

DRAFT MEMORANDUM

Date: June 5, 2020

To: Mr. Jamey Matalka
Assistant Chief Financial Officer
California High Speed Rail Authority
700 L Street
Sacramento, CA 95814

Re: 2020 Business Plan Update to PFAL's August 2, 2017 Review of the 2016 Business Plan's Ridership and Revenue and Operations and Maintenance Costs for Phase 1 (Anaheim to San Francisco) of the California High-Speed Rail System to Assess Whether the Phase 1 Operations Will or Will Not Require an Operating Subsidy

Disclaimer

Project Finance Advisory Limited ("PFAL") and its subconsultants have performed an independent review of the operations and maintenance costs and ridership and revenue forecasts for the Phase 1 system as directed by the California High-Speed Rail Authority ("Authority") and as described in PFAL's executed Task Order 9 with the Authority dated January 27, 2020. This independent review of the forecasts for the operations and maintenance costs and the revenue was performed using documents and information provided by the Authority (listed in the body of this Memo) and developed using currently accepted professional practices and procedures. PFAL, with the Authority's permission, has relied upon the accuracy and completeness of the documents and information provided by the Authority. While Authority assumptions relevant to PFAL's analysis were reviewed for reasonableness, the accuracy of the documents and information provided by the Authority and other publicly available material reviewed by PFAL in connection with this Memo were not independently verified by PFAL (except as otherwise explicitly described in this Memo). PFAL does not assume responsibility for verifying such material.

PFAL's opinions regarding the necessity of an operating subsidy as provided in this Memo are made with reference to the assumptions contained within the operations and maintenance cost review as well as the assumptions contained in the ridership and revenue review previously undertaken on behalf of the Authority. This Memo does not serve as an accounting audit. Furthermore, this Memo should not be relied upon for any financing or investment decision. It is possible that there are other elements of risk associated with the Authority's Operations and Maintenance Cost Model and Ridership and Revenue Model beyond those presented. Any financial estimates, analysis or other conclusions in this Memo represent PFAL's professional opinion as to the general expectancy concerning events as of the evaluation date and are based solely upon the information provided by the Authority and PFAL's analysis described in this Memo. However, the accuracy of any financial estimate, analysis or other information set forth in this Memo is dependent upon the occurrence of future events, which cannot be assured. Additionally, these estimates and analyses rely upon the assumptions contained therein, the accuracy of which remains subject to validation, further refinement and the occurrence of uncertain future events. Estimates should not be construed as statements of fact. There may be differences between the projected and actual results because events and circumstances may not occur as expected.

The information and conclusions presented in this Memo should be considered as a whole. Selecting portions of any individual conclusion without considering the analysis set forth in this Memo as a whole may promote a misleading or incomplete view of the findings and methodologies used to obtain these findings.

EXECUTIVE SUMMARY

On January 27, 2020 the California High-Speed Rail Authority (“Authority”) directed Project Finance Advisory Limited (“PFAL”) and their subconsultant, First Class Partnerships Limited (“FCP”), to review changes between current 2018 Authority Business Plan and the draft 2020 Authority Business Plan to evaluate whether forecasted revenue in the Business Plan can be expected to cover forecasted ongoing operating and maintenance costs. This Memo is based on the Draft 2020 Business Plan (“2020 Business Plan”) and the supporting Technical Documents issued in February 2020 by the Authority.

This Memo details PFAL’s review of the 2020 Business Plan as an update to PFAL’s *Review of the 2016 Business Plan’s Ridership and Revenue and Operations and Maintenance Costs for Phase 1 (Anaheim to San Francisco) of the California High-Speed Rail System to Assess Whether the Phase 1 Operations Will or Will Not Require an Operating Subsidy Memorandum* dated August 2, 2017. To update the changes between the 2020 Business Plan and the 2016 Business Plan, PFAL performed an interim step of independently evaluating the 2018 Business Plan. The 2020 Business Plan analysis is based on the iterative process between the 2016 Business Plan, 2018 Business Plan, and 2020 Business Plan.

In the previous review of the 2016 Business Plan we undertook a detailed review of the modelling process, including confirmation that inputs were suitably processed resulting in appropriate outputs. The current review did not repeat this activity. The Authority confirmed that the model has not changed from the 2018 BP and that the only changes compared to the 2016 BP are documented in the ridership modeling documentation of the 2020 Business Plan. As a result, this updated analysis of changes between the 2016 and 2020 Business Plan assumes the same revenue and cost models are being used, and that any changes in inputs are being correctly processed, and hence valid outputs are being produced. In the previous more detailed reviews of the modelling, we found the Authority’s ridership and revenue and O&M cost projection were produced using sound methodology which reflects industry best practice. Given the continuity of approach since 2016, this finding remains valid.

PFAL review noted a number of the recommendations suggested in PFAL’s August 2, 2017 Memorandum were implemented by the Authority in the 2018 Business Plan and carried through into the 2020 Business Plan. In summary, this includes recommendations to:

- Reduce the 2016 Business Plan fleet size;
- Remove the 2016 Business Plan terminal control facilities;
- Add one training day per year for all employees;
- Include allowance in ridership and revenue forecasts for non-California residents;
- Include additional induced demand; and
- Add allowance for the long access/egress journeys.

PFAL also noted the involvement of the Early Train Operator (“ETO”), DB Engineering & Consulting USA Inc., in developing the 2020 Business Plan as a positive change in development of the 2020 Business Plan compared to the 2016 Business Plan.

The review of the 2020 Business Plan was conducted and this Memo is structured in three parts:

- **Part 1 - Ridership & Revenue:** PFAL independently evaluated changes to inputs that underpin the Authority’s 2020 Ridership and Revenue model for reasonableness. Where PFAL deemed appropriate based on industry benchmarks, adjustments to the forecasts were made to provide an alternative outlook compared to the Authority forecasts.

- Part 2 – Operations & Maintenance (“O&M”):** Changes to inputs in the Authority’s 2020 O&M cost model (“Cost Model”) were evaluated for reasonableness, as was the change in methodology for calculating traincrew, train maintenance and station staff requirements. Where PFAL deemed appropriate, based on industry benchmarks, adjustments to the O&M cost model inputs were made.
- Part 3 – Risk:** Using the analysis in Part 1 – Ridership & Revenue and Part 2 – Operations & Maintenance, PFAL evaluated whether the revenue in the Business Plan can be expected to cover the ongoing operating and maintenance costs.
- Part 4 – Subsidy Analysis:** To evaluate whether the Phase 1 service will require an operating subsidy, we reviewed the Authority’s Central Case in the 2020 Business Plan and then applied the PFAL adjustments to both revenue and O&M cost.

It is important to note that PFAL’s review of ridership and revenue is of their accuracy based on information available at the time of preparation of the 2020 Business Plan. As such it does not consider any impact due to COVID-19 or other possible regulatory changes as a result. This is discussed further in Part 3 on risk.

Summary of Part 1 - Ridership & Revenue

PFAL relied on the following definition of Revenue provided by the Authority for the purposes of this Memo: *fare box revenue (income from ticket sales), and Ancillary revenues (income the Authority may receive from sources related to the everyday business operations of the high-speed rail, including but not limited to on-board sales (e.g., sales of foods or sundries), station-related revenues, advertising, and revenues from leases of excess or non-operating right-of-way parcels or areas, as well as areas above or below operating rights-of-way or of portions of property not currently being used as operating rights-of-way). Ancillary income does not include unexpected or “one time” events.*

Our review of the 2020 Business Plan’s changes and PFAL’s proposed sensitivities to test the reasonableness of the central case forecast for ridership on the Valley to Valley (“V to V”) service reached a similar view to the Authority’s and within a similar range before taking account of ramp-up. For Phase 1 in 2033, our sensitivities on the 2020 Business Plan’s changes reach a higher ridership (approximately 10%) and revenue (approximately 16%) compared to the Authority’s with the difference increasing to approximately 16% (ridership) and approximately 21% (revenue) by 2040, again before taking account of ramp-up.

The Authority has taken an optimistic view on ramp-up in the 2020 Business the revenue side of the equation due to the introduction of the initial operation of the Central Valley Segment (CVS) between Merced and Bakersfield several years before Valley to Valley service, as well as different timing of the Phase 1 operation compared to the begin of the V2V operation.

The Business Plan assumes that the introduction of the initial operation of Central Valley before Valley to Valley will have a 2-fold impact: On one hand, the 2020 Business plan has eliminated the ramp-up for operations and maintenance costs assuming a much more conservative approach than in 2018 accounting for 100% of the costs on day one of revenue service for each section, On the other hand, the 2020 BP has adjusted the revenue and ridership ramp-up base factors reflecting a faster ramp-up of revenue including also a section by section ramp-up approach.

In regard to the changes in the revenue ramp-up, we consider the section-by-section ramp-up approach based on the actual date of start of operation appropriate, but for the specific ramp-up factors used for each section PFAL would recommend a more conservative approach in the central and low case scenarios. Using the PFAL ramp-up factors, this significantly reduces the revenue forecasts for the years

up to 2037 by up to 11% in central forecasts (in 2034 forecasts) and up to 25% in low forecasts (in 2034 forecasts), but the ongoing revenue (2038 onwards) and high forecasts are unaffected.

At central case forecasts, load factors appear reasonable. If actual ridership turns out to be higher, the high load factor issue may be reduced with an appropriately calibrated revenue management system during the operations phase by raising fares at busy times and spreading the passengers across less crowded trains.

Summary of Part 2 - Operations & Maintenance Cost

As a component of this analysis, PFAL relied on the following definition of O&M costs to address whether the planned passenger service to be provided by the Authority (or pursuant to its authority) will not require an operating subsidy. This has the meaning set within the Streets and Highways Code section 2704.08, subdivision (d)(2)(D): *ongoing operating and maintenance costs, that is, the cost of running the trains and maintaining the infrastructure and rolling stock in a state of good repair. It does not include capital asset renewal (or lifecycle) costs, which is the cost of replacing or refurbishing worn out components at the end of their useful life.*

PFAL's review found that there have been a number of input changes in the O&M costing model between the 2016, 2018 and 2020 Business Plan, including the methodology for calculating the number of train crews required to operate the planned service. While the methodology itself is sound, our review found that the Authority has assumed 85% of traincrew time will be productive. Our experience and professional opinion is that a figure of 75% is more appropriate for this stage of planning which results in a larger staff base and additional O&M costs (\$1.67M in 2033 and \$5.30M in 2040 – excluding contingency) this will account for an additional 1% to 1.5% annual operations and maintenance expenses.

In addition to the train crew recommendation, the Authority is proposing a fleet size of 72 trains, 66 trainsets for operation and 6 for Protection and Maintenance. In our view, the size of the train fleet is too small to cover the requirements of the proposed operational plan and there is a requirement for up to 6 additional trains to do so.

This results in some additional O&M costs which are detailed below. If a different operational plan is offered with less protect trains, then the additional trainsets required could be reduced. This is explained in more detail in Section 8. Note, the impact of the capital cost associated with the additional trains is outside the scope of this Memo.

PFAL understands that the authority is currently developing the train procurement documents and that the maintenance strategy will be a fundamental component of this process. Therefore, it is expected that as scheme development progresses, and more information is produced, the overall size of the train fleet and the allocation between passenger service, protect duties and maintenance activities will continue to develop.

The Authority has eliminated the ramp-up for operations and maintenance costs assuming a more conservative approach than in 2018 by accounting for 100% of the costs on day one of revenue service for each section. Also, the Authority has included additional 10% mark-up of the total maintenance costs compared to the 2018 Business plan to better reflect the potential contractual setup with the maintenance contractors.

Summary of Part 3 - Risk

As part of the PFAL review, we assessed the risk for the likely need for an ongoing operating subsidy with the proposed 2020 Business Plan. The Business Plan uses estimates the probability of a Net Cash Flow deficit as an indication of subsidy requirement.

From the data provided with the revenue forecasts, PFAL found the input information was developed using appropriate industry standard assumptions, and revenue forecasts are acceptable in the long-term, excluding any potential effects of COVID-19 or regulatory changes. However, PFAL noted the short-term ramp-up of revenue appear more optimistic due to a revised approach reflecting a new implementation strategy and ramping up of operation as compared to prior business plans. With a lower ramp up rate, the risk of a deficit in the 2033-2036 period is higher, but the modeling still indicates a probability that operating revenues will exceed O&M costs during this period. PFAL's additional risk analysis resulted in decreased revenues and increased costs, and even with those adjustments, the central case resulted in positive cash flows.

The indicative analysis confirms the low risk of a deficit for 2040 as shown in the 2020 Business Plan. The higher forecast revenue produced by PFAL more than mitigates the impact of the additional O&M costs from crewing and fleet numbers. However, the analysis of the impact of slower ramp up of ridership in 2033 and marginal increase in O&M costs, 1.2% in 2033 and 1.8% in 2040, has an impact on increasing the probability of Net Cash Flow deficit in 2033. The implications of the slower ramp up dissipates very quickly and it is concluded that there is a very high probability of a positive cash flow from 2037 onwards.

There is a 24.7% contingency based on the detailed allocation of risk against each cost item presented in Table 27 of the Operations and Maintenance Model Documentation already accounted for within the O&M costs. Therefore, it is expected that as scheme development progresses, and more information is produced, the level of contingency will be reduced.

Further work by the Authority, such as developing timetable and crew rostering schedules, which are not available at the current time, would provide the basis to reduce the level of contingency. It is recommended and it would be reasonable to expect that such activities commence in the next business plan update.

Summary of Part 4 - Operating Subsidy Analysis

To evaluate whether the Phase 1 service will require an operating subsidy, we reviewed the Authority's Central Case in the 2020 Business Plan and then applied the PFAL adjustments to both revenue and O&M cost.

In both cases, (with and without PFAL's adjustments), revenue exceeds O&M costs throughout Phase 1 operations.

Table 1: Phase 1 Service Operating Surplus- Central Case (with PFAL adjustments)

Authority Figures (in 2019\$)	Phase 1 Operation							
	2033	2034	2035	2036	2037	2038	2039	2040
Authority Farebox Revenue	793	1684	1972	2176	2320	2391	2420	2450
PFAL Revenue Adjustment	(59)	(199)	130	264	326	408	444	473
PFAL Adjusted Farebox Revenue	734	1485	2102	2440	2646	2807	2864	2923
Authority O&M Cost	(509)	(992)	(1041)	(1057)	(1078)	(1093)	(1096)	(1094)
PFAL Adjustments to O&M Cost	(13)	(17)	(17)	(17)	(17)	(17)	(17)	(17)
PFAL Adjusted O&M Cost	(522)	(975)	(1024)	(1040)	(1061)	(1110)	(1113)	(1111)
Surplus/(Deficit)	212	510	1078	1400	1585	1697	1751	1812

PART 1 – RIDERSHIP & REVENUE

1. RIDERSHIP & REVENUE REVIEW METHODOLOGY

The starting point of the review of changes to the 2020 Business Plan ridership and revenue was the documents developed and provided by the Authority, notably the 2020 Business Plan and the 2020 Ridership and Revenue Forecasting technical supporting document. In addition, the Authority provided a significant amount of backup data to support these documents. Following the review of the provided documents and data, one question was put to the Authority for clarification. There were fewer changes between the 2018 and 2020 Business Plans than in previous years. Many of the changes recommended by PFAL from the review of the 2016 Business Plan were implemented in the 2018 Business Plan and then carried through to the 2020 Business Plan.

The changes introduced by the Authority between 2018 and 2020 consisted of:

- Updates to population, household and employment forecasts;
- Updates to auto costs;
- Revisions to the timetable, especially for Valley to Valley including the inclusion of Merced and Millbrae in the V2V alternative;
- Modifications to the opening date of the different Phases and reflection of the initial operation in the Central Valley between Merced and Bakersfield;
- Revision to ramp-up factors due in part to the revised phasing;
- Revenue figures updated to 2019 price levels.

Some of the above changes affected the central case forecast, other changes just affected the risk profile. The identified changes were then quantified. In some cases, the quantification was provided in the Authority's documentation or the Authority responses to PFAL's single question on ramp up. In other cases, PFAL made an appropriate estimate using the available information, industry standards and benchmarks.

The effects of all the changes were then combined and applied to the 2018 Business Plan to confirm they approximately reproduce the ridership and revenue in the 2020 Business Plan. Once the changes were confirmed, the changes were individually evaluated to determine:

- Is the quantification of each change appropriate?
- Are there other changes that should have been considered?

Risks around the forecasts and the changes were then evaluated. Again, this was based on the analysis PFAL undertook for the review of the 2018 Business Plan but were adjusted, where assumptions had changed, in particular for the new service and stations for V to V.

Finally, we examined the load factors implied by the ridership forecasts matched this to the proposed number of trains per day and hence commented on their achievability from this point of view.

The Cambridge Systematics, Inc. ("CS") revenue model was run for the same three years (2029, 2033, 2040) as in the 2018 Business Plan, with interpolation adjustments made to give forecasts for the currently anticipated opening dates of late 2031 ("V to V") and late 2033 ("Phase 1"). We have come to an independent assessment of the reasonableness of the ridership and revenue for each of the three

years (2029 Valley to Valley, 2033 Phase 1, 2040 Phase 1). We also considered the phasing of ridership and revenue over the period up to 2040. It is important to note the stated forecasts and views are dependent on the infrastructure, rolling stock and timetable being operated as detailed in the 2020 Business Plan.

It is important to note that PFAL's review of ridership and revenue is based on information available at the time of preparation of the 2020 Business Plan. As such it does not consider any long-term impact due to COVID-19 or regulatory changes. At this stage, no-one can know what impact COVID-19 may have, except that it will adversely affect economic growth, and is also likely to have an impact on travel behavior particularly in the business market (as video-conferencing replaces face to face meetings) and commuting to work (as more people work from home) and possibly some regulatory operational changes. However long-term forecasts typically rely on a steady-state situation and do not consider short-term or medium-term fluctuations in travel demand. Future model runs and revisions should investigate whether there are longer-term impacts from the COVID-19 crisis and if there is the need for adjustments.

2. 2020 BUSINESS PLAN REVISED ASSUMPTIONS FOR RIDERSHIP AND REVENUE

2.1 Data Changes

Two forecast years have changed in the 2020 Business Plan compared to the 2018 Business Plan:

- 2029 has been delayed until December 1, 2031 for V to V services;
- 2033 delayed until December 1, 2033 for the Phase 1 services.

This has implications for elements which change over time; however, the CS Ridership and Revenue Forecasting Technical Report is still based on forecasts made for 2029, 2033 and 2040 as in 2018 Business Plan but the ridership and revenue streams use an interpolation process to obtain appropriate annual estimates. Additionally, the price level has changed by 7.1% from 2017 to 2019, the Californian Inflation Rate between the two years presented in (<https://www.dir.ca.gov/OPRL/CPI/EntireCCPI.PDF>). The price level change results in revenue forecasts being 7.1% higher but the model does not reflect any further adjustments in the user reaction since it assumes that willingness to pay increases at the same rate than the inflation or the fares. The cost calculations reflect the same inflationary adjustments to June 2019 Dollars.

Further data changes include:

- Modest population, household and employment changes made based on latest forecasts;
- The train timetables have changed, in terms of journey times and for V to V an additional service is operated and two new stations (Merced and Millbrae) were introduced;
- The costs of driving (auto costs) have changed based on latest forecasts;

2.2 Impact of Data Changes in 2020 Business Plan

This section details PFAL’s assessment of the impact of the above changes in the 2020 Business Plan by evaluating the extent of these impacts and also whether there remain other impacts that should be considered. The impact of the changes listed in Section 2.1 are shown in Table 2 below. Note, the impact of the change in opening dates and ramp-up of ridership and revenue are discussed later.

Table 2: Impact of changes from 2018 Business Plan to 2020 Business Plan (factor)

Issue	V to V	Phase 1	Phase 1
	2029	2033	2040
Inflation (for revenue, not ridership)	1.0712	1.0712	1.0712
Population	0.978	0.973	0.968
Auto costs	1.027	1.007	0.987
New Station at Millbrae	1.0136	1.0075	1.0075
Timetables (incl service to Merced)	1.0594	1.0079	1.0081
TOTAL IMPACT – RIDERSHIP	1.079	0.996	0.970
TOTAL IMPACT - REVENUE	1.155	1.067	1.039

Table 2 demonstrates the various changes made by the Authority in the 2020 Business Plan resulted in slightly higher forecasts of ridership and revenue in the case of the Valley to Valley service, but slightly lower for Phase 1. Note, if effect of inflation is ignored.

Table 3 on the following page shows how the factors values in Table 2 correlate between the 2018 Business Plan and the 2020 Business Plan. Table 3 demonstrates the estimate of the impact of the changes is close to that seen in the 2020 Business Plan for Phase 1 in both years. For the Valley to Valley Service, the 2020 Business Plan figures are about 3% - 4% higher than would have been expected based on the adjustments made. The assessment above is approximate in its nature; but PFAL concludes it is close to the more detailed analysis undertaken by Cambridge Systematics that underpins the 2020 Business Plan forecasts for Phase 1.

We noted the forecast impact of the timetable change in the Valley to Valley Service (mainly the addition of the Merced to Bakersfield service, and the new station at Millbrae); there are significant ridership increases for trips within San Joaquin Valley (“SJV”) and to/from SACOG (Sacramento Region) which are plausible. However, there are also significant increases in ridership for trips between Metropolitan Transportation Commission (“MTC”) (San Francisco) and San Joaquin Valley and other locations. While the timetable has only slightly changed to/from San Francisco, the addition of the Millbrae and Merced stations seem to open additional markets that were not reflected in the 2018 Business Plan. The 16% increase in demand between MTC and SJV is related to these changes of the V2V operation.

The Authority has explained that the revised timetable enables trips between Merced and San Francisco via an interchange at Madera. We recognize this as a possibility but remain unconvinced that it represents a significant improvement over what is on offer in 2018 Business Plan timetable. The model

uses service frequency rather than actual timetable, so assumes a 30 min wait time in one direction and 15 minutes in other direction in the peak (30 minute both directions in the off-peak).

Considering the actual time taken is an implied 42 minute (27 minutes one direction in the peak) and typical drive time from Merced to Madera is 35 minutes (up to 45 minutes in peak) for many people the difference between driving to Madera and driving to Merced will be less than this. Therefore, people will generally be indifferent between driving to Madera and using High Speed Rail (“HSR”) to access Madera from Merced. Transport models, correctly, apply weightings to different elements of time:

- Drive access time is weighted double (making 70 – 90 minutes);
- HSR wait time is multiplied by a factor 2.5 minutes and 5 minutes transfer penalty added, making 87 minutes off-peak and 49 or 87 minutes in the peak (dependent on direction).

In the off-peak driving appears preferable, in the peak there is likely to be a small preference for HSR access dependent on highway congestion.

The changes in the MTC region in V2V include all trains stopping in Millbrae (not included in the 2018 BP) with direct access to the SFO airport and a direct transfer possibility to and from the BART system. This transfer provides much better connectivity to the Eastbay and San Francisco destinations. The Authority provided estimates of the usage of Millbrae Station and how much of this is generated (ie would not have used San Francisco or San Jose in absence of Millbrae). This seems to explain approximately half of the increase in demand between these regions.

Overall, the new service does offer an improvement on the 2018 Business Plan timetable for this market, but the ridership increase appears to be at the top of the likely range. We have therefore excluded part of this element of the impact of timetable change and new stations from the assessment of the change between 2018 and 2020 Business plans as shown in Table 3.

Table 3: Change between 2018 Business Plan and 2020 Business Plan

Total Impact Ridership (millions)	V to V 2029	Phase 1 2033	Phase 1 2040
2018 Business Plan - Ridership	14.4	36.2	40.0
2020 Ridership Calculated from Table 2 Factors	15.5	36.0	38.8
2020 Business Plan Ridership	16.2	35.6	38.6
Difference Between 2020 Ridership Calculated from Table 2 Factors and 2020 Business Plan Ridership	-4.1%	1.2%	0.6%
Total Impact Revenue (millions)	V to V 2029	Phase 1 2033	Phase 1 2040
2018 Business Plan Revenue	\$823	\$2,098	\$2,344
2020 Revenue Calculated from Table 2 Factors	\$951	\$2,238	\$2,436
2020 Business Plan Revenue	\$982	\$2,207	\$2,410
Difference Between 2020 Revenue Calculated from Table 2 Factors and 2020 Business Plan Revenue	-3.2%	1.4%	1.1%

2.3 Further Adjustments to 2020 Business Plan Ridership and Revenue

PFAL’s review of the 2016 Business Plan recommended a number of adjustments to the ridership and revenue forecasts as a means to evaluate a range of potential impacts. The 2018 Business Plan incorporated a number of the PFAL recommendations made for the 2016 Business Plan, notably including an estimate of non-Californian residents and increased induced demand. The 2020 Business Plan took on board the recommendations adopted in the 2018 Business Plan, but no other recommendations made in the 2016 Business Plan review were included in the 2020 Business Plan since the model carried forward the 2018 Business Plan approach.

For this analysis, PFAL again evaluated potential sensitivity adjustments to reflect PFAL’s review of the 2020 Business Plan. The access/egress adjustment made within the ridership and revenue model is difficult to assess its impact as it uses a complex approach and its impact is only shown in combination with all the other changes made. From what can be assessed, the access/egress adjustment reduces demand by an average of 10% discussed in our review of 2018 Business Plan. The figure of 10% is a combination of larger adjustment on some flows and zero adjustment on others. This is viewed as a reasonable adjustment in the case of Phase 1 services that mainly serve people from the SACOG region (Sacramento and the surrounding area) with long access. For the Valley to Valley service, this access/egress adjustment appears to be lower than originally recommended in the 2016 review; in this case, as well as SACOG, Los Angeles and beyond has a very long access/egress journey to Bakersfield. PFAL, as in the review of the 2018 Business Plan, recommends a similar additional

adjustment, as seen in Table 4, be made. The actual adjustment would be large for the affected flows and zero for unaffected flows, but is represented as a further 10% on average over all flows

It is noted CS demand model still does not allow for any abstraction from long distance bus services, and PFAL, as it recommended in the 2016 Business Plan review, recommends an additional 5% ridership from this source. No allowance is made for the high-speed rail service creating jobs and housing through land use changes around stations in the CS demand model.

Our opinion, based on industry benchmarks, is this might add 5% revenue in 2029 and 2033, and 10% revenue by 2040. Finally, the CS demand model still assumes an average fare, whereas PFAL would expect (and strongly recommend) the use of a revenue management system similar to airlines. This might add 5% to revenue (but not to ridership).

The Authority informed us that abstraction from long distance bus services, inducement effects through land use changes and the yield management system were not reflected in the demand model revision since they represent potential upsides and the ridership model and forecasting process is using a conservative approach.

Table 4 below also includes a downward adjustment of 3.5% for Valley to Valley services to reflect the concern over the impact of the timetable change, as detailed in section 2.2.

The net effect on ridership and revenue of each of the above adjustments is shown in Table 4.

Table 4: Further Adjustments to Forecasts

Adjustment Factors	V to V 2029	Phase 1 2033	Phase 1 2040
Timetable Impacts	0.965	1.00	1.00
Fares/ Revenue management System (applies to revenue only)	1.05	1.05	1.05
Intercity bus	1.05	1.05	1.05
Development impacts (including induced commuting)	1.05	1.05	1.10
Time sensitivity/ Long access	0.90	1.00	1.00
Total Factor for Ridership	0.96	1.10	1.16
Total Factor for Revenue	1.01	1.16	1.21

2.4 Comparison with International Experience

When PFAL examined the forecasts for high-speed rail in California based on the 2016 Business Plan, we sought to compare the forecast mode shares with experience elsewhere in US and Europe. It is accepted that the market is very different between countries and indeed across the US; hence such a comparison can only be indicative at best. Nevertheless, the exercise has been repeated for 2020 Business Plan as a sense check, without seeking additional data from elsewhere for the European and

US comparator flows. Figure 1 below shows the rail share of the rail/air market for a number of different flows.

Figure 1: 2020 Rail Share

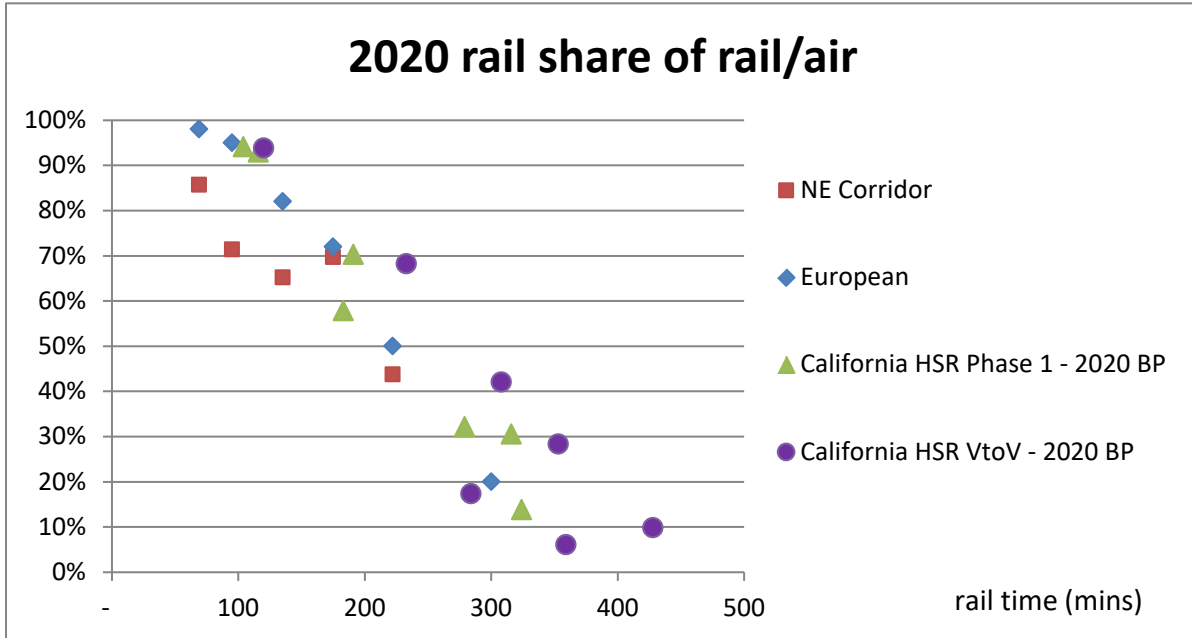


Figure 1 shows the forecasts in the 2020 Business Plan for Phase 1 are very close to those for European experience, while as in 2016 (and 2018), they are above those for the North East (“NE”) Corridor of the US. However, as noted in PFAL’s review of the 2016 Business Plan, it is suspected that the NE Corridor figures may include transfer passengers within the air figures.

The rail mode share forecasts for the Valley to Valley service are higher than the rail mode share for other forecasts, including the forecasts for Phase 1 (when an adjustment is made for the different rail journey times). As stated above, comparisons of mode share such as these can only be indicative, but it does suggest the forecast mode share for the Valley to Valley service is high.

It should also be noted that some of the adjustments (e.g. development impacts) proposed in Table 4 relate to the total market, and the implied rail market share following Table 4 adjustments will not increase as much as might appear at first.

3. PFAL RIDERSHIP AND REVENUE SENSITIVITY

3.1 Ridership and Revenue Sensitivity Approach

This section provides broad sensitivities based on the analysis described in Section 2 around the revenue for each of the three years (2029, 2033, 2040) before any ramp up is applied. The ramp up period is addressed in Section 3.5 below.

It is important to note that the estimates are based on the assumptions that were used by CS. If trains are faster or slower, more or less reliable, or priced lower or higher than assumed, the ridership and revenues will be different.

3.2 Valley to Valley Service 2029 Sensitivity

The table below sets out PFAL’s sensitivities of the central case forecast for the Valley to Valley service in 2029 before ramp-up is considered. It also provides a range for the forecast; in keeping with our previous memos, the range we present is an assessment of 10% to 90% probability, whereas that presented as low and high in the 2020 (and previous) Business Plans is 25% to 75% probability. The table considers 2029 as this is the year forecast by CS, even though it is not now expected to open until late 2031.

Table 5: Quantification of Risk and Upside Potential 2029 Valley to Valley Service

PFAL Ridership Adjustments	Impact on Central Forecast V to V	Range	Comment
Mode constant for HSR	1 (neutral)	±25%	This risk identified by CS (with larger range)
Survey validation and timetable impacts	0.965 (downside)	±20%	Based on observed ridership elsewhere plus timetable impact detailed in Section 2.2 and 2.3 above
Fares	1.05 (upside)	±10%	-5% for air fares; +10% for HSR fares
Intercity bus	1.05 (upside)	±5%	Market not included in CS model up to 10% increase in ridership
Population	1 (neutral)	±4%	Evidence is that population forecasts are becoming volatile and this risk should be included
Development impacts (including induced commuting)	1.05 (upside)	±10%	Limited potential for new development by 2029

Time sensitivity / Long access	0.9 (downside)	±10%	Impacts flows with long access journeys or greater journey times than presented in SP; factor takes into account that many flows not significantly affected
Car rental	1 (neutral)	±10%	No impact on central forecast, but failure to model egress separately from access increases risk
Auto travel times / autonomous vehicles	1 (neutral)	±3%	New risk identified by CS
Auto operating costs	1 (neutral)	±10%	New risk identified by CS
Reliability	1 (neutral)	±3%	New risk identified by CS
Induced Demand	1 (neutral)	±5%	Higher Induced demand now included by CS
Combined Revenue Factors			
Central	1.01	±39%	Combination of above ranges assuming they are statically independent
Lower	0.61		
Upper	1.40		
PFAL Central Case Sensitivity – 15.5million ridership		Median	
PFAL Lower Case Sensitivity - 9.6 million Ridership		10 th Percentile	This approximates to the 2020 Business Plan 10 th Percentile
PFAL Upper Case Sensitivity - 21.4 million Ridership		90 th Percentile	This approximates to the 2020 Business Plan 75 th Percentile
PFAL Central Case Sensitivity - \$987 million Revenue			
PFAL Lower Case Sensitivity - \$600 million Revenue		10 th Percentile	This approximates to the 2020 Business Plan 10 th Percentile
PFAL Upper Case Sensitivity - \$1,375 million Revenue		90 th Percentile	This approximates to the 2020 Business Plan 75 th Percentile

It can be seen that PFAL's central sensitivity case for ridership of 15.5 m is below (-4.3%) the 2020 Business Plan figure of 16.2 m, but revenue is almost identical (+0.5%). The reason for the difference is that the fares increment only affects revenue, not ridership. PFAL's low case sensitivity for revenue is approximately the same as the 10% probability in the 2020 Business Plan, with our high case sensitivity

of 90th percentile being approximately equal to the 75% probability in the 2020 Business Plan. It is worth commenting that the PFAL probability distribution of outcomes is approximately symmetric (ie the difference between central and low is the same as that between high and central), whereas in the CS assessment made for the Authority, the distribution is not symmetric with the difference between high and central being significantly larger than that between central and low.

3.3 Phase 1 Service 2033 Sensitivities

The table below sets out our sensitivity of the central forecast for the Phase 1 service in 2033 before ramp up is considered. It also provides a range for the forecast.

Table 6: Quantification of Risk and Upside Potential 2033 Phase 1

PFAL Ridership Adjustments	Impact on Central Forecast Phase 1	Range	Comment
Mode constant for HSR	1 (neutral)	±25%	This risk identified by CS (with larger range)
Survey and validation	1 (neutral)	±20%	Mainly based on observed ridership elsewhere
Fares	1.05 (upside)	±10%	-5% for air fares; +10% for HSR fares
Intercity bus	1.05 (upside)	±5%	Market not included in CS model, up to 10% increase in ridership
Non-Californian	1 (neutral)	±3%	Market now included in CS model
Population	1 (neutral)	±5%	Evidence is that population forecasts are becoming volatile and this risk should be included
Development impacts (including induced commuting)	1.05 (upside)	±10%	Limited potential for new development by 2033
Time sensitivity/ Long access	1 (neutral)	±10%	CS assessment of this factor appears reasonable for Phase 1 services, but there remains some risk
Car rental	1 (neutral)	±10%	No impact on central forecast, but failure to model egress separately from access increases risk
Auto travel times/ autonomous vehicles	1 (neutral)	±3%	New risk identified by CS

Auto operating costs	1 (neutral)	±10%	New risk identified by CS
Reliability	1 (neutral)	±3%	New risk identified by CS
Induced Demand	1 (neutral)	±5%	Higher Induced demand now included by CS
Combined Revenue Factors			
Central	1.16	±41%	Combination of above ranges assuming they are statically independent
Lower	0.69		
Upper	1.63		
PFAL Central Case Sensitivity – Ridership	39.2 million	Median	
PFAL Lower Case Sensitivity - Ridership	23.8 million	10 th Percentile	This approximates to the 2020 Business Plan 10th Percentile
PFAL Upper Case Sensitivity - Ridership	54.7 million	90 th Percentile	This approximates to the 2020 Business Plan 85th Percentile
PFAL Central Case Sensitivity - Revenue	\$2,555 million	Median	
PFAL Lower Case Sensitivity - Revenue	\$1,520 million	10 th Percentile	This approximates to the 2020 Business Plan 10th Percentile
PFAL Upper Case Sensitivity - Revenue	\$3,590 million	90 th Percentile	This approximates to the 2020 Business Plan 85th Percentile

PFAL’s central case sensitivity for Phase 1 ridership in 2033 is 12% above that of the Authority, and revenue is 16% higher. PFAL’s low case sensitivity for revenue is approximately the same as the 10% probability in the 2020 Business Plan, with PFAL’s high case sensitivity being approximately equal to the 85% probability in the 2020 Business Plan.

3.4 Phase 1 Service 2040 Sensitivity

The table below sets out our sensitivities of the central forecast for the Phase 1 service in 2040. It also provides a range for the forecast.

Table 7: Quantification of Risk and Upside Potential 2040 Phase 1

PFAL Ridership Adjustments	Impact on Central Forecast Phase 1	Range	Comment
Mode constant for HSR	1 (neutral)	±25%	This risk identified by CS (with larger range)
Survey and validation	1 (neutral)	±20%	Mainly based on observed ridership elsewhere
Fares	1.05 (upside)	±10%	-5% for air fares; +10% for HSR fares
Intercity bus	1.05 (upside)	±5%	Market not included in CS model up to 10% increase in ridership
Population	1 (neutral)	±7%	Evidence is that population forecasts are becoming volatile and this risk should be included
Non-Californian	1 (neutral)	±3%	Market now included in CS model
Development impacts (including induced commuting)	1.1 (upside)	±10%	More potential for new development by 2040
Time sensitivity/ Long access	1 (neutral)	±10%	CS assessment of this factor appears reasonable for Phase 1 services, but there remains some risk
Car rental	1 (neutral)	±10%	No impact on central forecast, but failure to model egress separately from access increases risk
Auto travel times/ autonomous vehicles	1 (neutral)	±3%	New risk identified by CS
Auto operating costs	1 (neutral)	±10%	New risk identified by CS

Reliability	1 (neutral)	±3%	New risk identified by CS
induced Demand	1 (neutral)	±5%	Higher Induced demand now included by CS
Combined Revenue Factors			
Central	1.21	±42%	Combination of above ranges assuming they are statically independent
Lower	0.71		
Upper	1.72		
PFAL Central Case Sensitivity – Ridership	44.6 million	Median	
PFAL Lower Case Sensitivity - Ridership	26.5 million	10 th Percentile	This approximates to the 2020 Business Plan 15th Percentile
PFAL Upper Case Sensitivity - Ridership	62.7 million	90 th Percentile	This approximates to the 2020 Business Plan 90th Percentile
PFAL Central Case Sensitivity – Revenue	\$2,923 million	Median	
PFAL Lower Case Sensitivity - Revenue	\$1,702 million	10 th Percentile	This approximates to the 2020 Business Plan 15th Percentile
PFAL Upper Case Sensitivity - Revenue	\$4,143 million	90 th Percentile	This approximates to the 2020 Business Plan 90th Percentile

PFAL’s central case sensitivity for Phase 1 ridership in 2040 is 16% above that of the Authority, and revenue is 21% higher. PFAL’s low case sensitivity is approximately the same as the 15% probability in the 2020 Business Plan, with PFAL’s high case sensitivity being approximately equal to the 90% probability in the 2020 Business Plan. By 2040, the PFAL central forecasts are significantly higher than those of the Authority with the result that the low (10%) forecasts are also higher, but the high (90%) forecasts are similar due to the higher upside potential considered by the Authority.

3.5 Opening Year and Ramp Up

The Authority has made some changes to ramp up factors in the 2020 Business Plan. They have used the same ramp up for the initial central Valley service, but more aggressive ramp up for the subsequent Valley to Valley service and Phase 1 service. Table 7 sets out the figures used in the Business Plan and Table 9 presents PFAL’s assumptions.

Table 8: Ramp Up assumptions used in the Business Plan

Factors	Year 1	Year 2	Year 3	Year 4	Year 5
2018 BP Ridership and Revenue	40%	55%	70%	85%	100%
2020 BP V to V ridership	50%	68%	86%	97%	100%
2020 BP V to V revenue	49%	66%	84%	96%	100%
2020 BP Phase 1 ridership	68%	79%	89%	97%	100%
2020 BP Phase 1 revenue	63%	75%	86%	96%	100%

Table 9: Ramp Up assumptions used by PFAL

Factors	Year 1	Year 2	Year 3	Year 4	Year 5
V to V ridership and revenue	43%	59%	74%	89%	100%
Phase 1 ridership and revenue	43%	59%	74%	89%	100%

It can be seen that for Authority's Phase 1 ramp up factors in Table 8 are significantly more aggressive in the early years than PFAL's factors in Table 9. The Authority's argument to support the proposed ramp up is that the preceding central Valley service will create awareness in the market and that regional operation between Gilroy and San Francisco and Burbank to Anaheim have established rail markets and reflect a brownfield condition. This may be the case but is an optimistic opinion that may not apply to the two largest markets (San Francisco and Los Angeles) which are not served by the central Valley or these existing services.

The Authority provided evidence from Eurostar, French TGV services, Spanish AVE services and Acela (Amtrak NE Corridor) plus a number of urban contexts and airport services that PFAL does not considered sufficiently relevant. Given the unprecedented nature of the Phase 1 service in California, these services do not provide a strong evidence-based rationale for the assumptions. For example, Acela services did not have the order of magnitude change in travel speeds of "true" HSR services, so it is probably less relevant. Furthermore, ramp up is highly dependent on the extent and quality of the marketing. The PFAL view is that the revised ramp up factors are reasonable for a high scenario, but not for a central or low scenario. We consider the 2018 ramp-up assumptions to be more appropriate for the low scenarios and hence recommend retaining them. The process used by the Authority in 2020 Business Plan differs from prior Business Plans since prior processes used a constant set of factors for all of the three scenarios as a conservative approach.

For the central forecasts we have re-examined the issue of ramp up.

- We note that the 2020 Business Plan has a strategy for phased introduction of services intended to maximize the build-up of ridership and revenue. The initial Central Valley service (2029) will build awareness in the markets it serves; this is followed by the Valley to Valley service (December 2031) and finally the Phase 1 service in December 2033.

- We have adjusted ramp up applied in 2018 Business Plan to remove the effect of the ramp up of timetables. The Authority has assumed that ridership has an elasticity to train miles of about 0.4 to 0.45; i.e. a 20% change in train miles results in a 8% change in ridership. Using evidence from the UK of sensitivity of ridership to train frequency (applied at typical HSR frequencies in Authority’s timetables) we have estimated an elasticity of 0.25; i.e. a 20% change in train miles results in a 5% change in ridership. This gives ramp up factors for years 1, 2, 3, 4 of 43%, 59%, 74% and 89% respectively. In comparison, the 2020 Business Plan ramp-up factors for station pairs with new operation are 47%, 63%, 79% and 94%.
- An existing conventional rail service does not affect ramp up when a full HSR service is introduced, as the scale of improvement due to HSR is comparable to that seen in Europe on which much of ramp up evidence is based and, in most cases greater than that seen on North East Corridor of the US with introduction of Acela services. For relatively short distance services within the Bay Area and within southern California, the Acela services may provide a reasonable comparator.
- The initial Central Valley service means that ramp up in this corridor starts in 2029 when that service is introduced.
- Ramp up is applied to incremental ridership and revenue; in other words, the ramp up for Phase 1 services applies to the incremental ridership and revenue over the Valley to Valley services; this applies in Low and High sensitivities as well.

Table 10 shows the impact of using the revised central ramp up factors and the 2018 Business Plan factors (Low sensitivity) in place of the revised 2020 Business Plan ramp up factors in the early years.

Table 10: Impact of Revised Ramp Up Assumptions

Areas of Impact	2031	2032	2033	2034	2035	2036	2037	2038
Impact on ridership (Central case)	2%	-1%	-7%	-15%	-10%	-4%	-2%	0%
Impact on revenue (Central case)	4%	1%	-4%	-11%	-7%	-3%	-2%	0%
Impact on ridership (Low sensitivity)	-20%	-20%	-21%	-29%	-20%	-10%	-6%	0%
Impact on revenue (Low sensitivity)	-18%	-18%	-18%	-25%	-18%	-9%	-6%	0%

It can be seen that using the 2018 Business Plan ramp up factors (Low sensitivity) in the 2020 Business Plan reduces revenue by up to 25% in 2034 and 18% in other early years. The revised central case reduces revenue by up to 11% in 2034, general revenue impacts range from +4% to – 7% in other years.

4. LOAD FACTORS

Using the Authority’s central forecasts for 2040 and trains with 450 seats, the load factor averaged along the route, and across the year, is 59%, whereas PFAL’s sensitivities estimate approximately 68%. Both of these figures are in line with international experience, where load factors averaging up to 80% across the year are achieved.

In 2029 when only 3 trains per hour are expected to be operated in the peak and 2 trains in off-peak, the average load factor for the network is calculated at 70% across all trains throughout the year for Authority’s and 66% for PFAL’s sensitivity analysis, before taking account of ramp up. While these are typical of international experience, the loadings between the two services is not balanced, and the trains to/from San Francisco are more crowded than those to/from Merced; under the Authority’s unadjusted forecasts, the trains from San Francisco have a load factor of 92% which is unlikely to be achievable as an average across the year. Experience of High-Speed Rail in other countries supports this view. However, ramp up is expected to be 50% in year 1 (2031), 68% in year 2 (2032), 86% in year 3 (2033); after that Phase 1 should be implemented. Taking account of ramp up the load factors will not become excessive, even on the San Francisco services.

The load factor analysis provides a sense check that the ridership projected can be reasonably accommodated assuming the current operating plan. If load factors did become excessive, for example with the high forecasts (implying sufficient space is not available to accommodate riders), an active revenue management system can manage down ridership to an acceptable level, with only limited impact on revenue.

5. CONCLUSIONS ON RIDERSHIP AND REVENUE

PFAL’s central case sensitivity based on analysis described in Section 2 through 4 for ridership on the Valley to Valley service is similar to the Authority’s with a similar range before taking account of ramp up. For revenue, our sensitivity analysis shows very similar values but ridership was slightly lower by 4% in 2031 without ramp up. For Phase 1 in 2033, PFAL’s central case sensitivity shows approximately 10% higher ridership and approximately 16% higher revenue than the Authority with the gap growing by 2040.

However, the ramp up assumptions have changed noticeably in the 2020 Business Plan, based on a new phased implementation approach of the HSR operation and segments and a refined process that attempts capturing the implications of this phasing on ridership. PFAL understands the reasoning behind this approach but we suggest different values for the ramp-up factors in both the central case and risk analysis. While recognizing the uncertainty around ramp-up factors, we consider it prudent to be cautious in the low case and utilize the ramp-up factors from the 2018 Business Plan. Using the 2018 Business Plan ramp up assumptions in the 2020 Business Plan may reduce revenue by 18% in 2031 – 2033, 25% in 2034, 18% in 2035, 9% in 2036 and 6% in 2037, with no material impact thereafter. For the central case we have set out an alternative approach to ramp up that marginally increases revenue in 2031 and 2032, reduces revenue by 4% in 2033, 11% in 2034, 7% in 2035, 3% in 2036 and 2% in 2037, with no material impact thereafter.

Based on the provided information, sensitivities, and benchmark comparisons, the estimate of the range of likely outcomes (10% probability) is about +/- 40% (slightly lower in early years, slightly higher in later years), with uncertainty in ramp up being in addition to those figures.

At central case estimates, load factors look reasonable. If actual ridership turns out to be higher than this level, then there might be some overcrowding, but there is a low risk to revenue as the revenue management system should address the issue of load factors (higher demand than capacity) by managing the fares to influence some passengers to spread to less busy trains.

It is important to note that PFAL's review of ridership and revenue is of their accuracy based on information available at the time of preparation of the 2020 Business Plan. As such it does not take into account any potential long-term impact due to COVID-19. This is discussed further in Part 3 on risk.

Part 2 – Operations & Maintenance

Part 2 presents an analysis of the changes to O&M costs between the 2018 Business Plan and the 2020 Business Plan. The content of this part is divided into the follow sections:

- O&M Analysis Methodology
- Operations
- Rolling Stock and Maintenance
- Maintenance of Infrastructure
- Conclusions

6. O&M ANALYSIS METHODOLOGY

Changes to O&M assumptions and costs between the 2016 and 2018 Business Plan were first evaluated to support the review of changes between the 2018 and 2020 Business Plans. Changes were identified through a review of the relevant Business Plans and supporting technical reports. For each identified change, an assessment of both the logic for the change and its impact has been made. PFAL raised a number of clarification questions with the Authority and also discussed specific issues in more detail. The responses to clarification questions, discussions with the Authority and supplemental information arising from these have formed part of our assessment of the 2020 Business Plan.

7. OPERATIONS

7.1 Train Crew Numbers and Costs

The 2020 Business Plan uses a new methodology from previous Business Plan's to calculate the number of train crew required which builds up the crew requirement from a calculation of the total time trains are in passenger service, making dead head moves or on protect duties. A universal factor of 1,794 hours per annum at work for each employee is used, together with the staffing compositions used for different activities, to calculate the number of each grade of train crew required and hence their cost. Table 11 below shows the different staffing compositions for train crew:

Table 11: Staffing Composition for Train Crew

Personnel	Engineer	Conductor	Asst. Conductor
Revenue Generating	1	1	2
Deadhead	1	1	0
Protect Trains	1	1	1

PFAL's analysis of the service and train crew requirements returned a higher staff requirement than the Authority's. In discussion with the Authority, we were informed that an efficiency factor of 85% is applied to the calculation of the train crew requirement (i.e. it is assumed that 85% of train crew working time can be allocated to the three tasks of passenger service, deadhead movements or protect duties while 15% is unproductive time).

The efficiency of train crew is driven by a number of factors including:

1. Time required for booking on / booking off at the start and end of the working day
2. Time required for train preparation before entering service
3. The availability of different lengths of rostered work for staff that can be aggregated over a working week to maximize productive time
4. Local working practices

In our experience, an 85% efficiency factor for train crew operating a long distance, high speed service is ambitious and the actual figure in operation could be much lower. Calculation of the actual level of efficiency to apply to the service requires detailed train and crew scheduling to be completed. We would expect to see this work started in the next iteration of the business plan and continued as the project moves closer to implementation. However, we do believe that a 75% efficiency factor is more appropriate given the likely impact of inefficiency factors. For the year 2040, this would lead to an increase in traincrew numbers and cost as shown in the table below:

Table 12: Impact of Reduced Efficiency Factor

Personnel	Additional Train Crew 2040	Additional Cost 2040
Engineer	40	\$4.0m
Conductor	40	\$3.3m
Assistant Conductor	40	\$2.9m
Totals	120	\$10.2m

The cost figures in the table above are in 2019 dollars for the year 2040 and exclude contingency. The figure of \$10.2m for these O&M costs are consistent with the range of 1.0 to 1.5% provided by the ETO in response to a question about the impact of 75% efficiency on the costs. In the risk analysis in Part 3, the equivalent figures include the contingency of 24.7% because contingency figures were included in the Monte Carlo simulation undertaken by the Authority. Therefore the \$10.12m becomes \$12.15m with the inclusion of contingency.

8. ROLLING STOCK AND MAINTENANCE

8.1 Universal Factors

The model assumes that the system workload will be completed by FTEs and that no employee will need to work overtime and be paid at overtime rates. While we understand that this is planning assumption, we have commented in previous reviews that assuming there will be no overtime is unrealistic given the nature of the operating railway. Therefore, we believe a small provision for overtime working at enhanced rates of pay should be made in next iteration of the business plan. It is anticipated that more detailed analysis of staffing and hours would be undertaken once there has been a firming up of the location of the facilities.

The universal factor used to calculate the number of general and administrative personnel is that they make up an additional 10 percent of the total workforce (including supervisors, managers and engineers). Overall, this is an appropriate assumption for the current state of development of the 2020 Business Plan and one we expect to see strengthened by more disaggregated planning assumptions in future business plans.

8.2 Maintenance of Rolling Stock and Staff

Staff Working Hours

From a review of the staff numbers, we were concerned that the 1,794 hours per annum used for each member of staff assumed 100% productivity and was therefore too high. However, from clarification with the Authority we understand that a utilization factor of 75% has been used for rolling stock maintenance staff, which is appropriate and aligns with industry practice. We suggest this is made clear within the supporting documents for the 2020 Business Plan.

Maintenance & Failure Repairs

We noted that repairs arising from maintenance and failures are set as 936 hours per unit (train), per year. This is similar to our own view that a 25% allowance for repairs arising is appropriate.

We note that wheel changeout has been decreased from 1,800,000-miles in 2018 business case to 1,200,000-miles. From clarification provided by the Authority, it has been confirmed that 1,200,000 miles has been selected in the 2020 Business Plan, as a conservative approach and to align with the 1,200,000 miles bogie change out. This approach is appropriate and aligns with industry practice.

From a review of the heavy maintenance staff and materials, we understand that the final strategy may be out-sourced overhaul. While the strategy in the 2020 Business Plan is for “in-house” maintenance, the costs are appropriate and enable sufficient to support either “in-house” or “out-sourced” maintenance strategies.

Within the 2020 Operation and Maintenance Cost Model, the size of the Light Maintenance Facility has been confirmed. We would estimate that this provides approximately four maintenance tracks and five servicing tracks at both San Francisco Bay and Los Angeles depots. Combined with around eight maintenance tracks and ten servicing tracks in the Heavy Maintenance facility, this provides an estimated 38 maintenance tracks, which is sufficient and appropriate to support the rolling stock fleet size of 72 trainsets.

8.3 Operating Plan and Fleet Size

The timetable and operating plan for Phase 1 that underpin the 2020 Business Plan require 66 trains to be in passenger service and 6 trains to be on protect duties each day. This means that 72 trains are required in frontline service each day. The total fleet size detailed in the 2020 Business Plan to be procured and operated is 72 trains. Therefore, the 2020 Business Plan assumes that the entire train fleet will be in service on each day of operation which leaves no capacity for planned and unplanned maintenance.

During the clarification process, the Authority explained that in practice the trains allocated to protect duties would also be available for maintenance as required. In our view, the allocation of trains to protect and maintenance activities should be clarified. This will ensure that operational plans can deliver both a resilient train service and the required number of trains for maintenance each day.

Through clarification discussions with the ETO and Authority, we understand that the fleet size issue has already been recognized and a recommendation to increase the fleet size has been made to the

Authority. In our view, to maintain the current operating plan of 66 trains in service plus six protect trains, the fleet size should be increased by a further six trains on the following basis:

- **Units for Light Maintenance (LM): 2 Trainsets**
 - While we understand that light maintenance will be completed overnight, we believe it would be appropriate to assume that the 92-day exam may take more than the 6-hrs, and therefore a provision of 2 units should be assumed to be on maintenance.
- **Units for Heavy Maintenance (HM): 1 to 2 Trainsets**
 - The heavy maintenance is completed at 600k, 1,200k and 1,800k, which means that around 1 to 2 trainsets, at any one time will be in heavy maintenance, and not available for service
- **Units for Failure and Performance: 2 to 3 Trainsets**
 - From our experience we would suggest an allocation of 2 to 3 trainsets on repair or failed, would be appropriate for a service requirement of 66 trainsets.
- **Total Spares = 6 Units**

Further, as a result of any increase in the fleet size, and as the light maintenance is based on the number of days from previous exam, an increase in the fleet size of 6 trainsets, will require a subsequent increase in light maintenance of around 9% (staff and materials). It is assumed that the fleet mileage does not change, and therefore there is no resultant increase in heavy maintenance.

We estimate that the additional cost associated with an increase of 6 trains is in the order of \$4.25m in 2040 in 2019 dollars (excluding contingency).

In the sections above, we have identified a small number of items where we believe the costs in the 2020 Business Plan should be increased. There are other areas which present opportunities for the Authority to reduce costs or at least offset some of additional costs identified and these are presented below:

1. **Protect Trains** – The current operating plan contains 6 protect trains which are crewed and ready to enter service throughout the 18-hour operating day. While we support the use of protect trains as a means of responding quickly to service perturbations, industry experience indicates the number could be reduced to 4 trains and even as low as 2 trains with little impact on passengers. If 2 protect trains were utilized then one should be stationed at each end of the route.
2. **Maintenance Planning** – We recognize that the current draft of the timetable has been produced for financial business plan purposes and has not yet been optimized. Within it, there are some long layovers for individual trains, e.g. train numbers 61-66, required for a single AM service and then for a single PM service that could be utilized for train maintenance activities.
3. **Fleet Size Optimization** – Optimizing the number of protect trains required each day together with using train maintenance opportunities contained in the timetable would enable the fleet size to be optimized. In the section above we have recommended an increase in fleet size of 6 additional trains to maintain the current operational plan. However this number could be reduced, with consequent savings in O&M and capital costs by a combination of actions, including points 1 & 2 above.

8.4 Staff for Cleaning of Rolling Stock

We note that the 12 staff allocated to Yard Train Cleaning Team, have been removed from the Operation and Maintenance Cost Model 2020 business case, and a strategy of outsourcing the work through a support contract has been adopted. This seems appropriate for the level of work and support required.

8.5 Operations Startup and Commissioning

The forecasted procurement and fleet ramp up appear to be appropriate with a conservative rate of rolling stock introduction. This conservative rate supports the growth of reliability and development of continuous improvement processes.

9. MAINTENANCE OF INFRASTRUCTURE

9.1 Wi-Fi Connection Charges

Wi-Fi connection charges have risen by 9.1% between the 2016 and 2018 Business Plans. The current rates are based on trial data from the Northern Indiana Commuter Transportation District. While the charge used is appropriate for current planning purposes, we would recommend looking at international comparators of high speed and intercity services to improve the estimate of data consumption from high-speed train services and therefore likely costs.

9.2 Insurance

We note the more detailed methodology used to calculate the cost of insurance and the higher estimate that this results in.

10. CONCLUSIONS

Overall, the changes in O&M assumptions and costs between the 2018 and 2020 Business Plans are minor. Our analysis has identified two areas where costs should be increased relating to train crew efficiency factors and train fleet size. In addition, we have identified some opportunities to reduce costs which are set out in Section 8.3.

We expect to see further changes in assumptions and costs as the business planning process continues and in relation to the remit of this review, particularly in regard to fleet size, Wi-Fi connection charges and track access payments for running on shared infrastructure.

In addition, the assumption that there will not be an increase in real wage inflation, i.e. wages will rise with CPI, is not one we can readily accept in the long-term. This assumption may be appropriate where investment in technology can reduce staffing but as far as this business case is concerned there is no evidence to that effect.

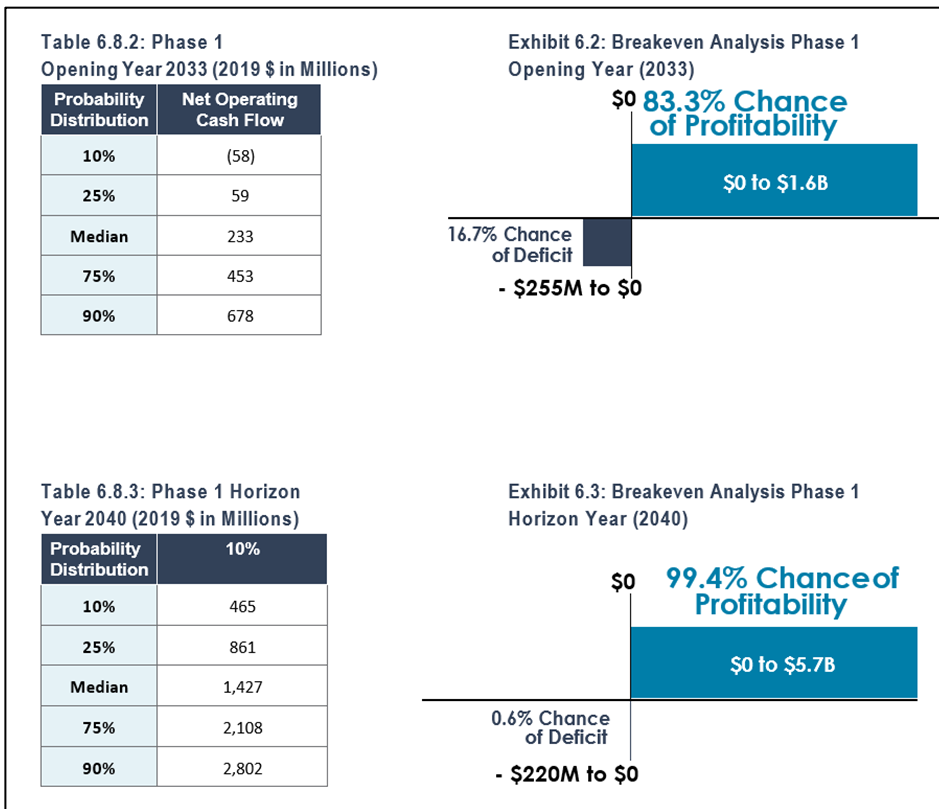
Part 3 – Risk

11. RISK ANALYSIS

11.1 Introduction

An initial analysis has been undertaken of the risk of deficit in Net Operating Cash Flow for 2033 and 2040 presented in Table 6.8.2, Exhibit 6.2, Table 6.8.3 and Exhibit 6.3 of the 2020 Business Plan. Net Operating Cash Flow is used as an indicator of the likelihood for requiring supporting subsidy. The Business Plan states that “*The Breakeven Analysis measures the likelihood that farebox revenue is equal to or greater than operations and maintenance costs in a given operating year. A Monte Carlo analysis is used to conduct this review*”.

Figure 2: 2020 Business Plan: Forecast Risk of Deficit 2033 and 2040



These tables and figures imply the 2020 Business Plan is a low risk operation. In 2033 the greatest potential loss is \$255m but there is only a 10% chance of a loss greater than \$58m, with only a 16.7% probability of a negative Net Cash Flow (i.e. a deficit). A 0.6% chance of deficit in 2040 is lower than international comparisons because the latter typically includes rolling stock leasing costs that the Authority will not incur. Such leasing cost would be in the order of \$200 m per annum and add to operating cost.

Table 13 below is the revenue forecast risk profile from the Ridership and Revenue Forecasting Report. These figures exclude the ramp up effect. Table 14 shows the risk profile for the O&M costs provided in response to a request from PFAL for the same level of information as already provided in the business plan supporting documentation for revenue.

Table 13: 2020 Business Plan: Revenue Risk Distribution - No Ramp Up Effect (2019\$ millions)

Probability	2029 V2V	2033 Phase 1	2040 Phase 1
Minimum	\$279	\$668	\$707
1%	\$436	\$1,027	\$1,077
10%	\$626	\$1,477	\$1,547
25%	\$803	\$1,866	\$1,961
Median	\$1,066	\$2,422	\$2,558
75%	\$1,396	\$3,098	\$3,273
90%	\$1,732	\$3,755	\$3,987
99%	\$2,339	\$4,917	\$5,299
Maximum	\$3,298	\$6,694	\$7,643

Table 13 demonstrates a significantly higher upside risk than downside risk bandwidth in the revenue forecasting. It demonstrates an upside skew in that the gap between the Maximum and the Median is greater than between the Minimum and the Median in each year. For example, in 2040 the gap between the Median and the Minimum is \$1,851 (\$2,558m minus \$707m), whereas the gap between the Maximum and the Median is nearly three times this greater at \$5,085m (\$7,643m minus \$2,558m).

Figure 3: Revenue Risk Distribution - No Ramp Up Effect (2019\$ millions) from the Business Plan

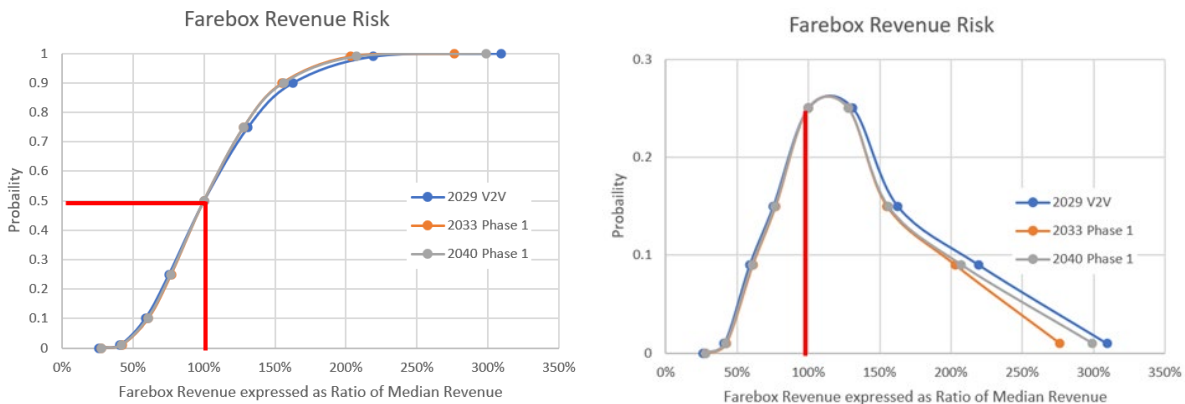


Figure 3 demonstrates the distribution is not normal but skewed to the upside. As such it can be concluded that the median value is less than the Expected Value of the possible outcomes, i.e. the revenue weighted by the probability. In short, the Business Plan revenue assumptions, the Base Run scenario, which in 2029, 2033 and 2040 are lower than the median values, and the median values are conservative. Figure 4 present the distribution applied by PFAL. It is very similar to that shown in Figure

3. The tail ends of the PFAL profile, less than 10th percentile and greater than 90th percentile, have been derived from the relationships in Figure 3. Identifying these outlying values is beyond the scope of this work and would not materially impact on the results of the PFAL analysis.

Figure 4: Revenue Risk Distribution - No Ramp Up Effect (2019\$ millions) from PFAL

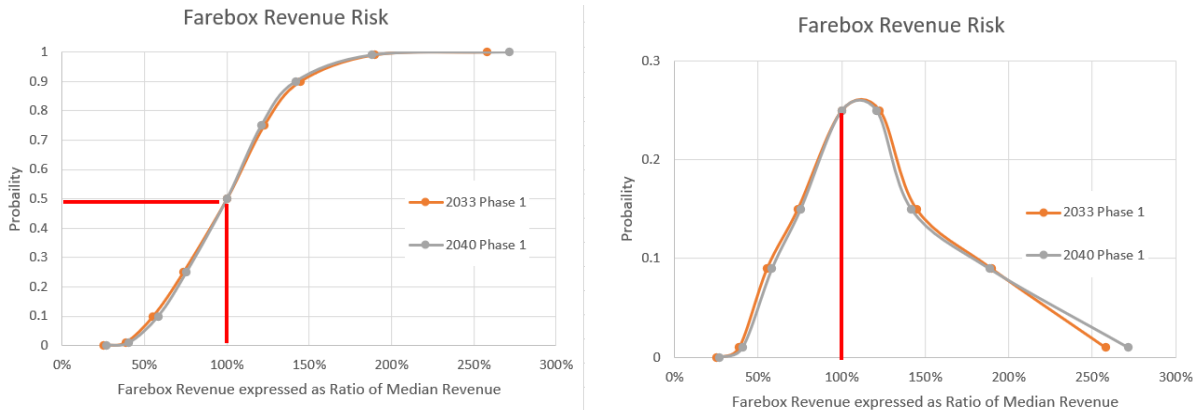


Table 14: 2020 Business Plan: O&M Risk Distribution (2019\$ millions)

Probability	2031	2033	2040
Minimum	\$29.8	\$436	\$938
1%	\$30.5	\$446	\$960
10%	\$32.0	\$469	\$1,008
25%	\$33.5	\$491	\$1,055
Median	\$35.7	\$522	\$1,121
75%	\$38.1	\$557	\$1,196
90%	\$40.2	\$588	\$1,264
99%	\$43.4	\$634	\$1,362
Maximum	\$45.8	\$669	\$1,451

The maximum O&M values for 2033 and 2040 presented in Table 14 are higher than the median by 28% and 29% respectively.

Figure 5: O&M Risk Distribution (2019\$ millions) shown at Ratios to the Median Cost presented in the Business Plan

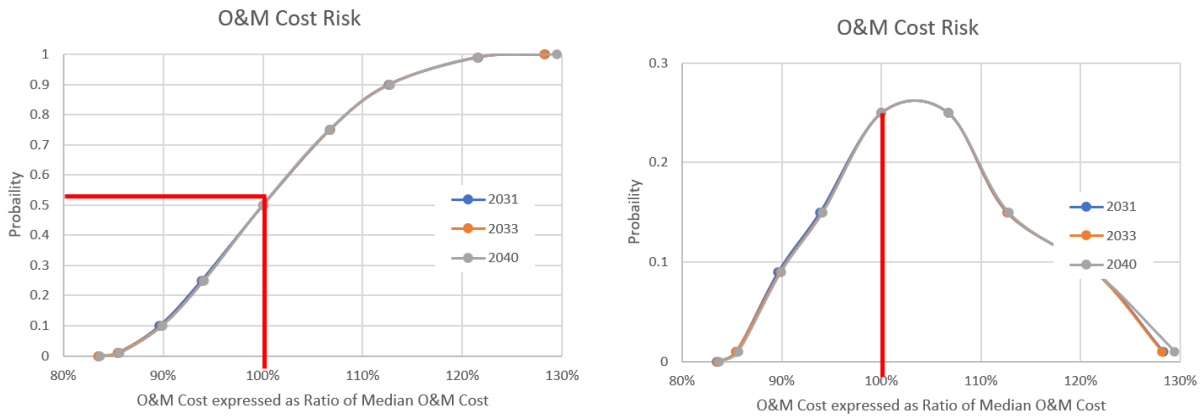


Figure 5 shows the relationship between the costs linked to each probability in Table 12 and the median cost. The slight divergence in the range of risk between 2033 and 2040 is shown in the second graph, at the higher end of the cost risk. This relationship has been accepted by PFAL.

11.2 Indicative Risk Analysis – Authority view

The following Monte Carlo Simulation analysis concentrates on confirming the potential probability of an operating loss in 2033 and 2040 of 16.7% and 0.6% respectively.

The approach is based on applying the O&M cost risk profile, provided by the Authority in response to a question (Table 14), to the revenue risk profile provided in the Ridership and Revenue Forecasting report (as presented in Table 13). It is appreciated that some of the O&M costs will be correlated with ridership, i.e. more passengers will incur higher costs. However, it is our view this would only influence a small proportion (estimated to be 10%) of the O&M costs. It does not take account of PFAL's views of the robustness of the costs and revenue.

The revenue risk profiles in the Ridership and Revenue Forecasting document excluded the impact of ramp up consistent with the process applied since the 2012 Business Plan. Analysis of the revenue for 2033 in the Business Plan and supporting documents revealed a factor to take account of continued ramp up of the Valley to Valley services and the first month of the full Phase 1 operation. This figure of 31.75% was applied to each of the values in the risk profile for 2033 to account for the continued ramp up. For example, the unfactored 25th percentile revenue for that year, of \$1.866m, became \$635m. This figure is similar to the maximum cost in that year of \$669m and hence it can be seen that in all probability the chance of deficit will be small. Table 6.8.2 in the Business Plan, presented in Figure 2 above, shows 16.7%.

In 2040 all services are fully ramped up. Matching the 90th percentile operating cost of \$1,264m with the 10th percentile revenue of \$1,547m does indicate that the chance of a deficit will likely be small. Table 6.8.3 in the Business Plan, presented in Figure 2, shows a chance of deficit of 0.6%.

On the basis of this analysis it appears that the Monte Carlo simulation results in the Business Plan present the order of risk of deficit one would expect using the revenue and O&M profiles shown in Tables 11 and 12.

11.3 Simplified Risk Modelling – Based on Authority figures

A simplified Monte Carlo Simulation for the Net Cash Flow was undertaken using the Authority’s data in Table 13 and Table 14. This modelling was conducted for 2033 and 2040.

The following assumptions were made to generate the results in the comparison table below:

- The revenue for 2033 in Figure 2 was factored by 31.75% to take account of the ramping up of Valley to Valley service and the one month of full Phase 1 services.
- There was no correlation between revenue and costs.
 - It is accepted that in reality there is some correlation in that high ridership would result in some additional costs and low ridership would tend to result on lower patronage related costs.

Table 15 shows the minimum (0th percentile) and maximum (100th percentile) Net Cash Flow results and the probability of deficit from Figure 2. The results for these variables from the simplified risk modelling are shown for comparison purposes.

Table 15: Net Cash Flow Comparison based on Authority figures (2019\$)

Data Source	Minimum 0 th Percentile	Maximum 100 th Percentile	Probability of Deficit
2033 in Business Case	-\$255m	\$1.6bn	16.7%
2033 in Simplified Model	-\$337m (-\$270m)	\$1.7bn (\$1.7bn)	6.0%
2040 in Business Case	-\$220m	\$5.7bn	0.6%
2040 in Simplified Model	-\$353m (-\$208m)	\$6.8bn (\$6.7bn)	0.7%

The values in brackets are an estimate of the minimum and maximum values with an assumption on the correlation between some cost items and the volume of patronage. It was assumed that 10% of cost was directly linked to the quantum of revenue. This is a sensitivity test attempting to replicate a level of correlation. For this purpose, 10% of the minimum cost is added to maximum Net Cash Flow and 10% of the maximum cost is deducted from the minimum net cash flow. This presents a much better fit for the minimum values; because of the low minimum revenue, the impact on the maximum net cash flow is small.

Based on the revenue and O&M forecasts profiles presented with the Business Plan, the analysis above supports the output of the risk model in the Business Plan that there is a low risk of deficit presented in 2033 and 2040. However, the detailed analysis of operations and maintenance costs in sections 6 through to 10 indicate some concern over these values, and PFAL also noted difference in opinion over the assumed ramp up of ridership and revenue.

11.4 Alternative Risk Modelling – PFAL View

The following is analysis of risk of deficit based on PFAL's assessment of revenue and costs, namely:

- Lower ramp up of revenue in 2033 and slightly higher base revenue in 2040 as described in Section 3.
- Inefficiency rate of 25% for train crews instead of 15% as applied in the business case with a resulting increase in annual cost.
- Additional light maintenance costs attached to the increase of trainset numbers for Phase 1 from 72, as reported in the Business Plan, to 78.

The resulting impacts on O&M costs from trainset and crew related costs are shown in Table 16. It has been assumed that the cost impact of additional trainsets applies to 2033 on a pro-rata basis.

Table 16: Additional Costs and Impacts (2019\$)

Year	2033	2040
Fleet related	\$1.67m	\$5.30m
Crew related	\$3.47m	\$12.66m
Total	\$5.14m	\$17.96m
Base Run Costs – O&M v2	\$422.84m	\$994.54m
Increase in costs	1.2%	1.8%

Using the simplified Monte Carlo model, PFAL has identified that impact of the changes to costs and revenue, discussed above, on the probability of Net Cash Flow deficit.

Applying the absolute percentage change in risk of deficit in the simplified model to the figure in the Business Plan results in the following:

- 2033 probability of deficit increasing from 16.7% to 19.6%
- 2040 probability of deficit changing from 0.6% to 0.3%.

These estimates of change should be viewed as a broad indication of the quantum of impact of the PFAL recommendations for revenue and costs presented in this note.

It is also important to note that these are based on information available at the time of the development of the draft 2020 Business Plan, and in particular exclude any effect that COVID-19 might have on future revenue/ridership and operational costs.

11.5 Conclusion

PFAL is required to opine on the likely levels of risk for operating subsidy support as indicated in the Business Plan. From the data provided the revenue is considered acceptable in the long term excluding any potential effects of COVID-19. The analysis and information available for our review was completed prior to events related to COVID-19. Irrespective of the COVID-19 impacts, there are still concerns over the short-term ramp up of ridership and revenue levels.

We note the O&M costs in the 2020 Business Plan included a 24.7% contingency. It is expected that as the project planning development progresses for the next business plan, and more information is produced, the level of contingency will be reduced. For example, the provision of a working timetable, with a schedule of crew rostering, would likely reduce the level of contingency required.

The indicative analysis in Section 11.2 and the simplified Monte Carlo Simulation in Section 11.3 supports the profile of risk of deficit for 2040 shown in the Business Plan. However, the analysis of the impact of slower ramp up of ridership in 2033 and marginal increase in O&M costs has a material impact on the probability of Net Cash Flow deficit in that year.

The indicative risk analysis concluded that the risk of deficit in 2040 is very small. Given that the main difference between PFAL's revenue forecast occurs during the ramp-up period, there is a strong probability of surplus in Net Cash Flow in the years from 2035.

Part 4 – operating subsidy analysis

12. OPERATING SUBSIDY ANALYSIS

To evaluate whether the Phase 1 service will require an operating subsidy, we reviewed the Authority's Central Case in the 2020 Business Plan and then applied the PFAL adjustments to both revenue and O&M cost.

Table 17 below shows the Authority's Central Case for the first 8 years of the Phase 1 operation.

Table 17: Phase 1 Service Operating Surplus (Authority's Central Case)

Authority Figures (in 2019\$)	Phase 1 Operation							
	2033	2034	2035	2036	2037	2038	2039	2040
Farebox Revenue	793	1684	1972	2176	2320	2391	2420	2450
O&M Cost	(509)	(992)	(1041)	(1057)	(1078)	(1093)	(1096)	(1094)
Surplus/(Deficit)	284	692	930	1119	1242	1297	1324	1356

Table 18 below shows the Authority's Central Case for the first 8 years of the Phase 1 operation with PFAL's adjustments.

Table 18: Phase 1 Service Operating Surplus- Central Case (with PFAL's adjustments)

Authority Figures (in 2019\$)	Phase 1 Operation							
	2033	2034	2035	2036	2037	2038	2039	2040
Authority Farebox Revenue	793	1684	1972	2176	2320	2391	2420	2450
PFAL Revenue Adjustment	(59)	(199)	130	264	326	408	444	473
PFAL Adjusted Farebox Revenue	734	1485	2102	2440	2646	2807	2864	2923
Authority O&M Cost	(509)	(992)	(1041)	(1057)	(1078)	(1093)	(1096)	(1094)
PFAL Adjustments to O&M Cost	(13)	(17)	(17)	(17)	(17)	(17)	(17)	(17)
PFAL Adjusted O&M Cost	(522)	(975)	(1024)	(1040)	(1061)	(1110)	(1113)	(1111)
Surplus/(Deficit)	212	510	1078	1400	1585	1697	1751	1812

In both cases, (with and without PFAL's adjustments), revenue exceeds O&M costs throughout Phase 1 operations.