# Auckland Metro Rail Electrification: Report of the Working Group

4 August 2009

## Purpose of Report

1. This report provides analysis of the options for delivering the upgrade and electrification of Auckland's rail network, within available funding parameters, whilst meeting the region's expectations of the rail service and patronage forecasts for the planning period up to 2018.

## Summary and Findings

2. Since the development of the Auckland Rail Development Plan, and subsequent investment decisions taken by the Crown and the region, a number of factors have contributed to the situation where available funding is insufficient to complete the project to a level expected by key stakeholders.

3. Factors include higher than forecast patronage forecasts, new service patterns, revised budgets, and more information about the adequacy of current network improvements.

4. The Working Group explored a number of options to deliver the electrification of Auckland's rail network within a fiscal envelope of $1.6 billion. This assumes existing funding of $1.1 billion to support network improvements remains extant and funding of $500 million for the purchase of electric rolling stock is available.

5. The Working Group has identified a plausible option if (i) stakeholders are willing to accept a higher degree of operational risk pre-2018, and (ii) a second tranche of Electric Multiple Units (EMUs) is procured post 2018 to replace aging diesel rolling stock, and ideally, to provide operational flexibility and address seating/standing ratios. The Working Group believes, subject to confirmation by operational modelling, this can be delivered within the $500 million funding envelope, and will provide sufficient capacity to meet the Auckland Regional Transport Authority's (ARTA's) revised future patronage growth forecasts at 10-minute peak frequencies to at least 2018 if not beyond. The cost of the option is $493 million including acceptable contingencies.

| **Table One: Total Cost for Working Group Option** | |
|---|---|
| Requirement | Cost ($m) |
| Rolling Stock, Upgrades, Maintenance and Stabling Facilities (75 EMUs cost $263 million) | 439 |
| Network Infrastructure Improvements | 54 |
| Total | 493 |

*Network Infrastructure Improvements*

6. Additional network infrastructure is required to deliver reliable ten minute peak hour frequencies. This is in addition to funding already agreed for Project DART and the electrification of the rail network. The Working Group identified the completion of the core network as a priority and in the absence of other funding sources has recommended funding a proportion of additional network construction costs from the

rolling stock funding allocation. This fiscal risk has risen from $97 million to $151 million. The Working Group recommends funding $54 million of additional network construction.

*Optimal Number of EMUs*

7. The Working Group has identified only one workable option that fits both within the capital envelope and meets the broad aims of government and the region (i.e. electrification of core network, construction of Manukau Rail Link, and minimal degradation to planned service levels).

8. Subject to further analysis, the Working Group advises a minimum order of 75 EMUs, but a higher number is preferable. The exact number required is subject to further modelling and identification of the operating cost impacts.

9. The option requires:

    9.1. the procurement of a minimum of 75 twenty-four metre EMUs in the first tranche

    9.2. the operation of 14 electric locomotives (plus required spares) to haul existing SA/SD carriage sets, most likely by upgrading KiwiRail's existing fleet of 19 EF locomotives

    9.3. upgrading the Onehunga line and operate a diesel shuttle from Onehunga to either Newmarket Station, or to the junction on the main trunk line near Penrose (as opposed to an electric through service to Britomart Station).

    9.4. refurbishment of the existing Diesel Multiple Units (DMUs) beyond their current "end-of-life" (2013/14) to enable them to run shuttle services from the non-electrified sections into the electrified sections of the Southern, Western and Onehunga lines until 2018

    9.5. a second tranche will be required to be in service after 2018 to replace expired DMUs on the shuttle services[1].

10. This compares with the original ARTA EOI requirement for 140 twenty-metre EMUs. The Working Group was able to consider a smaller number of EMUs by increasing the length of the carriages to 24-metres[2], accepting a higher number of passengers will stand, and operating the existing DMUs for longer than planned. ARTA's original proposal would have provided sufficient rolling stock to meet demand and cover shuttle services until at least 2023. Refer to Annexes A, B and C.

[1] The Working Group advises that, under this option, a second tranche of rolling stock purchases will be required around 2018 to enable retirement of the DMU shuttles, and ideally to provide operational flexibility and address some loading issues. Further analysis is required, but up to 33 additional EMUs could be required in the second tranche.

[2] The original ARTA EOI requirement of 20-metre EMUs was based on a combination of the maximum length of platforms, signalling and track alignment limitations. Since the EOI was issued, KiwiRail has updated the maximum length allowed on the network, permitting a longer carriage to be considered.

11. The proposed option largely meets the region's requirements and is similar to the region's original proposal other than running fewer new trains with a higher proportion of standing passengers and greater use of existing stock.

12. Procuring a minimum of 75 EMUs will meet ARTA's revised demand forecasts on the core network. However, a higher number of EMUs would enable more reliable services by providing additional spares, earlier retirement of older diesel rolling stock and contingency for additional, unforeseen patronage growth. The Working Group advises against procuring fewer than 75 EMUs, mainly to avoid compromising operational effectiveness reliability.

13. Other options were explored and included continuation continuing the purchase of 140 EMUs as per the ARTA EMU EOI, reductions in network improvements and limiting peak hour service frequency. None of these options were considered workable given the objectives of the Crown and region. Other options could be considered, but would require either additional funding or a decision not to deliver on one or more of the broad aims of the project.

## Background and Problem Definition

14. In 2006 and 2007, the government agreed to improvements in the Auckland rail network to increase reliability, service frequency, reach and safety.

15. The initial investment decision, Project DART, had a cost to the Crown of $600 million. Project DART is a series of improvements to Auckland's rail network which will enable more frequent and reliable passenger services and improve pedestrian safety around the rail network. DART includes the development of Newmarket station and junction, the construction of New Lynn station and trenching the rail line through the New Lynn township, the construction of a new rail link and station at Manukau City, completion of the Western line duplication to Swanson and a series of other track improvements to allow increased frequency of services. In 2007, Ontrack committed to reopening the Onehunga Line for metro services and costs were absorbed in the overall contingencies for Project DART. Project DART is underway and due for completion in 2010. KiwiRail Network is responsible for delivering the project, and as of June 2009, $384 million of KiwiRail's $600 million budget had been expended and most of the remainder has been committed.

16. The ARC invested $190 million to June 2009 in trains and station upgrades as its share of the above track/below track split proposed under Project DART. A further $190 million expenditure is programmed by the region over the coming 10 years. Auckland City Council (ACC) constructed the Britomart station, and other local councils are also investing significantly in the rail upgrade.

17. At Budget 2007, the government confirmed funding of $500 million to build the infrastructure required for electrification of the Auckland metropolitan rail network. This followed the production by ARTA and Auckland Regional Council (ARC) of the Auckland Rail Development Plan, and subsequent work by a Technical Working Group comprising the Treasury, the Ministry of Transport, ARTA and ARC. As of June 2009, $40 million of the $500 million budget had been expended and within the budget, $95 million has been committed to a signalling contract. KiwiRail Network is responsible for delivering the project. This budget included the electrification of the extensions of the Auckland metro network, (i.e. Manukau rail link) and the Onehunga line.

18. The key objectives for electrifying Auckland's rail network include:

    18.1. The provision of a rail network capable of operating at ten-minute peak frequencies as envisaged in the 2006 Rail Development Plan (i.e. 6 trains per hour from Papakura and Manukau in the south and from Swanson in the west).

    18.2. The acquisition of sufficient rolling stock to meet ten-minute peak frequencies

    18.3. Electrification of the core network

    18.4. Electrification of the Manukau rail link and the Onehunga line.

18.5. A patronage forecast of 15.7 million trips per year in 2016[3].

19. In October 2008, the government adopted an Order in Council agreeing to the introduction of a regional fuel tax scheme in the Auckland region to facilitate the purchase of electric rolling stock together with other related rail project activities. In November 2008, the ARC adopted an amended 2006-16 LTCCP to reflect the Auckland regional fuel tax scheme and to facilitate electrification of Auckland's rail network. Funding for this package of improvements was from debt to be repaid by regional fuel tax, distributions from Auckland Regional Holdings (ARH), and rates.

20. ARC budgeted $512 million capex for the acquisition of 140 Electric Multiple Units ($410 million), the refit of existing electric locomotives and SA/SD sets ($28 million), stabling and maintenance facility ($53 million) and project management ($20 million), and fitting overrun protection to existing rolling stock ($13 million).

21. In March 2009, the government revoked the regional fuel tax and assumed responsibility for purchasing the new electric rolling stock. A NZ Transport Agency (NZTA) loan is to be made available to assist the ARC to complete their commitment for the purchasing of additional SA carriages from KiwiRail, along with funding for new and improved rail stations. The government also decided in principle, that KiwiRail would be the owner of any new electric rolling stock.

22. Between early 2008 and June 2009 and as a result of significant engineering modelling being undertaken of Auckland Regional Transport Authority's (ARTAs) service plan, KiwiRail and ARTA identified the requirement of up to an additional $151 million of improvements to below track work to deliver a reliable ten-minute peak hour service. This has contributed to a situation where the costs to meet the objectives of the Rail Development Plan exceed the funding available.

23. Given the Crown's current fiscal constraints, the Minister of Transport has signalled that no additional funding would be made available to meet cost increases. A Working Group was convened to assess how the electrification project could be delivered whilst adhering to the funding envelope and delivering on the Crown's and regional objectives. The Working Group consists of senior staff from the Ministry of Transport, NZTA, KiwiRail, ARTA and Veolia. The Working Group reports collectively to the Chief Executives of the Ministry of Transport, KiwiRail, ARTA, and the ARC, NZTA, Veolia and Treasury are invited to the Chief Executive (CE) discussions.

24. The Working Group has worked through a number of scenarios and issues. Following consideration of the Working Group's findings by the respective CE's, a report will be submitted to the Minister of Transport.

## Agreement and Funding for Additional Below Track Infrastructure Requirements

25. In October 2008, ARTA and Ontrack commissioned modelling to assess what timetables could be operated on the Auckland rail network post DART and electrification. A number of different morning peak service patterns were modelled to see if they could reliably run on the DART infrastructure. The results demonstrated

[3] This is a modelled demand from the APT. A subsequent APT model run undertaken in 2008 to inform the ARTA EMU purchase, which better matched observed patronage to date, resulted in a revised forecast demand of 17.3 million.

that none of the service patterns were able to operate. Each modelled timetable suffered from a number of operational problems which demonstrated that there was insufficient capacity on the post DART network.

26. At the time, it was estimated that the cost of additional infrastructure to enable ten-minute services with eight=car trains was $97 million. Of this, $50 million was required for DART to deliver ten-minute frequency and associated patronage, and $47 million to deliver additional robustness and facilitate freight and patronage growth.

27. Further work since October 2008, has identified a total of $151 million in potential additional network infrastructure expenditure. This comprises:

| **Table Two: Additional Infrastructure Requirements to DART as at June 2009** | | |
|---|---|---|
| Required For Reliable 10-minute Frequency For 8 Cars | | $m |
| Station works | BTC/ Quay Park | 0.260 |
| | BTC/ Quay Park conflicts | 7.620 |
| | BTC additional train axle counter computer | 0.275 |
| | Newmarket Branch robustness and reduce signalling headways | 0.390 |
| | Newmarket Branch Higher curve speeds | 2.590 |
| Track works | Puhinui platforms/double track branch | 6.467 |
| | Puhinui increase headways | 1.166 |
| | Papakura reduction of clearance times | 0.388 |
| | Papakura (terminating trains) | 1.128 |
| | Swanson third platform | 3.298 |
| | Swanson extra crossovers | 0.260 |
| Platform extensions | Network platforms to 144m | 24.750 |
| | Network platforms to 170m | 28.272 |
| Reduce freight/pax conflicts | Puhinui/Westfield third line | 28.512 |
| | Westfield junction grade separation | 7.776 |
| Desired Infrastructure Improvements in Addition to DART Provision | | |
| | Onehunga station | 10.000 |
| | Mt Smart (events station) | 1.500 |
| | Parnell station | 7.335 |
| | Drury station | 3.000 |
| | Takānini station | 3.000 |
| | Strand station | 3.000 |
| | Pedestrian Overbridges (eg Pukekohe, Puhinui) | 10.000 |
| Total | | 150.987 |

28. The Working Group agreed as a working premise that ensuring the reliability and resilience of the core network within acceptable parameters should be a major priority to ensure the benefits of existing investment commitments are unlocked[4]. The Working Group assessed and agreed a base level of network projects which should be considered for additional funding. The projects total $54 million and exclude costs for overrun protection which is recommended for funding within the rolling stock procurement budget. The projects are set out in Table Three below:

| **Table Three: Projects to Enable Reliable 10-minute Peak Services** | | | |
|---|---|---|---|
| Location | Addition | Function | ($m) |
| Britomart/Quay Park | Additional crossover Up Main to Waterside on NIMT closer to Quay Park | This will enable bi-directional running on the waterside track | 0.260 |
| Britomart/Quay Park | Conflict free access to third platform from city side | This will allow up to 14tph to come from Newmarket | 7.620 |
| Britomart | Train axle counter computer | Will provide additional resilience and robustness to Britomart train control system and de-risks CPU failure of train counter system | 0.275 |
| Newmarket Branch | Reduce signalling headways to 90 seconds and change approach to catering for freight. 4-aspect signalling | Needed to maintain timetable on stretch of track with a lot of traffic | 0.390 |
| Newmarket Branch | Higher curve speeds | Increased robustness | 2.590 |
| Puhinui | Access to all platforms to/from Manukau (effectively double tracking whole branch) | This will increase stability in the timetable by enabling greater flexibility. *This project can be reduced by 3,000,000 if the Manukau Spur is deferred. | 6.467 |
| Puhinui to Papakura/Drury | 2 minute signal headways (4-aspect signalling) | Needed for increased traffic on this stretch of track | 1.166 |
| Southern line – provision for shuttle services | Third platform face (existing suburban platform) | This allows an additional turn back facility for shuttle operations | 1.128 |
| | Higher speed through turnouts | Reduction in clearance times | 0.388 |
| Western line – provision for shuttle services to and from Swanson | Third platform face on Waitakere direction side | This is required to enable shuttle operations | 3.298 |
| | Additional crossover east of station | This is required to enable shuttle operations | 0.260 |

[4] International benchmarks of 95 percent punctuality (within five-minutes) and similar reliability

| | | | |
|---|---|---|---|
| Network | Platforms to 144-metres | To enable 6-car trains | 24.725 |
| Safety | Half of pedestrian overbridge cost | Enables overbridges of high safety priority to proceed | 5.000 |
| Total | | | 53.567 |

29. The Working Group agreed that a number of projects within the additional scope can be deleted or deferred by around seven years when, or if, further capital funding is available. These include:

    29.1. A Puhinui to Westfield third line for freight

    29.2. Westfield junction grade separation

    29.3. Station extensions to 170 metres

    29.4. The development of Parnell station

    29.5. Additional station upgrades, including Onehunga (above the current baseline station design for this project), Drury and Takānini

    29.6. Half of the pedestrian overbridge costs.

30. The combined value of these deferrals or deletions is $94.4 million.

31. To fund $54 million of additional infrastructure within allocated or assumed funds will require changes to the scope of either the remainder of the DART project, the below track electrification allocation, or the assumed allocation for electric rolling stock. In the absence of additional funding the Working Group has assumed the funds will be netted off the electric rolling stock allocation. This will have the effect of reducing the funding available for rolling stock procurement. The Working Group has not explored the opportunities for trade-offs within Ontrack's $1.1 billion allocation ($600 million for DART plus $500 million for below track electrification), although opportunities might exist. A firmer view of the adequacy of the $500 million electrification budget allocation will be known over the next two months.

## ARTA's Original EMU Proposal

32. In 2008, ARTA developed a procurement strategy, which was endorsed by NZ Transport Agency and ARC as the then joint funders of electric rolling stock across its lifecycle. The procurement strategy was based on a 'build and maintain' model in which both capital and operating costs of EMUs were to be negotiated with a preferred supplier, selected through the EOI/RFT process.

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

33.1. the design and supply of 140 twenty-metre EMUs

33.2. 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)

33.3. maintain the EMUs for 13 years from the commissioning of the last unit of the first order

33.4. supply spare parts and technical support for 15 years from the commissioning of the last unit of the first order.

34. ARTA also extended the existing Veolia service contract from 2009 to 2014, to provide for the current operator to assist with the transition period to electric services.

35. ARTA's budget for EMU procurement, as at February 2009, was:

| **Table Four: ARTA Estimate for 140 EMU Procurement** | |
|---|---|
| Requirement | Cost ($m) |
| EMU Rolling Stock 1 - 35 (35 four car sets = 140 cars) | 410 |
| Electric Locomotives and SA/SD Refit for Electrification | 28 |
| Project Management | 20 |
| Long Term Stabling and Maintenance Depot | 53 |
| Total | 509 |

36. The EOI provided for the purchase of 35 four-car EMUs, and allowed for flexibility by requesting suppliers to consider providing a mix of three-car and four-car sets in order to enable the operation of seven-car and eight-car services at peak times to enable a patronage of 17.3 million (21,600 each two hour morning peak) in 2016[5].

37. The ARTA EMU budget was for a total of $410 million with payments forecast to be spread over the years 2009/10 to 2014/15.

38. This budget was originally based on a per car price of US$1.82 million for each of the 140 cars to be purchased and assumed an exchange rate of NZ$0.70 to the US Dollar resulting in a price of NZ$2.6m per car. This cost was based on the estimated Wellington EMU cost. The Auckland EMUs will operate on 25 KVA which requires additional equipment to the Wellington EMUs. The estimate of the cost of this additional equipment, based on industry information, is an extra NZ$0.250 million per car and hence the December 2008 budget estimates were determined at NZ$2.6 million per car.

39. This was revised in February 2009 to NZ$2.93 million per car to provide a contingency for exchange rate fluctuation, and to make some provision for the holding of emergency spares in New Zealand, a cost which was not included in the Wellington EMU purchase price (as this was a 'supply only' purchase).

[5] Modelling for the Rail Development Plan estimated forecast patronage at 15.7 million by 2016. In 2008 this was increased to 17.3 million.

40. The ARTA electrification budget included $27.8 million for the costs of refurbishing electric locomotives for passenger use and reconfiguring the SA/SD fleet for electric locomotive haulage including some conversion of SD driving cabs to SA carriages.

41. This provision was based on the refurbishment of 11 EF locomotives deployed in 11 seven-car SA's, and a further seven diesel-hauled four-car SA's for the diesel shuttles (including one seven-car and one four-car spare). The exact costs of the electric locomotive refit had not been agreed with KiwiRail at the time the ARTA budget was set.

42. The ARTA EOI required that the rolling stock supplier take responsibility for maintaining vehicles for a period of 13 years (from delivery of the first EMU) and that the supplier be responsible for designing, building and outfitting a maintenance depot for 50 EMUs, with scope for future expansion of this facility together with storage for a total fleet of 200 EMUs adjacent to the maintenance depot.

43. ARTA's estimate of the cost of an EMU maintenance facility was $52.9 million, based on similar facilities built in Australia and the United Kingdom. This budget did not include provision for any payment to KiwiRail for the land on which the facility was to be located.

44. ARTA budgeted $13 million for installation of overrun protection on the SA fleet (both electric and diesel hauled). Both the timing and the amount of this cost was not clear at the time of the budget, so this was an estimate only. This was to be funded by ARC through the regional fuel tax, but is subsequently unfunded. The updated cost of supplying overrun protection on metro rolling stock is $26 million.

## Options Analysis

45. The Working Group worked through a range of scenarios and identified only one plausible option that works within the capital funding envelope and meets the objectives of the Crown and the region. The options considered included:

    45.1. **Proceed with purchase of 140 EMUs as per ARTA EOI**: The Working Group recalibrated the current EOI at a NZD:USD rate of 0.64c. The total cost of purchasing the EMU package plus recommended infrastructure upgrades is between $62 million and $112 million above the available funding envelope (figures vary depending on the low and high cost estimates for each EMU) and would require an additional $30 million for network improvements to lengthen platforms to 170 metres. The option was discounted as unaffordable (requiring $92million -$142 million more than assumed funding) and because the Working Group has agreed it would not make sense to proceed with the acquisition of 20-metre EMUs following KiwiRail's revision of acceptable train length on the network.

    If full funding were available, this option would provide sufficient rolling stock to retire all DMUs once the full electric fleet is delivered (estimated to be 2014). It would allow for a more homogenous fleet on the network, which Veolia advise would make the operational management of the fleet considerably easier than compared to a more mixed fleet.

The option would purchase sufficient capacity to provide for an annual patronage of 21 million trips, which is consistent with forecasts of patronage growth beyond 2023. The construction of the CBD loop tunnel would generate a further step change in demand and require additional rolling stock.

As a new fleet, rates of reliability and maintainability would be considerably improved over existing reliability. Operational costs are expected to reduce on a per passenger basis as electric trains are more fuel-efficient and require fewer on-board staff.

45.2. **Reduce the scope of planned network improvements**: The Working Group considered reductions in the scope of planned network developments, such as deferral of the Manukau Rail Link or non-electrification of one of the main lines. Taking into account the commitments for network improvements which have already been made, with the exception of a deferral in the electrification of the Onehunga line, the Working Group discounted these options. In general the group also considered a reduction in the scope of network improvements, would be likely to result in negative operational and patronage implications.

45.3. **Reduce peak hour service frequencies:** The Working Group considered limiting peak hour frequencies to current standards, rather than achieving ten--minute peak hour frequencies. The Working Group was advised that current peak hour frequencies are either at, or near to ten-minutes. The Eastern line is currently at ten-minutes, the Southern line at 12-minutes and the Western line is at 15-minutes. Frequencies on the Western line are currently disrupted by engineering works, and rates will improve when construction work is complete. The current ARTA plan is to improve Southern line frequencies to ten-minutes in February 2010 and Western line to ten-minutes in October 2010 following completion of the New Lynn station. Maintaining current frequencies would result in a reduction in forecast patronage growth and a consequential reduction in overall benefits.

45.4. **Procure EMUs in two tranches:** The Working Group considered a number of factors which influence the quantum of EMUs required, including increased carriage length, increased carrying capacity of the EMUs, greater utilisation of existing rolling stock and alterations to the service provision on the non-core network. Subject to further in depth analysis, the Working Group believes a workable solution comprising of the purchase of at least 75 (at 24-metres) EMUs, the upgrade of existing assets and further investment in network infrastructure, will meet patronage demand on the core network until approximately 2023 and within available funding parameters. However, additional rolling stock will be required in 2018 as older DMUs need to be retired.

This option was considered the only workable option given the capital funding constraint and high level policy objectives. The option is discussed in greater detail below.

**Procure EMUs in two tranches**

46. This option requires the purchase of a first tranche of a minimum of 75 EMUs at twenty-four metres in length. These would be deployed in three-car sets across all three lines according to demand. Operational flexibility is essential to allow six-car trains to be used where required. Most existing diesel stock assets would be utilised either as service units or maintenance spares, as follows:

    46.1. All 104 SA units converted for electric locomotive haulage and used to provide services on the core urban network (including the Manukau line)

    46.2. A mix of EMUs and electric-hauled SA's on all lines in order to manage within tight rolling stock parameters. This creates additional operational complexity and may impact on reliability and patronage

    46.3. The ADL DMUs retained in service until 2018

    46.4. One 4-car SX DMU as a spare

    46.5. By 2018, new EMUs will be required as the DMUs will have reached the end of their (third) useful life and would require considerable capex for a further life extension.

47. This option is also based on the assumptions that:

    47.1. EMU length is 24-metres as opposed to the original requirement of 20-metres

    47.2. standing/seating ratio targets (planning standards) are increased from 1.4 to 1.7 (i.e. 4 people standing for every ten seated) and ARTA'S 15-minute target on standing time is breached for some services

    47.3. the Onehunga branch line is a diesel shuttle, diesel services from Onehunga will only run to Newmarket, not Britomart and electrification on the Onehunga line is deferred until 2019

    47.4. diesel shuttle services will operate from Pukekohe to Puhinui and from Huapai to Henderson

    47.5. the electric locomotive hauled fleet has the same or very similar traction profile as EMUs.

48. Under this option, passenger forecast demand to 2018 would be met, although most peak trips would have standing loads with five trips forecast above ARTA's 1.4 planning standard in the morning peak. The disadvantages of this option include a risk of a lower level of customer satisfaction and therefore reduced patronage growth, greater operational complexity and lack of contingency capacity if patronage forecasts are exceeded.

| Table Five: Requirements by 2018 | | | | | | |
|---|---|---|---|---|---|---|
| | Type | DC | ADL | EFT | SA | EMU |
| West | 8x3 EMU | | | | | 24 |
| | 5x6 SA | | | 5 | 30 | |
| South | 4x3 EMU | | | | | 12 |
| | 6x6 SA | | | 6 | 36 | |
| East | 9x3 EMU | | | | | 27 |
| | 3x6 SA | | | 3 | 18 | |
| Huapai | 3x2 ADL | | 6 | | | |
| Onehunga | 2x2 ADL | | 4 | | | |
| Pukekohe | 3x2 SA | 3 | | | 6 | |
| *Sub-total* | | *3* | *10* | *14* | *90* | *63* |
| Spares | | 1 | 4 | 3 | 14 | 12 |
| Total | | 4 | 14 | 17 | 104 | 75 |

49. Modelling infers there is sufficient capacity in the rolling stock to meet forecast demand, but additional capacity will be required from 2018 (in order to retire the ADL fleet which will be replaced by diesel-hauled SA units), and ideally to address some loading and standing time issues (although loadings remain within the 1.7 target which applies in Australia and other jurisdictions until 2023) With 75 EMUs (assuming no second tranche EMU purchase by 2019 and continued forecast patronage growth), in 2023 a third of the core network services will experience loadings of more than 1.4, although only one service will have a loading in excess of 1.7[6].

| Table Six: Maximum Forecast Passenger Loads for the AM Peak with 75 EMUs[7] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Line** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
| West | 1.15 | 1.22 | 1.30 | 1.34 | 1.37 | 1.41 | 1.44 | 1.48 | 1.52 | 1.56 |
| South | 1.20[8] | 1.28 | 1.36 | 1.41 | 1.44 | 1.48 | 1.52 | 1.56 | 1.60 | 1.64 |
| East | 1.28 | 1.36 | 1.45 | 1.49 | 1.53 | 1.58 | 1.62 | 1.66 | 1.70 | 1.75 |

50. Modelling infers that over half of services on the Eastern line would experience standing loadings for 15-minutes or more in both 2018 and 2023. Mitigating standing times would require longer train sets, which will require additional expenditure to construct longer platform, or additional rolling stock to enable increased frequency.

[6] Eastern line 8.20am service loading factor of 1.75

[7] This table shows the point of maximum loading for the 12 AM peak services on each line. Maximum loadings are only maintained for one stop.

[8] For example: on average, in the morning peak hours on the Southern line, modeling suggests that for every 10 passengers seated, two will stand.

51. This option will raise operational challenges. It requires between two and four different configurations of trains to operate on each of the lines during the peak periods. This is likely to increase risk of service disruption and poorer reliability.

52. This option utilises the EMU and SA fleets to very high levels, with minimal allowance for spare sets, which are needed to allow for breakdowns and rotation of units for deep maintenance.

53. Costs for this option range between $429 million and $467 million excluding additional below track infrastructure, with the range depending on the assumed price for the EMUs.

| **Table Seven: Costs for 75 EMU Purchase** | |
|---|---|
| Requirement | Cost ($m) |
| EMU Rolling Stock (75 cars at $3.5 million per car) | 263 |
| Existing Fleet Upgrades | 17 |
| Long Term Stabling and Maintenance Depot | 53 |
| Project Management at 10 percent | 33 |
| Overrun Protection | 26 |
| Contingency at 15 percent (excl maintenance and overrun) | 48 |
| *Subtotal for above (low estimate = $423m, high = $467m)* | *439* |
| Base Infrastructure | 54 |
| Total | 493 |

54. By 2018, additional EMUs will be required to provide for the retirement of the DMU fleet and electrify the Onehunga line. Ideally, additional EMUs would also be procured to address loading and standing time issues on some services and provide for additional operational flexibility. This could require up to 33 additional EMUs (11 three-car sets), but further analysis, including economic analysis, is required to confirm this number.

55. As the EMU procurement and infrastructure construction progress, costs against budget will be confirmed. Unexpended funds within the $500 million envelope will be made available to fund the following:

    55.1. Additional EMUs, up to 33 in number, to ease maintenance and spares pressure and facilitate improved service reliability and punctuality

    55.2. Onehunga branch line electrification with EMUs

## Risks

EF Locomotives

56. The options recommended rely on the use of electric locomotives to pull SA carriages, given the purchase of fewer EMUs than originally planned. This will require a commitment by KiwiRail to make the number required available (up to 17 of the existing 20-locomotives). It is not yet known if this will impact adversely on the fleet availability on the North Island Main Trunk line (NIMT) for KiwiRail freight operations. “Dieselisation” of the NIMT would allow KiwiRail to improve the utilisation of its fleets. Preliminary planning suggests that only seven additional diesel locomotives would be required. As 26 diesel locomotives will be used in ARTA service at the peak this would create a net surplus of 19 diesel locomotives for growth elsewhere on the network.

57. There are a range of possible technical concerns, such as electrical harmonics, which need to be assessed before the locomotives can be accepted for operation on the network. In addition, the 18-tonne axle load of the EF will be significantly heavier than the rest of the suburban fleet, and this may have an impact on track and infrastructure maintenance costs. In terms of the performance the EF locomotive, and the carriage set being hauled, may not perform identically to the new EMU trains. Braking performance will be inferior to that offered by EMUs. As a result modification may be required and/or a different vehicle performance profile could result in passenger delay and on time performance concerns. If the performance is significantly poorer additional trainsets will be required. At this time, no clear scope of work or cost is available to determine feasibility and accurate capital or operating costs for these key elements of the proposed fleet.

Safety

58. Veolia is concerned that the detailed scope of the safety systems proposed is agreed and understood by all concerned. The application of Automatic Train Protection (ATP) is planned and is part of the overall signals upgrade which KiwiRail is responsible for. At this stage and the costs are indicative and the need to apply ATP to all vehicles (including freight trains) which operate in the Auckland network remains unclear. Further, ATP requires a major revision of the operating rules and procedures around Auckland, followed by refresher training for drivers and signallers. This project requires participation from all operators, network and vehicle suppliers to in order to be successfully. KiwRail Network has recently awarded a contract to Westinghouse. The project is in the preliminary design phase and resource allocation from key participants is yet to be worked through.

Project Management

59. The overall outcome of an electrified Auckland network will require coordination of a multitude of different project work streams, including;

    59.1. KiwiRail infrastructure (DART) works

    59.2. Electrification infrastructure works

    59.3. EMU procurement testing and commissioning

    59.4. New signalling (Westinghouse)

    59.5. EF locomotive hauled operations

    59.6. New operating and maintenance regimes including the construction of a new maintenance depot

    59.7. A new 'safety case' for Veolia and KiwiRail

    59.8. Completion of the station upgrade programme

60. Presently, work is managed by a number of different organisations. There is benefit in considering how the overall project will be managed to ensure coordination is improved and risk (delivery, integration and cost) is mitigated.

## Managing Cost Increases

61. A high degree of certainty on the cost estimates will not be available until further analysis is undertaken and engagement with the market commences. This will result in some cost movement. As a precaution the Working Group has included a contingency of 15 percent in its calculations.

## Unidentified Costs

*Operating Costs*

62. The analysis in this report does not contain an estimate of the impact on operating costs. Additional operating costs will be incurred if older rolling stock are retained beyond original estimates. Funding operating costs is a joint responsibility of the ARC and NZTA.

63. The Working Group recommends that further work is undertaken to identify the operating costs of the preferred option.

*Funding Responsibilities*

64. Most options assume the upgrade and continuation of existing rolling stock. Decisions will be required on the source and responsibility of any additional costs where assets are owned by either the Crown or ARTA.

| **Table Eight: Current Rolling Stock Ownership** | | |
|---|---|---|
| Type and Number | Ownership | Estimated capital upgrade cost |
| 7 * DC locos | KR | ? |
| 10 * 2-car ADL | ARTA | $10 million |
| 4.5 * 4-car ADK | ARTA | Retire |
| 81 * SA and 23 * SD units | ARTA | $7 million<br>Includes provision for conversion of SD driving cabs to SA carriages. |
| Up to 17 * EFT locos | KR | Included in total cost, but assumes the locomotives are provided without charge by KiwiRail |
| 1 * 4-car SX DMU | ARTA | No cost<br>Retain as spare only |

## Fiscal vs. Economic

65. The Working Group has assessed options within a capital constraint and only advised on the financial capital cost[9]. As a result, the Working Group has not conducted an economic assessment between options to determine the optimal economic solution, for example, within a 40-year period.

## Timing of Decision

66. The analysis contained in this report is based on the assumption that new rolling stock will be available from 2013. Although tender documentation is already in circulation, any change to the current EMU procurement approach could result in a delay of at least one-year with the timeline dependent on the complexity associated with ownership and financing. The original procurement process envisaged a contract in place in late 2009, with the first EMUs arriving in 2011 and final deliveries by 2013.

*Current EMU EOI*

67. ARTA and KiwiRail have agreed to jointly defer the expiry of the validity of the ARTA EMU EOI to 31 December 2009. Decisions will be required on how, or if, the current procurement process is continued. Potentially, if the ARTA EOI is adjusted and progressed, a contract could be in place by late 2010 with first EMUs arriving in 2012 and final delivery by 2014.

[9] In the time available, costs have been estimated based on the Working Group's professional judgement. The costs require peer reviewing before they are accepted as robust estimates.

68. This delay in the rolling stock procurement, with earliest first delivery by 2012, will place increased risk on service reliability and service performance through low volume percentage of spare trainsets between 2011 - 2013 Further delay of the EMU procurement will extend this period of service performance risk to reliability through high pressure on spare trainsets.

*Manukau Rail Link*

69. The Manukau Rail Link is due for completion in late 2010. The opening was timed based on the assumption that new rolling stock would be available shortly after. A delay in rolling stock procurement will mean either that existing rolling stock will have to be diverted to service Manukau City Centre (and a reduction in services elsewhere on the network) or the line's commissioning will need to be deferred until sufficient rolling stock is available.

# Annex A: Working Assumptions

A key driver for fleet mix assumptions is the maximum load point for each service on each of the lines. This is the largest number of passengers at any one time on a service, taking into account the number of people getting on and off that service. This defines the capacity that a particular service needs to be able to provide in order to meet patronage demand. A peak load of 719 passengers in 2018 which is forecast for the eastern line after the Orakei station therefore requires a train capable of carrying this amount of people.

The peak load factors used by the Working Group come from two sources.

The first is ARTA's rail network patronage estimate. This was updated in 2008 to reflect the higher than expected patronage growth on the rail network. The updated estimate, which was modelled using the Auckland Passenger Transport model, saw the patronage projection for 2016 increase from 15.7 million, which was the basis for the Rail Development Plan, to 17.3 million. Modelling for this estimate assumed the provision of ten-minute service frequencies on the core rail network. This estimate provides the total level of demand that the network is expected to generate and needs to be able to meet. Demand has been projected forward from the modelled year of 2016 based on an expected increase of an additional 500,000 passengers per year until 2023. Demand is expected to plateau after this point unless further adjustments to the network are made.

The specific profile of demand across lines over the two hour peak period has been based on ARTA's recent patronage surveys. These recorded the number of passengers getting on and off services at all stations across the network over the peak period. These surveys provide the maximum load point for each line, along with the profile of demand across the peak. This showed that 68 percent of peak period demand occurs within a single hour, with sharp peaks occurring before work starting times. This demand profile has been scaled and matched to the forecast for total rail network demand, and projected forward on year by year basis. The profile has also been 'smoothed' to reflect the expected changes in passenger behaviour assumed to occur when service frequencies increase, particularly on the Western and Southern lines.

The demand profile used by the working group differs from that used in the work by Interfleet that underpinned elements of ARTA's EOI process. This reflects differences between the results of the Auckland Passenger Transport model, which underpinned Interfleet's data, and observed demand data used by the working group. Total forecast patronage remains the same for each year, but the profile is different. ARTA's latest modelling has a higher overall passenger load factor than that used by Interfleet. Due to a higher proportion of "through" passengers the maximum load is 77 percent of total boardings, not 73 percent as modelled. Whilst overall patronage demand remains the same the demand distribution between the Southern and Eastern lines is changed, which results in higher demand over the peak hour, and a different distribution between lines, with much higher demand on the Eastern line. This observed profile drives a higher capacity requirement.

## 2. EMU Length

The Working Group assessed options on the basis of 24-metre EMUs, as opposed to 20-metre EMUs as requested in ARTA's EOI. Across a six-car train, a 24-metre EMU provides a significantly higher capacity than 20-metre rolling stock units. For example, a six-car train of 24-metre EMUs provides around the same capacity as an eight-car train of the current fleet of SA and SD cars. However, the 24-metre EMU train is shorter, avoiding the need to lengthen stations and providing significantly easier handling characteristics, as well as lower

operating costs. Two consequences of this longer vehicle are possible increases in infrastructure maintenance requirements due to higher axle loads, and increased dwell times.

The change preferred vehicle length between the EOI and this report reflects a change by Ontrack in the specification for the length of vehicle allowed to operate on the network. This has enabled the Working Group to assume the operation of a longer vehicle.

## 3. The Use of Existing Rolling Stock

By 2013 the ARC will have a fleet of 104 SA/SD units, which can be configured in sets ranging from three-cars to six-cars. These are currently hauled by diesel locomotives. The Working Group has assumed that, following electrification of the network, the SA/SD sets will be hauled by electric locomotives capable of hauling a seven-car set, currently owned by KiwiRail and in use on freight services in the South Island. These locomotives will need to be overhauled and significantly modified. The use of these locomotives will need to be confirmed in more detailed work. Once the DMU fleet is retired some SA/SD's will be hauled by the current diesel locomotives on the shuttle services.

The ARC also has a fleet of ADL and ADK diesel multiple units. These were planned for retirement with the introduction of the electric fleet, due to their age and high operational cost. The Working Group has assumed their continued availability as an option to provide shuttle services on the non-electrified parts of the network.

## 4. Internal Capacity – 'The Planning Standard'

The capacity of a rail vehicle is determined by its overall size, internal seating arrangements and standing capacity. The relationship between numbers of seated and standing passengers is called the 'planning standard'. In its EOI, ARTA assumed a planning standard of 1.4, meaning that for every ten seated passengers, four will be standing.

There are ranges of planning standards applied worldwide. Long-distance passenger services tend to have lower standards, typically 1.0 while short duration metro services may have standards in excess of 3.0, as far fewer seats are provided with more standing room. Australian rail services generally run at between 1.7 and 2.0.

The planning standard is an important factor in determining capacity and cost. A low planning standard will ensure more passengers are seated, but will be exceeded more quickly, requiring either a longer train or more frequent services.

The Working Group has used a planning standard of 1.7, as opposed to ARTA's EOI of 1.4, and has also extended the 15 minute maximum standing time. This is based on:

- Use of a lower standard quickly drives the requirement for a longer vehicle on a number of services and therefore significantly higher capital costs
- This standard is consistent with Australian practice
- The standard is expected to result in standing passengers in close proximity, but not at intolerable levels of crowding.
- Standing times of over 15-minutes are not common on metro rail services, so no information is available to gauge the effect on patronage

- There is capacity on the peak shoulders for passengers to choose more lightly loaded services.

## 5. Standing Time

Ideally, passengers will not have to stand for too long. ARTA's specifications included a target of a maximum standing time of 15 minutes. The Working Group notes that the UK target is 20-minutes, although not strictly comparable. As with planning standards, this is a balance of passenger experience versus cost and practicality. Rather than using a particular standing time target, the Working Group has reported on modelled results for standing time with the plausible option having a maximum standing time of 31-minutes between Puhinui and Britomart on the southern Line from 2018.

## 6. Carriages per Train

The number of carriages per train is the major determinant of train capacity. Trains are grouped in sets of carriages, which are kept constant for ease of operation. Set configurations and associated patronage figures are provided in the table below.

| Train set | Cars (units) per set | Train seated capacity | Train capacity at 1.4 | Train capacity at 1.7 |
|---|---|---|---|---|
| EMU (24-metre) | 3 | 234 | 328 | 398 |
| EMU (24-metre) | 6 | 468 | 656 | 796 |
| Electric loco hauled SA/SD (20 metres) | 4 | 250 | 350 | 425 |
| Electric loco hauled SA/SD (20-metres) | 6 | 384 | 538 | 653 |
| Electric loco hauled SA/SD (20-metres) | 8 | 518 | 725 | 881 |
| ADL's | 2 | 138 | 193 | 235 |

## 7. Numbers of Train Sets

The number of train sets required for each line is driven by the length of each line and the time it takes to return to the start of a line to begin a new service. For example, on the Eastern line delivering 12 peak hour services requires eight train sets. Therefore the first train returns to the start of the line to deliver the ninth service, the second train delivers the tenth service and so forth.

This approach can mean that the trains used on early services may be longer than necessary – for example six cars are used when three would do - to enable them to meet patronage demand on their second run of the peak.

The number of train sets required to provide ten-minute services on each line is set out below.

| Line (including options) | Trains required per two hour peak |
|---|---|
| Eastern line option: Manakau to Britomart (via Glen Innes) | 8 |
| Eastern line option: Otahuhu to Britomart | 6 |
| Southern line: Papakura to Britomart | 10 |
| Western line: Swanson to Britomart | 11 |
| Onehunga shuttle option: Onehunga to Britomart | 2 |
| Onehunga shuttle option: Onehunga to Newmarket | 2 |
| Western line shuttle: Huapai to Henderson | 3 |
| Southern line shuttle: Pukekohe to Puhinui | 3 |

A number of shuttle line services overlap with services on the core network. This is driven by ARTA's planning assumption to minimise the need for passengers to transfer between services. For example, a passenger travelling from Pukekohe could get to Manukau, Glen Innes or Newmarket with only one transfer between trains, or link with a network of bus services. In addition if Britomart was their final destination, at worst they would have a five-minute transfer wait (five-minute service). The Working Group has not tested the economics of this approach, but assumes that it does not significantly drive demand for additional trains.

## 8. Putting it Together

The total requirement for rolling stock is determined by matching train capacity (type of train and number of car units) to peak demand for each service on each line.

Ideally, a homogenous fleet would be operated on each line. For example, the Eastern line might only run electric locomotive hauled SA/SD carriage trains, while the southern line might only run EMUs. However, the Working Group has concluded that mixing vehicle types for different services on the same line will deliver a more optimal result within limited funding. This is assumed to be possible due to the similar operating characteristics of the electric locomotive hauled SA/SD trains and the EMUs. Further work is required to confirm this assumption.

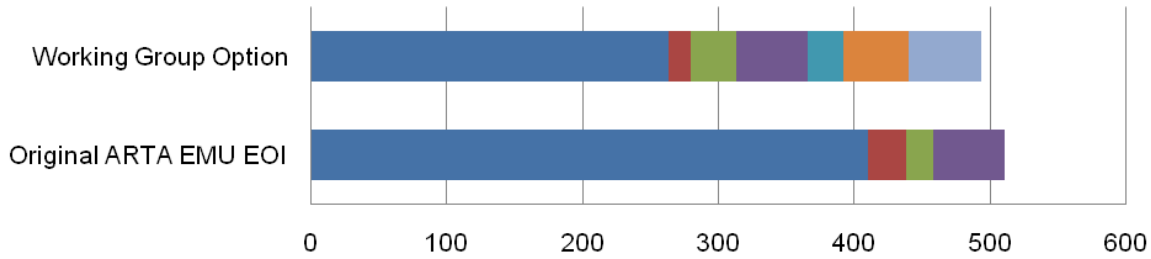
However operational reliability is reduced due to the need for rolling stock to be dispatched in a certain order and the limited ability for rolling stock to "recover" another type – eg. an electric locomotive can recover an EMU but an EMU could not recover a loco-hauled SA train set.

# Annex B: Comparison of ARTA's Original EMU EOI and Working Group Option

| **Comparison of Options** | | |
|---|---|---|
| | Original ARTA EOI | Working Group Option |
| Number of EMUs | 140 | 75 |
| Length per Carriage (metres) | 20 | 24 |
| Target Planning Ratio | 1.4 | 1.7 |
| Total Seating Capacity | 9,800[10] | 5,850 |
| Total Standing Capacity | 3,920 | 4,095 |
| Total Carrying Capacity | 13,720 | 9,945 |
| Electric Locomotives | 11 | 17 |
| SA/SD carriages | 104 | 104 |
| DMUs (ADL/ADK) | 0 | 27 |
| Core Network Capacity Until | 2023+ | 2018-23 |
| Shuttle Services Until | 2023+ | 2018 |
| Estimated Cost per EMU ($m) | 2.93 | 3.5 |
| Total Cost for EMUs ($m) | 410 | 263 |

[10] Source: ARTA EOI PW0815

# Annex C: Cost Comparison of ARTA's Original EMU EOI and Working Group Option




| | Original ARTA EMU EOI | Working Group Option |
|---|---|---|
| EMU Cost | 409.99 | 263 |
| Existing Fleet Upgrade | 27.811 | 17 |
| Project Management | 19.999 | 33 |
| Long Term Stabling and Maintenance | 52.892 | 52.892 |
| Overrun Protection | 0 | 26 |
| Contingency | 0 | 48 |
| Base Infrastructure | 0 | 53 |

## Annex D: Conclusions of the Previous Working Group

In December 2006, a Technical Working Group (TWG) comprising members of the Ministry of Transport, Treasury, ARTA and ARC, convened to explore options for a new permanent fleet for Auckland's metropolitan rail system.

The TWG examined three options, compared to a fourth default option:

- electrification with a new fleet of EMUs as soon as possible (2013). TWG believed this option would facilitate the network extensions and sub-ten-minute frequency services that will be needed to continue growing rail patronage beyond 2016;

- delaying electrification by five years (2018). The TWG advised that this option would provide the above benefits but delayed. Further, there were disadvantages in the interim in terms of reliability and capacity as a result of running SA trains. TWG concluded that delaying electrification makes sense only if the rail patronage growth is likely to be slower than forecast *or* if there were difficulties with funding, such as a capital constraint; and

- a new fleet of DMUs as soon as possible (2011-2012), requiring capital expenditure the earliest. The TWG was not convinced that this option achieved the upgrade significantly quicker than electrifying by 2013, and it seemed less amenable to future service intensification.

These options were compared also to a default option of making do with a fleet of SA trains. The TWG concluded that continuing with SA trains indefinitely was unlikely to result in the patronage growth benefits that underpin the Rail Development Plan.

The TWG found that there is no material difference in the economic cost of the options over a 40-year period.

The Working Group found that the benefits to passengers of new EMUs and new DMUs were very similar, but that their long term operational potential differs according to the rail patronage growth scenario used.

Given that the economic evaluation did not provide a clear indication of a preferred approach, the TWG advised Ministers that they were faced with a qualitative decision based on the best long term strategy for Auckland and the availability of funding.

The TWG found that the *cheapest* option in purely financial cost terms is the default option of continuing to run SA trains indefinitely (although only marginally so compared to electrifying in 2018). However, the most economic option with the best combination of costs and benefits over 40 years was to electrify in 2018, and run SA trains to provide the interim service[11]. For both electrification years (2013 or 2018), a phased introduction is marginally cheaper than a rapid roll-out.

[11] The Treasury led technical working group concluded this on the basis of patronage forecasts which have now been exceeded, and noted at the time that this was true only under a 'slow growth' scenario. Their conclusion therefore should be viewed based on actual rail patronage of 7.6 million trips in 2008/09.

The default option of running SA trains indefinitely is marginally the most uneconomic due to its higher operating costs, and a significant loss of benefits due to its lesser service quality and lower passenger growth.