to grow. Table 31 shows that as the Silicon Valley to Central Valley line progresses through the ramp-up period to Phase 1 operations that the probability of equaling or exceeding breakeven reaches 100 percent.

Table 31 Probability of System Revenue Exceeding Operations and Maintenance Costs in Select Years

Timing	Silicon Valley to Central Valley Line Opening Year (2031)	Phase 1 Opening Year (2033)	Phase 1 Horizon Year (2040)
Breakeven Probability	71%	83%	99%

APPENDIX A: ASSUMPTIONS REGISTER

1. Universal

Opening years of the train service:

- Silicon Valley to Central Valley: December 2031
- Phase 1: December 2033

Fringe benefits:

- $19,031.88 for the health, vision, dental and retiree health plans
- 5.50 percent of wage up to $17,787 for Railroad Unemployment Insurance Act benefits
- 13.1 percent of wage up to $98,700 for Railroad Retirement Tier 2
- 6.2 percent of wage up to $132,900 for Railroad Retirement Tier 1
- 7.45 percent with no limit (1.45 percent for Medicare and 6 percent for Federal Employers Liability Act compensation)

Overtime:

- The model doesn't assume overtime hours, as all workload needs are converted into regular FTE terms. It is assumed, that one FTE works 1,794 hours per year.

General and administrative staffing:

- General and administrative personnel are assumed to be 10 percent of the total workforce (including frontline supervisors).

Seasonality:

- The same number of trains, and therefore the same number of crews, will operate every day. Crews will work a 40-hour workweek, with relief days covered by separate crews.

Inflation:

- All cost items and wages are in June 2019 dollars.

Shared asset costs:

- For shared assets, it is assumed that the other party is paying track access fees.
    - Silicon Valley to Central Valley and Phase 1: The Authority pays track access fees from San Francisco to CP Lick using Caltrain assets. Caltrain pays track access fees to the Authority for the section CP Lick to Gilroy.
    - Phase 1 (additionally): The Authority pays track access fees to Metrolink for the section from Burbank to Anaheim.

2. Train Operations

Crew size:

- Crew size is calculated based on the total service time, including deadhead miles of the trains.

Single trainset crews:

- A single trainset crew consists of: one engineer, one conductor, two assistant conductors.

Protect crews:

- A protect crew, single trainset crew consists of: one engineer, one conductor, one assistant conductor.

Road manager:

- Up to 100 employees to be supervised: The number of Road Managers increases proportionally comprising 10 percent of the employees. In this range, the workload of the Road Manager is considered to be 50 percent leadership/supervision and 50 percent administration.
- Beyond 100 employees to be supervised**:** The efforts for administration increase proportionally at 50 percent for leadership/supervision, but only at 25 percent for administration, as administrative synergies will become more effective. This leads to a Road Manager's quota of 7.5 percent starting with the 101st employee.

Shunting driver:

- Headcount for 24 hours per stabling yard, is equivalent to five FTE.
- Silicon Valley to Central Valley: 10 FTE
- Phase 1: 15 FTE

Other positions:

- One Planning Director, one Performance and Data Manager for Silicon Valley to Central Valley and Phase 1
- One Scheduler for Silicon Valley to Central Valley and two Schedulers for Phase 1

Energy costs:

- $0.1312 per kWh, based on PG&E transmission voltage rates available in the E-20 tariff

Energy consumption:

- 41.5 kWh per trainset mile during Silicon Valley to Central Valley Line and 43.0 kWh per trainset mile during Phase 1

Vehicles:

- 15 4WD Ext. Cab Pick Up/SUV for Silicon Valley to Central Valley, 40 for Phase 1
- Two Minibuses for Silicon Valley to Central Valley and Phase 1

3. Dispatching

Operations Control Center:

- There will be one Operations Control Center on the system.
- The Operations Control Center will have one Director—Operations Control, one Chief Line Dispatcher (5 FTE), two Line Dispatchers (10 FTE) in the Silicon Valley to Central Valley Line and three Line Dispatchers (15 FTE) in Phase 1.
- There will be one Information Controller for Silicon Valley to Central Valley and Phase 1.
- The Operations Control Center will be on for three tours per day.

Yard:

- Two Depot Dispatchers per yard (10 FTE) for Silicon Valley to Central Valley and three per yard (15 FTE) for Phase 1

Vehicles:

- Two 4WD Ext. Cab Pick Up/SUV for Silicon Valley to Central Valley and Phase 1

4. Maintenance of Rolling Stock

Regulatory inspection staffing:

- See Table 8

Regulatory inspection frequency:

- Daily, 321 inspections per year per trainset
- Monthly, 12 inspections per year per trainset
- 92 days, four inspections per year per trainset
- Wheel Truing: each 300,000 miles
- Corrective maintenance: once per year per trainset

Regulatory inspection materials costs:

- Daily, $272 per inspection
- Monthly, $2,594 per inspection
- 92 days, $5,000 per inspection

Overhaul staffing (bogie inspection):

- See Table 9

Regulatory inspection frequency:

- Bogie inspection: each 600,000 miles
- General inspection: each 1,200,000 miles
- Wheel changeout: each 1,200,000 miles

Overhaul material costs:

- Bogie inspections cost: $137,910 per inspection
- General inspection cost: $955,596 per inspection
- Wheel changeout cost: $162,886 per trainset

Energy:

- Maintenance facility utility costs are estimated at 27 kWh per square foot.

Facility levels:

- Level 5: HMF
- Level 3: Bay Area

- Level 3: Los Angeles Area

Facility size:

- HMF—727,800 sq. ft.
- Bay Area—303,505 sq. ft.
- Los Angeles Area—303,505 sq. ft.

Cost rationalization:

- Seven-year rolling average with the first half of the model's period difference allocated 1/6, 1/3, 1/2 for the first three years, and the second half of the model's period difference spread evenly over the last three years,

Vehicles:

- One car per maintenance facility
- Two stake body trucks at the HMF

Tools:

- 5 percent of total labor cost

5. Maintenance of Infrastructure

Staffing:

- See Table 15 and Table 16

Materials:

- 15 percent of Maintenance of Infrastructure labor cost

Tools:

- 5 percent of Maintenance of Infrastructure labor cost

Vehicles

- See Table 32 and Table 33

Table 32 Silicon Valley to Central Valley Maintenance of Infrastructure Costs

Division	Type	Model	Vehicle or Equip.?	Quantity	Purchase Price	Total Purchase Price	Fuel Type	Fuel Consump-tion	Annual Mileage	Annual Fuel Consump-tion	Annual Mtce as % of capex	Lease Rate 5%	Fuel Cost Per Gallon $4.25	Annual Mtce Cost	Annual Licensing as % of Purchase 2%	Insurance per Vehicle $5,000	Total Annual Cost	Life Expect-ancy
CS	4X4 HR Crew Cab Truck	F-250	Vehicle	3	75,000	225,000	G	12	20,000	5,000	3%	51,969	21,250	6,750	1,039	15,000	96,009	5
CS	Bridge Inspection Truck-HR		Equipment	2	854,584	1,709,167	D	10	20,000	4,000	2%	221,345	17,000	34,183	4,427	10,000	286,955	10
CS	Pick-up Truck-Extended cab	F-150	Vehicle	3	40,000	120,000	G	10	20,000	6,000	3%	27,717	25,500	3,600	554	15,000	72,371	5
CS	Vacuum Truck-HR		Equipment	1	344,292	344,292	D	5	10,000	2,000	3%	44,587	8,500	10,329	892	5,000	69,308	10
RS Maint.	Stake Body Truck		Vehicle	1	125,000	125,000	D	10	15,000	1,500	3%	16,188	6,375	3,750	324	5,000	31,637	10
Facilities	Pick-up Truck-Extended cab	F-150	Vehicle	7	40,000	280,000	G	10	8,000	5,600	3%	64,673	23,800	8,400	1,293	35,000	133,166	5
Facilities	Stake Body Truck		Vehicle	1	125,000	125,000	D	10	15,000	1,500	3%	16,188	6,375	3,750	324	5,000	31,637	10
G&A	SUV		Vehicle	16	40,000	640,000	G	15	20,000	21,333	3%	147,824	90,667	19,200	2,956	80,000	340,647	5
Ops	SUV		Vehicle	17	40,000	680,000	G	15	20,000	22,667	3%	157,063	96,333	20,400	3,141	85,000	361,937	5
T&S	4X4 HR Crew Cab Truck	F-250	Vehicle	4	75,000	300,000	G	12	20,000	6,667	3%	69,292	28,333	9,000	1,386	20,000	128,012	5
T&S	Backhoe-HR		Equipment	2	286,359	572,718	D	5	3,500	1,400	3%	55,177	5,950	17,182		10,000	88,309	15
T&S	Bucket Loader		Equipment	2	450,000	900,000	D	5	3,500	1,400	3%	63,857	5,950	27,000		10,000	106,807	25
T&S	Bucket Truck-OCS		Equipment	4	225,000	900,000	G	10	20,000	8,000	2.5%	116,554	34,000	22,500	2,331	20,000	195,385	10
T&S	Catenary Car		Equipment	1	2,065,752	2,065,752	D	3	10,000	3,333	1%	199,019		20,658			219,677	15
T&S	Excavator		Equipment	2	550,000	1,100,000	D	3	6,000	4,000	2%	105,977	17,000	22,000	2,120	10,000	157,096	15
T&S	Flat Cars		Equipment	3	11,476	34,429				0	5%	2,443	-	1,721		15,000	19,164	25
T&S	Fuel & Lube Truck		Equipment	1	527,490	527,490	D	10	20,000	2,000	3%	68,312	8,500	15,825	1,366	5,000	99,003	10
T&S	Hi-Rail Inspection Truck	F-250	Vehicle	4	65,000	260,000	G	10	30,000	12,000	3%	60,053	51,000	7,800	1,201	20,000	140,055	5
T&S	Inspection Car		Equipment	1	28,690,996	28,690,996				0	1%	1,866,390	-	286,910			2,153,300	30
T&S	Locomotive		Equipment	1	2,295,280	2,295,280	D	3	10,000	3,333	5%	149,311		114,764			264,075	30
T&S	Logging Truck-HR		Equipment	3	375,000	1,125,000	D	5	15,000	9,000	2%	145,693	38,250	22,500	2,914	15,000	224,356	10
T&S	Lowboy trailer		Vehicle	2	150,000	300,000				0	3%	28,903	-	9,000		10,000	47,903	15
T&S	Pick-up Truck-Extended cab	F-150	Vehicle	17	40,000	680,000	G	10	20,000	34,000	3%	157,063	144,500	20,400	3,141	85,000	410,104	5

Division	Type	Model	Vehicle or Equip.?	Quantity	Purchase Price	Total Purchase Price	Fuel Type	Fuel Consump-tion	Annual Mileage	Annual Fuel Consump-tion	Annual Mtce as % of capex	Lease Rate 5%	Fuel Cost Per Gallon $4.25	Annual Mtce Cost	Annual Licensing as % of Purchase 2%	Insurance per Vehicle $5,000	Total Annual Cost	Life Expect-ancy
T&S	Production Tamper		Equipment	0	3,400,000	-	D	2		0	3%	-	-	-			-	20
T&S	Rail Dollies		Equipment	2	20,000	40,000				0	1%	3,210	-	400			3,610	20
T&S	Rail Puller		Equipment	2	11,476	22,953				0	5%	5,302	-	1,148	106	10,000	16,555	5
T&S	Speedswing		Equipment	2	350,000	700,000	D	5	20,000	8,000	2%	49,667	34,000	14,000	993	10,000	108,660	25
T&S	Stake Body Truck		Vehicle	1	125,000	125,000	D	10	15,000	1,500	3%	16,188	6,375	3,750	324	5,000	31,637	10
T&S	Swivel Dump-HR		Equipment	4	369,338	1,477,353	D	5	15,000	12,000	1.5%	191,324	51,000	22,160	3,826	20,000	288,311	10
T&S	Tractor trailer		Vehicle	2	450,000	900,000	D	5	7,000	2,800	2.5%	86,708	11,900	22,500		10,000	131,108	15
T&S	Utility Trucks-Mechanic		Vehicle	3	75,000	225,000	D	10	20,000	6,000	3%	51,969	25,500	6,750	1,039	15,000	100,259	5
T&S	Utility Trucks-Power		Vehicle	3	65,000	195,000	G	12	20,000	5,000	3.5%	45,040	21,250	6,825	901	15,000	89,016	5
T&S	Utility Trucks-Signal		Vehicle	11	65,000	715,000	G	12	20,000	18,333	3.5%	165,147	77,917	25,025	3,303	55,000	326,392	5
T&S	Utility Trucks-Signal Crew		Vehicle	3	70,000	210,000	G	12	20,000	5,000	3.5%	48,505	21,250	7,350	970	15,000	93,075	5
T&S	Water Tank		Equipment	2	25,000	50,000				0	2%	4,012	-	1,000	80	10,000	15,092	20
T&S	Welders Truck		Vehicle	3	325,000	975,000	D	10	20,000	6,000	2%	126,267	25,500	19,500	2,525	15,000	188,792	10
			TOTAL	136		49,635,428				219,367		4,628,938	903,975	838,029	43,478	655,000	7,069,420	

Table 33 Phase 1 Maintenance of Infrastructure Costs

Division	Type	Model	Vehicle or Equip.?	Quantity	Purchase Price	Total Purchase Price	Fuel Type	Fuel Consump-tion	Annual Mileage	Annual Fuel Consump-tion	Annual Mtce as % of capex	Lease Rate 5%	Fuel Cost Per Gallon $4.25	Annual Mtce Cost	Annual Licensing as % of Purchase 2%	Insurance per Vehicle $5,000	Total Annual Cost	Life Expect-ancy
G&A	SUV		Vehicle	16	40,000	640,000	G	15	20,000	21,333	3%	147,824	90,667	19,200	2,956	80,000	340,647	5
Ops	SUV		Vehicle	47	40,000	1,880,000	G	15	20,000	62,667	3%	434,233	266,333	56,400	8,685	235,000	1,000,651	5
RS Maint.	Stake Body Truck		Vehicle	1	125,000	125,000	D	10	15,000	1,500	3%	16,188	6,375	3,750	324	5,000	31,637	10
Facilities	Stake Body Truck		Vehicle	1	125,000	125,000	D	10	15,000	1,500	3%	16,188	6,375	3,750	324	5,000	31,637	10
Facilities	Pick-up Truck-Extended cab	F-150	Vehicle	10	40,000	400,000	G	10	8,000	8,000	3%	92,390	34,000	12,000	1,848	50,000	190,238	5
CS	4X4 HR Crew Cab Truck	F-250	Vehicle	5	75,000	375,000	G	12	20,000	8,333	3%	86,616	35,417	11,250	1,732	25,000	160,015	5
CS	Bridge Inspection Truck-HR		Equipment	2	854,584	1,709,167	D	10	20,000	4,000	2%	221,345	17,000	34,183	4,427	10,000	286,955	10
CS	Pick-up Truck-Extended cab	F-150	Vehicle	3	40,000	120,000	G	10	20,000	6,000	3%	27,717	25,500	3,600	554	15,000	72,371	5
CS	Vacuum Truck-HR		Equipment	2	344,292	688,584	D	5	10,000	4,000	3%	89,175	17,000	20,658	1,783	10,000	138,616	10
T&S	4X4 HR Crew Cab Truck	F-250	Vehicle	4	75,000	300,000	G	12	20,000	6,667	3%	69,292	28,333	9,000	1,386	20,000	128,012	5
T&S	Backhoe-HR		Equipment	2	286,359	572,718	D	5	3,500	1,400	3%	55,177	5,950	17,182	1,104	10,000	89,412	15
T&S	Bucket Loader		Equipment	2	450,000	900,000	D	5	3,500	1,400	3%	63,857	5,950	27,000	1,277	10,000	108,084	25
T&S	Bucket Truck-OCS		Equipment	4	225,000	900,000	G	10	20,000	8,000	2.5%	116,554	34,000	22,500	2,331	20,000	195,385	10
T&S	Catenary Car		Equipment	1	2,065,752	2,065,752	D	3	10,000	3,333	1%	199,019	14,167	20,658		5,000	238,843	15
T&S	Excavator-HR		Equipment	2	550,000	1,100,000	D	3	6,000	4,000	2%	105,977	17,000	22,000	2,120	10,000	157,096	15
T&S	Flat Cars		Equipment	3	11,476	34,429				0	5%	2,443	-	1,721		15,000	19,164	25
T&S	Fuel & Lube Truck		Equipment	1	527,490	527,490	D	10	20,000	2,000	3%	68,312	8,500	15,825	1,366	5,000	99,003	10
T&S	Hi-Rail Inspection Truck	F-250	Vehicle	9	65,000	585,000	G	10	30,000	27,000	3%	135,120	114,750	17,550	2,702	45,000	315,123	5
T&S	Inspection Car		Equipment	1	28,690,996	28,690,996				0	1%	1,866,390	-	286,910		5,000	2,158,300	30
T&S	Locomotive		Equipment	1	2,295,280	2,295,280	D	3	10,000	3,333	5%	149,311		114,764		5,000	269,075	30
T&S	Logging Truck-HR		Equipment	4	375,000	1,500,000	D	5	15,000	12,000	2%	194,257	51,000	30,000	3,885	20,000	299,142	10
T&S	Lowboy trailer		Vehicle	2	150,000	300,000				0	3%	28,903	-	9,000		10,000	47,903	15
T&S	Rail Dollies		Equipment	2	20,000	40,000				0	1%	3,210	-	400		10,000	13,610	20

Division	Type	Model	Vehicle or Equip.?	Quantity	Purchase Price	Total Purchase Price	Fuel Type	Fuel Consump-tion	Annual Mileage	Annual Fuel Consump-tion	Annual Mtce as % of capex	Lease Rate 5%	Fuel Cost Per Gallon $4.25	Annual Mtce Cost	Annual Licensing as % of Purchase 2%	Insurance per Vehicle $5,000	Total Annual Cost	Life Expect-ancy
T&S	Rail Puller		Equipment	2	11,476	22,953				0	5%	5,302	-	1,148	106	10,000	16,555	5
T&S	Speedswing		Equipment	2	350,000	700,000	D	5	20,000	8,000	2%	49,667	34,000	14,000	993	10,000	108,660	25
T&S	Stake Body Truck		Vehicle	2	125,000	250,000	D	10	15,000	3,000	3%	32,376	12,750	7,500	648	10,000	63,274	10
T&S	Pick-up Truck-Extended cab		Vehicle	31	40,000	1,240,000	G	15	15,000	31,000	3%	286,409	131,750	37,200	5,728	155,000	616,087	5
T&S	Swivel Dump-HR		Equipment	4	369,338	1,477,353	D	5	15,000	12,000	1.5%	191,324	51,000	22,160	3,826	20,000	288,311	10
T&S	Tractor trailer		Vehicle	2	450,000	900,000	D	5	7,000	2,800	2.5%	86,708	11,900	22,500		10,000	131,108	15
T&S	Utility Trucks-Mechanic		Vehicle	4	75,000	300,000	D	10	20,000	8,000	3%	69,292	34,000	9,000	1,386	20,000	133,678	5
T&S	Utility Trucks-Power		Vehicle	4	65,000	260,000	G	12	20,000	6,667	3.5%	60,053	28,333	9,100	1,201	20,000	118,688	5
T&S	Utility Trucks-Signal		Vehicle	15	65,000	975,000	G	12	20,000	25,000	3.5%	225,200	106,250	34,125	4,504	75,000	445,079	5
T&S	Utility Trucks-Signal Crew		Vehicle	4	70,000	280,000	G	12	20,000	6,667	3.5%	64,673	28,333	9,800	1,293	20,000	124,100	5
T&S	Water Tank		Equipment	2	25,000	50,000				0	2%	4,012	-	1,000	80	10,000	15,092	20
T&S	Welders Truck		Vehicle	4	325,000	1,300,000	D	10	20,000	8,000	2%	168,356	34,000	26,000	3,367	20,000	251,723	10
			TOTAL	201		53,629,720				297,600		5,432,870	1,250,633	952,833	61,938	1,005,000	8,703,274	

6. Stations Operation and Station Cleaning

Station classification:

- Group I: SF Transbay, LA Union Station
- Group II: Landside, depending on the respective phase
- Group III: Trackside, depending on the respective phase
- Madera is environmentally cleared and funded by others and therefore considered as a Group III station.

Staffing:

- Group I stations will be staffed with four customer service representatives (=15 FTE) during peak hours (off-peak: three=11 FTE)
- Group II stations will be staffed with three customer service representatives (=11 FTE) during peak hours (off-peak: two=8 FTE)
- Group III stations will be staffed with two customer service representatives (=8 FTE) during peak hours (off-peak: one=4 FTE).
- No Stations Manager assumed, instead Manager Passenger Service, 1 for Silicon Valley to Central Valley, 2 for Phase 1

Other station services:

- Subcontractors assumed for
  - Janitorial Services
  - Landscaping
  - General Maintenance Services

Train cleaning location:

- Trains going from revenue service to revenue service will generally be cleaned in the stations where they are being turned.
- Trains going from revenue service to deadhead or from deadhead to revenue service will be cleaned at the maintenance facilities.

Train cleaning staff at stations and maintenance facilities:

- Service is assumed to be subcontracted

Energy:

- Stations are assumed to use 14.3 kWh per square foot.
- For Station Sizes, please see Table 13 and Table 14.

Vehicles:

- One car is assumed per station and for the HMF/LMF facilities.
- Additionally, one Stake Body Truck at the HMF for Rolling Stock Maintenance and one Stake Body Truck for Facility purposes assumed.

7. Police and Security

Policing:

- All policing for the California High-Speed Rail System (train and infrastructure) will be provided by the California Highway Patrol funded through a legislative budgetary action.

Security

- Staffing:
  - Group I station: 12
  - Group II/III station: 7.5
  - Maintenance of Rolling Stock/Maintenance of Infrastructure facility: 6

8. Commercial Costs

Marketing:

- The following contracts are assumed:
  - Advertising agency service contract
  - Customer Call Center
  - Loyalty program
  - PR/crisis communications firm service contract
  - Web and mobile integration and analytics support

Advertising:

- Three campaigns per year are assumed with an effective frequency of five.
- For counties that will have advertising in each phase, please see section 11.1.2. For their populations by year, please see County Population Projections in Appendix E.
- Cost per 1,000 impressions is assumed to be $27.16.

Revenue collection:

- To cover all payment related costs, including credit card costs, 5 percent of the revenue is assumed.

Bus costs:

- Connecting bus services cost $3.52 per mile.
- Connecting bus services average 15.3 percent deadhead miles.

9. General and Administrative Costs

Staffing levels:

- General and administrative staffing is assumed to be 10 percent of total other staffing.
- Within general and administrative, the following breakdown is assumed:
  - Executives—5 percent
  - Senior managers—10 percent
  - Mid-managers—25 percent
  - Administrative and low-level corporate staff—60 percent

Vehicles:

- 16 cars for Silicon Valley to Central Valley and for Phase 1 assumed

10. Insurance

- Rate per insurance category: see Table 26.

11. Contingency

Unallocated contingency:

- 5 percent of subtotal costs

Allocated contingency:

- See Table 27.

12. Operations Startup and Commissioning

Testing and commissioning:

- Not part of routine operations and maintenance costs; included in capital costs.

Rolling stock procurement schedule:

- Illustrative schedule for rolling stock commissioning is shown in Table 28.

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APPENDIX B: WAGES

Wages for the staff positions described in this Technical Supporting Document were obtained from various experts. The assumptions for the salaries are based on comparable Amtrak positions as well as the experts' estimates.

The following table shows the salaries used in the Operations and Maintenance Cost Model:

Table 34 Raw Wage Data Collected by Position (2019 dollars)

Position Type	Position Title	Wage (2019 dollars)
Transportation	Road Manager	130,000
Transportation	Train Engineer	99,050
Transportation	Conductor	83,433
Transportation	Assistant Conductor	71,865
Transportation	On-board Attendant (not used)	45,668
Dispatching	Operations Control Director	150,000
Dispatching	Chief Line Dispatcher	106,598
Dispatching	Line Dispatcher	102,056
Dispatching	Yard Train Dispatcher	81,786
Dispatching	Information Controller	60,000
Maintenance of Equipment	Supervisors	100,000
Maintenance of Equipment	Technicians (including electrical and mechanical technicians)	75,752
Maintenance of Equipment	Storehouse Employees	69,068
Maintenance of Equipment	Laborers	70,936
MOI—Engineering	Chief Engineer	223,696
MOI—Engineering	Deputy Chief Engineer	200,000
MOI—Engineering	Administrative Assistant	60,000
MOI—Track and Systems	Stores Manager	85,000
MOI—Track and Systems	Stores Clerk	69,068
MOI—Track and Systems	Stores Handling	69,068
MOI—Track and Systems	Procurement Speacialist	75,975
MOI—Track and Systems	Track Manager	130,000
MOI—Track and Systems	Track Engineer	100,000
MOI—Track and Systems	Track Supervisor	100,000
MOI—Track and Systems	Track Inspector/ Foreman	75,235

Position Type	Position Title	Wage (2019 dollars)
MOI—Track and Systems	Track Laborer	62,183
MOI—Track and Systems	Equipment Operator	71,372
MOI—Track and Systems	Welder	69,872
MOI—Track and Systems	Mechanic	71,935
MOI—Track and Systems	Systems Manager	150,000
MOI—Track and Systems	Systems Inspector	87,687
MOI—Track and Systems	Systems Tech.	81,255
MOI—Track and Systems	Systems Engineer	130,000
MOI—Track and Systems	Power/OCS Manager	150,000
MOI—Track and Systems	OCS Supervisor	130,000
MOI—Track and Systems	Power/OCS Inspector/Foreman	85,474
MOI—Track and Systems	Power Techs	77,748
MOI—Track and Systems	OCS Tech	77,748
MOI—Track and Systems	OCS tech. (CDL License)	83,588
MOI—Facilities	Facilities Manager	150,000
MOI—Facilities	Asst. Facility Manager	130,000
MOI—Facilities	Facilities Foreman (HMF & LMF)	85,474
MOI—Facilities	Facilities Technician (HMF & LMF)	77,748
MOI—Facilities	Facilities Foreman (Stations)	85,474
MOI—Facilities	Facilities Technician (Stations)	77,748
MOI—Structures	Structure Foreman	76,360
MOI—Structures	Structures Laborer	68,409
MOI—Structures	Bridge Inspector	130,000
MOI—Structures	Structures Manager	130,000
MOI—Structures	Structures Engineer	130,000
MOI—Work Train	Train Engineer	99,050
MOI—Work Train	Train Conductor	83,433
Others—Managers	Executives	223,696
Others—Managers	Senior Management	200,00
Others—Managers	Mid-Level Managers	130,000
Others—Managers	Admin/Lower Level Corporate Staff	60,00

Position Type	Position Title	Wage (2019 dollars)
Others—Marketing and Branding	Senior Manager: Marketing	126,000
Others—Marketing and Branding	Specialist: Advertising/Marketing Program	84,000
Others—Marketing and Branding	Specialist: Channel Marketing/Sales	84,000
Others—Marketing and Branding	Graphic Artist	65,000
Others—Marketing and Branding	Manager: Communications	105,000
Others—Marketing and Branding	Specialist: Communications	84,000
Others—Marketing and Branding	Specialist: Passenger Communications	84,000
Others—Marketing and Branding	Coordinator: Community Outreach	50,000
Others—Marketing and Branding	Manager: Product	105,000
Others—Marketing and Branding	Data Analyst: Product	70,000
Others—Marketing and Branding	Senior Manager: Customer Service	126,000
Others—Marketing and Branding	Specialist: Customer Service	84,000
Others—Marketing and Branding	Customer Engagement Director	157,500
Others—Marketing and Branding	Executive Assistant	63,000
Others—Stations	Manager Passenger Services	105,000
Others—Stations	Ticket Clerk/Customer Service Representative	73,270
Others—Security	Unsworn Security officer	60,000

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APPENDIX C: MAINTENANCE OF INFRASTRUCTURE POSITION DESCRIPTIONS

Position	Description
Foreman/Inspector	All work crews perform prescribed work under the supervision of the Foreman. This position requires the experience, training and proven ability to lead employees to successfully and safely complete work as assigned. The Foremen reads work orders and prescribes corrective action, applying appropriate materials and personnel. This person is responsible to report time and material usage for work completed and advises the Dispatcher that the work group is clear of the track, and the track can be returned to service. A maintenance leader may have expertise in a special area such as production surfacing, turnout-surfacing, continuous welded rail repair, structures or other maintenance activities and be assigned accordingly. Track Foreman/Inspectors perform required inspections of all tracks and report findings. They review all climatic and wheel/rail reporting and determine at field locations the accuracy of data reported by remote and wireless reporting equipment.
Inspector	Structure Inspectors perform regulatory visual inspections of all bridges, aerial structures, tunnels, culverts, buildings and system facilities. Inspections are performed on foot and by hi-rail trucks and bucket trucks.
Welder	Welders are responsible for completing all welding and grinding requirements for track, bridges, aerial structures, tunnels and other related tasks. Welders are to be qualified for oxy-acetylene, wire-feed and in-field electronic welding applications. Working in conjunction with work gangs, their work is performed as prescribed by the daily work orders. They are equipped with a hi-rail specially outfitted vehicle such to perform any welding task.
Equipment Operator	Equipment Operators are trained on specific equipment units for their safe and practical use. They may be trained on multiple equipment units and assigned various work assignments during each work window. They report to the Foreman as assigned and have total responsibility for safe and practical operation of assigned equipment.
Laborer	Laborer positions support the work group as assigned under the direction of the Foreman leader and are responsible to provide such non-technical, miscellaneous labor services as required for an assigned task. Specifically, licensed and qualified individuals will operate trucks requiring a commercial driver license.
Mechanic	Mechanics are responsible for maintaining non-revenue equipment.
Systems Inspector	Systems Inspectors are responsible for all signal and communications maintenance activities and manage the Systems Technicians assigned to their territory. Systems Inspectors are responsible for ensuring that all required preventative maintenance tasks are performed within the required timeframes and that corrective maintenance activities are performed in accordance with the systems manuals.
Systems Technicians	Systems Technicians are responsible for the maintenance of all signal and communications equipment. Systems Technicians perform the required maintenance inspections and are the first responders to systems problems on the alignment.
Power/OCS Inspector/Foreman	The Power/OCS Inspector/Foreman is responsible for overseeing the Power and OCS personnel and performing inspections of the OCS.
OCS Technician	The OCS Technician is responsible for the maintenance activities for the overhead catenary systems.
Power Technician	The Power Technician is responsible for the maintenance of the electric traction systems.
Structures Foreman	The Structures Foreman is responsible for the maintenance of the bridges, tunnels, retaining walls, drainage systems and the MOW facilities. The Structures Foreman manages the Structures Laborers.

Position	Description
Structures Laborer	Structures Laborers report to the Structures Foreman and are responsible for performing the maintenance tasks related to bridges, tunnels, retaining walls, drainage systems and the MOW facilities.
Facilities Foreman	The Facilities Foreman is responsible for the maintenance activities related to the Heavy Maintenance Facility, Light Maintenance Facilities and Stations. The Facilities Foreman is responsible for various subcontractors performing tasks such as janitorial services, HVAC system maintenance and landscaping. The Facilities Foreman manages the Facilities Technicians.
Facilities Technician	Facilities Technicians are responsible for performing the maintenance activities at the Heavy Maintenance Facility, Light Maintenance Facility and Stations that do not require a specialized license or are not being performed by a subcontractor. The Facilities Technicians perform minor repairs and manage subcontractors when a Facilities Foreman is not available.

APPENDIX D: MAINTENANCE OF ROLLING STOCK COST RATIONALIZATION EXAMPLE

The model approximates the operations and maintenance planning that would be done by the system operator to maintain a relatively stable profile of bogie inspection and overhaul general inspection costs. The approximation involves a seven-year rolling average for all years besides the first and last three. An approximate allocation of the remaining costs is then made for the remaining years. Below is an example using fictitious numbers to demonstrate how the process is applied in the model.

The example dataset includes the following numbers:

Dataset by Years

Dataset	Total	1	2	3	4	5	6	7	8	9	10
Initial Set	48.0	1	2	4	3	8	4	8	7	3	8

Applying the rolling average to all of the years except for the first and last three yields the following results:

Dataset by Years

Dataset	Total	1	2	3	4	5	6	7	8	9	10
Rolling Averages	20.6				4.3	5.1	5.3	5.9			

To fill in the first and last three years, the model calculates the total from the first half of the years and subtracts the total from the rolling average for those years, then allocates the remainder to the empty years. For this example, for the first half, the total from the initial set was 18 while the total from the rolling average was 9.4. So, the difference (18-9.4 = 8.6) is allocated between the first three years as 1/6 in the first year, 1/3 in the second year and 1/2 in the third year. This creates the following values:

Dataset by Years

Dataset	Total	1	2	3	4	5	6	7	8	9	10
First 3 Years Allocation	8.6	1.4	2.9	4.3							

The same method is applied to the second half of the costs and the last three years, but the assumed allocation is simply 1/3 in each year. The results of the last three years of allocation produce this:

Dataset by Years

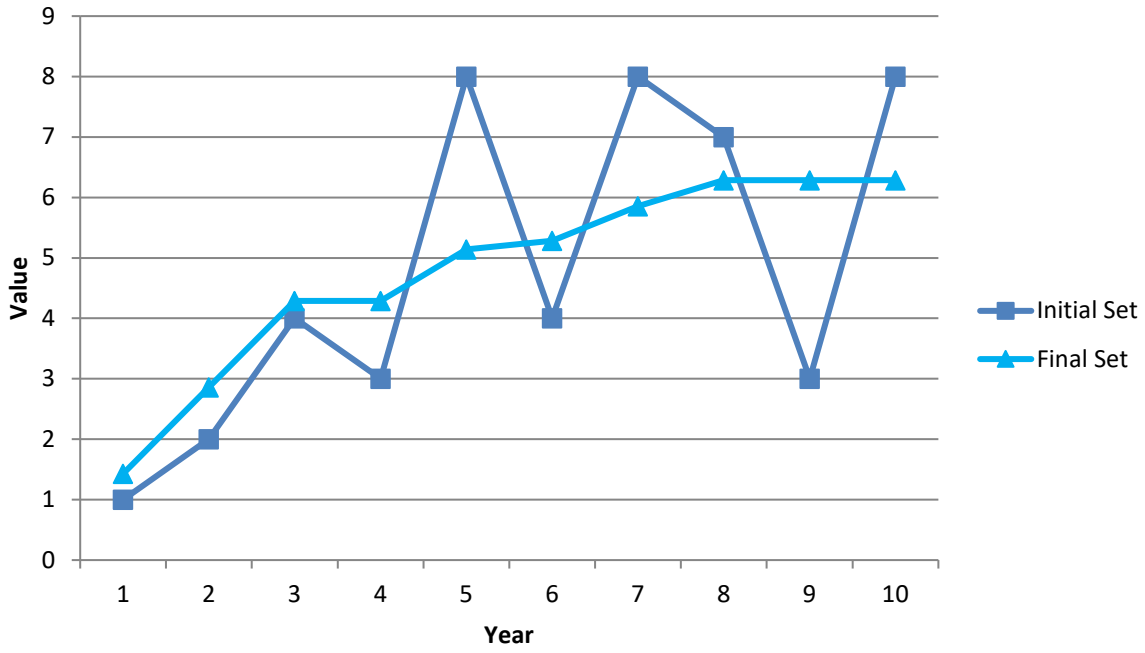
Dataset	Total	1	2	3	4	5	6	7	8	9	10
Last 3 Years Allocation	18.9								6.3	6.3	6.3

The final result of the rolling average and allocation produces the following results:

Dataset by Years

Dataset	Total	1	2	3	4	5	6	7	8	9	10
Initial Set	48.0	1	2	4	3	8	4	8	7	3	8
Final Set	48.0	1.4	2.9	4.3	4.3	5.1	5.3	5.9	6.3	6.3	6.3

The impact of the rationalization is best seen graphically:



APPENDIX E: COUNTY POPULATION PROJECTIONS

Population (thousands)

County	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Alameda	1,695.86	1,764.85	1,833.93	1,904.84	1,977.96	2,043.02	2,102.20	2,154.11	2,202.01	2,248.81	2,296.60
Alpine	1.15	1.15	1.15	1.14	1.12	1.10	1.07	1.05	1.05	1.04	1.03
Amador	38.50	40.78	42.91	44.39	45.82	46.32	46.84	47.57	48.60	49.80	51.03
Butte	232.35	243.32	254.16	263.42	271.16	278.82	286.90	294.91	303.13	311.02	319.12
Calaveras	45.31	46.32	47.39	48.72	50.07	50.34	50.72	51.43	52.60	54.03	55.49
Colusa	23.03	23.80	24.62	25.74	26.99	27.59	28.07	28.52	29.03	29.54	30.07
Contra Costa	1,170.88	1,217.64	1,265.44	1,315.78	1,363.70	1,405.22	1,440.16	1,469.64	1,498.10	1,526.05	1,554.52
Del Norte	27.40	28.05	28.78	29.88	31.11	31.33	31.52	31.81	32.27	32.83	33.39
El Dorado	190.99	200.24	207.16	210.90	223.75	230.58	236.83	243.56	252.50	262.37	272.63
Fresno	1,025.18	1,068.45	1,113.80	1,169.38	1,227.82	1,278.89	1,327.97	1,376.02	1,424.65	1,476.09	1,529.39
Glenn	29.62	30.17	30.95	32.69	34.50	35.17	35.71	36.23	36.76	37.30	37.84
Humboldt	137.35	138.44	138.97	138.43	139.67	139.32	139.19	139.00	138.95	138.71	138.46
Imperial	196.03	207.41	218.47	228.15	237.75	249.00	259.87	270.43	281.09	292.34	304.03
Inyo	18.57	18.39	18.28	18.46	18.64	18.54	18.27	17.95	17.72	17.51	17.30
Kern	917.93	956.51	998.80	1,057.29	1,117.77	1,182.86	1,245.56	1,307.24	1,370.49	1,436.71	1,506.14
Kings	154.65	161.68	168.73	175.86	182.99	190.94	198.52	205.93	213.05	220.06	227.31
Lake	65.83	66.82	68.22	71.57	75.32	76.82	78.53	80.54	82.91	85.42	88.01
Lassen	30.60	30.92	31.14	31.34	32.13	31.60	31.14	30.70	30.37	30.15	29.94
Los Angeles	10,370.03	10,519.07	10,674.18	10,846.22	11,007.32	11,081.19	11,115.84	11,107.81	11,072.54	11,029.58	10,986.80
Madera	163.08	173.62	184.41	195.98	207.26	219.64	231.83	243.78	256.39	269.10	282.44

County	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Marin	265.61	267.39	269.59	273.24	276.56	276.24	274.61	271.86	269.33	267.33	265.35
Mariposa	18.02	17.99	18.02	18.32	18.60	18.70	18.82	19.02	19.35	19.73	20.12
Mendocino	89.37	89.12	89.22	90.64	91.93	92.06	92.09	92.22	92.64	93.28	93.92
Merced	286.40	305.04	323.36	340.74	358.60	378.83	398.50	418.29	438.92	460.90	483.98
Modoc	9.38	9.26	9.25	9.78	10.43	10.21	10.01	9.90	9.84	9.82	9.79
Mono	14.18	14.89	15.63	16.62	17.71	17.65	17.44	17.10	16.76	16.47	16.18
Monterey	448.97	455.24	462.27	472.09	481.55	492.73	501.45	508.09	513.43	517.97	522.56
Napa	144.31	146.20	148.41	151.59	154.35	156.82	158.73	160.13	162.01	164.03	166.07
Nevada	99.96	101.88	103.19	103.75	106.88	109.07	111.00	114.08	118.25	122.85	127.62
Orange	3,240.20	3,305.82	3,367.82	3,413.02	3,454.74	3,491.91	3,515.52	3,523.74	3,520.56	3,515.24	3,509.93
Placer	398.10	427.49	455.61	481.49	511.57	535.17	556.07	577.02	598.79	621.73	645.55
Plumas	19.13	18.60	18.19	18.26	18.23	17.77	17.41	17.24	17.28	17.40	17.52
Riverside	2,495.37	2,669.80	2,843.19	3,009.95	3,173.07	3,302.16	3,416.73	3,519.21	3,613.09	3,707.99	3,805.38
Sacramento	1,564.27	1,634.16	1,705.50	1,785.88	1,871.18	1,952.41	2,031.44	2,108.07	2,185.52	2,264.81	2,346.97
San Benito	61.44	66.38	71.15	75.21	79.15	82.15	84.85	87.45	90.18	93.11	96.14
San Bernardino	2,233.29	2,344.14	2,457.34	2,578.83	2,698.73	2,822.06	2,945.71	3,070.62	3,200.07	3,337.64	3,481.11
San Diego	3,391.54	3,497.71	3,602.54	3,694.90	3,776.50	3,862.58	3,942.36	4,012.26	4,074.98	4,137.24	4,200.45
San Francisco	902.80	945.26	986.36	1,024.22	1,065.42	1,100.03	1,136.27	1,174.96	1,214.58	1,255.40	1,297.59
San Joaquin	768.96	798.98	832.43	880.68	930.58	971.53	1,007.89	1,041.03	1,071.45	1,102.37	1,134.19
San Luis Obispo	284.79	292.65	299.91	304.50	308.69	309.10	307.92	306.47	305.54	304.60	303.66
San Mateo	787.00	809.65	832.38	855.74	879.64	895.83	909.80	921.11	929.72	937.73	945.81
Santa Barbara	456.97	465.89	475.25	486.00	496.28	505.44	512.36	517.73	522.40	526.84	531.32

County	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Santa Clara	1,992.66	2,066.79	2,144.51	2,237.61	2,332.31	2,429.08	2,517.75	2,597.82	2,674.19	2,752.29	2,832.67
Santa Cruz	280.56	284.93	289.59	295.08	300.08	304.97	309.04	313.12	317.69	322.66	327.71
Shasta	181.69	187.26	193.06	199.63	206.04	209.52	213.38	217.42	221.90	226.37	230.94
Sierra	3.02	2.86	2.72	2.65	2.58	2.52	2.47	2.44	2.44	2.46	2.48
Siskiyou	44.25	44.02	43.95	44.50	45.01	44.79	44.73	44.99	45.66	46.51	47.38
Solano	449.64	467.45	485.15	502.40	519.68	539.72	558.07	575.21	592.31	609.67	627.53
Sonoma	513.32	523.20	533.60	545.00	554.79	563.07	568.18	572.17	576.35	580.94	585.57
Stanislaus	568.85	597.72	627.56	661.22	694.77	720.41	743.06	763.16	781.92	801.79	822.17
Sutter	100.47	103.36	106.64	111.93	117.88	122.42	126.69	131.18	135.83	140.94	146.24
Tehama	65.55	67.87	70.35	73.56	76.91	78.51	80.20	82.01	84.19	86.56	89.00
Trinity	13.48	13.38	13.34	13.83	14.69	14.72	14.89	15.23	15.75	16.32	16.90
Tulare	488.00	512.58	536.16	556.30	577.31	600.84	621.97	641.77	660.78	680.22	700.24
Tuolumne	55.49	57.86	60.14	62.11	64.18	64.23	64.44	65.02	66.00	67.21	68.44
Ventura	868.44	886.85	905.04	921.42	936.43	947.77	953.68	956.18	958.00	959.07	960.14
Yolo	226.47	237.67	249.22	262.45	276.04	292.38	308.48	324.42	340.70	357.57	375.27
Yuba	79.03	82.62	86.24	89.97	93.68	96.41	98.78	100.77	102.62	104.38	106.17
Grand Total	40,445	41,758	43,085	44,475	45,866	47,050	48,099	49,029	49,905	50,798	51,722

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APPENDIX F: AMTRAK THRUWAY AND RURAL INTERCITY BUS COSTS

Route	Full Year Estimated Expense/Bus Miles (2018 dollars)
Fresno – Bakersfield – Los Angeles – San Diego	$3.51
Bakersfield – Los Angeles – Long Beach/San Pedro	$3.51
Bakersfield – Van Nuys – Torrance (Santa Clarita)	$3.51
Stockton – Sacramento – Chico – Redding	$2.50
Fresno – Bakersfield – Los Angeles – San Diego	$3.31
Stockton – Sacramento – Chico – Redding	$3.23
Stockton – Sacramento – Chico – Redding	$2.50
Stockton – San Jose	$3.50
Martinez – Napa – Santa Rosa – Eureka – Mckinleyville	$3.30
Bakersfield – Las Vegas	$3.51
Bakersfield – Santa Barbara	$3.33
Victorville – Bakersfield	$3.51
Hanford – Santa Maria	$3.46
Visalia – Hanford	$3.45
Bakersfield – Riverside – Hemet/Bakersfield – Riverside – Palm Springs – Indio	$3.51
San Luis Obispo – Santa Barbara	$3.45
Santa Barbara – Los Angeles	$3.45
Fullerton – Palm Springs	$3.45
Palm Springs – Indio	$3.45
Weighted Average	**$3.45**

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APPENDIX G: ALLOCATED CONTINGENCY RISK/UNCERTAINTY RATINGS AND PERCENTAGES

Table 35 Overall Team Member Assessment and Allocated Contingency Percentages

Cost Factor	Team Member 1 Assessment	Team Member 2 Assessment	Team Member 3 Assessment	Team Member 4 Assessment	Average	Contingency
Labor						
Maintenance of Rolling Stock	4	4	4	4	4.00	20.00
Maintenance of Infrastructure	3	4	3	4	3.50	22.50
On-board staff (including Road Manager and protect crews)	3	4	3	5	3.75	21.25
Dispatching	5	5	5	4	4.75	16.25
Train Cleaning and Station Maintenance Staff	4	5	4	4	4.25	18.75
Stations	3	3	4	4	3.50	22.50
Police and Security	4	4	-	5	4.33	18.33
General and Administrative Staff	3	4	4	4	3.75	21.25
Materials, Tools and Other Direct Costs						
Maintenance of Infrastructure Materials (including stations)	3	4	4	3	3.50	22.50
Maintenance of Infrastructure Tools, Uniforms, Etc.	2.5	5	5	3	3.88	20.63
Maintenance of Infrastructure Vehicle Leasing Rates	2	3	3	4	3.00	25.00
Vehicles Besides Maintenance of Infrastructure and Police and Security	3	4	-	4	3.67	21.67
Police and Security Vehicles	4	4	-	4	4.00	20.00
Police and Security Equipment	4	4	-	4	4.00	20.00
Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.) for Every Department	4	4	-	5	4.33	18.33

Cost Factor	Team Member 1 Assessment	Team Member 2 Assessment	Team Member 3 Assessment	Team Member 4 Assessment	Average	Contingency
Maintenance of Rolling Stock Tools, Uniforms, Etc.	2.5	5	5	3	3.88	20.63
Maintenance of Rolling Stock Regulatory Inspections	3	4	4	4	3.75	21.25
Maintenance of Rolling Stock General Overhauls and Bogie Inspections	3	5	4	2	3.50	22.50
Utilities						
Train Operations Energy	3.5	5	4	4	4.13	19.38
Stations and Maintenance Facilities Energy	4	3	3	4	3.50	22.50
Station and Maintenance Facility Water and Sewer	3.5	2		4	3.17	24.17
Other Costs						
Bus Costs	4.5	2	4	3	3.38	23.13
Advertising	4	4	-	3	3.67	21.67
Revenue Collection	4	4	-	4	4.00	20.00
Marketing & Branding, incl. Advertising and Call Center	3	4	-	4	3.67	21.67
Insurance	4	4	-	5	4.33	18.33

APPENDIX H: ANCILLARY REVENUE TECHNICAL DOCUMENTATION

Overview of Ancillary Revenues

The Authority's business plans contemplate the potential for the high-speed rail system to generate revenues ancillary to farebox revenues that support the system's financial feasibility. These ancillary revenues (i.e., non-farebox operating revenues) are captured in the final *2020 Business Plan* as a percentage of farebox revenues.

Developing a List of Ancillary Revenue Opportunities

The Authority regularly evaluates opportunities to pursue ancillary revenues. In prior business plans, the Authority included planning assumptions, indicating ancillary revenues could range from 1 percent to 4 percent of farebox revenues. Since the publication of the *2016 Business Plan,* the Authority has undertaken more extensive research and market analysis of potential ancillary revenue sources from the system's real property, rights of way and ridership.

The methodology to calculate an ancillary revenue estimate for the final *2020 Business Plan* follows the guiding principles and values driving the Authority's advancement of the high-speed rail program. Ancillary revenue opportunities potentially available to the Authority were identified and screened. The screening process included:

- **Research into peer agencies and the airline industry,** which enabled the sourcing of creative commercial options, identification of a potential range of benefits and identification of benchmarks from which estimates could be evaluated; and
- **An Authority review process** that identified and narrowed the field of available opportunities, as well as determined order of magnitude estimates for each opportunity.

Categorizing the Ancillary Revenues

The Authority's ability to access and generate revenue from an ancillary revenue opportunity is dependent, in part, on the ease of implementation and alignment with its policies and regulatory environment.

The ancillary revenue opportunities were grouped into four stand-alone categories (i.e., Category 1, Category 2, Category 3 and Category 4), which correspond to their relative implementation profile. The revenue categories were defined as follows:

- **Category 1 – Line of Site Opportunities:** Category 1 ancillary revenues represent the most directly accessible revenue sources, given their low complexity of implementation.
- **Category 2 – Joint Development/Partnership:** Category 2 ancillary revenues represent the next most accessible grouping. Each contemplates or materially is tied to a partnership with a public partner, developer or third-party to commercially develop station sites, right-of-way and/or other Authority-owned parcels. Consequently, the feasibility of achieving revenue related to these sources hinges on the Authority's ability to enter into commercial agreements.
- **Category 3 – Public Tools for Financing/Funding Development:** Category 3 ancillary revenues represent potential tools for financing and funding development at or within a certain radius of the station sites.
- **Category 4 – New Tax/Fee:** Category 4 ancillary revenues represent the least accessible set of options based on the relevant approvals required for a new tax or fee.

Shortlisting and Benchmarking Revenue Opportunities for the Final *2020 Business Plan*

The Authority undertook a review of various ancillary revenue opportunities and down-selected 13 streams for inclusion in the final *2020 Business Plan*. Down-selection of these 13 opportunities was informed by the opportunities' ease of implementation, as well as a desire to arrive at a reasonable and conservative estimate for planning purposes. Opportunities potentially requiring legislative action and/or posing significant risk were excluded. For the purpose of estimating ancillary revenue to inform the final *2020 Business Plan,* the 13 ancillary revenue opportunities outlined in Figure 2 were included.

For each of the ancillary revenue opportunities included in the final *2020 Business Plan,* the Authority analyzed peer agencies and comparable operators (both in the transit and airline sectors), as well as local market conditions, to establish a set of low, medium and high order of magnitude benchmarks to estimate the ancillary revenue potential. Each of these benchmarks was applied against a base metric such as ridership, number of stations or right of way. By way of example, transit agencies and airport advertising contracts were researched to determine a low, medium and high benchmark for advertising revenue per passenger. These benchmarks were then applied against the system's annual ridership forecasts provided by the Authority's technical consultants. Each of the ancillary revenues were calculated on a net ancillary revenue basis, taking into account the costs of their pursuit. Revenue from each opportunity incorporated key timing parameters and drivers of project phases, including the timing of pre-operations, operations and mature operations periods for the Silicon Valley to Central Valley Line and Phase 1 segments as in Figure 2 below.

The major difference with the *2018 Business Plan* is that the baggage fees were not included in the *2020 Business Plan* and that a new revenue source, Low Carbon Fuel Standard Credits were included in the *2020 Business Plan*. The decision to exclude/include these revenue sources, respectively, was a policy decision by the Authority.

Excursus:

California's Low Carbon Fuel Standards (LCFS) are a set of regulations intended to reduce the carbon intensity of California's transportation fuels by creating a commodity (LCFS credits), of which positive amounts (credits) are generated by low-carbon fuel producers and negative amounts (deficits or obligations) are generated by high-carbon fuel producers. LCFS credits are traded by generators, obligated parties and intermediaries/traders.

As a fixed-guideway transportation system, under current California Air Resources Board (CARB) regulations, the Authority will be eligible to generate LCFS credits from its use of electricity as a transportation fuel.

LCFS regulations determine eligibility to generate credits as well as the formulas for the quantity of credits generated. The volume of credits depends on the transportation fuel being used, the carbon intensity (CI) of the fuel, the fuel that is being displaced (either gasoline or diesel), the CI of the displaced fuel and the amount of fuel being used for transportation by the reporting party.

The marketplace determines the value of the credits.

Under current regulations, electrified heavy-rail transportation coming into service after January 1, 2011 produces LCFS credits according to the following formula. This formula uses input values from CARB (2018); Energy Economy Ratio is EER.

Credits = [Diesel CI – (Grid Electricity CI / EER)] * EER * Energy Density / 1,000,000 * kWh

The *2020 Business Plan* does not include any revenues from LCFS credits. The actual program expires before the Silicon Valley to Central Valley operation starts. Even if a follow-up program is implemented, to maintain a conservative approach, no revenues are considered.

Ancillary Revenue Opportunities Evaluated for the Final *2020 Business Plan*

1. Category 1 ancillary revenue opportunities (12 total):
   - Billboard advertising
   - Advertising (rolling stock and station level)
   - Excess land (fee simple interest)
   - Parking fees
   - Retail (station level)
   - Sponsorship – branding exclusivity
   - Sponsorship – station naming
   - Sponsorship – system naming
   - Telco – towers
   - Telco – longitudinal fiber[44]
   - Web-based advertising
   - Low carbon fuel standard credits
2. Category 2 ancillary revenue opportunities (one total):
   - Ground leases
3. Category 3 ancillary revenue opportunities (zero):
   - None were considered for inclusion in the *2020 Business Plan*[45]
4. Category 4 ancillary revenue opportunities (zero):
   - None were considered for inclusion in the *2020 Business Plan*[46]

Ancillary Revenue Analysis Results

The analysis for the final *2020 Business Plan* estimates ancillary revenues available to the Authority, assuming a delivery of the Silicon Valley to Central Valley Line segment (San Francisco to Bakersfield) in December 2031, with the balance of Phase 1 delivered in December 2033, and offers estimates in the form of revenues available and as a percentage of farebox revenue assuming high, medium and low ridership as forecasted by the Authority's technical consultants. The results of the analysis are presented as follows:

Ancillary totals in the table on the next page are raw model outputs used to derive a 2 percent estimate, and reflect opportunities through 2060 (inclusive of pre-operations, operations and mature operations periods).

[44] While the Authority believes there is market support for the telecommunications fiber revenue opportunity, it likely requires some changes to existing legislation or executive action for revenues to be realized by the Authority.

[45] Category 3 and 4 opportunities are excluded from this analysis due to their uncertainty and the high degree of complexity associated with realizing such revenues.

[46] Category 3 and 4 opportunities are excluded from this analysis due to their uncertainty and the high degree of complexity associated with realizing such revenues.

Table 36 Ancillary Revenue Benchmarks for Silicon Valley to Central Valley Line to Phase 1 System

Benchmark	Low Ridership (%)	Low Ridership ($'MM 2019)	Medium Ridership (%)	Medium Ridership ($'MM 2019)	High Ridership (%)	High Ridership ($'MM 2019)
Cumulative Farebox Revenues	56,824		67,277		94,485	
Low Cumulative Ancillary Revenue Benchmark	1.2%	704	1.0%	704	0.7%	704
Medium Cumulative Ancillary Revenue Benchmark	2.3%	1,327	2.0%	1,327	1.4%	1,327
High Cumulative Ancillary Revenue Benchmark	3.5%	2,002	3.0%	2,002	2.1%	2,002

Please note that cumulative ancillary revenue estimates vary by low, medium and high scenario assumptions. These assumptions do not include changes in ridership, as they are not expected to have a material impact on the current ancillary revenue categories used in the *2020 Business Plan*.

The analysis yielded a range of ancillary revenues from 1 percent to almost 4 percent of farebox revenues. Based on these results and consistent with the medium ancillary revenue benchmarks, **a flat 2 percent of farebox revenues will be applied as the ancillary revenue estimate** in each year of operations for the high, medium and low ridership scenarios in the final *2020 Business Plan.*

APPENDIX I: FRA WORK BREAKDOWN STRUCTURE

Below is the chart of accounts produced by the model in the form of the Federal Railroad Administration developed work breakdown structure for operations and maintenance costs.

100 Maintenance of Way

101 Maintenance of Way Track

- 101.1 Maintenance of Infrastructure Track Salary + Benefits
  - 101.1.01 Maintenance of Infrastructure Track Foremen
  - 101.1.02 Maintenance of Infrastructure Track Inspectors
  - 101.1.03 Maintenance of Infrastructure Track Assistant Inspectors
  - 101.1.04 Maintenance of Infrastructure Track Equipment Operators
  - 101.1.05 Maintenance of Infrastructure Track Laborers
  - 101.1.06 Maintenance of Infrastructure Track Mechanics
  - 101.1.07 Maintenance of Infrastructure Track Truck Drivers
  - 101.1.08 Maintenance of Infrastructure Track Welders
  - 101.1.09 Maintenance of Infrastructure Track Welder Helpers
  - 101.1.10 Maintenance of Infrastructure Track Manager
  - 101.1.11 Maintenance of Infrastructure Track Engineer
  - 101.1.12 Maintenance of Infrastructure Track Supervisor
  - 101.1.13 Maintenance of Infrastructure Track Overtime
  - 101.1.14 Weed Spraying Cost
- 101.2 Maintenance of Infrastructure Surfacing Salary + Benefits
  - 101.2.01 Maintenance of Infrastructure Surfacing Foremen
  - 101.2.02 Maintenance of Infrastructure Surfacing Assistant Formen
  - 101.2.03 Maintenance of Infrastructure Surfacing Inspectors
  - 101.2.04 Maintenance of Infrastructure Surfacing Equipment Operators
  - 101.2.05 Maintenance of Infrastructure Surfacing Mechanics
  - 101.2.06 Maintenance of Infrastructure Surfacing Truck Drivers
- 101.3 Maintenance of Infrastructure Rail Grinding Salary + Benefits
  - 101.3.01 Maintenance of Infrastructure Rail Grinding Equipment Operators
  - 101.3.02 Maintenance of Infrastructure Rail Grinding Laborers
  - 101.3.03 Maintenance of Infrastructure Rail Grinding Technicians
  - 101.3.04 Rail Grinding Cost
- 101.4 Maintenance of Infrastructure Condensed Track Inspection Salary + Benefits
  - 101.4.01 Maintenance of Infrastructure Condensed Track Inspection Equipment Operators
  - 101.4.02 Maintenance of Infrastructure Condensed Track Inspection Laborers
  - 101.4.03 Maintenance of Infrastructure Condensed Track Inspection Technicians
- 101.5 Maintenance of Infrastructure Work Train Salary + Benefits
  - 101.5.01 Maintenance of Infrastructure Work Train Locomotive Engineer
  - 101.5.02 Maintenance of Infrastructure Work Train Conductor
- 101.6 Maintenance of Infrastructure Track, Surfacing, Grinding and Track Inspection Tools, etc.
  - 101.6.01 Track
  - 101.6.02 Surfacing
  - 101.6.03 Rail Grinding
  - 101.6.04 Condensed Track Inspection
  - 101.6.05 Work Train
- 101.7 Maintenance of Infrastructure Track, Surfacing, Grinding and Track Inspection Vehicle Leasing Costs

101.7.01 Track
101.7.02 Surfacing
101.7.03 Rail Grinding
101.7.04 Condensed Track Inspection
101.7.05 Work Train
101.8 Maintenance of Infrastructure Track, Surfacing, Grinding and Track Inspection Materials Costs
101.8.01 Track
101.8.02 Surfacing
101.8.03 Rail Grinding
101.8.04 Condensed Track Inspection
101.8.05 Work Train
101.9 Track Access Fee
101.9.01 Track Access Fee
102 Maintenance of Way Communications & Signal
102.1 Maintenance of Infrastructure Signal Salary + Benefits
102.1.01 Maintenance of Infrastructure Signals Foremen
102.1.02 Maintenance of Infrastructure Signals Equipment Operators
102.1.03 Maintenance of Infrastructure Signals Systems Engineers
102.1.04 Maintenance of Infrastructure Signals Engineers
102.1.05 Maintenance of Infrastructure Signals Inspectors
102.1.06 Maintenance of Infrastructure Signals Maintainers
102.1.07 Maintenance of Infrastructure Signal Systems Manager
102.1.08 Maintenance of Infrastructure Signal Overtime
102.2 Maintenance of Infrastructure Communication Salary + Benefits
102.2.01 Maintenance of Infrastructure Communications Foremen
102.2.02 Maintenance of Infrastructure Communications Equipment Operators
102.2.03 Maintenance of Infrastructure Communications Engineers
102.2.04 Maintenance of Infrastructure Communications Technicians
102.2.05 Maintenance of Infrastructure Communications Inspectors
102.3 Maintenance of Infrastructure Signal and Communications Tools etc.
102.3.01 Signal
102.3.02 Communications
102.4 Maintenance of Infrastructure Signal and Communications Vehicle Leasing Costs
102.4.01 Signal
102.4.02 Communications
102.5 Maintenance of Infrastructure Signal and Communications Materials Costs
102.5.01 Signal
102.5.02 Communications
103 Maintenance of Way Electric Traction
103.1 Maintenance of Infrastructure Overhead Catenary Salary + Benefits
103.1.01 Maintenance of Infrastructure Overhead Catenary Foremen
103.1.02 Maintenance of Infrastructure Overhead Catenary Assistant Foremen
103.1.03 Maintenance of Infrastructure Overhead Catenary Inspectors
103.1.04 Maintenance of Infrastructure Overhead Catenary Equipment Operators
103.1.05 Maintenance of Infrastructure Overhead Catenary Laborers
103.1.06 Maintenance of Infrastructure Overhead Catenary Truck Drivers
103.1.07 Maintenance of Infrastructure Overhead Catenary Lead Wiremen

- 103.1.08 Maintenance of Infrastructure Overhead Catenary Electricians
- 103.1.09 Maintenance of Infrastructure Overhead Power/OCS Manager
- 103.1.10 Maintenance of Infrastructure Overhead Power/OCS Supervisor
- 103.1.11 Maintenance of Infrastructure Overhead Overhead Catenary Overtime

103.2 Maintenance of Infrastructure Electric Transmission Salary + Benefits

- 103.2.01 Maintenance of Infrastructure Electric Transmission Foremen
- 103.2.02 Maintenance of Infrastructure Electric Transmission Inspectors
- 103.2.03 Maintenance of Infrastructure Electric Transmission Equipment Operators
- 103.2.04 Maintenance of Infrastructure Electric Transmission Laborers
- 103.2.05 Maintenance of Infrastructure Electric Transmission Overtime

103.3 Maintenance of Infrastructure Overhead Catenary and Electric Transmission/Substation Tools, etc.

- 103.3.01 Overhead Catenary
- 103.3.02 Electric Transmission/Substation

103.4 Maintenance of Infrastructure Overhead Catenary and Electric Transmission/Substation Vehicle Leasing Costs

- 103.4.01 Overhead Catenary
- 103.4.02 Electric Transmission/Substation

103.5 Maintenance of Infrastructure Overhead Catenary and Electric Transmission/Substation Materials Costs

- 103.5.01 Overhead Catenary
- 103.5.02 Electric Transmission/Substation

104 Maintenance of Way Bridges and Buildings

104.1 Maintenance of Infrastructure RR Structures Salary + Benefits

- 104.1.01 Maintenance of Infrastructure RR Structures Foremen
- 104.1.02 Maintenance of Infrastructure RR Structures Inspectors
- 104.1.03 Maintenance of Infrastructure RR Structures Equipment Operators
- 104.1.04 Maintenance of Infrastructure RR Structures Laborers
- 104.1.05 Maintenance of Infrastructure RR Structures Truck Drivers
- 104.1.06 Maintenance of Infrastructure RR Structures Manager
- 104.1.07 Maintenance of Infrastructure RR Structures Engineer
- 104.1.08 Maintenance of Infrastructure RR Structures Overtime

104.2 Maintenance of Infrastructure Right-of-Way Structures Salary + Benefits

- 104.2.01 Maintenance of Infrastructure Right-of-Way Structures Foremen
- 104.2.02 Maintenance of Infrastructure Right-of-Way Structures Inspectors
- 104.2.03 Maintenance of Infrastructure Right-of-Way Structures Equipment Operators
- 104.2.04 Maintenance of Infrastructure Right-of-Way Structures Laborers
- 104.2.05 Maintenance of Infrastructure Right-of-Way Structures Truck Drivers

104.3 Maintenance of Infrastructure Stations / Wayside

- 104.3.01 Maintenance of Infrastructure Stations / Wayside Foremen
- 104.3.02 Maintenance of Infrastructure Stations / Wayside Equipment Operators
- 104.3.03 Maintenance of Infrastructure Stations / Wayside Laborers
- 104.3.04 Maintenance of Infrastructure Stations / Wayside Truck Drivers
- 104.3.05 Maintenance of Infrastructure Stations / Wayside Electricians
- 104.3.06 Maintenance of Infrastructure Stations / Wayside Plumbers
- 104.3.07 Maintenance of Infrastructure Stations / Wayside Chief Engineers
- 104.3.08 Maintenance of Infrastructure Stations / Wayside Journeyman Engineers
- 104.3.09 Maintenance of Infrastructure Stations / Wayside Utility Engineers

- 104.3.10 Maintenance of Infrastructure Stations / Wayside Facility Managers
- 104.3.11 Maintenance of Infrastructure Stations / Wayside Assistant Facility Managers
- 104.3.12 Maintenance of Infrastructure Stations / Wayside Overtime
- 104.3.13 Maintenance of Infrastructure Station Subcontractor Costs

104.4 Maintenance of Infrastructure RR & Right-of-Way Structures and Stations Tools etc.

- 104.4.01 RR Structures
- 104.4.02 Right-of-Way Structures
- 104.4.03 Stations/Wayside

104.5 Maintenance of Infrastructure RR and Right-of-Way Structures Vehicle Leasing Costs

- 104.5.01 RR Structures
- 104.5.02 Right-of-Way Structures
- 104.5.03 Stations/Wayside

104.6 Maintenance of Infrastructure RR and Right-of-Way Structures Vehicle Leasing Costs

- 104.6.01 RR Structures
- 104.6.02 Right-of-Way Structures
- 104.6.03 Stations/Wayside

105 Maintenance of Way Supplies & Expenses

105.1 Maintenance of Infrastructure Supplies & Expenses

- 105.1.01 Total Uniform and Supplies Costs
- 105.1.02 Total IT/Software Costs
- 105.1.03 Total Cell Phones Costs

106 Maintenance of Way Allocated Contingencies

106.1 Allocated Contingencies

- 106.1.01 Maintenance of Infrastructure Labor (Allocated Contingency)
- 106.1.02 Maintenance of Infrastructure Materials (including stations) Allocated Contingency Rate (Allocated Contingency)
- 106.1.03 Maintenance of Infrastructure Tools etc. Allocated Contingency Rate (Allocated Contingency)
- 106.1.04 Maintenance of Infrastructure Vehicle Leasing Rates Allocated Contingency Rate (Allocated Contingency)
- 106.1.05 Maintenance of Infrastructure Supplies + Expenses (Allocated Contingency)

201 Maintenance of Rolling Stock Turnaround

201.1 Station Train Turn Salaries (Turn Based)

- 201.1.01 Station Train Turn Salaries (Turn Based)

201.2 Maintenance of Rolling Stock Inspection Cleaners Salary + Benefits

- 201.2.01 Maintenance of Rolling Stock Inspection Cleaners Total Salary and Benefits

201.3 Station Train Turn Subcontractor Cost

- 201.3.01 Station Turn Subcontractor Costs

202 Loco Maintenance

203 Car Maintenance

203.1 Monthly and Quarterly Inspection Costs

- 203.1.01 Annual Monthly Inspection Cost
- 203.1.02 Annual 92-Day Inspection Cost

203.2 Maintenance of Rolling Stock Technician Wages + Fringe (Ex Overhauls)

- 203.2.01 Maintenance of Rolling Stock Inspection Supervisors Total Salary and Benefits
- 203.2.02 Maintenance of Rolling Stock Inspection Technicians Total Salary and Benefits
- 203.2.03 Maintenance of Rolling Stock Inspection Laborers Total Salary and Benefits

- 203.2.04 Maintenance of Rolling Stock Inspection Storehouse Employees Payroll
- 203.3 Maintenance of Rolling Stock Tools etc. (Ex Overhauls)
  - 203.3.01 Maintenance of Rolling Stock Tools etc. (Ex Overhauls)
- 203.4 Routine Inspection Costs
  - 203.4.01 Annual Daily Inspection Cost
- 203.5 Maintenance and Cleaning Costs
  - 203.5.01 Total Trainset Corrective Maintenance Costs
  - 203.5.02 Total Trainset Cleaning Costs

204 Major Repairs - Expensed

- 204.1 Overhaul and Bogie Inspection Crew Salaries + Benefits
  - 204.1.01 Smoothed Maintenance of Rolling Stock Technician Wages + Fringe
- 204.2 Overhaul and Bogie Inspection Materials Costs
  - 204.2.01 Smoothed Trainset Maintenance of Rolling Stock Costs + Wi-Fi Costs
- 204.3 Maintenance of Rolling Stock Tools etc.
  - 204.3.01 Maintenance of Rolling Stock Tools etc.

205 Maintenance of Rolling Stock Energy

- 205.1 Maintenance Facility Energy Usage
  - 205.1.01 HMF Square Feet Maintenance Facility Energy Cost
  - 205.1.02 Brisbane Facility Square Feet Maintenance Facility Energy Cost
  - 205.1.03 Los Angeles Facility Square Feet Maintenance Facility Energy Cost

206 Maintenance of Rolling Stock Vehicles

- 206.1 Vehicles
  - 206.1.01 Total Cost of Vehicles for Maintenance of Rolling Stock

207 Maintenance of Rolling Stock Supplies & Expenses

- 207.1 Employee Supplies & Expenses
  - 207.1.01 Total Uniform and Supplies Costs
  - 207.1.02 Total IT/Software Costs
  - 207.1.03 Total Cell Phones Cost
- 207.2 Water & Sewer
  - 207.1.01 Total Water Costs for Maintenance Facilities
  - 207.1.02 Total Sewer Costs for Maintenance Facilities

208 Maintenance of Rolling Stock Allocated Contingencies

- 208.1 Allocated Contingencies
  - 208.1.01 Maintenance of Rolling Stock Labor (Allocated Contingency)
  - 208.1.02 Maintenance of Rolling Stock Tools etc. Allocated Contingency Rate (Allocated Contingency)
  - 208.1.03 Maintenance of Rolling Stock Regulatory Inspections Allocated Contingency Rate (Allocated Contingency)
  - 208.1.04 Stations Energy Allocated Contingency Rate (Allocated Contingency)
  - 208.1.05 Train Cleaning Staff Allocated Contingency Rate (Allocated Contingency)
  - 208.1.06 Maintenance of Rolling Stock General Overhauls and Bogey Inspections Allocated Contingency Rate (Allocated Contingency)
  - 208.1.07 Maintenance of Rolling Stock Supplies + Expenses (Allocated Contingency)
  - 208.1.08 Vehicles for Maintenance of Rolling Stock (Allocated Contingency)
  - 208.1.09 Maintenance Facility Water and Sewer (Allocated Contingency)

301 Onboard Services (OBS)

- 301.1 Onboard Personnel

301.1.01 Assistant Conductors - Single Trainset Total Salary and Benefits
301.1.02 Assistant Conductor - Double Trainset Total Salary and Benefits
301.1.03 On-Board Assistants (OBA) - Single Trainset Total Salary and Benefits
301.1.04 On-Board Assistants (OBA) - Double Trainset Total Salary and Benefits
301.2 Protect Crews
301.2.01 Assistant Conductor - Protect Total Salary and Benefits
302 Trainmen & Enginemen (T&E)
302.1 Onboard Personnel
302.1.01 Locomotive Engineers - Total Salary and Benefits
302.1.02 Locomotive Engineers - Double Trainset Total Salary and Benefits
302.1.03 Conductors - Single Trainset Total Salary and Benefits
302.1.04 Conductors - Double Trainset Total Salary and Benefits
302.2 Protect Crews
302.2.01 Locomotive Engineers - Protect Total Salary and Benefits
302.2.02 Conductor - Protect Total Salary and Benefits
303 Yard
303.1 Yard Dispatch Salaries + Benefits
303.1.01 HMF - Facility Train Dispatcher Total Salary and Benefits
303.1.02 Trainset Maintenance Facility - Facility Train Dispatcher Total Salary and Benefits
303.2 Drill Crews
303.3.01 Drill Crew Locomotive Engineers Total Salary and Benefits
303.3.02 Drill Crew Conductors Total Salary and Benefits
304 Fuel
305 Power - Electric Traction
305.1 Systemwide Trainset Energy Costs
305.1.01 Systemwide Single Trainset Energy Cost
305.1.02 HVAC Energy Cost
306 Train Movement
306.1 Operations Control Center
306.1.01 Operations Control Center - Director of Operations Control Total Salary and Benefits
306.1.02 Operations Control Center - Deputy Director of Operations Control Total Salary and Benefits
306.1.03 Operations Control Center - Train Dispatcher Total Salary and Benefits
307 Train Movement - Railroad Services
308 Vehicles
308.1 Operations
308.1.01 Total Cost of Vehicles for Operations
308.2 Dispatching
308.2.01 Total Cost of Vehicles for Dispatching
309 Supplies & Expenses
309.1 Employee Supplies & Expenses
309.1.01 Total On-Board Employees Uniform Costs
309.1.02 Total On-Board Frontline Employees Office Supplies Costs
309.1.03 On-Board Frontline Cell Phones, Tablet, and Field Device Allowance Cost
309.1.04 Total Dispatchers Employees Office Supplies Costs
309.1.05 Dispatchers Cell Phones, Tablet, and Field Device Allowance Cost
310 Transportation Support
310.1 Operations

310.1.01 Road Manager - Total Salary and Benefits
310.1.02 Operations Control Center Energy Cost
301.1.05 Planning Director - Total Salary and Benefits
301.1.06 Scheduler - Total Salary and Benefits
301.1.07 Performance and Data Manager - Total Salary and Benefits

311 Connecting Bus Services

311.1 Bus Contracts

311.1.01 Total Bus Contract Costs

312 Transportation Allocated Contingencies

312.1 Allocated Contingencies

312.1.01 Bus Costs Allocated Contingency Rate (Allocated Contingency)
312.1.02 On-Board Staff Labor (Allocated Contingency)
312.1.03 Dispatching Labor (Allocated Contingency)
312.1.04 Train Operations Energy Allocated Contingency Rate (Allocated Contingency)
312.1.05 On-Board Supplies + Expenses (Allocated Contingency)
312.1.06 Dispatching Supplies + Expenses (Allocated Contingency)
312.1.07 Vehicles for Operations (Allocated Contingency)
312.1.08 Vehicles for Dispatching (Allocated Contingency)

401 Sales

401.1 Credit Card/Bank Fees

401.1.01 Credit Card/Bank Fees
401.1.02 Revenue Collection Costs

402 Information & Reservations

402.1 Call Center

402.1.01 Call Center Commissions

403 Marketing

403.1 Marketing & Advertising Costs

403.1.01 Alameda County Marketing Cost
403.1.02 Alpine County Marketing Cost
403.1.03 Amador County Marketing Cost
403.1.04 Butte County Marketing Cost
403.1.05 Calaveras County Marketing Cost
403.1.06 Colusa County Marketing Cost
403.1.07 Contra Costa County Marketing Cost
403.1.08 Del Norte County Marketing Cost
403.1.09 El Dorado County Marketing Cost
403.1.10 Fresno County Marketing Cost
403.1.11 Glenn County Marketing Cost
403.1.12 Humboldt County Marketing Cost
403.1.13 Imperial County Marketing Cost
403.1.14 Inyo County Marketing Cost
403.1.15 Kern County Marketing Cost
403.1.16 Kings County Marketing Cost
403.1.17 Lake County Marketing Cost
403.1.18 Lassen County Marketing Cost
403.1.19 Los Angeles County Marketing Cost
403.1.20 Madera County Marketing Cost

403.1.21 Marin County Marketing Cost
403.1.22 Mariposa County Marketing Cost
403.1.23 Mendocino County Marketing Cost
403.1.24 Merced County Marketing Cost
403.1.25 Modoc County Marketing Cost
403.1.26 Mono County Marketing Cost
403.1.27 Monterey County Marketing Cost
403.1.28 Napa County Marketing Cost
403.1.29 Nevada County Marketing Cost
403.1.30 Orange County Marketing Cost
403.1.31 Placer County Marketing Cost
403.1.32 Plumas County Marketing Cost
403.1.33 Riverside County Marketing Cost
403.1.34 Sacramento County Marketing Cost
403.1.35 San Benito County Marketing Cost
403.1.36 San Bernardino County Marketing Cost
403.1.37 San Diego County Marketing Cost
403.1.38 San Francisco County Marketing Cost
403.1.39 San Joaquin County Marketing Cost
403.1.40 San Luis Obispo County Marketing Cost
403.1.41 San Mateo County Marketing Cost
403.1.42 Santa Barbara County Marketing Cost
403.1.43 Santa Clara County Marketing Cost
403.1.44 Santa Cruz County Marketing Cost
403.1.45 Shasta County Marketing Cost
403.1.46 Sierra County Marketing Cost
403.1.47 Siskiyou County Marketing Cost
403.1.48 Solano County Marketing Cost
403.1.49 Sonoma County Marketing Cost
403.1.50 Stanislaus County Marketing Cost
403.1.51 Sutter County Marketing Cost
403.1.52 Tehama County Marketing Cost
403.1.53 Trinity County Marketing Cost
403.1.54 Tulare County Marketing Cost
403.1.55 Tuolumne County Marketing Cost
403.1.56 Ventura County Marketing Cost
403.1.57 Yolo County Marketing Cost
403.1.58 Yuba County Marketing Cost
403.1.59 Marketing - Total Salary and Benefits
403.1.60 Marketing - External costs

404 Sales and Marketing Allocated Contingencies

404.1 Allocated Contingencies

404.1.01 Advertising Allocated Contingency Rate (Allocated Contingency)
404.1.02 Distribution Allocated Contingency Rate (Allocated Contingency)
404.1.03 Credit Card Sales Allocated Contingency Rate (Allocated Contingency)

501 Stations

501.1 Station Maintenance

- 501.1.01 Station Maintenance - A Total Salary and Benefits
- 501.1.02 Station Maintenance - B Total Salary and Benefits
- 501.1.03 Station Maintenance - C Total Salary and Benefits
- 501.1.04 Station Maintenance Subcontractor Costs
- 501.1.04 Station Maintenance Frontline Total Salary and Benefits

501.2 Station Service Staff

- 501.2.01 Agent/Station Manager - Int Total Salary and Benefits
- 501.2.02 Ticket Clerk - Int Total Salary and Benefits
- 501.2.03 Agent/Station Manager - Key Int Total Salary and Benefits
- 501.2.04 Ticket Clerk - Key Int Total Salary and Benefits
- 501.2.05 Agent/Station Manager - Term Total Salary and Benefits
- 501.2.06 Ticket Clerk - Term Total Salary and Benefits
- 501.2.07 Station Crew Frontline Total Salary and Benefits

501.3 Station Utilities

- 501.3.01 Station Energy Usage (kWh) Cost

501.4 Station Access Fee

- 501.4.01 Station Access Fee

502 Vehicles

502.1 Station Vehicles

- 502.1.01 Total Cost of Vehicles for Stations

503 Supplies & Expenses

503.1 Employee Supplies & Expenses

- 503.1.01 Total Uniform and Supplies Costs
- 503.1.02 Total Cell Phones Costs
- 503.1.03 Total Software/IT Costs

503.2 Water & Sewer

- 503.2.01 Total Water Costs for Stations
- 503.2.02 Total Sewer Costs for Stations

504 Stations Allocated Contingencies

504.1 Allocated Contingencies

- 504.1.01 Stations Labor (Allocated Contingency)
- 504.1.02 Stations Energy Allocated Contingency Rate (Allocated Contingency)
- 504.1.03 Stations Supplies + Expenses (Allocated Contingency)
- 504.1.04 Vehicles for Stations (Allocated Contingency)
- 504.1.05 Station Water and Sewer (Allocated Contingency)

601 Police and Security

601.1 Sworn Police Officers

- 601.1.01 Sworn Officers at Maintenance Facilities Total Salary and Benefits
- 601.1.02 Level B/C Station Sworn Officer Salary and Benefits
- 601.1.03 Level A Station Sworn Officer Salary and Benefits
- 601.1.05 Sworn Police Officer Frontline Salary and Benefits

601.2 Unsworn Security Officers

- 601.2.01 Unsworn Officers at Maintenance Facilities Total Salary and Benefits
- 601.2.02 Level B/C Station Unsworn Officer Salary and Benefits
- 601.2.03 Level A Station Unsworn Officer Salary and Benefits
- 601.2.06 Unsworn Police Officer Frontline Total Salary and Benefits

602 Supplies & Equipment

602.1 Personal Equipment
- 602.1.01 Total Sworn Officer Equipment and Supplies Costs
- 602.1.02 Total Unsworn Officer Equipment Costs

602.2 Vehicles & Fuel
- 602.2.01 Total Security Vehicles and Fuel Costs

603 Environmental & Safety

603.1 Environmental Health and Safety
- 603.1.01 Environmental Health and Safety Staff Salary + Benefits
- 603.1.02 Environmental Health and Safety Certificates Costs

604 Police, Security, & Environmental Allocated Contingencies

604.1 Allocated Contingencies
- 604.1.01 Station Security Labor (Allocated Contingency)
- 604.1.02 Maintenance of Infrastructure Security Labor (Allocated Contingency)
- 604.1.03 Maintenance of Rolling Stock Security Labor (Allocated Contingency)
- 604.1.04 Station Security Equipment (Allocated Contingency)
- 604.1.05 Maintenance of Infrastructure Security Equipment (Allocated Contingency)
- 604.1.06 Maintenance of Rolling Stock Security Equipment (Allocated Contingency)

701 Corporate Administration

701.1 Management and Administration
- 701.1.01 Executives (general and administrative) Total Salary and Benefits
- 701.1.02 Senior Management (general and administrative) Total Salary and Benefits
- 701.1.03 Mid-Managers (general and administrative) Fringe
- 701.1.04 Admin/Other Corporate (general and administrative) Total Salary and Benefits

702 Centralized Services

702.1 Insurance
- 702.1.01 Liability Insurance
- 702.1.02 Real and Personal Insurance
- 702.1.03 Rolling Stock Property Insurance
- 702.1.04 Business Interruption Insurance
- 702.1.05 Track & Infrastructure Assets Insurance
- 702.1.06 Earthquake and Flood Insurance

703 Supplies & Expenses

703.1 Employee Supplies & Expenses
- 703.1.01 Total G&A Employees Office Supplies Costs
- 703.1.02 G&A IT/Software Cost
- 703.1.03 G&A Cell Phones, Tablet, and Field Device Allowance Cost
- 703.1.04 Total Travel Expenses

704 Vehicles

704.1 General & Administrative Vehicles
- 704.1.01 Total Cost of Vehicles for General & Administrative

705 General & Administration Allocated Contingencies

705.1 Allocated Contingencies
- 705.1.01 General & Administrative Labor (Allocated Contingency)
- 705.1.02 Insurance Allocated Contingency Rate (Allocated Contingency)
- 705.1.03 General & Administrative Supplies + Expenses (Allocated Contingency)
- 705.1.04 Vehicles for General & Administrative (Allocated Contingency)

APPENDIX J: ILLUSTRATIVE ORGANIZATION CHART

Below are illustrative, preliminary and indicative organization charts that incorporate all positions currently included in the model. At the current stage of design, a fully developed organizational chart is not feasible as procurement and other decisions are yet to be made. The examples below are meant to depict the levels of the organization currently included in the model. The actual organization structure will be determined at a future date. The first organization chart shows the overall corporate organization structure at a very high level. The subsequent charts look at the operations and personnel included under the Senior Vice President of Operations.

Figure 2 Illustrative Overall Corporate Organizational Structure

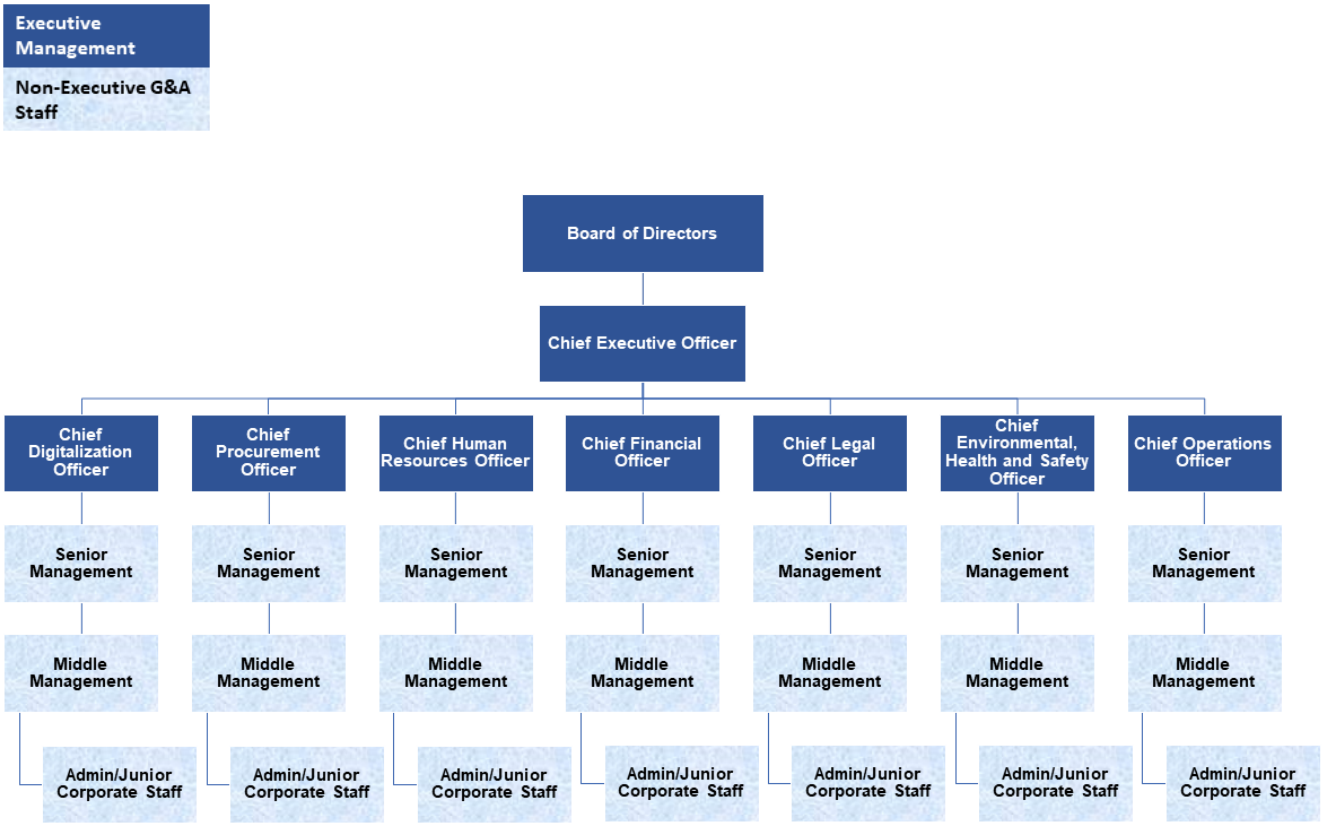


Figure 3 Illustrative Operations and Maintenance Staff Structure—On-board Personnel and Dispatching

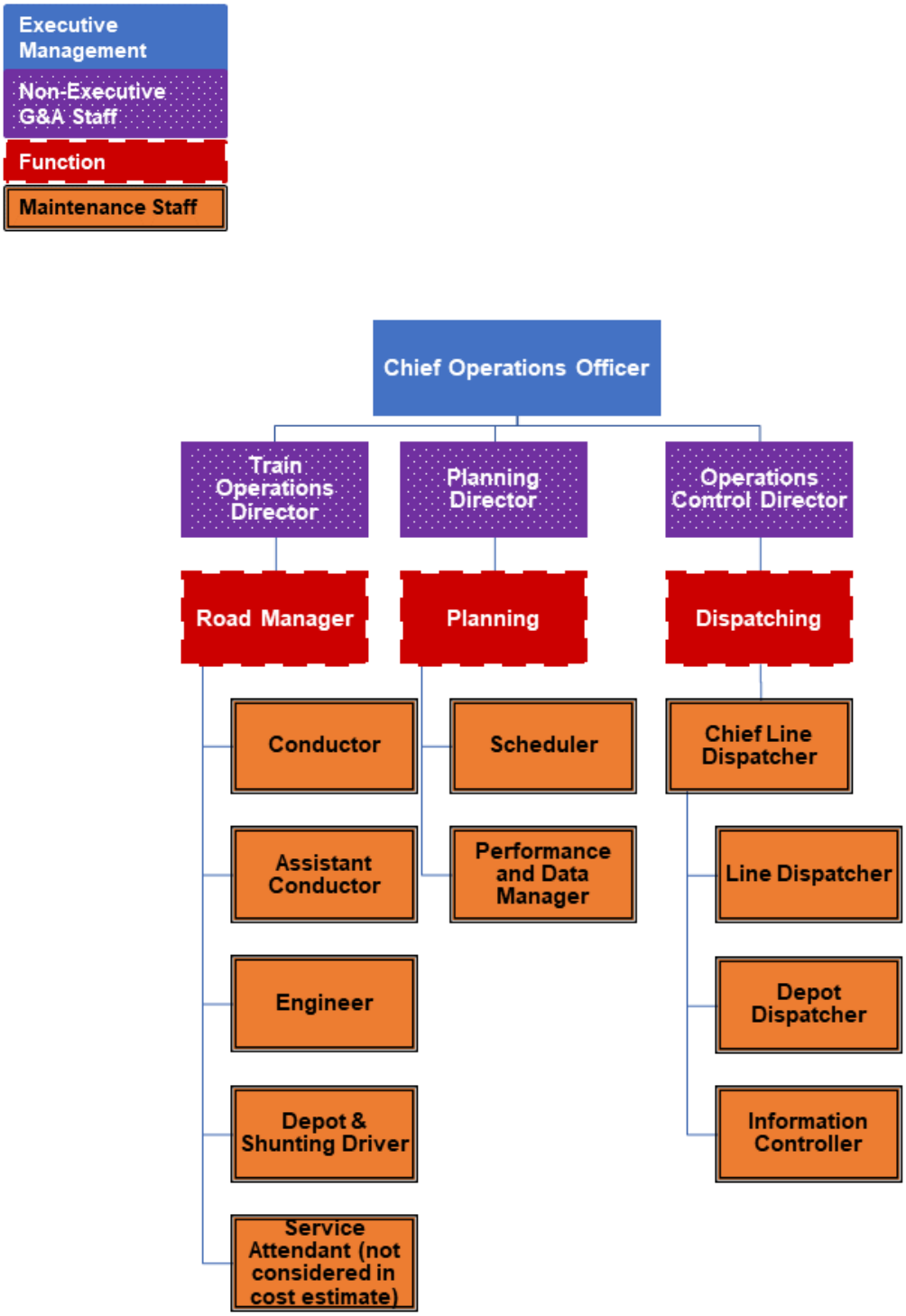


Figure 4 Illustrative Operations and Maintenance Staff Structure—Maintenance of Rolling Stock

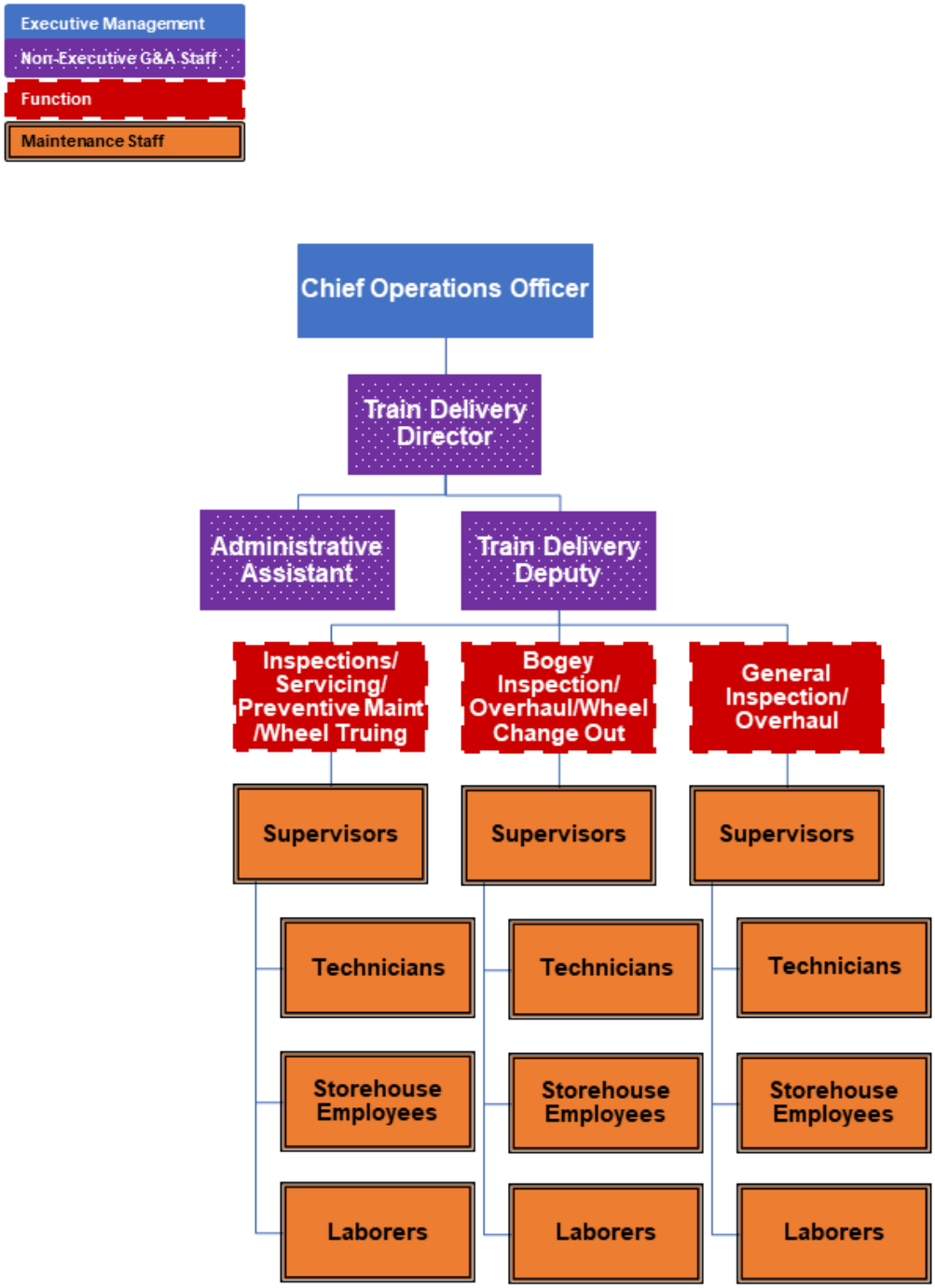
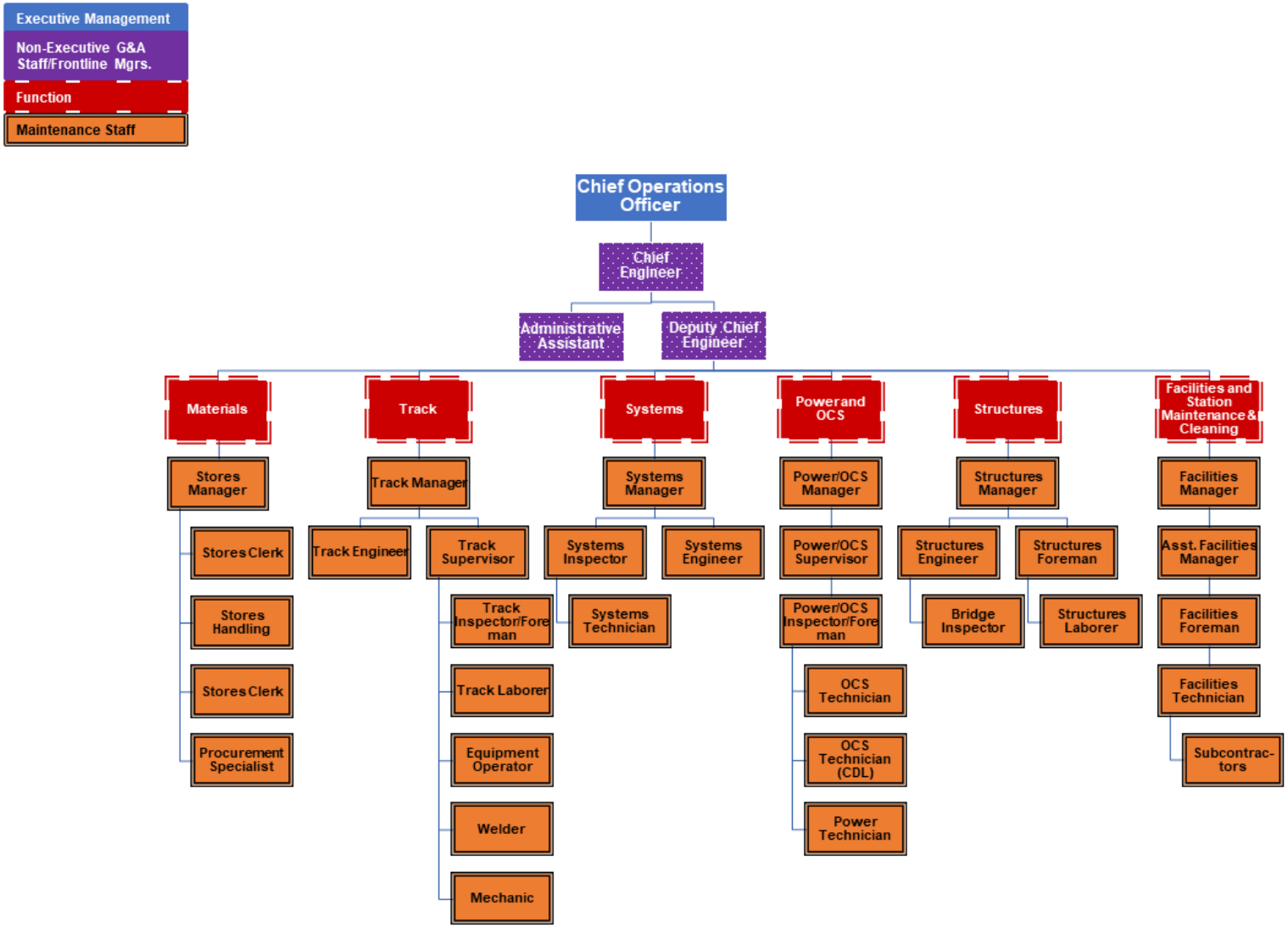


Figure 5 Illustrative Operations and Maintenance Staff Structure—Maintenance of Infrastructure Facility Staff



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