CALIFORNIA
High-Speed Rail Authority

Operations and Maintenance Cost Model Documentation

2016 BUSINESS PLAN: TECHNICAL SUPPORTING DOCUMENT

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Prepared by 

for the California High-Speed Rail Authority

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Table of Contents

Figures

Tables

Appendixes

Acronyms

BNSF	Burlington North Santa Fe Railway
FRA	Federal Railroad Administration
GSA	General Services Administration
HMF	Heavy Maintenance Facility
kWh	Kilowatt hour
LGV	Lignes à Grande Vitesse
O&M	Operations and Maintenance

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1 Introduction

The California High-Speed Rail Authority is responsible for planning, designing, building and operation of the first high-speed rail system in the nation. 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 2029, 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 (O&M) 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 operations of the system.

The Department of Transportation Inspector General's *High-Speed Intercity Passenger Rail Best Practices: Operating Costs Estimation* report serves as a guiding document for many of the cost categories, where it is applicable.[1] The Department of Transportation Inspector General Report lays out general parameters for estimates in the preliminary, intermediate, final, and commercial closeout stage of program development. However, as described in the report, programs rarely fall in just one of these categories and will usually overlap between several of these categories. In that context, large parts of the model are best interpreted as an intermediate stage forecast, with some portions still in their preliminary stage, and some portions further advanced towards the final stage.

Although the O&M model uses the Department of Transportation Inspector General Report as a guiding document, it does not attempt to follow every estimating method in the report as there are project-specific elements that do not fall neatly into all of the methods laid out by the Department of Transportation Inspector General. Instead, the model aims to achieve the same intended *outcomes* as the guidance in the report (such as accounting for all of the appropriate categories, using best practices, etc.).

The model includes the following categories of operations and maintenance costs: train operations, dispatching, maintenance of equipment, maintenance of infrastructure, station operations and train/station cleaning, police and security, commercial, and general and administrative. Each section summarizes assumptions for headcounts, tours, personnel wages, material and tool costs, and other expenses around which conceptual operating strategies are developed. The model does not attempt to optimize the operations to reduce costs but provides an achievable operating scenario that could be further improved upon by a private operator.

The model used for the *2016 Business Plan* builds upon the model used for the *2014 Business Plan*, using the same model structure and base. A summary of updates to the model can be found in Section 3. The assumptions and inputs in this document are largely based on a compilation of railroad operations requirements and data, discussions with industry experts and various reference documents.

[1] US Department of Transportation Office of Inspector General. *HSIPR Best Practices: Operating Costs Estimation*. US Department of Transportation, June 2011. 14 Nov. 2012. <http://www.oig.dot.gov/sites/dot/files/OIG-HSR-Best-Practice-Operating-Cost-Report.pdf>

2 Purpose of the Model

The O&M cost model aims to test different operating scenarios, ridership, service, commercial, and procurement options. Specifically, the model helps test whether these different scenarios would be in compliance with 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 that will be needed to run the system.

3 Updates to the Model since the 2014 Business Plan

The *2016 Business Plan* O&M cost model is based on the structure and foundation of the *2014 Business Plan* O&M cost model, but with a variety of updates and modifications. The 2014 O&M 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.

3.1 Wireless Internet (Wi-Fi) Cost Module

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 O&M 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 Equipment overhaul costs (described in Section 7).
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 $45.70 (2015 dollars). This estimate is based on internet connection charges the Northern Indiana Commuter Transportation 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.[2]
5) Each California High-Speed Rail trainset would include 8 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 $4,387.

6) Wi-Fi service is categorized as a Maintenance of Equipment expense in the O&M model. As with other Maintenance of Equipment trainset expenditures, an allocated contingency rate of 23% is applied on top of annual Wi-Fi expenditures. Please see Section 14.2 for more information on allocated contingency rates.

3.2 Model Start Year and Phasing

The *2014 Business Plan* assumed the first year of operations to be 2022. The *2016 Business Plan* assumes a 2025 opening year, which is driven by current plans for the program.

There are two initial operating segments analyzed in the *2016 Business Plan*:

- Silicon Valley to Central Valley line: San Jose to North of Bakersfield
- Silicon Valley to Central Valley Extension: San Francisco to Bakersfield

[2] "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.html>

Both Silicon Valley to Central Valley scenarios will run from 2025 through 2028. Phase 1, with service between San Francisco and Anaheim, will begin in 2029. The *2014 Business Plan* previously assumed that an Initial Operating Segment would begin in 2022, that there would be an intermediate Bay-to-Basin service period beginning in 2027, and that the full Phase 1 system would open by 2029.

3.3 Ramp Up Factor

The *2014 Business Plan* model assumes separate ramp-up factors for the Initial Operating Segment, Bay to Basin, and Phase 1 periods. The *2016 Business Plan* model assumes one eight-year ramp-up series for the Silicon Valley to Central Valley line/Silicon Valley to Central Valley Extension and Phase 1 periods. Ramp-up factors are used in the O&M cost model because California High-Speed Rail service, like many newly opened systems around the world, will be phased in and introduced over a number of years after initial service start-up. The ramp-up factor captures the time for a rail operator to hire adequate personnel, introduce rail service in new travel markets, account for ridership ramp-up over time, and procure sufficient trainsets for service expansion. Table 1 captures the new ramp-up series assumed in the model.

Table 1. Ramp-Up Factors used in 2016 Business Plan O&M Model

Factor	2025	2026	2027	2028	2029	2030	2031	2032	2033
Ramp-Up Factor	70%	73.75%	77.5%	81.25%	85%	88.75%	92.5%	96.25%	100%
Phase	Valley to Valley	Valley to Valley	Valley to Valley	Valley to Valley	Phase 1	Phase 1	Phase 1	Phase 1	Phase 1

3.4 Escalation

2014 Business Plan unit prices and salaries were escalated from 2012 dollars to June 2015 dollars using the California Consumer Price Index-Urban Wage Earners and Clerical Workers series.[3] The index produces a compound annual growth rate of 1.569% between 2012 and 2015.

3.5 Frontline Supervisors

To better align with operating assumptions on comparable high-speed rail operations around the world, frontline supervisors were reduced in each labor category to reflect the highly-automated nature of the California High-Speed Rail System. In the *2014 Business Plan* model it was assumed that there would be 1 frontline supervisor per 10 non-contracted positions. This assumption has been updated in the 2016 model to be 1 frontline supervisor per 20 non-contracted positions, based on Network Rail's Maintenance Practices 2b2c Maintenance Organization document, which reflect Network Rail's railway maintenance restructuring program (phase 2b2c) in the United Kingdom in 2010[4].

[3] California Consumer Price Index. California Department of Industrial Relations. Accessed September 2015. <https://www.dir.ca.gov/OPRL/CPI/EntireCCPI.PDF >

[4] Network Rail works with the Rail Delivery Partners as an advisor to the California High-Speed Rail Authority. Network Rail is the operator and maintainer of both high-speed and conventional rail network infrastructure in the United Kingdom

3.6 Regional Control Center, Roustabout Crews, and 2nd System Unit

The *2014 Business Plan* assumed that there would be a Regional Control Center to handle traffic on shared railroad track (e.g., blended segments with both high-speed rail and conventional rail train service). Each Regional Control Center crew included 11 operations control personnel. Regional Control Centers were removed from the *2016 Business Plan* O&M cost model to reflect the current understanding of dispatching needs, staffing levels on blended service segments, and planned technology in the system's centralized Operations Control Center. With its modern dispatching and communications equipment, the Operations Control Center is expected to be adequate to serve the entire system and can effectively manage the duties of traditional Regional Control Centers.

Roustabout crews have also been removed from the 2016 model. Roustabout crews in the 2014 model were responsible for moving broken trains, providing replacement rolling stock, and responding to other train issues. Each roustabout crew had 3 on-board personnel. Due to the evolved design of the project and the anticipated automated elements on rolling stock and at maintenance facilities, Drill Crews were deemed sufficient to cover roustabout responsibilities.

Similarly, 2nd system units were removed from the *2016 Business Plan* O&M Cost Model. The 2014 O&M cost model previously assumed 2nd system units would provide additional Maintenance of Infrastructure equipment and support crews when the system expanded during Phase 1. Each 2nd system unit consisted of 10 additional surfacing maintenance personnel and 14 additional overhead catenary specialists, along with associated surfacing and catenary maintenance equipment. However, as maintenance activities are now anticipated to be scheduled further in advance, freeing up initial system units for maintenance work, the 2nd system unit was removed from the model. In addition, the initial system unit is anticipated to be mobile and highly mechanized, ensuring that the initial system unit is sufficient to ensure timely and effective remediation of maintenance issues on the system.

3.7 Energy Costs

An updated energy cost of $0.074 per kilowatt hour (2015 dollars) was assumed for the system based on the California Public Utilities Commission's Biennial Renewables Portfolio Standard Program Update from January 2016.[5] The *2014 Business Plan* assumed an energy cost of $0.09 per kilowatt hour (in 2012 dollars) based off earlier Renewables Portfolio Standard reports from 2012 (see Section 5.3).

3.8 All Other Model Assumptions and Inputs

All other model assumptions and inputs from the *2014 Business Plan* O&M 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 *2016 Business Plan* O&M Cost Model, and where necessary, California Consumer Price Index escalation was used to escalate unit cost amounts from 2012 dollars into 2015 dollars (see Section 4).

[5] California Public Utilities Commission Renewables Portfolio Standards Reports. January 2016. <http://www.cpuc.ca.gov/RPS_Reports_Docs/>

This Technical Supporting Document captures only the assumptions for the O&M cost model (which covers operations and routine maintenance). For an understanding of 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:

1. The model assumes the phasing as proposed in the *2016 Business Plan*:

Table 2. System Implementation Phasing from the 2016 Business Plan

Step	End Points	Anticipated Opening Year
Silicon Valley to Central Valley*	Silicon Valley to Central Valley line: San Jose to North of Bakersfield	2025
	Silicon Valley to Central Valley Extension: San Francisco 4th & King to Bakersfield	
Phase 1	San Francisco Transbay to Anaheim	2029

*Both Silicon Valley to Central Valley line and Silicon Valley to Central Valley Extension scenarios were assessed in the *2016 Business Plan O&M forecasts*

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 *2016 Business Plan* and Technical Supporting Document: Service Planning Methodology. This information builds on the system assumptions used in the development of the *2014 Business Plan*, but includes some key differences.
3. Unit cost assumptions from the *2014 Business Plan* California High-Speed Rail System O&M Model that are being used again in the *2016 Business Plan* California High-Speed Rail System O&M Model were escalated to June 2015 dollars from 2012 dollars using the California Consumer Price Index Annual Series. The escalation rate assumed between 2012 and 2015 on an annual basis is approximately 1.569%.
4. Fringe rates are applicable to all positions except those that are contracted.
5. Fringe rates, as extracted from the Brotherhood of Locomotive Engineers and Trainmen document on fringe rates are escalated to 2015 dollars using the California Consumer Price Index, with the addition of costs for the Federal Employers Liability Act[6], are as follows:
    - $19,638 for the health, vision, dental, and retiree health plans
    - 5.50% of wage up to $17,163 for Railroad Unemployment Insurance Act benefits
    - 12.1% of wage up to $93,358 for Railroad Retirement Tier 2
    - 6.2% of wage up to $115,257 for Railroad Retirement Tier 1

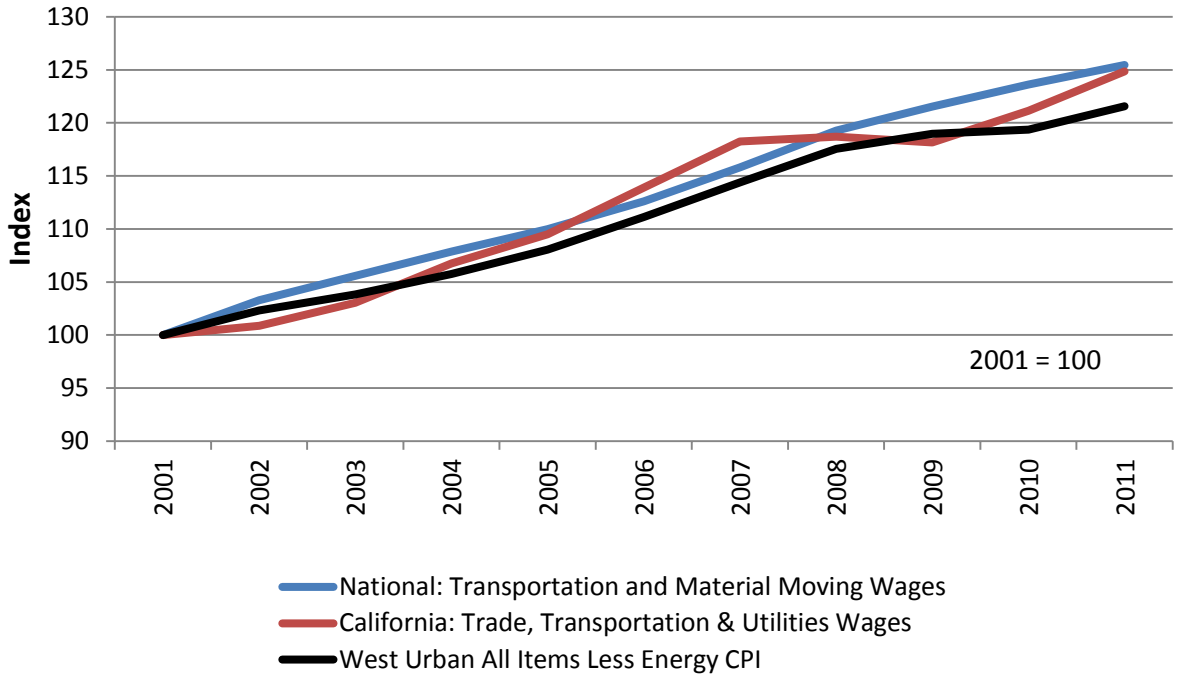
[6] Brotherhood of Locomotive Engineers and Trainmen. *Fringe Benefits 2012*. Dec. 2011. 13 Nov. 2012. <http://www.ble-t.org/Fringe_Benefits_2012.pdf >

- 7.45% with no limit (1.45% for Medicare and 6% for Federal Employers Liability Act compensation)

6. The model assumes that the system will be fully staffed such 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 will improve their labor costs by using overtime for short additional labor needs instead of using higher levels of personnel as currently assumed in the model.
7. One frontline supervisor is assumed for every 20 non-contracted positions.
8. General and administrative personnel are assumed to be an additional 10% of the total workforce (including frontline supervisors, managers, and engineers).
9. Frontline supervisors earn 10% more than each category's highest wage.
10. Of the 365 days in the year, employees will be unavailable to work on some days. For positions that need to be covered 7 days per week, the unavailability is assumed to be 141 days out of 365 days per year. Unavailable time includes 104 days for weekends, 15 days (average) for vacation, 10 days for sickness, 8 holidays, and 4 days for training or other absences. For positions that are only needed 5 days per week, the unavailability is assumed to be 29 out of 252 days (which excludes the weekends and holidays). Whether employees fall under each type of availability calculation is described in each section for each type of employee.
11. To account for unavailability, each regular crew assignment is multiplied by a factor of 1.63 (365 days per year/224 days per year = 1.63) for 7-days per week crews and 1.13 (252 days per year/224 available days per year = 1.13) for 5-days per week crews. These factors are described in this documentation as the "availability calculation".
12. Generally, the availability calculation applies to non-contract positions. The availability assumption is not applicable to contractors and management and administrative staff.
13. 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.
14. Wages were gathered from existing railroad and transit properties across the country and adjusted for regional wage differences between California and the original sources (see Appendix 2—Wages).
15. A 0.267 percent per year real inflation rate is applied to wages based on historic differences in the rate of increase of the wages in the California Trade, Transportation, and Utilities sector and the U.S. Consumer Price Index. Figure 1 shows the difference in U.S. Consumer Price Index growth relative to national and California wages in representative categories for the transportation industry. The growth in California transportation wages above Consumer Price Index over the 10-year period is equivalent to the 0.267 percent.[7]

[7] Bureau of Labor Statistics. Wage and CPI indexes.

Figure 1. Changes in wages relative to changes in Consumer Price Index from 2001 to 2011



16. The costs for shared facilities (i.e., the Caltrain corridor and others) have been fully assumed in the model pending agreements that would allow some of these costs to be shifted to other operators. Future agreements may result in reduced costs but there is no established basis for a distribution of costs for shared facilities at this time so all costs necessary to run the system are included and assumed to be borne by the California High-Speed Rail Authority or its contractors.

5 Train Operations Cost

The Train Operations portion of the model consists of personnel and costs directly involved in the operation of train service.

5.1 Related Personnel

For the purpose of the O&M model, personnel in the calculation of train operations cost are considered to be on-board train crews consisting of train engineers, conductors, assistant conductors, and on-board attendants, protect crews, and drill crews.

5.2 Assumptions and Model Inputs for Train Operations Personnel

5.2.1 Primary Drivers

Many factors that may not move in a strictly linear fashion affect operating headcount growth as a start-up operation matures. For the purposes of this model, the following assumptions pertaining to the categories of operating personnel are made to allow order of magnitude comparison of costs when operating conditions change:

1. The primary driver affecting escalation of on-board personnel headcount is assumed to be the total number of runs that trains make each day and the efficiency of the crews. It is assumed that once Phase 1 is fully inaugurated that crews will be able to cover 0.85 round trips per day and that crew changes will be used, per federal guidelines, to ensure the operating efficiency and safety of the system.
2. Protect crews will operate to fill in when originally planned personnel cannot make their runs because of delays, sickness, emergencies, or any other reason that causes them to be absent.
3. Drill crews will be based at each yard and maintenance facility to move equipment around as necessary.

5.2.2 General Assumptions

The following describes the specific assumptions that have been made:

1. The number of On-Board Attendants will increase if on-board refreshment services are added. It is assumed that no on-board refreshment service will be provided under any of the phases. However, one on-board attendant will be on board trains without food service to respond to passenger needs and assist the core train crew in case of an emergency. An extra one on-board attendant will be added if on-board services are added. On-board personnel staffing in the model is conservative in nature to account for federal and state requirements for train operations and emergency situations.
2. Double consist trainsets will have the same number of transportation crew members as single trainsets. However, the number of on-board attendants will double.
3. It is assumed that crews will start and finish at the same location, whether crews are operating a train or deadheading.

4. It is assumed that road crews will make non-revenue trips to position equipment at outlying terminals for AM service, cycle trains to maintenance facilities, deadhead to their start locations, and for other reasons. It is assumed that non-revenue deadhead trips will not exceed one hour.

5.2.3 Personnel Headcount

1. The following on-board personnel are assumed for each type of crew:
    - For a single-consist train: 1 train engineer, 1 conductor, 2 assistant conductors, and 1 on-board attendant if there is no food service and 2 on-board attendants if there is food service (Table 3).
    - For a double-consist train: 1 train engineer, 1 conductor, 2 assistant conductors, and 2 on-board attendants if there is no food service and 4 on-board attendants if there is food service (Table 4).
    - Protect crews consist of 1 train engineer, 1 conductor, and 1 assistant conductor (Table 5).
    - Drill crews consist of 1 train engineer (Table 5).
    - Roustabouts have been removed from the 2016 model, as with the evolved design of the project and the automated nature of rolling stock and maintenance yards, drill crews were deemed sufficient to cover roustabout responsibilities. See Section 3.6 for more information.
    - On-board personnel staffing assumptions are conservative in nature to account for federal and state safety requirements for train operations, emergency situations, and evacuation procedures.
2. The following other assumptions are applied to these crews:
    - The number of **Protect Crews** assumes 2 tours per day with crews stationed at each system terminal (Level A Station).
    - The number of **Drill Crews** and how many tours they are on is based on the maintenance facilities and yards that are in operation at any given point. Each Level V Heavy Maintenance Facility (HMF) is assumed to have 1 drill crew for 3 tours per day while each other facility and yard is assumed to have 1 drill crew for 2 tours per day.

Table 3 through Table 5 summarizes the information discussed above for each type of on-board crew:

Table 3. Headcount per Revenue Single-Consist Train

Position	Without On Board Services	With On Board Services
Train Engineer	1	1
Conductor	1	1
Assistant Conductor	2	2
On-Board Attendant	1	2
Total	**5**	**6**

Table 4. Headcount per Revenue Double-Consist Train

Position	Without On Board Services	With On Board Services
Train Engineer	1	1
Conductor	1	1
Assistant Conductor	2	2
On-Board Attendant	2	4
Total	**6**	**8**

Table 5. Headcount per Protect Crew and Drill Crew

Position	Protect Crew	Drill Crew
Train Engineer	1	1
Conductor	1	0
Assistant Conductor	1	0
Total	**3**	**1**

5.2.4 Wages

Table 6 summarizes wages for Train Operations.

Table 6. On-board Staff Wages (2015 dollars)

On board Staff	Salary	Availability?
Train Engineer	$74,398	Yes, 7-day
Conductor	$71,803	Yes, 7-day
Assistant Conductor	$56,753	Yes, 7-day
On-board Attendant	$42,782	Yes, 7-day

5.3 Energy Costs

Energy costs are based on the usage of energy for the movement of trains, usage at maintenance facilities, and related to stations. The California High-Speed Rail Authority has committed to using 100% renewable energy so the price for energy is based on the cost of renewables.

5.3.1 Energy Cost Calculation

The cost of renewable energy has been estimated using the California Public Utilities Commission's *Renewables Portfolio Standard Biennial Program Update* from January 2016. The renewable energy cost from the January 2016 report is $0.074 per Kilowatt hour (2015 dollars). In discussions with the California Energy Commission, officials stated that their forecasts for the future expected prices to stabilize as the market has approached equilibrium. Thus, no further real growth or reduction is expected beyond inflation.

5.3.2 Energy Usage

Based on energy use simulation modeling, rolling stock energy consumption at the pantograph is assumed to be 41.5 kWh per trainset mile during the Silicon Valley to Central Valley phase and 43.0 kWh per trainset mile during Phase 1.[8] Energy losses during transmission and distribution are assumed to be part of the energy cost.

5.4 Uniforms, Vehicles, and Supplies

5.4.1 Uniforms

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 2015 dollars.[9] Uniform costs are estimated at $293 per employee per year. This does not apply to frontline employees or management.

5.4.2 Vehicles

On-board employees will require a small number of non-rail vehicles for supervisors to respond to incidents and get between crew bases in occasions when rail service is not an option. The vehicle fleet will consist of 1 car at each terminal and 4 cars at the HMF. The vehicles are priced based on the wet rate of $30,126 per car per year based on Metrolink's rate for Std. 4WD Ext. Cab Pick Ups (escalated to 2015 dollars) as a representative vehicle cost.

5.4.3 Supplies and cell phones

Frontline personnel will incur office supply costs and will require cell phones. The office supplies are assumed to be $412 per year per frontline employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2015 dollars).[10] The cell phone allowance is estimated at $681 per year per frontline employee based on the U.S. General Services Administration Cost Per Person Model (escalated to 2015 dollars).[11]

5.4.4 Travel

Based on the assumption that each employee would do a daily roundtrip and return to their home bases, and the additional staff added to allow for that, it is assumed that on-board personnel will not incur travel costs or have to stay overnight between runs. Some efficiency could potentially be gained by reducing the staffing level and allowing some employees to incur overtime and travel costs.

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[8] Specific Energy Consumption for Electric Traction— California High-Speed Train Project. *Technical Memo*. November 20th, 2012.
[9] SFMTA. S*FMTA Operating Budget for FY 2013-2014.* 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>
[10] SFMTA. S*FMTA Operating Budget for FY 2013-2014.* 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf>
[11] U.S. General Services Administration. *Cost Per Person Model V2.0*. 14 October, 2013. <http://www.gsa.gov/portal/content/105134>

6 Dispatching and Control Costs

The Dispatching and Control portion of the O&M model consists of the personnel and costs directly related to directing and controlling train operations.

6.1 Related Personnel

Dispatching and control personnel include dispatchers (both train and power) and various operations controllers such as the rolling stock operations controllers, infrastructure operations controllers, public information controllers, yardmasters, and so forth. The O&M cost model estimates the costs for generic "dispatcher" positions that would encompass all of these functions.

6.2 Assumptions and Model Inputs

6.2.1 Primary Drivers

For the purposes of this model, the following assumptions pertaining to the dispatching and control personnel are made to allow order of magnitude comparison of costs when operating conditions change:

1. The primary driver of increases in the control center personnel headcount is assumed to be the phase of operations (as indicative of the length of the system and complexity of the operation).
2. It is assumed that each section of track that includes significant blended operations where high-speed rail trains interline with conventional rail will be managed by a combination of the Operations Control Center, Terminal Control Facility for station approaches as well as Caltrain's dispatching centers where applicable. Previously, the model assumed Regional Control Centers in Northern California coordinated blended service on shared track with Caltrain. However, given that Regional Control Center functions can be effectively managed by the Operations Control Center (who will also be responsible for remote monitoring), all Regional Control Center personnel were removed for the *2016 Business Plan*.
3. Terminal Control Facility personnel are driven by the stations' role as a temporary or permanent system terminal. Terminal Control Facility personnel control the movement of trains between tracks. It is anticipated that the system will not need Terminal Control Facility personnel given the nature of dedicated high-speed rail operations. However, given that the O&M Model is a conservative forecast of operating costs, Terminal Control Facility personnel have been left in the model pending the completion of station and track design and will likely be removed once there is more certainty regarding dispatching needs.

6.2.2 Personnel Headcount

Train dispatching consists of three sets of functions: the Operations Control Center, the Terminal Control Facilities, and the Yard Dispatchers. The Operations Control Center staffing is based on the phase of operation. Terminal Control Facility staffing depends on the stations that are on the system. Finally, the yard dispatching is needed for each yard and maintenance facility.

The following is the staffing for the Operations Control Center under different phases of the system for each of 3 tours:

Table 7. Operations Control Center Headcount per Tour by System Length

Position	Silicon Valley to Central Valley	Phase 1
Director Operations Control	1	1
Deputy Director—Operations Control	1	1
Train Dispatcher	5	10
Total	**7**	**12**

The Terminal Control Facility staffing is dependent on the level of the station (Level A, B, or C) as described in Table 8. The Terminal Control Facilities are staffed while trains are in operations, which is 2 tours per day. Additionally, the Level A and B Station Terminal Control Facilities are minimally staffed for 1 tour per day when trains are not running (i.e., at night). Level C stations have no Terminal Control Facility staffing. It is anticipated that Terminal Control Facility staffing may not be necessary for system operations given the unique nature of high-speed rail operations and the ability to dispatch trains from a central system. However, as station and track design is yet to be finalized and until a private operator makes a final decision, Terminal Control Facility staffing has been left in the model to account for potential dispatching costs at stations and to maintain consistently conservative assumptions. Once the design of the project is finalized, Terminal Control Facility staffing will likely be removed from future iterations of the model. The Terminal Control Facility staffing assumed in the model is as follows:

Table 8. Terminal Control Facility Headcount per Tour by Terminal Type

Position	Level B Stations (during train operations)	Level B Stations (not during train operations)	Level A Stations (during train operations)	Level A Stations (not during train operations)
Deputy Director—Operations Control	1	1	1	1
Train Dispatcher	2	1	6	1
Total	**3**	**2**	**7**	**2**

Each maintenance facility is assumed to have 2 train dispatchers for yard dispatch duties (these would be yardmasters and facility dispatchers). Yard dispatchers are assumed to be on for 3 tours per day at the HMF and 2 tours per day at each of the other facilities.

6.2.3 Wages

Table 9. Dispatcher position wages (2015 dollars)

Employee(s)	Salary/Contract Cost	Availability Applicable?	Source/Notes
Operations Control Center			
Director Operations Control	$111,072	Yes, 7-day	
Deputy Director—Operations Control	$96,557	Yes, 7-day	Midpoint of dispatcher and Director—Operations Control
Train Dispatcher	$82,042	Yes, 7-day	
Terminal Control Facility			
Deputy Director—Operations Control	$96,557	Yes, 7-day	Midpoint of dispatcher and Director—Operations Control
Train Dispatcher	$82,042	Yes, 7-day	
Yard			
Train Dispatcher	$82,042	Yes, 7-day	

6.3 Vehicles and Supplies

6.3.1 Vehicles

Dispatchers will require a small number of non-rail vehicles for supervisors to respond to incidents and get between locations in occasions when rail service is not an option. The vehicle fleet will consist of 2 cars at the Operations Control Center. The vehicles are priced based on the wet rate of $30,126 per car per year based on Metrolink's rate for Std. 4WD Ext. Cab Pick Ups as a representative vehicle cost (escalated to 2015 dollars).

6.3.2 Supplies and cell phones

All dispatch personnel including frontline will incur office supply costs and the frontline personnel will require cell phones. The office supplies are assumed to be $412 per year per dispatch employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2015 dollars).[12] The cell phone allowance is estimated at $681 per year per frontline employee based on the U.S. General Services Administration Cost Per Person Model (escalated to 2015 dollars).[13]

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

[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 Equipment Costs

The Maintenance of Equipment 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 starts).

7.1 Related Personnel

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

1. Rolling Stock Maintenance Technicians
2. Rolling Stock Maintenance Supervisors
3. Mechanical Technicians
4. Electrical Technicians
5. Laborers
6. Storehouse Employees

7.2 Assumptions and Model Inputs

7.2.1 Inspections

1. Regulatory inspections are guided by the Code of Federal Regulations.
2. Each maintenance facility will perform regulatory inspections. Each team that will be doing routine maintenance will each consist of 12 people as follows:
   - 1 Supervisor
   - 7 Technicians
   - 2 Laborers
   - 2 Storehouse employees
3. The number of teams and tours at each facility depends on the amount of maintenance anticipated to take place there. The following number of tours and teams is assumed for each facility (note that for the number of teams listed is over *all* of the planned tours and the tours are generally listed for information purposes only):

Table 10. Maintenance Facility Regulatory Inspection Staffing

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

Note: All facility locations are preliminary and subject to change.

4. Assumptions for occurrence of inspections:
    - Daily, every 48 hours, 182.5 inspections per year per trainset
    - Monthly, every 30 days, 12.167 inspections per year per trainset
    - 92 days, 4 inspections per year per trainset
5. Material costs for these inspections (escalated to 2015 dollars)[14]:
    - Daily, $524 per inspection
    - Monthly, $2,337 per inspection
    - 92 days, $524 per inspection

7.2.2 Overhauls

1. Bogie Inspections and overhaul generation inspections are driven by the mileage of the trainsets.
2. Overhauls occur only at HMF and once they start additional personnel are added beyond the requirements of the regulatory inspections. For each 600,000 miles that a trainset covers, a Bogie Inspection needs to be performed. Once a Bogie Inspection begins, the following staff needs to be added at the HMF:
    - 6 Supervisors
    - 37 mechanical technicians
    - 17 electrical technicians
    - 8 laborers
    - 10 storehouse employees
3. Wheel change outs will occur, on average, at every third Bogie Inspection or every 1.8 million miles and are added to the basic cost for that Bogie Inspection
4. 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. Section 3.1 has more detail on connection charges for this equipment, which is estimated to be $4,387 per trainset per year based on operational data from the Northern Indiana Commuter Transportation District.
5. In addition, for every 1.2 million miles, each trainset needs to have an overhaul general inspection. Once these starts, the following personnel need to be added at the HMF (on top of the personnel hired for the Bogie Inspections s):
    - 4 Supervisors
    - 20 mechanical technicians
    - 16 electrical technicians
6. Materials for overhauls include:

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

- Bogie/truck inspections cost $133,070 per inspection (escalated to 2015 dollars)[15]
- Overhaul General Inspection cost $922,060 per inspection (escalated to 2015 dollars)[16]
- Wheel change outs cost $157,169 per trainset (escalated to 2015 dollars)[17]

7.2.3 Wages

Table 11 summarizes the wages for Rolling Stock maintenance personnel.

Table 11. Rolling Stock and Building/Yard Maintenance Wages (2015 dollars)

Employee(s)	Salary/Contract Cost	Availability Applicable?
Maintenance of Equipment Supervisors	$78,547	7-day for inspections, 5-day for overhauls
Maintenance of Equipment Technicians (including electrical and mechanical technicians)	$62,064	7-day for inspections, 5-day for overhauls
Storehouse Employees	$44,970	7-day for inspections, 5-day for overhauls
Laborers	$50,132	7-day for inspections, 5-day for overhauls

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]

7.3.2 Water and Sewer

Maintenance facility water and sewer costs are estimated at $0.184 per year per square foot and $0.169 per year per square foot, respectively. These are based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2015 dollars).[19]

7.3.3 Facility Size

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

[15] Costs based on the Taiwan High-Speed Rail Corporation overhaul records
[16] Ibid.
[17] Ibid.
[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. S*FMTA 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.

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

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

Table 12. Maintenance Facilities and Levels by Phase

Facility	Silicon Valley to Central Valley	Phase 1
Level 5: HMF	On	On
Level 3: Palmdale	Off	On
Level 3: Bay Area	On	On
Level 2: Los Angeles Area	Off	On

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

Table 13. 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
Maintenance of Way 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 14. Non-HMF Maintenance Facility Buildings and Sizes

Maintenance Facility Buildings and Sizes	Sizes (square feet)	Palmdale	Bay Area	LA Area
Support & Administration Building	127,960	X	X	X
Maintenance Building	45,935	X	X	X
Wheel True Building	24,610	X	X	
Maintenance of Way Building	18,050	X	X	X
Car Wash Building	26,250	X	X	
Paint & Body Shop Building	24,610			
Service & Inspection Building	60,700	X	X	X
Total (square feet)	**—**	**303,505**	**303,505**	**252,645**

Note: Facility sizes are preliminary and subject to change.

7.4 Uniforms, Vehicles, Tools, Supplies, and Information Technology/Software

7.4.1 Uniforms

Each member of the Maintenance of Equipment 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 2015 dollars).[21] Uniform costs are estimated at $293 per employee per year. This does not apply to frontline employees or management.

7.4.2 Vehicles

Maintenance of Equipment 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 2 cars for each maintenance facility and 4 cars at the HMF. The vehicles are priced based on the wet rate of $30,126 per car per year based on Metrolink's rate for Std. 4WD Ext. Cab Pick Ups as a representative vehicle cost (escalated to 2015 dollars). Additionally, there will be 2 flatbed stake trucks at each maintenance facility and 4 flatbed stake trucks at the HMF. The flatbed stake trucks are priced at the Metrolink wet rate of $40,801 (escalated to 2015 dollars).

7.4.3 Tools

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

7.4.4 Supplies and cell phones

Frontline personnel will incur office supply costs and will require cell phones. The office supplies are assumed to be $412 per year per frontline employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2015 dollars).[22] The cell phone

[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.>

allowance is estimated at $681 per year per frontline employee based on the U.S. General Services Administration Cost Per Person Model (escalated to 2015 dollars).[23]

7.4.5 Information Technology / Software

Maintenance of Equipment facilities will require some Information Technology/software functionality. Based on the General Services Administration (GSA) per person cost model (escalated to 2015 dollars), the Information Technology costs are estimated at $5,239 per user profile. It is assumed that each maintenance facility will have 10 user profiles.

In addition, the 2016 O&M Cost Model now includes expenditure rows for trainset Wi-Fi service. Wi-Fi expenditures are categorized as a Maintenance of Equipment expense. Please see Section 3.1 for more information on trainset Wi-Fi service.

7.5 Cost Rationalization for Bogie Inspection and Overhaul General Inspection 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.

It would be impractical to attempt to plan the equipment manipulation to this level of detail at this time. Instead, the model assumes that the operations will successfully rationalize the Bogie Inspection and Overhaul General Inspection schedules. The model uses a 7-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 Equipment 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 inspections work at set cycles over the modeling period. However, this variance (with peaks and troughs) is mitigated with the cost rationalization methodology that has been applied to Maintenance of Equipment costs in the model. For a simplified example of how the rationalization is applied, please see Appendix 3 Maintenance of Equipment Cost Rationalization Example.

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

8 Maintenance of Infrastructure

The Maintenance of Infrastructure portion of the model includes the personnel, materials, tools, and equipment required to maintain the tracks and other infrastructure. It is assumed that most Maintenance of Infrastructure activities will occur during one tour at night and that daytime Maintenance of Infrastructure staffing will be aimed at maintenance that does not negatively impact train service and responding to unscheduled outages as they occur.

8.1 Related Operating Personnel

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

1. Maintenance of Infrastructure Facility Units
2. System Units
3. Specialty Units, including HMF Addition Unit, Crane/Tractor Unit, Facility Gang Addition Units

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. **Basic Maintenance of Infrastructure Facility**—a work force / equipment component providing Maintenance and Inspection functions. A Basic Maintenance of Infrastructure Facility component will be added for each new line segment placed into service. It is assumed that the new line segment will be 100-150 route miles (proposed line segments which do not fall within these limits will require special consideration). This component includes work force and equipment to address responsibilities in the Track (including visual track inspection), Structures, Signal, Communications, Overhead Catenary System (OCS), Electric Traction, and Utilities areas. It does not include track surfacing and alignment responsibilities which will be provided by a system work force.
2. **Initial System Unit**—a work force /equipment component, not attached to a specific facility, which has system-wide (or major line segment responsibility in an expanded system) responsibility for machine vision inspection, track replacement, alignment, surfacing and rail grinding, as well as, catenary repair, replacement and tensioning. The Initial System Unit will be augmented by the local Maintenance of Infrastructure Facility Unit as required.
3. **HMF Addition**—a work force /equipment component work, added to a Basic Maintenance of Infrastructure Facility component to maintain the yard track, switches, signals, and structures at the Heavy Maintenance Facility where major rolling stock repair, overhaul, and storage takes place.
4. **Facility Gang Addition**—a work force / equipment component, added to a Basic Maintenance of Infrastructure Facility component, work to provide additional support due to the challenges presented in certain locations. This component will be added for each Level 3 Maintenance of Equipment facility and when service through the Tehachapi Mountains begins. When the

system expands beyond the Phase 1 system (into Phase 2), further analysis will be required to identify other challenges requiring Facility Gang Additions.

8.2.2 Phasing of Units

1. It is envisioned that a Basic Maintenance of Infrastructure Facility will be commissioned when one segment of the system is in operation for construction, equipment testing, or other purpose. Additional Basic Maintenance of Infrastructure Facilities are required when each segment of 100 - 150 route miles is added. An Initial System Unit is required when two line segments are in operation.
2. The Heavy Maintenance Facility Addition and Facility Gang Additions will be added as those components of the system are brought online.
3. The following gangs are anticipated for each phase at this time:

Table 15. Number of Maintenance of Infrastructure Gangs by Phase (as currently planned)

	Silicon Valley to Central Valley	Phase 1
Basic Maintenance of Infrastructure Facility	2	5
Initial System Unit	1	1
HMF Addition	1	1
Facility Gang Additions	3	3

8.2.3 Personnel Headcount

The following personnel are needed for the Maintenance of Infrastructure with each team working one tour per day. Descriptions of each staff position are summarized in Appendix 3. Assignments listed as "Day" will have coverage seven (7) days each week. Assignments listed as "Night" will be covered five (5) days. Each team will be managed by supervisory staff specialized in the area of responsibility for each team. Manpower is assigned as follows:

Table 16. Maintenance of Infrastructure Staffing Levels by Facility/Addition

	Basic Maintenance of Infrastructure Facility		Initial System Unit		HMF Addition		Facility Gang Addition*	
Labor	Night 5 day	Day 7 day	Night 5 day	Day 7 day	Night 5 day	Day 7 day	Night 5 day	Day 7 day
Track								
Foreman	1	1			1		1	
Inspector	1				1		1	
Asst. Inspector	1							
Operator	2	1			1		1	
Laborer	2	1			1		1	

	Basic Maintenance of Infrastructure Facility		Initial System Unit		HMF Addition		Facility Gang Addition*	
Labor	Night 5 day	Day 7 day	Night 5 day	Day 7 day	Night 5 day	Day 7 day	Night 5 day	Day 7 day
Mechanic	1	1				** This component will be added for each Level 3* Maintenance of Equipment *facility and when service through the Tehachapi Mountains begins.*		
Truck Driver	1							
Welder	1							
Welder Helper	1							
Surfacing								
Foreman			1					
Asst. Foreman			1					
Inspector			1					
Operator			5					
Mechanic			1					
Truck Driver			1					
Rail Grinding								
Operator			1					
Technician			2					
Laborer			1					
Condensed Track Insp.								
Operator			1					
Technician			2					
Laborer			1					
Work Train								
Train engineer			1					
Conductor			1					
RR Structures								
Foreman	1							
Inspector	1						1	
Operator	1							
Laborer	2							
Truck Driver	1							
Right-of-Way Structures								
Foreman	1							
Inspector	1							
Operator	1							

	Basic Maintenance of Infrastructure Facility		Initial System Unit		HMF Addition		Facility Gang Addition*	
Labor	Night 5 day	Day 7 day	Night 5 day	Day 7 day	Night 5 day	Day 7 day	Night 5 day	Day 7 day
Laborer	1							
Truck Driver	1							
Signal								
Foreman	1	1			1			
Operator	1	1						
Systems Engineer	1							
Signal Engineer	1	1						
Signal Inspector	1							
Signal Maintainer	3	1			1		1	
Communications								
Foreman	1							
Operator	1							
Comm. Engineer	1	1						
Comm. Technician	1							
Comm. Inspector	2	1						
Overhead Cat. System								
Foreman	1	1						
Asst. Foreman								
Inspector	1						1	
Operator	2	1						
Laborer	2	1						
Truck Driver	1							
Lead Wireman	1							
Electrician (Hi Volt.)	1	1						
Electric Transmission								
Foreman	1							
Inspector	1						1	
Operator	1							
Laborer	1							

Labor	Basic Maintenance of Infrastructure Facility		Initial System Unit		HMF Addition		Facility Gang Addition*	
	Night 5 day	Day 7 day	Night 5 day	Day 7 day	Night 5 day	Day 7 day	Night 5 day	Day 7 day
Stations / Wayside								
Foreman	1	1			1			
Operator	1	1						
Laborer	1	1			1			
Truck Driver	1							
Electrician	1	1			1			
Plumber	1	1			1			
TOTAL	**56**	**19**	**19**	**0**	**10**	**0**	**8**	**0**

In addition to the 5% of staff for frontline management, another 10% (cumulative of frontline staff and personnel in the field) is added for general administration and overhead staff and is part of the general and administrative staff described in the General Administration and Executive Management section.

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% of the total Maintenance of Infrastructure labor cost.[24]
2. An additional 5% of the total labor cost (including frontline management) is assumed for miscellaneous tools, uniforms, and so forth.
3. Stations and other buildings are assumed to be maintained by the same maintenance teams as the infrastructure and their maintenance material costs are assumed to be the same percentage of the total costs.

8.2.5 Maintenance Vehicles

1. The Maintenance of Infrastructure teams will also need to have both rubber tired and on-track vehicles. All vehicles are assumed to be leased with their costs based on Metrolink's actual wet costs for similar equipment where available. Where no data on the cost of leasing the vehicle was available, the annual wet lease cost is assumed to be 1/5th of the estimated purchase price. The cost for vehicle leasing/maintenance (wet rates) and the number of vehicles of each type needed are described in the following tables:

[24] 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>

Table 17. Maintenance of Infrastructure Equipment Assigned to Manpower Units

Equipment	Basic Maintenance of Infrastructure Facility	Initial System Unit	HMF Addition	Facility Gang Addition
Track				
Hi-Rail Power Unit (Brandt Truck or Equiv.)	1			
1 Ton 4WD HR Crew Truck	1		1	
3/4 Ton 4WD HR Inspection	1			1
2 1/2 Ton HR Boom Truck	1			
2 1/2 Ton HR Welders Truck	1			
4WD Ext. Cab Pick Up	1			2
1 Ton Stake Bed Truck	1		1	
966 CAT (or equiv.) End Loaders	1			
Extended Reach Fork Lift	1			
Mechanics Truck (specialized)	1			
Fuel Lube Truck	1			
Speed Swings	1			
4WD HR Backhoes	1			
2.5 Ton HR Swivel Bed Dump Truck	1			
Field Induction Welding Truck HR (specialized)	1			
Rail Heaters (rail mounted)	2			
Ballast Cars	3			
Flat Cars	2			
Truck Mntd. Hydra. Rail Puller	2			
2 1/2 Ton HR Water Trucks (fire suppression and dust control)	1			
PorTable Rail Train / Dollies	1			
Tie Exchangers		1		
2 ½ Ton, Hi-Rail Weed Spray Vehicle		1		
Surfacing				
1 Ton 4WD HR Crew Truck		1		
4WD Ext. Cab Pick Up		1		
Mechanics Truck (specialized)		1		
Production Multi. Tamper		1		
Dynamic Track Stabilizer		1		
Ballast Regulator		1		
Tractor w/Low Boy & Flatbed Trailer				

Equipment	Basic Maintenance of Infrastructure Facility	Initial System Unit	HMF Addition	Facility Gang Addition
Kirow Crane				
Rail Grinding				
4WD Ext. Cab Pick Up		1		
Rail Grinder		1		
2 1/2 Ton HR Vacuum Truck		1		
Condensed Track Insp.				
Comprehensive Insp. Train		1		
Work Train				
Work Locomotive		1		
RR Structures				
1 Ton 4WD HR Crew Truck	1			
3/4 Ton 4WD HR Inspection	1			
2 1/2 Ton 4WD HR Bridge Inspection Boom Truck	1			
Hydraulic, Self-Propelled Rail Lifts	1			
Right-of-Way Structures				
4WD Ext. Cab Pick Up	1			
Signal				
1 Ton 4WD HR Crew Truck	1			
3/4 Ton 4WD HR Inspection	1			1
2 1/2 Ton HR Boom Truck	1			
4WD Ext. Cab Pick Up	2		1	
3/4 Ton HR 4WD Maintainer / Wireman Truck (specialized)	4			
1 Ton Stake Bed Truck	1		1	
Communications				
2 1/2 Ton HR Boom Truck	1			
4WD Ext. Cab Pick Up	2			
Overhead Cat. System				
1 Ton 4WD HR Crew Truck	1			
4WD Ext. Cab Pick Up	1			
3/4 Ton HR 4WD Maintainer / Wireman Truck (specialized)	1			
Overhead Contact System (Catenary) Equipped Wire Cars/Reel Trailer	1			
2 Piece Wire Stringing Unit				

Equipment	Basic Maintenance of Infrastructure Facility	Initial System Unit	HMF Addition	Facility Gang Addition
1 Ton 4WD HR Crew Truck	1			
2 1/2 Ton HR Boom Truck	1			
4WD Ext. Cab Pick Up	1			
3/4 Ton HR 4WD Maintainer / Wireman Truck (specialized)	1			
Stations / Wayside				
2 1/2 Ton HR Boom Truck	1			
4WD Ext. Cab Pick Up	4		1	
TOTAL	**55**	**11**	**5**	**4**

Table 18. Maintenance of Infrastructure Equipment Leasing Costs (2015 dollars)

Rubber Tire Maintenance of Infrastructure Equipment	Monthly Lease Rate (Metrolink 2012 Base)	Unit Purchase Cost (2014 $)	Yearly Unit Cost/Rate (2015 $)
Hi-Rail Power Unit (specialized Brandt Truck or equiv.)		$2,500,000	$523,898
1 Ton 4WD, Hi-Rail Crew Trucks	$3,245		$40,801
3/4 Ton 4WD, Hi-Rail Inspection Vehicles	$3,245		$40,801
2 ½ Ton, Hi-Rail Boom Trucks (specialized)	$9,418		$118,418
2 ½ Ton, 4WD, Hi-Rail Bridge Inspection Boom Trucks (specialized)	$12,245		$153,959
2 ½ Ton, Hi-Rail Welders Trucks (specialized)	$4,369		$54,938
Std. 4WD Ext. Cab Pick Ups	$2,396		$30,126
3/4 Ton Hi-Rail, 4WD Maintainer/Wireman Trucks (specialized)	$4,217		$53,025
1 Ton, Stake Bed Trucks	$3,245		$40,801
966 CAT (or equivalent) End Loaders	$11,464		$144,143
Extended Reach Fork Lifts	$3,840		$48,282
Mechanic's Trucks (specialized)	$4,217		$53,025
Fuel Lube Truck	$8,096		$101,795
Speed Swings	$3,840		$48,282
FWD, Hi-Rail Backhoes	$4,103		$51,589
Production Multiple Tamper	$20,822		$261,806
Dynamic Track Stabilizer	$32,358		$406,855
Ballast Regulator	$8,793		$110,559
Overhead Catenary Equipped Wire Cars/Reel Trailer		$1,800,000	$377,207
2 ½ Ton, Hi-Rail Swivel Bed Dump Truck	$5,292		$66,539

Rubber Tire Maintenance of Infrastructure Equipment	Monthly Lease Rate (Metrolink 2012 Base)	Unit Purchase Cost (2014 $)	Yearly Unit Cost/Rate (2015 $)
Field Induction Welding Truck, Hi-Rail, (specialized)		$700,000	$146,691
Ballast Cars		$10,000	$2,096
Flat Work Cars		$10,000	$2,096
Tractor with Low Boy and Flat Bed Trailer		$600,000	$125,736
Rail Heaters (rail mounted)	$7,816		$98,275
Truck Mounted Hydraulic Rail Pullers		$10,000	$2,096
PorTable Rail Train/Dollies	$11,339		$142,571
Hydraulic, Self-Propelled Rail Lifts		$8,000	$1,676
Tie Exchangers		$800,000	$167,647
Work Locomotive Unit		$2,000,000	$419,118
Rail Grinder		$2,500,000	$523,898
Revenue Vehicle Mounted (Vehicle Truck Interaction Equipped)		$200,000	$41,912
2 ½ Ton, Hi-Rail Vacuum Truck		$300,000	$62,868
2 ½ Ton, Hi-Rail Water Trucks (fire suppression / dust control)	$3,947		$49,628
2 ½ Ton, Hi-Rail Weed Spray Vehicle	$3,947		$49,628
Comprehensive Inspection Train (Track/Cat./Signal)		$25,000,000	$5,238,979
Kirow Crane		$2,500,000	$523,898
Two Piece Wire Stringing Unit		$7,500,000	$1,571,694

8.2.6 Wages

Table 19 summarizes wages for Maintenance of Infrastructure personnel. Note that some positions are not listed specifically under the Signal, Communications, and Overhead Contact System (Catenary) teams if they are already listed under the Track, Surfacing, Rail Grinding and Inspection, Structures, Stations/Wayside, and Electric Transmission/Substation Teams, in which case their wages are assumed to be the same.

Table 19. Maintenance of Infrastructure Wages (2015 dollars)

Position	Salary	Availability Applies?
Track		
Foreman	$71,135	5-day for night crew, 7-day for daytime protect crews
Inspector	$66,665	5-day for night crew, 7-day for daytime protect crews
Asst. Inspector	$63,992	5-day for night crew, 7-day for daytime protect crews
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Laborer	$50,132	5-day for night crew, 7-day for daytime protect crews
Mechanic	$59,662	5-day for night crew, 7-day for daytime protect crews

Position	Salary	Availability Applies?
Truck Driver	$50,121	5-day for night crew, 7-day for daytime protect crews
Welder	$58,553	5-day for night crew, 7-day for daytime protect crews
Welder Helper	$49,713	5-day for night crew, 7-day for daytime protect crews
Surfacing		
Foreman	$71,135	5-day for night crew, 7-day for daytime protect crews
Asst. Foreman	$68,283	5-day for night crew, 7-day for daytime protect crews
Inspector	$66,665	5-day for night crew, 7-day for daytime protect crews
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Mechanic	$59,662	5-day for night crew, 7-day for daytime protect crews
Truck Driver	$50,121	5-day for night crew, 7-day for daytime protect crews
Rail Grinding		
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Technician	$62,064	5-day for night crew, 7-day for daytime protect crews
Laborer	$50,132	5-day for night crew, 7-day for daytime protect crews
Condensed Track Inspection		
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Technician	$62,064	5-day for night crew, 7-day for daytime protect crews
Laborer	$50,132	5-day for night crew, 7-day for daytime protect crews
Work Train		
Train engineer	$74,398	5-day for night crew, 7-day for daytime protect crews
Conductor	$71,803	5-day for night crew, 7-day for daytime protect crews
RR Structures		
Foreman	$71,135	5-day for night crew, 7-day for daytime protect crews
Inspector	$66,665	5-day for night crew, 7-day for daytime protect crews
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Laborer	$50,132	5-day for night crew, 7-day for daytime protect crews
Truck Driver	$50,121	5-day for night crew, 7-day for daytime protect crews
Right-of-Way Structures		
Foreman	$71,135	5-day for night crew, 7-day for daytime protect crews
Inspector	$66,665	5-day for night crew, 7-day for daytime protect crews
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Laborer	$50,132	5-day for night crew, 7-day for daytime protect crews
Truck Driver	$50,121	5-day for night crew, 7-day for daytime protect crews
Signal		
Foreman	$79,733	5-day for night crew, 7-day for daytime protect crews
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Systems Engineer	$70,073	5-day for night crew, 7-day for daytime protect crews
Signal Engineer	$56,562	5-day for night crew, 7-day for daytime protect crews

Position	Salary	Availability Applies?
Signal Inspector	$70,386	5-day for night crew, 7-day for daytime protect crews
Signal Maintainer	$68,223	5-day for night crew, 7-day for daytime protect crews
Communications		
Foreman	$79,733	5-day for night crew, 7-day for daytime protect crews
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Comm. Engineer	$74,692	5-day for night crew, 7-day for daytime protect crews
Comm. Technician	$61,412	5-day for night crew, 7-day for daytime protect crews
Comm. Inspector	$68,480	5-day for night crew, 7-day for daytime protect crews
Overhead Cat. System		
Foreman	$79,733	5-day for night crew, 7-day for daytime protect crews
Asst. Foreman	$73,715	5-day for night crew, 7-day for daytime protect crews
Inspector	$70,386	5-day for night crew, 7-day for daytime protect crews
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Laborer	$50,132	5-day for night crew, 7-day for daytime protect crews
Truck Driver	$50,121	5-day for night crew, 7-day for daytime protect crews
Lead Wireman	$51,953	5-day for night crew, 7-day for daytime protect crews
Electrician (Hi Volt.)	$62,254	5-day for night crew, 7-day for daytime protect crews
Electric Transmission/ Substations		
Foreman	$79,733	5-day for night crew, 7-day for daytime protect crews
Inspector	$70,386	5-day for night crew, 7-day for daytime protect crews
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Laborer	$50,132	5-day for night crew, 7-day for daytime protect crews
Stations / Wayside		
Foreman	$71,135	5-day for night crew, 7-day for daytime protect crews
Operator	$51,177	5-day for night crew, 7-day for daytime protect crews
Laborer	$50,132	5-day for night crew, 7-day for daytime protect crews
Truck Driver	$50,121	5-day for night crew, 7-day for daytime protect crews
Electrician	$61,853	5-day for night crew, 7-day for daytime protect crews
Plumber	$60,275	5-day for night crew, 7-day for daytime protect crews

8.3 Uniforms, Supplies, and Information Technology/Software

8.3.1 Uniforms

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 2015 dollars).[25] Uniform costs are estimated at $293 per employee per year. This does not apply to frontline employees or management.

8.3.2 Supplies and cell phones

Frontline personnel will incur office supply costs and will require cell phones. The office supplies are assumed to be $412 per year per frontline employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2015 dollars).[26] The cell phone allowance is estimated at $681 per year per frontline employee based on the U.S. General Services Administration Cost Per Person Model (escalated to 2015 dollars).[27]

8.3.3 Information Technology / Software

Each Maintenance of Equipment facility will require some Information Technology/software functionality. Based on the GSA per person cost model (escalated to 2015 dollars), the Information Technology costs are estimated at $5,239 per user profile. It is assumed that each maintenance facility will have 10 user profiles.

[25] SFMTA. S*FMTA Operating Budget for FY 2013-2014.* 14 October, 2013. <http://www.sfmta.com/sites/default/files/FY2013FY2014BUDGETBOOKopt.pdf.>
[26] SFMTA. S*FMTA 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 as well as in yards are also included in this section.

9.1 Related Personnel

Station personnel include terminal managers, station managers, ticket agents/ passenger assistance representatives, facility maintenance managers, station cleaners and so forth. 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.

9.2 Assumptions and Model Inputs

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

9.2.1 Station Operations and Cleaning

9.2.1.1 Primary Drivers

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

Table 20. Station levels and descriptions

Level	Description	Stations
Level A	Final system configuration terminals	• Los Angeles Union Station • San Francisco Transbay Transit Center (Phase 1 only)
Level B	Stations that serve as terminals under some phases of development or other major stations that are not Level A stations.	• Anaheim • Bakersfield (Silicon Valley to Central Valley Extension only, Level C during Phase 1) • Merced • North of Bakersfield (Silicon Valley to Central Valley line only, temporary station during opening phase) • San Jose • San Francisco 4th & King (Silicon Valley to Central Valley Extension only)
Level C	Intermediate stations that never serve as system terminals	• All Other Stations

9.2.1.2 General Assumptions

1. Station personnel consist of an agent/station manager, a building systems manager, and ticket clerks/customer service representatives. Ticket clerks will hold a dual role as a customer service representative. 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. Level A and Level B stations have more staffing than Level C stations. Level B stations maintain their staffing levels even after they are no longer terminals on the system because they still maintain a prominent role on the system.

2. Each station is assumed to be staffed for customer operations utilizing 2 tours per day. Stations may be open for customer operations for up to 18 hours. The tours of the station personnel will be staggered in order to provide the required coverage. In stations that have Terminal Control Facility capabilities, station staffing is in addition to Terminal Control Facility staffing except for the Building Systems Manager position, which is shared between the Terminal Control Facility and the station staffing for Level A stations. For Level B Stations, the Building Systems Manager is assumed to be on for 1 tour per day during the Silicon Valley to Central Valley phase and 2 tours per day in the other phases.
3. All stations that have passengers going through them will also require personnel to clean them. The level of staffing for station cleaning will depend on the level of the stations. Part-time cleaning positions are assumed to be half-time positions (4 hours per day).

9.2.1.3 Personnel Headcount

Table 21. Level C Station Headcount per Tour

Position	Headcount
Agent/Station Manager	1
Ticket Clerk/Customer Service Representative	3
Total	**4**

Table 22. Level B Station Headcount per Tour by Phase

Position	Silicon Valley to Central Valley	Phase 1
Agent/Station Manager	1	1
Ticket Clerk/Customer Service Representative	3	5
Total	**4**	**6**

Table 23. Level A Station Headcount per Tour

Position	Headcount
Agent/Station Manager	1
Ticket Clerk/Customer Service Representative	6
Total	**7**

Table 24. Station Cleaning Staff by Station Level

Station Level	Number of Cleaning Crew Tours	Staff per Tour	Total Staff
Level A	2	8	16
Level B	2	5	10
Level C	1	2 (part-time)	1

9.2.2 Train Cleaning Staff

9.2.2.1 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.

9.2.2.2 Personnel Headcount

Stations that have trains that terminate there and start a new revenue service run there 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 that 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.
4. Yard Train Cleaning Teams will consist of 12 people and will work in conjunction with the yard maintenance teams.

[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.

5. The number of cleaning teams and tours at each facility depends on the amount of maintenance anticipated to take place there (that is based on the number of trainsets expected to be there). The following number of tours and teams is assumed for each facility (note that the number of teams listed is over *all* of the planned tours and the tours are generally listed for information purposes only):

Table 25. Maintenance Yard Cleaning Staffing Tour

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

9.2.3 Wages

Table 26 summarizes the wages for Station and Cleaning personnel.

Table 26. Station Administration and Station and Train Cleaning Wages (2015 dollars)

Employee(s)	Salary/Contract Cost	Availability Applicable?	Source/Notes
Agent/Station Manager	$69,390	Yes, 7-day	
Ticket Clerk/Customer Service Representative	$51,496	Yes, 7-day	
Station and Train Cleaning			
Trainset and Station Cleaning	$38,366	Yes, 7-day	

9.2.4 Utilities

9.2.4.1 Energy Usage

Table 27 summarizes the total building area of each station as they are planned at this point. 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 total energy costs for stations. Station utility costs are estimated at 14.3 kWh per square foot based on the Energy Information Agency's average for retail buildings.[29]

[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 27. Station Building Areas during Phase 1 (subject to change as design advances)[30]

Station	Total Building Area (square feet)
San Francisco Transbay (incl. Caltrain)	640,000
Merced	131,400
Millbrae	125,000
San Jose	294,000
Gilroy	136,600
Fresno	168,800
Kings/Tulare	145,200
Bakersfield	140,200
Palmdale	163,200
Burbank	192,200
LA Union Station	427,200
Gateway Cities/Orange County	145,200
Anaheim	112,300

9.2.4.2 Water and Sewer

Station water and sewer costs are estimated at $0.184 per year per square foot and $0.169 per year per square foot, respectively. These are based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2015 dollars).[31]

9.3 Uniforms, Vehicles, Tools, Supplies, and Information Technology/Software

9.3.1 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 $293 per employee per year (escalated to 2015 dollars). This does not apply to frontline employees or management.

9.3.2 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 1 car at each terminal. The cars are priced based on the wet rate of $30,126 per car per year based on Metrolink's rate for Std. 4WD Ext. Cab Pick Ups (escalated to 2015 dollars) as a representative vehicle cost. Additionally, there will be 1

[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>

flatbed stake truck at the HMF. The flatbed stake trucks are priced at the Metrolink wet rate of $40,801 (escalated to 2015 dollars).

9.3.3 Supplies and cell phones

Frontline personnel will incur office supply costs and will require cell phones. The office supplies are assumed to be $412 per year per frontline employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2015 dollars).[33] The cell phone allowance is estimated at $681 per year per frontline employee based on the U.S. General Services Administration Cost Per Person Model (escalated to 2015 dollars).[34] Cleaning personnel will require cleaning supplies. The cleaning supplies are priced at $74 per year per employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2015 dollars).

9.3.4 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 $5,239 per user profile (escalated to 2015 dollars). It is assumed that each station will have two user profiles and each terminal will have 4 user profiles.

[33] SFMTA. S*FMTA 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>

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 the position titles, 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 (Level A, B, or C).
3. Supervisory requirements for a workforce of various sizes.

10.2 General Assumptions

1. Personnel are divided into two categories:
    - A **Sworn Police Officer** is a trained law enforcement officer provided by a local jurisdiction. Each station will have three sworn officers to cover all necessary functions. Level A stations will have an additional three sworn officers. The sworn officer will be responsible for policing their station and patrolling the right-of-way. Other duties aside from normal policing include parking lot patrols, fare evasion detection, receiving criminal complaints from patrons, crowd control, and patron assistance (as necessary).
    - 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. The Level A stations will have 12 total unsworn officers, Level B and C stations will have 7.5 total unsworn officer FTEs, and maintenance facilities and Maintenance of Infrastructure bases will have 6 unsworn officers.
2. The positions identified above are assumed that they will be personnel under law enforcement agreements with local jurisdictions for the police function and under security service agreements with private security firms for the security function. 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.
3. Command staff will consist of “frontline supervisors” (sergeants) and management staff (lieutenants, etc.). Frontline supervisors will be assigned as 5% of the positions needed. Management of the police and security functions will fall in the 10% of management and administration staff that is assumed.
4. Security guards and sworn police officers are assumed to work 40-hour weeks.
5. Many separate contracts will need to be negotiated for each station and for security under each phase.

10.3 Personnel Headcount

The following assumptions are applied to police and security staff:

Table 28. Baseline Assumptions: Police and Security Positions

Facility Types	Police Positions (Total FTEs)	Security Positions (Total FTEs)
Maintenance Facility / Maintenance of Infrastructure Base	0	6
Level B and C Stations	3	7.5
Level A Stations	6	12

10.4 Wages

Table 29 summarizes the wages for station police and security personnel.

Table 29. Station Police and Security Wages (2015 dollars)

Employee(s)	Salary/Contract Cost	Availability Applicable?
Sworn Officer	$78,585	Yes, 7-day
Unsworn Officer	$37,721	Yes, 7-day

10.5 Equipment, Vehicles, Supplies, Disposables

The police and security functions will require significant amounts of equipment for their operations. The equipment needs and drivers are as follows:

Table 30. Police and Security Equipment, Vehicles, and Disposable Supplies, Fuels, etc.

Equipment	Driver	Annual Cost
Equipment		
Personal equipment (e.g., uniforms, guns, handcuffs, etc.)	Sworn officers including command staff (frontline and general and administrative)	$2,096 / officer
Personal equipment	Unsworn officers including command staff	$1,048 / officer
Vehicles		
Police Vehicles (2 per station)	Level A stations	$8,083 / car (amortized cost)
Police Vehicles (1 per station)	Level B and C stations	$8,083 / car (amortized cost)
All-Terrain Vehicles (1 per station)	Level A stations	$3,143 / All-Terrain Vehicle (amortized cost)
Disposables		
Car fuel and disposables	Cars	$20,956 / car
All-Terrain Vehicle fuel and disposables	All-Terrain Vehicle s	$5,239 / All-Terrain Vehicle
Supplies for each Officer (flares, gloves, etc.)	Sworn Police Officers	$1,048 / officer

11 Commercial Costs and Functions

11.1 Marketing and Distribution

11.1.1 Marketing and Advertising

Marketing and advertising costs are based on the number of people that the advertising campaign is trying to reach and the number of impressions that will be required for the campaign to have an impact. People generally need to see an advertisement more than once for them to be influenced by it. This concept is called the effective frequency of the advertising and it generally ranges from three to five, depending on the campaign, product, target audience, etc.[35] For purposes of the estimate produced here, five will be considered the effective frequency. It is assumed that there will be three campaigns per year, each with five as their effective frequency (for a yearly frequency of 15 for all campaigns).

When the operator of the system will design their advertising campaign, they will target specific market segments and populations. However, it is premature at this point for the plans to go into that level of detail. Instead, the model assumes that the campaign will reach every person in a select number of counties in California. For purposes of the model, it is assumed that no advertising will take place in other states. The counties that will be targeted by each phase are as follows:

Table 31. Counties to be targeted by the advertising campaign for each phase

County	Valley to Valley Line	Valley to Valley Extension	Phase 1
Alameda	Yes	Yes	Yes
Alpine			
Amador			Yes
Butte			
Calaveras			Yes
Colusa			
Contra Costa		Yes	Yes
Del Norte			
El Dorado			
Fresno	Yes	Yes	Yes
Glenn			
Humboldt			
Imperial			
Inyo			
Kern	Yes	Yes	Yes
Kings	Yes	Yes	Yes
Lake			
Lassen			
Los Angeles			Yes
Madera	Yes	Yes	Yes
Marin		Yes	Yes
Mariposa			Yes
Mendocino			

[35] Professional Advertising. Advertising Planning. <http://www.myprofessionaladvertising.com/Advertising%20Planning.htm> Accessed 11.7.12.

County	Valley to Valley Line	Valley to Valley Extension	Phase 1
Merced	Yes	Yes	Yes
Modoc			
Mono			
Monterey			Yes
Napa		Yes	Yes
Nevada			
Orange			Yes
Placer			
Plumas			
Riverside			Yes
Sacramento			Yes
San Benito			Yes
San Bernardino			Yes
San Diego			Yes
San Francisco		Yes	Yes
San Joaquin			Yes
San Luis Obispo			Yes
San Mateo	Yes	Yes	Yes
Santa Barbara			Yes
Santa Clara	Yes	Yes	Yes
Santa Cruz	Yes	Yes	Yes
Shasta			
Sierra			
Siskiyou			
Solano	Yes	Yes	Yes
Sonoma			Yes
Stanislaus	Yes	Yes	Yes
Sutter			
Tehama			
Trinity			
Tulare	Yes	Yes	Yes
Tuolumne			Yes
Ventura			Yes
Yolo			
Yuba			

The populations of those counties in future years are listed in County Population Projections. To calculate the cost of the advertising, the number of impressions needs to be multiplied by the cost per impression. Costs for media purchases and impressions vary by the media type to be used. It is expected that the high-speed rail system would advertise on some combination of television, online, print, radio, and outdoor media.

According to eMarketer's Online Brand Management Report, the costs for these various media types vary significantly. Since it is too early to create an advertising plan by media type, it assumed that the

advertising cost will be equal to the highest cost in eMarketer's data, which is $10.25 (in 2008 dollars) per 1,000 impressions for broadcast television.[36] Escalated to 2015 dollars using Consumer Price Index escalation yields a cost of $11.28 per 1,000 impressions. Since the actual mix of media purchases is unknown at this time, the highest cost was assumed in an effort to remain conservative. Similarly, the number of impressions and the demographics to be reached are also taken as worst case options to avoid underestimating of costs.

11.2 Distribution and Credit Card Sales

Distribution costs include those costs that will be incurred to sell tickets and operate other customer-centered functions such as call centers. For purposes of the model, the main distribution costs that have been included are the costs associated with operating a call center, website and credit card fees on ticket sales.

The website is assumed to be able to generate advertising revenue and be cost neutral. The call center costs are estimated as a top-down commission on a portion of the sales. Based on Société Nationale des Chemins de fer Français' experience, 2 percent of ticket purchases are assumed to be through call centers in all but the first two years. For the first two years, it is assumed that the call center purchase percentage will be 4 percent to account for people getting used to the service. The rest of the sales are assumed to take place over the internet and in stations.

Call centers have two costs: for sales and for information. It is assumed 1/3 of the calls will be for information only and 2/3 will be for ticket purchases. To cover the total cost of all of the calls, it is assumed that a 15 percent commission will be applied to the sales conducted through the call center. Thus the cost of the center will be 0.6 percent of sales in the first two years and 0.3 percent of sales thereafter.

Credit card sales costs are calculated as a percentage of total revenue generated. For the *2016 Business Plan* O&M model, it was assumed that mobile payment assumptions such as Apple Pay and Google Wallet fall under the credit card sales cost category given similarities in transaction fee structure. As the rates charged by individual credit card companies and mobile payment processors vary by transaction type and amount, it would not be practical to model each type. Instead, a general percentage is used based on Amtrak's testimony in front of the Subcommittee on Financial Services and General Government of the Senate Committee on Appropriations on Amtrak's experience with credit card sales.[37] According to the testimony, 90 percent of Amtrak's ticket sales were purchased with credit cards and the average transaction fee cost was 2.27 percent of the ticket revenue. The model assumes that transaction fees for the system will be similar to Amtrak's at 2.27 percent but that 100 percent of the

[36] Geoffrey Ramsey. Online Brand Management: Connecting the Dots. eMarketer. <http://www.emarketer.com/docs/emarketer_online_brand_measurement_report.pdf> Accessed: 11.7.12.
[37] *Statement of Janet Langenderfer Senior Director, Credit Cards National Railroad Passenger Corporation*, 111th Cong. (2010) (testimony of Janet Langenderfer). <http://www.amtrak.com/ccurl/798/198/2010-06-16%20Langenderfer%20Sen%20Approps,0.pdf> Accessed 11.13.12.

transactions will be with credit cards/mobile payment options to account for the continued expansion of credit card/mobile payment use in coming years.[38]

11.3 Bus Costs

11.3.1 Cost per Mile

The cost of dedicated feeder coach service was estimated from a review of data and discussions with contract operators. In a recent study by Caltrans, rural intercity bus operations in the state were found to have costs per revenue service mile ranging from $1.25 to $3.62 (in 2007 $) with a weighted average of $2.60 per mile and with very light density service accounting for the upper end of the cost spectrum.[39] Discussion with one intercity coach industry executive produced an estimate of around $65-$75 per revenue service hour, including the supply of coaches, operation, and establishment / operation of depot and maintenance facilities for a more intense service as would be needed to meet high-speed rail trains.[40] Additionally, data from Amtrak's Thruway service showed costs ranging from $1.99 to $4.07 (in 2012 $) per revenue service mile for the various routes with a weighted average cost of $3.16 per mile. The data from Caltrans' rural intercity bus service study and from Amtrak's Thruway buses is shown in Amtrak Thruway and Rural Intercity Bus Costs.

The model uses $3.31 per mile (Amtrak's $3.16 Figure escalated to 2015 dollars using Consumer Price Index escalation) as the cost for connecting bus service as the Amtrak Thruway buses are more representative of the service that would be provided than the rural intercity bus routes. However, the rural intercity routes provide a good cross-check on the value for bus costs and the Amtrak Thruway weighted average falls in the higher part of the range for those routes.

11.3.2 Bus Miles

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 a bus miles total. Caltrans Division of Rail provided the deadhead percentage for a representative medium-distance bus route (Sacramento to Reno and Sparks, NV) of 7.4%.[41] 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.

11.4 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

[38] It is acknowledged that even in future years there will likely be some small percentage of transactions that will be paid for with cash. However, to avoid underestimating potential costs by assuming a smaller than necessary percentage of credit card/mobile payment sales, 100 percent of sales was used.

[39] KFH Group, "California Statewide Rural Intercity Bus Study, Final Draft", Caltrans Division of Mass Transportation, 2007, table 3-9, online at <http://www.dot.ca.gov/hq/MassTrans/Docs-Pdfs/5311/Bus-Study/Chapter-3.pdf>

[40] Conversations with Stanley G. Feinsod, Chairman of the Board, MacDonald Transit Associates and Fullington Auto Bus Company, and business development advisor to RATP Dev USA.

[41] Data provided by Caltrans Division of Rail on 11/16/12.

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.

11.5 Tax Liability

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

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 (CEO, President, or Executive Director) chairs this group whose 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 of the organization consists of the *Chief Executive Officer*—the top officer of the organization. The Chief Executive Officer 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:

1. The *Senior Vice President of Operations* 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 the 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 *Vice President of Safety* 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 *General Counsel* is responsible for representing the railroad in general legal matters and litigation as determined by the General Counsel. It is commonly related to corporate law, liability and claims, contracts, labor law, insurance, and so forth.
4. The *Vice President of Finance* is responsible for the development of the budget, payroll, general accounting, accounts payable, revenue accounting, and pertinent financial policies and procedures for the organization. It manages financial forecasting and reporting, bookkeeping, and other corporate finance responsibilities as necessary.
5. The *Vice President of Human Resources* 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.
6. The *Vice President/Director of Labor Relations* 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 area is often included in the Human Resources section.

7. The *Director of Contracts* directs and manages the development of contracts for material and services needed by the organization.
8. The *Vice President of Planning* is responsible for a range of corporate planning functions to include capital program infrastructure and fleet procurement plans, strategic (long term) investment and planning, and may include train service planning.
9. The *Vice President of Systems and Information Technology* is responsible for developing the corporate strategy, policies, and procedures on information systems based upon the technology needs of the organization. It directs the purchase, development, installation, and maintenance of the information systems.
10. The *Vice President/Director of Public Affairs/Marketing* directs the corporate communication strategy and manages communications with the media, with the public, with offices at all government levels. It represents the organization in public venues and develops policies and procedures for the management of information at the railroad.
11. 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. These sections or departments are most often structured in the senior staff level of the railroad. Their position in the structure depends upon the "corporate organization" philosophy and thus not assured of this positioning. They are included here for the purpose of creating an illustrative structure and establishing a placeholder for the functions required at this level.

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 organization below this level.
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 the general and administrative staffing is based on a comparison with other railroad properties in the U.S. and high-speed rail systems abroad.

12.2.1 Wages

Table 32 summarizes wages for executive and corporate personnel.

Table 32. Executive and Corporate Wages (2015 dollars)

Employee (s)	Salary	Availability Applies?
Executives	$209,559	No
Senior Management	$157,169	No
Mid-Level Managers	$104,780	No
Admin/Lower Level Corporate Staff	$52,390	No

12.3 Vehicles, Tools, Supplies, Information Technology/Software, and Travel

12.3.1 Vehicles

General and administrative personnel will require a small number of non-rail vehicles to personnel around, as necessary. The vehicle fleet will consist of 8 cars in the Silicon Valley to Central Valley phase, and 16 cars in Phase 1. The cars are priced based on the wet rate of $30,126 per car per year based on Metrolink's rate for Std. 4WD Ext. Cab Pick Ups as a representative vehicle cost (escalated to 2015 dollars).

12.3.2 Supplies and cell phones

All general and administrative personnel will incur office supply costs and the managers will require cell phones. The office supplies are assumed to be $412 per year per general and administrative employee based on the San Francisco Municipal Transportation Agency Operating Budget for FY 2013-2014 (escalated to 2015 dollars).[42] The cell phone allowance is estimated at $681 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 2015 dollars).[43]

12.3.3 Information Technology/Software

Each general and administrative employee will require Information Technology/software functionality. Based on the GSA per person cost model, the Information Technology costs are estimated at $5,239 per user profile (escalated to 2015 dollars). It is assumed that each general and administrative employee will have a user profile.

12.3.4 Travel

It is assumed that the managers would incur some amount of travel expenses per year. With most in-state trips being done via the high-speed rail system, most of the travel cost would be out-of-state travel. The costs are estimated at $1,048 per year for mid-managers, $3,143 per year for senior managers, and $10,478 per year for executive managers. These estimates are based off figures established for the *2014 Business Plan* and escalated to 2015 dollars using Consumer Price Index escalation.

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

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

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

13 Insurance

Insurance costs were estimated at $25 million per year during the Initial Operating Segment and $50 million per year during Phase 1 in the *2014 Business Plan* (2012 dollars). This estimate was created based on review of current insurance costs for commuter rail agencies across the country. To further evaluate the system's potential purchased and self-insurance costs, the California High-Speed Rail Authority continued work with an insurance consultant to produce estimates for liability, property, and business interruption insurance, among others. However, a reasonable way to model the impacts of the high-speed rail system's enhanced safety features on the anticipated insurance costs is still being derived. The California High-Speed Rail Authority continues to investigate the potential insurance costs for the system but without high-speed rail precedents in the U.S., there are few reliable examples to use.

While the analysis of insurance costs continues, the California High-Speed Rail Authority continues to use the insurance assumptions generated for the *2014 Business Plan*, escalated to 2015 dollars using Consumer Price Index escalation. Insurance during the Silicon Valley to Central Valley phase is assumed to be $26 million per year, with insurance during Phase 1 assumed to be $52 million per year.

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 (of 20-40 percent total contingency) and the Union Internationale des Chemins de fer's recommendation that contingencies for the O&M model should be consistent with those used in the lifecycle capital cost model.

14.1 Unallocated Contingency

Unallocated contingency was set at 5 percent of costs before 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

In the *2014 Business Plan*, allocated contingency percentages were applied to account for risk and uncertainty associated with individual elements in the model based on the team's evaluation of the quality and reliability of information that is being used. To create the allocated contingency percentages, each team member provided an evaluation of 1 to 5 of the reliability of each of the elements (with 1 being low reliability/confidence and 5 being high reliability/confidence). Additionally, each team member provided the reasons for their confidence or lack of confidence in the estimate.

These ratings were averaged between the team members and a contingency percentage was assigned so that total contingency fell in the range recommended by the Department of Transportation Inspector General. The minimum allocated contingency (for a rating of 5) was 15 percent and the maximum (for a rating of 1) was 35 percent.[44] The ratings and allocated contingency percentages are presented in

[44] The range of allocated contingencies considered was 15 to 35 percent because there is 5 percent unallocated contingency leading to a total contingency of 20 to 40 percent, as recommended by Department of Transportation Inspector General.

Table 33. The full table of ratings from each team member and reasons for their confidence/lack thereof are presented in Allocated Contingency Risk/Uncertainty Ratings and Percentages in Appendix 7. The overall contingency levels ranged from 16 percent to 25 percent, consistent with the capital cost estimates and with the expectations in the Department of Transportation Inspector General report for a system moving through the intermediate stage of design.

The allocated contingency percentages were kept consistent in the *2016 Business Plan* O&M cost model. More quality and reliable information is now available for each cost category, and as a result, confidence ratings will likely have increased since 2014. However, to remain consistent with the *2014 Business Plan* and to maintain a level of conservatism in the allocated contingency assumptions, allocated contingency percentages remain the same.

Table 33. Allocated contingency percentages by cost category

Cost Category	Average Team Confidence Rating	Allocated Contingency Percentage (%)
Labor		
Maintenance of Equipment	4.00	20.00
Maintenance of Infrastructure	3.50	22.50
On-board staff (including drill crews and protect crews)	3.75	21.25
Dispatching	4.75	16.25
Train Cleaning and Station Maintenance Staff	4.25	18.75
Stations	3.50	22.50
Police and Security	4.33	18.33
General and Administrative Staff	3.75	21.25
Materials, Tools, and Other Direct Costs		
Maintenance of Infrastructure Materials (including stations)	3.50	22.50
Maintenance of Infrastructure Tools, Uniforms, etc.	3.88	20.63
Maintenance of Infrastructure Vehicles	3.00	25.00
Vehicles besides Maintenance of Infrastructure and Police and Security	3.67	21.67
Police and Security Vehicles	4.00	20.00
Police and Security Equipment	4.00	20.00
Station Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4.33	18.33
On-board Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4.33	18.33
Dispatch Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4.33	18.33
Maintenance of Infrastructure Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4.33	18.33
Maintenance of Equipment Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4.33	18.33
General and Administrative Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4.33	18.33
Maintenance of Equipment Tools, Uniforms, etc.	3.88	20.63
Maintenance of Equipment Regulatory Inspections	3.75	21.25
Maintenance of Equipment General Overhauls and Bogie Inspections	3.50	22.50
Utilities		
Train Operations Energy	4.13	19.38
Stations and Maintenance Facilities Energy	3.50	22.50

Cost Category	Average Team Confidence Rating	Allocated Contingency Percentage (%)
Station and Maintenance Facility Water and Sewer	3.17	24.17
Other Costs		
Bus Costs	3.38	23.13
Advertising	3.67	21.67
Credit Card Sales	4.00	20.00
Distribution (Call Center)	3.67	21.67
Insurance	4.33	18.33

15 Operations Startup and Commissioning

15.1 Rolling Stock Procurement

Table 34 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 Silicon Valley to Central Valley scenarios and Phase 1; and, the rate of ridership growth projected in the *2016 Business Plan*.[45] This delivery schedule may be modified at the time of purchase based on vendor input and capital considerations.

Table 34. Potential Rolling Stock Delivery Schedule

Delivered and accepted by	System Development Step	San Francisco Anaheim (Valley to Valley Line)		San Francisco Anaheim (Valley to Valley Extension)	
		Incremental	Total	Incremental	Total
2025	Valley to Valley	-	7	-	7
2026	Valley to Valley	2	9	3	10
2027	Valley to Valley	2	11	3	13
2028	Valley to Valley	2	13	3	16
2029	Phase 1	15*	28	15*	31
2030	Phase 1	15*	43	15*	46
2031	Phase 1	15*	58	12*	58
2032	Phase 1	10	68	10	68
2033	Phase 1	10	78	10	78

*Assumes excess trains beyond 10 in these years will be delivered early in 2026, 2027, and 2028, but not begin revenue service until Phase 1 commences in 2029.

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.

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

16 Monte Carlo Risk Analysis

Monte Carlo simulations rely on repeated random sampling from a range of variable inputs to determine the probability of different cost, schedule, revenue or other outcomes.

In a traditional, 'bottom-up', analysis, point estimates, e.g., how long a planned activity in a schedule is expected to take, are replaced with a range of possible durations so that instead of '45 days' the activity may take between 40 and 60 days. The possibility of unplanned activities or unexpected costs (risks) may also be included as inputs. The algorithm takes this information and simulates a possible outcome given the underlying schedule or cost estimate and uncertainty/risk. By doing this thousands of times, the program can determine the probability of a particular outcome and answer questions such as how likely it is that a project will finish on time or on budget.

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, e.g., that, a particular revenue projection will be met or costs will be below a certain target.

Monte Carlo simulations are part of a broad class of computational algorithms that rely on repeated random sampling to determine the range of possible outcomes along with the probability of those outcomes. Monte Carlo simulations are used in a variety of ways on this program to determine possible cost, schedule or revenue outcomes when uncertainty and risk are incorporated into the underlying models. Consistent with the *2014 Business Plan,* the *2016 Business Plan* utilized a top-down reference class analysis based on comparable rail projects around the globe to evaluate risks to the O&M 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. To this may be added risk 'events' that may or may not happen 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 so on down the line 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 goes back and does it again to get 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.

In the *2014 Business Plan,* both a bottom-up analysis and a top-down analysis were conducted to analyze potential cost saving opportunities and threats-conditions or situations that may lead to lower or higher than expected costs. The top-down analysis was deemed most appropriate for future business planning as it is based on actual rail project outcomes from across the globe and less subject to bias.

For the *2016 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. 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 California High-Speed Rail Authority's Risk Management Plan.

Table 35. Reference Project Cost Variances from Plan

System (Boldface indicates HSR)	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%

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 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, in order 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 O&M risk analysis employs a reference-class methodology for O&M 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% chance that your trip will take between 41 and 57 minutes' or 'there is a 2% chance that your trip will take longer than 80 minutes'.

For the O&M risk analysis, the California High-Speed Rail Authority identified six reference projects (see Table 35). Based on these results, the California High-Speed Rail 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%

The Minimum ('best case' scenario) was set as the medium cost scenario plus unallocated contingency only. Unallocated contingency was equivalent to 5% 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. The Minimum and Most Likely cost scenarios have been updated since the *2014 Business Plan* to better reflect the current risk profile of O&M cost forecasts. As in the *2014 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% 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 O&M cost model is not yet optimized. Once a private operator begins implementing and overseeing O&M of the system, there are expected to be many areas that can be made more efficient that the Medium cost forecasts do not consider.
- In their review of the *2016 Business Plan* O&M model, industry experts Network Rail listed several cost areas that include very conservative assumptions, including, but not limited to:

  - Terminal control facilities are not expected to be necessary, given the likely ability to dispatch trains from a central location.
  - Certain station staffing can be replaced with ticket-vending machines.
  - On-board personnel assumptions may be high and has not been optimized to reflect service plans.
  - All positions are assumed to be filled; however, in many cases it would be optimal to pay overtime instead of filling all positions.
- The Lignes à Grande Vitesse (LGV) Rhone-Alps and LGV Nord reference cases show 4% and 6% cost overruns, respectively, and are the two most 'on-point' cases in the reference set as they are both high-speed rail systems.[46] Nevertheless, the Maximum parameter was set based on the worst case in the reference set, a 34% 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 line, and Phase 1 as well as for each year of All (combining the Silicon Valley to Central Valley line 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 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 and Phase 1 phases. During the significant expansion in operations from the Silicon Valley to Central Valley line to Phase 1 during the transition between years 2028 and 2029, it is assumed that the year-to-year relationship for costs is significantly weaker, though still positive. Correlation rates used in the risk analysis are summarized below:

Table 36. Correlation Rates used for 2016 Business Plan Risk Analysis

Category	Years 2025 2028; 2030 and beyond	Year 2029 (transition year between Valley to Valley and Phase 1)
Correlation Rate	+ 0.50	+ 0.16

Each Monte Carlo simulation consisted of 10,000 iterations. The parameters for each exposure curve along with the results of these analyses, the totals for each phase, are presented in Table 37.

[46] Even these, relatively minor, cost overrun percentages may overstate actual cost overruns. In a review of the *2014 Business Plan* O&M risk analysis, industry experts noted that these cost overruns may actually reflect scope changes in service only.

Table 37. Probabilistic outcomes of Monte Carlo simulations for each (2015 dollars, Valley to Valley Line)

All SF-ANA Parameters	V2V Line $O\&M_{TOT}$	Ph1 $O\&M_{TOT}$	ALL $O\&M_{TOT}$
Min: Base Case w/ unalloc. cont. ONLY	$8,855	$15,227	$24,082
Mode: Base Case (includes alloc. and unalloc. cont.)	$10,613	$18,135	$28,748
Max: Base Case (includes alloc. and unalloc. cont.) * 1.34	$14,222	$24,301	$38,523
OUTPUT	**$10,922**	**$18,678**	**$29,600**
Percentile			
Minimum	$8,888	$15,279	$24,164
1%	$9,128	$15,671	$24,798
5%	$9,429	$16,171	$25,600
10%	$9,661	$16,556	$26,216
15%	$9,845	$16,864	$26,709
20%	$10,008	$17,136	$27,144
25%	**$10,158**	**$17,388**	**$27,547**
30%	$10,301	$17,628	$27,930
35%	$10,440	$17,861	$28,301
40%	$10,576	$18,091	$28,666
45%	$10,712	$18,319	$29,031
50%	**$10,849**	**$18,550**	**$29,399**
55%	$10,989	$18,785	$29,774
60%	$11,133	$19,029	$30,161
65%	$11,283	$19,283	$30,566
70%	$11,443	$19,553	$30,995
75%	**$11,615**	**$19,844**	**$31,459**
80%	$11,806	$20,167	$31,973
85%	$12,024	$20,539	$32,563
90%	$12,292	$20,992	$33,284
95%	$12,663	$21,623	$34,287
99%	$13,251	$22,624	$35,878
Maximum	$13,996	$23,852	$37,891
		Values in $ Millions	

Notes: Scenario depicted is Silicon Valley to Central Valley line in 2025 and Phase 1 in 2029. Each column, Silicon Valley to Central Valley line, Phase 1, and 'All' are the product of an individual simulation and values for any particular probability in Silicon Valley to Valley line and Phase 1 cannot be summed to determine the 'All' value for that probability.

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 farebox revenues to be equal to or greater than O&M costs. The analysis used the same revenue and O&M cost models discussed in the *2016 Business Plan* and in this Technical Supporting Document. In addition, the analysis assumed a 0.50 positive correlation factor between farebox revenue and O&M 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 O&M costs. The results provide a probability distribution pairing different profit or loss outcomes with their likelihood, which allows the California High-Speed Rail Authority to determine the probability of system revenues equaling or exceeding O&M costs.

The results of the risk analysis show that the Silicon Valley to Central Valley line scenario has a 69 percent probability of generating positive cash flow over the first five years of operations, without considering the inclusion of Phase 1 operations in 2029. The analysis looked at this period cumulatively in order to reflect how a private operator would manage and mitigate its financial risk over a potential contract period. As the system extends to Phase 1 and ridership continues to increase, the probability improves to >99 percent by 2040.

Given the multi-year nature of the planned operating contract, the breakeven projections and the expertise of a private sector operator, the California High-Speed Rail 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 38 presents the results of the breakeven analysis during (i) the Silicon Valley to Central Valley line opening year; (ii) an out year of operations for Silicon Valley to Central Valley line only; (iii) the Phase 1 opening year; (iv) an out year of operations for Phase 1; (v) the cumulative breakeven probability for the first five years of operations. 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 38 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 almost 100 percent.

Table 38. Probability of system revenue exceeding O&M costs in select years

Timing	Valley to Valley Line Scenario Opening Year (2025)	Valley to Valley Line Scenario Horizon Year (2029)	Cumulative First 5 Years of Operations (Valley to Valley Line Only) (2025 2029)	Phase 1 Opening Year (2029)	Phase 1 Horizon Year (2040)
Breakeven Probability	32%	91%	69%	88%	>99%

Appendix 1—Assumptions Register

#	Area	Assumption
Universal		
1	Opening Years	• Silicon Valley to Central Valley —2025 • Phase 1—2029 Both Silicon Valley to Central Valley line and Silicon Valley to Central Valley Extension variants were modeled and assumed to open in 2025.
2	Fringe Benefits	• $19,638 for the health, vision, dental, and retiree health plans • 5.55% of wage up to $17,163 for Railroad Unemployment Insurance Act benefits • 12.1% of wage up to $93,358 for Railroad Retirement Tier 2 • 6.2% of wage up to $115,257 for Railroad Retirement Tier 1 • 7.45% with no limit (1.45% for Medicare and 6% for Federal Employers Liability Act compensation)
3	Overtime	Employees are not paid overtime.
4	Frontline	One frontline supervisor is assumed for every 20 non-contracted positions.
5	Frontline	Frontline supervisors earn 10% more than each category's highest wage
6	General and administrative Staffing	General and administrative personnel are assumed to be 10% of the total workforce (including frontline supervisors).
7	Staff Availability Factors	Each regular crew assignment is multiplied by a factor of 1.63 (365 days per year/224 days per year = 1.63) for 7-days per week crews and 1.13 (252 days per year/224 available days per year = 1.13) for 5-days per week crews.
8	Staff Availability Factors	The availability assumption is not applicable to contractors and management and administrative staff.
9	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.
10	Real Inflation on Wages	A 0.267 percent per year real inflation rate is applied to wages based on historic differences in the rate of increase of the wages in the California Trade, Transportation, and Utilities sector and Consumer Price Index.
11	Shared Facility Costs	The costs for shared facilities (i.e., the Caltrain corridor and others) have been fully accounted for in the model pending agreements that would allow some of these costs to be shifted to other operators.
Train Operations		
1	Crews	It is assumed that each crew will be able to cover one round trip per day (two legs), with the exception of the Phase 1 system, where crews can cover slightly less than one full round trip per day. Crew changes will be used, where necessary, to maintain this efficiency.
2	Single-Trainset Crews	For a single-consist train: 1 train engineer, 1 conductor, 2 assistant conductors, and 1 on-board attendant if there is no food service and 2 on-board attendants if there is food service

#	Area	Assumption
3	Double-Trainset Crews	For a double-consist train: 1 train engineer, 1 conductor, 2 assistant conductors, and 2 on-board attendants if there is no food service and 4 on-board attendants if there is food service
4	Protect Crews	• Protect crews consist of 1 train engineer, 1 conductor, and 1 assistant conductor • The number of Protect Crews assumes 2 tours per day with crews stationed at each system terminal.
5	Drill Crews	• Drill crews consist of 1 train engineer • Each Level V facility (HMF) is assumed to have 1 drill crew for 3 tours per day while each other facility and yard is assumed to have 1 drill crew for 2 tours per day
6	Wages and Availability	• Train Engineer - $74,398, 7-day availability • Conductor - $71,803, 7-day availability • Asst. Conductor - $56,753, 7-day availability • On-Board Attendant - $42,782, 7-day availability
7	Energy Cost	$0.074 per kWh based on California Public Utilities Commission Renewable Portfolio Standards Biennial Update from January 2016.
8	Energy Consumption	41.5 kWh per trainset mile during Valley to Valley and 43.0 kWh per trainset mile during Phase 1
9	Uniforms, Vehicles, and Supplies	• **Uniform:** $293 per on-board employee per year. This does not apply to frontline employees or management. • **Vehicles:** $30,126 per car with 1 car at each terminal and 4 cars at the HMF. • **Supplies and Cell Phones:** $412 per year per frontline employee for office supplies. $681 per year per frontline employee for cell phones. • **Travel:** Based on the assumption that each employee would do a daily roundtrip and return to their home bases, and the additional staff added to allow for that, it is assumed that on-board personnel will not incur travel costs or have to stay overnight between runs.
Dispatching		
1	Operations Control Center	• There will be 1 Operations Control Center on the system • The Operations Control Center will have 1 Director—Operations Control, 1 Deputy Director—Operations Control, 5 dispatchers in the Valley to Valley, and 10 dispatchers in Phase 1 • The Operations Control Center will be on for 3 tours per day

#	Area	Assumption
2	Terminal Control Facility	• There will be one Terminal Control Facility in each Level A and B station • Level B stations will have 1 Deputy Director—Operations Control and 2 dispatchers during operations (2 tours per day) and 1 Deputy Director—Operations Control and 1 dispatchers during non-revenue operating hours (1 tour per day) • Level A stations will have 1 Deputy Director—Operations Control and 6 dispatchers during operations (2 tours per day) and 1 Deputy Director—Operations Control and 1 dispatchers during non-revenue operating hours (1 tour per day) • It is anticipated that Terminal Control Facilities may not be needed once the design of dispatching facilities is finalized. However, they have been left in the O&M Model as it is a conservative forecast of future operating expenditures.
4	Yard	• Each maintenance facility is assumed to have 2 train dispatchers for yard dispatch duties. • Yard dispatchers are assumed to be on for 3 tours per day at the HMF and 2 tours per day at each of the other facilities.
5	Wages and Availability	• Director Operations Control—$111,072, 7-day availability • Deputy Director—Operations Control - $96,557, 7-day availability • Train Dispatcher - $82,042, 7-day availability
6	Vehicles and Supplies	• **Vehicles:** 2 cars at the Operations Control Center at $30,126 per car per year • **Supplies and cell phones:** $412 per year per dispatch employee for office supplies. $681 per year per frontline employee for cell phones.
Maintenance of Equipment		
1	Regulatory Inspection Staffing	Each maintenance facility will perform regulatory inspections. Each team that will be doing routine maintenance will each consist of 12 people as follows: • 1 Supervisor • 7 Technicians • 2 Laborers • 2 Storehouse employees

2	Regulator Inspection Teams	The maintenance facilities will have the following number of teams in each phase:
		• Silicon Valley to Central Valley:
		  ○ HMF—2 teams over 3 tours
		  ○ Bay Area—2 teams over 2 tours
		• Phase 1:
		  ○ HMF—3 teams over 3 tours
		  ○ Palmdale—3 teams over 3 tours
		  ○ Bay Area—3 teams over 3 tours
		  ○ Los Angeles Area—2 teams over 2 tours

3	Regulator Inspection Frequency	Assumptions for occurrence of inspections: • Daily, every 48 hours, 182.5 inspects per year per trainset • Monthly, every 30 days, 12.167 inspections per year per trainset • 92 days, 4 inspections per year per trainset

#	Area	Assumption
4	Regulator Inspection Materials Costs	Material costs for these inspections: • Daily, $524 per inspection • Monthly, $2,337 per inspection • 92 days, $524 per inspection
5	Overhaul Staffing (Bogie Inspection)	Overhauls occur only at HMF and once they start additional personnel are added beyond the requirements of the regulatory inspections. For each 600,000 miles that a trainset covers, a Bogie Inspection needs to be performed. Once Bogie Inspections begin, the following staff need to be added at the HMF: • 6 Supervisors • 37 mechanical technicians • 17 electrical technicians • 8 laborers • 10 storehouse employees
6	Overhaul Staffing (Overhaul General Inspection)	For every 1.2 million miles, each trainset needs to have an overhaul general inspection. Once these starts, the following personnel need to be added at the HMF (on top of the personnel hired for the Bogie Inspections: • 4 Supervisors • 20 mechanical technicians • 16 electrical technicians
7	Overhaul Material Costs	Bogie/truck inspections cost $133,070 per inspection Overhaul General Inspection cost $922,060 per inspection Wheel change outs cost $157,169 per trainset
8	Energy	• Maintenance facility utility costs are estimated at 27 kWh per square foot
9	Facility Levels	• Level 5: HMF • Level 3: Palmdale • Level 3: Bay Area • Level 2: Los Angeles Area
10	Facility Size	• HMF—727,800 sq. ft. • Palmdale—303,505 sq. ft. • Bay Area—303,505 sq. ft. • Los Angeles Area—252,645 sq. ft.
11	Cost Rationalization	7-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
12	Wages and Availability	• Maintenance of Equipment Supervisors - $78,547, 7-day for inspections, 5-day for overhauls • Maintenance of Equipment Technicians (including electrical and mechanical technicians) - $62,064, 7-day for inspections, 5-day for overhauls • Storehouse Employees - $44,970, 7-day for inspections, 5-day for overhauls • Laborers - $50,132, 7-day for inspections, 5-day for overhauls

#	Area	Assumption
13	Uniforms, Vehicles, Tools, Supplies, Information Technology /Software	• **Uniform:** $293 per Maintenance of Equipment employee per year. This does not apply to frontline employees or management. • **Vehicles:** $30,126 per car with 2 cars at each maintenance facility and 4 at the HMF. Additionally, $40,801 per flatbed stake truck with 2 flatbed stake trucks at each maintenance facility and 4 flatbed stake trucks at the HMF. • **Supplies and Cell Phones:** $412 per year per frontline employee for office supplies. $681 per year per frontline employee for cell phones. • **Tools:** 5 percent of total labor cost • **Information Technology/Software:** $5,239 per user profile with 10 user profiles for each maintenance facility. • **Wi-Fi Connection Charge:** It is assumed that the Wi-Fi connection charge per trainset is $4,387 per year.
14	Wi-Fi	• Wi-Fi maintenance to be covered in the Maintenance of Equipment overhaul process
Maintenance of Infrastructure		
1	Units/Gangs	• **Basic Maintenance of Infrastructure Facility** - A work force/equipment component providing Maintenance and Inspection functions. A Basic Maintenance of Infrastructure Facility component will be added for each new line segment placed into service. This component includes work force and equipment to address responsibilities in the Track (including visual track inspection), Structures, Signal, Communications, Overhead Catenary System, Electric Traction, and Utilities areas. It does not include track surfacing and alignment responsibilities which will be provided by a system work force. • **Initial System Unit** - a work force/equipment component, not attached to a specific facility, which has system-wide (or major line segment responsibility in an expanded system) responsibility for machine vision inspection, track replacement, alignment, surfacing and rail grinding, as well as, catenary repair, replacement and tensioning. The Initial System Unit will be augmented by the local Maintenance of Infrastructure Facility Unit as required. • **HMF Addition** - a work force/equipment component work, added to a Basic Maintenance of Infrastructure Facility component to maintain the yard track, switches, signals, and structures at the Heavy Maintenance Facility • **Facility Gang Addition** - a work force/equipment component, added to a Basic Maintenance of Infrastructure Facility component, work to provide additional support due to the challenges presented in certain locations. This component will be added for each Level 3 Maintenance of Equipment facility and when service through the Tehachapi Mountains begins.

#	Area	Assumption

2	Units/Gangs	The phases will have the following number of Maintenance of Infrastructure Gangs (based on the build-up described above):
		• Silicon Valley to Central Valley:
		  ○ Basic Maintenance of Infrastructure Facility - 2
		  ○ Initial System Unit - 1
		  ○ HMF Addition - 1
		  ○ Facility Gang Additions - 3
		• Phase 1:
		  ○ Basic Maintenance of Infrastructure Facility - 5
		  ○ Initial System Unit - 1
		  ○ HMF Addition - 1
		  ○ Facility Gang Additions—3

3	Staffing Levels	See Table 16.
4	Materials	15% of Maintenance of Infrastructure labor costs
5	Tools, uniforms, etc.	5% of Maintenance of Infrastructure labor costs
6	Vehicles	See Table 17.
7	Vehicle Costs	See Table 18.
8	Wages and Availability	See Table 19.
9	Uniforms, Supplies, Information Technology/Software	• **Uniform:** $293 per Maintenance of Infrastructure employee per year. This does not apply to frontline employees or management. • **Supplies and Cell Phones:** $412 per year per frontline employee for office supplies. $681 per year per frontline employee for cell phones. • **Information Technology/Software:** $5,239 per user profile with 10 user profiles for each maintenance base.
Station Operations and Train/Station Cleaning		
1	Station Levels	See Table 20.
2	Station Staffing Tours	Stations are assumed to be staffed for 2 tours per day, except the Building Systems Manager for Level B stations in the Silicon Valley to Central Valley phase, where she/he is assumed to be on for one tour per day.

#	Area	Assumption

3	Station Staffing Levels	The stations are assumed to have the following staffing per tour:
		• Level C
		  ○ Agent/Station Manager - 1
		  ○ Ticket Clerk/Customer Service Rep - 3
		• Level B
		  ○ Silicon Valley to Central Valley
		  Agent/Station Manager—1
		  Ticket Clerk/Customer Service Rep - 3
		  ○ Phase 1:
		  Agent/Station Manager—1
		  Ticket Clerk/Customer Service Rep - 5
		• Level A
		  ○ Agent/Station Manager - 1
		  ○ Ticket Clerk/Customer Service Rep – 6

4	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.
5	Train Cleaning Staff at Stations	• Station Train Cleaning Teams will consist of 10 people. However, these teams can be split into half-teams when necessary. • 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 that station rounded to the nearest half-team with no cleaning staff if three or fewer trains will be turned.
6	Train Cleaning Staff at Maintenance Facilities	• Yard Train Cleaning Teams will consist of 12 people and will work in conjunction with the yard maintenance teams. • The number of cleaning teams and tours at each facility depends on the amount of maintenance anticipated to take place there. • The number of teams and tours is the same as the number of regulatory inspection teams.
7	Energy	• Stations are assumed to use 14.3 kWh per square foot. • For station sizes, please see Table 27.
8	Wages and Availability	• Agent/Station Manager - $69,390, 7-day availability • Ticket Clerk/Customer Service Rep - $51,496, 7-day availability • Trainset and Station cleaning - $38,366, 7-day availability
9	Uniforms, Vehicles, Supplies, Information Technology/Software	• **Uniform:** $293 per station employee per year. This does not apply to frontline employees or management. • **Vehicles:** $30,126 per car with 1 car at each terminal. Additionally, $40,801 per flatbed stake truck and 1 flatbed stake truck at the HMF. • **Supplies and Cell Phones:** $412 per year per frontline employee for office supplies. $681 per year per frontline employee for cell phones. $74 per year per cleaning employee for cleaning supplies. • **Information Technology/Software:** $5,239 per user profile with 2 user profiles for each station and 4 user profiles at each terminal.

Police and Security		
1	Police and Security Staffing Levels	For station and maintenance facility/base police and security staffing levels please see Table 28.
2	Wages and Availability	• Sworn Police Officer- $78,585, No availability (already applied) • Unsworn Officer - $37,721, No availability (already applied)
3	Equipment, vehicles, supplies, fuel, and disposables	For costs for equipment, vehicles, supplies, fuel, and disposables please see Table 30.
Commercial Costs		
1	Marketing/ Advertising Costs	• Assumed 3 campaigns per year with an effective frequency of 5 • For counties that will have advertising in each phase, please see Table 31 and for their populations by year please see County Population Projections in Appendix 5. • Cost per 1,000 impressions is assumed to be $11.28
2	Distribution Costs and Credit Card Fees	• Call center volumes assumed to be 4 percent of sales in first two years and 2 percent thereafter • 2/3 of call center costs are assumed to be for ticket purchase, 1/3 for information • A 15% commission on call center costs is assumed • Website is assumed to be able to generate revenue through advertising that will offset website costs • All ticket sales are assumed to be with credit cards or mobile payment option • Credit card fees/mobile payment transaction fees are assumed to average 2.27 percent of revenue
3	Bus Costs	• Connecting bus services cost $3.31 per mile • Connecting bus services average 7.4 percent deadhead miles.
General & Admin Costs		
1	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: • Executive—5 percent • Senior Managers—10 percent • Mid-Managers—25 percent • Administrative and low-level corporate staff—60 percent
2	Wages and Availability	• Executive—$209,559, no availability • Senior Managers—$157,169, no availability • Mid-Managers—$104,780, no availability • Administrative and low-level corporate staff—$52,390, no availability

3		• **Vehicles:** $30,126 per car with 8 cars in the Valley to Valley and 16 cars in Phase 1. • **Supplies and Cell Phones:** $412 per year per general and administrative employee for office supplies. $681 per year per management employee (does not include admin/junior corporate staff) for cell phones. • **Information Technology/Software:** $5,239 per user profile with each general and administrative staff member having a profile. • **Travel:** $1,048 per year per mid-manager for travel, $3,143 per senior manager, $10,478 per executive manager.
Insurance		
1	Total Insurance Cost	$26 million per year during the Silicon Valley to Central Valley phase, and $52 million per year during Phase 1
Contingency		
1	Unallocated Contingency	5 percent of subtotal costs
2	Allocated Contingency	See Table 33.
Operations Startup and Commissioning		
1	Testing and Commissioning	Not part of routine Operations and Maintenance costs; included in capital costs
2	Rolling Stock Procurement Schedule	Illustrative schedule for Maintenance of Equipment cost estimating is shown in Table 34.

Appendix 2—Wages

Wages for the staff positions described in this Technical Supporting Document were obtained from an exhaustive analysis of wages for similar positions on existing rail systems across the country. The wages were gathered from available public and private sources and include over 100 data points across the various positions. The wages were regionally adjusted based on the Bureau of Labor Statistics data on mean annual wages for each region/state. This appendix lays out the wages that were collected and the geographic adjustments that were made to produce California wages. The geographic adjustment process was as follows:

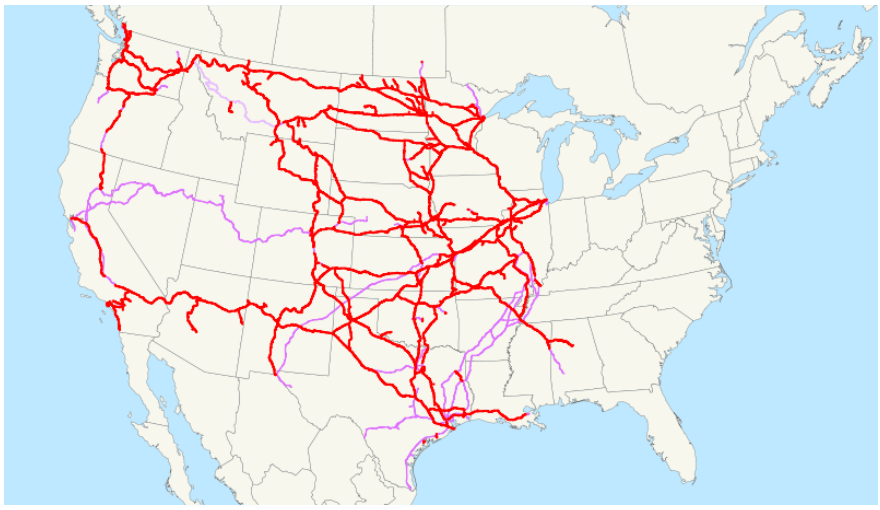
General

To convert the provided wages to their California equivalent, the mean average annual wages for the following locations were used based on the locations of the original data sources.

Source	Mean Average Wage
Amtrak	National
Bureau of Labor Statistics	California
LA MTA	Los Angeles-Long Beach-Santa Ana Municipal Transportation Agency
Long Island Railroad	New York-Northern New Jersey-Long Island
Maryland MTA	Maryland Municipal Transportation Agency
Metrolink	Los Angeles-Long Beach-Santa Ana
Metro North	New York-Northern New Jersey-Long Island
SFMTA	Northern California
Unions	National
Washington Metropolitan Area Transit Authority	District of Columbia
Other	National

Burlington North Santa Fe Railway

The Burlington North Santa Fe Railway (BNSF) system covers the following census regions West North Central (ND, SD, NE, KS, MN, IA, MO) West South Central (OK, TX, AR, LA), Mountain (MT, ID, NV, WY, UT, CO, AZ, NM) and Pacific (AK, WA, OR, CA, HI). The factor applied to the BNSF wages to convert them to California values uses a weighted average (by employment) of the 2010 annual mean wages of those regions.[47]



CSX Transportation

The CSX Transportation system covers the following census regions Middle Atlantic (NY, NJ, PA), South Atlantic (MV, MD, DC, VA, NC, SC, GA, FL), East North Central (WI, IL, IN, MI, OH) and East South Central (KY, TN, MS, AL).The factor applied to the CSX Transportation wages to convert them to California values uses a weighted average (by employment) of the 2010 annual mean wages of those regions.[48]

[47] <http://www.bls.gov/ncs/ocs/compub.htm>

[48] <http://www.bls.gov/ncs/ocs/compub.htm>

Norfolk Southern

The Norfolk Southern Railway system covers the following census regions Middle Atlantic (NY, NJ, PA), South Atlantic (MV, MD, DC, VA, NC, SC, GA, FL), East North Central (WI, IL, IN, MI, OH) and East South Central (KY, TN, MS, AL).The factor applied to the Norfolk Southern Railway wages to convert them to California values uses a weighted average (by employment) of the 2010 annual mean wages of those regions.[49]

Union Pacific (UP)

The UP system covers the following census regions East North Central (WI, IL, IN, MI, OH), West North Central (ND, SD, NE, KS, MN, IA, MO) West South Central (OK, TX, AR, LA), Mountain (MT, ID, NV, WY, UT, CO, AZ, NM) and Pacific (AK, WA, OR, CA, HI). The factor applied to the UP wages to convert them to California values uses a weighted average (by employment) of the 2010 annual mean wages of those regions.[50]

[49] <http://www.bls.gov/ncs/ocs/compub.htm>

[50] <http://www.bls.gov/ncs/ocs/compub.htm>

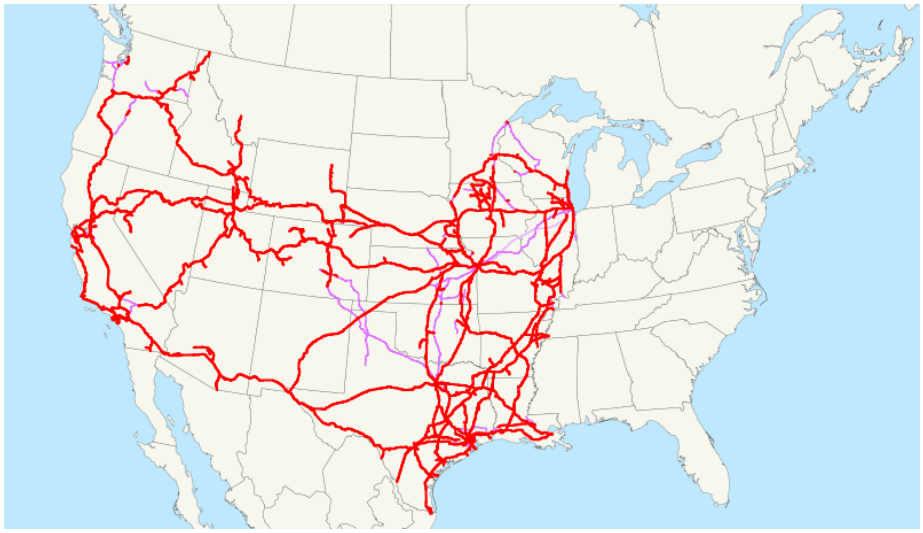


Table 2-1. Wage conversion factors from other geographic locations to California

Conversion From	Conversion to California
National	1.11
California	1.00
New York-Northern New Jersey-Long Island	0.92
District of Columbia	0.69
Maryland	1.00
Southern California	0.81
Central Valley	1.20
Northern California	1.01
BNSF	1.10
CSX	1.13
Norfolk Southern	1.13
Union Pacific	1.11

Table 2-2. Raw wage data collected by position (before adjustment to California wages, 2012 dollars)

Employee (s)	Amtrak	AAR	BART	BLS	BNSF	CSX	LA MTA	LIRR	Maryland MTA	Metrolink	Metro North	NS	UP	SFMTA	Unions	VTA	WMATA	Other	Median
	National	National	NoCal	California	West/Midwest	South/Midwest	SoCal	NY/NJ/Long Island	MD/DC/VA/WV	SoCal	NY/NJ/Long Island	South/Midwest	Midwes/West	NoCal	National	NoCal	MD/DC/VA/WV	National	
MOE																			
MOE Supervisor			$90,402				$88,292									$93,069			**$90,402**
MOE Technician	$51,896				$56,805	$52,062	$58,521	$64,865	$44,023	$60,174		$54,392	$45,053		$56,555		$53,248		**$54,392**
Storeroom Employee	$38,542		$62,955				$47,190							$53,284		$51,866			**$51,866**
Train and Station Cleaning Staff (non-contract)	$32,968					$30,883	$37,005							$47,660		$41,456			**$37,005**
Transportation																			
On-Board Staff																			
Locomotive Engineer	$65,343			$47,611				$75,390		$80,660	$79,562				$52,083				**$70,367**
Conductor				$52,208				$75,390		$67,704	$75,481				$51,753				**$67,704**
Asst. Conductor	$40,352							$68,126							$48,768				**$48,768**
On-Board Attendant				$40,643							$44,536								**$42,590**
Dispatchers																			
Director Operations Control (DOC)			$117,112				$92,757			$108,522	$116,656								**$112,589**
Deputy DOC																			
Train Dispatcher			$91,171	$59,260	$85,000		$75,461	$94,582		$93,854	$80,073			$99,595	$91,885	$73,862			**$88,086**
TCF																			
Train Dispatcher			$91,171	$59,260	$85,000		$75,461	$94,582		$93,854	$80,073			$99,595	$91,885	$73,862			**$88,086**
Yard																			
Train Dispatcher			$91,171	$59,260	$85,000		$75,461	$94,582		$93,854	$80,073			$99,595	$91,885	$73,862			**$88,086**
Stations																			
Agent/Station Manager	$71,610		$62,856					$73,285			$71,903			$72,801					**$71,903**
Ticket Clerk/Customer Service Rep	$41,475		$69,451				$43,837	$58,248			$56,684			$61,016		$52,851			**$56,684**
Station Cleaning																			
Train and Station Cleaning Staff (non-contract)	$32,968					$30,883	$37,005							$47,660		$41,456			**$37,005**
MOI																			
Track, Surfacing, Rail Grinding, and Isnpection, Structures, Stations/Wayside, and Elec Trans/Sub Sta Teams																			
Foreman	$64,293		$76,651					$82,398			$73,712					$82,830			**$76,651**
Asst. Foreman											$70,757								**$70,757**
Inspector			$77,446				$56,472	$70,566		$74,274	$70,429			$55,227					**$70,498**
Assistant Inspectors																			
Welder	$50,315		$61,510		$49,483		$58,929	$64,817			$58,179			$72,646					**$58,929**
Welder Helper											$51,514								**$51,514**
Equipment Operator	$47,466		$58,224			$45,115								$53,694					**$50,580**
Truck Driver	$44,325				$42,224		$44,283							$68,455					**$44,304**
Laborers					$44,408	$44,762	$47,270						$39,374	$55,227					**$44,762**
Plumber							$53,498	$65,487			$59,430			$88,827					**$62,458**
Mechanic					$51,771	$52,208	$54,180						$44,595			$75,857			**$52,208**
Signal, Communications, and OHC Teams																			
C&S Foreman			$81,756					$91,409			$74,056					$104,268			**$86,582**
Asst. Foreman								$84,204			$68,565								**$76,385**
Communications Engineer			$77,373				$70,428	$83,671											**$77,373**
Comm. Inspector							$64,570												**$64,570**
Systems Engineer			$83,028					$87,535						$51,450					**$83,028**
Signal Engineer								$72,227						$51,450					**$61,838**
Electrician (hi. volt.)	$55,619					$52,208		$65,206	$55,619		$59,157	$54,517	$45,178	$83,239					**$55,619**
Lead Wiremen									$44,023		$60,013								**$52,018**
Signal Inspector	$62,650						$64,077	$70,764			$75,108								**$67,420**
Communications Technician			$74,211		$53,290	$49,962	$61,271	$71,664	$44,023		$53,199		$39,770			$76,177			**$53,290**
Signal Apprentice					$46,322	$40,352							$51,813						**$46,322**
Signal Maintainer					$68,139	$59,176		$69,060			$63,594								**$65,866**
Engineering Technician								$75,390			$71,129					$70,248	$65,240		**$70,688**
Facility Electrician			$74,049		$52,208		$59,012						$45,178	$89,394		$72,527			**$65,770**

Table 2-3. Wage data collected by position (adjusted to California wages, 2012 dollars)

	Amtrak	AAR	BART	BLS	BNSF	CSX	LA MTA	LIRR	Maryland MTA	Metrolink	Metro North	NS	UP	SFMTA	Unions	VTA	WMATA	Other	Median
MOE																			
MOE Supervisor			$72,816				$89,367									$74,964			$74,964
MOE Technician	$57,638				$62,476	$58,608	$59,233	$59,742	$43,893	$60,906		$61,231	$50,121		$62,813		$36,782		$59,233
Storeroom Employee	$42,807		$50,708				$47,764							$42,919		$41,776			$42,919
Train and Station Cleaning Staff (non-contract)	$36,616					$34,766	$37,455							$38,389		$33,392			$36,616
Transportation																			
On-Board Staff																			
Locomotive Engineer	$72,573			$47,611				$69,436		$81,641	$73,278				$57,846				$71,005
Conductor				$52,208				$69,436		$68,528	$69,520				$57,479				$68,528
Asst. Conductor	$44,817							$62,746							$54,164				$54,164
On-Board Attendant				$40,643							$41,019								$40,831
Dispatchers																			
Director Operations Control (DOC)			$94,330				$93,886	$106,005		$109,842	$107,443								$106,005
Deputy DOC																			
Train Dispatcher			$73,435	$59,260	$93,487		$76,379	$87,112		$94,996	$73,749			$80,221	$102,052	$59,494			$78,300
TCF																			
Train Dispatcher			$73,435	$59,260	$93,487		$76,379	$87,112		$94,996	$73,749			$80,221	$102,052	$59,494			$78,300
Yard																			
Train Dispatcher			$73,435	$59,260	$93,487		$76,379	$87,112		$94,996	$73,749			$80,221	$102,052	$59,494			$78,300
Stations																			
Agent/Station Manager	$79,534		$50,629					$67,497			$66,225			$58,639					$66,225
Ticket Clerk/Customer Service Rep	$46,064		$55,941				$44,371	$53,648			$52,208			$49,147		$42,570			$49,147
Station Cleaning																			
Train and Station Cleaning Staff (non-contract)	$36,616					$34,766	$37,455							$38,389		$33,392			$36,616
MOI																			
Track, Surfacing, Rail Grinding, and Isnpection, Structures, Stations/Wayside, and Elec Trans/Sub Sta Teams																			
Foreman	$71,407		$61,740					$75,890			$67,890					$66,717			$67,890
Asst. Foreman											$65,169								$65,169
Inspector			$62,380				$57,159	$64,993		$75,178	$64,867			$44,484					$63,624
Assistant Inspectors																			
Welder	$55,883		$49,544		$54,424		$59,646	$59,698			$53,584			$58,514					$55,883
Welder Helper											$47,445								$47,445
Equipment Operator	$52,718		$46,898			$50,788								$43,249					$48,843
Truck Driver	$49,229				$46,440		$44,822							$55,138					$47,835
Laborers					$48,842	$50,390	$47,845						$43,804	$44,484					$47,845
Plumber							$54,149	$60,315			$54,736			$71,547					$57,525
Mechanic					$56,940	$58,772	$54,839						$49,612			$61,100			$56,940
Signal, Communications, and OHC Teams																			
C&S Foreman			$65,852					$84,190			$68,207					$83,985			$76,096
Asst. Foreman								$77,554			$63,150								$70,352
Communications Engineer			$62,322				$71,285	$77,063											$71,285
Comm. Inspector							$65,356												$65,356
Systems Engineer			$66,877					$80,622						$41,441					$66,877
Signal Engineer								$66,522						$41,441					$53,982
Electrician (hi. volt.)	$61,773					$58,772		$60,056	$55,455		$54,485	$61,371	$50,260	$67,046					$59,414
Lead Wiremen									$43,893		$55,273								$49,583
Signal Inspector	$69,582						$64,857	$65,175			$69,176								$67,176
Communications Technician			$59,775		$58,610	$56,244	$62,017	$66,004	$43,893		$48,998		$44,243			$61,358			$58,610
Signal Apprentice					$50,946	$45,426							$57,641						$50,946
Signal Maintainer					$74,942	$66,617		$63,606			$58,571								$65,111
Engineering Technician								$69,436			$65,511					$56,583	$45,065		$61,047
Facility Electrician			$59,644		$57,421		$59,730						$50,260	$72,004		$58,418			$59,031

Appendix 3—Maintenance of Infrastructure Position Descriptions

Table 3-1. Maintenance of Infrastructure position descriptions

Track, Surfacing, Rail Grinding, Inspection, Structures, Stations/Wayside, and Electric Trans/Sub Station Teams	
Foreman	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. Read work orders and prescribe corrective action applying appropriate materials and personnel. This person is responsible to report time and material usage for work completed, and advises the Employee in Charge at the completion of a work task that the track is safe for revenue service and his work group is clear of the main track. 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.
Asst. Foreman	This position reports to the Foreman and assists the Foreman in the supervision of work crews. An Asst. Foreman may be assigned due to the size of the work crew, the complexity of the work or the geographic span of the work site.
Inspector	Track Inspectors perform regulatory visual inspections of all mainline tracks and report findings. Inspections will be performed on foot and by Hi-Rail vehicles at slow speeds. They review all climatic, and wheel/rail reporting and determine at field locations the accuracy of data reported by remote and wireless reporting equipment. 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.
Assistant Inspectors	Assistant Inspectors accompany Inspectors to assist in operation of the Hi-Rail Inspection Vehicle and with visual/manual inspections
Welder	Welders are responsible to complete all welding and grinding requirements for track, bridges, aerial structures, tunnels, and other related tasks. Welders to be qualified for Ox-Acetylene, Wire-Feed, and In-Field electronic welding applications. Working in consist 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.
Welder Helper	Reports to the Welder and performs all tasks as necessary to support and protect welding operations as they are performed. Responsible to maintain and store all welding equipment in a safe and practical manner including protection of the welder during hot work.
Equipment Operator	Equipment operators are trained on specific equipment units for their safe and practical use. They may also be trained on multiple equipment units and assigned various work assignments each work window. They report to the Foreman as assigned and have total responsibility for safe and practical operation of assigned equipment.
Truck Driver	Truck Driver must be Commercial Driver's Licensed in the State of California and specifically trained to travel and operate equipment as assigned. They will report to the supervisor of the work crew as assigned and be totally responsible for the operation, maintenance, and safe operation of their assigned equipment.
Laborers	These 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.
Plumber	Plumbers shall be licensed as required by the State of California and qualified accordingly for the inspection, maintenance, and repair of all water and sewer systems to include gravity and pressurized systems. They will report to the appropriate supervisor as assigned and must be responsible for any the inventory and reporting of any materials utilized.

Appendix 4—Maintenance of Equipment 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 overhaul general inspection costs. The approximation involves a seven-year rolling average for all years besides the first and last three and then an approximate allocation for those years. Below is an example using dummy numbers to demonstrate how the process is applied in the model.

The example dataset includes the following numbers:

	Total	Year	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:

	Total	Year	1	2	3	4	5	6	7	8	9	10
Rolling Average	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 and then allocates the rest 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:

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

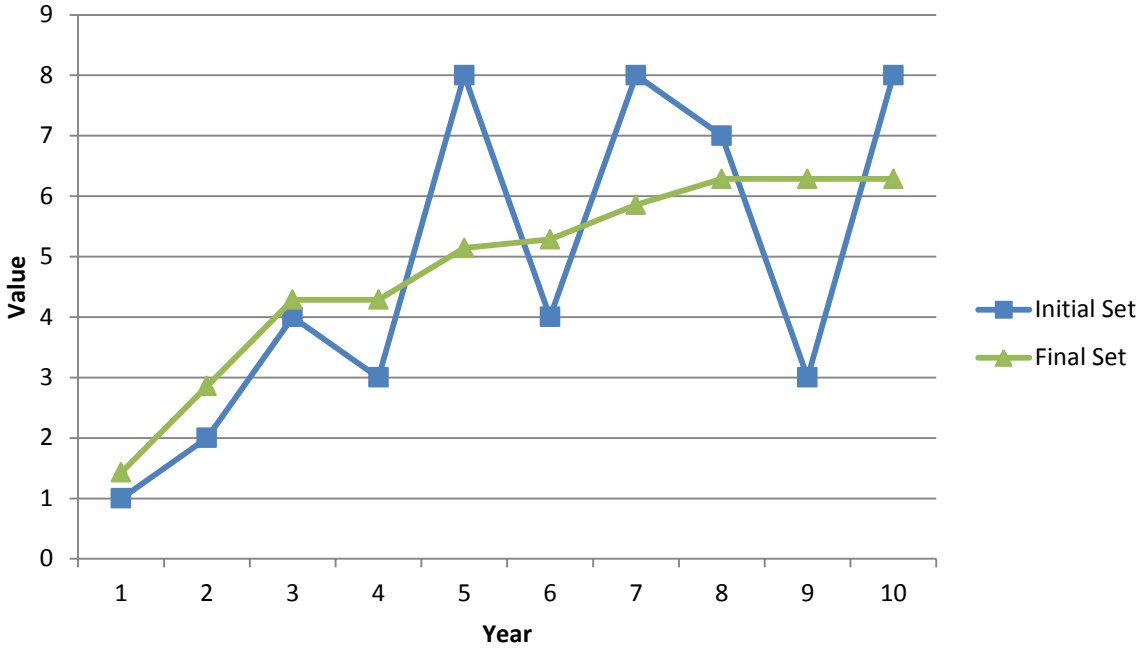
The same method is applied to the second half of the costs and the last three years but the assumed allocation is simply 1/3 in each year. The results of the last three years of allocation produce this:

	Total	Year	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:

	Total	Year	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:



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Appendix 5—County Population Projections

Population (Thousands)	2020	2025	2030	2035	2040	2045	2050	2055	2060
Alameda	1,656.16	1,750.56	1,842.79	1,940.10	2,037.90	2,140.25	2,247.73	2,360.61	2,479.16
Alpine	0.89	0.84	0.80	0.77	0.76	0.74	0.73	0.72	0.71
Amador	41.10	42.27	43.60	44.86	46.14	47.44	48.78	50.16	51.58
Butte	238.13	248.49	258.48	270.59	285.04	300.48	316.75	333.91	351.99
Calaveras	53.67	56.39	59.36	62.24	65.13	68.10	71.20	74.45	77.84
Colusa	24.27	25.53	26.84	28.13	29.43	30.75	32.14	33.58	35.10
Contra Costa	1,194.86	1,278.19	1,360.49	1,447.16	1,534.81	1,626.83	1,724.37	1,827.76	1,937.34
Del Norte	30.41	31.06	31.71	32.40	33.06	33.73	34.41	35.11	35.83
El Dorado	202.90	215.61	229.21	244.93	261.57	279.43	298.52	318.90	340.68
Fresno	1,050.92	1,108.90	1,167.19	1,234.03	1,312.94	1,397.61	1,487.75	1,583.70	1,685.83
Glenn	30.31	31.25	32.19	33.13	34.07	35.03	36.01	37.02	38.05
Humboldt	132.74	134.17	135.58	136.98	138.40	139.82	141.25	142.70	144.15
Imperial	193.98	206.36	218.59	231.75	245.84	260.88	276.84	293.77	311.73
Inyo	16.61	16.44	16.34	16.27	16.24	16.21	16.18	16.16	16.13
Kern	926.83	979.59	1,036.40	1,095.41	1,155.66	1,222.11	1,292.38	1,366.70	1,445.29
Kings	169.95	180.19	190.70	202.70	216.59	231.69	247.84	265.12	283.60
Lake	72.61	75.62	78.84	81.94	85.07	88.27	91.59	95.03	98.60
Lassen	36.64	37.49	38.30	39.13	39.96	40.79	41.64	42.50	43.39
Los Angeles	11,023.59	11,601.31	12,161.71	12,747.91	13,317.36	13,908.59	14,526.06	15,170.95	15,844.47
Madera	187.14	207.40	229.22	253.09	279.18	308.06	339.92	375.08	413.88
Marin	266.32	273.78	280.95	288.64	295.50	302.42	309.50	316.75	324.17
Mariposa	18.72	19.05	19.42	19.78	20.14	20.50	20.88	21.25	21.64
Mendocino	87.06	87.45	87.77	88.04	88.37	88.68	88.99	89.30	89.61
Merced	288.23	306.97	325.67	345.85	367.41	390.42	414.88	440.86	468.47
Modoc	8.68	8.56	8.46	8.40	8.35	8.31	8.28	8.24	8.20

Population (Thousands)	2020	2025	2030	2035	2040	2045	2050	2055	2060
Mono	13.56	13.81	14.04	14.26	14.49	14.73	14.96	15.20	15.44
Monterey	451.02	472.68	492.50	512.96	533.34	554.88	577.29	600.61	624.87
Napa	148.05	155.05	160.88	167.05	175.22	183.82	192.85	202.32	212.25
Nevada	105.41	108.61	111.87	115.05	118.29	121.55	124.90	128.35	131.89
Orange	3,405.27	3,584.57	3,761.56	3,953.23	4,160.22	4,388.87	4,630.09	4,884.57	5,153.04
Placer	463.80	521.14	581.81	649.26	720.70	798.29	884.24	979.45	1,084.90
Plumas	19.41	19.02	18.72	18.43	18.19	17.97	17.76	17.56	17.35
Riverside	2,531.53	2,730.15	2,931.60	3,140.38	3,350.87	3,583.73	3,832.77	4,099.11	4,383.97
Sacramento	1,592.05	1,692.90	1,800.84	1,925.46	2,057.34	2,198.95	2,350.31	2,512.09	2,685.00
San Benito	54.34	54.67	54.92	55.32	55.81	56.36	56.92	57.49	58.06
San Bernardino	2,112.93	2,179.12	2,250.60	2,329.86	2,411.91	2,507.74	2,607.39	2,710.99	2,818.71
San Diego	3,570.85	3,834.19	4,075.13	4,325.24	4,618.56	4,936.72	5,276.80	5,640.30	6,028.84
San Francisco	901.74	941.75	980.89	1,021.91	1,060.06	1,098.75	1,138.85	1,180.41	1,223.49
San Joaquin	795.15	838.18	881.92	931.87	983.63	1,038.43	1,096.27	1,157.34	1,221.81
San Luis Obispo	323.28	343.41	364.02	388.79	419.25	452.64	488.69	527.61	569.63
San Mateo	781.77	812.21	841.81	872.97	901.67	930.72	960.70	991.66	1,023.61
Santa Barbara	450.38	472.24	493.44	515.16	536.65	560.42	585.25	611.18	638.26
Santa Clara	1,985.62	2,100.09	2,211.84	2,330.67	2,453.92	2,583.33	2,719.57	2,863.00	3,013.98
Santa Cruz	275.12	289.02	301.66	316.27	341.48	369.37	399.53	432.16	467.45
Shasta	195.41	202.22	207.17	212.16	218.90	226.04	233.41	241.02	248.88
Sierra	2.92	2.83	2.78	2.74	2.72	2.70	2.68	2.67	2.65
Siskiyou	44.81	44.96	45.09	45.25	45.39	45.54	45.68	45.82	45.97
Solano	423.11	433.18	442.17	452.51	462.39	472.67	483.19	493.93	504.92
Sonoma	534.23	559.91	585.19	615.40	652.64	692.91	735.67	781.06	829.26

Population (Thousands)	2020	2025	2030	2035	2040	2045	2050	2055	2060
Stanislaus	567.87	600.94	635.76	678.88	734.21	793.60	857.80	927.18	1,002.18
Sutter	98.79	100.62	103.11	107.80	114.18	120.91	128.03	135.56	143.55
Tehama	66.77	69.15	71.66	74.15	76.62	79.15	81.76	84.45	87.24
Trinity	15.08	15.53	15.99	16.47	16.93	17.40	17.89	18.39	18.90
Tulare	538.62	588.45	637.49	688.25	738.79	793.29	851.81	914.65	982.12
Tuolumne	56.73	57.08	57.57	57.95	58.39	58.82	59.26	59.71	60.15
Ventura	909.77	960.92	1,014.95	1,072.01	1,132.28	1,201.88	1,275.75	1,354.16	1,437.40
Yolo	238.83	259.22	280.94	305.53	331.56	359.64	390.09	423.12	458.95
Yuba	81.71	84.64	88.05	93.29	99.99	107.06	114.63	122.73	131.41
Grand Total	**41,708.66**	**44,065.93**	**46,398.61**	**48,900.79**	**51,531.52**	**54,351.50**	**57,325.80**	**60,462.87**	**63,771.60**

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Appendix 6—Amtrak Thruway and Rural Intercity Bus Costs

Amtrak California Connecting Bus Service[51]		
San Joaquin & Pacific Surfliner Routes	Route	Full Year Estimated Expense/ Bus Miles (2012 dollars)
1	Bakersfield- Los Angeles Union Station	$3.46
3	Redding – Stockton	$3.11
4	Los Angeles Union Station - Santa Barbara	$2.80
6	San Jose Diridon Station – Stockton	$3.20
7	Willits – Martinez	$3.00
9	Bakersfield- Las Vegas	$3.06
10	Bakersfield- Santa Barbara	$3.31
12	Bakersfield- Palmdale	$3.16
15	Merced – Yosemite	$1.99
17	Santa Barbara - San Luis Obispo	$3.09
18	Hanford - San Luis Obispo	$2.68
19	Bakersfield- Indio	$3.12
34	Stockton - San Francisco Central Terminal	$4.07
39	Fullerton – Indio	$2.60
WEIGHTED AVERAGE		**$3.16**

[51] Provided by Caltrans Division of Rail

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Caltrans Rural Intercity Bus Study[52]

Table 3-9: PERFORMANCE OF CURRENT S.5311(F) PROJECTS

Agency	5311(f) Route	Total Passengers	Revenue Miles	Revenue Hours	Total Operating Costs	Farebox Recovery Ratio
Redwood Coast Transit Authority	Arcata-Smith River	12,847	138,576	4605	$ 193,673.00	54.90%
Inyo-Mono Transit	Crest Route	4,467	106,812	2660	$ 313,451.00	28.06%
Kern Regional Transit	East Kern Express	63,974	403,989	10640	$ 643,720.00	18.56%
	Mojave Ridgecrest	7,907	75,654	1850	$ 111,940.13	12.69%
San Benito County Local Transportation Authority - County Express	Intercounty - Greyhound	3,075	28,286	982	$ 49,683.45	9.42%
Marin Transit	South Route 61	14,022	65,956	3,701	$178,565	9.3%
	Coastal Route 62					
	(new route implemented 4/1/07)	542	7,256	332	$16,472	4.5%
	North Route 68	16,491	66,539	3,756	$185,306	10.4%
San Diego Metropolitan Transit System	888	6,453	74,505	2,348	207,669	8.0%
	891	1,000	19,697	675	54,902	4.7%
	892	939	17,206	594	47,959	5.0%
	894	25,527	132,169	4,523	368,398	17.8%
	867	5,572	69,803	2,647	194,563	7.3%
	889	2,052	34,581	1,564	96,388	5.5%
	891A	108	2,686	87	7,487	3.7%
	892A	125	3,917	118	10,918	2.9%
	893	133	4,164	132	11,606	2.9%
Monterey Salinas Transit	Line 23 Salinas-King City	79,868	213,771	7496:37:00	$705,688	
	Line 53 South County-Monterey Peninsula Express	3,320	44,397	1417:14:00	$130,861	
San Luis Obispo RTA	RTA Route 10	104,547	230,067	8,482.32	$746,967	14.90%
Lake Transit	Route 7 - Lakeport-Ukiah	8,406	114,038	3,873	$182,108	7.4%
	Route 4 - Clearlake Extension	4,193	17,023	559	$26,284	13.0%
Napa County Transportation Planning Agency	Vine Route 11 - St. Helena, Calistoga, Santa Rosa FY 06/07	2751		2097	158,025	5%
	Vine Route 11 - St. Helena, Calistoga, Santa Rosa FY 05/06	2610			165,858	4%
	Vine Route 11 - St. Helena, Calistoga, Santa Rosa April - June, 2005	445		423.53	77325	1%
YARTS	Hwy 140	59,469	238,570	7282	819,111	26.35
	Hwy120E/395	1954	49930	669	75,568	
Sam Trans	Route 294	106,535.00	156,268.00	5,156.73	$ 565,183	21.30%
Modoc Transportation Agency / Sage Stage	Alturas - Susanville - Reno	1,696	63,083.2	1,812.0	$ 123,378.11	20.5%
	Alturas - Burney - Redding	761	30,007.0	909.8	58,689.70	15.9%
	Alturas - Tulelake - Klamath Falls	1,077	21,475.0	662.0	26,791.91	29.8%
Blue Lake Rancheria of California	Blue Lake Rancheria to Blue Lake to Arcata					

[52] KFH Group, "California Statewide Rural Intercity Bus Study, Final Draft", Caltrans Division of Mass Transportation, 2007, table 3-9, online at <http://www.dot.ca.gov/hq/MassTrans/Docs-Pdfs/5311/Bus-Study/Chapter-3.pdf>

Appendix 7—Allocated Contingency Risk/Uncertainty Ratings and Percentages

Table 7-1. 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 Equipment	4	4	4	4	4.00	20.00
Maintenance of Infrastructure	3	4	3	4	3.50	22.50
On-board staff (including drill crews 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	no opinion	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
Station Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4	4		5	4.33	18.33
On-board Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	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
Dispatch Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4	4		5	4.33	18.33
Maintenance of Infrastructure Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4	4		5	4.33	18.33
Maintenance of Equipment Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4	4		5	4.33	18.33
General and Administrative Employee Supplies and Expenses (e.g., uniforms, Information Technology, cell phones, office supplies, etc.)	4	4		5	4.33	18.33
Maintenance of Equipment Tools, Uniforms, etc.	2.5	5	5	3	3.88	20.63
Maintenance of Equipment Regulatory Inspections	3	4	4	4	3.75	21.25
Maintenance of Equipment 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	no opinion	3	3.67	21.67
Credit Card/Mobile Payment Sales	4	4	no opinion	4	4.00	20.00
Distribution (Call Center)	3	4	no opinion	4	3.67	21.67

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Appendix 8—FRA Work Breakdown Structure

Below is the chart of accounts produced by the model in the form of the Federal Railroad Administration (FRA) developed work breakdown structure for O&M 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
101.2	Maintenance of Infrastructure Surfacing Salary + Benefits
101.2.01	Maintenance of Infrastructure Surfacing Foremen
101.2.02	Maintenance of Infrastructure Surfacing Assistant Foremen
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
101.4	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
102	**MoW 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
102.2	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
103.2	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
103.3	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
104.2	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
104.4	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 Support**
105.1	Frontline
105.1.01	Maintenance of Infrastructure Track Frontline
105.1.02	Maintenance of Infrastructure Surfacing Frontline
105.1.03	Maintenance of Infrastructure Rail Grinding Frontline
105.1.04	Maintenance of Infrastructure Condensed Track Inspection Frontline
105.1.05	Maintenance of Infrastructure Signals Frontline
105.1.06	Maintenance of Infrastructure Communications Frontline
105.1.07	Maintenance of Infrastructure Overhead Catenary Frontline
105.1.08	Maintenance of Infrastructure Electric Transmission Frontline
105.1.09	Maintenance of Infrastructure RR Structures Frontline
105.1.10	Maintenance of Infrastructure Right-of-Way Structures Frontline
105.1.11	Maintenance of Infrastructure Stations / Wayside Frontline
105.1.12	Maintenance of Infrastructure Work Train Frontline
106	**Maintenance of Way Supplies & Expenses**
106.1	Maintenance of Infrastructure Supplies & Expenses
106.1.01	Total Uniform and Supplies Costs
106.1.02	Total Information Technology/Software Costs
106.1.03	Total Cell Phones Costs
107	**Maintenance of Way Allocated Contingencies**
107.1	Allocated Contingencies
107.1.01	Maintenance of Infrastructure Labor (Allocated Contingency)
107.1.02	Maintenance of Infrastructure Materials (including stations) Allocated Contingency Rate (Allocated Contingency)
107.1.03	Maintenance of Infrastructure Tools etc. Allocated Contingency Rate (Allocated Contingency)
107.1.04	Maintenance of Infrastructure Vehicle Leasing Rates Allocated Contingency Rate (Allocated Contingency)
107.1.05	Maintenance of Infrastructure Supplies + Expenses (Allocated Contingency)

200	Maintenance of Equipment
201	**Maintenance of Equipment Turnaround**
201.1	Station Train Turn Salaries (Turn Based)
201.1.01	Station Train Turn Salaries (Turn Based)
201.2	Maintenance of Equipment Inspection Cleaners Salary + Benefits
201.2.01	Maintenance of Equipment Inspection Cleaners Total Salary and Benefits
202	**Locomotive 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 Equipment Technician Wages + Fringe (Ex Overhauls)
203.2.01	Maintenance of Equipment Inspection Supervisors Total Salary and Benefits
203.2.02	Maintenance of Equipment Inspection Technicians Total Salary and Benefits
203.2.03	Maintenance of Equipment Inspection Laborers Total Salary and Benefits
203.2.04	Maintenance of Equipment Inspection Storehouse Employees Payroll
203.3	Maintenance of Equipment Tools etc. (Ex Overhauls)
203.3.01	Maintenance of Equipment Tools etc. (Ex Overhauls)
203.4	Routine Inspection Costs
203.4.01	Annual Daily Inspection Cost
204	**Major Repairs – Expensed**
204.1	Overhaul and Bogie Inspection Crew Salaries + Benefits
204.1.01	Smoothed Maintenance of Equipment Technician Wages + Fringe
204.2	Overhaul and Bogie Inspection Materials Costs (includes Wi-Fi Equipment Costs)
204.2.01	Smoothed Trainset Maintenance of Equipment Costs (includes Wi-Fi Equipment Costs)
204.3	Maintenance of Equipment Tools etc.
204.3.01	Maintenance of Equipment Tools etc.
205	**Maintenance of Equipment Support**
205.1	Frontline
205.1.01	Maintenance of Equipment Technician Frontline (Ex-Overhauls) Total Salary and Benefits
205.1.02	Train Turn Frontline Total Salary and Benefits
206	**Maintenance of Equipment Energy**
206.1	Maintenance Facility Energy Usage
206.1.01	HMF Square Feet Maintenance Facility Energy Cost
206.1.02	Palmdale Square Feet Maintenance Facility Energy Cost
206.1.03	Bay Area Square Feet Maintenance Facility Energy Cost
206.1.04	Los Angeles Area Square Feet Maintenance Facility Energy Cost
207	**Maintenance of Equipment Vehicles**
207.1	Vehicles
207.1.01	Total Cost of Vehicles for Maintenance of Equipment

208	**Maintenance of Equipment Supplies & Expenses**
208.1	Employee Supplies & Expenses
208.1.01	Total Uniform and Supplies Costs
208.1.02	Total Information Technology/Software Costs (includes trainset Wi-Fi connection charges)
208.1.03	Total Cell Phones Cost
208.2	Water & Sewer
208.1.01	Total Water Costs for Maintenance Facilities
208.1.02	Total Sewer Costs for Maintenance Facilities
209	**Maintenance of Equipment Allocated Contingencies**
209.1	Allocated Contingencies
209.1.01	Maintenance of Equipment Labor (Allocated Contingency)
209.1.02	Maintenance of Equipment Tools etc. Allocated Contingency Rate (Allocated Contingency)
209.1.03	Maintenance of Equipment Regulatory Inspections Allocated Contingency Rate (Allocated Contingency)
209.1.04	Maintenance Facilities Energy Allocated Contingency Rate (Allocated Contingency)
209.1.05	Train Cleaning Staff Allocated Contingency Rate (Allocated Contingency)
209.1.06	Maintenance of Equipment General Overhauls and Bogie Inspections Allocated Contingency Rate (Allocated Contingency)
209.1.07	Maintenance of Equipment Supplies + Expenses (Allocated Contingency)
209.1.08	Vehicles for Maintenance of Equipment (Allocated Contingency)
209.1.09	Maintenance Facility Water and Sewer (Allocated Contingency)
300 Transportation	
301	**On-board Services**
301.1	Onboard Personnel
301.1.01	Assistant Conductors - Single Trainset Total Salary and Benefits
301.1.02	Assistant Conductors - Double Trainset Total Salary and Benefits
301.1.03	On-Board Assistants - Single Trainset Total Salary and Benefits
301.1.04	On-Board Assistants - Double Trainset Total Salary and Benefits
301.2	Protect Crews
301.2.01	Assistant Conductors - Protect Total Salary and Benefits
302	**Trainmen & Enginemen (T&E)**
302.1	Onboard Personnel
302.1.01	Locomotive Engineers - Single Trainset 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	Conductors - 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
303.2.01	Drill Crew Locomotive Engineers Total Salary and Benefits
303.2.02	Drill Crew Conductors Total Salary and Benefits
304	**Fuel**
305	**Power - Electric Traction**
305.1	System wide Trainset Energy Costs
305.1.01	System wide Single Trainset Energy Cost
305.1.02	System wide Double Trainset 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
306.2	Terminal Control Facility
306.2.01	Small Terminal Station Terminal Control Facility Wages and Fringe (Day)
306.2.02	Ultimate Terminal Station Terminal Control Facility Wages and Fringe (Day)
306.2.03	Ultimate Terminal Station Terminal Control Facility Wages and Fringe (Night)
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 Allowance cost
309.1.04	Total Dispatchers Employees Office Supplies Costs
309.1.05	Dispatchers Cell Phones Allowance cost
310	**Transportation Support**
310.1	Frontline
310.1.01	On-Board Personnel Crew Frontline Total Salary and Benefits
310.1.02	Protect Crew Frontline Total Salary and Benefits

310.1.03	Drill Crew Frontline Total Salary and Benefits
310.1.04	HMF/ Trainset Maintenance Facility Frontline Total Salary and Benefits
310.1.05	Operations Control Center Crew Frontline Total Salary and Benefits
310.1.06	Terminal Control Facility Crew Frontline 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)
400	**Sales and Marketing**
401	**Sales**
401.1	Credit Card/Bank Fees
401.1.01	Credit Card/Bank Fees
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
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)
500 Stations	
501	
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 Frontline Total Salary and Benefits
501.2	Station Service Staff
501.2.01	Agent/Station Manager—Level C Total Salary and Benefits
501.2.02	Ticket Clerk/Customer Service Rep—Level C Total Salary and Benefits
501.2.03	Agent/Station Manager—Level B Total Salary and Benefits
501.2.04	Ticket Clerk/Customer Service Rep—Level B Total Salary and Benefits
501.2.05	Agent/Station Manager—Level A Total Salary and Benefits
501.2.06	Ticket Clerk/Customer Service Rep—Level A 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
502	
502.1	Station Vehicles
502.1.01	Total Cost of Vehicles for Stations
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/ Information Technology Costs
503.2	Water & Sewer
503.2.01	Total Water Costs for Stations
503.2.02	Total Sewer Costs for Stations
504	
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		
	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		
	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		
604		
	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 Equipment 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 Equipment Security Equipment (Allocated Contingency)
700	**General & 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
	702.1	Insurance
	702.1.01	Total Insurance
	703.1	Employee Supplies & Expenses
	703.1.01	Total General and Administrative Employees Office Supplies Costs
	703.1.02	General and Administrative Information Technology /Software cost
	703.1.03	General and Administrative Cell Phones Allowance cost

703.1.04	Total Travel Expenses
704.1	General and Administrative Vehicles
704.1.01	Total Cost of Vehicles for General and Administrative
705.1	Allocated Contingencies
705.1.01	General and Administrative Labor (Allocated Contingency)
705.1.02	Insurance Allocated Contingency Rate (Allocated Contingency)
705.1.03	General and Administrative Supplies + Expenses (Allocated Contingency)
705.1.04	Vehicles for General and Administrative (Allocated Contingency)

Appendix 9—Illustrative Organization Chart

Below are illustrative, preliminary, and indicative organization charts that incorporate all of the 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 so this is meant to depict the levels of the organization that are modeled at this point. 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 functions included under the Senior Vice President of Operations.

Figure 9-1. Illustrative overall corporate organizational structure

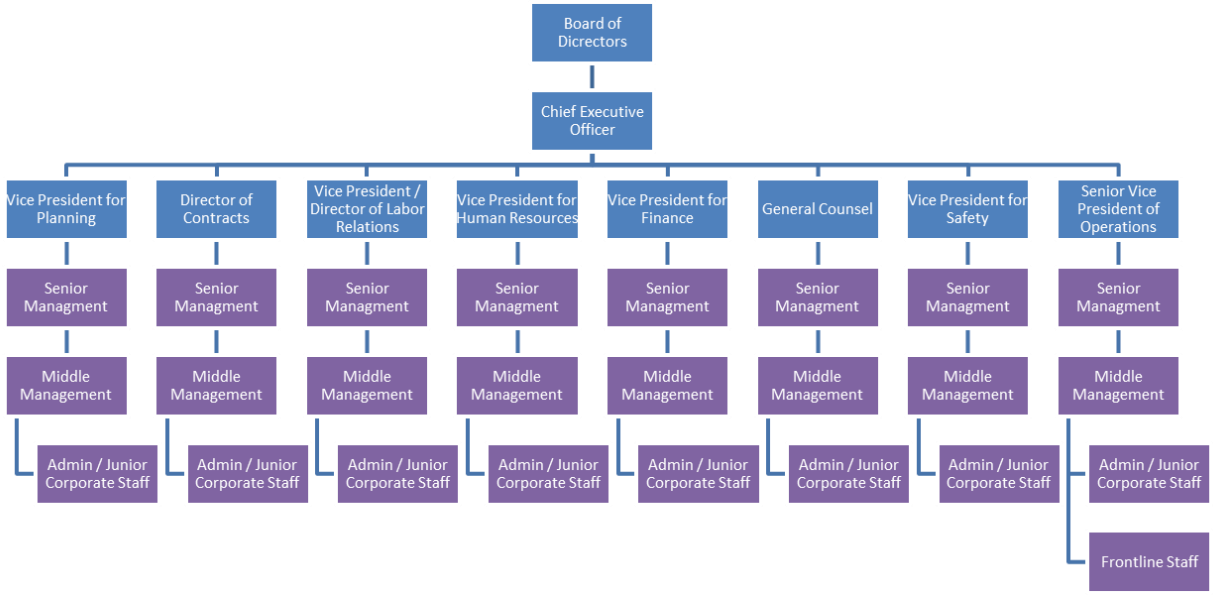

Figure 9-2. Illustrative operations and maintenance staff structure—on-board personnel

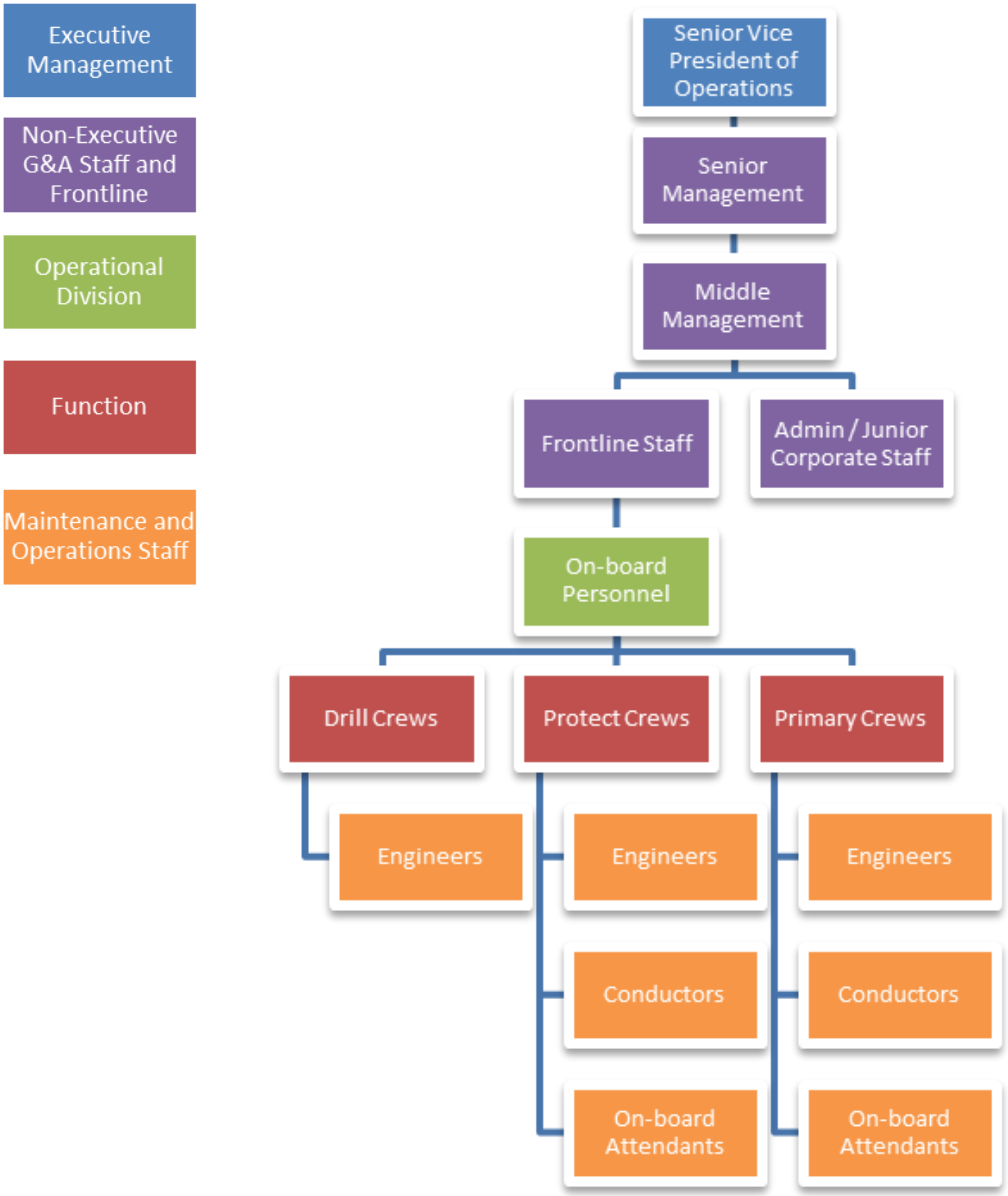

Figure 9-3. Illustrative operations and maintenance staff structure—dispatching

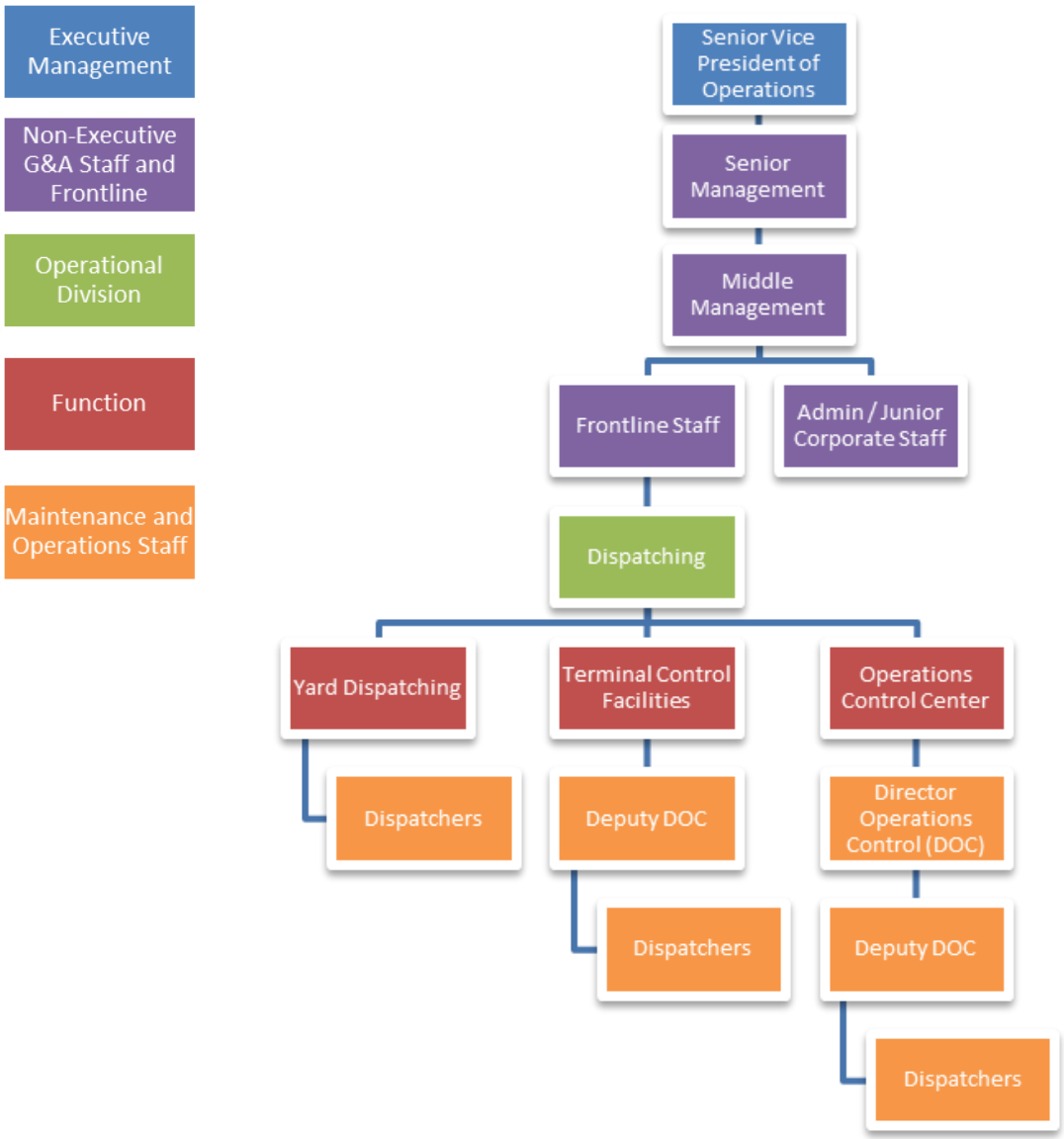

Figure 9-4. Illustrative operations and maintenance staff structure—maintenance of equipment

Figure 9-5. Illustrative operations and maintenance staff structure—maintenance of infrastructure basic Maintenance of Infrastructure facility staff

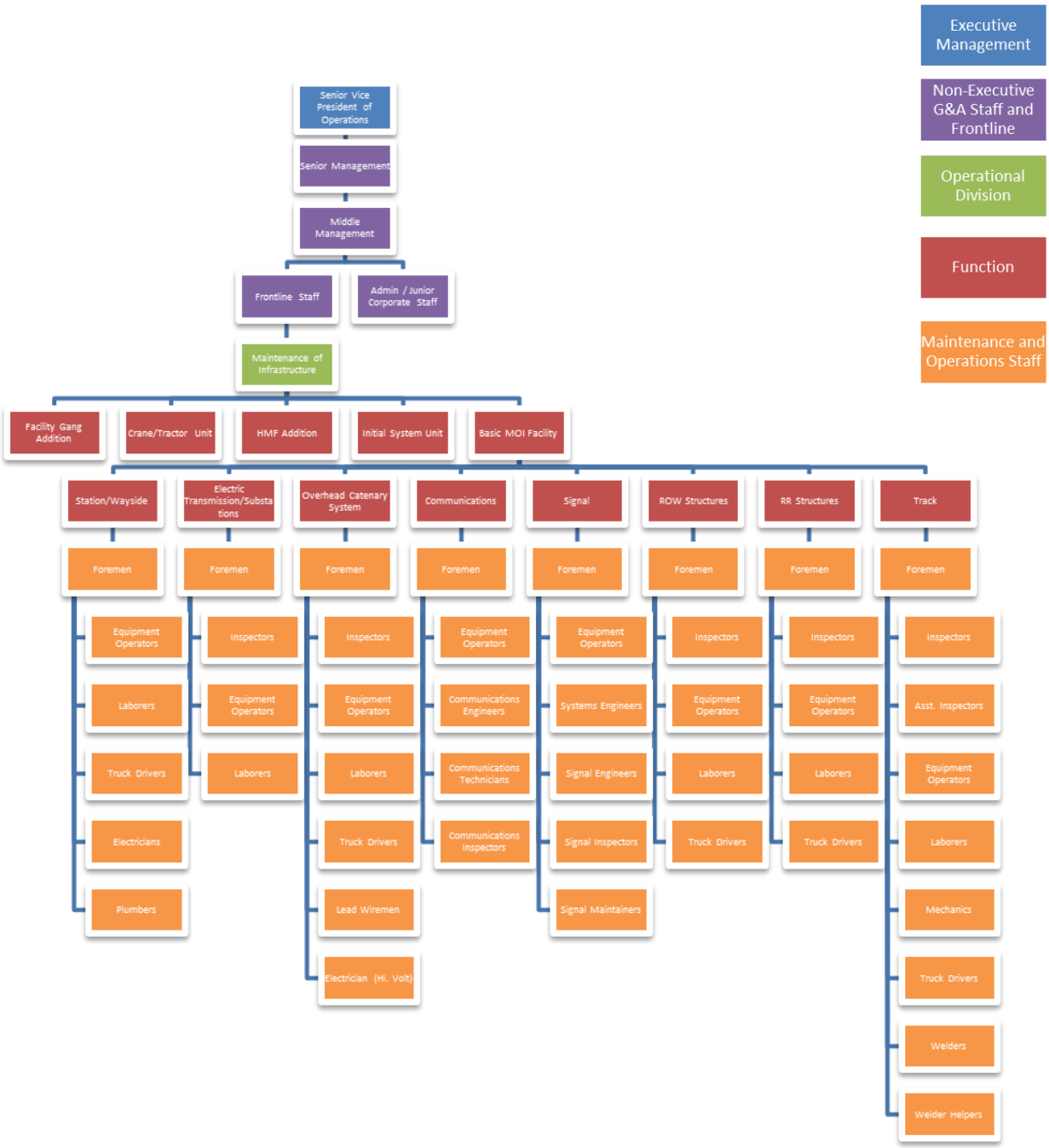

Figure 9-6. Illustrative operations and maintenance staff structure—maintenance of infrastructure all other gangs

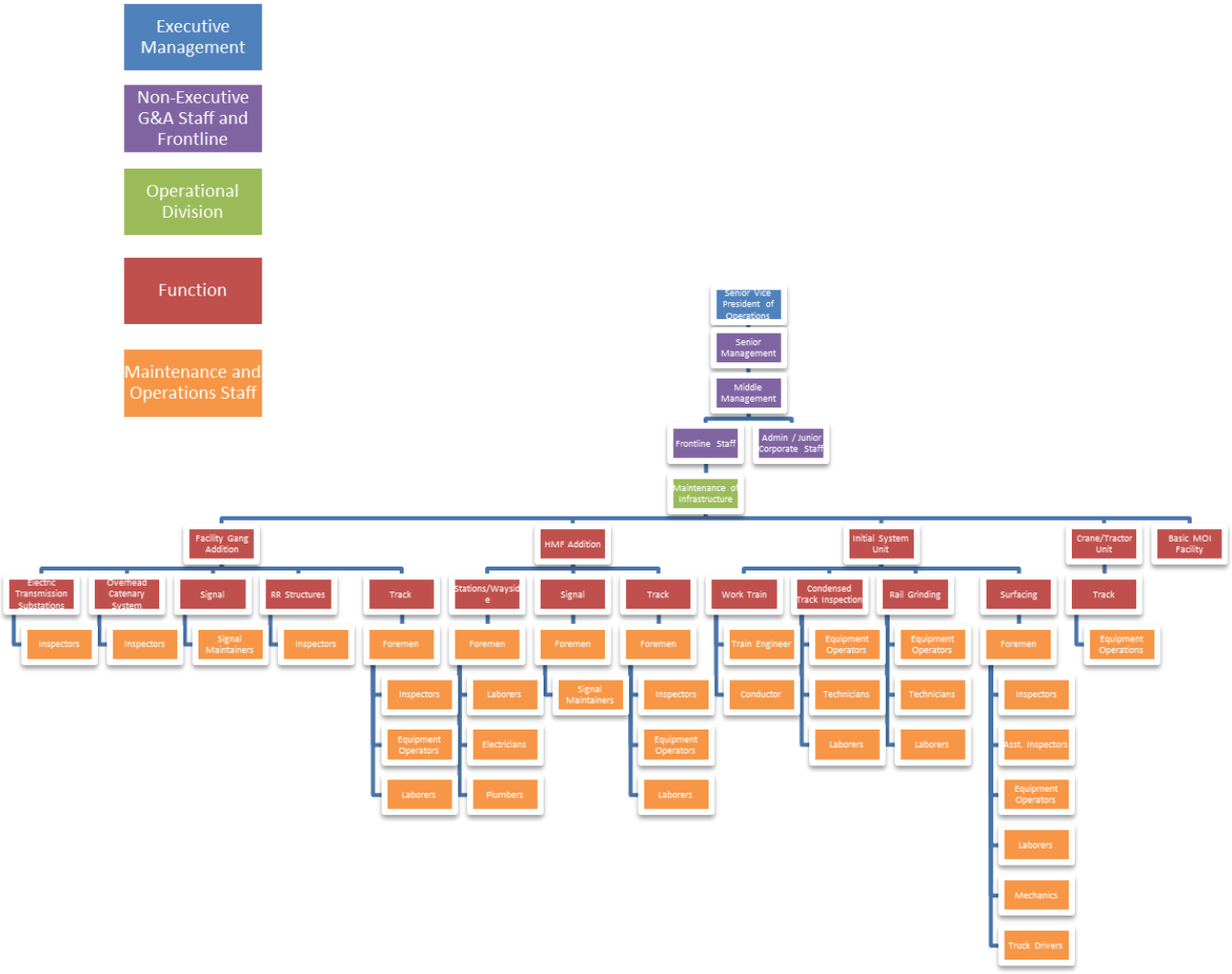

Figure 9-7. Illustrative operations and maintenance staff structure—Stations and Police and Security