Detailed Business Case

AUCKLAND METRO TRAIN CAPACITY – JUNE 2017

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GLOSSARY

Acronym	Description
AFA	Auckland Forecasting Centre
AT	Auckland Transport
ATAP	Auckland Transport Alignment Project
AUP	Auckland Unitary Plan
BCR	Benefit Cost Ratio
CCFAS	City Centre Future Access Study
CFC	Customer Focus Committee
CRL	City Rail Link
DMU	Diesel Multiple Unit
EEM	Economic Evaluation Manual
EMU	Electric Multiple Unit
EOI	Expression of Interest
ETCS	European Train Control System
GPS	Government Policy Statement
HIF	Housing Infrastructure Fund
IO	Investment Objective
IPEMU	Independently Powered Electric Multiple Unit
MoT	Ministry of Transport
NZTA	New Zealand Transport Agency
PwC	Price Waterhouse Coopers
RFT	Request for Tender
RLTP	Regional Land Transport Plan
RTN	Rapid Transit Network
RUB	Rural-Urban Boundary
SHA	Special Housing Area
SOI	Statement of Intent
TDAK	Transdev Auckland
TFUG	Transport for Urban Growth
WEB	Wider Economic Benefit

EXECUTIVE SUMMARY

AT needs urgently to procure 17 IPEMUs at a cost of $207m

This business case recommends that Auckland Transport (AT) procures a set of 17 Independently Powered Electric Multiple units (IPEMUs) for introduction into the Metro rail fleet from 2019. The cost is calculated at $207m. The IPEMUs will allow AT to address two major issues:

- By mid-2019 there will be no unused capacity available on the electrified rail network to cater for further patronage growth during the morning peak period
- Growth areas – especially to the south – are not adequately served by public transport.

… and deliver against an ATAP priority

Providing additional trains to cater for growing passenger numbers delivers against a central recommendation of the joint Auckland Council, AT and Government, Auckland Transport Alignment Project – ATAP - to provide capacity for Auckland's continuing growth and to avoid negatively impacting Auckland's economy[1]. ATAP identifies an explicit key short-term improvement: *Additional trains to cater for growing passenger numbers*.

When patronage reaches capacity in 2019 customers will suffer delay and congestion on the trains and roads

Recent investment in the Metro rail service alongside Auckland's rapid population and employment growth have led to large and continuing patronage growth. As a result, loading standards are expected to be breached during 2019 and many would-be passengers will be forced to find different ways to travel. Some will use cars, imposing increased traffic volume and contributing to road congestion. Those who can use the rail services will experience significant crowding, above the levels considered acceptable.

Growth areas need better public transport

At the same time, the substantial population growth is putting pressure on the transport network in the growth areas to the south served by a legacy diesel service that requires transfer at Papakura from Pukekohe and does not serve intermediate locations such as the Drury area. In the northern Waikato, growth locations at Pokeno and Tuakau will need an effective transport option to make them attractive to future residents and Auckland workers. A good alternative to driving is needed if the current congestion, causing excessive journey times and poor reliability on the state highways[2], is not to get worse.

The only short-term opportunity is to make 3-car trains into 6-car

Before the City Rail Link (CRL) becomes available in 2023, there are no opportunities to increase service frequencies at Britomart. Effective optimisation measures are close to being exhausted. Therefore, the best option available to AT is to increase the capacity of the current services, notably those which still operate with 3-car Electric Multiple Units (EMUs). Converting the remaining 3-car services to 6-car should cater for the 'best estimate' growth – which assumes that the current 17% annual growth drops to 10% next year and then 8% each year until the CRL opens in 2023.

Optimised use of the existing EMU fleet, particularly during the peak periods, has been progressed over recent years and further is planned through to a mid-2018 timetable change, reducing station dwell times and journey times and allowing trains to be repositioned to offer greater capacity. Work is also progressing in parallel on a review of seating and internal layout to increase capacity within policy limits.

Even higher growth will require different services

[1] Auckland Transport Alignment Project Recommended Strategic Approach September 2016, Ministry of Transport et al, pages 21 and 31.

[2] NZ Transport Agency Long Term Strategic View – Growth Centre Auckland, March 2017

If the growth rate continues at 10% or higher, AT would need to convert all the remaining 3-car services to 6-car and also to look at additional alternative service patterns with some services bypassing Britomart. These additions could be required to target particular routes and services experiencing the highest load levels in the two-hour morning peak. Peak / off-peak differential fare pricing may also be required to spread demand across the peak and shoulder peak periods.

Battery technology now allows off-grid services

EMUs using new technology - on-board energy storage - could provide early opportunities for enhanced rail services to growth areas south of Papakura. New battery developments have resulted in IPEMUs becoming available that allow the benefits of electrification to be provided without the need for fixed infrastructure (i.e. “wires and poles”).

IPEMUs can service the Growth areas and retire the diesel fleet

The business case proposal is to procure 17 IPEMUs for delivery starting at the end of July 2019. This number of units could allow AT to build all services (except Onehunga) to 6-car trains and utilise all possible capacity at Britomart prior to the opening of the CRL in 2023. AT could also retire the current diesel fleet (DMUs) while having future opportunities to serve Drury and the growth areas in the northern Waikato.

There is a sound economic return

This option has a capital cost of $207m. It would provide significant operating and maintenance cost savings through retiring the DMUs and gives practical advantages such as not having a separate maintenance facility, simplifying driver rosters and generating environmental benefits. The economic appraisal gives a best estimate benefit cost ratio (BCR) of 2.8 (range: 2.0 - 4.1). The IPEMUs could be later redeployed should they be replaced by further traditional-style electrification, offering future flexibility to extend services into more areas.

IPEMUs would support HIF proposals for Drury

The IPEMUs could also provide a service to Drury, complementing the Housing Infrastructure Fund (HIF) initiative to expedite growth in that area by funding new stations. Doing so supports an explicit Government objective set out in its Government Policy Statement on Land Transport (GPS)[3].

… and growth further south

The ability to extend services beyond Pukekohe at a later date is seen a significant extra benefit on top of those that have been monetised in the BCR. The Waikato Regional Council has instigated a review of the public transport needs of its fast-growing northern areas. A future opportunity for a rail service will be a major asset in connecting this area to Auckland’s employment markets. The quantified benefits of such extended services have not been included in the business case as they are seen as logical but still conceptual at this time.

IPEMUs have additional benefits

The IPEMUs also offer:

- Operational resilience due to the ability to recover services to the next station in power outages
- Renewable energy source replacing carbon emitting diesel
- The ability to maintain passenger services during period of planned overhead isolation

EMUs would only provide some of the benefits

As a fall back, AT could procure 15 EMUs which would address the short-term capacity challenge on the existing electrified lines. This option would cost $133m and have a best estimate BCR of 3.2 (range 2.2 – 4.4), but does not address the needs of the southern growth areas and does not allow the DMUs to be retired.

The IPEMUs would be procured from CAF – under certain conditions

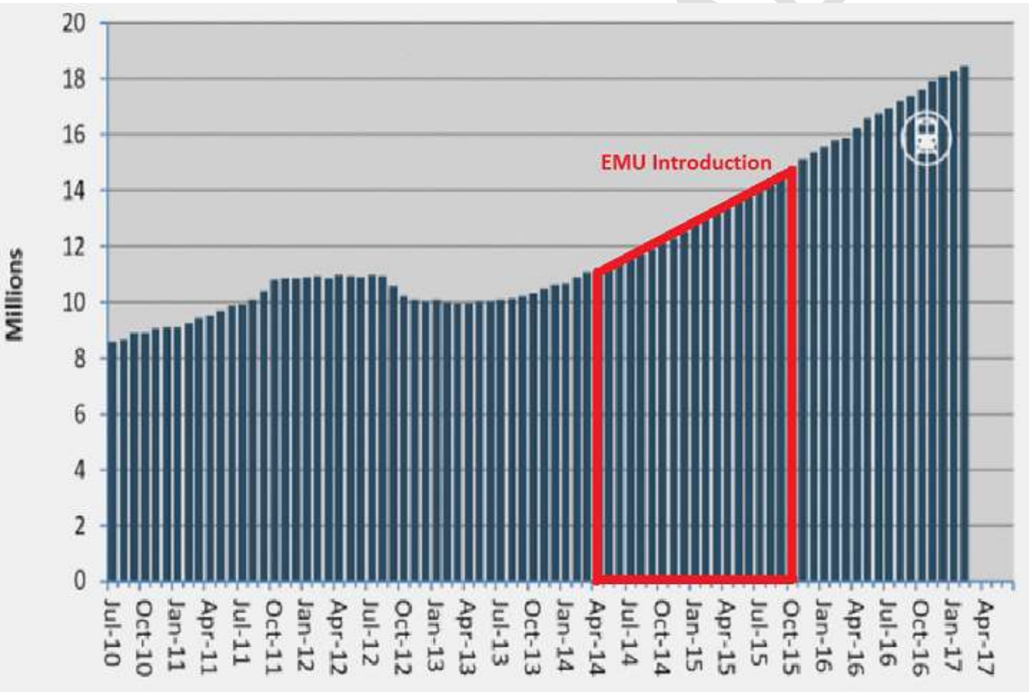
[3] Draft Government Policy Statement on Land Transport February 2017 2018/19 – 2027/28

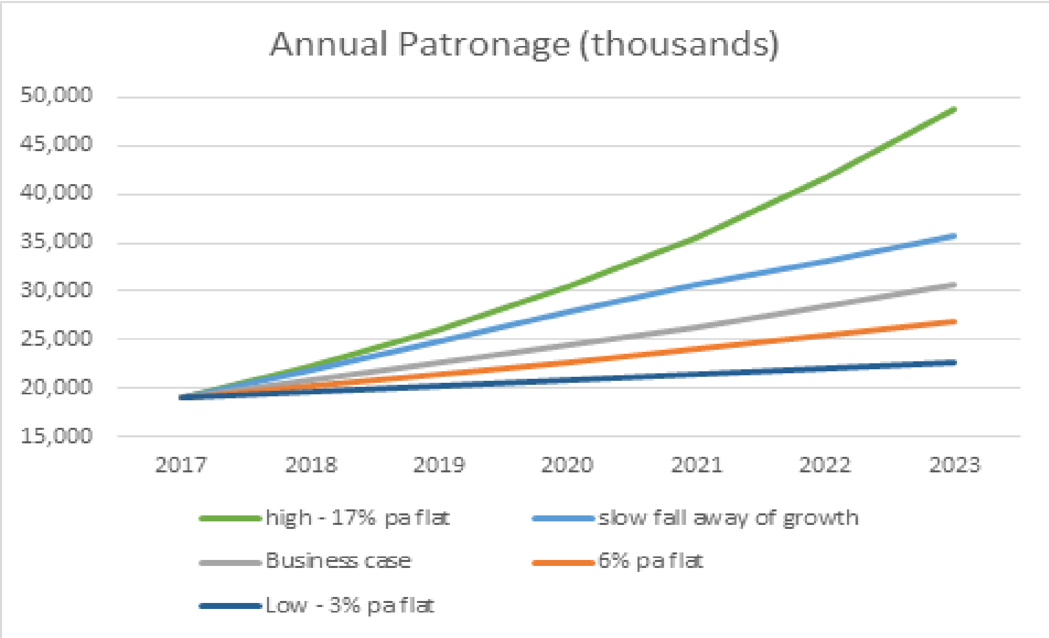
The business case proposes a direct procurement from CAF - Construcciones Auxiliar de Ferrocarriles - (the provider of the current EMU fleet) conditional on CAF maintaining the prices for the base EMUs, with acceptable and transparent cost additions for the battery technology in the IPEMUs. CAF have offered a fully warranted battery solution that in AT's opinion is low risk but high cost. AT has sourced alternative battery systems that promise simplified installation, improved range at reduced capital cost. The alternatives are still work in progress until compliance to industry standards has been demonstrated, therefore the CAF IPEMU solution has been treated as the base at $207m and the alternative solution as a sensitivity test at $173m. AT will work with CAF and the alternate battery supplier to determine whether the alternate solution can be successfully engineered and deliver the value anticipated.

The growth assumption is derived from recent experience
The graph below shows how the rail patronage in Auckland is growing. At a continuing 17% pa, the current rate of growth significantly exceeds the level anticipated when the present fleet was procured. Unless further capacity is provided pre-CRL there will be a certainty of excess crowding and customers not able to use a core element of the public transport network and further congesting the roads.

… aligned to agreed targets in ATAP
The business case uses a level of future rail patronage growth consistent with ATAP, Council and AT goals and expectations for public transport use to double by 2026 from 2013 levels, to total annual public transport trips of around 146 million.

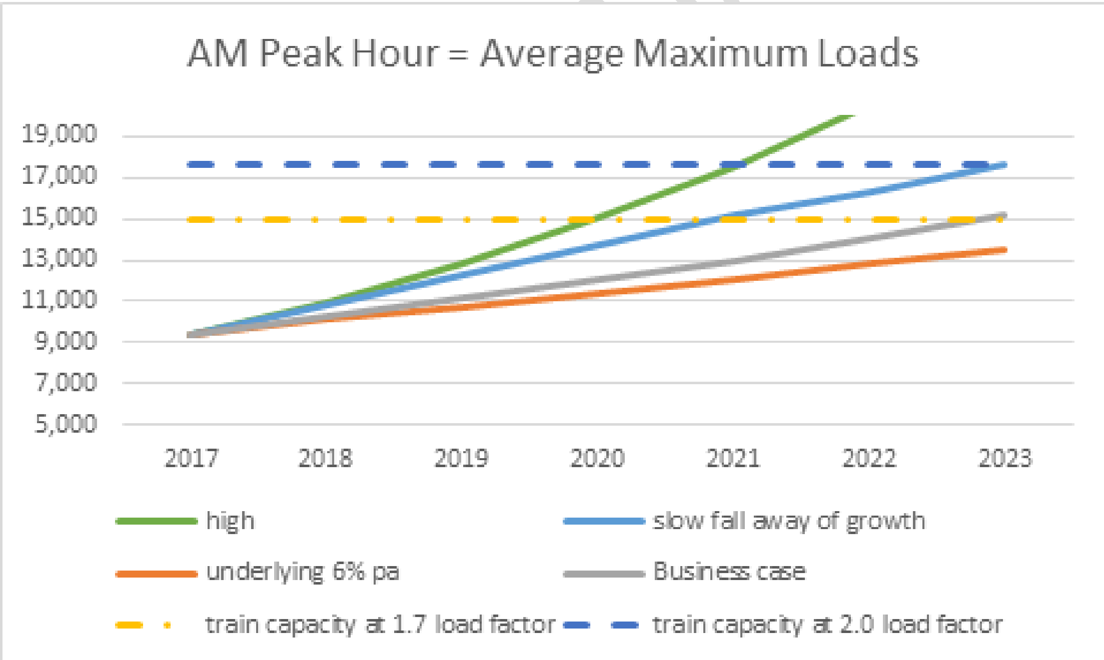
Train Patronage Rolling total





Higher growth can be provided for

A contractual Option would be negotiated with CAF to extend the IPEMU order if growth in the next two years is higher than is allowed for with the core procurement, so that new services could be introduced that did not serve Britomart. Any exercising of the Option would be subject to a further business case at that time.



… but lower growth would not be a concern

If lower than predicted growth occurs in the short-term the underlying population and employment growth will mean that any excess is quickly taken up.

A further business case will address needs beyond 2023

AT recognises that it will need further tranches of rolling stock after the opening of the CRL. Those additional units will trigger the need for more infrastructure – stabling, power supply, maintenance and depot facilities. It would therefore be appropriate for AT to return to the market for these further procurements supported by an appropriate business case.

AT has a well-established EMU project team that would take responsibility for introducing the increment to the fleet, and has planned appropriate testing and assurance for IPEMUs.

Battery technology and risk
Any IPEMU battery system will use proven Li-Ion technology and be manufactured and tested to appropriate international standards. Key potential risks have been assessed as safety due to fire and electrocution, reliability and maintenance degradation and substandard battery life. Any system deployed will be compliance tested against stringent international standards and be designed such that batteries are segregated from passenger compartments by a fire barrier and that battery elements are separately contained. Considerable independent modelling has been undertaken by AT's advisors to determine battery power and energy requirements which has then been compared with modelling undertaken by CAF and the alternate battery suppliers. CAF would warrant their solution and any alternate solution would carry the battery manufacturer's warranty for at least five years' service. The first vehicles that enter service will initially be used as EMUs to build peak capacity on critical trains, de-risking IPEMU introduction by providing extra time to complete battery system development and testing. In either option the base vehicle will be the proven AM class EMU just with the addition of battery systems to the roof and underframe of the central or T-car.

PART 1 – THE CASE FOR THE ACTIVITY

1 BACKGROUND

Rail is a key part of the core Auckland rapid transit network, forming the backbone of the new AT Metro multi-modal connected network. Growth in rail patronage over the last fifteen years has been substantial and has been approximately 17% for the last two years on the back of the introduction of the Electric Multiple Unit (EMU) fleet, higher service frequencies and the improved service delivery performance, requiring continued capacity planning to accommodate the growth.

This level of growth is already putting considerable pressure on available capacity pre-CRL with the near certainty that the peak period trains that remain 3-car will be heavily loaded by 2019 and will need to be increased to 6-car. There is no way to achieve this vital extra capacity without procuring more rolling stock – additional EMUs. There is, however, no provision as yet in any formal funding plan for additional units.

Without the expanded capacity, the levels of loading will approach crush levels with the result that some customers will be unable to board the trains and will look for such alternatives as there are, with an impact on the accessibility of the city centre and increased road congestion. Customers on the peak trains will be packed in with many having to stand for much longer than the target maximum of 15 minutes.

A likely scenario will be that some customers who would otherwise be train passengers will use cars causing disproportional impact on the roads. This effect has been assessed on conservative assumptions as leading to some additional 7,500 private vehicle trips on the road network each morning peak period – the equivalent to more than two full lanes of traffic. Given the inability to increase the capacity of the road network the consequence would be further deterioration of travel times and significant spreading of the peak.

Earlier work (the City Centre Future Access Study – CCFAS – jointly between AT, Council and the Government[4]) found that without significant additional public transport capacity traffic speeds in central Auckland could fall as low as 5 – 7 kph.

There will be a poor reputational outcome for Auckland Transport (AT), the NZ Transport Agency, Auckland Council and the Government if the core rail service becomes significantly over-crowded by 2019, exacerbated by these impacts coming within three years of when the Auckland Transport Alignment Project – ATAP – was completed. ATAP identified a requirement early in the first decade for additional rolling stock and train capacity, which aligns to this business case for delivery of the IPEMUs from 2019 onwards.

A further potential outcome is that some of the projected employment growth in the city centre – New Zealand' most productive location – will, over time, be stifled by the lack of accessibility.

The proposed solution of purchasing additional rolling stock to convert all (non-Onehunga) trains to 6-car units and increase shoulder peak capacity is the maximum that can be achieved with the current number of train slots, which is limited by the capacity at Britomart. Providing more capacity at Britomart can only happen through the construction of the City Rail Link (CRL). As an interim measure, AT could choose to procure extra EMUs to introduce alternative services that would not use Britomart. The latter

[4] City Centre Future Access Study Technical Report Executive Summary, 2011

option is clearly not attractive from a customer perspective but may be necessary in the short-term if growth is higher than the current central estimate on particular peak services.

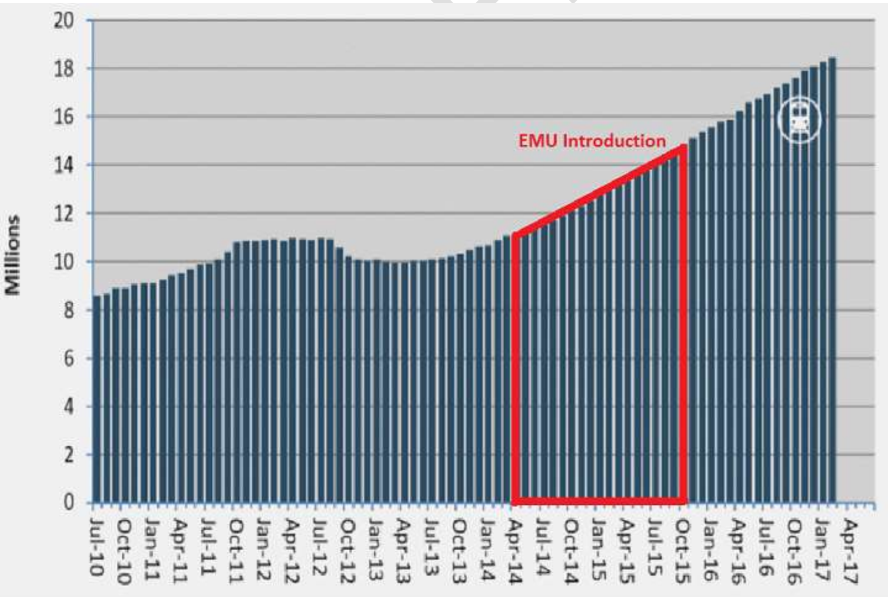
Auckland is also addressing the needs of its housing growth areas of which those in the south could be served by efficient rail services given their location on or close to the Main Trunk Line. At present, there is a lower frequency service using older diesel multiple units (DMUs) between Pukekohe and Papakura, where customers have to change to continue their journey. Growth areas further south such as Pokeno[5] and Tuakau[6] in the Waikato would benefit from an attractive train service which would prevent such areas being 'transport disadvantaged', expand the catchment of Auckland's critical employment area and reduce congestion on State Highway One. These potential services could thus reduce the long and unreliable drive times[7] that would otherwise be required for residents of these outer areas to contribute to Auckland's growing economy.

In the Drury area, there is an opportunity to accelerate growth by such mechanisms as accessing the Government's Housing Investment Fund – HIF – to fund stations. A better rail service would complement such initiatives.

1.1 Observed Patronage Growth

Current rail network growth is around 17% pa. The base values adopted for the business case is for growth of 10% in 2017/18 and then 8% pa to continue to 2023. There is a high risk that this will be exceeded given the recent history so opportunities for some additional capacity beyond that needed to meet the base growth estimates must also be explored. As shown in the graph below, rail patronage growth has been rapid and very steady since the EMUs have been introduced from 2013 and higher frequencies in operation with the total patronage likely to have doubled from 10 million pa in 2013 to 20 million by the end of 2017[8]. The total reached 19 million in April 2017, a 16.7% observed increase in one year.

Figure 1.1 Train Patronage Rolling total



5 http://openwaikato.co.nz/attachments/docs/2017-wdc-factsheet-pokeno.pdf
6 http://openwaikato.co.nz/attachments/docs/2017-wdc-factsheet-tuakau.pdf
7 NZ Transport Agency Long Term Strategic View, Op cit
8 Auckland Transport Board paper, Op cit

The chart above shows that rail patronage has been growing at some 16 – 17% pa, well above the overall public transport growth level of 5-7%.

This level of growth and the continuing trend is much higher than had been forecast when the original 57 3-car units were purchased. Original business case modelling in 2009 projected patronage of 17.8 million in 2017 and 20.8 million by 2023 with growth below 3% per year between 2016 and 2023[9]. AT Statement of Intent (SOI) Patronage for 2016-17 is targeted to reach 19.5m by the end of the 2016/17 financial year (a 16.5% projected increase on 2015-16), 21.9 million by mid-2019 and 22.8 million by mid-2020. Additional rolling stock procurement is not currently identified in the existing Long-term Plan or Regional Land Transport Plan as patronage growth assumptions at the time were based on the original EMU business case assumptions, which are now being exceeded.

1.2 Transport Planning Context - ATAP

The Auckland Transport Alignment Project[10] (ATAP) provides the crucial context for the business case as it represents the agreed transport strategy for Auckland between central and local government.

Its recommendations were published in September 2016[11].

ATAP identified four critical transport challenges to be the focus over the next decade. They included: "Increasing public transport mode share on congested corridors".

For the *Strengthen strategic transport networks* priority ATAP noted that "Auckland's strategic road, rail and public transport networks are the most critical elements of the city's transport system. It is essential to maintain and develop strong, safe and resilient strategic networks **that can cope with increased demand**. (p. 20, emphasis added). Similarly, ATAP identified two key drivers for prioritising development of the strategic public transport network:

- Addressing emerging capacity constraints as demand increases
- Expanding the network to improve overall corridor efficiency and throughput.

ATAP further commented: "mode choice for strategic network improvements should be driven by capacity requirements to meet forecast demand, integration with the wider network and achieving value for money". (p. 21)

For the priority: *Enabling rail passenger and freight growth*, the report stated:

"Ongoing investment will be needed to provide an integrated and resilient rail network that can effectively provide for projected growth in passenger and freight demand and Auckland's planned passenger service patterns. Auckland Transport and KiwiRail have developed a 30-year indicative Rail Development Plan that identifies the investments needed to deliver this.

- Other key short term improvements likely to be required include:
    - **Additional trains to cater for growing passenger numbers**." (para. 81, p. 31, emphasis added)

9 Auckland Metro Rail Electrification: Report of the Working Group 4 August 2009
10 http://www.transport.govt.nz/land/auckland/atap/
11 Auckland Transport Alignment Project Recommended Strategic Approach September 2016, Ministry of Transport et al

The Early Rail Development Plan priorities in paragraph 81, quoted above, were included among the *Indicative priorities for major new investments* for completion in decade 1.

1.2.1 Future Growth

ATAP made some very specific comments with regard to public transport growth:

"**Public transport mode share:** Both the current plan and the indicative package project a strong increase in public transport mode share, from 7% in 2013 to 11% by 2026. This equates to a doubling in total annual public transport trips over that period, to around 146 million by 2026. Further improvements are projected under the indicative package, with mode share increasing to 16% by 2046 (276 million passengers)." (Para 94, p. 39)

In the year ending December 2016, public transport in Auckland carried 84.8 m passengers. If the 2026 projection of 146m passengers pa is to be reached, then overall public transport patronage would need to grow at an average of 5.5% pa until 2026. As noted above, while average public transport use has been growing at 5% in recent years, the dominant growth has been rail patronage. If it is assumed that the factors driving rail patronage will start to reduce then a growth rate of 8% for rail and 5% for other public transport results in the doubling of total public transport use. Alternatively, 10% pa on rail and 4% on other public transport also doubles total public transport patronage.

This business case therefore uses patronage growth profiles that are consistent with ATAP.

1.3 The Baseline

The current fleet of 57 Electric Multiple Units (EMUs) is fully utilised daily, with 54 units in service, and three in planned maintenance (EMU "units" comprise three cars coupled together). Three-car EMUs can be coupled to make 6-car trains. Operation of trains longer than six cars is restricted by the length of platforms across the network. The limit to capacity that can be supplied is further affected as the full set of units is not always available reducing the effective capacity. There is often pressure on achieving required availability due to operational incidents and vandalism and when special events overlap with peak demand periods. The maintainer is at times required to defer maintenance activities to free up units.

There is a significant reputational risk for AT and its partners if the patronage growth cannot be accommodated. In the short-term the effects of the step-change in the quality of rail offering appears to be continuing to drive growth. In the medium-longer term the capacity of the trains will need to meet the increased demand arising from population increase, changes in the bus network following the implementation of the new network (which uses a hub and spoke delivery model with transfers at Rapid Transit Network (RTN) interchanges) and potential changes in land use that may impact on future travel patterns.

While operational efficiencies and improvements have been made (and continue to be made), to improve the capacity and utilisation of the existing fleet up to and beyond the original EMU purchase business case, additional units are required to ensure demand can be met from 2019 onwards. An augmented fleet is required to ensure full benefit continues to be extracted from previous investment in Auckland passenger rail and the desired growth in public transport usage can continue to be accommodated. An adequate supply of rolling stock also needs to be available into the future, which will require further tranches of EMUs and additional stabling, depot and maintenance facilities in the mid-2020s, or earlier.

Assuming a 24-30-month manufacturer lead time and a need to meet the 2019 timescale, a decision to acquire additional units is required in mid-2017 and an order placed.

Whilst the large majority of the AT Metro rail services are now electrified and operated by EMUs, the exception is the Papakura line to Pukekohe which is operated by older diesel multiple units (DMUs). The DMUs are costly to run, require high maintenance and separate maintenance facilities. Passengers on this line have to change at Papakura. With the adoption of the Auckland Unitary Plan the high level of growth to the south has been confirmed with many developments underway.

Whilst a separate business case is being prepared to consider the electrification of the line, introduction of new stations and an enhanced frequency, there is an opportunity for an interim upgrade with the new independently powered rolling stock becoming available, and, perhaps serving new stations in the growth areas. This opportunity could support other initiatives, e.g. through use of the HIF, to bring forward development between Papakura and Pukekohe with additional stations.

To the west of Auckland, the tunnel between Swanson and Waitakere limits AT's ability to provide standard electrified rail services.

AT recognises additional rolling stock will be required over time to support the continuing role of the metro rail network. The scale of the rolling stock required in later decades (some 50-60 units by 2046) and the associated infrastructure will mean that a comprehensive business case and new procurement approach will be necessary when that procurement is considered. The current business case focuses on the period 2019 – 2023, before the CRL comes into operation, and aims to maximise available capacity with existing infrastructure.

1.4 Work Completed to Date

AT has determined that there is a major risk to its customers if it is unable to accommodate the growth in patronage that is occurring now. It has therefore been working on options that will allow additional capacity to be provided in the period 2019 to 2023, when CRL will open. It will be able to review needs beyond CRL in 2019 and subsequently to reflect the scale of patronage growth that occurs in the interim period. AT is also considering the needs of the southern line through to Pukekohe as noted above.

AT in cooperation with Transdev, Auckland (TDAK), has previously conducted reviews for reducing run times and dwell times for passenger services operated by the current EMU fleet. Quicker turn backs and reducing run times in some areas has assisted in releasing three EMU units over the past seven months which have been redeployed to create more six-car trains.

The reviews further determined that through adopting minor procedural changes to the train dispatch process, dwell times can be reduced by between seven and 12 seconds dependent on the station and the time of the day (av. 10 seconds), for example peak vs off-peak. Modelling has indicated that this saving may reduce overall journey times on the southern and western lines by approximately two minutes which is, however, insufficient to release any additional units to address passenger capacity requirements.

Further technical and procedural changes are planned over the next two years that may reduce the dwell times by a further 8 to 10 seconds if successfully implemented. Modelling indicates that if both initiatives are successfully implemented, dwell time reduction may release one unit. These initiatives will deliver customer outcomes but not supply any appreciable number of extra units in the immediate future.

AT will also look at other ways of increasing capacity further such as a possible move from transverse to longitudinal seats, although this may affect acceptable standing times given that the Metro rail service caters for longer-distance routes than are typically served with such seating configurations.

The AT project team, working with TDAK has established that the scale of increase in the total fleet needed for the interim period (2019 – 2023) will not trigger the requirement for ancillary changes such as additional stabling or maintenance facilities. An additional tranche of EMU rolling stock in 2019 may therefore be considered as an increment to the present fleet and way of operating rather than a major change, which may be required post-CRL opening in 2023.

AT project team has carried out initial discussions with the current supplier, Construcciones Auxiliar de Ferrocarriles (CAF) as to their ability to provide either further units of the same specification at the original cost (as indexed), or an alternative independently powered equivalent based on the original units, ready for the possibility that AT would seek to procure further units. The initial indication from CAF is that it would honour the original pricing for EMUs and has access to an effective battery powered alternative

The possibility of a single source supplementary tender has been tested with the AT Board's Customer Focus Committee (CFC) which stressed the importance of management being confident that the product would remain as originally specified and that any cost changes would reflect minor scope changes and underlying CPI inflation only. The CFC further emphasised the importance of the procurement taking account of the ongoing maintenance contract with CAF, the inventory of spares which may otherwise be duplicated and interoperability of rolling stock.

The CFC was particularly concerned that AT should take a proactive position in ensuring that sufficient capacity was available to permit the anticipated patronage growth and should not limit that growth occurring given its importance for the Auckland economy.

The AT Board members reminded the team the recent high patronage growth should be seen as a success and it was important to build on that success with what might be a relatively moderate but vitally important further investment in the shorter term.

1.5 Project Governance and Organisation Structure

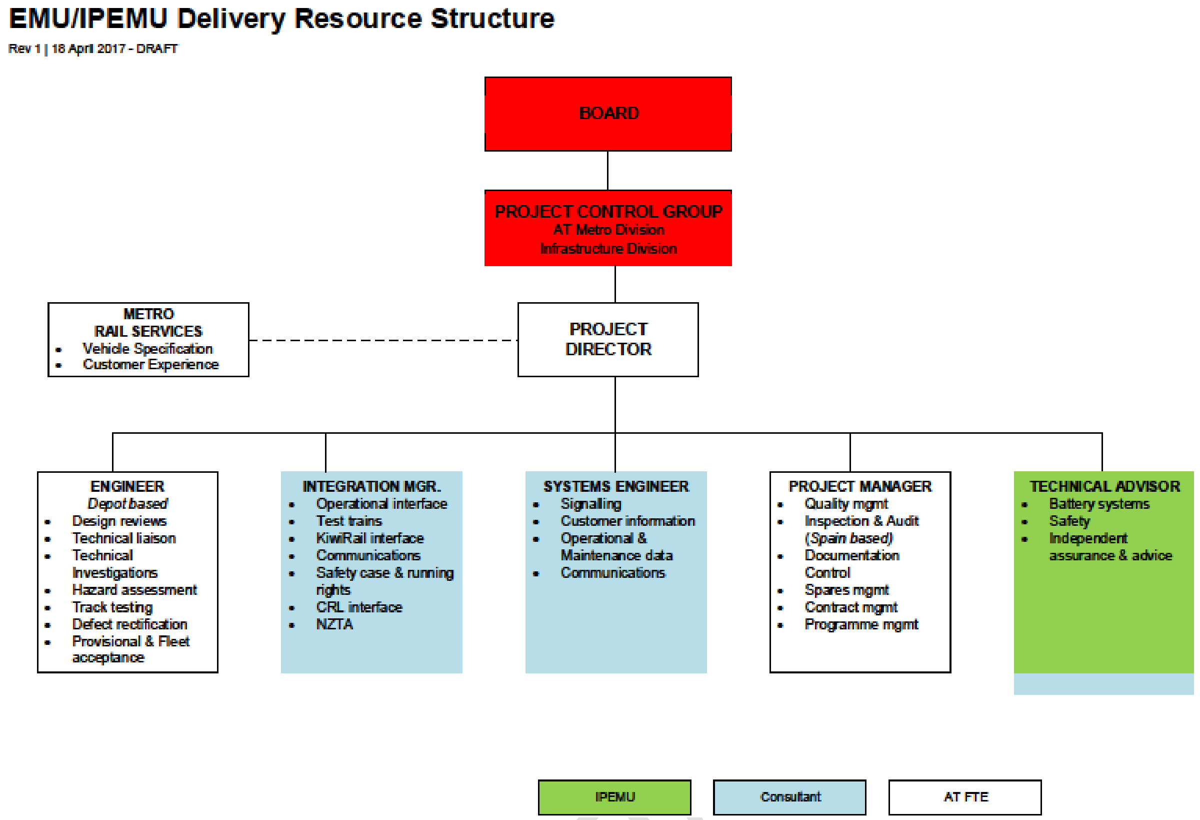
The Project is being advanced by a project team within AT with suitable specialist staff led by the AT Manager, Train Services, and including the EMU Project Director and EMU Integration Manager, who have been responsible for the successful introduction of the current fleet of 57 units.

The project team reports through a Project Control Group chaired by the Group Manager, AT Metro Operations and with representation from the AT Strategy Division, to the Chief AT Metro Officer and the Chief Executive.

Ultimate responsibility in the AT structure lies with the Board to whom regular reports are made.

NZ Transport Agency staff are assisting in progressing the business case.

Once the project is approved the structure below will be used to deliver the vehicles into service.


EMU/IPEMU Delivery Resource Structure
Rev 1 | 18 April 2017 - DRAFT
BOARD
PROJECT CONTROL GROUP
AT Metro Division
Infrastructure Division
METRO RAIL SERVICES
• Vehicle Specification
• Customer Experience
PROJECT DIRECTOR
ENGINEER
Depot based
• Design reviews
• Technical liaison
• Technical Investigations
• Hazard assessment
• Track testing
• Defect rectification
• Provisional & Fleet acceptance
INTEGRATION MGR.
• Operational interface
• Test trains
• KiwiRail interface
• Communications
• Safety case & running rights
• CRL interface
• NZTA
SYSTEMS ENGINEER
• Signalling
• Customer information
• Operational & Maintenance data
• Communications
PROJECT MANAGER
• Quality mgmt
• Inspection & Audit (Spain based)
• Documentation Control
• Spares mgmt
• Contract mgmt
• Programme mgmt
TECHNICAL ADVISOR
• Battery systems
• Safety
• Independent assurance & advice
IPEMU
Consultant
AT FTE

2 PROBLEMS, OPPORTUNITIES AND CONSTRAINTS

2.1 Problems and Benefits

The Transport Agency and AT representatives agreed the following problems and benefits for the business case:

Problem 1: High growth in demand is leading to significant congestion[12] and long and variable travel times that are constraining access to economic growth centres. (60%)

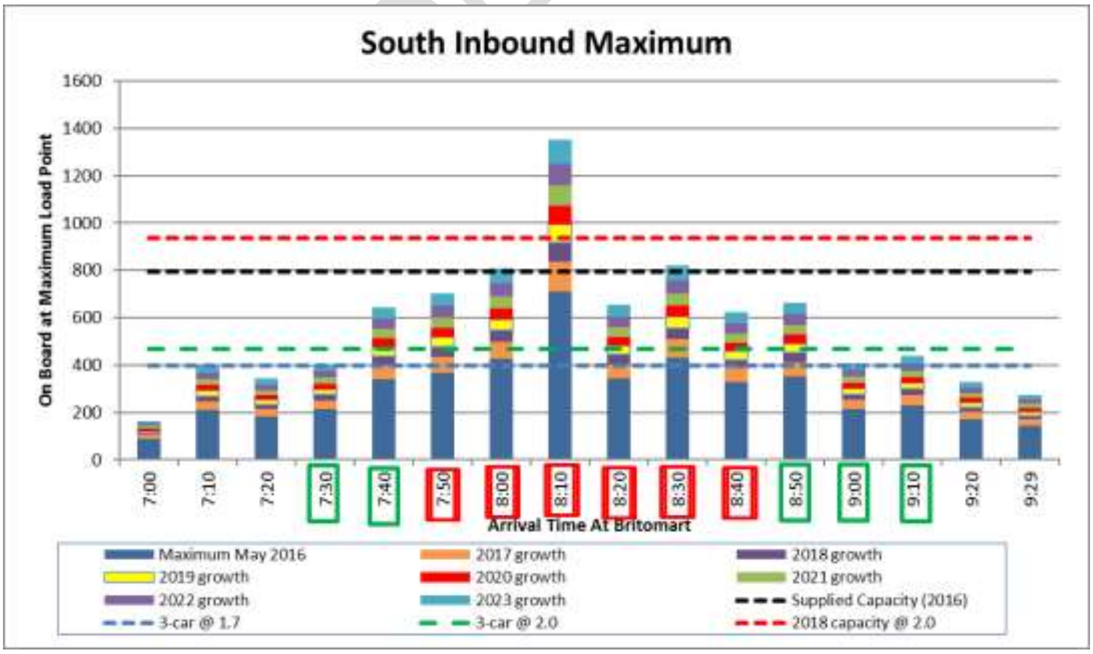
Problem 2: The public transport network is very constrained with public transport services having little ability to accommodate the strong patronage growth leading to increasing overcrowding and the expectation of passengers being unable to board. (20%)

Problem 3: Auckland's population growth on the outskirts of the current built-up area is leading to long, unreliable and unattractive journeys. (20%)

Problem 1 directly relates to ATAP's first two objectives:

i. To support economic growth and increased productivity by ensuring access to employment/ labour improves relative to current levels as Auckland's population grows
ii. To improve congestion results, relative to predicted levels, in particular, travel time and reliability in the peak period and to ensure congestion does not become widespread during working hours

Problem 2 is evidenced by the load factors now being experienced and anticipated. The graph below illustrates the issue, with further examples included in Appendix B. It can be seen that some 3-car services are already (2017) exceeding the 1.7 standard (ie seven standing passengers for ten seated) with more expected to do so by 2023 (green boxes).



12 Congestion includes crowding on public transport services

Problem 3 has been identified in the Supporting Growth[13] studies which pointed to increasing congestion affecting access to jobs from the west and parts of the south (and a need to increase public transport mode share)

Benefit 1: Economic growth in Auckland will not be constrained by poor access to employment centres. (40%)

Benefit 2: Congestion and travel time variability will be reduced. (40%)

Benefit 3: Future development areas in the south[14] can be served with effective transport options providing access to critical employment areas. (20%)

These Problem and Benefit statements were used to generate a set of Investment Objectives and Key Performance Indicators – KPIs – that were used for the evaluation of the short-listed options (see sections 2.9.1 and 4.1).

2.2 Programme context

Since the original fleet was ordered in 2010 Auckland has undergone multiple changes that have affected demand on the transport network, and especially on the rail network:

- A continuing in-migration to New Zealand and especially Auckland at record levels[15].
- Auckland Plan – additional 400,000 houses earmarked by 2042, 30-40% in Greenfield areas.
- Unitary plan re-zoning has designated an additional 50,000 dwellings for the isthmus relative to the Auckland Plan.
- ATAP has identified that early transport rail investment is required to support Special Housing Areas (SHAs), address current deficiencies and enable a faster rate of development in North West and South.
- Major greenfield development areas have been confirmed in North, North West and South, with latter two close to rail connections. Some brownfield development options are also close to rail corridors.

As noted above (S. 1.1) electrification and the introduction of the EMUs has been more successful than forecast in stimulating patronage growth which shows no sign of abating.

Looking ahead, the opening of the CRL in 2023 – much earlier than had been initially expected - and strong growth in Greenfield areas close to rail corridors are expected to induce significant demand.

2.3 Auckland's Population and Employment Growth

Auckland is expected to experience significant growth in population, employment, and economic activity in upcoming decades. This will in turn pose new opportunities and challenges for the city's transport system.

2.3.1 Expected Population and Employment Growth

According to Statistics New Zealand's most recent medium population projections (released November 2014), Auckland's population is expected to grow 50% over the 2013-2043 period, adding a total of

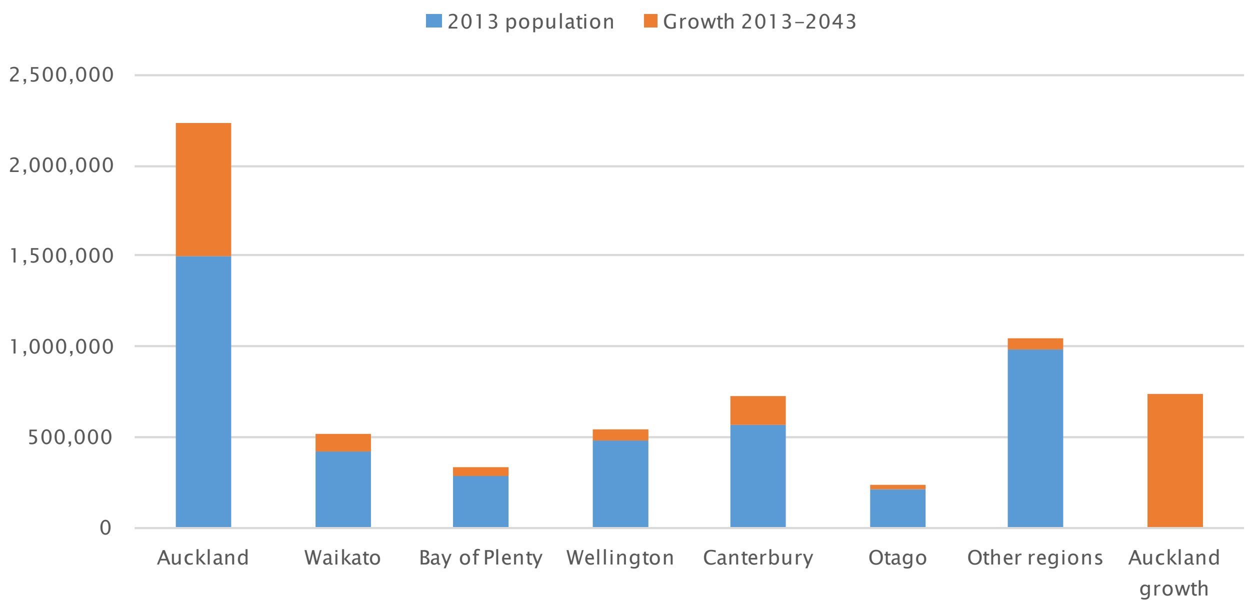
13 Supporting Growth – Delivering transport networks, AT, Auckland Council, NZTA, NZ Government, May 2017

14 Areas in the west may also benefit in the longer-term

15 Migrant arrivals at new record of 129,500 a year – Media Release, States NZ, 26 April, 2017

736,000 new residents. This represents a continuation of the rapid growth in recent decades. As shown in Figure 1, the city is expected to account for the majority (60%) of New Zealand's overall population growth. This highlights the nationally significant nature of Auckland's growth, as well as the fact that Auckland's economic performance will be increasingly important to the performance of the national economy.

Figure 1: Regional medium population growth projections, 2013-2043 (Statistics NZ, 2014)



Statistics New Zealand's population growth projections expect Auckland to grow steadily over this period. Between 2018 and 2028 they expect Auckland to grow from around 1.65 million people to around 1.89 million people, which would mean adding around 244,000 new residents, which will increase pressures on transport networks.[16]

Population growth is expected to be accompanied by employment and economic growth. Based on the Auckland Forecasting Centre (AFC) ART model projections, the number of jobs in Auckland is projected to increase from just under 600,000 to more than 850,000 over the next 30 years.

Auckland's future growth is expected to be distributed throughout the city, with growth occurring both 'upwards' and 'outwards'. Projected changes in population and employment in Auckland over the 2013-2046 period, based on the Auckland Plan Land Use Scenario 19 indicate that there will be significant increases in residential population densities on the Auckland isthmus, around metropolitan centres, and in greenfield growth areas such as Northwest Auckland, Silverdale, and Drury. However, most areas of the city are expected to experience some degree of population growth. South of the Council boundaries, areas in North Waikato are also developing quickly, especially with more affordable housing.

Growth in employment is expected to be concentrated in and around key business areas, such as the city centre and fringe area (which is expected to grow from 21% of citywide employment in 2013 to 26% in 2046), the business park around Auckland Airport, and new and existing Metropolitan Centres such as Takapuna, Westgate, Henderson, and Albany.

16 Trends in net migration – ie the difference between the number of people entering the country and the number of people leaving – over this period may result in a higher or lower figure. Net migration has traditionally been highly variable in response to the relative performance of the New Zealand economy. It is currently at a record-high level.

2.3.2 Drivers of Auckland's Economy

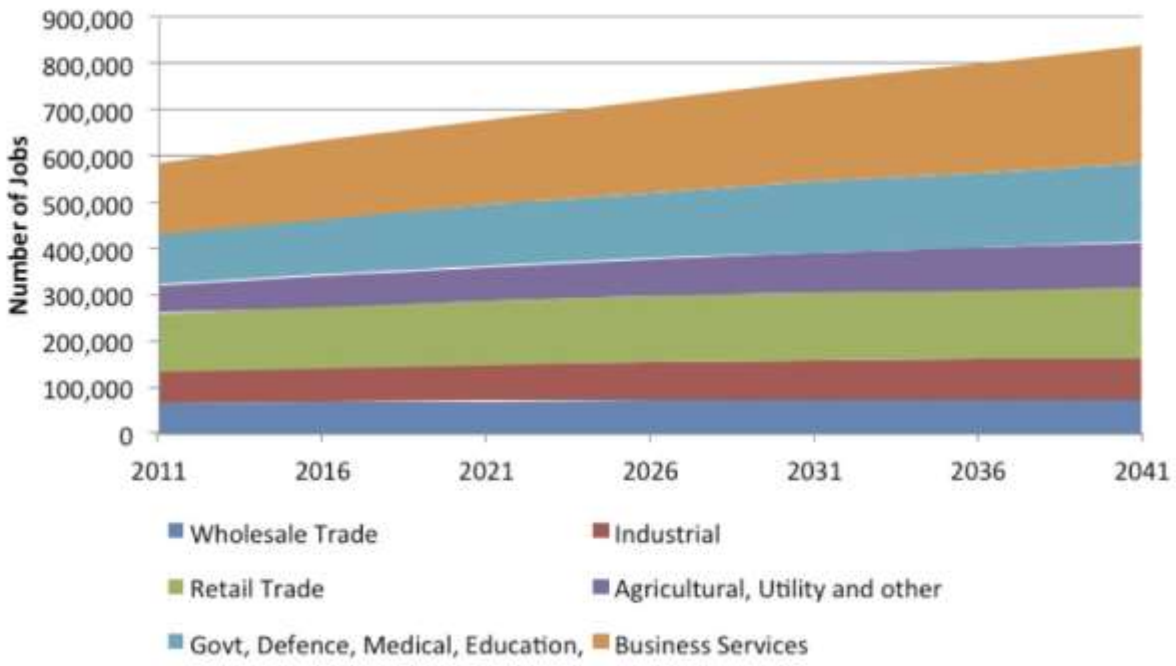
Auckland's economy is also expected to evolve over this period, with changing composition of employment and economic output and strengthening urban agglomeration.

Auckland is already New Zealand's dominant commercial centre. It accounts for 34% of overall employment in New Zealand and a significantly higher share of employment in high-productivity service sectors and transport and logistics, including 53% of employment in information media / telecommunications, 51% of employment in finance and insurance services, 45% in professional and scientific services, and 41% in administrative and support services.

Auckland's economic specialisations reflect the advantages that the city derives from its international connections, including the presence of the country's main international airport (Auckland Airport) one of its major ports (the Ports of Auckland), as well as urban agglomeration. Agglomeration contributes to Auckland's relatively high level of economic productivity compared to other New Zealand cities. After controlling for the fact that Auckland firms tend to specialise in higher-productivity sectors such as business services and the fact that Auckland tends to attract higher-skilled workers, Maré[17] finds that firms in other urban areas are on average 13.5% less productive than firms in Auckland.

The structure of Auckland's economy is expected to evolve further towards service sectors. As shown in Figure 2, employment is expected to grow significantly, especially in business services and health and educational services, while remaining relatively flat in industrial sectors (including transport and logistics). This will in turn influence the spatial distribution of growth and transport requirements to meet it. Forecast further increases in business service employment is likely to be reflected in higher employment levels in Auckland's city centre, which will place additional pressure on city centre access - especially the rail system.

Figure 2: The projected future composition of Auckland's economy (Auckland Council Business Futures Model, 2012)



[17] Labour Productivity in Auckland Firms, Mare 2008, Motu Economic and Public Policy Research Trust. See also Auckland and Productivity Dave Maré, Motu Research 'Auckland productivity' workshop Auckland Policy Office 4 March 2016

2.4 Policy Framework for Enabling Growth

The Auckland Unitary Plan (AUP) establishes the regulatory framework for land use and development, including the location and density of future housing and employment growth. It therefore influences where, when, and how population and employment growth will occur in existing urban areas and Future Urban Zone (FUZ) areas.

The AUP is expected to enable the land use forecasts incorporated into the AFC modelling of future transport demands (land use scenario I9). However, the timing and sequencing of development is less certain, as the Unitary Plan opens up more opportunities for development. This reflects three key elements of the AUP:

- First, the FUZ has been extended to provide for additional development on the urban fringe
- Second, although the Rural-Urban Boundary (RUB), which identifies the areas that will urbanise over the longer term, has been maintained, the Unitary Plan allows for private plan changes to enable urban development in areas outside the RUB. This 'Soft RUB' will create more uncertainty about the extent of further development outside the existing urban boundaries
- Third, residential zoning rules have been relaxed, enabling denser development both in new subdivisions and additional infill and redevelopment in the existing urbanised area. This has been achieved through changes that permit smaller lot sizes and more dwellings per site in residential zones, as well as 'rezoning' of some suburbs to allow for apartment buildings and terraced housing.
- In the Waikato there are similar plans to allow and support growth in townships such as Pokeno and Tuakau.

2.5 Auckland's Transport System

Auckland's transport system faces multiple challenges around current and expected future performance. These arise from the city's physical geography and existing transport networks.

2.5.1 Description of Existing Transport System

Auckland's transport network currently includes the following elements:

- A region-wide network of motorways, arterial roads, and local roads
- A region wide public transport network that includes a rapid transit system with several rail lines and the Northern Busway, ferries providing service to destinations in the Waitemata Harbour and Hauraki Gulf, and a bus network that provides service to many destinations throughout the city[18]
- A partial network of cycle facilities
- A network of footpaths along most, but not all, roads.

2.5.2 Current and Expected Future Transport Outcomes

At present, Aucklanders rely mainly upon private vehicles to meet their transport demands. 79% of overall trips and 84% of commute trips are in a motor vehicle. However, there has been recent very

[18] Rapid transit stations are often, but not always, located at major employment centres such as New Lynn, Albany, and Manukau, as well as suburban and coastal locations.

significant growth in rail use with the system likely to hit 20m passengers per year in 2017 up from only 10m in 2011[19].

Morning peak travel into the CBD has now been provided in the majority (51%) by active and public transport modes for the first time in recent history.

The ATAP report – see section 1.2 - has set the scene for the future outcomes with an expected much higher reliance on public transport which means that the core Rapid Transit Network (RTN) must be able to function effectively, including having adequate capacity.

2.6 Problems and Opportunities

2.6.1 Patronage Growth and Load Standards

The growth in patronage is significantly higher than forecast placing considerable pressure on capacity (original EMU business case modelling in 2009 projected patronage of 17.8m in 2017 and 20.8m by 2023 with growth of below 3% per year between 2016 and 2023[20]). Patronage for 2016-17 is now expected to reach 19.5m which is a 16.7% increase on 2015-16, 21.9M by mid-2019 and 22.8M by mid-2020. The current fleet size was based on modelling using the 1.7 load factor. With the growth that has occurred and is anticipated in the short-term, load factors of 2.0 or more are now increasingly being experienced and are expected to become the norm even in the pre-CRL period (2019-2023).

The planning standard of 1.7 was used in the design of the EMUs[21]. The 1.7 load factor considerations include:

- It is consistent with Australian practice, and since it represents an average, recognises that some individual trains will be at higher load factors

- The standard accepts standing passengers in close proximity, but not at intolerable levels of crowding.

2.6.2 Possible Responses

Peak capacity can be increased by:

- Accepting a load factor above 1.7 on average (not recommended as this reduces customer experience and caps patronage growth). High load factors also affect dwell times and therefore reliability
- Increasing peak service trains (except Onehunga) from 3-car to 6-car (or possibly 4-car) and/or
- Improving frequency to less than 10-minute headway on each line - only possible through reducing peak train congestion at junctions by altering service patterns (e.g. not operating all lines through to Britomart) or increasing signaling and infrastructure capacity at junctions beyond the current two to three-minute headway where lines converge.

Each of the latter two options will require additional units.

19 http://www.aucklandcouncil.govt.nz/SiteCollectionDocuments/aboutcouncil/committees/transportcommittee/meetings/transportcomminatt220110607.pdf

20 ARTA, op cit

21 Auckland Metro Rail Electrification: Report of the Working Group 4 August 2009

As noted above (S. 1.4), other operational approaches have been assessed, applied as possible and their limitations reached. AT Metro has also considered such different methods of limiting the problem as differential pricing or changing seating configuration. The former creates additional issues for rolling stock availability as the shoulders of the peaks already are not served as well as is desired and could compound the difficulty of achieving Government targets for farebox recovery rates.

The latter would not meet AT's statutory adopted policies for duration of standing and would lock-in lower customer service levels.

2.6.3 Requirements

The journey time reductions in the March 2017 timetable change released two 3-car train sets to increase two of the remaining 3-car peak services to 6-cars, enabling sufficient capacity to be provided through the peak hours until mid-2019.

Between 2019 and 2023, a bare minimum of six 3-car EMUs in traffic will be needed to increase a further six 3-car peak service trains to 6-cars to help accommodate the expected growth rates prior to CRL while all 14 remaining 3-car services will be required to be upgraded to 6-car if there is to be prudent provision against growth that is even only a little higher than the central estimate. An additional 3-car EMU would provide a maintenance spare to maintain 95% availability. The basic requirement is therefore 15 more EMUs.

There is currently no funding identified for additional trains, other than in general terms early in the first decade of ATAP. To meet current requirements and projected patronage growth, additional trains are required to enable the capacity needs of the rail system to be met.

2.7 Issues and Constraints

AT has been planning for several years to extend the electrification to Pukekohe. Planning until now, as shown in ATAP, has been that the electrification would take place in the mid-2020s. Independently Powered EMUs (IPEMUs) provide a potential way to achieve the benefits of electrification earlier, removing the older DMUs and avoiding the need for passengers to change trains at Papakura. The ability to achieve these advantages in the short-term is treated as an objective in this business case, with the alternative of full electrification addressed in a separate business case.

When the CRL opens in 2023, it is expected to lead to a further boost in patronage as travel times are greatly improved and customers have access to new city centre stations. The CRL business case anticipated that additional rolling stock would, nevertheless, not be required immediately, owing to the greater productivity achievable with the shortened journeys, especially from and to the west[22] and the expectation that patronage growth leading up to the start of CRL would be at a level that would leave adequate residual capacity in the existing fleet. With the continuing rapid increase in rail patronage this assumption will be reviewed for fleet orders to be delivered after 2023.

The current business case is, however, focused on the pre-CRL patronage and capacity requirement and allows for post-CRL patronage to be reconsidered in 2019.

It had been expected that there might be some "damping down" of patronage as CRL is constructed – for example with the disruption to the Britomart station. There is so far no evidence of this effect, though

22 City Rail Link Business case, AT, 2015, S.1.3 and S.5.8

it may possibly occur when works are required to "tie-in" the new line at Britomart and Mt Eden. The effect is not seen as likely to be more than a temporary respite.

AT is very aware of the challenging timescale to procure and introduce new rolling stock. The constraint might be seen as limiting the options available, with the existing supplier in a potentially dominant position. AT will not allow this factor to mean that it enters an unfavourable contract, but will look to options available (including delay) if it perceives any evidence of anti-competitive behaviour from the initial supplier (CAF).

2.8 Strategic Outcomes

This section reviews the planning context for the business case, including how the possible procurement of additional EMUs aligns with the statutory transport plans. It demonstrates that the goal of expanding capacity on the metro rail service is fully in accord with strategy at both local and national levels.

2.8.1 RLTP/RPTP

The Auckland Regional Land Transport Plan[23] (RLTP) and Regional Passenger Transport Plan[24] (RPTP) together set the statutory context for the Auckland public transport network and its planning.

The RLTP states that:

"all funding decisions and delivery agencies are aligned toward the need to address:

- Growth: infrastructure is required to support Auckland's increase in new housing, jobs, student numbers and tourists.
- Congestion: long-standing issues with traffic flows will only get worse as Auckland grows. Public transport is one dimension but investment to support freight movement and improve key road corridors is needed.
- Business-as-usual: a large stock of existing infrastructure investments needs to be maintained, and safety and environmental factors kept to the fore."

The RLTP has as one of five strategic themes:

- "Prioritise rapid, high frequency public transport to achieve the Auckland Plan outcome of moving to outstanding public transport."

➢ The procurement of additional EMUs is therefore consistent with the RLTP.

The RPTP has a vision "for an integrated, efficient and effective public transport network that caters for a wider range of trips and is valued by Aucklanders.

23 Auckland Regional Land Transport Plan 2015 - 2025, AT, July 2015
24 Auckland Regional Public Transport Plan 2015, AT, 2015

To achieve this vision, Auckland's public transport system needs to deliver the following outcomes:

- Services that align with future land-use patterns
- Services that meet customer needs
- Increased passenger numbers
- Increased public transport mode share
- Improved value for money

The RPTP includes a specific policy with regard to customer service and loading:

> *"2.9 Enable timely and cost effective service adjustments to meet demand*
>
> *a. Put mechanisms in place within the PTOM contracting environment to allow service provisions to be adjusted efficiently and effectively to match demand, fare revenue and service yield changes and respond to new service opportunities by taking into account the following thresholds for patronage levels that trigger a service review:*

- *Maximum loading thresholds: frequencies and capacity are monitored and adjusted to ensure that average loadings at the peak loading point on any route do not exceed 85 per cent of total capacity (including standing space) in any 15-minute period during the peak period, or 60 per cent of total capacity (including standing space) in any 60-minute period during off-peak periods. (p. 34)"*

➢ The procurement of additional EMUs is therefore effectively a *requirement* of the RPTP to meet both the vision and the relevant policies.

2.8.2 AT Board Priorities

The AT Board has adopted a set of strategic priorities with which the project is also well-aligned.

- *Prioritise rapid, high frequency public transport* - The options recommended for inclusion in a business case for the next batch of electric trains for the Auckland fleet will increase capacity at key times on the existing Auckland rail network through to at least 2023 with the programmed opening of CRL.
- *Continually transform & elevate the customer experience* - Additional electric train fleet will ease overcrowding during the peak periods on the Auckland rail network and provide future additional capacity through to 2023.
- *Build network optimisation and resilience for travel times* - The rail network is a critical component of the Auckland transport system. Additional units will maximise carrying capacity prior to the introduction of additional network infrastructure. Retirement of the DMU fleet and standardisation of the fleet will improve maintenance and reliability.
- *Enable quality urban growth to meet demand* - Increasing the fleet size through an innovative IPEMU solution will permit the short-term provision of electric trains and the enhanced customer experience through to Pukekohe without transfer at Papakura and potential progressive expansion of the coverage of the electric train network beyond Pukekohe and Swanson, for example to Pokeno.

- *Fast-track creative, innovative and efficient transport services* - Potential provision of an IPEMU solution opens opportunities for efficient and effective rail growth to Pukekohe prior to electrification of the line and potentially beyond

2.8.3 Government Policy Statement

The latest (draft) Government Policy Statement on Land Transport[25] (GPS) notes that improved returns from public transport have occurred that have seen more people using and relying on public transport in the main metropolitan areas. These increases have occurred alongside increasing fare box recovery, indicating that the investment is resulting in more efficient outcomes.

The GPS will support this result by:

- continuing to invest in public transport, including modal integration where appropriate
- continuing the momentum set by GPS 2015 to increase the efficiency of public transport investment." (p. 17)

"The Minister expects that the NZ Transport Agency will work closely with Auckland Transport to:

- target improvements to Auckland's key transport challenges, in a way that delivers best value for money, strengthens the core transport networks, and enables and supports growth
- focus strongly on making better use of Auckland's current transport networks to increase throughput on key routes including through better use of transport technology
- maximise opportunities to influence travel demand, including by focusing on better integrating transport infrastructure and services with land use, and actively encouraging increases in vehicle occupancy." (p. 30)

In the *Focus on high urban growth areas* (p. 14) the GPS comments that "well-connected and accessible cities are critical to our economic and social prosperity. As our urban areas expand, and population in these areas increases, roads, public transport and walking/cycling networks play an increasingly vital role in creating more accessible cities.

"GPS 2018 focuses on assisting high growth areas by supporting the Housing Infrastructure Fund and the Auckland Transport Alignment Project.

"To support the Housing Infrastructure Fund, GPS 2018 prioritises lead and other investments in transport infrastructure to help supply serviced land for housing development in high growth urban areas.

"Auckland has the strongest population growth in New Zealand. Between 2012 and 2015, Auckland has grown by approximately 120,000 people, roughly the population of Tauranga City. Auckland's population growth has driven a marked increase in travel demand. In 2015:

- total vehicle travel increased by around 10 percent, with over 100 million additional trips by car
- total public transport boardings increased by around 20 percent, to 83 million trips.

[25] Draft Government Policy Statement on Land Transport February 2017 2018/19 – 2027/28

"Auckland's population is projected to increase by 45 percent to 2.2 million people over the next 30 years, accompanied by over 243,000 jobs being created."

- The procurement of additional EMUs is therefore also consistent with the GPS. It will enable better use of the current rail network and relates to growth and supporting the HIF. IPEMUs would be an example of "better use of transport technology".

2.9 Project Outcomes

2.9.1 Investment Objectives

Section 2.1 sets out the problems and benefits for the business case. They have been used to generate the Investment Objectives (IOs):

Investment Objective 1: Improve access to Auckland's economically critical employment centres.

Investment Objective 2: Reduce congestion and travel time variability.

Investment Objective 3: Provide an effective transport option for developing areas to critical employment centres.

ATAP had similar objectives with supporting measures and "headline" KPIs[26], which were adapted for the business case.

Objective	Measure	Headline KPI
Improve access to Auckland's economically critical employment centres	Access to employment and labour within a reasonable travel time*	Jobs accessible by public transport within a 60-minute trip in AM peak#
Reduce congestion and travel time variability	Impact on general traffic congestion*	Per capita annual delay (compared to maximum throughput)*
		Proportion of total travel time subject to volume to crowding greater than 1.7 during AM peak, PM peak and inter-peak#
Provide an effective transport option for developing areas to critical employment centres.	Access to employment from southern growth area#	Jobs accessible by public transport from southern growth area within a 60-minute trip in AM peak#

* as used in ATAP

adapted from ATAP measure

The Measures and KPIs can provide a basis for assessing the project's effectiveness in the Assessment Profile – see Section 4.11.

26 ATPA Supporting Information, Ministry of Transport et al, 2016

2.10 Stakeholders

2.10.1 Partners

The Transport Agency is effectively acting as a partner for the development of the business case. AT will continue to keep Ministry of Transport (MoT) and others briefed, although the business case is being prepared to meet Transport Agency requirements, for their funding decision, which is independent of MoT and other agencies, such as Treasury. The latter may, however, be consulted depending on financial case decisions.

2.10.2 Customers

Given that AT (and Auckland Council) have carried out extensive consultation in relation to transport projects in recent years and the programme essentially represents a continuation of the current strategy, the business case can rely on AT's information from the RLTP and RPTP (see S. 2.8.1) and Council's Long-term Plan feedback.

The engagement on the draft RLTP in conjunction with the AC Long-term Plan was carried out between 23 January and 16 March 2015. Over 27,000 written submissions were received, over 1,000 Aucklanders attended public meetings to share their views in person and 1,354 submissions were received through social media[27].

The key themes from the submissions and oral presentations were that submitters:

- want and will use better public transport, but it has to be convenient, reliable and quicker
- want to walk and cycle but it has to be safe
- want funding to be reallocated towards public transport, walking and cycling
- want better transport but have mixed views on how to raise the additional investment required.

2.10.3 Professional Engagement Process

The Operator: Transdev Auckland, are the contracted Operator of passenger rail services in Auckland. Transdev will be engaged for the final specification agreed between AT and CAF (see below) for any additional trains purchased by AT. They will also be required to support, through agreement and acceptance, the design, manufacture (quality control), testing and commissioning and potential extension of areas serviced by the new trains.

CAF Maintenance: CAF through the EMU Maintenance Agreement (contracted till 2025), will be required to maintain the additional trains purchased by AT and operated by Transdev. If the final specification of the new trains has technical changes from the current 57 EMUs in service, a review will be undertaken with the operator, CAF and AT to determine the significance of the change and whether modifications to the current fleet is required. If modifications are agreed, this will not be part of the procurement process and funding will be progressed separately to the procurement of new trains.

Rail Maritime and Transport Union: The rail industry union covering rail services in Auckland, the Rail Maritime and Transport Union, were involved in the design acceptance of the initial fleet on 57 EMUs. If the decision is to maintain the current design, there would be a process to advise of additional units but no agreement on design acceptance would be required. Transdev had an agreement following testing and commissioning of the previous fleet that the union representatives had to approve each train

[27] Regional Transport Committee Meeting| 02 July 2015 Agenda item no. 5, Adoption of the 2015 Regional Land Transport Plan

prior to entering revenue service. AT do not agree on this requirement, however, will with the support of the operator ensure there are no delays following provisional acceptance.

The Public Transport Accessibility Group: AT engage the Public Transport Accessibility Group (PTAG) in the specification and final design of new trains. Although there would appear to be minimal amenity and functionality changes, PTAG would be engaged through all stages from design through to delivery in to service. Particular areas of interest are seating, accessibility (doors - level boarding and visual awareness) and communications on the train sets.

KiwiRail: KiwiRail provide access to the network for approved rolling stock that meets the National Rail System Standards (NRSS) which they administer. The AT EMU team undertook extensive works in the initial approval process and the current fleet complies with all safety system requirements. It is assumed that unless there are fundamental technical changes to the train then AT would adopt an advice process on each vehicle following provisional acceptance and get approval for each specific train. If re-signalling is undertaken between Pukekohe and Papakura, validation testing for this section will be undertaken by KiwiRail. KiwiRail and AT will also need to engage Siemens in the testing of each train's on-board ETCS system and ensure that there are no faults or system interface problems. Siemens will issue a Safety Authorisation for each train prior to entering revenue service.

3 ALTERNATIVE AND OPTION ASSESSMENT

This section of the business case covers the options that were considered and assessed in deriving a short-list of options to consider further (Section 4). The long-list evaluation was carried out in-house based on operational and cost considerations in addressing the problems. The results were reported to and confirmed by the AT Board's Customer Focus Committee.

3.1 Assumptions Used in Evaluating Options

Assumed growth in patronage	Patronage is assumed to increase at the following rates based on figures reviewed and endorsed by the AT Board's Customer Focus Committee (as discussed in Section 1.1). 2016/2017 17.5% 2017/2018 10% 2018/2019 8% 2019/2020 8% 2020/2021 8% 2021/2022 8% 2022/2023 8% Growth in 2015/2016 was slightly higher than 20% and the SOI forecast for 2016/2017 is 16.5% which is tracking accurately at present. (However, it would clearly be prudent to undertake contingency planning for these levels to be exceeded given recent history)
Electrified Network limits	Pukekohe electrification is assumed as 2025. No electrification beyond Swanson or Pukekohe.
Fleet impacts (DMU)	DMUs will continue to provide shuttle services between Papakura and Pukekohe until electrification, however, growth and transport demand, particularly on SH1, is forecast to grow as new residential developments occur..
2023 – 2033 Post CRL	This procurement process is Stage 1 in dealing with immediate demand through to 2023. Due to the uncertainty introduced by the recent patronage growth against previously forecast growth, any further orders to sustain the growth with the post-CRL train plan should be reviewed once 2017 to 2019 growth is known. AT will then know how much, if any, capacity will be available after 2023. The review in 2019 should also address any additional stabling, power supply, depot and maintenance facilities that may be required.
Network Capacity Limits	Britomart Station at 24 trains per hour is at capacity in the AM and PM peak prior to CRL opening. Other network junctions present capacity limitations at converging lines due to signaling and headway limits.

3.2 Options excluded at long-list stage

3.2.1 Option: augment rail services with additional bus capacity (Do-Minimum)

The option of providing additional bus capacity for the shorter term was evaluated earlier as a part of Auckland's Transport for Urban Growth (TFUG) analysis. It was ruled out as;

- The number of bus services able to be provided has recently been reviewed as part of the New Network process. The strategy in the New Network is to reduce city centre bus services, where possible, owing to the lack of street and stop capacity, by converting some services to rail feeders.
- Being contrary to agreed policy, as confirmed through ATAP.

The earlier 2011-12 CCFAS[28] study had determined that:

> "Many bus corridors in Auckland were already operating at 80 to 100 buses per hour which resulted in the unstable flow and queuing seen on the inner city streets. Fanshawe, Customs, Wellesley, Albert and Symonds Streets were operating at the 80 to 100 bus level with unstable flow already apparent. Platooning or bunching of buses was common on high frequency routes like Dominion Road and Pakuranga Highway."

While the CRL reduces some of the on-street pressure, CCFAS acknowledged that there would remain corridors such as those from the central isthmus where the high volumes of buses would remain problematic.

Increasing service frequency on such corridors to meet demand would further reduce network performance, and higher forecast demand for services, would also lead to increasing dwell times at stops as a result of more boarding and alighting activity, exacerbating the issue.

3.2.2 Use Surplus KR Electric Locomotives to Operate Surplus SA Train-sets

AT owns a fleet of surplus SA rolling stock that has been parked out-of-service since the introduction of full electric services in July 2015. KiwiRail has announced that the fleet of EF class electric locomotives will be taken out of service in favour of diesel hauling on the NIMT.

An option of using the EF locomotives to haul the SA carriage stock was therefore considered to provide additional peak capacity.

It was concluded that EF hauled SA train sets should not be deployed in Auckland to provide short term peak capacity. The minimum cost to establish seven trainsets would be at least $10M, which would need to be written-off by 2023 at the start of CRL operations, due primarily to lack of fire system compliance to allow the trains to operate in the new tunnels and stations.

The poor reliability that arises from mixing locomotive-hauled services amongst those provided with EMUs would seriously damage customer service and operational performance. The EF reliability will be half that of the EMUs[29] and the consequence of failure much higher with longer delays due to the difficulty in train recovery.

There are very high technical risks in trying to use old freight locomotive technology in a metro environment with high stakeholder expectations. For example, the electrical harmonics produced by

28 CCFAS op cit

29 KiwiRail confidential communication

the locomotive converters may well cause interference with the EMU power supplies. The power quality under regeneration is particularly noisy. This is a high-risk area.

3.3 Long-list assessment

The short-listing addressed multiple long-list options to provide the required immediate capacity with a variety of configurations including 4-car options as well as different combinations of 3-car and 6-car EMU and IPEMU sets. The assessment is included in Appendix A.

The options considered included:

a. Acquire a suitable number of additional units to extend trains from 3-car operation to 6-car operation, as required, to meet demand with the existing pattern of services - Option 1

b. Acquire a suitable number of additional trailer cars, extend some trains from 3-car operation to 4-car operation, or reduce from 6-car operation to 4-car operation, as required, displacing 3-car EMUs to become available to create 6-car trains where necessary – Option 2

c. With the acquisition of a suitable number of 3-car hybrid EMUs, create a 20-minute service between Pukekohe and Britomart forming half of the Papakura – Britomart 10-minute pattern, without the need to electrify to Pukekohe, whilst at the same time meeting predicted demand across the network – Option 3

d. With the acquisition of a suitable number of trailer car battery vehicles creating 4-car hybrid units, create a 20-minute service between Pukekohe and Britomart forming half of the Papakura – Britomart 10-minute pattern, without the need to electrify to Pukekohe, whilst at the same time meeting predicted demand across the network – Option 4

Sub-options of the Pukekohe services that were considered included deciding whether splitting and joining hybrid EMUs and ordinary EMUs at Papakura would be more effective than operating 6-car hybrids end to end.

Analysis showed that in terms of hybrid units to Pukekohe, opting to split and join services at Papakura as opposed to working 6-car hybrid units through the length of the route only reduced the need for additional 3-car units by one, once the displacement of ordinary units to other lines was taken into account, and, because of the additional journey time and operational risk associated with splitting and joining trains, was discounted.

Opting to extend trains to 4-car by the provision of additional trailer vehicles suitable to turn the unit into a hybrid would reduce the number of vehicles required in this early tranche. However, the creation of 4-car units would bring issues to both maintenance and stabling, as well as passenger information challenges regarding train stop positions and mobility access positions on platforms once multiple unit lengths were in operation. The need to meet demand from Pukekohe undermined the desire to have a homogenous new build and would introduce a mix of 4-car and 3-car hybrid units (or 8-car train operation).

HIGH LEVEL ASSESSMENT

	Addresses passenger capacity through till 2023	Delivers alternative for Papakura to Pukekohe through services prior to electrification	Provides options for further service expansion	Meets timeframes for delivery
Option 1: Additional EMUs to support capacity through to 2023	✓✓✓	✗	✗	✓✓✓
Option 2: 4-car EMUs	✓	✗	✗	✓✓
Option 3: 3-car IPEMUs through to Pukekohe	✓✓✓	✓✓	✓✓	✓✓
Option 4: 4-car IPEMUs through to Pukekohe	✓	✓	✓	✓

✓	Meets base criteria
✓✓	Meets criteria and interoperability with the current fleet
✓✓✓	Meets criteria and interoperability with the current fleet and network
✓	Risk of adding another layer of complexity to operational interface issues
✓✓	Achievable but interoperability with current fleet is limited by time and patronage risk
✗	Does not meet criteria

3.4 Conclusions

Whilst significantly cheaper in the short run, extending trains to 4-cars would only be a valid strategy up until 2023, after which many of the trains for which 4-car operation would be suitable have too much demand and need to be extended to 6-car operation.

There is a high risk that if passenger demand growth is even marginally higher than predicted the 4-car option would be found to offer inadequate capacity and that outcome would be too late to be able to rectify the situation and meet demand.

Operating hybrid units between Britomart and Pukekohe, prior to the CRL there is a relatively small saving to be made, in terms of additional units required, by choosing to split and join services at Papakura. This saving would be offset by the increased operational costs of additional train crews and higher performance risks.

Based on the assessment, the concept of extending 3-car trains to 4-car trains (options 2 and 4) as a means of significantly deferring the need for 6-car trains, was discounted owing to the high risk of not meeting demand.

The idea of planning to split and join trains at Papakura was also agreed to be discounted as impractical.

It was agreed to continue to develop the case for additional units to be procured pre-CRL, including possible hybrid trains operating to and from Pukekohe (options 1 and 3).

The implications of the short-listing were clear. Additional 3-car units are required for 2019. The determination of the optimal quantum of units and their power source was the focus of the next step.

3.5 Number of Units to be Procured

The assessment of the quantum of units required has taken account of the number of services that could be expected to exceed the higher 2.0 loading standard – one standing passenger for each seated passenger (noting that the adopted policy is for loading not to exceed 1.7 ie seven standing passengers for every 10 seated).

The graphs in Appendix B show that if a growth rate of 8% is sustained between 2018 and 2023 then six additional 3-car services exceed capacity. If the growth is a sustained 10%, however, a tipping point is reached and all 3-car services need to be upgraded. As noted in the appendix, the problem will be compounded as passengers 'cascade' from the most heavily loaded services in the peak of the peak to those that are not as packed.

Given this vulnerability to only slightly higher growth levels and the guidance given by the AT Board's Customer Focus Committee that AT should ensure sufficient capacity was available to enable patronage growth, the project team determined options for up to 8 additional IPEMUs be allowed for to provide contingency against 10% rate continuing.

Taking the precautionary approach was assessed as being more likely to deliver effectively against the investment objectives.

There remains a risk that despite all peak services becoming 6-car there will still be some services from 2019 onwards that experience very high loadings. Against this possibility, AT should include an Option in its contract to extend the order for further EMUs that could be used for additional services avoiding Britomart. The Option would only be exercised following a further business case.

4 DETERMINING THE RECOMMENDED PROJECT OPTION

4.1 Short-list

From the assessment of the long-list and refinement of the operational requirements, two options have been taken forward for more detailed evaluation. Option A is a specific variant of what was previously referred to as Option 1 which makes all existing services 6-car, whilst Option B also improves the service to growth areas and removes the diesel fleet, previously Option 2:

- Option A – Address growth on the existing network, purchase 15 three-car EMUs so all peak trains (except Onehunga) can operate as 6-car trains – cost $125m. This quantum of EMUs is the maximum that can be realistically used prior to CRL (without using a non-Britomart service pattern) and is designed to provide a buffer against growth continuing at 10% after 2017/18 rather than reducing to 8%.
- Option B - Address growth (as Option A) and also service Pukekohe with IPEMU technology, purchase 17 three-car IPEMUs to also deliver through services and new trains to Pukekohe ahead of electrification – cost $207m. This option would allow AT to discontinue use of the DMUs and may provide the future opportunity to provide passenger rail services to more distant growth areas. The direct cost saving from retiring the DMUs is $50m.

4.2 Scope

The EMU Project Team has undertaken assessments of multiple alternative train configurations which have been short-listed to two options that can meet the 8 – 10% patronage growth per year through to 2023 and come into service delivery by late 2019. Additionally, consideration was given to any potential network enhancements, including extension of the areas serviced by the EMUs.

The project team are currently finalising the Draft Specifications for the possible EMUs that includes communication system upgrades for passenger information and display systems and CCTV, changes to the cab layout and potential passenger amenity changes. The amenity design changes are yet to be finalised but will not have a cost impact and can be finalised after manufacture has commenced.

Work on the specification has been underway for a period of months and the specification is agreed in principle. The specification has considered how to improve systems such as door operations, passenger information (audio and visual), CCTV and train information download, compliance for operating in tunnels (CRL) and train to ground communications. Both the Operator and the train provider have been kept informed of all potential changes to the trains to ensure acceptability and to avoid potential impacts to safety cases and constructability.

Both the preferred options have been assessed as being compatible with the current electrified network (bound by Swanson and Papakura) and can be stabled within the existing facilities.

For the independently powered EMUs, stabling would be undertaken at Pukekohe and further assessment of requirements for charging points and shore power decided in the final assessment of the two remaining options. It is assumed that there is no increase in passenger train numbers in the peak periods.

Note: The inter-peak and weekend services may increase in frequency but will still be less than the peak period timetable.

4.3 Option Evaluation

4.3.1 Environmental

The main impacts to consider from the environmental perspective are the reduction in emissions from cars through providing capacity on the core services – both options – and not having diesel services (and associated $C0_2$ emissions) with Option B.

4.3.2 Operational flexibility and resilience

A major advantage of Option B is that it provides flexibility for extension of the electrified network – without having to formally electrify significant additional lengths of line. The Papakura to Pukekohe line could have these services with present battery technology.

In the future, with battery development continuing, more housing growth areas further out, such as Pokeno and Huapai could be serviced without the high cost of overhead wiring. The former could be served without further addition to the proposed number of units once the suitable batteries are available. Alternatively, the Pokeno area could be served using the IPEMUs from Pukekohe once conventional electrification reaches there - assumed for 2025 - noting that growth will be progressive as the population of Tuakau and Pokeno grows from approximately 6,000 (current) to 20,000 people over the next 30 years.

IPEMUs are unaffected by power outages and have higher resilience than do standard EMUs and are able to operate when power outages occur or when track maintenance is being undertaken requiring an isolation of the overhead line. When needed, IPEMUs have the ability to self-propel to the next station, including on the standard electrified network.

Option B allows AT to have an operating fleet that does not mix older DMUs with modern electric units.

The operational advantages of avoiding this EMU/DMU mix include:

Further operational benefits:

- No cross conversion training for drivers
- Optimisation of driver rosters
- No Train Managers required (DDO)
- No empty running to Westfield depot for maintenance
- No diesel fuel costs (circa $0.72 per litre), logistics related to maintaining a bulk fuel installation and the logistics of a tanker arriving to refuel said installation adjacent to the new Pukekohe bus terminal

4.3.3 Property Impacts

No property is expected to be required.

4.3.4 Option Evaluation Outcome

The two options were assessed at an internal AT workshop. The recommendation of the AT internal team is to support Option B given the enhanced operational flexibility, the opportunity to support growth areas and the likelihood that the monetised differences will reduce as technology advances.

The major factors considered were:

- Introduction of IPEMUs provides significant flexibility for AT to service growth areas as strongly favoured by AT, Council and Government and endorsed by ATAP
- IPEMUs offer a more resilient service than EMUs on a long service such as Papakura to Pukekohe
- With Option B, AT is able to retire its remaining diesel rolling stock, avoiding having a mix of EMUs and DMUs with higher maintenance costs, unnecessary complications for operations (e.g. complex and more expensive driver training and rosters)
- Option B provides a future opportunity to extend services to Pokeno when the electrified network is extended beyond Papakura and support HIF enabled opportunities further north subject to satisfactory safe operation through the Waitakere tunnel (not investigated as part of this proposal)
- Option A is cheaper and does not have any technology risks, while Option B can be implemented as base EMU in the event of development and commissioning risk realisation of battery power
- Both options have a good economic return, with Option B offering greater opportunities for improving that return.

4.4 Risks relating to size of possible procurement

The two options would increase the fleet size to the realistic maximum that can be operated usefully prior to the CRL (unless alternative services are introduced not serving Britomart). If the procurement provides immediate excess capacity (with growth less than allowed for) then it can be expected to be required within a very short period given Auckland's underlying population and employment growth.

Subsequent major EMU procurement tranches are now likely to be required earlier than predicted for previous AT rail planning, and monitoring of the growth over the next two years as well as a re-evaluation of the impact on demand of opening of CRL will be required to identify the scale and timescale of the subsequent tranches and at the same time consider the most appropriate timing of electrification to Pukekohe. Contingency planning should include an Option to extend the order (following appropriate assessment).

Technical evaluation has shown the IPEMUs acquired in this first tranche of additional rolling stock would still be suitable for use post-CRL.

Section 4.11.7 assesses the technical risk related mainly to IPEMUs.

4.5 Economic Analysis

4.5.1 Overview

The method used in this analysis is derived from processes outlined in the New Zealand Transport Agency's Economic Evaluation Manual (EEM).

There are seven benefits estimated in the analysis below. The first three are calculated as dis-benefits avoided relative to the do minimum. The remaining benefits are calculated as a benefit achieved relative *to the do-minimum. The do-minimum is the current rail operations without further capacity added to the fleet.*

1. *Travel time dis-benefit from having to shift the time of travel due to the crowding levels on the train service. This will occur at the peak of the peak, when trains are crowded, but there remains some capacity on the services either side.*
2. *Travel time dis-benefits arising from being forced to switch travel modes: from travel via a faster train to a slower bus or private vehicle. This is used as a proxy to estimate the benefits of having sufficient capacity on the train network with a larger fleet.*
3. *The dis-benefit from being a seated train passenger to being a standing train passenger is estimated, to reflect the customer experience benefits from sufficient capacity of the train network.*
4. *Reduction in vehicle operating costs by providing sufficient capacity for the displaced passengers to travel by rail instead of private vehicle.*
5. *Network decongestion benefits from removing private vehicle trips in the do minimum, as these people are now able to travel by rail.*
6. *The public transport user benefit associated with ride quality from shifting from a bus trip to a rail trip, consistent with the guidance in Section A18.7 of the EEM. No other factors in Section A18.7 were considered to be applicable given the impact of the options over the do minimum.*
7. *The benefit from removing the need to transfer at Papakura station, from a DMU and then onto an EMU as the network is not electrified between Papakura and Pukekohe. Instead, passengers travelling from Pukekohe are able to travel beyond Papakura on a single IPEMU, without the risk of a missed connection. This benefit applies to Option B and is consistent with the guidance in Section A18.5 of the EEM.*

Due to the detailed nature of the rail service operations and the demand profile that is observed in the peak period, simply using the Auckland Forecasting Centre's standard Auckland Public Transport model (APT3) was not considered appropriate. APT3 does not model individual rail services or demand profiles. It is a strategic model and by nature, services and demands are averaged across the modelled period and this does not reflect the observed patronage patterns. For these reasons, any benefits generated through an increase in fleet size would not be adequately picked up and reflected in APT3, at least not for a considerable number of years.

The methodology has therefore been developed from first principles in conjunction with the EEM to identify the economic benefits from increasing Auckland's Metro train fleet. Updated APT3 runs, were subsequently used to confirm the levels of patronage calculated using the methodology outlines below, which is based on annual expected growth and earlier modelling for CRL.

The following steps were completed for the analysis:

1. *Estimate unrestricted demand over time using current demand[30] and projected growth rates[31] by individual rail service for all inbound services arriving at Britomart before circa 9.30am. This is based on the current service pattern, which will alter with the opening of CRL. However, for the purpose of this evaluation, the service pattern is largely unrelated to demand used in the analysis. The increase in demand caused by the service pattern is incorporated through using*

30 AT Metro passenger data (May 2016)

31 Utilising CRL Business Case modelling forecasts from APT. This incorporates both the do minimum (current rail operations) pre-CRL and the impact that CRL opening is expected to have.

the percentage growth forecast post CRL opening (discussed further below) and is not relevant to this analysis.

2. *Identify the point on each line where demand begins to plateau (ie beyond that point, station boardings and alightings are very similar). This point is referred to as the 'high load point'.*

3. *Identify the point on each line where demand begins to reduce (ie alightings start to noticeably outweigh boardings). This point is referred to as 'drop point'.*

4. *Identify the excess demand that cannot be accommodated on the do minimum rail services (with the existing fleet). That is the number of people exceeding the train capacity at two persons per seat. There are two components to this excess demand.*

The first is the number of people above capacity at the high load point, who would be displaced[32]. The second is the net number of people who cannot board the train between the high load and drop points as the train is at capacity over this portion of the service. This net number is taken as the station boardings minus the station alightings (over that section). For example, if two people are wanting to board the train, but only one person alights, then one person can board and one would be displaced. The calculations used the current scheduling for three and six car EMU services in the analysis, so the excess demand is reflective of the actual train capacity of individual services.

5. *Split this excess demand into those who travel by bus or private vehicle, using an assumption of an even split (ie 50% of displaced people to bus, 50% to private vehicle).*

6. *Identify the number of people standing on each service. This is capped at the train capacity less the number of seats, which for a load factor of 2.0 is equal to the number of seats.*

7. *Estimate the duration train passengers are standing.*

8. *Estimate the duration of the travel time differential between travel by train and by bus or private vehicle.*

9. *Calculate the additional bus and private vehicle travel distance to inform vehicle operating cost and decongestion calculations.*

10. *Identify the number of people who would benefit from the removal of the DMU-EMU timed transfer at Papakura station.*

11. *Identify the services either side (one service earlier or later) of the crowded service which have capacity to allow people to shift their time of travel.*

12. *Monetise the duration that the dis-benefits or benefits are experienced as per the following:*

    a. *People shifting from one service to an earlier/later service receive a time-shift penalty to reflect the change from their desired travel time*

    b. *People displaced at the high load point experience the full travel time differential (between the train and bus or private vehicle modes, or the disbenefit of using a train at a non-preferred time)*

    c. *The net people displaced between the high load and drop points experience half the travel time differential (to reflect the average trip length over that section)*

[32] Note that with strong growth, that the high load point may shift to a station earlier in the inbound service (further from the city centre) in later years, and therefore the disbenefit experienced by passengers would increase, making the assessment conservative in this regard.

d. *Private vehicle operating costs based on total additional distance travelled (which is avoided in the options)*

e. *People standing who can now sit experience the benefit through the difference in the values of time for seated and standing passengers.*

f. *People who no longer need to transfer from DMU to EMU at Papakura experience the benefit of removing a transfer (5 minute penalty) and a 3 minute travel time benefit (the current DMU-EMU transfer is timed for 4 minutes up and 3 minutes down).*

13. *These benefits are then annualised and assessed over a standard 40 year period (using a 6% discount rate) to estimate the Net Present Value (NPV) of the benefits.*

There are a number of benefits that have not been incorporated in this evaluation, including:

- Environmental benefits achieved through reductions in emissions from taking the DMUs out of service and reducing the number of private vehicle trips
- Potential safety benefits through enabling more travel by rail
- Improved travel time reliability benefits for public transport customers shifting from bus (in the do minimum) to rail (in the options)
- Improved travel time reliability benefits for people shifting from private vehicle (in the do minimum) to rail (in the options)
- Improved travel time reliability benefits for private vehicles remaining on the network resulting from a drop in private vehicle trips. These benefits are partially incorporated through the estimation of decongestion benefits.

Most of these benefits (particularly environmental and safety benefits), are expected to be very modest, and if further quantification were carried out, the overall benefits of the options would be expected to increase slightly. The reliability benefits from shifting from private vehicle to rail travel would be the only benefit from those above to have a noticeable impact on the overall magnitude of the benefits.

4.5.2 Alternative method

The method outlined in Simplified Procedures 10.1 (SP10.1) in the EEM was used as an alternate way to estimate the benefits associated with increasing Auckland's Metro train fleet. While the method is generally intended for application to small infrastructure or service investment assessments, it provides insight into the magnitude of the potential benefits taking account of the disbenefits to the road network due to the displacement of rail users into private vehicles.

The steps to implement this method were:

1. *Assume a percentage of the displaced passengers identified off the rail network shift to private vehicles*
2. *Estimate the average train trip length (in km) for each service from the crush point to Britomart*
3. *Generate a ratio of the average rail trip length per service relative to the average Auckland rail trip length in the EEM (16.5 km)*
4. *Adjust the monetised value for the benefits per additional passenger boarding in the peak period*[33] *on the rail network using the ratio from point 3 above.*

33 The sum of the road traffic reduction benefits and public transport user benefits was used

5. *Apply the benefit uplift factor and then apply the monetised value to the number of passengers displaced onto private vehicles*

6. *Annualise and then discount the benefits over a 40 year period using the standard 6% discount rate.*

4.5.3 Overall assumptions

A number of assumptions were required to support the analysis. These are outlined in Table 4.1 (transport modelling assumptions),

Table 4.2 (EEM assumptions) and

Table 4.3 (project assumptions). These are informed by appropriate data sources where applicable and are generally considered to be conservative. In particular, the expected growth for rail patronage is expected to be higher than 2%-3% per annum (post-CRL) as forecast by APT3. While the recent trend of large (>10%pa) growth on the rail network is not likely to be sustainable in the long term, APT3 typically errs on the conservative side of growth for highly reliable public transport services (e.g. modelled forecasts for the Northern Busway and the rail network). This means the actual growth could be expected to be somewhere in between the two growth rates. The conservative rate was adopted for this analysis.

The introduction of new service patterns post-CRL will cause a step change in patronage over a short time. The difference in line patronage with and without CRL from the CRL Business Case modelling has been used to account for this growth, split over two years. For example, the APT3 forecasts show a 33% increase in patronage on the Western Line with the CRL open (compared to no CRL) and for the purpose of this analysis, that increase was split over two years to reflect the time over which that change would occur (in reality it may occur faster, but any impact will be insignificant for this purpose).

Table 4.1 Transport modelling assumptions

Assumption	*Value*	*Source*
PT patronage growth: • *2018 - 2023* • *2024/2025 (CRL impact)*	 *8% pa* *16%pa (Western Line)* *13%pa (Southern/Eastern Line)*	 *Auckland Transport* *CRL Business Case modelling* *CRL Business Case modelling*
• *Post CRL*	*2%-3% pa*	*CRL Business Case modelling*
High capacity load factor	*2.0 persons per seat*	*Auckland Transport*
Key points by train line: • *Western Line* • *Southern Line* • *Eastern Line*	*'High load' / 'Drop'* *Avondale / Kingsland* *Homai / Remuera* *Meadowbank / Orakei*	*Auckland Transport*

Assumption	*Value*	*Source*
Transfer penalty (for switching modes)	*5 mins per person*	*Auckland Transport (consistent with APT3)*
Time-shift penalty (disutility)	*10 mins per person*	*PwC assumption, based on approximate service headway (unplanned) and inconvenience (planned)*
Pukekohe/Papakura transfer	*90% of passengers boarding from Pukekohe transfer from DMUs to EMUs at Papakura*	*Auckland Transport (AT HOP data)*
Mode shift of displaced passengers	*50% to bus, 50% to private vehicle*	*PwC assumption*
Private vehicle occupancy	*1.2 people per vehicle*	*Auckland Transport*
Annualisation factor	*375*	*PwC assumption and Auckland Transport HOP data* *The analysis (and therefore benefits) is based on AM period HOP data. There are 250 weekdays per year, so a factor of 250 would be appropriate to capture the benefits from the AM period.* *However, early indications from PM period HOP data show similar capacity constraints will be evident (though not as pressing). As a proxy for the benefits generated in the PM period, the annualisation factor has been increased by 50%.*

Table 4.2 EEM assumptions

Assumption	*Value*	*Source*
Base value of time	*$7.80 / hr*	*EEM (July 2002) for commuting to/from work for vehicle occupants (Table A4.1(b))*
Congestion increment • 100% applied to private vehicle occupants • 50% applied to bus passengers	*$3.15 / hr*	*EEM (July 2002) for commuting to/from work for vehicle occupants (Table A4.1(b))* Application is PwC assumption

Assumption	Value	Source
Value of time – seated bus and train passenger (commuting)	*$4.70 / hr*	*EEM (July 2002)* *Table A4.1(a)*
Value of time – standing bus and train passenger (commuting)	*$6.60 / hr*	*EEM (July 2002)* *Table A4.1(a)*
User benefit – bus to rail ride quality	*Equivalent to 1.2 minutes travel time*	*EEM A18.7, Table A18.3*
Benefit update factor for July 2002 travel time values	*1.45* 1.02	*EEM (to July 2016)* RBNZ (2016 to 2017)
Vehicle operating costs	*Urban – 27.7 cents/km (avg speed 20kph)* Motorway – 22.7 cents/km (avg speed 40kph)	*EEM Table A5.1*
Additional congestion increment for vehicle operating costs	*Urban – 2.9 cents/km (V/C ration = 0.9)* *Motorway – 22.7 cents/km (V/C ratio =1.0)*	*EEM Table A5.16* EEM Table A5.18

Table 4.3 Project assumptions

Assumption	Value	Source
Procurement / purchase	*2017 - 2019*	*Auckland Transport*
Year operational	*2019*	*Estimated lead time for rolling stock purchase*
Pukekohe Electrification	*2026*	*Auckland Transport*

Pukekohe Electrification is assumed to occur in approximately 2026. Therefore the benefit of removing the transfer at Papakura for passengers travelling to/from Pukekohe is only applicable until 2026.

Beyond the values of time identified in the EEM for seated/standing passengers, no further benefits associated with reducing crowding levels on public transport services have been incorporated. While the difference in seated/standing passenger value of time places a 40% penalty on standing, the UK's Passenger Demand Forecasting Handbook (PDFH) identifies much greater impacts of crowding on passengers' generalised journey time. The PDFH notes that the first standing passenger treats the journey as being twice as long as the actual journey, and at the same time, because all the seats are taken, the seated passengers treat the journey as taking 13% longer. Once the train is at 200% loading the seated passengers treat the journey as 80% longer, the standing passengers 275% longer. This could be reflected through adjusting travel times or values of time.

This means that there could be further perceived benefits from reducing crowding levels beyond those captured in the EEM and the analysis carried out could be viewed as being considerably conservative.

4.5.4 Data

Specific APT3 modelling outputs have not been used in the analysis as the model estimates average patronage over the morning peak without a demand profile. This means that it does not represent the peak of the peak period, where capacity is currently an issue. As such, the analysis used AT HOP card data matched to AT train schedules, to provide insight into demand and supply in the morning peak period.

As discussed above, the analysis used the modelled forecasts developed for the CRL Business Case to help inform growth rates and the growth associated with CRL opening. Updated APT3 runs were subsequently used to confirm the levels of patronage used in the analysis were broadly consistent with modelled demands.

For the transfer at Papakura, AT HOP data was used to identify Pukekohe boardings and then transfers at Papakura. Approximately 90% of customers from Pukekohe transfer to a service at Papakura.

4.5.5 Demand

AT HOP card data for train patronage on all lines was used to inform the current demand, which would then be projected over a 40 year evaluation period based on the growth rates outlined above.

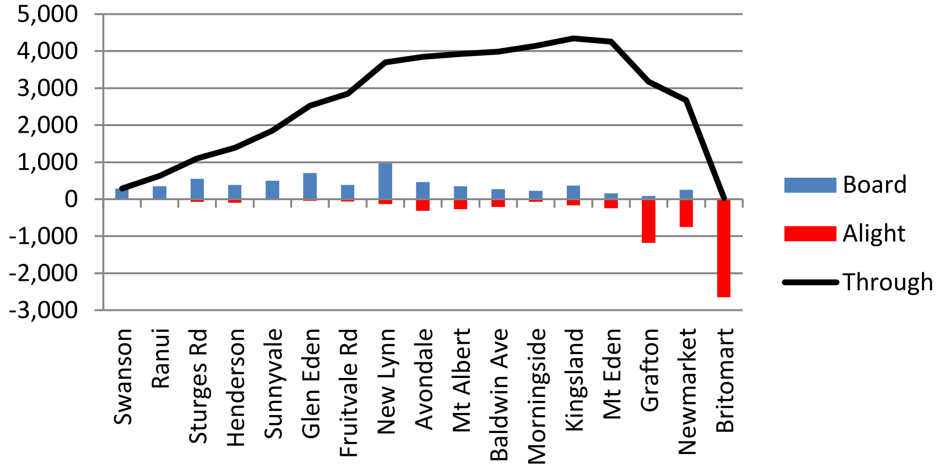
The maximum on-board train capacity on all lines was identified for all arrivals into Britomart between 7am and 9.30am using data from May 2016. The stop at which the on-board demand plateaued was identified and used as the 'high load point' as discussed earlier.

The example shown in Figure 4.1, taken from AT HOP card data for the Western line, shows that demand begins to plateau after New Lynn, but Avondale was selected as the conservative baseline.

The number of passengers who board (or alight) after the high load point is also identified using the AT HOP card data from May 2016 to inform the number of people displaced between the high load and drop points as described earlier.

The total number of displaced persons is taken as those people above the train capacity at the high load point plus the excess passengers (boardings minus alightings) between the high load and drop points.

Figure 4.1 Assessment of the Western line



Source: Auckland Transport

4.5.6 Travel time

Auckland Transport data on travel times by train line for all arrivals into Britomart was used.

The travel time by bus was estimated using General Transit Feed Specification (GTFS) data originating from Auckland Transport (part of the AT HOP dataset), from the departure point to the arrival point, to arrive by 8.30am. The difference between the travel time by train and the travel time by bus was estimated. Any degradation over time for bus travel times have not been incorporated. It is expected that the majority of these routes have a significant proportion of travel in bus lanes, so most of the journey time should be maintained. However, as general congestion worsens there is likely to be some impact on bus travel times, which makes the assessment undertaken conservative in this regard.

Private vehicle travel times were estimated using Google's travel time data for arrival at Britomart circa 8:30am from the three high load points. As expected, the travel time is highly variable and the bus travel times fall within the expected private vehicle travel time range, towards the higher end. As noted above and also identified in ATAP, private vehicle travel times in the peak periods is only expected to worsen over time. For the purposes of this assessment, the analysis has therefore adopted the same travel time for bus and private vehicle, noting that in the future in particular, this will likely be conservative.

Table 4.4 Travel time assumptions

Departure point	*Arrival point*	*Train time (mins)*	*Vehicle time (mins)*	*Bus Time (mins)*	*Differential (mins)*	*Source*
Avondale	*Britomart*	*32*	*30-60*	*55*	*23*	*Auckland Transport and GTFS data for public transport*
Homai	*Britomart*	*43*	*45-90*	*70*	*27*	
Meadowbank	*Britomart*	*10*	*20-45*	*45*	*35*	
Ellerslie	*Britomart*	*20*	*20-40*	*50*	*30*	Google for private vehicle

Source: PwC analysis of Auckland Transport and GTFS data

The above travel time differentials were halved to estimate the average travel time for passengers who board after the high load point. This is considered appropriate as the boarding profile is relatively constant between the high load point and the city centre and will account for shorter journey times from stations that are closer to the city centre.

4.5.7 Options

Two options have been assessed as part of the analysis.

Option A:
Purchase of 15 additional EMUs. In this option, the DMU shuttle service between Papakura and Pukekohe is retained, and passengers are still required to transfer between DMU and EMU services at Papakura. This option has a lower capital cost than Option B and has additional rail operating costs when compared to the do minimum to provide the additional capacity.

Option B:
Purchase of 17 additional IPEMUs. In this option, the DMU shuttle service between Papakura and Pukekohe is replaced by an extension of the Papakura service, enabled by the IPEMUs operating on battery south of Papakura. This option has a higher capital cost than Option A, but generates rail operating cost savings due to the DMU trains being taken out of service.

It is assumed that both options deliver the same overall capacity increase across the network prior to CRL, and therefore with the exception of the benefit from the removal of the DMU – EMU transfer at Papakura, the benefits are the same between the two options before the introduction of CRL. Once CRL opens, there is additional flexibility introduced through being able to increase service frequencies (i.e. small trains more often). This means that once CRL opens (and Pukekohe Electrification is complete) Option B can provide additional capacity compared to Option A. Option A provides a 26% increase in fleet capacity (an additional 15 trains over the current 57 train fleet). Option B provides a 30% increase in fleet capacity (an additional 17 trains over the current 57 train fleet). The analysis has therefore assumed an additional 4% capacity post-CRL in Option B over Option A.

4.5.8 Benefits – travel time savings

One of the key risks of insufficient capacity on the train network is that travellers are displaced to another mode. This could be walking, buses, cycling or private vehicles. This analysis assumes that travellers who are displaced shift to a mixture of bus and private vehicle travel and therefore experience longer travel times than when travelling by train. The additional bus passengers also create the need to provide additional bus services, adding to overall bus operating costs which is discussed later when assessing the net operating costs. The impact of those people assumed to be travelling by private vehicle will also further impact the network travel times through the additional congestion they create. There has been no not attempt to quantify the travel time impacts for other private vehicles on the network as part of this analysis.

Based on the projected growth rates in public transport, outlined in Table 4.5, during peak travel periods, by 2056, the number of displaced travellers (either off the network or to a less preferred time) is estimated to be approximately 6.6m trips annually.

Table 4.5 Number of displaced trips off the train network

Line	*Number of displaced or re-timed trips in 2056*
Western line	*2.3m*
Southern line	*2.5m*
Eastern line	*1.8m*
Total	*6.6m trips*

Source: PwC analysis

The monetised travel time dis-benefits from displacement from a faster mode (train) to a slower mode (bus or private car) and passengers having to time shift are outlined in below.

*Table 4.*6 *below.*

Table 4.6 Benefits – travel time savings

	Undiscounted over 40 years	Present Value (PV) over 40 years
Option A	$1,004m	$250m
Option B	$1,025m	$256m

Source: PwC analysis

4.5.9 Benefits – customer experience

The customer experience benefits include the benefits for passengers shifting from standing to seated travel and for those moving from bus (in the do minimum) to rail (when sufficient capacity is provided). The first benefit is estimated as the differential between the value of time for standing and seated passengers. The second is taken as 1.2 minutes per passenger shifting from bus to rail to reflect the improvement in ride quality they experience. As the customer experience declines, there is increasing risk that even more patrons shift to private vehicles, with further spillover effects for the road transport network, increasing congestion and travel times.

The undiscounted and discounted customer experience benefits over a 40 year evaluation period are shown in Table 4.7. The benefits have been capped appropriately to reflect that the seating and overall capacity increase provided by the additional units is not unlimited.

Table 4.7 Benefits – customer experience

	Undiscounted over 40 years	PV over 40 years
Option A	$166m	$50m
Option B	$167m	$50m

Source: PwC analysis

4.5.10 Benefits – vehicle operating costs

With half the displaced passengers assumed to change to private vehicle travel in the do minimum, there are vehicle operating costs that can be reduced in the options by providing the capacity to enable those trips to occur on rail. As described earlier, the people who are displaced from rail are split into those at high load point and those between the high load and drop points. The distances of those trips are taken to be consistent with the rail trip. A vehicle occupancy rate of 1.2 people per vehicle is also incorporated to reflect the fact that not all journeys would be single occupancy trips.

This allows a total distance travelled by these people to be calculated. The vehicle operating costs outlined in
Table *4.2* are then applied to determine the cost of those journeys which can be avoided in the options with increased rail capacity.

The undiscounted and discounted vehicle operating cost benefits over a 40 year evaluation period are shown in

Table 4.8.

Table 4.8 Benefits – vehicle operating costs

	Undiscounted over 40 years	PV over 40 years
Option A	$180m	$44m
Option B	$185m	$46m

Source: PwC analysis

4.5.11 Benefits – network decongestion

There are network wide decongestion benefits that occur as a result of removing private vehicle trips from the network. This is a relatively complex procedure due to the fact that the transport system is a network and each trip that occurs generally has a small impact on a large number of other trips once congestion reaches a certain level.

To estimate the magnitude of those decongestion benefits at a network level, typically transport modelling outputs from ART3 and APT3 would be used. However, as discussed earlier, the capacity problems evident are too detailed for the regional models to represent effectively, particularly in the short term. An alternative approach has therefore been used to estimate the potential network wide decongestion benefits. APT3 has an inbuilt methodology where the decongestion benefits are calculated on a trip length basis.

NZTA Research Report 489 *"The costs of congestion reappraised",* February 2013, identified the total cost of congestion in Auckland at $250m annually, compared to when the network operates at capacity. This used regional modelling outputs as part of the overall methodology to determine that value including total trips and vehicle km travelled.

Back calculating from the total cost of congestion, using those trip metrics and the broad assumption that each trip or kilometre travelled contributes equally to the total the cost of congestion, the congestion cost rates are summarised as follows:

- $551 (2010 dollars) annual congestion cost per trip in the morning peak period
- $38.50 (2010 dollars) annual congestion cost per vehicle km travelled in the morning peak period

These values are updated to 2017 dollars using a factor of 1.12[34].

From the analysis undertaken as part of the overall methodology, both the number of private vehicle trips made in the morning period and the distance travelled have been calculated and can be used to estimate the decongestion benefits associated with the options to increase the Metro train fleet.

The calculation based on the vehicle km travelled provides a more conservative estimate of the decongestion benefit and has been used in the subsequent calculations. The difference between the two approaches is approximately $5m (PV) over 40 years.

34 RBNZ inflation calculator from Q1 2010 to Q1 2017.

The undiscounted and discounted network decongestion benefits over a 40 year evaluation period are shown in

Table 4.9.

Table 4.9 Benefits – network decongestion

	Undiscounted over 40 years	PV over 40 years
Option A	$76m	$19m
Option B	$78m	$19m

Source: PwC analysis

4.5.12 Benefits – removing transfers at Papakura station

The analysis includes an indicative assessment of the benefits to passengers travelling from Pukekohe, who no longer need to transfer at Papakura station in Option B. There will be travel time benefits as the passengers do not need to wait for their transfer, as well as an inherent benefit as customers do not need to transfer at all.

The assumptions for this benefit are included in Table 4.10 below. The annualisation factor reflects all passengers travelling from Pukekohe to a destination beyond Papakura receive the benefit, not just those travelling in the morning peak.

This benefit only occurs up until 2026, when Pukekohe Electrification is assumed to be completed (included in the do minimum).

Table 4.10 Assumptions for removing transfers at Papakura station in Option B

Assumption	*Value*
Travel time benefit	*8 mins (5 min transfer penalty, 3 min wait time)*
Annualisation factor	*1100*

The benefits from removing the transfer at Papakura over a 40 year evaluation period are shown in Table 4.11 below. This is a modest total as these benefits are attributed to the electrification of the Pukekohe to Papakura segment and are therefore not included from 2026 onwards.

Table 4.11 Benefits of removing the transfer at Papakura station

	Undiscounted over 40 years	PV over 40 years
Option B only	$13m	$9m

Source: PwC analysis

4.5.13 Total benefits

The total benefits of increasing Auckland's Metro train fleet for Option A and Option B, over a 40 year period are shown below in Table 4.12. This estimate is considered to be conservative due to the application of a number of conservative assumptions discussed earlier.

Table 4.12 Total benefits of increasing Auckland's Metro train fleet

	Undiscounted over 40 years	*PV over 40 years*
Total benefits – Option A	*$1,426m*	*$363m*
Total benefits – Option B	*$1,469m*	*$380m*

Source: PwC analysis

The NZ Transport Agency advisers in the Auckland office have indicated that the consideration of wider economic benefits (WEBs) should be included as they would be enabled by the increased rail capacity. Estimating the WEBs at an additional 20% benefit (based on the calculations for the CRL business case) gives the overall BCR results as:

Table 4.13 Total benefits of increasing Auckland's Metro train fleet including an allowance for WEBs

	Undiscounted over 40 years	*PV over 40 years*
Total benefits – Option A	*$1,711m*	*$436m*
Total benefits – Option B	*$1,762m*	*$456m*

Source: PwC analysis

4.6 Costs

4.6.1 Capital expenditure

The analysis used the following costs:

Option A: *15 EMUs – total purchase price of $133.1m.*

Option B: *17 IPEMUs – total purchase price of $207m*

The capital expenditure profile was used to allocate the capital cost over time with the assumption ***that the additional rolling stock is available for service from late-2019.***

Table 4.14 Capital expenditure for the rolling stock

	Option A - undiscounted	*Option B – undiscounted*
Spend in FY2018	*$6.7m*	*$10.4m*
Spend in FY2019	*$20.0m*	*$31.1m*
Spend in FY2020	*$101.2m*	*$157.3m*
Spend in FY2021	*$3.2m*	*$5.0m*
Spend in FY2022	*$2.1m*	*$3.3m*
Total capital expenditure	*$133.1m*	*$207m*

Source: Auckland Transport, PwC analysis

4.6.2 Operational expenditure

It is expected that there will be additional operational expenditure from the expansion in the rolling stock. In Option A, this will be additional expenditure, but in Option B, this will be offset by operational savings arising taking the DMU fleet out of service to create an overall operational expenditure saving until 2025. In both options, the assumption is that additional bus operating costs would be required in the do minimum to facilitate travel for the displaced passengers. This is a considerable cost and has been estimated for inclusion in the analysis. It has been estimated using the number of buses required to move those passengers who are displaced from the rail services between the crush point and the city centre and bus operating costs of $1.70 per km and $60 per hour[35].
The operating costs for the additional rail rolling stock over a 40 year period is shown in Table 4.15 below. The avoided operating costs (i.e. DMU and bus) over a 40 year period are shown in Table 4.14.

Table 4.15 Operational expenditure (undiscounted over 40 years)

Operational expenditure item	*Option A – 15 EMUs*	*Option B – 17 IPEMUs*
Maintenance	*$21.7m*	*$24.6m*
Power	*$8.0m*	*$9.1m*
Driver	*n/a*	*$18.8m*
Track access	*$37.5m*	*$37.5m*
Upgrade	*$45.0m*	*$51.0m*
Battery costs	*n/a*	*-$1.3m*[36]
Total	*$112.2m*	*$139.7m*

Source: Auckland Transport, PwC analysis

35 Provided by AT Finance, in relation to PTOM contract pricing.

36 Assumes Pukekohe Electrification removes the need to replace the IPEMU batteries and the battery packs have a resale value of $75,000 each.

Table 4.16 Operational expenditure avoided (DMU and bus) (undiscounted over 40 years)

Operational expenditure item	Option A – 15 EMUs	Option B – 17 IPEMUs
DMU	n/a	$67m
Bus	$77m	$84m
Total	$77m	$151m

Source: Auckland Transport, PwC analysis

The net operating costs for the two options are shown in Table *4.17* below.

Table 4.17 Net operational expenditure (undiscounted over 40 years) (-ve is a saving)

	Option A – 15 EMUs	Option B – 17 IPEMUs
Net operating expenditure	$35m	-$11m

Source: Auckland Transport, PwC analysis

4.6.3 Total costs

The total costs (capital and operating) of the two options are outlined in Table 4.18 and Table 4.19 below.

Table 4.18 Total costs – Option A

	Undiscounted over 40 years	PV over 40 years
Capital expenditure	$133m	$120m
Operational expenditure	$35	$18m
Total expenditure	$168m	$138m

Source: Auckland Transport, PwC analysis

Table 4.19 Total costs – Option B

	Undiscounted over 40 years	PV over 40 years
Capital expenditure	$207m	$186m
Operational expenditure (-ve represents a saving)	-$11m	-$21m
Total expenditure	$196m	$165m

Source: Auckland Transport, PwC analysis

4.7 Initial BCR

The initial benefit-cost ratio (BCR) based on the Do-Minimum (bus alternative) approach is given in Table 4.20.

Table 4.20 Overall results

	Discounted PV over 40 years Option A	*Discounted PV over 40 years Option B*
Total benefits (incl. WEBs)	*$436m*	*$456m*
Total costs	*$138m*	*$165m*
BCR	*3.2*	*2.8*

Source: PwC analysis

4.8 Alternative method

The method outlined in Section 4.5.2 estimates the disbenefit to users who are displaced from the rail network allowing for some to drive. It uses the number of displaced passengers as in the travel time disbenefits estimated above, factored down by 50% assuming only 50% are displaced onto private vehicles. The following additional assumptions were used.

Table 4.21 Value of benefit per additional passenger

Assumption	*Value*	*Source*
Road traffic reduction benefits per additional passenger boarding for rail in Auckland (excluded from previous bottom-up approach)	*$17.27/additional passenger added*	*EEM, Table SP10.1 (July 2008)*
Public transport user benefits per additional passenger boarding for rail in Auckland	*$16.75/additional passenger added*	*EEM, Table SP10.1 (July 2008)*
Benefit update factor	*1.17*	*Update factor to adjust July 2008 to July 2016 values*

The base value per additional passenger is estimated as $39.80 per passenger, based on an average journey of 16.50km.

Table 4.22 Average journey distances for displaced travellers

Service	*Estimated rail distance*	*Ratio to apply to the base value*	*Value to apply per displaced passenger*
Avondale – Britomart	*11km*	*11/16.50 = 0.67*	*$26.54*

Service	*Estimated rail distance*	*Ratio to apply to the base value*	*Value to apply per displaced passenger*
Homai – Britomart	*25km*	*25/16.50 = 1.52*	*$60.31*
Meadowbank – Britomart	*7km*	*7/16.50 = 0.42*	*$16.89*

Applying these values per displaced passenger over 40 years and discounting to 2017 values results in a present value of benefits as shown in Table 4.23. The results are very similar for both Option A and B.

Table 4.23 Benefits – alternative method

	Undiscounted over 40 years	*PV over 40 years*
Total benefits	*$2.62b*	*$640m*

Source: PwC analysis

The BCR associated with these benefits calculated using this alternative methodology is **5.5 for Option A** and **4.6 for Option B.**

The analysis suggests that the number of private vehicle trips in the do minimum that could be avoided increases over time to approximately 2.8m annual trips (or a further 7,500 each morning period – the equivalent of more than two full lanes of traffic) by 2056, using an average occupancy rate of 1.2 persons per car. This number is similar for both Option A and Option B in this simplified analysis.

4.9 Sensitivity tests

Multiple sensitivity tests on the base analysis (summarised in Section 4.7) have been developed to assist in informing the outcomes and these are presented below. The benefits shown in each test include the allowance for WEBs, and only the discounted (PV) totals are shown for both the costs and benefits.

Test 1: Lower short-term rail patronage growth (pre-CRL) – delaying the need for additional capacity

Base assumption:	8%
Sensitivity test:	6%

Test 1: Results

	Option A		Option B	
	Base	Sensitivity Test	Base	Sensitivity Test
Total benefits	$436m	$334m	$456m	$351m

Total costs	$138m	$143m	$165m	$170150m
BCR	3.2	2.3	2.8	2.1

If there is lower growth, benefits reduce as there would be less reason to introduce additional capacity so early and the magnitude of future benefits would also be reduced. Effective costs go up as there are less bus operating costs avoided in the two options.

Test 2: Higher short-term rail patronage growth (pre-CRL) – accelerating the need for additional capacity

Base assumption:	8%
Sensitivity test:	10%

Test 2: Results

	Option A		Option B	
	Base	Sensitivity Test	Base	Sensitivity Test
Total benefits	$436m	$540m	$456m	$561m
Total costs	$138m	$133m	$165m	$160m
BCR	3.2	4.0	2.8	3.5

If there is higher growth, benefits increase and there would be a more urgent need to introduce additional capacity earlier. This higher initial growth would also increase the magnitude of future benefits. Effective costs go down as there are more bus operating costs avoided in the options.

Test 3: Lower cost IPEMUs using alternative battery technology

- Lower capital cost - $174m compared with $207m for Option B
- Battery replacement costs of $400,000 per battery pack, replaced every 8 years, instead of $600,000 per battery pack replaced every 10 years.

Test 3: Results

	Option B	
	Base	Sensitivity Test
Total benefits	$456m	$456m
Total costs	$165m	$135m
BCR	2.8	3.4

This test represents a lower cost alternative to Option B that delivers the same level of benefits and expected performance and means a noticeably higher BCR.

Test 4: Higher train load factor to determine the impact of passengers accepting a higher level of crowding in the future.

Base assumption:	2.0
Sensitivity test:	2.5

Test 4: Results

	Option A		Option B	
	Base	Sensitivity Test	Base	Sensitivity Test
Total benefits	$436m	$320m	$456m	$336m
Total costs	$138m	$145m	$165m	$172m
BCR	3.2	2.2	2.8	2.0

By allowing for higher degrees of crowding on board the trains, the effects are very similar to lowering the forecast growth rates – lower benefits and less bus operating costs avoided (increasing the effective cost).

Test 5: Lower annualisation factor to reflect the crowding on the Western Line being in-part attributable to the school peak. The sensitivity annualisation factor is a balanced reduction (i.e. not reduced to the number of school days) to reflect the other lines being less impacted by school student loadings.

Base assumption:	375
Sensitivity test:	330

Test 5: Results

	Option A		Option B	
	Base	Sensitivity Test	Base	Sensitivity Test
Total benefits	$436m	$386m	$456m	$405m
Total costs	$138m	$141m	$165m	$168m
BCR	3.2	2.7	2.8	2.4

The results of this test reduce the benefits, but only have a minor impact on costs. It shows that both options still have a BCR of around 2.5.

Test 6: Higher annualisation factor to reflect the potential upper bound limit of benefits if the PM peak benefits are similar to those in the AM peak.

Base assumption:	375
Sensitivity test:	500

Test 6: Results

	Option A		Option B	
	Base	Sensitivity Test	Base	Sensitivity Test
Total benefits	$436m	$574m	$456m	$596m
Total costs	$138m	$132m	$165m	$158m
BCR	3.2	4.4	2.8	3.8

The results of this test increase the benefits, and reduce the costs further through increased avoided operating expenditure, increasing the BCR of both options.

Test 7: Higher shift to private vehicles for displaced people in the do minimum. This reduces the need to provide additional bus services (reducing operating expenditure), but increases the benefits associated with network congestion and vehicle operating costs.

Base assumption:	50% bus, 50% private vehicle
Sensitivity test:	0% bus, 100% private vehicle

Test 7: Results

	Option A		Option B	
	Base	Sensitivity Test	Base	Sensitivity Test
Total benefits	$436m	$533m	$456m	$555m
Total costs	$138m	$148m	$165m	$175m
BCR	3.2	3.6	2.8	3.2

The results of this test show that the benefits increase by approximately 20% and operating costs also increase (due to lower avoided bus costs in the do minimum). The result is an improvement to the BCR of both options.

Test 8: Higher shift to bus travel for displaced people in the do minimum. This increases the need to provide additional bus services (increasing operating expenditure), but decreases the benefits associated with network congestion and vehicle operating costs.

Base assumption:	50% bus, 50% private vehicle

Sensitivity test:	100% bus, 0% private vehicle

Test 8: Results

	Option A		Option B	
	Base	Sensitivity Test	Base	Sensitivity Test
Total benefits	$436m	$340m	$456m	$356
Total costs	$138m	$125m	$165m	$151m
BCR	3.2	2.7	2.8	2.4

The results of this test show that while the benefits decrease, so do the net operating costs (due to higher bus costs in the do minimum) which means there is small reduction in the BCR, but both options stay around 2.5.

Test 9: Pukekohe Electrification is delayed in the do minimum, creating more operating cost savings (expensive DMUs replaced by cheaper IPEMUs) and a longer period over which the benefit of removing the transfer at Papakura is accrued. This test includes the cyclical cost of battery replacement in the IPEMUs. This is only a sensitivity test for Option B.

Base assumption:	In place in 2025
Sensitivity test:	Pukekohe Electrification in 2035 or 2040

Test 9: Results

	Option B		
	Base	Sensitivity Test (2035)	Sensitivity Test (2040)
Total benefits	$456m	$467m	$472m
Total costs	$165m	$128m	$115m
BCR	2.8	3.6	4.1

Assuming Pukekohe Electrification is not introduced until 2035, there is a modest impact on the benefits as it is really only the incremental benefit of removing the transfer at Papakura that is additional. However, the operating cost savings from taking the DMUs out of service are considerable and that helps to effectively reduce the overall cost, which in turn increases the BCR of Option B under this sensitivity test. The economic assessment is sensitive to the period that the DMUs are required in the do minimum. There would be an optimal timing for Pukekohe Electrification to be considered with IPEMU battery replacement cycles under Option B and potential flexibility in the timing associated with electrification.

In the alternative, if the electrification should occur much before 2025 the IPEMUs could revert to EMUs though the future flexibility would be lost.

Table 4.24 summarises the sensitivity tests undertaken above. The results presented do not consider the possibility of cumulative impacts, for example, higher growth initially, with a greater annualisation factor and delays to Pukekohe Electrification would generate a BCR considerably higher than the upper value shown.

Table 4.24 BCR summary

	Option A	Option B
Base BCR	3.2	2.8
Lower BCR	2.2	2.0
Upper BCR	4.4	4.1

4.10 Conclusions

The calculated starting values under this economic assessment indicate that the two options perform similarly from an economic perspective. Either option is, however, likely to generate considerable economic value. The base analysis is considered to be conservative for the reasons discussed earlier, and further refinements relating to the following factors would increase the BCR for both options:

- Further detailed analysis of afternoon peak benefits
- Degradation of private vehicle travel times (and bus to some extent) over time
- Peak load points moving further out in the future (meaning displaced journeys become longer)

Similarly, if the recent rail patronage growth rates that Auckland has been experiencing continue in the build-up to the opening of CRL, the need for the additional capacity and therefore the associated benefits will increase.

4.11 Option Selection

A multi-criteria analysis was carried out of the two short-listed options. This analysis used the standard Transport Agency approach with a seven point scale to assess the options against the achievement of the objectives (as in S. 2.9) then separately in their "achievability" taking account of cost, economic performance, environmental impact, risk and operational impact.

Table 4.25 Multi-criteria analysis

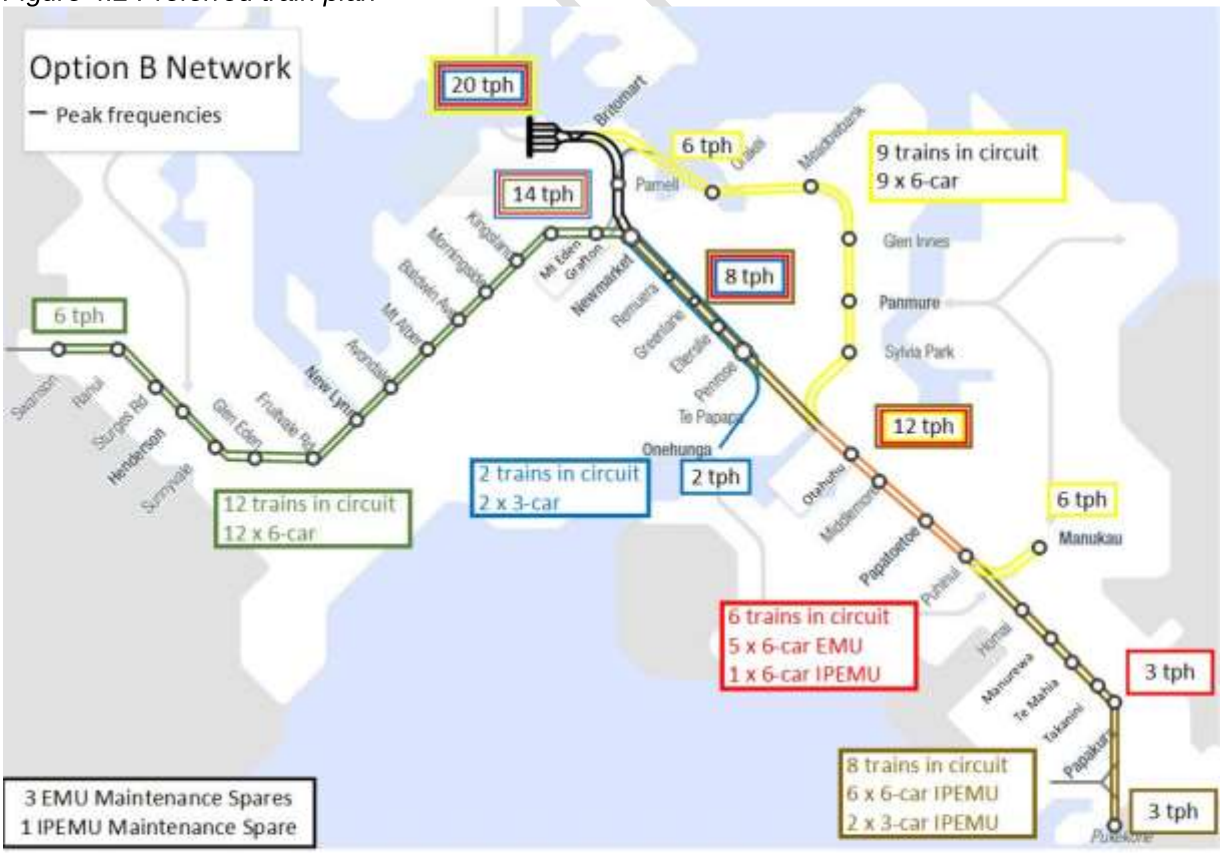
Criterion	**Weighting**	**Option A**	**Option B**
Objectives			
Improve access to Auckland's economically critical employment centres	50%	+2	+3
Reduce congestion and travel time variability	25%	+2	+3

Provide an effective transport option for developing areas to critical employment centres.	25%	0	+2
Objectives overall		**+1.5**	**+2.75**
Achievability			
Cost	30%	-2	-3
Economic Return	20%	+2	+1
Environmental impact	10%	0	+1
Risk	20%	0	-3
Operations	20%	0	+2
Achievability overall		**-0.6**	**-1.0**

Seven point scale: -3 to +3

Option B was assessed as being preferred given that its much superior performance against the objectives outweighed its somewhat poorer performance on the achievability measures.
It was noted that the main difference favouring Option A was for Risk (where Option B has been given the highest negative score of -3, taking a precautionary approach) and that any implementation of Option B should aim to reduce that factor. It is noted that the risk resides around the battery technology and mitigation is provided as the rolling stock can be operated as EMU on the electrified network that requires 15 of the 17 purchased under Option B.

Figure 4.2 Preferred train plan



4.12 Assessment Profile

The project was assessed using the Transport Agency's Assessment Framework. It is based on the accumulated strategic case, options assessment and economic case. An assessment profile of HHM (2.8-3.4) has been determined for the project using the Agency's funding allocation process as detailed below:

Strategic Fit – HIGH

This activity is for a public transport improvement in a major urban area that provides services for access to social and economic opportunities, including those with limited access to a private vehicle where the service provision does not meet current, or forecast, demand on its rapid transit corridors.

As noted in this business case, current loading on the EMUs is already in excess of the projected 1.7 loading capacity, and with continued growth, it is projected that the loading capacity will exceed 2.0.

Auckland is continuing to grow and there has been significant growth in rail patronage since the introduction of EMUs, integrated fares, higher frequencies and also the introduction of the new network services (which continue to be implemented).

The preferred option would also enable better service level to support the growth in the South, particularly in Pukekohe.

The activity is fully in accordance with ATAP.

Effectiveness – HIGH

Outcomes focused (H) – this activity aligns with the levels of service identified within the RPTP for services, the Rail Development programme.

Integrated (H) – this activity is part of a whole of network approach, integrating modes and improving access and mobility without adversely affecting the overall transport network. It is consistent with the network plans identified within the RPTP as part of the new network requirements which sees bus services transferring passengers to rail at key interchanges which will improve travel time reliability as the rail corridor is a rapid transit corridor (particularly for services to the south).

Correctly scoped (H) – the EMU procurement activity is aligned with the RPTP, the Rail Development Programme and ATAP, and the scale is appropriate to deliver on the projected patronage targets within the across the network.

Affordable (M) – there are a number of financial options identified within the financial case to provide funding certainty for this activity, however at this time no final agreement has been reached between the key funding partners.

Timely (H) – the rail network currently exceeds the identified capacity standard of 1.7. Therefore this activity will provide both customer experience and travel time (particularly during peak periods) benefits in the Auckland region. The additional units also provide operational benefits and are required to ensure that overall benefits of the progressive investment in rail services can be maximised in a timely manner.

Confidence (H) – Auckland Transport is confident that future risks and costs associated with this activity have been identified and will be managed appropriately.

Efficiency – MEDIUM

The lower bound range of the BCR for the preferred option (including WEBs) is 2.8 – 3.4 (or up to 4.6 using the alternative methodology), resulting in a MEDIUM assessment.

4.13 Financial Case

The proposal to increase the Metro train fleet is not currently funded in the RLTP as patronage growth to date has exceeded all previous forecasts that were used when the current RLTP was drafted. The fleet increase was included in ATAP early in the first decade, which coincides with this proposal and while ATAP was not a funding document, the fleet increase proposal will be included in the RLTP 2018-28.

4.14 Whole-of-life costs (based on IPEMU option)

4.14.1 Capital investment

Each IPEMU is expected to cost approximately NZ$11.6m. For the preferred option of 17 IPEMUs, this means a total capital investment of $207m (including project management fees).
Table 1.26 sets out the expected timing of this investment,

Table 1.26 Capital costs

2017 $m	*FY2018*	*FY2019*	*FY2020*	*FY2021*	*FY2022*
Capital costs	*10.4*	*31.1*	*157.3*	*5.0*	*3.3*

Source: Auckland Transport, PwC analysis

Note that no assumed costs of foreign exchange hedging related to the asset purchase have been included. Hedging was used for the purchase of the existing rolling stock, but given that a smaller number of units will be purchased this time, it is unclear whether hedging would be cost-beneficial.

4.14.2 Ongoing operating costs

The two tables below set out the expected costs for operating the 17 IPEMUs. Table 1.27 shows the operating costs which will be incurred every year, while Table 1.28 shows the operating costs incurred in regular cycles.

Table 1.27 Operating costs recurring annually

	Amount (2017 $m)	*Timing*
Maintenance	*0.66*	*Annually*
Power	*0.24*	*Annually*
Driver	*0.5*	*Annually*
Track access	*1.0*	*Annually*
Total	*2.4*	*Annually*

Source: Auckland Transport, PwC analysis

Table 1.28 Irregular operating costs

	Amount (2017 $m)	*Timing*
Upgrade	*17.0*	*Every 10 years, spread over 3 years each time ($1m per IPEMU)*
Battery	*10.2*	*Every 10 years (Note: not expected to be incurred due to assumed timing of Pukekohe Electrification)*
Battery resale	*-1.3*	*Every 10 years Resale value of $75,000 per battery pack. (Note: only occurs once due to assumed timing of Pukekohe Electrification)*

Source: Auckland Transport, PwC analysis

As noted earlier, there will be operational cost savings associated with taking the DMUs out of service and avoiding significant bus operating costs that are assumed to be required in the do minimum to provide the required capacity for public transport travel.

4.14.3 Whole-of-life costs

As shown in Table 1.29, the IPEMU option is expected to cost $196m over 40 years, or $165.3m in discounted terms. The whole of life operating costs are the net operating costs, which take into account the savings brought about through retiring the DMUs between Papakura and Pukekohe and the avoided bus operating costs as described in the economic analysis section.

Table 1.29 Whole-of-life costs (2017 $m)

	Capex	*Opex*	*Total*
Total cost over 40 years (undiscounted)	*207*	*-11.0*	*196*
Total cost over 40 years (discounted)	*186.5*	*-21.2*	*165.3*

Source: Auckland Transport, PwC analysis

4.15 Funding options

This section considers the options for funding and financing the proposed capital investment.

4.15.1 Long-list of options

The full long list of financing and funding options cast the net wide to understand the scope of the options for financing the EMU fleet. It considered all potential options for the rolling stock. This included provision by different stakeholders (AT, Auckland Council, the Transport Agency, Transdev, other (private) organisations, a Special Purpose Vehicle), funding and financing options by the various stakeholders, and options for the rolling stock itself (e.g. acquisition or lease).

Options were considered across a number of dimensions.

- Method of procurement:
  - Lease
  - Purchase
  - Purchase with buy-back arrangement
- If purchase, high-level financing approach:
  - Revenue funding
  - Debt funding
- If debt:
  - On which party's balance sheet will the debt sit?
    - Crown, Council
  - Who will make the repayments?
    - Crown/NLTF, Council
  - Where will the debt be sourced from?
    - Standard market sources, train supplier, specific private investors
  - What are the repayment arrangements, or other form of compensation for the lender?

4.15.2 Options to be evaluated

The following list of options for financing the rolling stock expansion was formally assessed as part of this business case.

1. Operating lease from train supplier
2. Up-front investment (i.e. purchase), financed through some form of 'revenue funding'
   a. Crown/NLTF investment
   b. Council investment (using rates funding)
3. Up-front investment (i.e. purchase), financed through debt (standard sources)
   a. Fully Crown debt, with repayments by Crown/NLTF
   b. Fully Council debt, with repayments by Council
   c. Combination of Crown and Council debt, with each party paying the repayments on their portion of debt
   d. Fully Council/AT debt, with repayments by both Crown/NLTF and Council
4. Up-front investment (i.e. purchase), financed through debt (alternative sources)
   a. Finance lease ('lease to own' arrangement with train supplier) (Note that while this is a 'lease', it is likely to be considered as debt for financial reporting purposes.)
   b. Private investment or securitisation (e.g. direct investment by a fund, special bond issuance)

The options in the list are all feasible approaches to financing the rolling stock. While they are not exhaustive of the full range of available combinations of debt and ongoing payments by different parties, they covers the breadth of the feasible options available.

Note that Option 3d is closest to the approach adopted to finance the existing rolling stock. The current debt sits on AT's balance sheet, with repayments being shared by Council and Crown/NLTF. A small Crown grant was also part of the original financing structure.

Specifically excluded from the above list of options are the following:

- Options where the train supplier purchases the rolling stock back at a future date. Given the special nature of the assets, and the reduced opportunity for the supplier to re-sell or re-purpose them, this option is not expected to provide any financial benefit to AT over and above a standard purchase approach.

- A private investment option, in return for non-financial compensation, such as naming rights or other means of advertising. AT already sells advertising spaces on its rolling stock, and has considered the merits of naming rights, as part of its 'business as usual' processes. It is not considered that a material amount of additional funding could be secured through this method, over and above that already obtained by AT (at least, not without a change to AT's policy about the type of advertising allowed). Furthermore, this investment will only relate to a subset of the full rolling stock, which introduces practical limitations. While this is not a feasible funding option for this investment, the merits of naming rights and advertising could be usefully re-investigated in the future.

- Complex private investment options where different types of risk are transferred to the private party, and/or where the private party has some control over the costs and can utilise innovative approaches. These are not considered to be feasible options in this case. Adding to the existing rolling stock is a routine transaction; there is no scope to transfer risk or incentivise innovation; and there is no ability to vary costs by a provider in relation to the fleet acquisition or lease of the rolling stock. However, the more complex options may be more appropriate for large scale procurement (e.g. doubling the fleet over time) if the operation and maintenance could be bundled into the deal (potentially triggering the need for a new depot). Currently, this scale of investment is not considered to be in the scope of the business case.

4.15.3 Assessment of options

Table 1.30 provides a multi-criteria analysis of the above specific options. The evaluation criteria were determined by a working group of AT and NZ Transport Agency staff, and cover both financial and non-financial issues.

Table 1.30 Multi-criteria analysis of funding options

Criteria	Option 1 Operating lease	Option 2a Up-front purchase using Crown revenue	Option 2b Up-front purchase using Council revenue	Option 3a Fully Crown debt with repayments by Crown/NLTF	Option 3b Fully Council debt with repayments by Council	Option 3c Combination of Crown/Council debt with debt repayments by each party	Option 3d Fully Council debt with repayments by Crown/NLTF and Council	Option 4a Finance lease	Option 4b Private debt
	Score	Score	Score	Score	Score	Score	Score	Score	Score
Availability of funding from each source	-2	3	-2	3	-1	1	0	-2	-2
Impact on Council balance sheet	2	3	2	3	-2	1	0	-3	-3
Whole of life cost	-3	1	1	2	0	1	0	-3	-3
Administrative complexity	3	3	3	2	2	0	0	0	-3
Logistics and feasibility under current policy settings	-2	-2	-3	-2	-2	-1	0	-2	-2
Summary	-2	8	1	8	-3	2	0	-10	-13

4.15.4 Discussion

The best way to consider the MCA results shown above is a balancing of minimising whole of life costs and balance sheet impacts with the need to satisfactorily address a number of potential practical issues. There is a natural preferential ordering of options based on cost/debt, and the option ultimately adopted will the best one practically available (or a combination of options considered in this same way).

Ideally, AT would seek a financing option which has the smallest negative impact on its balance sheet and cash flows. Therefore, should a grant be available from the Crown/NLTF, this would be preferred.

If a Crown/NLTF grant is not available (or not for the full investment), for example because of funding limitations or unacceptability to Crown/NZTA, then the next best option for AT is rates-based funding from Council.

If revenue funding is either not acceptable or not available, then an operating lease is the only other option without debt requirements. However, initial investigation has suggested that this is likely to involve the largest whole-of-life cost of all options formally evaluated.

Therefore, if revenue funding is not used, and an operating lease considered too expensive, then debt is required. The source of debt impacts its cost. Crown debt is cheaper than Council debt, which in turn will be cheaper than alternative debt sources. Both Crown and Council also have borrowing limits, after which financing costs will increase.

Crown debt is preferable from a whole-of-life perspective. If that is not available or not acceptable (or not for the full investment), then standard Council debt is the next best options. Private debt through a specific bond issuance, direct investment, or a finance lease with the supplier, would involve a higher cost. A key issue for which debt source is preferred is its availability, given funding constraints and any impacts on taxes/rates requirements.

The approach to financing the existing rolling stock was considered the lowest-cost option which was acceptable to all parties. A small portion of revenue funding was available from the Crown, but the majority of the investment required debt. Debt on Crown balance sheet was not considered acceptable, and so Council has the debt. NZTA was willing to fund a portion of the repayments through the NLTF, with Council funding the rest.

A possibility of future income from naming rights was considered, but not pursued.

4.15.5 Cash flows over time

This sub-section illustrates the potential cash flows for a funding option where the up-front investment is debt funded, the Crown/NLTF fund 51% of the repayments and Council fund the remainder.

Table 4.31 shows the expected annual repayments, for a 40-year loan, under different average interest rates for the debt.

Table 4.31 Annual cash flows

	Annual payments	
Interest rate	*Crown/NLTF*	*Council*
4%	*$5.2m*	*$5.0m*
6%	*$6.7m*	*$6.5m*
8%	*$8.4m*	*$8.0m*

Source: Auckland Transport, PwC analysis

4.16 Project Delivery Costs

4.16.1 Timing Assumptions

From the date “notice to proceed” (NTP) is provided the first vehicle will be available for service within 27 months, with deliveries then at three in each two month period; with all in service 36 months from order placement. NTP is therefore required no later than August 2017.

4.16.2 Design Costs

Design costs are within the purchase price but are due a milestone payment of 15% of the contract value on successful completion.

4.16.3 Construction Costs

Construction costs are within the purchase price but are due milestone payments based on the per unit purchase price for each and every unit of 56% on approval to transport, 20% on provisional acceptance and 2.4% on final acceptance.

4.16.4 Project Management

Project management costs have been set at 5% to cover design approvals, construction audits and inspections, test witnessing, vehicle acceptance and necessary assistance and support required to ensure safety case variations are achieved within the required timeframes.

4.16.5 Statutory Application Costs

There are no specific statutory application costs, but the project will incur in-kind costs to ensure running rights are provided by KiwiRail and that the appropriate safety case variations are achieved by CAF and TDAK.

4.16.6 Other Costs (insurances etc.)

These are $400k per trainset for the vehicle mounted signaling system and 5% of cost for contingency, risk and PM costs.

4.16.7 Risk Assessment

Risks are considered to be relatively low for a project of this type due to the ability to rely on a proven product which affords the opportunity to focus on the as yet unproven battery systems.
Key project risks identified are related to order quantity, the technology risk of the battery systems, and programme delays.

Technology Risk: in either option, the core EMU is fully-proven in service on the electrified Auckland area, therefore risk is low.

IPEMU battery option is a risk and will be mitigated through design and use of, and compliance to, appropriate industry standards. The specific risks considered were:

- Insufficient battery capacity to enable return round trips if dwells are extended at Pukekohe or if multiple stops are required for operational reasons
- The capability to service Papakura to Pukekohe reliably if battery life is less than forecast
- The likelihood and consequence of fire in a tunnel environment.

To mitigate this risk, all aspects will be specified and warranted by manufacturer. AT can revert to standard EMU order.

Voltage stability: The existing fleet is operating on the limits of voltage stability when feed from a single power supply in the so called contingency feed scenario. An alteration to the EMU traction converter control system has demonstrated an improvement in stability such that the fleet can be increased to 66 EMUs operating simultaneously off a single supply. CAF have agreed to work with AT to enable this operating outcome. The actual in-service fleet can be considerably larger as the converters only operate when trains are moving and trains at stations therefore are additional to this number.

Battery Risks: A key to reducing risks is to fully understand the operational requirements for the batteries. Without operating a prototype this is best done via simulation. On this project so far there have been three independent sets of simulations undertaken, each with multiple scenarios. In general, the energy requirements across all simulations have correlated well with the differences relating primarily to the assumptions used regarding energy required to power the auxiliary loads. As a consequence, data captured from existing EMUs in a range of services has been analysed to determine the typical heavy auxiliary load which has then been feed into the simulations. Alternate operating scenarios have been run to compare energy usage for express services against the case with two additional stations requiring intermediate stops, and for different operating line speeds. Alternate assumptions for energy recovery under braking have been made, but with all decisions on battery sizing being taken on assuming no energy recovery.

The CAF proposal would use batteries supplied by French company SAFT with whom they have a working relationship and experience from other similar projects.

The preferred alternate battery supply is from Korean company CS Enertech, which utilises commercially available LG Chem automotive cell technology and is attractive due to low cost, low mass and volume, ease of installation and high energy. While CAF does not have an existing working relationship with this company and the cell type offered is new by the time the actual battery system is delivered to CAF it will have been in the market for at least 18 months. The AT Project Team considers the key risk is in the use of innovative voltage control in-built into each module. This can be mitigated by extensive laboratory and factory testing followed by controlled on-train testing in Auckland potentially using modified existing EMUs prior to full scale release to production.

Saloon and cab temperature conditioning for startup: As IPEMUs will stable overnight at Pukekohe the battery systems will be required to condition the cab and saloons to an acceptable temperature. The batteries for which load the batteries will be correctly sized for the worst case auxiliary load. Battery life could be extended by installing a charge facility at Pukekohe to undertake this task and to recharge between trips. The benefits for doing this can be assessed in the future, but the preliminary assessment is that a facility to charge IPEMUs when stabled at Pukekohe would cost in the order of $2m.

Programme delays will have corresponding delays to delivery of units.

Risk is higher for the IPEMU option but as the contract value is also higher, any mitigations required will be managed out of the 5% project costs.

4.17 Ongoing Maintenance and Operations Costs

4.17.1 Operating Costs

The cost per train kilometre will reduce in either option as the same TDAK operational overhead structure for administration, training, safety and compliance will be utilised across a larger base.

As the IPEMUs (as well as any new EMUs) will be fully interoperable with the current EMU fleet existing procedures and processes can be used, including for driver training, with very modest changes required to cover the operational change to battery mode. Therefore, operational costs will be for the direct cost of operation, basically the cost of drivers.

There is a net operational cost benefit from replacing DMUs with IPEMUs as owing to DDO capability and the more efficient driver roster arising from the ability to utilise drivers from a combined roster.

Energy cost savings will arise as the cost of electricity per passenger km is much lower than that for diesel. IPEMUs would simply replace DMUs south of Papakura, and EMUs further north.

4.17.2 Maintenance Costs

The variable maintenance costs will be $1.50 (plus CPI) per train-set kilometre, with an assumption of at least 90,000 km per year per trainset.
Current overhead fixed cost is $3m per annum or $53k per EMU.
For the IPEMUs, it has been assumed the maintenance cost will increase by 5% on the current standard EMU per km charge due to the extra work involved with inspecting and maintaining the battery systems. This will still provide a significant reduction in maintenance cost compared to the existing DMU, potentially close to $2.5m per annum.

4.17.3 Renewals Costs

The maintenance contract covers renewals of all worn components within the 10-year period. Renewal costs will be the same as for the current fleet with the exception of battery replacements every eight years in the IPEMU option.
If the DMUs remain in-service they will require a full capital rebuild. Due to the age and uniqueness of this rolling stock there are considerable time and cost risks associated with this project. Retiring them in favour of the IPEMU solution removes this issue with a solution with a design life of 35 years.

PART 2 – READINESS AND ASSURANCE

5 COMMERCIAL ANALYSIS

5.1 Project Readiness

5.1.1 Implementability

The EMU Project Team (AT) will agree the final specification with the Operator in the early stages of procurement process. The final design will be reviewed against the applicable rail standards (NRSS) and interface standards, for example, ECP Standards for compliance.

The EMU specification, while being similar to the current fleet, will need to identify any changes that impact on the operations of the train, cab layout and amenity and engage with the RMTU to ensure acceptance for operations (see 2.9.2 above). This will be led by the Operator but the technical leads will be within AT's EMU Project Team. The main changes that will require RMTU delegate acceptance will be the interior cab design which will change significantly from the current design through consolidation of systems such as communication panels and CCTV screens.

The process adopted for the procurement of the initial 57 units engaged all industry stakeholders plus external stakeholders such as the Public Transport Accessibility Group (PTAG) in the final design and this process will remain unchanged.

5.1.2 Operability

The option of purchasing more of the same design EMU from the same manufacturer would provide considerable benefit provided the purchase price is still competitive with the previous marketed tested amount.

The current design has largely delivered to all specification requirements and has been well-received by the users and operators.

The same design ensures 100% compatibility and interoperability with the existing fleet, minimises project risk and costs, including for type approvals and operator acceptance and training. This includes continued use of all the training materials and the two driver simulators.

Any new designs would require exhaustive modelling of the impact on the overhead supply system in all feed and operating conditions to ensure electrical stability is maintained.

5.1.3 Asset Management

In either short-listed option the existing maintenance contract between AT and CAF would be extended to include the additional trainsets, if further procurement from CAF is confirmed. The recommended option(s) could use a variant of the already proven AM class EMU, that was designed, built and tested specifically for operation on the Auckland Electrified Network.

All systems have been fully type tested against specification and then proven in service.

Although the IPEMU would require some minor additions to maintenance processes, tooling and spares, in either case the new vehicles would utilise the same basic vehicle design including mostly identical components, assemblies and systems. This would enable a seamless integration into service and leveraging of the proven depot systems and process and AT purchased rotable and insurance inventory holdings. Apart from the IPEMU battery systems all other components and line replaceable units are already in use and supported by an inventory of spares and a suite of documentation covering maintenance, inspection, and operation. The battery system will be designed for change-out on a modular basis in the event of failure and replacement modules will be held in stock ready for change-out and the failed unit sent back to the manufacturer for repair. These costs are allowed for in the assessment.

Although some renegotiation of the fixed overhead portion of the maintenance cost may be required, because of the vehicle similarity the majority of maintenance cost will be based on distance travelled (again included in the assessment).

AT's asset management plans for the existing fleet would be able to be extended to incorporate the additional train-sets.

Software is fully protected through Escrow agreements and source code held in a vault in Wellington.

As the systems are proven and fully supported by existing inventory and established competencies, training, processes and procedures this procurement option is considered to be a superior solution to any other given the relatively small order size planned.

5.1.4 Statutory Requirements

There are currently three Rail Licence holders for Auckland passenger service operations, KiwiRail (network), Transdev and CAF.

AT believe that the only impact to both KiwiRail's and Transdev's Rail Licence would be in the form of a Safety Case variation for operating proven trains (EMUs) south of Papakura and potentially in the future beyond Swanson. If IPEMUs are to be deployed on the network, it would be more a case of 'advice' to the rail regulator. Frequency of service is not changing at this time so there will be no issues in regard to existing level crossing and road / rail interfaces.

The IPEMUs will increase the electrical load when charging under the overhead but as the rate of charging will be controlled at a low rate to preserve battery life the additional load on the supply network will be negligible.
There will be further requirements for KiwiRail should electrification of the Pukekohe to Papakura section be completed – indicated for mid 2020s but subject to a separate business case.

CAF will need to advise the NZ Transport Agency of any technical operating changes to the supplied trains. The Agency will then advise CAF on any requirements for submitting a Safety Case variation. If the existing design is applied to the new fleet then there should be no requirements beyond advising on each specific train set operating on the network along with CAF testing and commissioning documentation and associated KiwiRail approvals.

5.2 Assurance and Achievability

5.2.1 Output Based Specification

Note: Timeframes stated below are based on 'Notice to Proceed' being given by August 2017.

Option A (EMU):

If the decision is to proceed with the current (standard) EMU option then the proposed timeframes for delivery will be to have delivery commence in August 2019 with the final unit delivered and testing and commissioning completed in February 2020. Provisional acceptance will be completed by April 2020 for the final unit.

Option B (IPEMU):

The proposed timeframes for delivery will be to have delivery commence in June due to CAF expediting the first vehicle to enable increased track test time 2019 with the final unit delivered in March 2020.

Testing and commissioning would be completed between July 2019 and April 2020 prior to provisional acceptance. Provisional acceptance will be completed by June 2020 for the final unit.

The build-up of the identified six trains would commence in October 2019 and be complete by February 2020 with the replacement of the Pukekohe services commencing June 2020 and being completed in December 2020.

For either option the changes that will be agreed for the DDO project will be incorporated into the build specification.

5.3 Procurement - Implementation Strategy

The preferred implementation strategy is to commission CAF directly to supply the units as an effective extension of their initial contract – provided there is no indication of any price premium. The small scale of the intended order makes it virtually certain that no other manufacturer would be able to compete on price, given the need to design and 'tool-up' for a tailored product.[37]

Any new units must be fully compatible not only with the Auckland network's unique physical characteristics – e.g. gauge and platform height – but also with the electrical and communications systems. There is in addition a major inventory of spares valued at some $10m much of which would need to be duplicated if a different rolling stock were procured.

On the scale at which all reliable rolling stock manufacturers operate an order of up to some 30 closely specified units would be considered very small and it is most unlikely that there would be effective competition for the incumbent. Given that CAF would be equally as aware of these circumstances, however, AT must still be prepared to consider a different implementation strategy and 'test the market' if CAF appear to be exploiting their quasi-monopolistic position.

The proposed abbreviated procurement strategy is possible largely owing to the comprehensive approach initially adopted, and as set out below. Provided the new cost is broadly in line with that established through the earlier competitive process there can be confidence that value for money will be forthcoming.

There is also a major cost should an alternative supplier be selected. The AT project team has assessed this cost as follows:

Additional costs will be incurred in:

- Procurement process in legal and commercial advisor costs $5m
- Design development requiring specialist engineering advice and support $2.5m
- Independent Verification and Validation of the design $2.5m
- Specialist Safety advice $0.5m
- Additional consultation with Operational staff on cab and control layout $0.5m
- Additional costs for factory works inspection $5m
- Insurance and rotable spares for through-life support $5m
- Commercial settlement with CAF to ensure full train to train connectivity $10m
- Construction of an alternate maintenance facility $25m
- Test run costs $1m
- Simulator upgrade $1m
- Train to ground communication $1m

Total additional costs: $59m

[37] Even at the time of the initial order there were concerns as to "relatively small order by international standards" – ARTA Procurement Strategy for the Supply and maintenance of Electric Trains and their Operation, May 2008, Auckland Regional Transport Authority

5.3.1 Original procurement

In 2007-09 ARTA and its then partners, Land Transport New Zealand, and the Auckland Regional Council devised and implemented a thorough strategy to procure the EMUs required[38]. To overcome the small order size and the non-standard technical engineering train specifications and complex governance arrangements, ARTA and its partners commenced industry consultation in late 2007 to:

- Initiate the procurement process
- Announce the market details
- Build and maintain market interest prior to the EOI and RFT and to reduce the time in later stages
- Provide the market with information and time to prepare for the EOI and RFT
- Maximise potential participation in the EOI and tender process
- Assess feedback on potential procurement models.

ARTA employed specialists L.E.K Consulting and Firecone as its advisers who met and discussed the proposals with industry participants.

In December 2008, ARTA issued an EOI to supply and maintain new EMUs, which asked potential suppliers to bid for:

- The design and supply of 140 twenty-metre EMUs
- Design and maintain the maintenance facility for those EMUs, (with the construction of the facility undertaken by separate contract which may be let and managed by the supplier or by ARTA)
- Maintain the EMUs for 13 years from the commissioning of the last unit of the first order
- Supply spare parts and technical support for 15 years from the commissioning of the last unit of the first order.

ARTA and KiwiRail subsequently agreed to jointly defer the expiry of the validity of the ARTA EMU EOI to 31 December 2009, following central government revoking of the Regional Fuel Tax that would have funded the purchase. After a review by a joint Government Working Party informed by a technical report from Interfleet[39] […?]

In November 2009, the New Zealand Government approved funding to enable the procurement process to recommence. The Government instructed KiwiRail to be the procuring authority for the new rolling stock. KiwiRail produced an Industry Engagement Document (IED) to:

- announce the commencement of the EMU procurement process and engagement with industry stakeholders and interested parties
- provide an outline of the scope of the procurement project and an indicative process and timetable invite interested parties (including rolling stock manufacturers and rolling stock maintenance providers) to register their interest.

The IED superseded the previous documents, scopes and timetables provided to interested parties by ARTA in relation to the procurement of EMUs for the Auckland rail network. Contract Documentation and Specifications were produced and the RFT was issued in September 2010. Bids were received in January 2011, a shortlist agreed in May 2011 (Hitachi, Hyundai Rotem, Bombardier Transportation and a consortium of CAF and Mitsubishi[40], subsequently reduced to two[41]) and the preferred tenderer – CAF – was identified in August 2011.

AT assumed the management and governance of the EMU Procurement and Depot Construction from KiwiRail, prior to signing of the contract with CAF (4 October 2011)[42].

38 ARTA, ibid
39 A Comparison of Rolling Stock Options for the Auckland Metropolitan Rail Network, Interfleet, October 2009
40 http://www.railwaygazette.com/news/passenger/single-view/view/kiwirail-announces-auckland-electric-train-shortlist.html
41 http://www.voxy.co.nz/politics/joyce-good-progress-auckland-train-procurement-welcomed/5/88372
42 Auckland Electric Trains 7th November 2013, T A Salt. EMU Project Director

5.4 Contract Management

The intention would be to reuse the existing and well-proven EMU Supply Agreement comprising 24 schedules.
The key documents include the specification which will be slightly amended, price and payment schedules, network interface requirements, project management plans, design process, vehicle accreditation, documentation, systems assurance including verification, testing. Inspection and acceptance.

The design process will ensure that the requirements of the specification have been met before manufacture begins.

AT will maintain adequate presence during manufacture in order to expedite decisions as necessary, witness testing, ensure manufacture quality is maintained and to understand firsthand real progress to plan.

5.5 Schedule

Indicative timeline – IPEMU (Red), EMU (Green)

PROCUREMENT		KEY DATES
1.	Agreed fleet requirements	May 2017
2.	Business Case to AT Board	Jun 2017
3.	Funding approved	Aug 2017
4.	Notice to proceed to CAF	Aug 2017
DELIVERY		
1.	Design Review commences	Sept 2017
2.	GATEWAY - Design Review complete	Jul 2018
3.	Manufacture commences Standard EMU	May 2018 Sept 2018
4.	GATEWAY – Approval for Transport – unit 01 Standard EMU	Jun 2019 Jul 2019
5.	Delivery, Testing & Commissioning commences (Auckland) Standard EMU	Jul 2019 Aug 2019
6.	GATEWAY – Provisional acceptance – unit 01 Standard EMU	Oct 2019 Oct 2019
7.	Manufacture, Testing & Commissioning complete (Spain) Standard EMU	Apr 2020 Jan 2020
8.	Delivery, Testing & Commissioning in Auckland complete Standard EMU	Jul 2020 Apr 2020
9.	GATEWAY – Final acceptance – unit 01 Standard EMU	Aug 2020 Aug 2020
10.	GATEWAY – Pukekohe services fully IPEMU	Dec 2020
11.	Full fleet accepted Standard EMU	Jan 2022 Sept 2021

6 MANAGEMENT CASE

To be completed post-decision

6.1 Project Roles

Refer 1.5 Project Governance & Resource Structure. The proposed resource structure has been prepared based on what was required to deliver the previous order of 57 EMUs. It has been modified to include specialist resource for IPEMU.

6.1.1 Lessons Learned and Post Implementation Monitoring

6.2 Lessons Learned

6.3 Post Implementation Monitoring - Approach and Schedule

7 APPENDIX A – SHORT-LISTING

Option 1: 3-car EMUs to sustain increased patronage through till 2023: Minimum seven EMUs

Stabling	Stabling capacity for an additional seven units can be accommodated. Additional stabling for further increase in the EMU fleet may require different solutions such as using Britomart station.
Network compatibility	The overhead traction system operating on both substations will cope with the increase in fleet numbers, but to prevent voltage instability when operating on only one substation a change to the traction control on the EMUs is required.
Network capacity	No additional services. The increase in unit numbers is to increase train capacity (3-car built up to 6-car trains)

Option 2: 4-car trains to ease capacity

Stabling	Stabling would become difficult at all locations due to current configurations and previous assumptions that acknowledged only 3- and 6-car passenger services.
Maintenance	Maintenance at Wiri Depot would become problematic and require units to be split or extensive works undertaken to the Depot layout
Network operations	While 4-car trains can address the immediate challenge to patronage growth, if growth is marginally higher than forecast as above, then units would need to be extended creating 7-car trains and potentially 8-car trains. Seven-car trains may be able to accommodate all passenger doors on platforms (marginally), however, this would come at the expense of performance or Britomart berthing for 7-car trains could only be facilitated on platforms 1 and 5 which would cause significant resilience issues in times of disruption. It would be especially problematic on the Western line with many platforms on the border of level / pedestrian crossings.
Network compatibility	No change is required to the current overhead traction system and performance.

Option 3: IPEMUs to Pukekohe (Minimum 14 IPEMUs)

Service frequency	It is assumed that the current frequency between Papakura and Pukekohe will be maintained with the Pukekohe services extending to Britomart and supporting six tph north of Papakura in the peaks; three tph in the inter-peak and two tph in the off-peaks. The inter-peak and off-peak periods may change in mid-2018 due to the requirements of the RPTP. To achieve a balanced and symmetrical timetable and maintain run times, however, additional infrastructure will be required. If no infrastructure is provided to support an increase at these times, then the trade-off would be longer journey times.
Vehicle requirement	This Option proposes that 14 X 3 car IPEMU units will be required (13 for service and one for maintenance allowance) to support nine trains from Pukekohe and six trains from Papakura to maintain the current frequency and passenger capacity between Pukekohe and Papakura and north of Papakura.

Papakura transfer times (Interchange)	With the IPEMUs extending to Britomart, the transfer time will be removed and the transit time between Pukekohe and Britomart reduces by 5 – 7 minutes.
Draft IPEMU Rolling Stock Allocation Plan	Nine trains from Pukekohe in the peak periods – 4 * 6 car units and 5 * 3-car units.
Stabling	An assessment of stabling shows that a fleet increase of this size can be accommodated through the increased allocation of units to stable at Pukekohe. Seven IPEMUs would be stabled at Pukekohe and seven would be stabled at Wiri. Papakura stabling remains unchanged. Other units ex-Wiri and the Strand would be redeployed to the Strand and Henderson.
Pukekohe facilities to support IPEMUs	It has been assumed that the stabling facility at Pukekohe will not require a charging point for IPEMUs. If that changes, there is sufficient time allowed at Pukekohe for a 10-minute recharge. It is recommended that Shore Power supply be provided at Pukekohe to support service start-up mainly by powering the saloon and cab HVACs to bring the interior temperature to a comfortable setting, and any urgent out of schedule maintenance.
Fleet compatibility	There are no interface issues with the current EMUs and if/when electrification commences between Pukekohe and Papakura, the IPEMUs can operate as normal units on the electrified network – or redeployed.
Network compatibility	The overhead traction system operating on both substations will cope with the increase in fleet numbers, but to prevent voltage instability when operating on only one substation a change to the traction control on the EMUs is required.
Release of EMUs from Papakura to deal with network demand	The option outlined above will release sufficient EMUs from the Papakura Rolling Stock Allocation Plan to address the passenger capacity issues across the remainder of the network as outlined in Option 1.
ETCS	All passenger trains including the IPEMUs will be fitted with the current ETCS. Between Papakura and Pukekohe it will be operated in ETCS level 0 providing maximum speed protection only rather than full supervision level 1. Full supervision would require significant signal upgrades between Papakura and Pukekohe but is not warranted as the number of passenger trains is not increasing significantly.

Option 4: 4 car IPEMUs (Minimum 10 IPEMUs)

Service frequency	It is assumed that the current frequency between Papakura and Pukekohe will be maintained with the Pukekohe services extending to Britomart and supporting six tph north of Papakura in the peaks; three tph in the inter-peak and two tph in the off-peaks. The inter-peak and off-peak periods may change in mid-2018 due to the requirements of the RPTP for either three or four tph off peak
Vehicle requirement	This Option proposes that 10 * 4-Car IPEMU units will be required (nine for service and one for maintenance allowance) to support nine trains from Pukekohe and six trains from Papakura to maintain the current frequency between Pukekohe and Papakura and north of Papakura.
Papakura transfer times (Interchange)	With the removal of the DMUs and IPEMUs extending to Britomart, the transfer time will be removed and the transit time between Pukekohe and BRMT may reduce by 5 – 7 minutes.

	Note: If growth is slightly higher than the agreed forecast growth, coupling of IPEMUs and standard EMUs at Papakura would be required creating 7-car trains.
Network operations	While 4-car trains can address the immediate challenge to patronage growth, if growth is marginally higher than forecast as above, then units would need to be extended to 7-car trains at Papakura. Seven-car trains may be able to accommodate all passenger doors on platforms (marginal), however, this would come at the expense of performance or any dwell time benefits. Britomart berthing for 7-car trains could only be facilitated on platforms 1 and 5 which would cause significant resilience issues in times of disruption. It would be especially problematic on the Western line with many platforms on the border of level / pedestrian crossings.
Papakura transfer times (Interchange)	With the removal of the DMUs and IPEMUs extending to Britomart, the transfer time will be removed and the transit time between Pukekohe and Britomart reducing by 5 – 7 minutes. Note: If growth is slightly higher than the agreed forecast growth, coupling of IPEMUs and standard EMUs at Papakura will be required creating 7-car train and introducing an assumed five minute delay at Papakura to facilitate reliable coupling.
Stabling	An assessment of stabling shows that a fleet increase of this size can be accommodated through the increased allocation of units to stable at Pukekohe. Five IPEMUs would be stabled at Pukekohe and five would be stabled at Wiri. Papakura stabling remains unchanged. Other units ex-Wiri and the Strand would be redeployed to the Strand and Henderson.
Fleet compatibility	There are no interface issues with the current EMUs and when electrification commences between Pukekohe and Papakura, the IPEMUs can operate as normal units on the electrified network or redeployed.
Network compatibility	The overhead traction system operating on both substations will cope with the increase in fleet numbers, but to prevent voltage instability when operating on only one substation a change to the traction control on the EMUs is required.
Draft 4-car IPEMU rolling stock Allocation Plan	Nine trains from Pukekohe in the peak periods – all four cars to Britomart until patronage may require coupling at Papakura.
Additional rolling stock (EMUs)	While this 4-car option requires fewer IPEMUs for the Pukekohe extension, it will release fewer units from the Papakura Rolling Stock Allocation Plan and will require additional purchase of three 3-car EMUs to support coupling to the 4-car Pukekohe services in the peak periods if growth is marginally above the agreed forecast growth and also address other passenger capacity issues as outlined in Option 1.
ETCS	All passenger trains including the IPEMUs will be fitted with the current ETCS on-board the EMU fleet, but between Papakura and Pukekohe it will be operated in ETCS level 0 providing maximum speed protection only rather than full supervision level 1. Full supervision would require significant signal upgrades between Papakura and Pukekohe but is not warranted as the number of passenger trains is not increasing significantly.

Risk

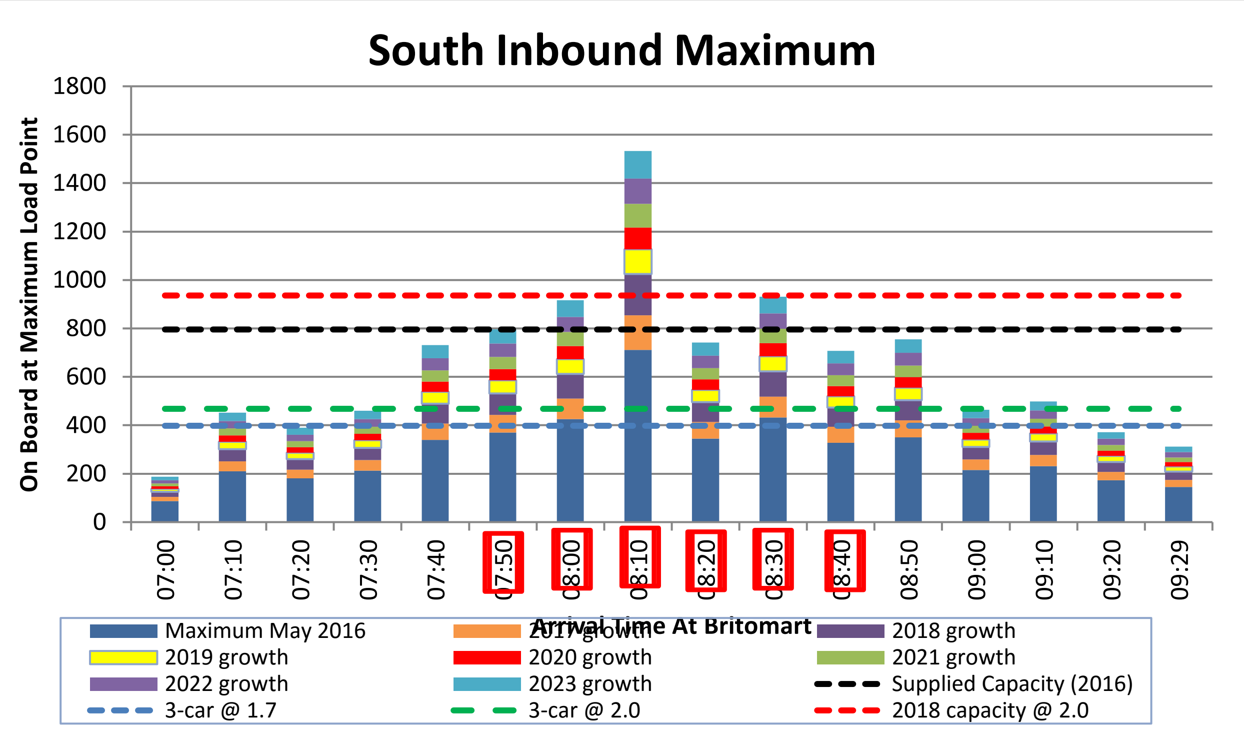
With the proposed increase in fleet size only just meeting predicted demand to 2023, there is a significant risk that more units may be required sooner than expected. If the growth in passenger demand does not moderate, the demand forecast for 2023 will be reached sooner. It is recommended that the patronage growth over 2017/18 and 2018/19 is carefully monitored and the patronage forecasts revised then to decide on the numbers of additional units required in the subsequent tranche, and the timescales for delivery.

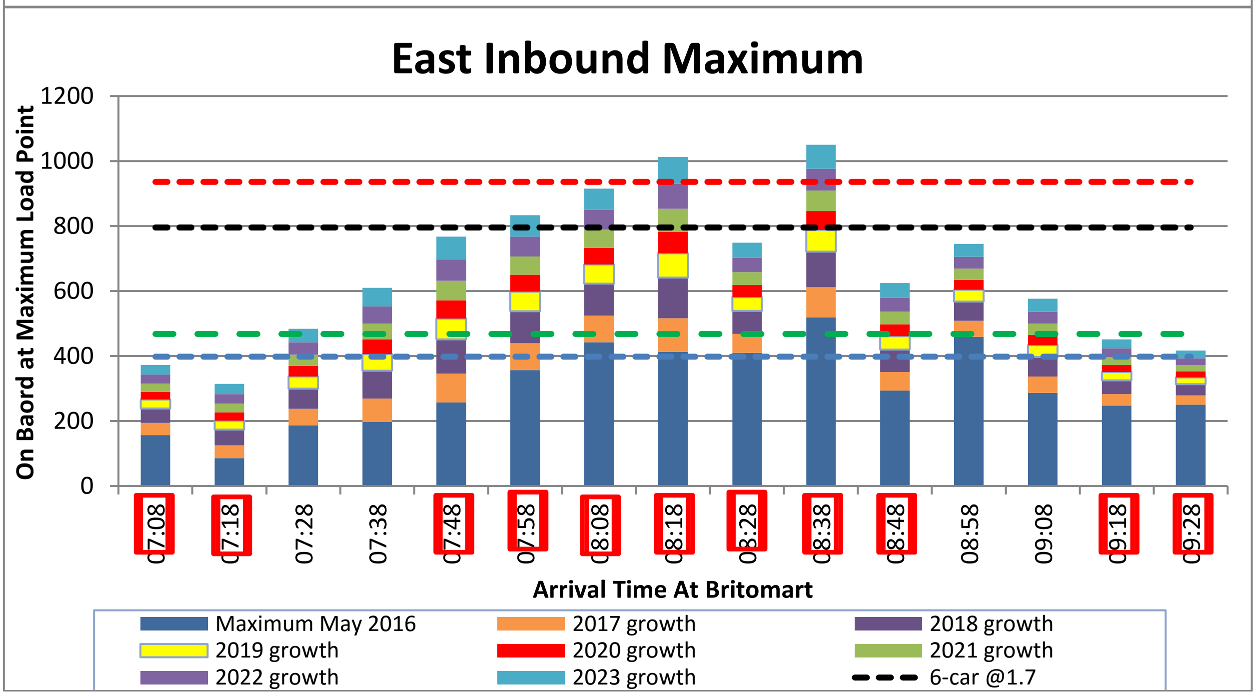
The CRL train plan currently has Pukekohe units operating to the CRL and then to Manukau. Such a service pattern would require a significant increase in the number of IPEMUs required to operate it, over the number required pre-CRL. The analysis as to the number of further units required will need to take that into account, also whether it would be better value-for-money to electrify to Pukekohe earlier rather than later, or whether the CRL train plan should be altered to take account of the relatively small number of IPEMUs that would be available.

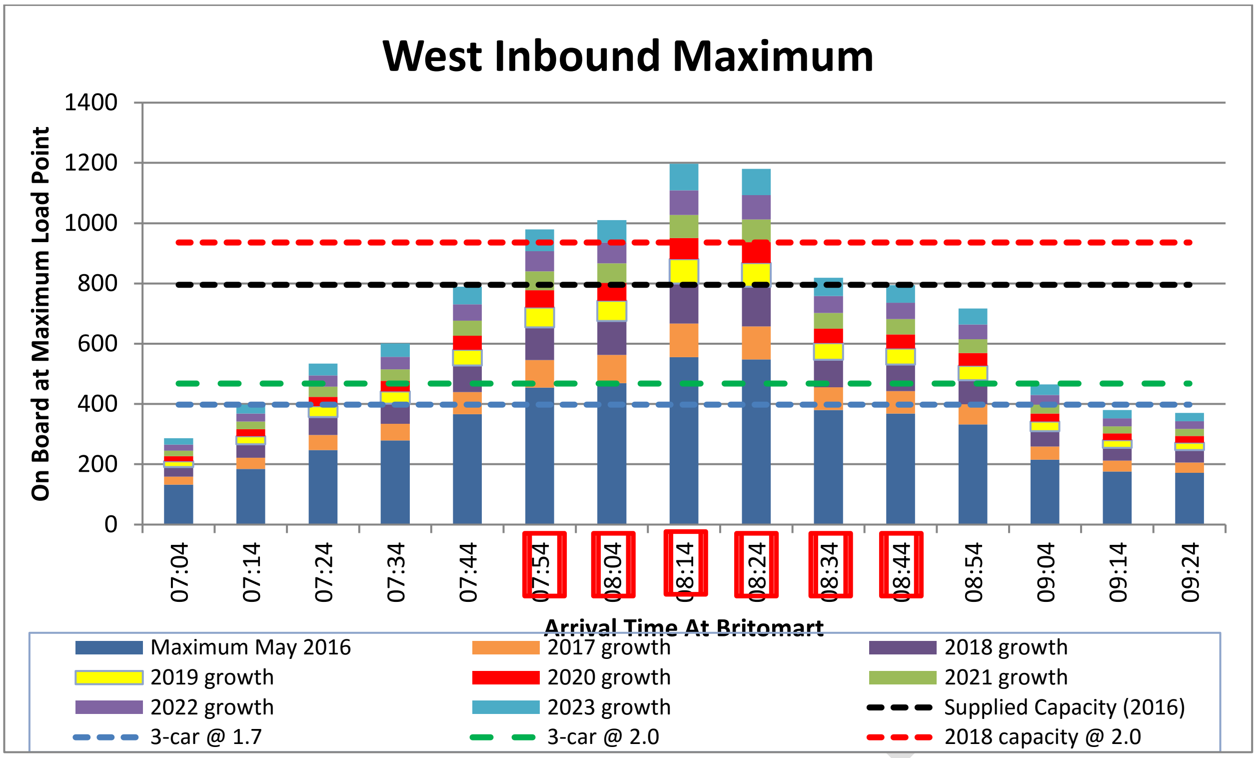
8 APPENDIX B – SERVICE BY SERVICE LOADINGS, 8% AND 10% SCENARIOS

Comparison of the sets of graphs below shows the significant change in the number of services that exceed the 3-car @2.0 loading level in going from 8% growth between 2018 and 2023 and 10% for those years. The problem will be compounded as passengers move from those services that are heavily loaded even with 6-cars to those where the loading is a little lower.

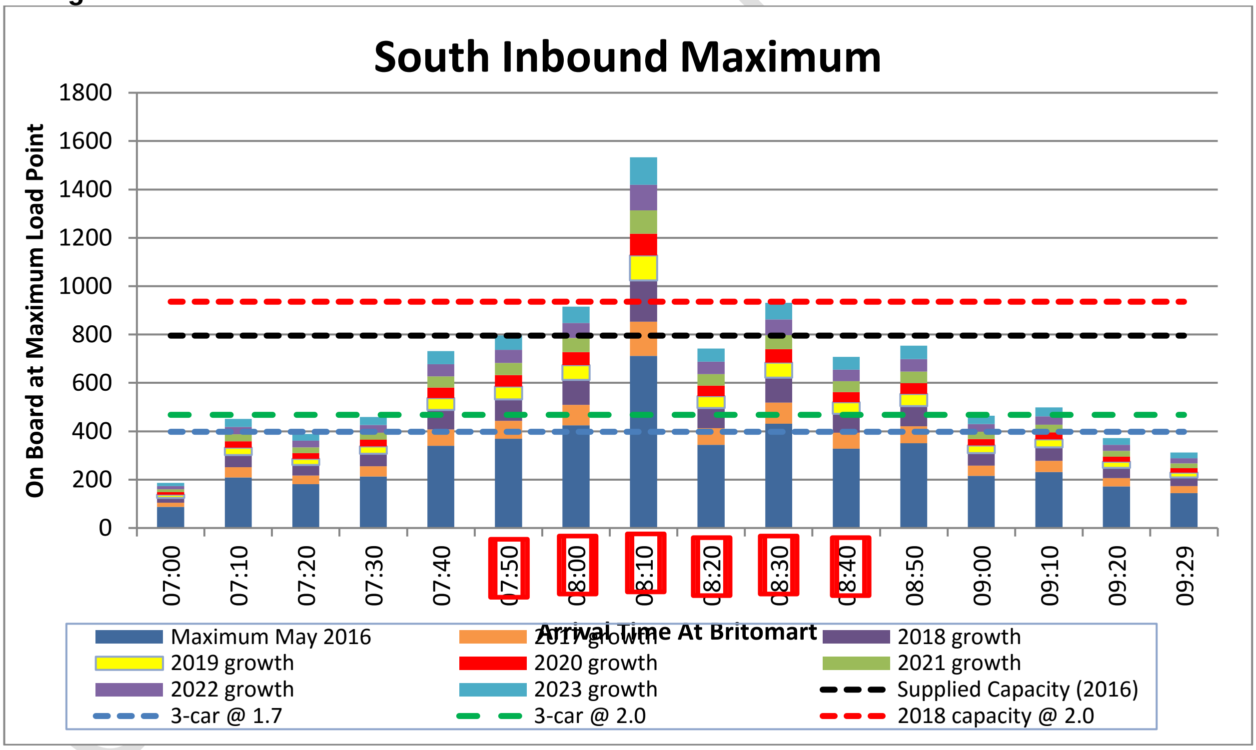
8% Scenario

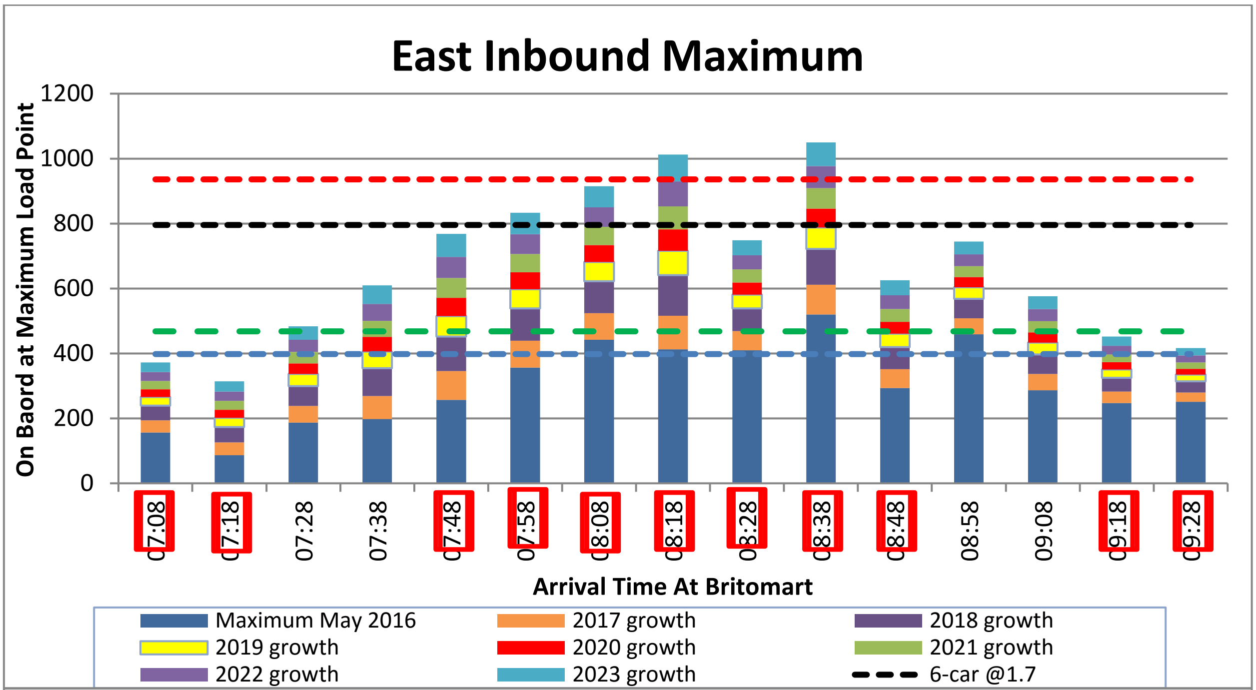


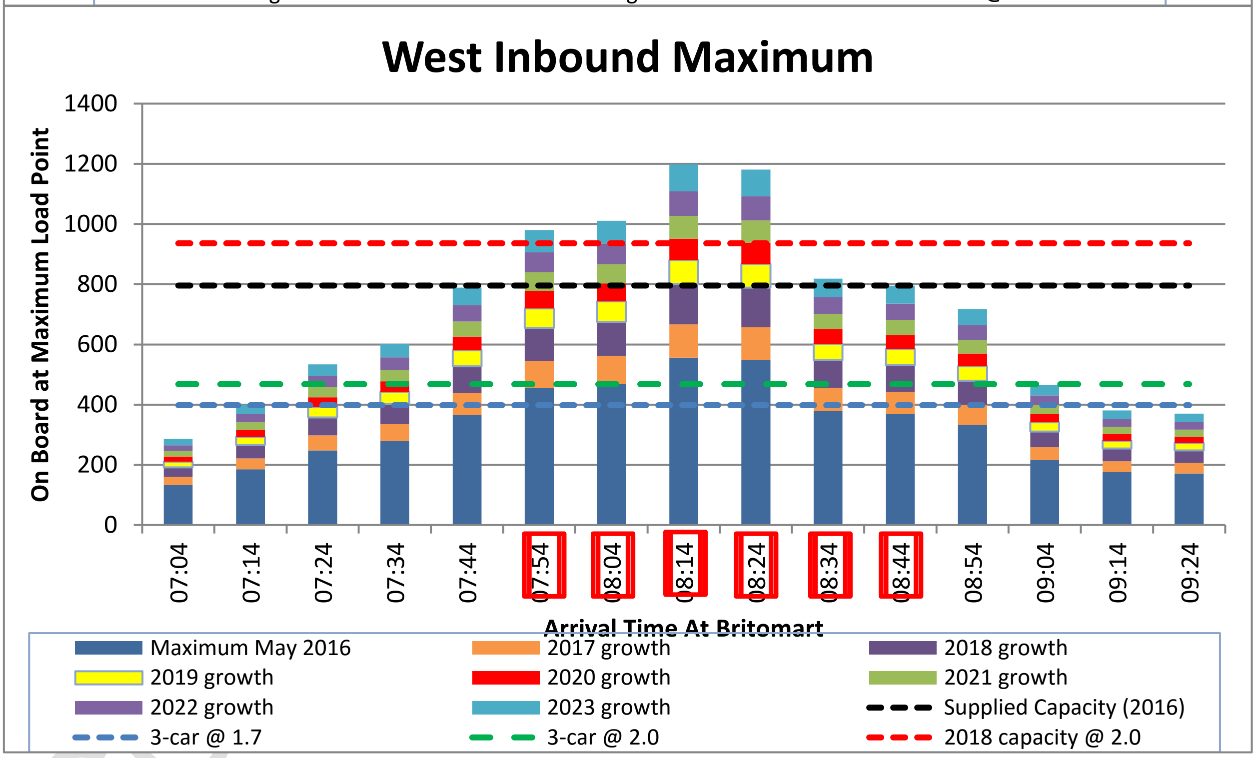




10% growth scenario




East Inbound Maximum
On Baord at Maximum Load Point
1200
1000
800
600
400
200
0
07:08
07:18
07:28
07:38
07:48
07:58
08:08
08:18
08:28
08:38
08:48
08:58
09:08
09:18
09:28
Arrival Time At Britomart
Maximum May 2016
2017 growth
2018 growth
2019 growth
2020 growth
2021 growth
2022 growth
2023 growth
6-car @1.7


West Inbound Maximum
On Board at Maximum Load Point
1400
1200
1000
800
600
400
200
0
07:04
07:14
07:24
07:34
07:44
07:54
08:04
08:14
08:24
08:34
08:44
08:54
09:04
09:14
09:24
Arrival Time At Britomart
Maximum May 2016
2017 growth
2018 growth
2019 growth
2020 growth
2021 growth
2022 growth
2023 growth
Supplied Capacity (2016)
3-car @ 1.7
3-car @ 2.0
2018 capacity @ 2.0