Auckland Transport
An Auckland Council Organisation

Light Rail Transit for Auckland

Business Case

April 2015

Table of contents

Glossary of Terms

Acronym	Description
Council	Auckland Council
AP	Auckland Plan
APT	Auckland Passenger Transport Model
ART	Auckland Regional Transport Model
AT	Auckland Transport
BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CBD	Central Business District
City Centre	Auckland City Centre as usually defined geographically by the motorway cordon to the south and Waitemata Harbour
CCFAS	City Centre Future Access Study
CCMP	City Centre Masterplan
D&C	Design and Construct
DBB	Design, Bid, Build
DBC	Detailed Business Case
DCM	Design, Construct and Maintain
ECI	Early Contractor Involvement
EEM	Economic Evaluation Manual
GDP	Gross Domestic Product
ITP	Integrated Transport Programme
KPI	Key Performance Indicator
Leq	Equivalent sound level
LRN	Light Rail Network - the nominal network including Stage One and four arterial road corridors
LRT	Light Rail Transit
LTP	Long-term Plan - Auckland Council's ten year strategy and budget document
MCA	Multi Criteria Analysis
NLTP	National Land Transport Programme, as defined by the Land Transport Management Act 2003
NPC	Net Present Cost
NPV	Net Present Value
NZTA	New Zealand Transport Agency
O&M	Operating and Maintenance

Acronym	Description
PBM	Proxy Bid Model
PPP	Public Private Partnership
PSC	Public Sector Comparator
RFP	Request for Proposal
RLTP	Regional Land Transport Plan, as defined by the Land Transport Management Act 2003
RLTS	Regional Land Transport Strategy, as defined by the Land Transport Management Act 2003
RPTP	Regional Public Transport Plan, as defined by the Land Transport Management Act 2003
TOC	Target Out - turn Cost

Introduction – an Integrated Public Transport Strategy

Auckland Transport (AT) has determined an up-to-date strategy as to the best way to employ different public transport modes to most efficiently and effectively serve the City Centre – as part of a wider strategy for the whole Auckland city-region[1]. The statutory Regional Public Transport Plan is being amended to reflect the latest analysis that demonstrates that LRT (light rail transit) needs to be in the mix. This section sets out AT's thinking on the roles of the different public transport modes for inclusion in the RPTP when it is formally re-adopted.

Each element of the strategy will be supported by its own business case and decision making framework. In some instances the projects extend their influence beyond the City Centre and will be assessed accordingly. This paper outlines the strategy from a City Centre perspective. Its purpose is to provide context for business cases, projects and changes to statutory documents by:

- Outlining a multi-modal public transport strategy for the City Centre as part of the wider public transport network; and
- Explaining the connection between modes (function, timing, logic).

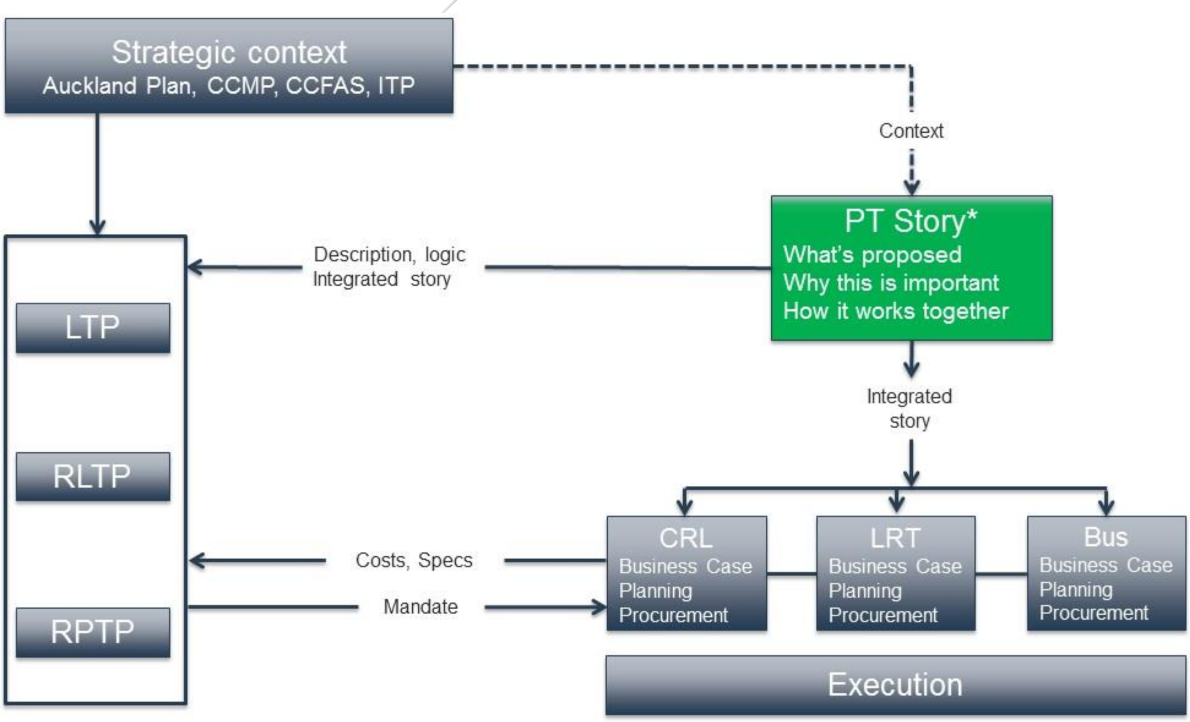


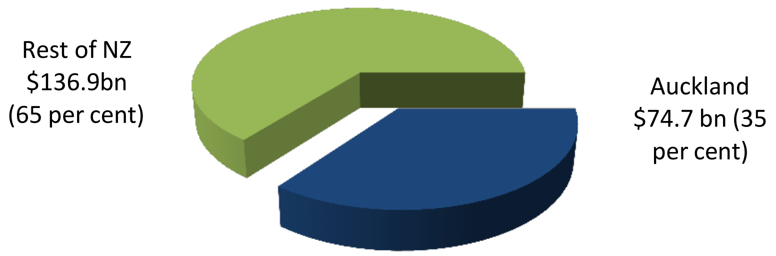
Figure 1: Role of the PT strategy paper

The body of this business case explains how the options were assessed for the Isthmus and City Centre corridors and the full rationale for LRT. The introduction draws on the strategy document to act as a scene setter across the modes.

[1] City Centre Integrated PT Story, AT, March 2015

Connecting Auckland to its Centre: The Public Transport Story

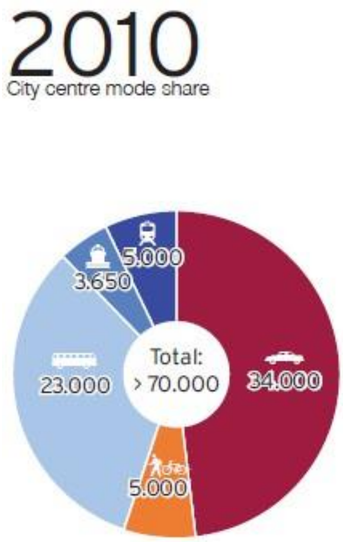
Auckland's City Centre is important. It is a major driver of economic growth on a national scale. Auckland's Gross Domestic Product (GDP) is currently 35 per cent of the nation's GDP. The City Centre currently accounts for 17 per cent of Auckland's GDP. By 2041 it is estimated to account for 25 per cent of Auckland's GDP and will grow faster than the rest of Auckland.

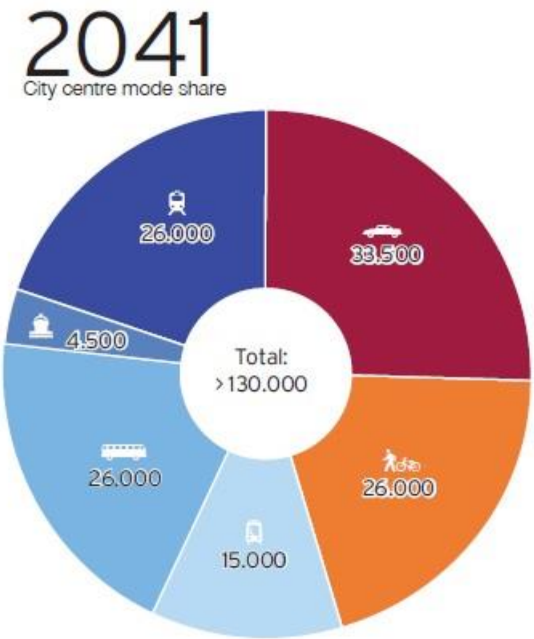


Unlocking the potential in the City Centre requires a combination of demand – which exists – and adequate access for the extra workers. Unless efficient access is provided through better public transport, the growth of the City Centre could be limited by its transport links leading to wasted economic potential.

Public transport is the important part of increasing capacity. Dedicated busways, LRT lines and railways can carry far more people than cars in any given corridor. Realistically these are the only way of allowing enough people to access the City Centre to meet demand.

By 2041 the picture of City Centre access will change to become dominated by public transport, assuming the services are provided. There are expected to be more people coming to the city centre, more on trains, more walking and cycling – about the same in cars and buses. Although buses will serve fewer markets as some are replaced with LRT, so more people will use buses from the markets they continue to serve.





Public transport, walking and cycling will need to accommodate all of the growth expected. Access by car cannot be expanded and would not be efficient use of space in any case. To make sure there is enough capacity for this growth a four-pronged public transport strategy has been developed.

Available modes and characteristics

Delivering on the access needs of the City Centre requires a multi-layered strategy. General road traffic, particularly for freight, deliveries and service related trips, remains important. Active modes are expected to increase significantly as a proportion of a growing travel market. Public transport is a vital part of the solution and is likely to carry the bulk of City Centre trips in the future.

The public transport element has two main ways of operating:

- Road based – using partial segregation, some priority or shared with traffic. This includes buses either on shared routes or segregated from traffic and LRT, either partially or fully segregated.

- Non road-based – fully segregated. This includes metro rail via the existing access to Britomart and the (planned) City Rail Link in the City Centre. *Note that the Northern Busway operates as a non-road based as far as Akoranga Station. South of Akoranga it has a prioritised on-street operating mode. For the purposes of this paper, with a City Centre focus, it is considered road-based.*

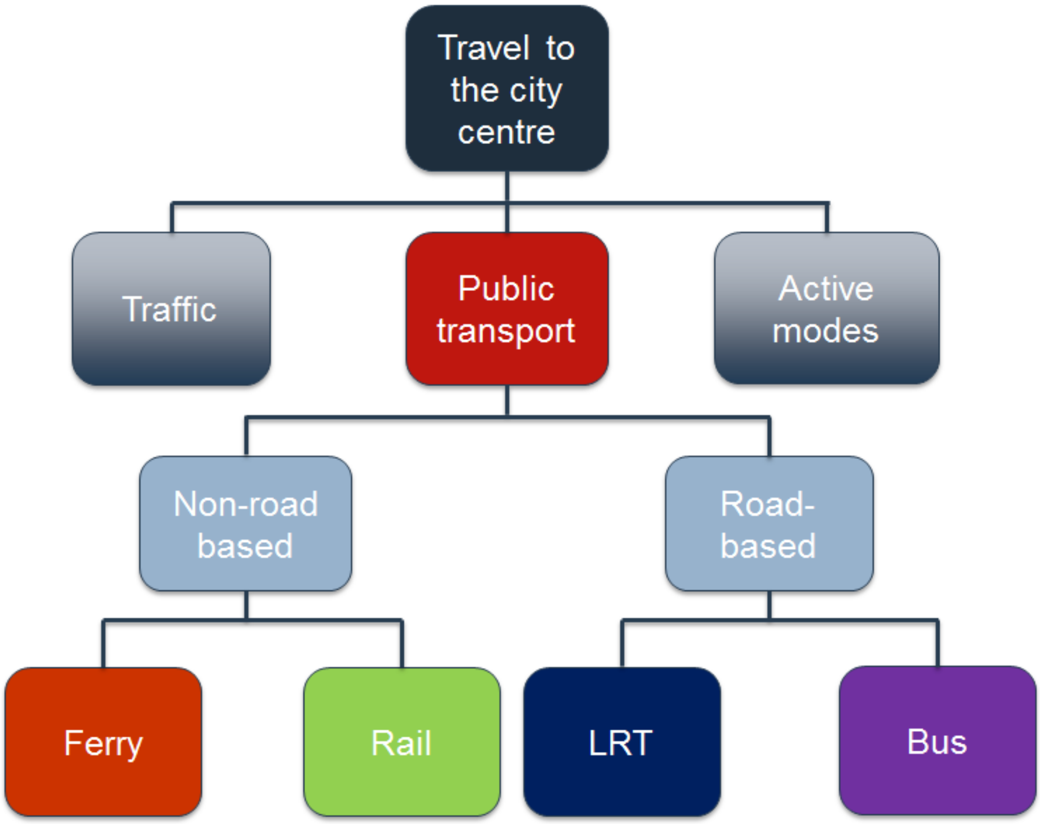


Figure 2: City centre access modes

The demand for travel to the City Centre and how it could be served is shown in the next figure.

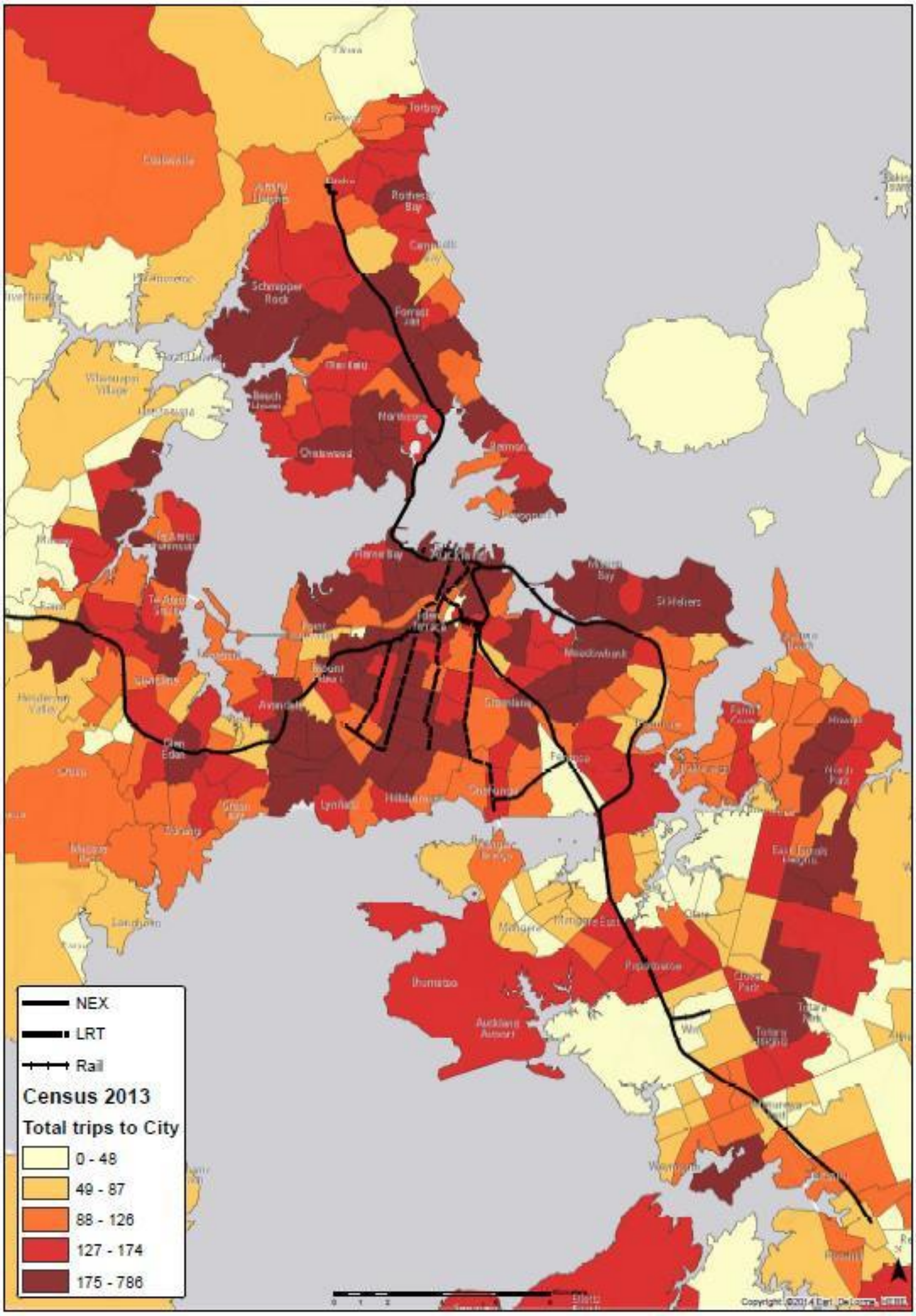


Figure 3: Demand for travel to the city centre: all modes (2013 Census)

The plan is to serve the City Centre with modes appropriate to their markets, both geographic and by scale of patronage. In broad terms this means that metro rail with its faster speeds, high capacity and more widely spaced stations should serve the outer areas (with busways performing a similar role, where rail doesn't run), standard buses serve inner areas, where slower speeds but more frequent stops are the best solution for the shorter distances, LRT- with characteristics between metro rail and buses is the best mode for the medium distance but heavy patronage area of the central isthmus. Ferries are also an efficient mode for some medium distance catchments and obvious special cases, such as islands.

It is important that the City Centre is a vibrant and exciting place that is easy to get around on foot and with quality urban spaces that people want to be in and invest in. Transport must be delivered in the City Centre in a way that does not detract from these qualities and in fact enhances them. The strategy has been developed to support these wider City Centre outcomes.

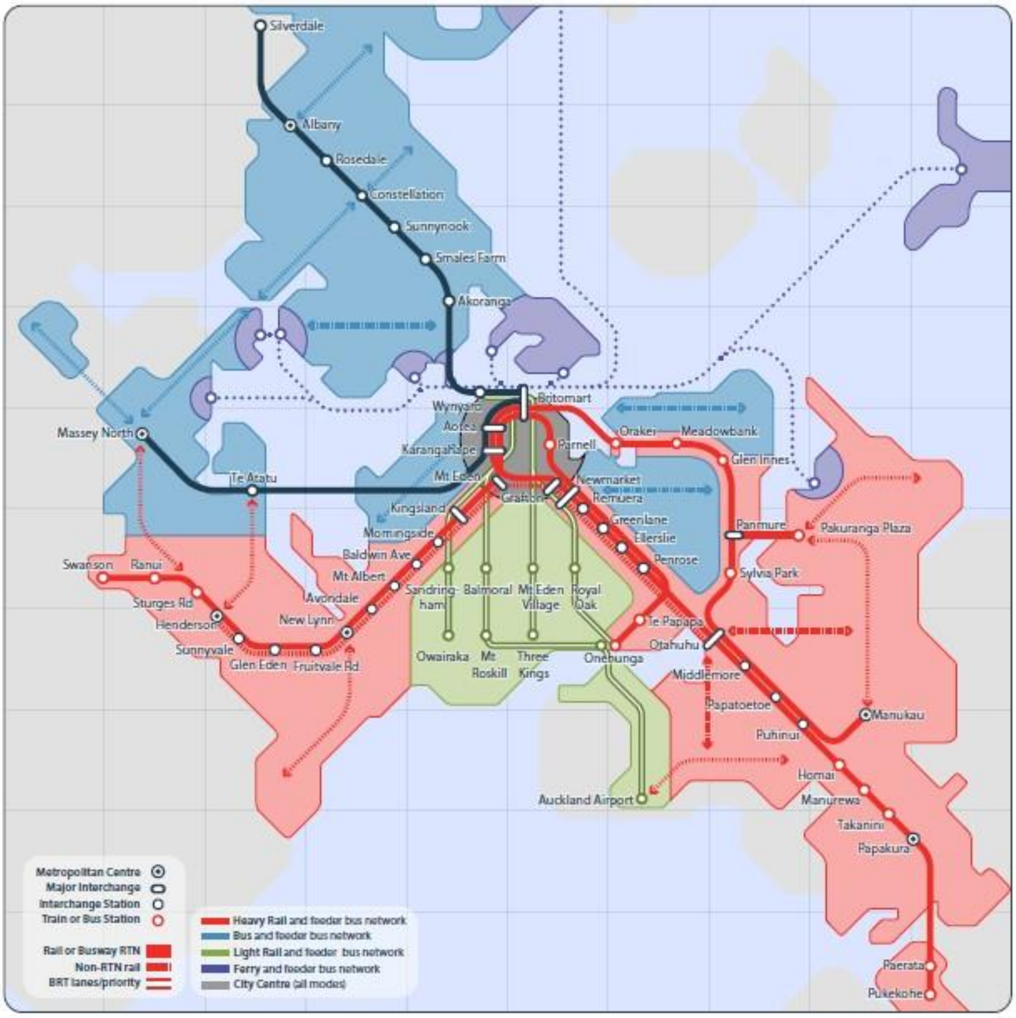


Figure 4: Overall public transport strategy

Business Case Executive Summary

- This business case explains the rationale for the introduction of a Light Rail Network (LRN) serving Auckland's City Centre and providing a sustainable public transport solution both for the City Centre and for a large section of the Isthmus where capacity for additional bus services has already been exhausted or will be in only a few years - while the rapidly increasing population is driving demand to unprecedented levels.

- The business case establishes that Light Rail Transit (LRT) serving the core of Auckland is required for a step change in capacity whilst also enhancing the amenity of the City Centre and overcoming numerous practical operational difficulties. The business case shows that there are network options that are economically justified in accordance with the New Zealand Transport Agency's Economic Evaluation Manual (EEM). It does not, however, fully define the preferred network to be served, over time, by LRT. Significant investigation, design and analysis are required to fully define and optimise such a network and plan for its delivery.

- The business case establishes that whatever network variant is chosen, a section along the full length of Queen Street is common to all and is an essential first and urgent step to introducing LRT to Auckland. Extending this stage to the vicinity of Kingsland provides an alternative service for customers from the west giving better linkages to parts of the City Centre and route options while the CRL is under construction. Ideally this first section needs to be operational in 2017.

- A second stage along Dominion Road should follow as soon as possible, to start to relieve the most heavily used road link – Symonds Street - and to reduce the number of terminating buses within the City Centre where space is severely limited. The opening of the Waterview section of SH20 in 2017 provides a once-off opportunity to undertake the necessary works while traffic on Dominion Road leading to operations commencing in 2019.

- A connection to the Wynyard Quarter, one of the country's largest and most important regeneration precincts and one that is very heavily dependent on effective higher capacity public transport to overcome its access challenges, could follow soon after.

- The Auckland Isthmus[2] contains a population of some 375,000[3], and some 340,000[4] jobs, and makes up the majority of the area of the former Auckland City, previously New Zealand's largest local authority. In the new greater Auckland, the area continues to be a vital economic and residential heart, but is not well-served by public transport in its core where traditional streets still attempt to carry numerous buses whilst also serving as arterial roads and commercial "high streets".

- Within the Isthmus, the City Centre is one of two priority - "Big Initiative" - areas in the Auckland Plan. Its success is critical to achieving the economic, land use and cultural outcomes that underpin the vision of Auckland being the world's most liveable city. The success of the City Centre is linked strongly to the performance of the adjoining area, the wider Auckland Isthmus.

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[2]Defined as the five local board areas of Waitemata, Orakei, Albert - Eden, Maungakiekie - Tamati, and Puketāpapa
[3]http://www.censusauckland.co.nz/local - board - view/ accessed 29 November 2014
[4]http://www.aucklandcouncil.govt.nz/EN/AboutCouncil/RepresentativesBodies/LocalBoards/Pages/home.aspx?utm_source=shorturl&utm_medium=print&utm_campaign=Local_per cent2BBoards accessed 29 November 2014

- Creating a stunning and economically productive central Auckland requires a transport network that will efficiently and effectively facilitate the movement of people to and through the City Centre - without itself degrading the quality of the City Centre or the wider neighbourhoods.

- The City Rail Link (the CRL) will help achieve the transformation of Auckland, by driving a major shift towards greater use of public transport and an increase in the density of residential and business development in the City Centre, and along the rail corridors.

- While the CRL will address regional needs it will not provide the total answer. It will deal with over-capacity access points from the west, Manukau (and points southwards) and the east but will not address access from the north and the triangle from the central and southern Isthmus. Critical locations such as the university campuses and the Wynyard Quarter cannot be served effectively by metro rail.

- The seminal City Centre Future Access Study (CCFAS), in 2012 demonstrated that while the CRL was an essential investment, no option existed that would fully address all movements and that bus numbers would be a future problem that needed to be further investigated.

- The CRL will assist in freeing up movement within the City Centre but buses from the areas not served by metro (commuter) rail will still create significant congestion and impact on local movement, amenity and ultimately economic growth. Further, terminal capacity for buses is already at a premium and will become a growing challenge from a cost and operational perspective.

- Analysis shows that LRT should be developed over time, but with an early start being required on the most heavily used access corridor to and through the City Centre in order to:

  - address the growing bus operational and general capacity problems which are already critical both on some individual links (notably Symonds Street) and for total required terminal capacity

  - provide an alternative service for customers on the western rail line which will be under severe pressure as a result of the rapid patronage growth being experienced and the service limitations that will be inevitable whilst the CRL is being linked into the North Auckland Line at Mt Eden

  - strengthen the transition to the urban form for Auckland set out in the Auckland Plan

  - overcome major construction difficulties that will arise in later years - the inevitable disruption to the roads and public transport network during implementation will be much harder to manage when the remaining capacity on the roads has been taken up by population - related traffic growth and the necessary additional bus services

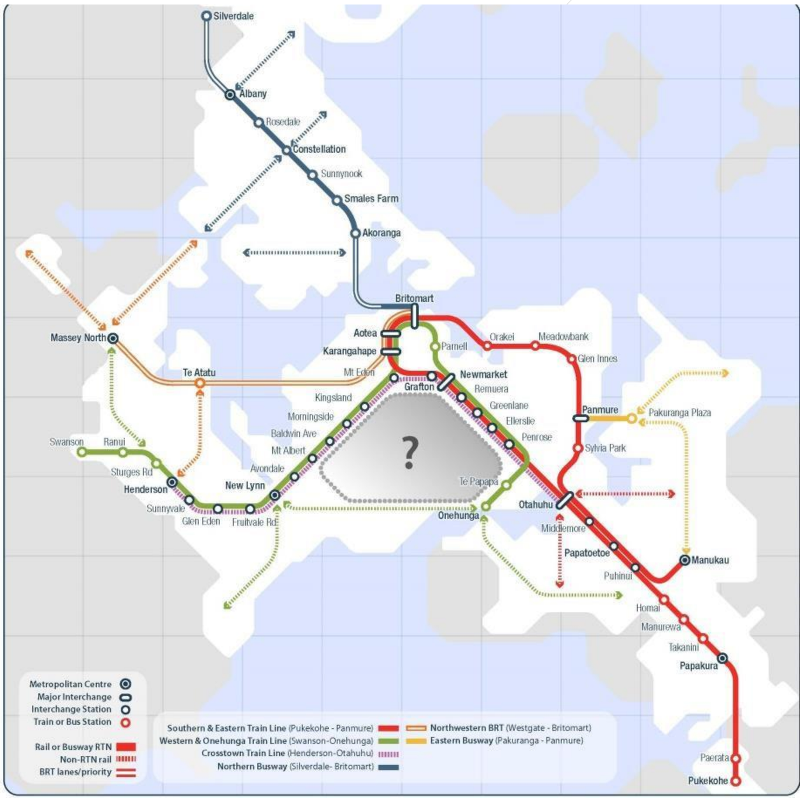
  - in particular the opening of the Waterview section of SH20 in 2017 will provide a one-off opportunity to construct the LRT tracks on Dominion Road when traffic levels are much reduced

  - ensure that core economic destinations are adequately served by appropriate public transport as soon as possible

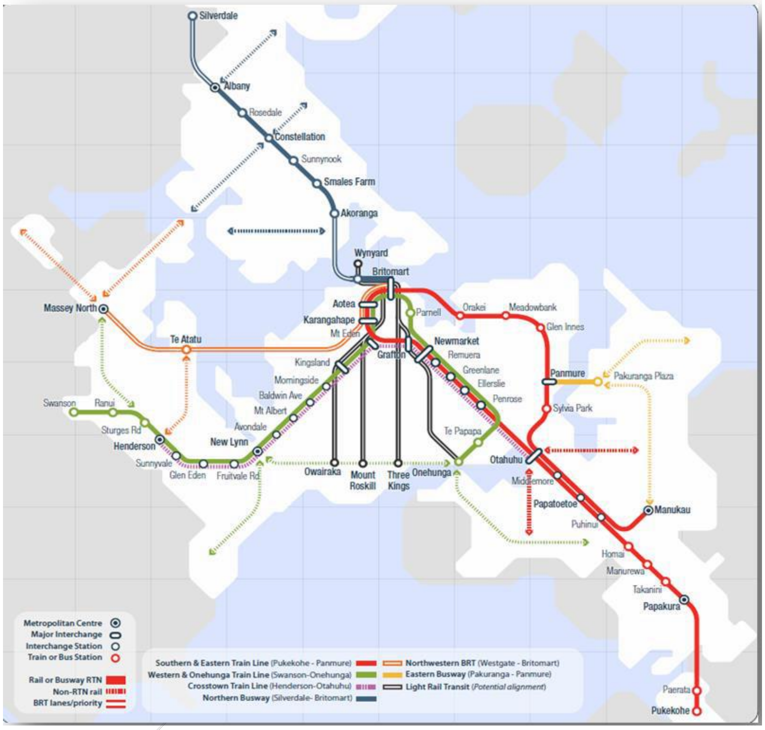
- bolster Auckland's role as an event and visitor destination – with heavy use expected of the initial Queen Street stage for such reasons

- signal unmistakably the commitment that Auckland will have a modern, competitive world class centre - a message that will reinforce its attractiveness as a place to live, study and do business.

Rapid Transit Network showing the 'void' in the central Isthmus



Analysis has been undertaken to identify a possible LRT system for the medium- to long term. The likely network is shown below (without an LRT link to the airport as that is the subject of separate investigations in the AT SMART (South Western Multimodal Airport Rapid Transit Project) study). Whilst this network has been shown to be a justifiable and desirable investment, further investigation will be carried out over time, as each stage is subject to its own detailed business case.



AT is studying the opportunity to convert the Northern Busway to LRT in the longer term. Planning for the NW busway is also being advanced with Council and the NZ Transport Agency. This work will include consideration of future proofing for LRT

Costs

The capital costs of the potential medium- to long-term LRN shown above are:

Capital costs (undiscounted)

Real $ (millions)	Stage One – Queen Street to Kingsland	Stage Two - Dominion Road (including depot)	Wynyard Quarter connection	Stage Three - Sandringham Road	Stages Four and Five - Customs Street to Onehunga	All stages
Physical works	420	630	100	295	1,395	2,840
LRV purchases	40	70	40	100	110	360
Physical works plus LRV	460	700	140	395	1,600	3,295

These costs would be off-set by reduced costs from requiring fewer buses and by the lower operating costs of LRT against equivalent bus services.

Economic assessment

A preliminary economic appraisal of an LRT network, based on serving Queen Street and Dominion Road in the short-term (followed by a link to the Wynyard Quarter) and the possible medium- to long-term network above, has been carried out. It shows that the expected economic benefits clearly exceed the costs using the New Zealand Transport Agency's Economic Evaluation Manual (EEM) and core parameters of a 40 year evaluation period and six per cent discount rate (a BCR of 1.2 to 1.4).

The true benefit cost ratio (BCR) is likely to be in the range 2.0 to 2.5, depending on the factors taken into account and the level of population growth. 2.4 is the mid-point BCR between medium and high growth based on the New Zealand Transport Agency's Economic Evaluation Manual (EEM) using a sixty year evaluation period and four per cent discount rate, as appropriate for a long-lasting project providing long term future benefits. A BCR of 2.2 is the central estimate of an alternative calculation based on the property value impacts observed on multiple similar schemes across the world.

EEM-based benefit calculation, discounted at six per cent over forty years.

Benefit category	Medium population growth NPV ($m)	High population growth NPV ($m)
Time travel benefits	1050	1190
Public transport user benefits	239	263
Reliability benefits	770	845
Noise	75	75
Health benefits from walking	66	88
City Centre pedestrian travel time	25	25
Emissions	4	3
Residual value	60	30
Agglomeration	157	179
Total	2365*	2653*

* Sums may not equate owing to rounding

The discounted capital and operating cost, allowing for savings from reduced bus costs, is $1934m (at 6 per cent discount rate over 40 years) giving the BCR range of 1.2 to 1.4. While the larger value relates to a higher population growth scenario, it could be considered also to represent a scenario consistent with the higher patronage growth that is currently being experienced.

On this basis there is a clear economic justification to proceed with LRT to achieve the changes set out in the Strategic Case.

Significant work is required in conjunction with AT's partners - especially Auckland Council and the New Zealand Transport Agency - to refine and optimise the LRN, look at possible extensions and to develop the implementation programme.

It is clear, however, that the Queen Street section needs to proceed as quickly as possible. The business case therefore also includes additional information relating to the timing of the initial stages.

1 Introduction

This Business Case is derived from the evaluation of transport options to address central Auckland access issues. The recommended solution - Light Rail Transit (LRT) - is the only option that fully addresses the problems and complements the proposed investment in the CRL, which remains the top priority. LRT is shown to be the best option, having assessed other possible ways to supplement the CRL, including further integration between buses and metro (commuter) rail or a more advanced bus system.

The need to develop a complementary programme to metro rail, with the CRL in place, relates to the residual problems of City Centre access not solved by the CRL, and their impact on the economic development potential for Auckland and on City Centre amenity.

Analysis for Auckland Transport's Integrated Transport Programme (ITP) showed the adopted transport plans will not reach the Auckland Plan targets:

- Double public transport from 70 million trips in 2012 to 140 million trips by 2022 (subject to additional funding)
- Increase the proportion of trips made by public transport into the City Centre during the morning peak, from 47 per cent of all vehicular trips in 2011 to 70 per cent by 2040
- Reduce the amount of human - induced greenhouse gas emissions by 10 - 20 per cent by 2020 based on 1990 emission levels

The new LRT proposals are vital to enhance progress towards the targets.

1.1 Purpose of the Auckland Isthmus LRT network

The purpose of the enhanced public transport programme (LRT) is to:

Provide an effective public transport solution for those parts of inner Auckland and the City Centre that cannot be served by the metro rail network, with CRL; that supports growth requirements in a way that maintains or enhances the quality and capacity of the City Centre streets; and thereby resolve the outstanding issues identified in CCFAS including the impact on urban amenity of a high number of buses.

1.2 Objectives

The enhanced public transport programme is required to achieve the following objectives:

- Improve transport access into and around the City Centre to address current problems and for a rapidly growing Auckland:
  - Provide a transport system that is best able to satisfy the immediate needs and the long term, rapidly growing customer demand in the City Centre and approaches
- Improve the efficiency and resilience of the transport network of the City Centre:
  - Improve journey time, frequency and reliability of transport access into and within the City Centre and City Fringe
  - Improve the linkages and service of key destinations, particularly those not served by the CRL, notably the university campuses and the Wynyard Quarter

- Maximise the benefits of existing and proposed investment in transport (including CRL)
- Release the capacity constraints around the City Centre's most important approach routes and nodes

- Significantly contribute to lifting and shaping Auckland's economic growth:
  - Support economic development opportunities including serving and stimulating the development of areas of potential higher activity in the City Centre plus City Fringe
  - Enable a more productive and efficient city
  - Provide the greatest amount of benefit for cost
- Provide a sustainable transport solution that minimises environmental impacts:
  - Limit visual, air quality and noise effects associated with the growth in public transport
  - Contribute to the country's carbon emission targets
  - Take account of 'whole of life' sustainability impacts
- Contribute positively to a liveable, vibrant and safe city:
  - Enhance the attractiveness of the City Centre and City Fringe as an outstanding place to live, work and visit
  - Protect our cultural and historic heritage for future generations
  - Help safeguard the city and community against rising transport costs
  - Reduce surface transport congestion
- Optimise the potential to implement a feasible solution
  - Ensure that the preferred option is achievable in target timeframes – to allow urgent issues to be addressed and to provide for the longer - term
  - Take account of the ability to stage a solution
  - Take account of the Resource Management Act 1991 and other legal process requirements.

1.3 Option Evaluation

The City Centre Future Access Study[5] (CCFAS) was a strategic and economic evaluation of possible ways to improve access to and through the City Centre. It concluded that the CRL was the best 'headline' project but needed to be complemented by improved bus services. Even with these enhancements, however, it was estimated that longer-term traffic speeds in the City Centre would be very low.

[5] City Centre Future Access Study, Sinclair Knight Merz for Auckland Transport, December 2012

As a result of these findings and AT's analysis around its initial Regional Public Transport Plan[6] (RPTP) and the ITP, investigation of further complementary public transport options has been carried out leading to this business case. Among the additional issues identified have been practical, bus operational difficulties that are already apparent.

A long list of options covering a broad range of potential solutions with a variety of public transport modes was evaluated, both qualitatively and quantitatively in line with the NZ Transport Agency's Economic (the Agency) Evaluation Manual.

LRT was identified as the preferred option. The Dominion Road corridor and Queen Street were shown to be the priority, with use of Queen Street as the critical factor to unlock the public transport constraints, as well as providing significant benefits in its own right.

Section 5 below discusses why the early sections are required urgently.

2 The Strategic Case

2.1 The strategic context

2.1.1 The Auckland Plan

The Auckland Plan[7] (the Plan) was adopted by Council in June 2012. It provides the overarching strategic framework for the long term development of the city - region. It sets out the vision and the outcomes, principles and transformative shifts required.

Two Council plans will help implement the Plan over its first 10 years:

- the Unitary Plan, the statutory plan under the Resource Management Act 1991 that determines how the city will develop (currently the Proposed Auckland Unitary Plan (PAUP)

- the Long-term Plan (LTP), under the Local Government Act 2002, which provides the funding to deliver the Plan on a staged basis.

Achievement of the Plan's overall objectives and growth projections has the following components:

- Making a Quality Compact Auckland Work: introduces the concept of "development areas" to accommodate growth based around town centres, corridors and suburban areas contiguous to town centres. The development areas have good transport access leveraging off past and future investment in Auckland's rapid transport network (RTN) and around rail stations.

- Development Strategy (urban core)[8]: the development strategy is designed to focus new development around the current and planned future RTN and horizontal infrastructure provision, with urban intensification around metropolitan centres, town centres and corridors.

[6] Auckland Regional Public Transport Plan, Auckland Transport, November 2013
[7] Auckland Plan, Auckland Council, June 2012
[8] Ibid, page 55

- Key structural Shapers and Enablers: Critical infrastructure, integration of land use and transport, blue and green networks and the principal economic gateways of the ports and airport.

- Two Big Initiatives: transformational change to the Auckland CBD to create a global city and destination of international significance; and the southern initiative that concentrates on addressing social needs.
- Working and Delivering with Others: achieving the objectives of the Plan through collaboration and commitment to transformational shifts and strategic directions.

2.1.2 The City Centre Masterplan and Waterfront Plan

The City Centre Masterplan[9] (CCMP) is a non-statutory document that expands on the Auckland Plan.

The CCMP sets out the Council's goals for the City Centre as a globally significant centre for business - the Engine Room of the Auckland economy with a vibrant and vital retail and commercial core. It specifies targets relating to commercial occupancy rates and an increase in the number of top 200 business head offices.

The CCMP also includes policies relating to increasing urban living and ensuring that major cultural institutions of quality are located in the City Centre to provide professional and international cultural events. The City Centre is seen as becoming the hub of an integrated regional transport system - with a range of public transport options.

Enhanced public transport, and in particular the CRL, are specified as vital enablers of the CCMP's aspirations for the City Centre to enable easy access to its employment opportunities and other offerings.

Similarly, the Waterfront Plan[10] envisages that over the next 30 years Auckland's waterfront redevelopment will directly and indirectly contribute to a total of 40,000 jobs for Auckland. It is expected that 61 per cent of waterfront jobs in 2040 will be in business services, 25 per cent in retail, food and beverage and 11 per cent in marine and fishing. Other industries that will feature prominently at the revitalised waterfront are the cruise industry, tourism and events and construction. A goal for the waterfront is to be a place that is "highly accessible, easy to get to and to move around in, where people feel connected to the wider city and beyond by improved pedestrian and cycling linkages, fast, frequent and low - impact passenger transport". The Waterfront Plan noted strong public support for "improving public transport services and connections (including ferries and trams)"[11].

The CCMP and Waterfront Plan help drive the process to transform the City Centre.

2.1.3 The Integrated Transport Programme

The Integrated Transport Programme[12] (ITP) is a non-statutory document that was prepared by Auckland Transport in collaboration with the Transport Agency and Council. Its purpose is to coordinate the investment and other activities of transport network providers to ensure they respond effectively and efficiently to the strategic vision, outcomes and targets of the Plan, and to the Government's wider transport policies. It does this by setting out a transport system

[9] City Centre Masterplan, Auckland Council, 2012
[10] The Water Front Plan, Waterfront Auckland, June 2012
[11] Ibid, pages 62, 14
[12] 2012 – 2041 Integrated Transport Programme, Auckland Transport, undated

investment programme to support the growth of the city in the moderately compact form proposed in the Plan.

The ITP is being developed and improved over time as it is implemented in a series of three year programmes (consistent with the Agency's National Land Transport Programme timelines). The second iteration has been used as the basis for the Mayor's proposal for the LTP (basic transport network). This version of the ITP has been used to define the base case - or "Do Minimum" on which the analysis of the LRT proposal has been based.

The analysis undertaken for the first, adopted, ITP and its draft successor contributes to the deficiency analysis used to establish the need for the LRN proposed in this business case.

The output of this business case will serve as input to the next ITP.

2.1.4 Regional Public Transport Plan

The Auckland Regional Public Transport Plan 2013[13] (RPTP) prescribes the public transport network that Auckland Transport proposes for the region, identifies the services that are integral to that network over the next 10 years, and sets out the policies and procedures that apply to those services.

As the RPTP is a statutory document that sets out the services to be procured by AT, a variation process taking account of statutory requirements[14] and using the consultation requirements under Section 125 (1) of the Land Transport Management Act 2003 will be required, for the proposed service changes in this business case as they would trigger the significance criteria in the document[15].

AT's vision in the RPTP is for an integrated, efficient and effective public transport network that caters for a wider range of trips and is valued by Aucklanders.

To achieve the vision, the RPTP states that 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.

LRT has now been identified as necessary to improve achievement of all five of the RPTP outcomes, and will be included in a variation of the RPTP. The variation is likely to be advanced in time for adoption in July 2015. Stakeholder (operators) consultation on the possible introduction of LRT is underway with more formal consultation in May 2015, if AT resolves to pursue the option.

2.1.5 Regional Land Transport Strategy to 2015

The Auckland Regional Land Transport Strategy 2010 - 2040 (RLTS) remains a relevant statutory document until June 2015, when it will be superseded by the first RLTP.

[13] Auckland Regional Public Transport Plan 2013, AT, adopted 23 September, 2013
[14] Ibid, Appendix 3 Statutory Requirements
[15] Ibid, Appendix 9 Policy on Significance

The strategy[16] is for Auckland:

> *"to develop a transport system which provides balanced levels of access, high reliability and safety, and where people and businesses have realistic choices about how and where they travel.*
>
> *"While this will require continued investment to complete the agreed strategic roading system, including giving greater attention to improving the efficiency of the network of arterial roads, there is a strong need for significantly greater investment in public transport (both infrastructure and services), walking, cycling, and behaviour change measures to counter long term under - investment in these modes."*

LRT is necessary to increase the level of reliable access through the Isthmus and to the City Centre in particular. The deficiency analysis (see Section 2.4 below) demonstrates that travel times and capacity will otherwise become progressively unsatisfactory and problematic.

2.1.6 RLTP (*proposed*) from 2015

The first RLTP has recently been the subject of wide consultation. It provides further context for the LRT proposal, which is specifically included in the document - and was widely supported, with the vast majority of those who commented on LRT, 1251 out of 1390 being favourable, 53 did not support and 74 did not state a preference. For any implementation of LRT the proposed RLTP, will need to be amended to include LRT (Stage One) as a specific *activity*[17]. The amendments to the proposed RLTP could be taken forward alongside those to Council's LTP.

2.1.7 AT Priorities

Auckland Transport has identified five 'strategic themes' as its priorities to achieve the Auckland Plan transport outcomes as shown:

Figure 1 : AT Strategic Themes

		Auckland Plan Strategic Directions				
		Increased access to a wider range of quality, affordable transport choices	Auckland transport system moves people and goods efficiently	Auckland's transport system enables growth in a way that supports communities and a high quality urban form	Reduce adverse effects from Auckland's transport system	Better use of transport investment
AT Strategic Themes	Prioritise rapid, high frequency public transport	Strong	Moderate	Moderate	Minor	
	Transform & elevate customer focus and experience	Strong	Minor	Moderate	Strong	
	Build network optimisation & resilience	Moderate	Strong	Minor		Minor
	Ensure a sustainable funding model					Strong
	Implement accelerated, adaptive, innovative solutions	Strong	Moderate	Moderate	Strong	Moderate

16 Auckland Regional Land Transport Strategy 2010 - 2040, Auckland Regional Council, April 2010, page eight

17 An activity is the terminology for an item to be included in the NLTP for funding

LRT is a direct contributor to the strategic themes and therefore to the corresponding Auckland Plan objectives. Achievement of the themes was used in a multi - criteria analysis to identify the best option for the enhanced public transport system.

2.1.8 Government transport strategy

The Government has three focus areas for transport, as outlined in the transport policy document, Connecting New Zealand[18], and the Government Policy Statement (GPS) on Land Transport Funding[19], being:

- Economic growth and productivity.
- Value - for - money.
- Road safety.

The GPS includes the following statements that resonate with the LRT rationale:

"GPS 2015 continues the approach started in 2009 of putting the wealth-generating capacity of our economy at the top of the agenda. It focuses on investments that will improve connectivity and reduce the costs of doing business. It maintains the impetus on improving the safety of travel, and puts a spotlight on the continued delivery of measurable value from land transport investment."[20]

In respect of Auckland, the GPS states: "Further increases in the capacity and productivity of the Auckland roading network, particularly those sections currently experiencing severe delays, will therefore remain a priority. This will involve ongoing investment in State highway and local road productivity across the network. *This will need to be complemented by significant investments in public transport. Initially this would help unlock the potential created by recent initiatives. Later, further investment will be needed to provide additional capacity on corridors serving our main business and education centres at peak periods*."[21]

Within the objective of**:** *A land transport system that addresses current and future demand for access to economic and social opportunities,* the GPS states*:*

"Well used and configured public transport can increase network productivity on key corridors at peak periods when they are under the most pressure. For example, while constraints on Auckland rail capacity are not expected in the next decade, as a result of the significant additional capacity on new electric trains[22], bus congestion in the Auckland central business district is expected to emerge as patronage grows and additional services are provided. GPS 2015 will enable:

- public transport to be provided and developed at levels appropriate to their patronage and network function
- improvements to metro rail services to be completed, and integrated ticketing and public transport network changes introduced to increase patronage, including transfer and interchange facilities
- targeted infrastructure improvements that improve transfers across the network and address emerging bus capacity constraints in central Auckland, Wellington and Christchurch

[18] Connecting New Zealand – A summary of the government's policy direction for transport, Ministry of Transport 2011
[19] Government Policy Statement On Land Transport 2015/16-2024/25, December 2014
[20] Ibid, Introduction
[21] Ibid, Auckland, section, page emphasis added
[22] Recent very rapid patronage growth on the rail network would test this comment

- gains in public transport productivity."[23]

2.2 The case for change - the need to respond to population increases and stimulate economic growth

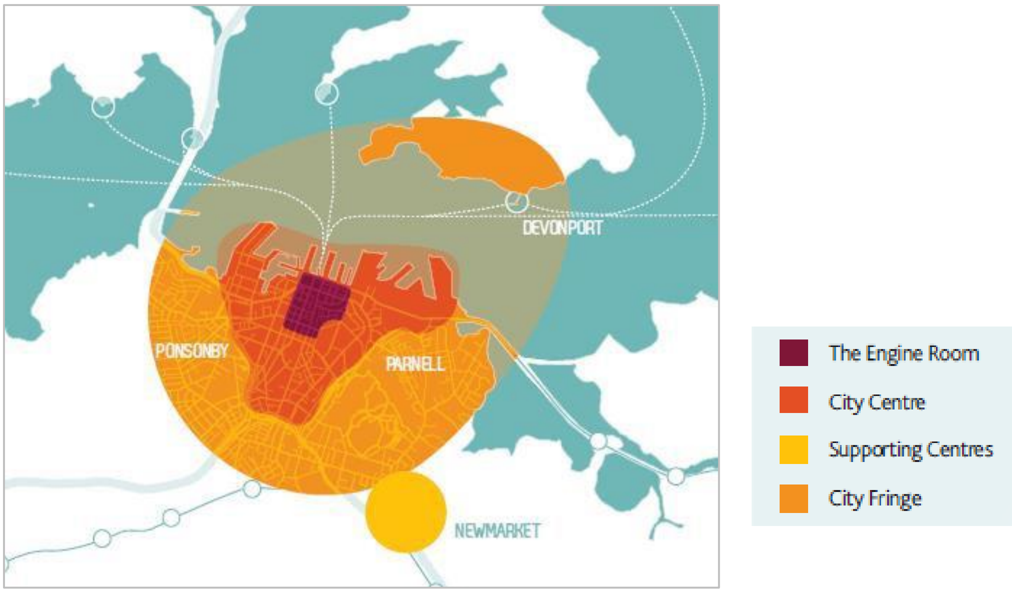
2.2.1 Regional growth

The Auckland Plan forecasts very substantial population growth for Auckland. By 2040 the Plan suggests that Auckland might have an additional one million people[24]. Even on a lower projection the increase is nearly three quarters of a million by 2045[25].

2.2.2 Residential growth in the City Centre

Within the overall regional growth, the residential population of the City Centre and Fringe is projected to almost double between 2011 and 2041. The City Centre is projected to grow by 96 per cent and the City Fringe by 99 per cent. These areas are shown in Figure 2.

Figure 2 : Auckland City Centre definition, source: CCMP, page 19



2.2.3 Economic and employment growth

The structure of the Auckland economy is changing. Just over one-third of Auckland's employment is currently in the production and distribution sectors; around one-quarter in each of the commercial sectors and retail, hospitality and recreation sectors, with the remaining employees in the education and health sector.

Auckland is expected to become increasingly specialised into commercial, office - based activity in the City Centre. Growth in the commercial sector will increase the demand for land and premises suitable for office - based activity, but may be restricted by poor access. Meanwhile, growth will occur in the production and distribution sectors, maintaining the demand for land to accommodate these sectors.

[23] Ibid, page 19
[24] Ibid, page 10
[25] Long-term Plan 2015-25, consultation document, December 2014, page 9

Table 1 : Forecast employment growth by sector and change in employment structure in Auckland, 2007 - 2041

Growth 2007 - 2041				Share of Auckland employment	
Industry sector	Net change	Annual average growth rate	Share of growth	2007	2041
Retail, hospitality and recreation	37,969	0.7 per cent	12 per cent	23 per cent	19 per cent
Commercial	129,411	1.7 per cent	39 per cent	26 per cent	30 per cent
Education and health	72,496	1.6 per cent	22 per cent	16 per cent	18 per cent
Total industry	329,126	1.2 per cent	100 per cent	100 per cent	100 per cent

Source: Auckland Council 2012, Auckland Growth Model.

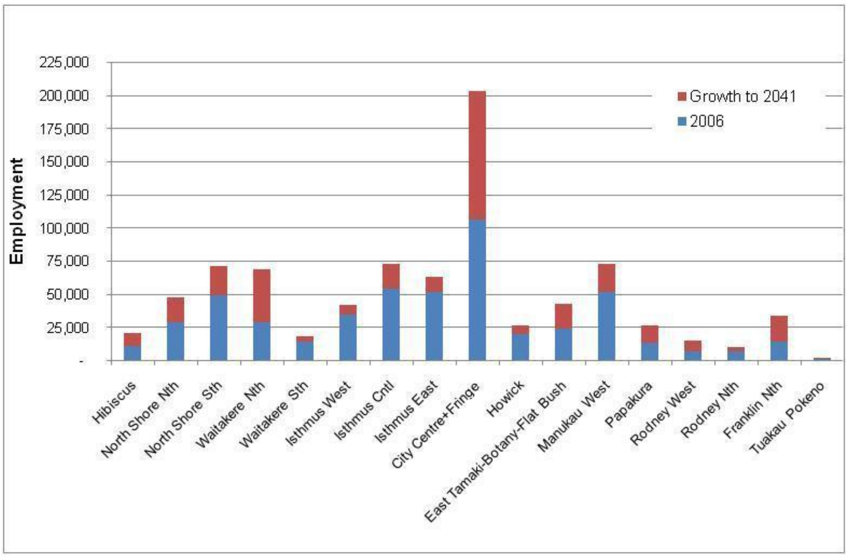
2.2.4 The growing importance of the City Centre

The City Centre plays a critical role in the region's and nation's economy. It accounts for 17 per cent of Auckland's Gross Domestic Product (GDP). By 2041 it is estimated that it could account for 25 per cent of the GDP. This is because the types of employment preferring to operate in a City Centre are growing at a much faster rate than the rest of Auckland industry. Achieving that level of employment growth in the City Centre is contingent on resolving the access and amenity issues. Evidence from multiple studies is that there is very limited capacity to increase road - based access to the City Centre. There is a limit to the number of buses that can be accommodated and metro rail is constrained by the current Britomart terminus - which will be addressed by the CRL, but not until around 2023.

The City Centre is a residential location, employment hub, education hub and the most important tourism and cultural destination in the region. Many of the surrounding areas of the Isthmus are identified in Auckland's planning documents as having high potential for supporting development – for more concentrated residential development, for example, but equally depend on having enhanced accessibility.

The employment numbers and the residential population of the City Centre and City Fringe are also projected to almost double between 2011 and 2041. Employment growth is shown in Figure 3 below. A further 15,000 (on top of the current 50,000 equivalent full time students (EFTS)) students is planned for at the tertiary institutions. These projections suggest that there will be increasing pressure on the access issues.

Figure 3 : Unconstrained projection of Auckland employment by area



City Centre employment growth is currently increasing at over 4.5 per cent, per annum[26]. If this rate of growth continues it will compound the need for urgent investment to start to address immediate problems and future proof the transport network.

It is vital to enable the City Centre to grow strongly to deliver the productivity benefits that concentrated city centres provide from service - based industries. The ability of people to specialise and develop expertise is significantly aided through the progressive intensification of cities.

Labour productivity in the Auckland region is estimated to have a premium of 30 to 50 per cent relative to the rest of New Zealand, with average labour productivity in Auckland's CBD at least twice that of the rest of New Zealand (excluding the Auckland Region)[27].

The City Centre critically underpins the ability of Auckland to achieve some of its wider goals around liveability and land use. The Plan and CCMP not only deliver an economic blueprint for the centre, but also provide the basis for more effective land use across the region, including the wider Isthmus. The City Centre has significant capacity for more employment locations, provided access and amenity are supportive.

2.3 The case for change - regional transport services

2.3.1 Overview

Auckland is a geographically dispersed city with multiple employment hubs and a large, relatively low density residential area. While the Plan and the dwelling growth discussed above support greater intensification, the Auckland region has required a transport system that serves dispersed travel patterns as well as the City Centre. That network with its emphasis on roads has been steadily provided over time. With the changing economic structure, however, it is increasingly important to address the critical issue of access to the City Centre. That need is

[26] Review of Government Patronage Targets for Accelerating the City Rail Link, PwC for Auckland Council April 2014

[27] Population and Growth: why bigger can be better, Rachael Logie – Senior Economist, Auckland Council, Auckland Economic Quarterly, January 2013 – citing Maré, D C. : Labour Productivity in Auckland Firms, Motu Working Paper 08 - 12 (and MED Occasional paper 08/09).

being addressed partially with the CRL but also needs complementary development of road - based public transport as discussed below.

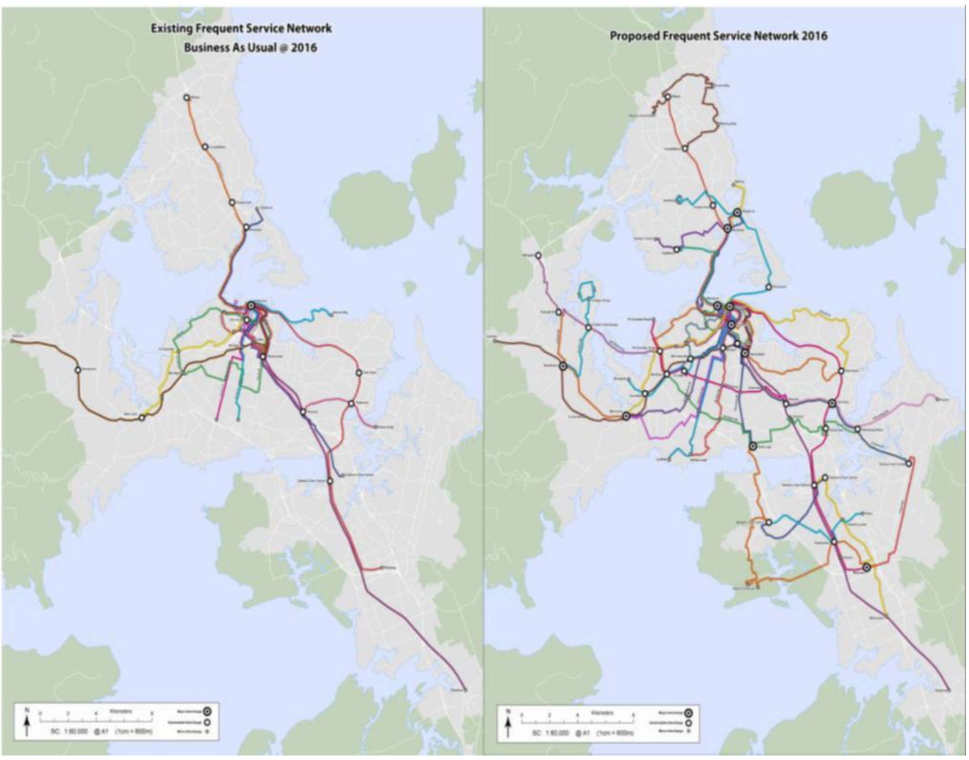
Significant work has been undertaken to optimise and improve efficiencies for the bus network. In particular, to rationalise the network to drive greater capacity and efficiency through the improvement of feeder services connecting to the Rapid Transit Network (RTN) (rail and the Northern Busway) and the removal of competing routes. The analysis shows, however, that significant deficiencies will remain.

2.3.2 Current City Centre access

The City Centre is the most important destination in the city and the most important transit route. Many people who have origins and destinations outside the City Centre pass through the City Centre and City Fringe.

The City Centre is serviced by a rail network encompassing four lines to the south, east and west. An improved Frequent Transit Network (FTN) will better connect bus services to the rail network providing a network effect.

Figure 4 : Frequent Transit Networks



Source: Auckland Transport

The FTN comprises public transport services which offer a 15 minute or better headway all day during weekdays. The current FTN shows the rail lines and some key radial bus routes as being the only services to offer this level of service. There are no frequent, cross - town services, so only small parts of Auckland are being served, and then this is only for travel to the City Centre. In the proposed FTN, there is a significant increase in frequent services, particularly cross - town, allowing many more transport choices. The new bus network will complement the FTN, and provide a range of other services.

The central section of the Isthmus, between the western and southern rail lines will continue to be served largely by traditional bus services that have an inherent conflict with adjoining land - uses through their high numbers and environmental impacts. There are also limited access points to the City Centre for geographical reasons.

2.4 The case for change - the evidence base

2.4.1 Deficiency analysis (with CRL in place)

The CRL will enable the metro rail network to deliver people into the City Centre more effectively from the west, east and south beyond the Isthmus, but will not serve either the north or the core of the Isthmus itself. Most of its benefits accrue to longer - distance travellers.

To assess the need for further change, a multimodal deficiency analysis was used to assess the future public transport deficiencies. The analysis identified the routes and trips where demand to access the City Centre exceeds the capacity of the public transport network. The deficiency analysis draws on a well - calibrated and validated transport model, and the anticipated number of public transport services operated.

The analysis is consistent with earlier work carried out - the CCFAS - which was the subject of extensive review.

The planning capacity used for the deficiency analysis was 80 per cent of the vehicular crush capacity. This means that when a transport route is identified as at or over capacity in this analysis, there may theoretically be some spare capacity. Continually operating a public transport system close to crush capacity, however, will have negative impacts on network performance through increased dwell times owing to issues with boarding and alighting from a heavily congested service. Rider sentiment will also be affected and public transport users are likely to look for other options if their service is continually operating above 80 per cent of crush capacity.

The capacity analysis includes several major radial routes into the City Centre. The eastern, western and southern rail lines all provide good service. The CRL increases rail capacity levels well in excess of those currently provided. The western line provides the most capacity with more than 9,000 people (nearly four times more than currently) able to travel between Henderson and the City Centre in the AM peak hour. The eastern and southern lines each provide capacity for approximately 4,500 people between Otahuhu and the City Centre. Southern line capacity increases to almost 7,000 as it joins the Onehunga line at Penrose.

Bus capacity city - bound on the harbour bridge exceeds 7,000 people in the AM peak hour. Other major routes include Sandringham Road, Dominion Road and Mount Eden Road, which provide capacity through the central Isthmus. Great North Road is the major bus route from west Auckland with an ability to transport approximately 1,500 commuters in the AM peak hour. Similarly, Great South Road provides a major bus corridor from the east.

Most of the inbound bus services in 2026 access the City Centre via Symonds Street, which gives extremely large modelled capacity values of over 8,000 people per hour. This represents more than 180 buses in the AM peak hour, which would most likely not be feasible in reality. Bus frequencies of more than 100 vehicles per hour per lane without off-line stopping facilities generally results in a degradation of performance with significant delays at stops and intersections. 130 buses per hour is a realistic operational maximum even for a route with a bus lane and off-line stops[28]. Even with a more conservative forecast for bus services, Symonds

[28] Eg Transit Capacity and Quality of Service Manual, Third Edition, Transportation Research Board, 2014

Street would remain a major access points for a significant number of bus routes throughout the Isthmus.

Fanshawe Street and Wellesley Street function as the major east - west bus corridors on the approach to, and through the City Centre.

By 2046 rail capacity on the western line is expected to increase to be able to cater for approximately 11,500 AM peak hour trips between Henderson and the City Centre. Service frequencies will remain at 2026 levels on other lines, although all 3 - car EMUs on the eastern and southern lines are to be replaced by 6 - car EMUs, providing an uplift in capacity for these services.

The bus network is modelled with a slight increase in capacity between 2026 and 2046. Total network - wide AM peak hour capacity increases by approximately six per cent. This increase occurs mainly in the outer regions of the model area such as Pukekohe in the south and Kumeu in the west.

While there was no capacity increase to the majority of bus routes modelled, in reality it is reasonable to expect some gradual capacity increases between 2026 and 2046 where that can occur. The City Centre, however, which requires the most capacity, is already significantly constrained and there is limited scope for large increases in bus capacity.

2.4.2 Relieving the total number of buses in the City Centre

Auckland has very confined space in the City Centre that is available for bus termination. The City Centre is already at the limit of the number of buses that can terminate there – 400 to 420 - with no prospect of adding capacity. Indeed maintaining that number requires a continuation of the present unsatisfactory situation with buses laying-over in inappropriate locations from operational and amenity perspectives.

There is no prospect for a major CBD bus interchange given the premium value of land (an underground option was investigated and rejected in CCFAS and again shown not to be viable in more recent assessments). While options are being investigated at Wynyard, Lower Downtown and in the Learning Quarter, they are not expected to add capacity, but rather to improve urban amenity and avoid some of the present unsatisfactory arrangements.

2.4.3 Demand analysis

In 2026, the western rail line carries over 5,000 people towards the city while the eastern and southern lines experience peak hour demand between 4,000 and 5,000. The busway from the North Shore is also a major access point into the City Centre with almost 7,000 inbound trips in the AM peak hour.

On the Central Isthmus, Sandringham Road, Dominion Road and Manukau Road experience significant demand. Great North Road is the major bus route from west Auckland with approximately 2,000 people using buses on this corridor on approach to the City Centre. Similarly, between 1,500 and 2,000 inbound trips are made on the Great South Road in the AM peak hour.

In the City Centre, Symonds Street experiences demand in excess of 7,000 inbound trips while Fanshawe Street and Wellesley Street carry more than 4,500 people west to east across the city centre.

In 2046 all rail services experience a significant increase in demand compared to the 2026 scenario. All lines carry more than 7,500 inbound AM peak hour trips as they approach the City

Centre. Bus demand on the harbour bridge also increases with almost 8,000 southbound trips occurring in the AM peak hour.

The northern ends of major bus corridors such as Great North Road, Great South Road and Manukau Road all experience inbound demand between 2,500 and 3,000 trips. Sandringham Road, Dominion Road and Mt Eden Road also continue to act as major city bound corridors with AM peak hour trips between 1,500 and 2,000.

Symonds Street is forecast to attract demand in excess of 11,000 trips. Wellesley Street carries more than 7,500 AM peak hour trips.

2.4.4 Volume - Capacity ratios

The forecast demand on the public transport network has been compared to the expected capacity to calculate volume - capacity ratios (VCR). This ratio shows areas of the network that may not be able to satisfy future public transport demand. A volume - capacity ratio of 1.0 indicates that demand is equal to capacity. Ratios less than 1.0 indicate spare capacity in the network while ratios above 1.0 indicate insufficient capacity.

VCRs in 2026 are shown for the greater Isthmus area in Figure 5 and for the City Centre in Figure 6. The ratios represent average values for all services on each link in the AM peak hour. For links with many services, VCR values would vary depending on the individual service. Services with the heaviest demand would experience VCRs higher than those calculated, whilst less patronised services would experience lower than average VCRs.

VCRs in 2046 are shown for the greater Isthmus area in Figure 7 and for the city centre in Figure 8.

Figure 5 : 2026 Volume - Capacity ratios

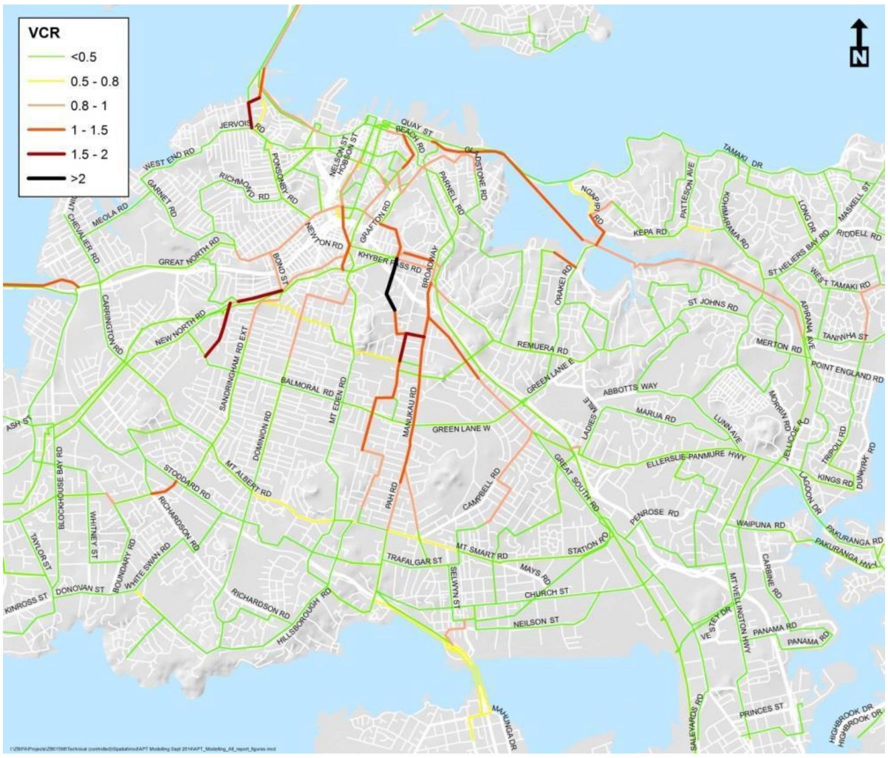


Figure 6 : 2026 Volume - Capacity ratios - city centre

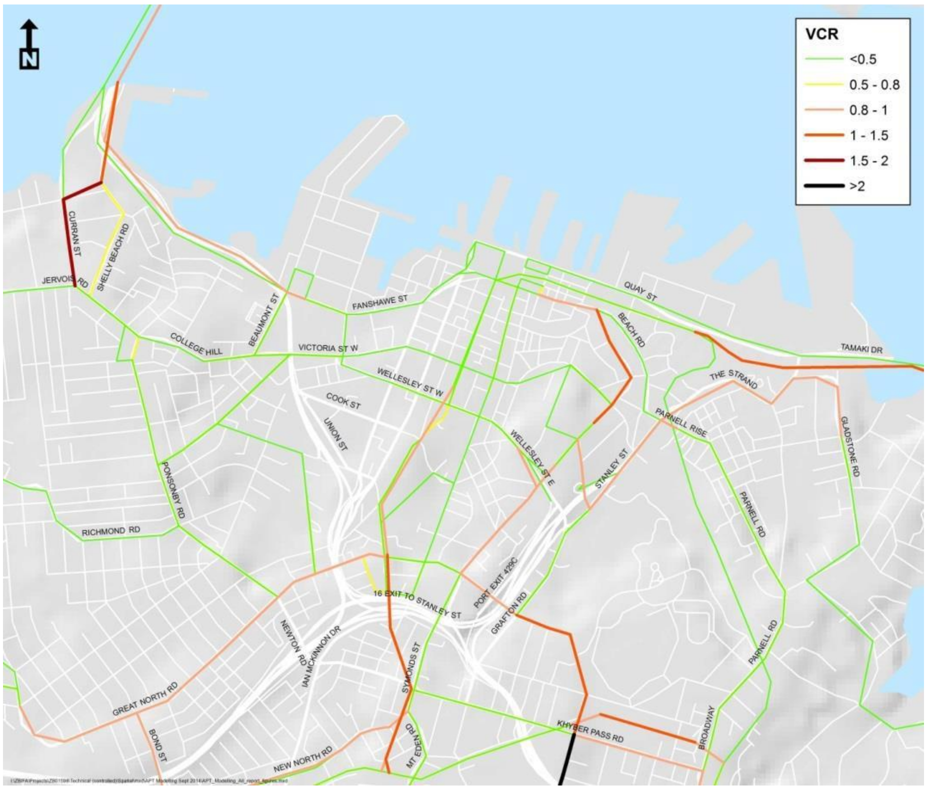


Figure 7 : 2046 Volume - Capacity ratios

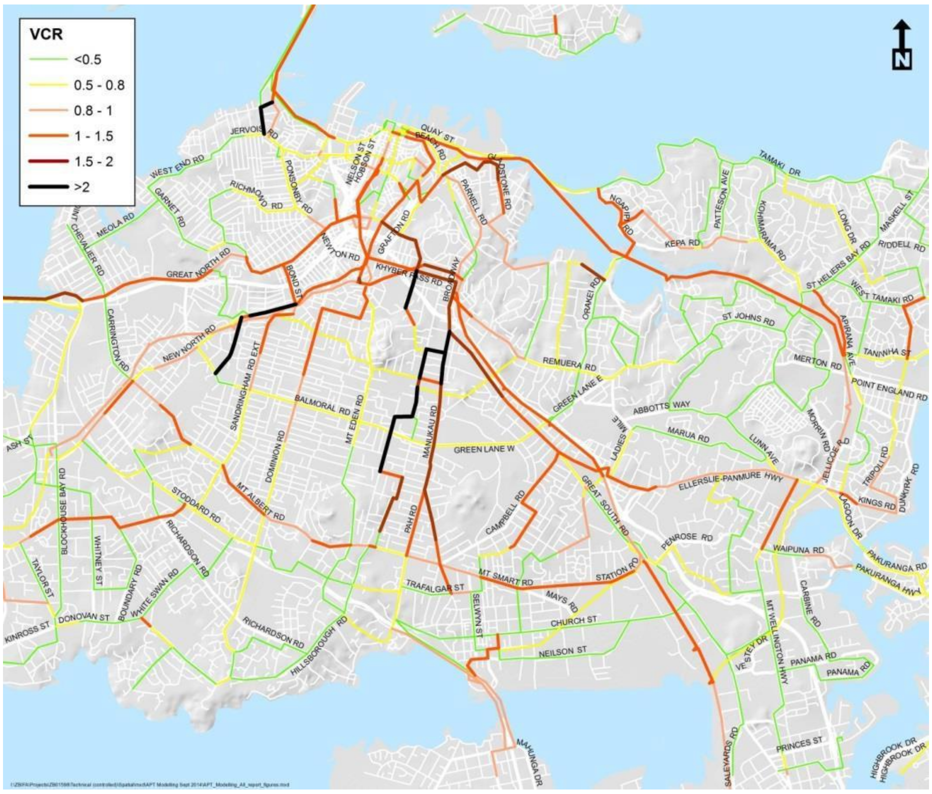


Figure 8 : 2046 Volume - Capacity ratios - city centre

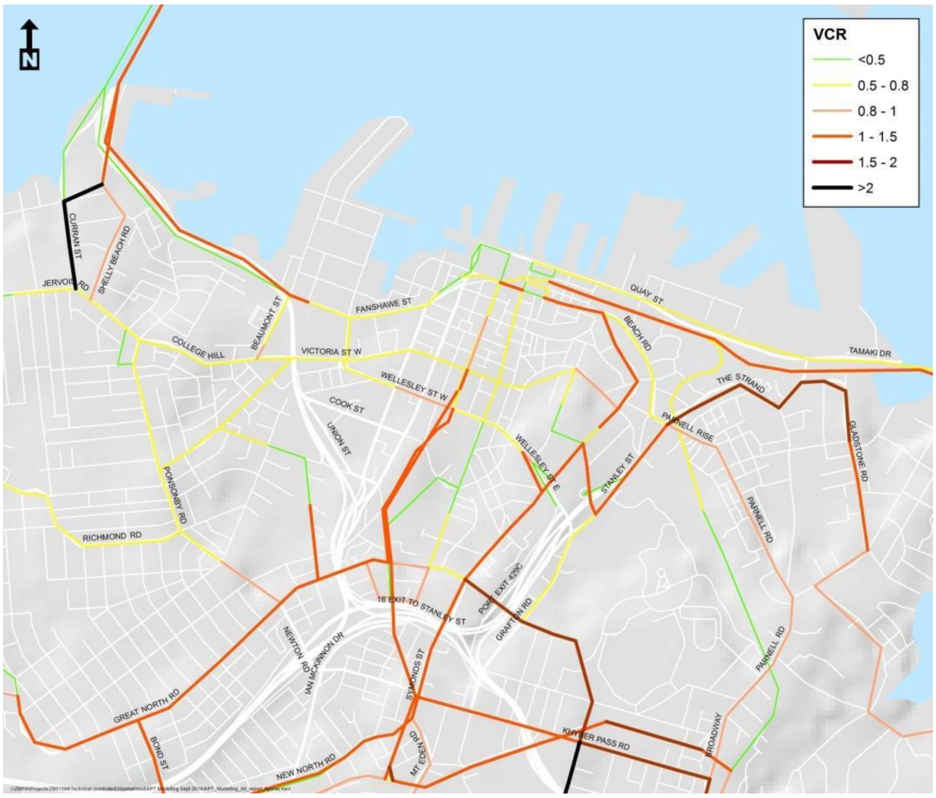


Table 2 below shows the growing problem with most VCRs below 1.0 in 2026, but with some very high ratios by 2046.

Table 2 : Critical VCRs by corridor (at peak location)

Corridor	VCR 2026	VCR 2046
Western Rail Line	-	-
Southern Rail Line	-	>0.8
Eastern Rail Line	>0.8	>1.0
New North Road	>1.5	
Great North Road	>0.8	>1.0
Sandringham Road	>0.8	>1.0
Dominion Road	>0.8	>1.0
Mount Eden Road	-	-
Manukau Road	>1.0	>1.9
Great South Road	>1.0	>1.5
Harbour Bridge	0.98	1.1
Park Road (Grafton Bridge)	>0.8	>1.5
Fanshawe Street	>0.8	>1.0
Symonds Street*	>0.8	>1.0

* Capacity unlikely to be achievable

2.4.5 Major bus corridors

There are several major bus corridors into the City Centre in the AM peak period. The seven busiest corridors are presented in Table 3 below. The peak demand on each route has been identified along with the available capacity as defined by the number of assumed services. Excess demand is shown in red text.

Table 3 Major bus corridor capacity deficiencies

Bus Corridor	Number of buses (capacity)	Peak demand 2026	Peak demand 2046
Great North Road	2,116 (46)	1,882	2,539
Sandringham Road	1,748 (38)	1,426	1,797
Dominion Road	1,656 (36)	1,640	2,176
Mount Eden Road	2,024 (44)	1,169	1,579
Manukau Road	1,380 (30)	1,846	3,046
Great South Road	1,840 (40)	2,027	3,051
Harbour Bridge	7,070 (125)	6,989	7,859

2.4.6 Deficiency analysis summary

The results of the deficiency analysis show that there are significant portions of the bus network that will not have sufficient capacity to cater for expected demand in 2026 and 2046. Most inbound routes reach capacity before they enter the City Centre. This is despite many links inside the City Centre having assumed very high bus frequencies of more than 150 buses per hour. This equates to more than 2.5 buses per minute in the AM peak which is unlikely to be feasible with only one dedicated bus lane. In reality, it can be expected that discrepancies between demand and capacity will be larger than presented in this analysis.

Before 2046, extra capacity will be required on or parallel to Symonds Street for public transport patrons arriving from the greater Isthmus area. Extra capacity will also be necessary for commuters arriving in the city from north of the harbour bridge.

Outside the City Centre, Manukau Road, Dominion Road, Sandringham Road and Great North Road all require extra bus capacity as they approach central Auckland.

In general, the rail network has sufficient capacity to meet future demand. Some over - capacity is observed in 2026 on the eastern line between Glen Innes and Britomart. However, this is rectified in 2046 with the proposed introduction of 6 - car EMUs to this line.

Some spare capacity is observed on the majority of the rail network in 2046, though over - capacity on services approaching the City Centre means that some potential passengers are being deterred from using the trains. The acceptable performance of the rail network results from the increased number of services enabled by the CRL.

2.5 The case for change - growing amenity deficiencies

A separate assessment was made of the effects of bus numbers on amenity values - defined, for example, in the RMA (section 2), as: "The qualities and characteristics of an [urban] place or area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes".

As a proxy for the multiple dimensions of poor amenity, visual impact was assessed in accordance with the following table.

Table 4 Amenity Impact of Buses

Approximate Frequency Ranges vs Visual Amenity of Buses on City Centre Streets	
Moving or Inter - stop	
40 - 80b/hr	Low issues (Current Typical)
80 - 130b/hr	Some to Moderate Issues - (Current busy)
130 - 160b/hr	Significant Issues - e.g. Symonds Street and Willis Street in Wellington
160<	Very Poor - e.g. Oxford Street London
Stationary or at stop	
40 - 80b/hr	Low issues (Current Typical)
80 - 100b/hr	Some to Moderate Issues - (Current typical/busy)
100 - 140b/hr	Moderate to Significant Issues - (Current busy) e.g. Symonds/Custom Street
140<	Very Poor (Current) Lower Queen Street (170 PM)

The preliminary findings were that there is an upper threshold between 130 buses/hr and 160 buses/hr where significant to very poor visual effects are prevalent.

Some existing bus routes including Symonds Street and Customs Street within the City Centre are close to the threshold for visual effects at present and will be well above them in future years. Lower Queen Street (CPO) can be considered currently as providing very poor visual quality, which will become appreciably worse if the bus numbers increase.

2.6 The case for change - impact of the public transport deficiency on Auckland and its strategic direction

If public transport capacity is not increased to meet the growing demand for City Centre access, Auckland will fail to provide for the forecast growth in employment, education and residential activity in the City Centre. This will lead to region - wide negative impacts on land use, accessibility and economic development.

One of the prime effects will be on Auckland's growing role as an events and tourist destination. In 2015 it played a major role in the Cricket World Cup, while in 2017 Auckland will be host to the World Masters' Games (April 2017) - which has more competitors than the Olympics and is the single biggest multi - sport event on earth. There is also a British Lions (June/July 2017) tour which is well - known for its number of travelling supporters. Trends in numbers of cruise ships and their size are such that a doubling of passengers is achievable by about 2030 with suitable commitment. The new National Convention Centre can be expected to add to this trend as can Waterfront developments.

The limitation on the travel options across the Isthmus to the various sporting venues and other attractions for participants and spectators visiting the city will be a growing issue as international visitors are heavy users of public transport and have expectations that a truly "liveable city" would have high quality services.

Maintaining a bus - based public transport system, with services increased, where that is possible, to cater for demand will increase the impact of emissions, noise, and the degradation of the City Centre amenity which will be a less safe and pleasant place to walk and cycle, to live, work and visit. Visual assessment has demonstrated that there are a number of City Centre streets that already have exceeded, or will soon exceed, the threshold of acceptability.

2.7 Airport connection

Among the variations of the wider network that will be considered is an LRT connection to the Airport. Analysis suggests that a line connecting to the Dominion Road corridor and with an interchange to the metro rail service at Onehunga, would be significantly lower cost than a metro rail connection. The evaluation of light rail and metro rail options to the airport is being finalised.

2.8 Land-use change

Multiple sources, including Paul Buchanan of UK specialist advisers, Volterra[29], have demonstrated that LRT has a particular advantage over other public transport modes in its ability to catalyse desirable land-use change.

Work for AT has identified that over the next 15 - 20 years a supportive approach to planning controls could yield an additional 11,000 to 23,000 people living along the corridors. A still more encouraging regime could increase the potential population increase to 19,000 to 38,000.

[29] Light Rail Transit Review, Auckland Transport, A report by Volterra Partners, February 2015

These population increases would have multiple benefits - increasing the patronage for LRT, reducing the pressure for population growth in other areas that are not so well-served by public transport, and helping to achieve the more sustainable urban form sought in the Auckland Plan.

Auckland City planners have informally indicated that changes to the Proposed Auckland Unitary Plan (PAUP) to allow intensification along LRT routes would be investigated and could be included through the Unitary Plan hearings process.

3 Option analysis

3.1 Route evaluation

3.1.1 Introduction

The purpose of the initial long-list evaluation was to identify the corridors that needed to be considered for public transport upgrades to achieve the objectives. The evaluation considered a wide range of corridors (including one outside the Isthmus) and streets in the City Centre.

All the assessments assumed the same project do minimum of the base network, with the CRL and the New Network bus changes specified in the Regional Public Transport Plan.

The main considerations for the assessment were:

- Achievement of project objectives
- Evaluation framework objectives (set out below)
- PT demand drivers
- Existing patronage (2012)
- Modelled demand (2026, 2046)
- Existing and potential catchment (Unitary Plan updated land use plans)
- Presence of transit-friendly street network and land use patterns.
- Interaction with network / other projects
    - Whether the CRL enhancement of the commuter, rail would help address the corridor needs
    - The relationship with the New Network

The evaluation framework objectives were:

Objective	Description
City Centre access	Improving the level of access to the city centre
City Centre mobility	Improving the ability to travel within the city centre
Regional movement	Improving regional access and mobility
Economic performance	Improving the economic performance of the city centre
Environment	Reducing environmental impacts
Built environment	Improving urban amenity

Implementation	Assessing the construction and implementation of the particular option
Cost	Capex and Opex of the option

3.1.2 Demand in the corridors for assessment

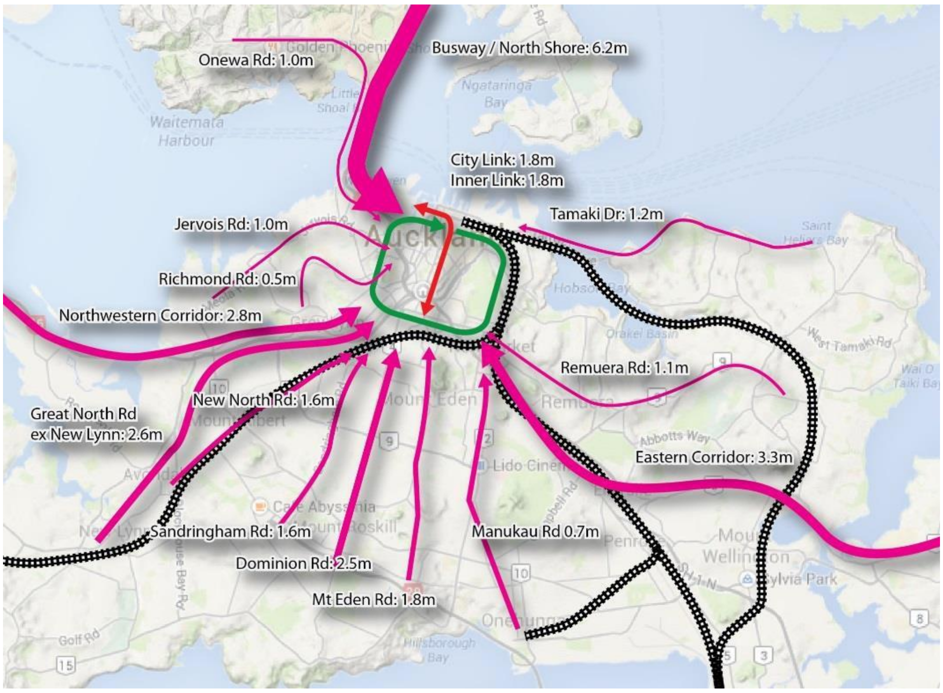
The main focus for developing the revised network is to service the highest demand areas. The demand assessment was based on current and forecast patronage data. The assessment targets intervention to where the highest benefit is likely on the following assumptions:

- The higher the patronage, the higher the passenger benefits
- The busier the existing corridor, the more buses removed, the better the amenity impact would likely to be
- High existing patronage/demand makes it more likely that the intervention will be successful from day one
- Strong patronage with all-day demand is needed to maintain good service levels and efficient operation
- Ten minute headways would be the expected service level for main routes, noting that

  Six buses per hour = One LRV per hour

  Six LRVs per hour = 36 buses per hour
- Patronage/fare revenue must be considered relative to Opex implications for farebox recovery ratio.

Figure 9 : Total Corridor Boardings 2012



3.1.3 Route by Route Assessment

The assessment covered all major public transport routes reaching City Centre in the Do minimum network, i.e. all Frequent Service routes from RPTP New Network. These routes approximately equate to all main radial roads on isthmus plus the motorway corridors.

Patronage and Volume Criteria

The ranges for assessing patronage and bus volumes were:

Table 5 : Ranges

Level	Passengers/hour	Buses/hour
High	> 1000	> 20
Medium	250 < 1000	5 < 10
Low	< 250	< 5

The routes assessed in the suburban network are shown below. These are currently the main passenger transport corridors in Auckland.

- North Shore / Busway
- Jervois Rd
- Richmond Rd
- Great North Road / SH16
- New North Rd
- Sandringham Rd
- Dominion Rd
- Mt Eden Rd
- Manukau Rd
- Great South Rd
- Remuera Rd
- Tamaki Dr

The detail of the assessment is contained in the supporting report: City Centre Future Access Study Long List Summary Paper, Auckland Transport, October 2014.

Table 6 : Summary of suburban route assessment

Included	Excluded (with reason)
Suburban corridors Dominion Rd Manukau Rd Sandringham Rd Mt Eden Rd Remuera Rd	**Insufficient demand/patronage** Jervois Road Richmond Road Tamaki Drive
	Rapid transit corridors North Shore/Busway Great North Road The aims of this study are to be incorporated into the specific corridor studies
	Duplicates commuter (metro) rail New North Road Great South Road

3.1.4 City Centre access points

Following the suburban corridor assessment outlined above, the two main passenger transport access points to the city centre are Eden Terrace and through Newmarket/Grafton. This fact was used in the development of the city centre options by identifying the access points, as shown in Figure 10.

Figure 10 : City Centre Access Points

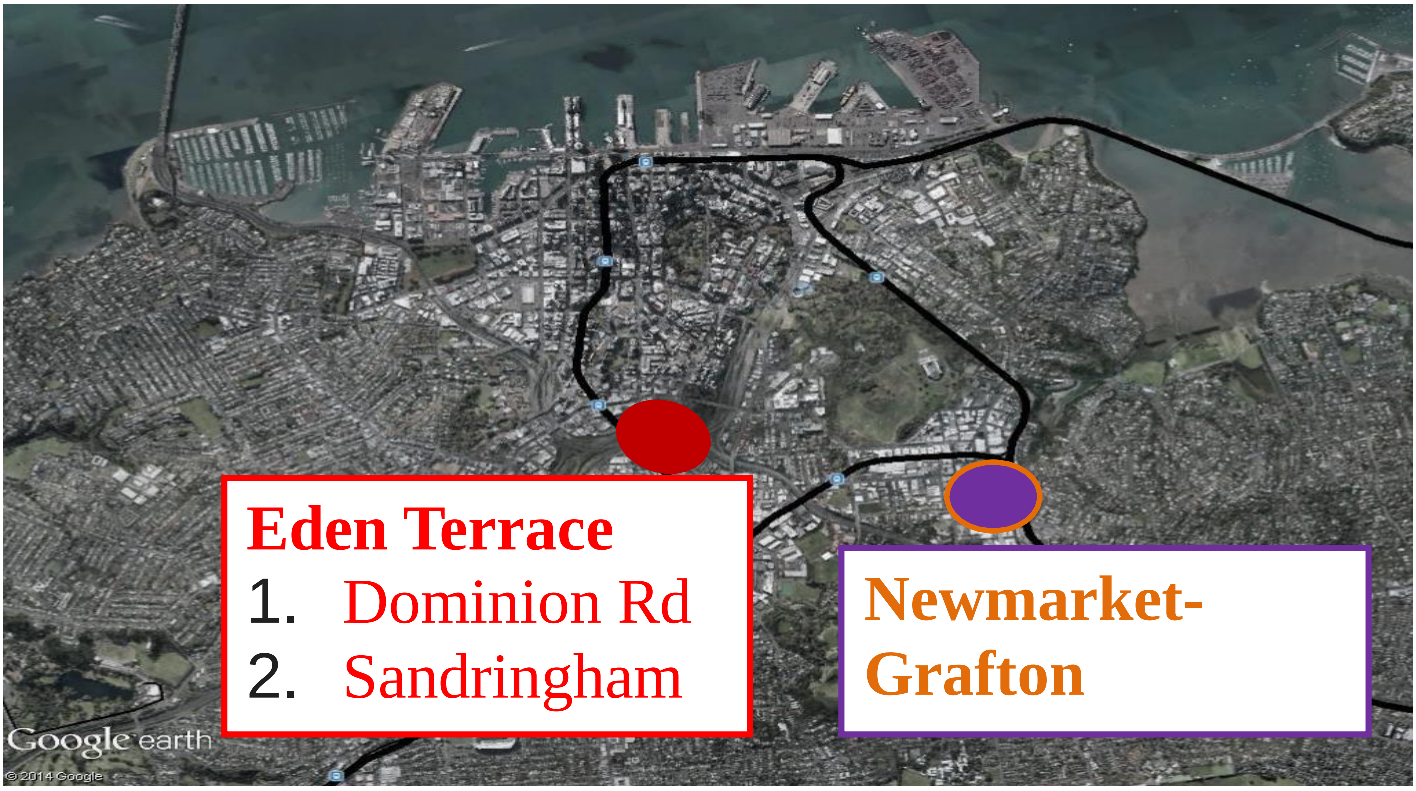


Figure 11 : Option for Double-decker buses on the New Network

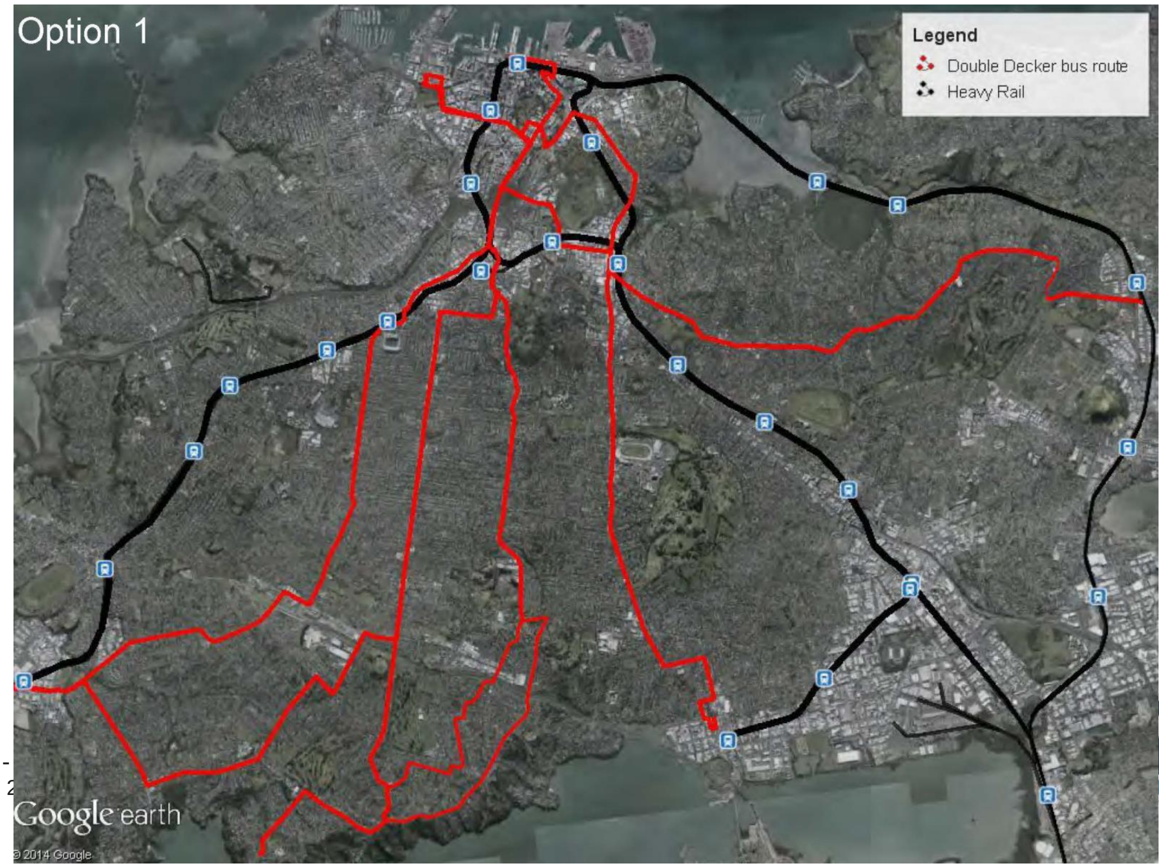


Figure 12 : Option for Double-decker buses plus underground bus interchange at Britomart

Figure 13 : Option for Metro rail (Mt Roskill Spur) and double-decker routes on Sandringham and Dominion roads

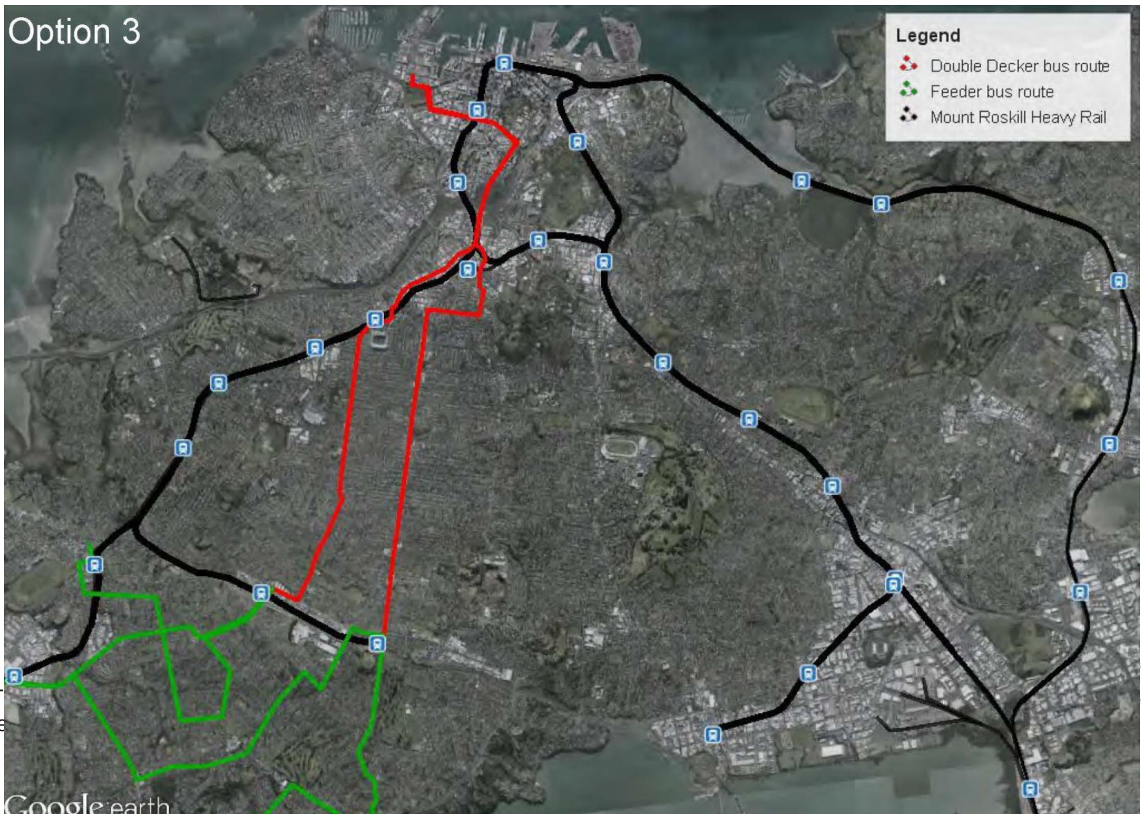


Figure 14 : LRT Option A: Dominion and Sandringham roads connecting to Queen Street with Manukau and Mt Eden Roads connecting to Symonds Street (i.e. a 50/50 split network)

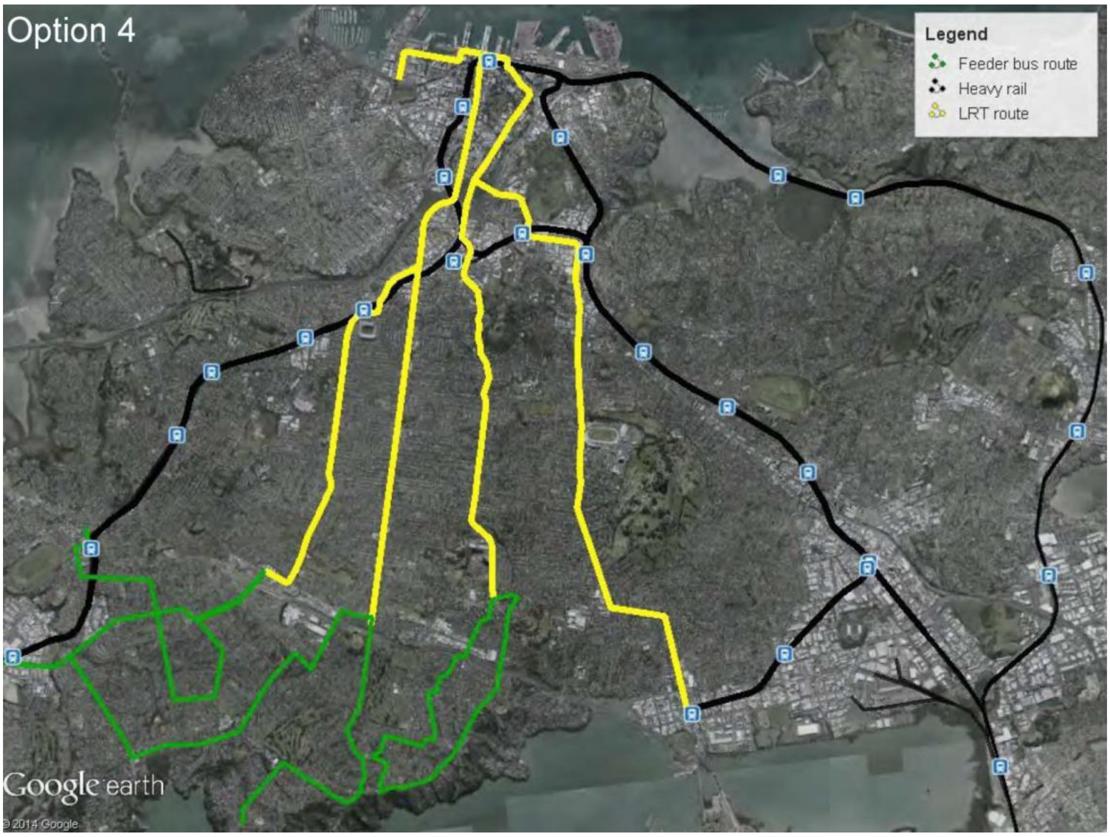


Figure 15 : LRT Option B: Dominion, Sandringham, Mt Eden roads connecting to Queen with Manukau and Remuera roads connecting to Symonds Street (full network)

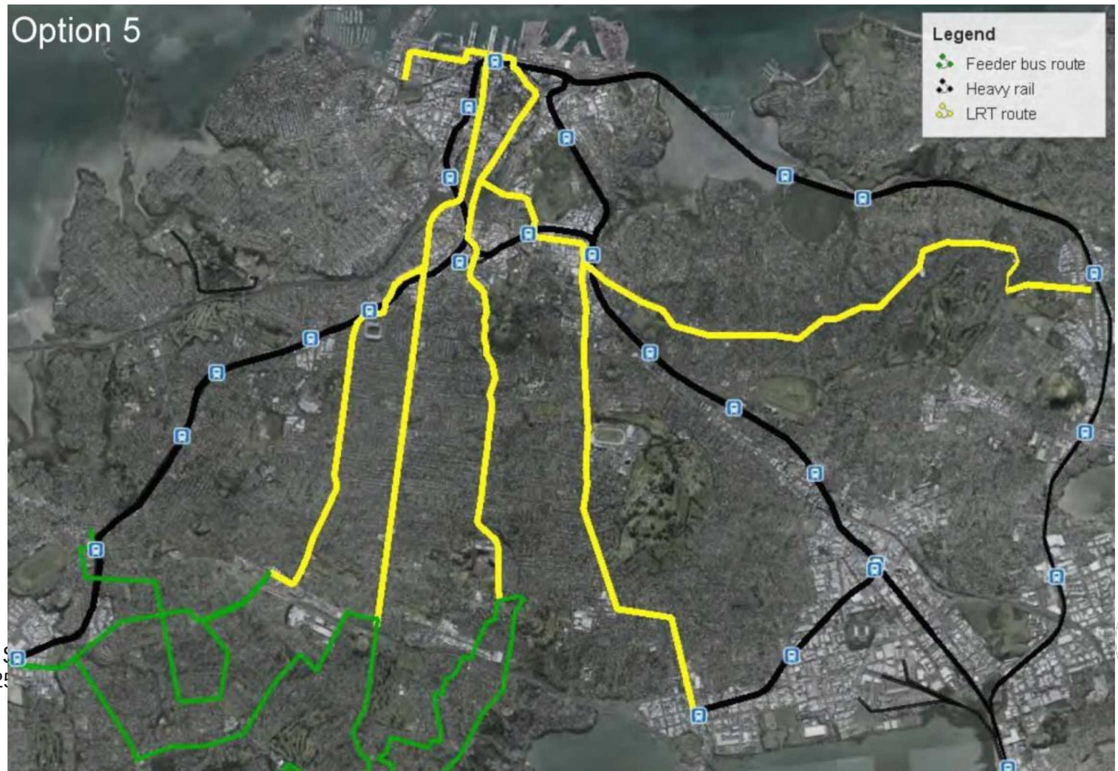


Figure 16 : LRT Option C: Dominion, Sandringham roads connecting to Queen Street with Manukau Road also connecting to Symonds/Wellesley/Queen (one CBD corridor)

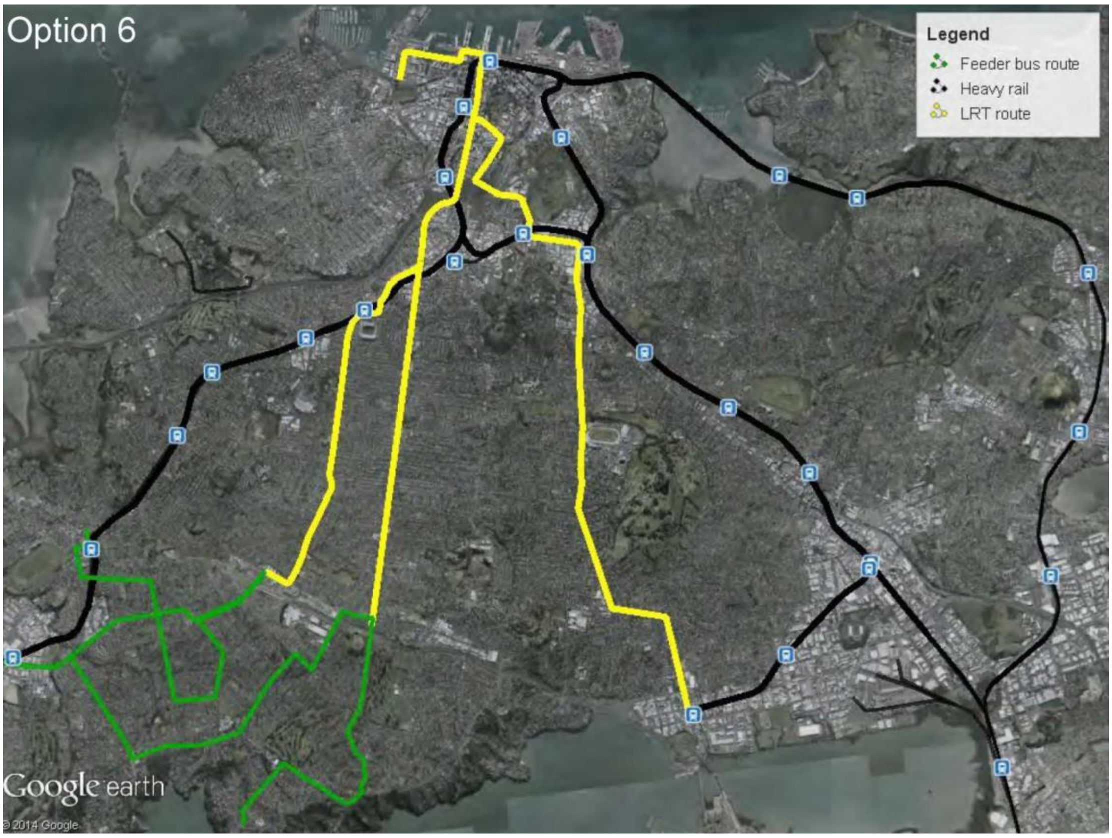


Figure 17 : LRT Option C: Dominion, Sandringham roads connecting to Queen Street with Manukau Road also connecting to Symonds/Wellesley/Queen (one CBD corridor)

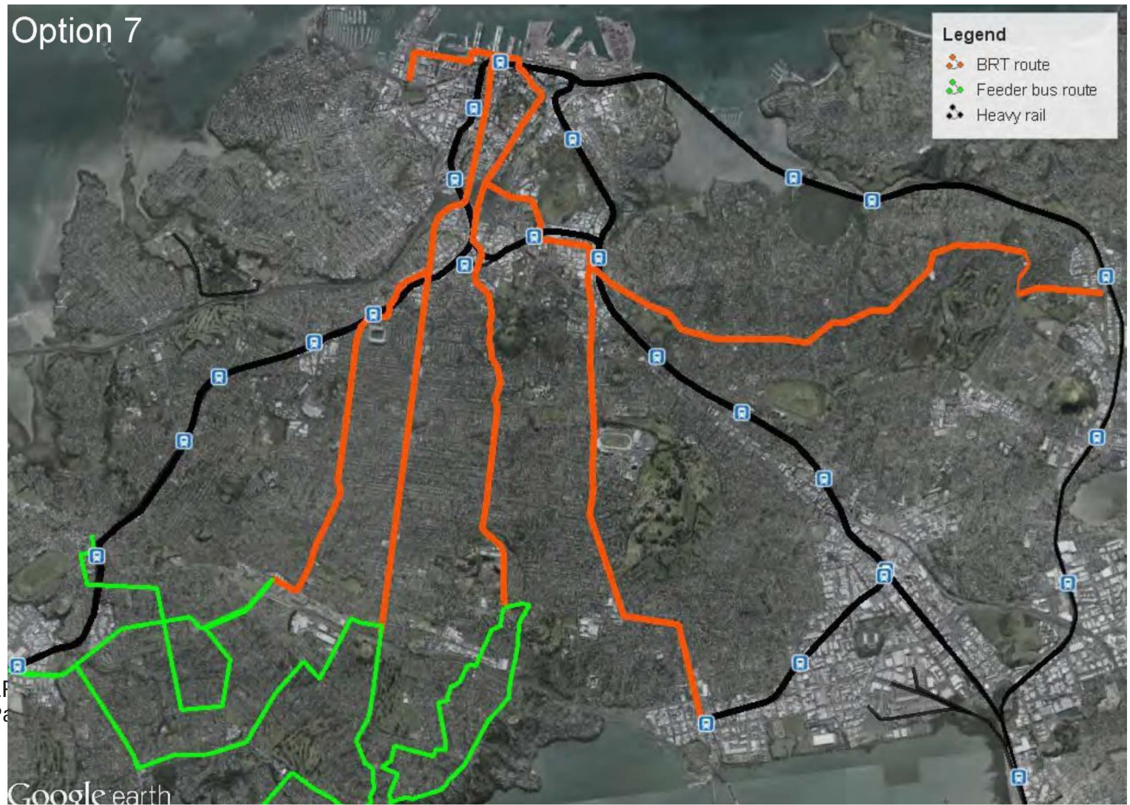


Figure 18 : LRT Option D: Dominion, Sandringham, Mt Eden roads to Queen Street (excluding a Wynyard connection)

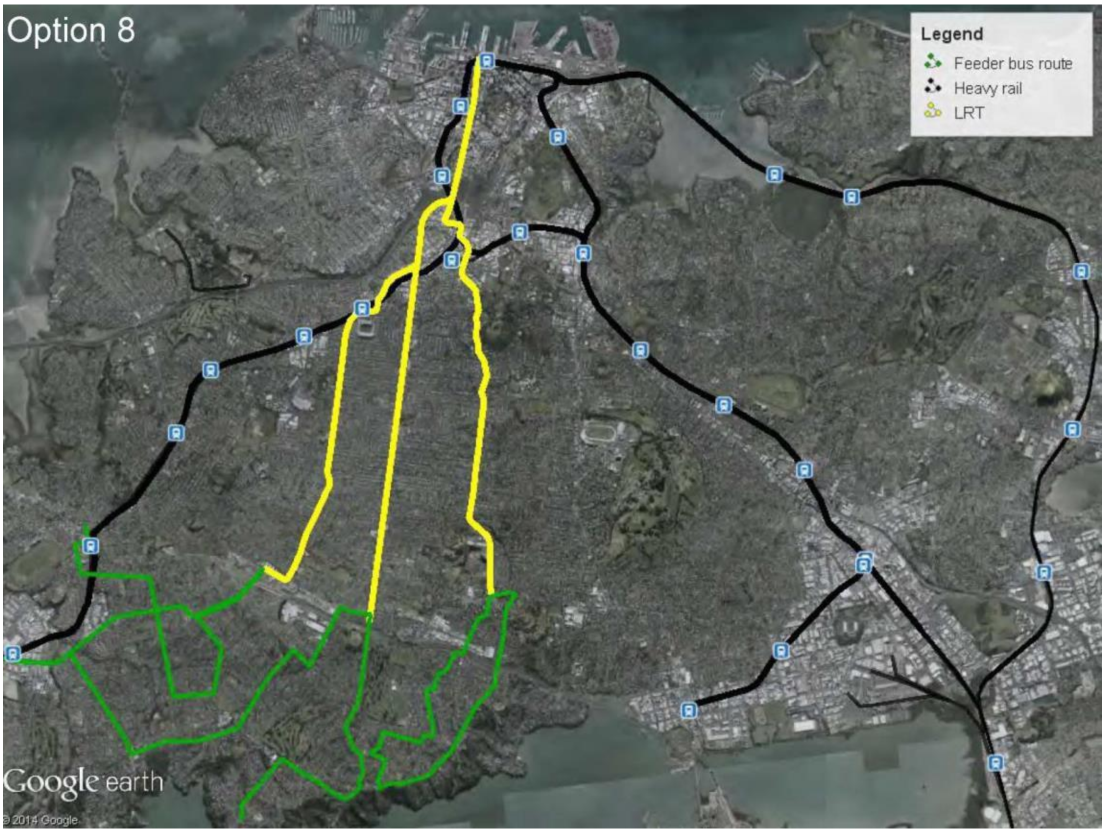


Figure 19 : Commuter / Light Rail hybrid: Mt Roskill Spur (as Option 3)+Manukau Road LRT

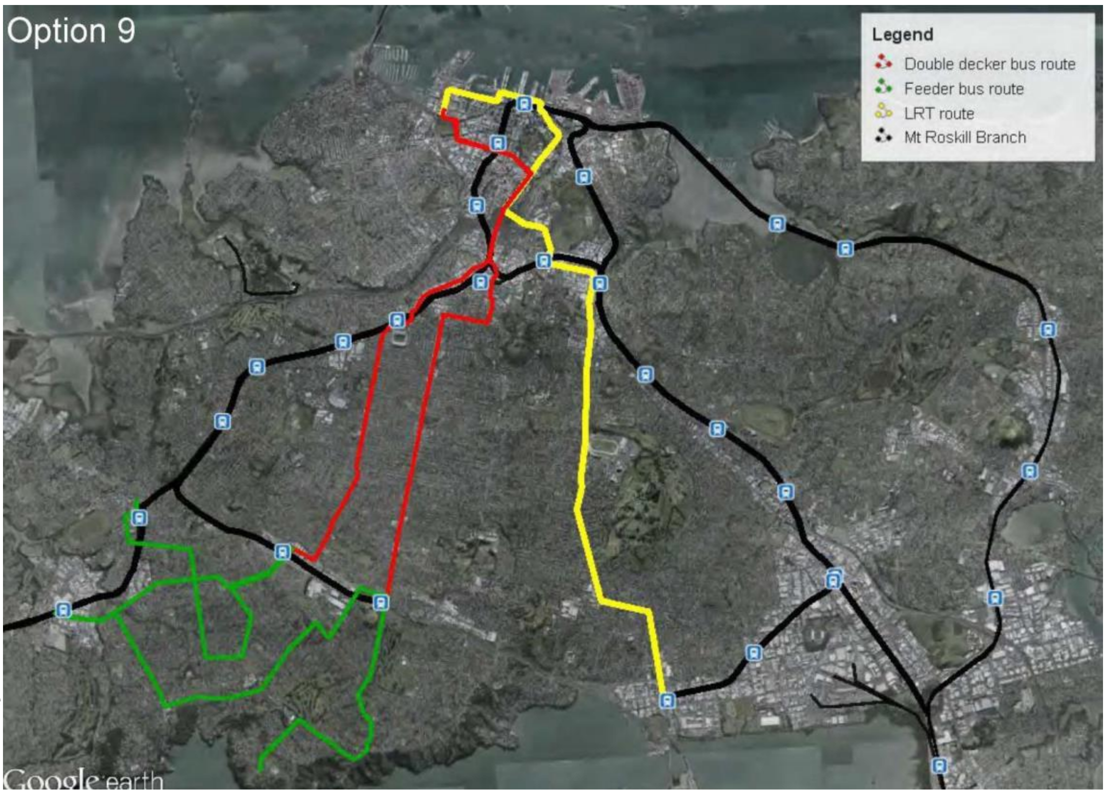
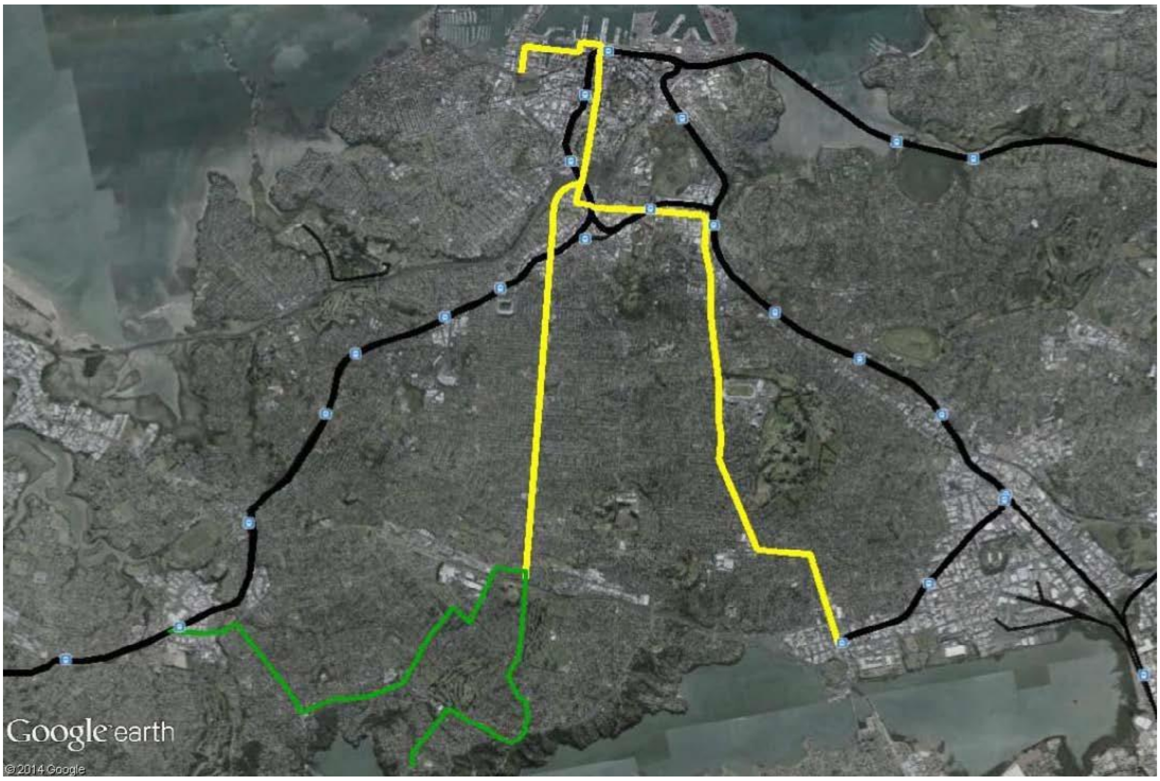


Figure 20 : LRT Option E: Dominion and Manukau roads with LRT Lines connecting to Queen Street (including a Wynyard connection).



As shown in Figure 21 below, a possible connection to Auckland Airport could follow the route of SH20 and SH20A.

Figure 21 : Possible LRT connection to Auckland Airport.

3.1.5 City Centre corridor options

The assessment reviewed all routes within the City Centre and considered how they connect to the identified priority node points in the City Centre:

- Wynyard Quarter
- Downtown
- Learning Quarter
- Auckland Hospital.

The assessment of suburban corridors had identified the routes that would not be short-listed. The following City Centre streets were also not considered further, as they connect only to suburban corridors that were not on the short-list:

The routes considered are described in the supporting report.

3.1.6 Summary of assessment outcomes

The following suburban routes were taken forward for detailed evaluation

- Dominion Road
- Manukau Road
- Sandringham Road
- Mt Eden Road
- Remuera Road

The objectives of this study were incorporated into separate studies reviewing access to the City Centre from the North Shore and North Western Corridors.

The following City Centre corridors were taken forward for further assessment.

- Queen Street
- Wellesley Street
- Customs Street
- Fort Street
- Broadway
- Karangahape Road
- Greys Avenue
- Beaumont Street - North of SH1
- Gaunt Street
- Jellicoe Street
- Tyler Street
- Gore Street
- Victoria Street
- Fanshawe Street
- High Street
- Grafton Road
- Carlton Gore Road
- Vincent Street
- Albert Street
- Daldy Street
- Madden Street
- Galway Street
- Commerce Street
- Quay Street - West of Britomart

3.2 Option short-listing

Having determined the routes that should be targeted for public transport upgrades, a series of options using different modes and levels of investment was developed for short-listing.

A range of city centre streets were identified as potential candidates. The city centre has a challenging topography, with a number of steep grades and tight corners within the existing network. For the options involving LRT, the physical characteristics of the candidate streets was taken into consideration with regards to route viability. LRT has a limit on the maximum vertical grade it can traverse, as well as horizontal curvature constraints. Therefore, for the LRT options, a number of candidate streets were eliminated from further consideration based on physical constraints.

It was also recognised that for the bus-based options, in addition to corridor capacity, bus interchange/terminus capacity was another potentially limiting feature. Britomart was identified as a critical bus terminal location which could require additional capacity to prevent it being the bottleneck in the bus system. Therefore a higher capacity form of terminal (underground station) was developed for consideration. The options for detailed assessment were:

1. Double-decker buses on the New Network
2. Double-decker buses plus underground bus interchange at Britomart
3. Metro rail (Mt Roskill Spur) and double-decker routes on Sandringham and Dominion roads
4. LRT Option A: Dominion and Sandringham roads connecting to Queen Street with Manukau and Mt Eden Roads connecting to Symonds Street (i.e. a 50/50 split network)
5. LRT Option B: Dominion, Sandringham, Mt Eden roads connecting to Queen with Manukau and Remuera roads connecting to Symonds Street (full network)
6. LRT Option C: Dominion, Sandringham roads connecting to Queen Street with Manukau Road also connecting to Symonds/Wellesley/Queen (one CBD corridor)
7. BRT Option: Dominion, Sandringham, Mt Eden, Manukau, Remuera Roads (full network)
8. LRT Option D: Dominion, Sandringham, Mt Eden Roads to Queen Street (excluding a Wynyard connection)
9. Commuter / Light Rail hybrid: Mt Roskill Spur (as Option 3)+Manukau Road LRT
10. LRT Option E: Dominion and Manukau Roads with LRT Lines connecting to Queen Street (including a Wynyard connection).

3.2.1 Evaluation criteria

The evaluation criteria used for the short-listing were:

Objective	Description
City Centre Access	Increasing the level of access to the City Centre
City Centre Mobility	Improving the ability for travel within the City Centre
Regional Movement	Improving regional access and mobility
Economic Performance	Improving the economic performance of the City Centre
Environment	Reducing environmental impacts

Built Environment	Improving urban amenity
Implementation	Assessing the construction and implementation of a particular transport option
Cost	CAPEX and OPEX of the option

The detail of the make-up of the criteria and their application is contained in the report: CCFAS2 Short List Summary Paper, Auckland Transport February 2015.

3.2.2 Multi Criteria Assessment Development

A Multi Criteria Assessment (MCA) framework was developed and applied to short-list the options. Using this as a starting point, the objectives were updated to reflect those adopted for CCFAS2, and evaluation criteria developed to evaluate the ability of each options to contribute to the objective.

A scoring method was adopted based on the following framework:

Rank	Points
++	2
+	1
0	0
-	-1
--	-2

Equal weighting was ascribed to each of the criteria within the framework. Different weightings were tested after the initial evaluation. The outcomes of that testing are documented below.

Two workshops were held on 18 and 20 November to undertake a MCA of the ten options. The workshops were attended by the advisors Auckland Transport had appointed for the study, along with key Auckland Transport representatives.

The assessment was largely qualitative, with discussion on scoring being led by the most appropriately qualified person. The scores were then recorded in the MCA alongside the reasoning for allocating those scores. A forecast year of 2046 was used for the evaluation. The full MCA is included in the report.

3.2.3 MCA results

The results of the MCA Assessment are summarised below.

Table 7 : MCA Results

Option	1	2	3	4	5	6	7	8	9	10
MCA Total	0.7	-0.6	0.5	2.8	2.8	2.0	0.7	2.5	1.7	1.9
Rank	7=	10	9	1=	1=	4	7=	3	6	5

3.2.4 Evaluation conclusions

- The Light Rail options scored highest overall
- All the bus based options scored poorly.
- Options 4 and 5 scored the highest overall.
- Given Option 5 has additional cost (Remuera Rd), and did not perform better, Option 4 was considered the better investment of the two. It was also recognised that Option 4 was compatible with a future addition of Remuera Rd if required

Option 4 was confirmed as the preferred option for the purpose of further development.

3.2.5 Sensitivity testing

Recognising that the MCA was based on an equal weighting of the evaluated criteria, a series of sensitivity tests were undertaken. These tests weighted each of the headline criteria higher individually to see whether that would have a material effect on the ranking of the options. The results are shown below.

Table 8 : Option Ranking

Option	1	2	3	4	5	6	7	8	9	10
Ranking - equal weighting by criteria, equal by objective	7	10	9	1	1	4	8	3	6	5
Ranking - unequal weighting by criteria, equal by objective	7	10	9	1	1	4	8	3	6	5
Ranking - equal weighting by criteria, unequal by objective	9	10	8	1	1	4	7	3	6	5
Ranking - equal weighting by criteria, unequal by objective	9	10	8	1	1	4	7	3	6	5

Based on the above assessment, Option 4 was considered by be robust under a series of different weighted scenarios.

The option of an LRT spur to the Airport was looked at separately in the South Western Multimodal Airport Rapid Transit (SMART) Project – concentrating on a comparison between heavy (metro) and LRT options.

Its inclusion as part of the overall possible future LRT network in this business case has been to demonstrate that variations to the main option that emerged – Option 4 - are also viable.

3.3 Further analysis of bus rapid transit option

As AT is aware that in some European cities - for example, Malmo in Sweden - that pseudo-LRT systems have been introduced in recent years, particular attention was paid to testing such an option for Auckland. This section therefore evaluates the efficacy of operating the proposed "Option 4" four-line LRT network with modern multiple-articulated hybrid-electric transit buses (BRT).

This is in order to evaluate whether a potentially cheaper bus-based system could deliver the same benefits and functionality as the proposed LRT design.

3.3.1 Specimen BRT vehicle system

The Van Hool "Equi-City" 24m double articulated bus was selected as a specimen model for this evaluation. This high capacity Bus Rapid Transit (BRT) bus is purpose designed for urban transit operations and it closely resembles a Light Rail Vehicle (LRV) in terms of functionality, appearance and passenger experience. This vehicle is pictured below:

The system is currently in revenue service in several European cities. It therefore represents a relatively mature technology that appears to be sufficiently reliable to consider for near-term procurement in Auckland.

This vehicle is nominally available from the operator in a variety of traction configurations, including hybrid diesel-electric, trolley pole, battery electric and alternative fuel. However the low emission hybrid-diesel configuration is standard and the most commonly used, so it was selected for the current evaluation.

AT assumes that this vehicle could be supplied in right-hand drive configuration, but note that all vehicles produced so far have been for the left-hand drive European market.

The vehicle has the following specifications:

- 24m length, 2.55m width, 3.3m height
- Four axles (two double tyre, two single tyre), conventional rubber tyres and steering mechanism
- Passenger capacity of 146 pax (42 seats + 104 standees at four standing per m2)
- Four doors on the kerb side, level floor with boarding height of 330mm
- Unladen weight: 22,750 kg
- Fully laden weight: 33,700 kg (+146 pax @ 75kg ea.)
- Assumed axle loading when laden: 8,425 kg per axle.
- Turning radius: 12.15m

This tram-like bus is approximately double the length of a conventional bus and can carry slightly more than double the passengers, owing to the extra length and an interior configuration with high standing capacity.

Conversely, the BRT vehicle (24m) is approximately half the length and passenger capacity of the specimen LRT vehicle (45m).

Because of the double articulations, the turning radius of this BRT vehicle is lower than many rigid chassis buses in the Auckland fleet. However, the vehicle is a uni-directional bus with a single driver cab and forward direction. Therefore it must be turned around at the end of each run, unlike a double ended bi-direction LRV.

This vehicle is over-dimension under current New Zealand regulations on at least four dimensions: length, width, gross weight. It would therefore require special dispensation to legally operate on Auckland streets.

3.3.2 Comparison to LRT

Initial assessment reveals that these BRT vehicles are fundamentally similar to LRT in terms of visual appearance, passenger experience, interior layout, ride quality and general transit functionality.

This analysis is therefore concerned with technical and operational characteristics.

3.3.3 Infrastructural requirements

By standard manufacture these vehicles would require all stops in side platform configuration due to the location of conventional kerbside doors. The specimen LRV has doors on both sides to allow either side or island boarding.

It is possible that is BRT vehicle could be supplied with doors on both sides as a special order. The analysis has, however, assumed that side stops are a requirement for current purposes.

It is assumed that the vehicles would operate an all-stops pattern without any express or skip-stop services. Therefore in-line stopping would be appropriate, without the need to provide indented bus bays or multiple bus lanes per direction.

The assessment assumed that high level (330mm) platform style stops with 'Kassel profile' self-locating kerbs would be required to provide direct level boarding with minimal gap between the vehicle and platform, as it specified in the LRT option. This is required to allow low dwell times at high passenger volumes, and to avoid the need for the driver to undertake special process (e.g. lowering a ramp and kneeling the suspension) to permit access by wheelchairs, prams etc.

This bus is substantially longer and heavier than any bus currently in the Auckland fleet. It would therefore require reconstruction of bus stops for additional length (see below), and reconstructed pavement along the full route.

Buses currently operate on some Auckland streets within 3.0m bus lanes. This is substandard for frequent operation even for conventional buses, requiring lower speed operation. The recommended minimum lane width is 3.5m, with 4.5m+ required where buses share with cyclists.

With large multi-articulated BRT buses 3.5m lane widths would be the absolute minimum to allow the bus driver to keep within the lane at relatively high speeds.

Furthermore, the LRT network proposes locating the LRT lanes within the median of the roadway on a kerbed plinth, in order to physically exclude traffic from the running way outside of major intersections. This was determined as essential for reliable, safe and fast operation of the LRT system.

For an equivalent BRT network, kerbed central median lanes would likewise be required. In this scenario additional width is required to offset from the drop kerb to one side, and for separation from oncoming BRT vehicles to the other. The minimum offset to the drop kerb should be 0.5m each side, with a similar 0.5m flush median between the opposing lanes.

This requirement results in a minimum raised-median BRT corridor of 8.5m width, comprising two 3.5m running lanes with 0.5m to the kerb each side and 0.5m separation in the centre.

This minimum is narrow and may be unacceptable to operators. By comparison, the minimum width on the two-way sections of the Northern Busway is 10m between barriers.

3.3.4 Projected demands and volumes

Future patronage demand was predicted by the APT3 base case. The following table represents the hourly peak demand at the peak load points at the city fringe for three decades. As with all the calculations, the one-hour peak demand was assumed to be 60 per cent of the two-hour demand as output by the model.

These patronage demands were translated into vehicle numbers at 146 pax per BRT, and 300 pax per LRV, as per the specimen designs. As is expected, the BRT option requires approximately double the number of vehicles as the LRT option at each stage.

Table 9 : Patronage Demands

	2026			2036			2046		
	Pax	LRVs	BRTs	Pax	LRVs	BRTs	Pax	LRVs	BRTs
Dominion Rd	1,571	6	11	1,824	7	13	2,077	7	15
Sandringham Rd	1,769	6	13	2,000	7	14	2,231	8	16
Queen Street Spine		***12***	***24***		***14***	***27***		***15***	***31***
Mt Eden Rd	1,162	4	8	1,348	5	10	1,534	6	11
Manukau Rd	2,017	7	14	2,638	9	19	3,260	11	23
Symonds Street Spine		***11***	***22***		***14***	***29***		***17***	***34***

3.3.5 Signal priority function at projected volumes

Signal priority systems work by advancing or maintaining a green signal for public transport, at the expense of other phases in the cycle. These other phases can be lengthened in following cycles to recover to the same level of throughput.

For the system to function correctly priority cannot be given to public transport at every single phase, as this would limit the other phases without giving any opportunity for subsequent recovery. Therefore as PT headway approaches the cycle time the priority system begins to lose utility, and is generally non-functioning when headway equals cycle time.

A nominal two minute cycle time was assumed. This translated into the following assumptions for signal priority function:

- **Full signal priority**: 12 or fewer vehicles per hour. 33 per cent or less probability that a given signal cycle is affected (i.e. one in three signal cycles affected, two in three available for recovery)
- **Limited signal priority**: 13 to 20 vehicles per hour. 33-50 per cent probability of signal cycle modification, 50-67 per cent available for recovery
- **No signal priority**: 20 or more vehicles per hour. 50 per cent or greater probability of signal cycle modification, less than 50 per cent available for recovery

The following table summarises the functionality of signal priority for each mode and corridor at the predicted AM peak-hour vehicle frequencies.

Table 10 : Opportunity for traffic signal priority

	BRT			LRT		
	2026	2036	2046	2026	2036	2046
Dominion Rd	YES	LIMITED	LIMITED	YES	YES	YES
Sandringham Rd	LIMITED	LIMITED	LIMITED	YES	YES	YES
Queen Street Spine	***NO***	***NO***	***NO***	***YES***	***LIMITED***	***LIMITED***
Mt Eden Rd	YES	YES	YES	YES	YES	YES
Manukau Rd	LIMITED	LIMITED	NO	YES	YES	YES
Symonds Street Spine	***NO***	***NO***	***NO***	***YES***	***LIMITED***	***LIMITED***

This indicates that in the first decade BRT would have functioning signal priority on two of the four suburban corridors, and limited priority on the remaining two. Where these come together on the shared city spine sections, the headway of BRT vehicles would exceed the signal time such that consistently prioritising BRT would not be possible.

In the second and third decade there is increasingly limited ability to provide signal priority to BRT vehicles.

Overall this means that the signal priority system would be unable to maintain reliable travel times and ensure separation between BRT vehicles. As a result some bunching would occur in the first decade with routine bunching occurring in the second and third decades. In other words the buses would routinely move through intersections and stops as a platoon of two or more vehicles. This translates into a requirement for stops to be able to support multiple vehicles simultaneously.

By comparison, the frequency of LRT vehicles required is sufficiently low that full signal priority can be maintained on all suburban corridors, and limited signal priority can be maintained on the two city spines across all three decades. As a result only one LRT vehicle would need to be accommodated at a time at city spine stops (at a 95 per cent confidence interval).

3.3.6 Stop length required

As noted above, BRT stops would be required to accommodate more than one vehicle at time, allowing for vehicle bunching with relatively random distribution of arrivals due to the lack of functional signal priority.

To have sufficient throughput capacity 95 per cent of the time, BRT stops would need to be double length in the first decade, and triple length in the second and third decades.

A triple length stop would need to accommodate three 24m vehicles with a nominal separation of 2m between vehicles and a 2m allowance for overshoot at the head of the stop. This allowance is required to provide the driver some leeway in stopping position such that they do not need to be especially slow and cautious on their approach. The LRT specification allows a similar ~2m allowance.

In total, this results in a required total BRT stop length of 78m at the shared stops in the City Centre (three vehicle length), however stops of 52m would be adequate on the suburban corridors (two vehicle length).

In comparison, the LRT system would only require a single stop length of 45m at any point on the network.

3.3.7 Terminus capacity required

At a terminus all passenger transit vehicles require a place to stop to offload and board passengers, but also to store the vehicle for a period of time, as a timing point to ensure reliable timekeeping. This terminus stop usually has to allow a minimum period for driver crew changes and toilet break. Current PTOM contracting proposes a seven minute stop at termini, comprised of two minutes for passenger work and five minutes for timekeeping. This seven minute stop time has been used in the current evaluation. This means that one stopping bay is required for every eight vehicles per hour operated on the terminating line.

This translates into the following requirements for BRT termination:

- First decade: three terminal bays per group, six in total
- Second and third decades: four terminal bays per group, eight in total

The proposed LRT network assumes that one group of lines would terminate in the Britomart area while the other would continue through Britomart to terminate in the Wynyard area.

Assuming the same arrangement for BRT, results in a requirement for four terminal bays to be provided at Wynyard, and four terminal bays plus three through-bays in each direction at Britomart.

The analysis has assumed for simplicity that the BRT vehicles layover in the passenger stop, nominally requiring a single stop of 104m length at the terminus. However a terminus configuration of two sets of two bays of 54m length each (one set for each suburban line) would be an efficient configuration.

Furthermore, the BRT vehicles require some means to turn around. At a purpose-built off-street bus station this would usually take the form of a roundabout (~20m radius), or an island station configuration surrounded by an apron of sufficient size to permit buses turning (this assumes that saw tooth station configurations that require buses to reverse are infeasible with double articulated BRT units). In the Auckland city centre context, turning a bus would most likely require the allocation of a suitable route around a city block, with bus lanes and bus turn signals where appropriate.

In comparison, the proposed LRT network would only require standard twin-platform station (45m length) to provide the two bays necessary to terminate and layover the required volume of vehicles through to beyond the third decade. As the LRVs are double ended they do not need to turn around, provided that a diamond crossover is installed in the tracks approaching the terminus.

3.3.8 Summary and Conclusion

A BRT system based around the Van Hool Equi-City 24m double articulated hybrid bus could be a functional alternative to an LRT system, particularly in the first decade of operation.

As these vehicles have half the length and passenger capacity of a 45m tram they require approximately double the number of vehicles per hour to move the same amount of passengers. This results in some adverse outcomes in comparison.

To meet the predicted patronage volumes and provide equivalent speed and reliability to LRT in the second and third decades, the following technical and spatial constraints arise:

- A pair of raised central median bus lanes with a minimum total width of 8.5m is required.

- Limited-to-no ability to provide signal priority to BRT owing to higher frequencies.
- Platooning/bunching of BRT vehicles becomes routine.
- Intermediate stops of 78m length capable of supporting a platoon of three vehicles at one time are required.
- Two sets of terminal stops totalling 104m length (four vehicles) each are required. The means to turn BRT vehicles around would also be required.
- Raised platforms with Kassel kerbs would be required at stops to allow level boarding of high passenger turnover.

An equivalent capacity LRT system would be able to maintain full signal priority and avoid any Platooning/bunching in routine operation to beyond the third decade. It would require a narrower median guide way and stops of only 45m (one vehicle) length. At the terminus a standard two-platform stop could accommodate all turning and layover requirements.

In summary, the key benefit of LRT relative to BRT is that the higher passenger capacity per vehicle allows relatively low service frequencies to be maintained, even at very high levels of passenger throughput. In turn this translates into functional signal priority, and relatively low spatial requirements at stops and termini.

In this regard the BRT as evaluated represents an intermediate capacity system, delivering an LRT-like service with superior performance to conventional buses, but with lesser capacity than true LRT.

The BRT system could be considered as a first step toward LRT, providing good operation without excessive spatial requirements for the first decade at least. It would not be possible to simply run these BRT vehicles in place of existing buses: significant infrastructure works would be required on the isthmus and city centre arterial roads to prepare the stops, termini and running way for these vehicles. The works required are likely to be approaching those required to construct and LRT system.

There may be other potential applications of this BRT technology within Auckland. Specifically, the Northern Busway currently features a wide dedicated running way, platform style stops of 100m+ length, and high durability concrete aprons at busway stations.

Unlike the isthmus arterials and city streets, the Northern Busway is already designed for BRT operations and may require little or no additional investment to run these modern BRT vehicles.

Apart from the city terminus, the busway has no spatial constraints at stops and termini, and does not need signal priority due to its largely grade-separated alignment. The design of the city approaches and terminus is currently being revised and could be made suitable for BRT.

4 Economic case

4.1 Overall approach

The economic case for the LRN has been determined through using standard NZTA Economic Evaluation Manual (EEM) calculations and parameters, by applying a scenario suggested in the EEM of using a lower discount rate as applying to a project with longer-term benefits (coupled with a longer than usual evaluation period) and by employing an alternative approach using values from observed, actual property value uplifts where similar LRT networks have been introduced, as suggested, for example, by Buchanan[30].

4.2 Base methodology

This section sets out the methodology and assumptions used in preparing the basic EEM compliant assessment of the benefits of the nominated LRN.

Assumptions made in the assessment are detailed in the relevant sections of this business case.

4.2.1 Underlying assumptions

The assessment is for LRT Option 4, set out in Section 3 above, which is the network consisting of four suburban lines and two City Centre lines.

The network is assumed to be built in five stages (Stage One has two components). These are summarised along with the estimated opening year of each stage:

- Stage 1Q: Kingsland to Lower Queen Street (via Sandringham Road, Ian McKinnon Drive, Upper Queen Street, Queen Street) - opening 2017
- Stage 1W: Lower Queen Street to Wynyard Quarter - opening 2021
- Stage 2: Dominion Road LRT line (extending from the Ian McKinnon Drive depot down Dominion Road, to SH20) - opening 2019
- Stage 3: Sandringham Road LRT line (from Kingsland via New North Road, Sandringham Road to Stoddard Road) - opening 2021
- Stage 4:Manukau Road LRT line (from Britomart via Anzac Avenue, Symonds Street, Grafton Bridge, through Newmarket to Onehunga) - opening 2030
- Stage 5: Mt Eden Road LRT line (from Symonds Street via Mt Eden Road to Three Kings at Mt Albert Rd) - opening 2038

The opening years are consistent with the assumptions in the cost assessment.

(The variant including the connection to the Airport assumes that route to be operational in 2025).

A standard 40 year evaluation period has been used with a six per cent discount rate which is standard with the EEM.

[30]Paul Buchanan, Light rail Transit Review, A report by Volterra partners, February 2015.

Demand is taken from Auckland's public transport model, APT3, for the do minimum scenario which includes CRL and is the peak period (two hour) demand. The peak load along each corridor is identified and used to represent the maximum demand on that corridor.

A peak hour factor of 0.6 is used for converting peak period (two hour) demands to peak hour.

Annualisation factors from the CCFAS[31] have been used for this assessment. The annualisation factor is 1100 for going from two hour peak to annual. The equivalent annualisation factor for going from peak hour to annual has been assumed to be 1100/0.6 = 1833.

4.2.2 Economic benefit categories

The following is a list of the benefit categories that have been:

- Travel time savings
- Public transport reliability
- Noise
- Health benefit from walking
- Residual value
- Emissions
- Public transport user benefits
- City Centre pedestrian travel time
- Agglomeration

4.2.3 Travel time savings

The travel time savings were extracted directly from the APT and ART model runs for existing and new public transport and road users and vehicle kilometres travelled by mode (bus, rail, ferry, LRT, heavy rail). The closest matching scenarios to the staging options were selected with interpolation between modelled years as required.

Standard values of time were applied to the travel time differences.

4.2.4 Emissions

The emission costs assumed are as follows:

- CO_2 : $40 / tonne (*Source: EEM Section A9.6)*
- PM_{10} : $399,000 / tonne (*Source*: *Nunns (2015), "Statement of evidence of Peter Nunns in the matter of C5.1 - Air Quality", On behalf of Auckland Council to the Auckland Unitary Plan Independent Hearings Panel)*
- NO_x : $10,400 / tonne (*Source: PWC (2014) Evaluating the impact of difference bus fleet configurations (Greater Wellington Regional Council))*

The cost of PM_{10} emissions is assumed to increase at the same rate as the population, as the two are directly proportional. The assumed rate of growth is 1.6 per cent per annum. This corresponds to the Statistics NZ medium projection for population growth in Auckland.

The annual service kilometres for both the relevant bus services and new LRT services are consistent with those calculated for the operating costs assessment.

[31] Op cit

The bus fleet for the relevant bus routes is assumed to consist of Euro V equivalent buses in terms of energy efficiency (12MJ/km) and emissions (PM_{10} 0.07g/km and NO_x 6.67g/km). The values for both these elements have been taken from *PWC (2014) Evaluating the impact of difference bus fleet configurations (Greater Wellington Regional Council) Table 9 and 10* respectively.

Each LRT vehicle is assumed to use 6.75kWh/km (*Source: Arup)* equating to 24.3MJ/km.

Diesel emissions (kg CO_2) per MJ are taken to be 0.07325 as per European Commission information.

Electricity emissions (kg CO_2) per kWh is currently approximately 0.15. The information within the PWC Bus Fleet report identifies that this is reducing over time to approximately 0.1. For the purpose of this assessment, a value of 0.12 kg CO_2 per kWh has been used. At 3.6MJ per kWh, this equates to an emission of 0.033 kg CO_2 per MJ.

The difference in annual costs of emissions from these three sources (CO_2, PM_{10} and NO_x) between the two scenarios is taken as the benefit attributable to the introduction of the LRT network.

4.2.5 Public transport reliability

Public transport reliability is a major issue for passengers. There are economic benefits that can be calculated in the EEM (Section A18). The following figure summarises the calculation to determine the benefit associated with improved journey time reliability.

Table 12 : Equivalent time to a minute ratios

Segment	Departure	In vehicle travel	Combined
All	5.0	2.8	3.9
Train	3.9	2.4	3.1
Bus	6.4	3.2	4.8
Work	5.5	2.8	4.1
Education	3.0	3.8	3.4
Other	5.4	2.0	3.7

Note: The combined value assumes a 50:50 split between departure and in vehicle time delay en route

Calculate the user reliability benefits using the formula below:

Reliability benefit = EL × (VTT($/h)/60) × AML × NPT

Where:

EL = equivalent time to a minute late ratio from table A18.1

VTT = vehicle travel time ($/h) from table A4.2 in Appendix A4

AML = reduction in average minutes late (minutes)

NPT = number of passengers affected

The equivalent time to a minute late ratio (EL) is taken as 4.8 in line with Table A18.1 for the "combined" delay.

The base vehicle travel time from Table A4.2 of the EEM is $17.10 / hour for a bus. The EEM update factor from 2002 dollars to 2014 dollars is 1.42 (*Source: EEM Section A12.3)* which give a vehicle travel time value of $24.28.

Morning peak (8am - 9am) travel times have been assessed using AT HOP data. The assessment is summarised in the table below.

Table 13

Corridor	Scheduled time (mins)	Avg travel time (mins)	Range (95 per cent) (mins)
Dominion Rd	36 (varies)	33	26 - 40
Sandringham Rd	36 (varies)	32	25 - 40
Mt Eden Rd	39 (varies)	39	30 - 50
Manukau Rd	45 (varies)	51	40 - 69

This shows that only the Mt Eden service is currently running approximately to timetable. All the other services are running (on average) different times to those which are timetabled. The 95th percentile ranges show the large variation in travel times for all the routes. The Manukau Road service in particular has 30 minutes (1/2 an hour) of variation between its fastest and slowest travel time in the morning peak hour.

Early arrival is just as frustrating as late arrival, especially for the passengers waiting to get on the service. It also represents 'wasted' time at the destination end. While timetables can be constantly adjusted to better reflect the mean travel time, they cannot reflect the potential large range of travel time. Reducing this range is considered to be as, if not more, important as ensuring the services run to the scheduled time[32].

Introducing the LRT network and associated priority improvements through complete segregation and significant improvements to signal pre-emption and priority will not only reduce the travel time along the corridors but make the travel times significantly more reliable, dramatically reducing the variation in travel times that are currently experienced. It is envisaged that all services would be able to run to within 2-3 minutes of the scheduled time.

Based on the current average travel times compared with scheduled times, the expected reductions in average minutes late (AML) are:

- 1 minute for Dominion Road services
- 2 minutes for Sandringham Road services
- 0 minutes for Mt Eden services
- minutes for Manukau Road services

These values do not fully reflect the large variations in travel time that are currently experienced, but are considered to be consistent with the EEM approach for calculating reliability benefits for public transport services.

[32] Eg Brennand, Incorporating travel time reliability in the estimation of assignment models, NZ Transport Agency research report 464, December 2011

The number of passengers affected is assumed to be all passengers along the route as those at the start of a route experience most of their delay 'in vehicle' and those nearer the end of the route experience most of their delay waiting for 'departure'. This is consistent with using the combined EL value.

The assessment has shown that even a 1 minute reduction in AML for every service gives a reliability benefit that is three times the benefit associated with the travel time improvements. This means that the reliability benefits have to be capped at value of the travel time benefits.

4.2.6 Public transport user benefits

Section A18 of the EEM identifies benefits associated with improving the quality of PT infrastructure and services.

Table A18.3 identifies feature values for rail services. These values have been used in the absence of light rail specific values. The introduction of LRT vehicles, replacing buses, will see an improved passenger offering by introducing vehicles with all the modern conveniences (such as on-board information and air conditioning). The costs of these quality improvements are, of course, included within the costs of the vehicles. The attributes that have been adopted (giving an improvement are:

Table 14

Attribute	Value (IVT mins)	Attribute	Value (IVT mins)
Ride	1.2	Seating - well maintained	1.5
Interior information	1.1	Air conditioning	1.5

This gives a total of 5.3 minutes In Vehicle Time (IVT) benefit for improved PT service. Adopting the 50 per cent reduction for multiple features in line with the EEM Section A18 guidance this reduces to 2.65 minutes benefit per passenger.

Table A18.5 identifies infrastructure features values for stops and stations, ticketing, security and information. The proposed LRT network will implement high quality stops along the route with a higher level of amenity and features compared to many of the current roadside bus stops. The costs of these features are included in the scheme costs.

The attributes that have been adopted (implying an improvement) are:

Table 15

Attribute	Sub-attribute	Value (IVT mins)	Sub-attribute	Value (IVT mins)
Stop	Condition	0.1	Cleanliness	0.1
	Size	0.1	Lack of litter	0.2
	Seating	0.1	Type	0.2
Ticketing	Roadside	0.1	Availability	0.2
Security	Security point	0.3	Lighting	0.1
	CCTV	0.3		
Information	Terminals	0.1	Contact Number	0.1
	Real-time information	0.8	Timetable	0.4
	Clock	0.1		

This gives a total of 3.3 minutes In Vehicle Time (IVT) equivalent benefit for improved infrastructure features. Adopting the 50 per cent reduction for multiple features this reduces to 1.65 minutes benefit per passenger.

Adding the service and infrastructure benefits together, a total of 4.3 minutes of IVT per passenger is calculated.

This time benefit is then applied to the patronage aboard the LRT services.

The base value of time is taken from Table A4.1(b) in the EEM (in line with the Section A18 guidance), corresponding to commuting purpose in congested conditions and is ($7.80 + $3.15 = $10.95) / hour. The EEM update factor from 2002 dollars to 2014 dollars is 1.42 (*Source: EEM Section A12.3)* giving a value of time of $15.55 / hour. It is assumed that during the morning peak, all users can be considered to be commuting.

4.2.7 Noise

The EEM defines the benefits associated with a reduction in noise as being $350 / dB / household / year. This figure is based on an average property price of $450,000 (*Source: EEM Section A8.2*).

The number of properties has been determined using a GIS assessment. They are summarised below along with the estimated average property price along the routes.

Table 11 : Properties affected by noise

Route / section	Number of properties	Estimated average property price
Queen Street section	250	-
Dominion Road	650	$ 900,000
Sandringham Road	470	$ 800,000
Mt Eden Road	630	$1,000,000
Manukau Road	807	$ 900,000
Symonds Street section	150	-

For the purpose of the assessment, the Queen Street properties have been included in the Dominion Road line and the Symonds Street properties have been included in the Manukau Road line.

A simplified noise model has been built to determine the *equivalent sound level* (Leq) along each section of the LRT lines. This is based on operation from 5am – midnight for both the bus and LRT scenarios. Service headways for the modes differ.

The day is assumed to be broken into peak, inter-peak and off-peak periods with corresponding frequencies for both bus and LRT.

- **Peak**: 7am - 9:30am, 4pm - 6:30pm
- **Inter-peak**: 6am - 7am, 9:30am - 4pm, 6:30pm - 8pm
- **Off-peak**: 5am - 6am and 8pm - 12pm

Bus frequencies in the peak period are the required frequencies in 2026 and 2046 along each corridor. Inter-peak bus frequencies are assumed to be 40 per cent of the peak frequencies and off-peak frequencies are assumed to be 20 per cent of the peak frequencies.

LRT frequencies are based on the forecast operating frequencies. These are six minute headway in the peak periods and 10 minute headway in the inter-peak and off-peak periods.

Noise levels for the two modes are assumed as follows:

- Bus noise level: 68 dB (*Source: Marshall Day)*
- LRT noise level: 64 dB (*Source: Marshall Day)*

The Leq is calculated for the bus and LRT scenario along each route and the difference is taken as the noise benefit associated with the introduction of the LRT. This difference in decibels is combined with the number and assumed value of properties to determine the annual economic benefit from removing buses and replacing them with LRT.

4.2.8 Health benefits from walking

The health benefits arising from walking come through the additional distance between the LRT stops/stations. The EEM has a base value of benefit per pedestrian km of $2.70. The EEM update factor from 2008 dollars to 2014 dollars is 1.14 (*Source: EEM Section A12.3)* giving a value of $3.08 per km.

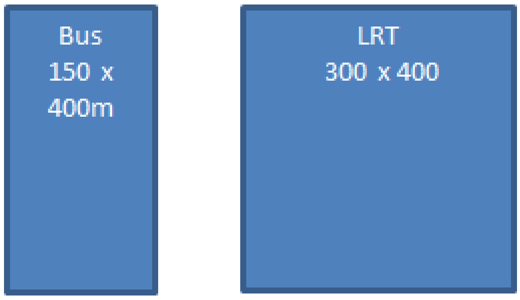
Passenger demand along each corridor is treated similarly to the calculation for the travel times.

‘Existing’ passengers are capped at those which can be catered for by bus. For example, Dominion Road has a passenger capacity of 1250 per hour. If the demand is 1500 per hour, then the existing customers are taken as 1250. They are assumed to already walk to their bus stop so only walk the incremental difference between bus and LRT stop spacing.

‘New’ passengers are those who want to travel by bus, but cannot due to capacity constraints. In the example above, this is the additional 250 people per hour. They are assumed to walk the average distance to the LRT stops.

Average bus stop spacing is approximately 300m and average LRT stop spacing is approximately 600m.

Assuming a grid type pattern of walking routes to any stop and 800m between key corridors, the assumed average walk distance is 275m for bus and 350m for LRT. The logic is explained in the following diagram where the catchment squares represent ¼ of the total stop catchment.



Assume grid pattern, gives 275m (150/2 + 400/2) avg walk dist
LRT scenario gives 350m (300/2 + 400/2) avg walk dist
75m extra for existing customers.
350m walk distance for new customers.

This means ‘existing’ customers walk an additional 75m and ‘new’ customers walk 350m.

The monetised benefit of this additional walking that is taking place is then annualised using the annualisation factor of 1833.

4.2.9 City Centre pedestrian travel time

The removal of general traffic from Queen Street and the improved efficiency of the signalised intersections (from the removal of turning traffic) means that pedestrians will be able to move more freely with less delay in the City Centre. They will have additional footpath space and be able to move along Queen Street in less congested conditions. Pedestrians will be able to cross Queen Street almost at will with only LRT vehicles and a small volume of service vehicles running up and down Queen Street in two running lanes.

Daily pedestrian volumes (2014) are approximately 50,000 on mid Queen Street and 42,000 on Lower Queen Street (*Source: City Centre Pedestrian Counts, Issue #5, January 2015 - Auckland Transport / Auckland Council)*. These counts are in the area that will benefit the most from the pedestrian improvements. For the purpose of this assessment, a daily pedestrian volume 70,000 people has been used. The counts pick up weekend pedestrian totals as well and these are slightly less than during the weekdays. Based on the surveyed information, a factor of 90 per cent has been used to estimate the volume of City Centre pedestrians on a weekend day. In 2012 and 2013 this factor was around 95 per cent, this factor reduces to 70 per cent in 2014 as the weekend Lower Queen Street count appears to be very low compared with historic data.

The base values of time are taken from Table A4.1(a) in the EEM and then updated using the EEM factor from 2002 dollars to 2014 dollars of 1.42 (*Source: EEM Section A12.3).* For the weekday volumes, there will be a mix of trip purposes and the proportion splits are shown in the table below. For the weekend volumes, all are assumed to be ‘other’.

Table 20

Trip purpose	Value of Time ($/hr - updated to 2014 dollars)	Assumed proportion of pedestrian totals (weekday)
Work	$30.81	20 per cent
Commute	$9.37	10 per cent
Other	$6.04	70 per cent

The assumed pedestrian growth rate is two per cent per annum. This is slightly higher than the medium projection for population in Auckland (1.6 per cent) to account for the slightly higher growth expected in the City Centre. This is less than the three per cent per annum growth experienced in the patronage on the City Link bus service used in the assessment of the Stage 1Q/1W benefits.

To annualise the daily totals, factors of 250 and 115 have been used for the weekdays and weekend days respectively.

The time saved per person has been estimated at 20 seconds.

The benefits associated with reductions in City Centre pedestrian travel times are assumed to begin when Stage 1Q/1W opens (2017).

4.2.10 Residual value

The residual value of the infrastructure associated with the network has been included as it will have a significantly longer life than the 40 year evaluation period.

The current estimated capital cost is $2,840b for the whole network.

The infrastructure component of this cost is taken as $1.215b (46 per cent of the total capital cost). This assumes the elements of the D&C cost portion (excluding design, project management and overheads) are the infrastructure costs and that the contingency and risk value is split proportionately to the individual element totals.

The residual value is assumed to be 50 per cent, which is the equivalent of an 80 year lifespan for the infrastructure.

The residual value is then calculated as 50 per cent of the infrastructure cost, discounted to the 40^{th} year of the evaluation period.

4.2.11 Agglomeration

The benefits associated with agglomeration have been assumed to be 15 per cent of the travel time and reliability benefits. This is consistent with similar projects. The value will be fully assessed in further work, as a range.

4.2.12 Economic benefit summary

The net present value (NPV) of the different benefit categories is summarised below on the basis of a 40 year evaluation period and six per cent discount rate.

Table 21

Benefit category	Medium population growth NPV ($m)	High population growth NPV ($m)
Time travel benefits	1050	1190
Public transport user benefits	239	263
Reliability benefits	770	845
Noise	75	75
Health benefits from walking	66	88
City Centre pedestrian travel time	25	25
Emissions	4	3
Residual value	60	30
Agglomeration	157	179
Total	2365*	2653*

4.2.13 Sensitivity test

The total NPV of the benefits using a 4 per cent discount rate and 60 year evaluation period is $??? m to ???

Further sensitivity tests will be carried out and scenario modelling applied as part of the process to refine and optimise the network.

4.2.14 Exclusions

The impacts on general traffic, whether positive in terms of decongestion, or negative in terms of creating additional congestion have yet to be quantified. Again these assessments will be part of the next step as the network is more fully assessed and optimised.

Along the corridors, the mid-block capacity is largely unaffected, but forcing left in / left out operation at priority intersections will cause re-routing for a large number of trips. It will put pressure on major signalised intersections whose capacity will be reduced due to maintaining the segregated LRT facility along the corridors. The problem may be significant if a network including multiple parallel arterial roads is implemented.

Similarly in the City Centre, the removal of general traffic from Queen Street will have some associated cost.

As noted, these impacts have not yet been quantified but it could be expected that they will have an overall negative effect, reducing the quantum of the benefits. This was not the finding in Sydney, however, where the analysis for the South East and CBD light rail found that there was a benefit to general traffic, resulting from the investment in improved intersections.

4.2.15 Benefit cost ratio

The NPV of the benefits is estimated to be $2,365 – $2,653m.

The costs for "Option Four" are provided in Appendix A. The NPV of the costs (capex and opex) is $1934m (*Source: PWC costing analysis*).

This gives a BCR of 1.2 to 1.4, depending on the growth scenario.

Using the 60 years evaluation period and a 4 per cent discount rate that is more appropriate for a project giving long term benefits, the BCR is 2.2 to 2.6 depending on the growth scenario.

4.3 Alternative economic evaluation approach[33]

4.3.1 Background: property value change and rapid transit infrastructure investment

Assessing property value changes in rapid transit corridors before and after infrastructure investment provides a method of measuring a wide range of economic impacts attributable to new infrastructure. The technique is increasingly contributing to ex-ante project appraisal, building on a more extensive range of ex-post evaluation studies.

4.3.2 A conceptual framework

Differential land values within cities reveal firms' and residents' willingness to pay for the advantages (and disadvantages) of particular locations. New rapid transit infrastructure can introduce significant impacts on the relative attractiveness of particular locations within urban areas that are reflected in changing property values.

Urban economics and transport planning theory explains positive relationships between transport investment and increased property values through improvements to the accessibility of particular locations. However, it is also recognised that land value impacts from new transport infrastructure are also likely to reflect a broader 'basket' of positive and negative factors distributed unevenly across different locations:

Transport infrastructure impacts positively on property values through improved accessibility and associated place-based improvements but can also introduce negative impacts such as increased pollution, noise, visual intrusion, traffic or nuisance associated with the infrastructure. The observed property value impact reflects the sum of all the positive and negative factors.

Urban economic theory suggests the most substantial impacts arising from transport investment can be explained through changes to the relative accessibility of locations. The theory suggests a chain of causality whereby new transport infrastructure establishes accessibility benefits that both strengthens agglomeration economies and (potentially) enables new property development opportunities that are in turn reflected in higher property values.

Agglomeration theory suggests a range of mechanisms linking improved accessibility with increased attractiveness of particular locations. For commercial property, firms located at more accessible locations can experience productivity advantages by being able to draw on wider labour pools, more ready access to inputs and outputs and easier access to flows of knowledge. More accessible residential locations will be more attractive in providing residents with access to a wider range of jobs, social and cultural opportunities. These advantages for both firms and households in more accessible locations are capitalised in higher property values and rents.

Economic theory linking transport investment with agglomeration economies and property values acknowledges that these relationships and potential positive benefits depend on a range of contextual conditions. Contextual conditions may include the background macro-economic climate and institutional factors such as supportive land-use planning policies.

[33] Auckland Light Rail Network: an evaluation using property value uplift, MRCagney and PwC, February 2015

4.3.3 Identification of potential impacts of Auckland LRT on property values based on previous studies

To identify a potential range of property value uplift percentages, the analysts conducted a literature review to identify studies on the impact of infrastructure on property values. They focused primarily on light rail infrastructure, although there is also a wealth of research on other rapid transit infrastructure.

The analysts compiled range of studies including several broad "meta-analyses" that summarised the results of various other studies. As these studies covered a wide variety of LRT systems in a number of different cities, they filtered the results to focus on the most comparable case studies. In doing so, they prioritised *ex-post* studies over *ex-ante* analysis as they are likely to provide a more accurate guide to the true impact of new infrastructure.

The analysis prioritised the following factors when selecting comparable projects to benchmark the potential impact of the full network in Auckland:

- New light rail infrastructure (rather than metro rail, bus rapid transit or roading projects)
- Corridors passing through residential and CBD commercial areas
- New infrastructure of a similar length
- Projects in cities with populations of 500,000 to 3 million people
- Projects in developed cities

There were no projects that matched all the selection criteria. Therefore, the analysts chose a number of projects which broadly fit within the criteria to represent a range of potential effects of the full network. The case studies selected were:

- Croydon Tramlink - four lines which make up a system length of 28km
- Sheffield Supertram - three lines which make up a system length of 29km in an urban area of 1.36 million people
- San Diego Trolley system - three lines in a city of population 1.37 million (but a metropolitan area population of 3.1 million)
- Santa Clara VTA Light Rail - three lines serving a metropolitan area of 1.84 million people
- Portland MAX Light Rail - four lines serving a metropolitan area of 2.23 million
- Sacramento Light Rail - three lines serving a metropolitan area of 2.15 million people
- St Louis MetroLink - two lines serving a metropolitan population of 2.79 million
- Manchester Metrolink - seven lines serving a metropolitan population of 2.71 million
- Newcastle Metro - two lines serving a metropolitan population of 1.11 million

Some light rail projects have been studied by multiple researchers, so there is a range of estimated effects available. These are summarised in the table below and further detail is available in the reference document[34]. The catchment areas studied were also variable in their distance/area from the station.

As shown in the table below, the range of results is wide but is likely explainable by city characteristics and infrastructure characteristics.

However, the impact on property values is generally positive, indicating that property values broadly increase with access to a LRT station. It also appears that the increase in property value is larger for commercial properties than residential properties although there is only one commercial property data point. Within the broader set of studies (including metro rail, BRT, larger cities), the commercial property uplift being greater than the residential property uplift, appears to be a generalised result.

Table 22 : Range of land value uplift observed following LRT projects in nine comparable cities

City	Residential property increase (per cent)	Commercial property increase (per cent)	Commercial rents increase (per cent)	Retail property increase (per cent)
Croydon	4 per cent			
Sheffield	0 per cent to 7 per cent			
San Diego	2 per cent to 7 per cent			167 per cent
Santa Clara	-10.8 per cent	15 per cent to 120 per cent	7 per cent to 13 per cent	
Portland	6.5 per cent to 10.6 per cent			
Sacramento	6.2 per cent			
St Louis	32 per cent			
Manchester	No discernible impact			
Newcastle	1.7 per cent			
Unweighted average	*5.5 per cent*			

4.3.4 Applying a property value uplift methodology to Auckland Light Rail

This section includes a scenario-based evaluation of the potential for property value uplift following the development of an Auckland LRT network. The analysis is based on:

- A range of scenarios for property value uplift in walk-up catchments around LRT stations, drawn from the *ex-post* studies in comparable cities

[34] Knowles and Ferbrache, An investigation into the Economic Impacts on Cities of Investment in Light Rail Systems, Report for UKTram, June 2014

- Current property values in walk-up catchments, determined using Auckland Council's ratings database and GIS analysis.

The literature suggests a range of potential values for the size of walk-up catchments around LRT stations in which property value uplifts are captured. These range up to 400-800 metres for commercial properties and up to 1 kilometre for residential properties. The analysis considers a range of catchment sizes from 350 metres (an extremely conservative estimate of catchment size) to 800 metres.

The base assumption is that the walk-up catchments will average 500 metres around stations, as shown in the above map. This is still more conservative than what has been observed in many studies.

Table 23 : Scenarios for property value uplift around LRT stations

Uplift scenario	Residential property	Commercial property
Low	2 per cent	3 per cent
Medium	6 per cent	9 per cent
High	10 per cent	15 per cent

Source: PwC / MRCagney analysis

4.3.5 Results of analysis for Auckland

The analysis applied these scenarios for property value uplift to the walk-up catchments around LRT stations in order to obtain a range of potential benefits from the project. Table 24 shows the potential range of benefits for residential and commercial properties in the LRT catchment area, and estimates the resulting range of benefit-cost ratios for the project.

Table 14 : Potential range of benefits from LRT (assuming 500m walk-up catchments)

Scenario for uplift	Benefits for residential properties	Benefits for commercial properties	Total benefits	BCR
Low	$0.4bn	$1.0bn	$1.3bn	0.7
Medium	$1.1bn	$2.9bn	$4.0bn	2.2
High	$1.8bn	$4.8bn	$6.6bn	3.7

The key finding of this analysis is that the BCRs may range from 0.7 to 3.7, with a medium outcome of 2.2. In other words, the lower range of benefits from this evaluation method is consistent with the value generated from a conventional transport appraisal under the NZTA's EEM rules, while the midpoint and upper end of the range are considerably higher. As these results are based on outcomes observed in *ex-post* studies of previous light rail projects, this suggests that conventional evaluation procedures may exclude or underestimate some benefits for users and neighbouring proper

5 Urgency of initial stages

5.1 Timing imperatives

Multiple factors come together to suggest AT should aim to open a first stage of LRT by 2017:

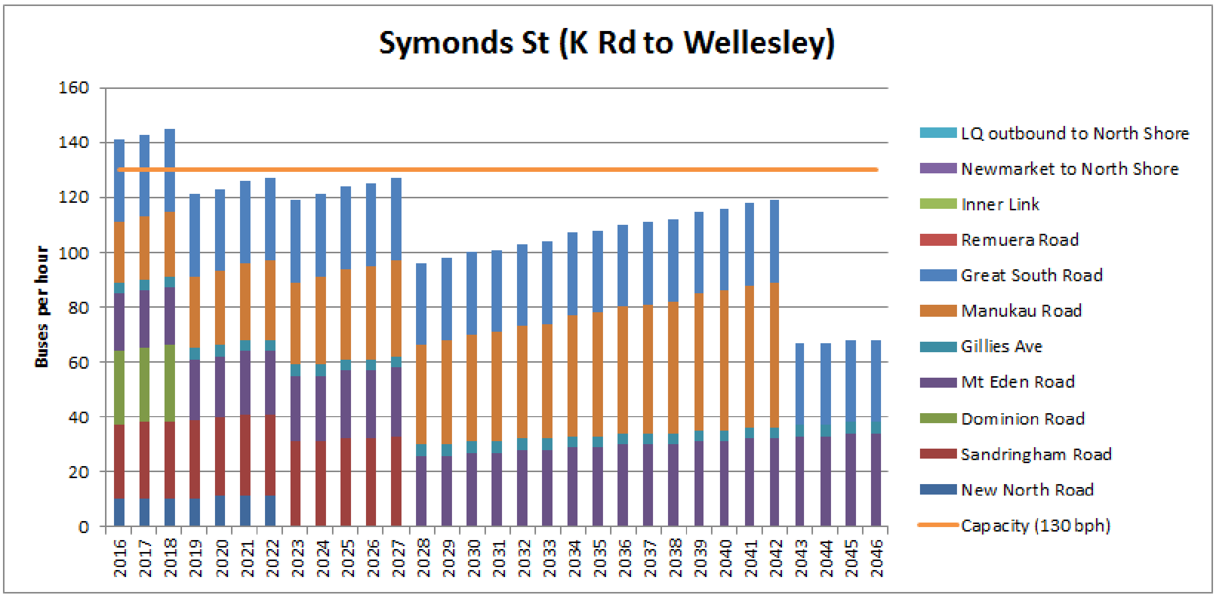
- Reducing bus numbers on Symonds Street – and more generally in the City Centre
- Relieving the total number of buses in the City Centre - terminal capacity
- Relieving bus numbers on the Sandringham/Dominion routes (at New North and View roads, respectively)
- Providing a contingency for the western metro (commuter) rail line if growth is consistently more than 11 per cent year on year
- Providing an alternative service during construction of the CRL in the Mt Eden area
- Expected high customer usage as estimated in the modelling.

5.2 Bus numbers on Symonds Street

As noted above, Symonds Street carries the highest number of buses of the normal street network at about 140 bph in the peak one hour. International standards[35] suggest that bus network performance deteriorates significantly above 100bph with a single bus lane, with a preferred limit of 80bph for both operational and amenity reasons. An accepted figure for the practical maximum capacity is 130bph. Symonds Street is already above this figure – with a consequential poor performance evident now with queuing and late running the norm.

The chart below shows the impact on Symonds Street if LRT is progressively introduced and corresponding bus services are removed with successive stages being required to reduce the number of buses below the 130bph ceiling.

The analysis assumes that LRT is introduced on Dominion Rd in 2019, Sandringham Rd, 2028, Manukau Rd, 2043 and Mt Eden Rd beyond 2046.



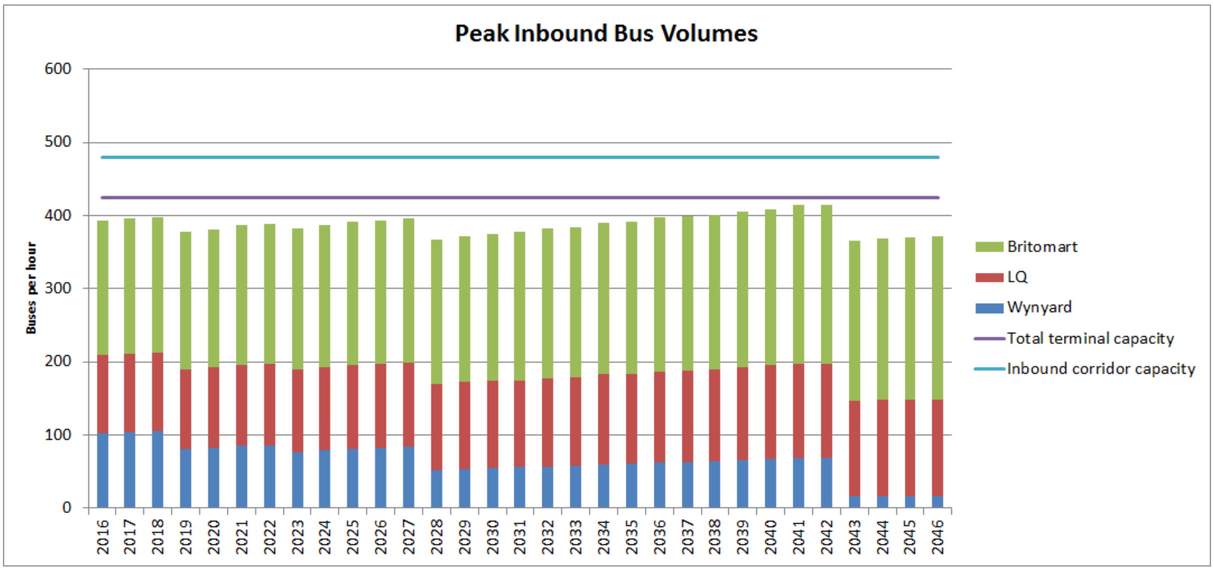
It could be argued that in a liveable city the lower threshold of 80bph should not be exceeded. Conversely, it is unlikely to be sound investment to target sufficient capacity for a relatively high level of service in the 'peak of the peak'. For these reasons – and noting pressure for investment across the city-region - the absolute limit of 130bph is used as the investment criterion. In order to avoid Symonds Street exceeding this limit a first stage of LRT is required as soon as possible, preferably by 2017.

[35]Eg Transit Capacity and Quality of Service Manual, Third Edition, Transportation Research Board, 2014

5.3 Relieving the total number of buses in the City Centre

Auckland has very confined space in the City Centre that is available for bus termination. There are already capacity issues and no opportunity for a major CBD bus interchange given the premium value of land (an underground option was investigated and rejected in CCFAS and again shown not to be viable in more recent assessments). While options are being investigated at Wynyard, Lower Downtown and in the Learning Quarter, they are not expected to add capacity, but rather to improve urban amenity and avoid some of the present unsatisfactory arrangements.

Providing LRT on Isthmus corridors allows the total number of buses to remain manageable despite increases on other services to areas for which no alternative exists, as demonstrated below for a medium growth scenario and the same sequence of LRT introduction as in section 5.2 above.



5.4 Relieving bus numbers on the Sandringham/Dominion routes

It is only once the first major bus corridor is replaced by LRT that the necessary drop in bus numbers can occur. Demand suggests that the Sandringham and Dominion bus routes should be replaced first with their connection to Queen Street – which will allow for later conversion of Symonds Street to LRT. The Dominion Road route would then be available for extension to the Airport – possibly for 2025 to meet the expected growth in passenger numbers and to match the Airport company's investment programme.

In addition there will be a unique opportunity to undertake the work on Dominion Road to construct the LRT track when Waterview opens in 2017 and there is a sharp drop in general traffic – which will be eroded with time.

5.5 Providing a contingency for the western metro (commuter) rail line

The western rail line is experiencing high growth in customer numbers (14% year on year) although the EMUs have not yet been introduced. If, as expected, there is a further substantial uplift with the EMUs then the capacity of the line may be exceeded before the CRL is in place to allow additional services.

LRT would provide substantial relief to the inner end of the line and provide options while changes are made to the metro rail network near Mt Eden station that will restrict capacity.

5.6 Expected patronage

The transport modelling shows that a first stage serving Queen Street would be well-patronised being a popular option for customers and replacing the City Link shuttle bus which is extremely busy along its short length, despite being highly unreliable and subject to traffic congestion. A connection to the metro (commuter) rail network at Kingsland would also provide customers with convenient interchange to access parts of the City Centre that are less well-served by commuter rail stations.

6 Summary financial forecasts

This Section contains financial projections for Stage One. Financial projections for the full LRN being assessed in this Business Case are included in Appendix One.

The projections included in this section are consistent with the projections used to estimate the costs for the economic benefit and cost analysis included in Section 4

The projections comprise:

- The cost of constructing the infrastructure. This includes land and property, investigation and reporting, design and construction.
- The cost of acquiring LRVs.
- The cost of providing the light rail services.
- The reduction in bus operating costs as a consequence of light rail displacing buses.
- The cost of ongoing renewals, capital expenditure for LRVs and infrastructure.
- Savings in bus capital expenditure as a consequence of reduced bus numbers.

The projections include an estimated cost of financing the capital expenditure required for the development of the infrastructure and the purchase of the LRVs. The cost of finance has been estimated on the basis of the Council borrowing to finance the capital expenditure. An estimate of the financing cost has also been made if the private sector were to provide the finance. This is discussed at the end of this Section.

An important output of the projections is the "public sector" funding requirement. This is the amount required on an annual basis to fund the:

- Net operating costs: the costs of operating the LRVs (fuel, personnel, maintenance etc.) after deducting the savings in costs from the reduction in the number of buses.
- Debt repayments: The funding requirement has been modeled to produce zero net cash flow in each year. This results a small profit or loss in the profit and loss statement because of differences between the depreciation charge included in the profit and loss and capital expenditure.
- Interest on the financing required for the LRT.

A summary of assumptions used to generate the projections is included in the financial case report (Stage One and the wider LRN) - LRT for Auckland Full Financial Case, PwC, February 2015. Key assumptions used for the Stage One projections are presented below:

Table 26 : Stage One Queen Street to Kingsland financial projections key assumptions

Assumption	Unit	Value/Quantity
Initial investment		
• Infrastructure	$M	420
• LRVs	$M	40
Capital expenditure/renewals		
• Asset lives		
- Infrastructure	Years	50
- LRVs	Years	30
- Buses	Years	20
• Replacement cost		
- LRVs	$M/LRV	6.8
- Buses	$M/Bus	0.5
Operating costs		
• LRNs	$M/pa	3.0
• Buses	$M/pa	3.0
Inflation rate	per cent pa	2.5
Interest rate	per cent pa	7.5

LRT operating costs comprise costs for staffing, power, LRV and infrastructure maintenance and infrastructure renewals. Bus operating costs comprise cost for staffing, fuel, RUC and maintenance. The operating costs are projected on the basis of service kilometers, services hours or track length (route length) as appropriate.

Projections have been produced for a 40 year period (with a sensitivity period of 60 years). This aligns with the requirements of the EEM.

Appendix A - Financial Projections Assumptions

Summary of results

The following summarises the net present value of costs modelled over a 40 year period commencing 1 July 2015.
The present values are as at 1 July 2015.

	Option 4	Stage 1
Operating expenditure	**NPC $m**	**NPC $m**
Bus staffing costs	(303)	(27)
Bus fuel, RUC etc	(231)	(13)
LRV staffing costs	97	20
LRV power	71	9
LRV 'marginal maintenance'	34	4
LRV network maintenance	23	4
LRV network renewals	8	1
Total operating expenditure	(300)	(1)
Capital expenditure		
Total capex - works	1,964	346
Capex for buses	(135)	(9)
Capex for LRV	320	57
Total capital expenditure	2,149	395
Total	**1,848**	**394**

Incremental costs and revenues

The cost forecasts are based on incremental costs of Light Rail. This is modelled as Light Rail capital expenditure and operating expenditure less the capital and operating expenditure associated with buses and bus services that will be avoided as a consequence of the implementation of the Light Rail services.

General

Evaluation period	40 years
Calculation periodicity	Quarterly
Costs escalation applies from	1 Jul 15
Inflation for works, capex, operations and maintenance	2.5% pa

Timing

Number of stages	4
Stage length	2 years
Total construction length	8 years

Construction of each stage occurs evenly over the eight quarters (two years).
A step-up in operating costs (and cost savings from bus reductions) occurs after each of the four stages is complete.

Physical works

Costs from the 'Final Summary' worksheet of 'CCFAS2 Draft Estimate estimate-current.xlsx'.

An additional notional $150m has been included as the physical works cost associated with the Wynyard Quarter section of Stage 1.

Total real physical works cost is $2,626m including the 'Contingency (P50)' and excluding the Wynyard adjustment.

Depreciation - Land	None
Depreciation - Other	50 year
Depreciation method	Straight line

Interest during construction is capitalised into the asset balance.

The capital expenditure tables show total physical works costs by stage.

Bus and LRT purchases and renewals

Purchases of LR units and buses avoided (including a 10% allocation for spares/rotation) are summarised as follows:

# of units	Stage 1	Stage 2	Stage 3	Stage 4	**Total**
LR purchases	8	15	15	16	**54**
Buses avoided	14	56	104	105	**279**

Stage 1 and Stage 2 from 'Stage 1 Costing' & 'Stage 2 Costing' in 'CCFAS2 costing sheet Option 4 Staging v2.1 (15-12-2014).xlsx'.

Stage 3 and Stage 4 implied from Option Four in 'Working Paper - Costing Summary for Options 6, 8, 9A, 4 - Revision (1.2).pdf'.

Light Rail

LR unit cost	$6.8m ea
LR useful life	30 years
LR unit renewal cost (in 2014 dollars)	$1.36m ea
LR renewals required	15 years

LR purchases and renewals are capitalised and depreciated.

LR purchases occur twice – once initially and again in 30 years time.

The capital expenditure tables shows total real cost associated with LRT purchases and renewals by stage.

Buses

Bus unit cost	$500k ea
Bus useful life	12 years
Bus unit renewal cost (in 2014 dollars)	$100k ea
Bus renewals required	6 years

Avoided bus capex and opex is included in the analysis.

Bus purchases and renewals are capitalised and depreciated.

The bus purchases are avoided four times – once initially and again after 12, 24 and 36 years time.

Operating and maintenance costs

A summary of the service hours, service kms and network length by stage is presented in the table below:

	Stage 1	Stage 2	Stage 3	Stage 4	**Total**
Light Rail					
Service hours pa	31,040	63,072	43,439	43,439	**180,990**
Service kms pa	308,786	904,250	861,044	861,044	**2,935,124**
Network length added km	4.19	12.27	7.80	7.80	**32.06**
Buses					
Service hours pa	49,472	160,898	256,754	256,754	**723,878**
Service kms pa	471,820	2,134,176	4,157,363	4,157,363	**10,920,721**

Stage 1 and Stage 2 from 'Stage 1 Costing' & 'Stage 2 Costing' in 'CCFAS2 costing sheet Option 4 Staging v2.1 (15-12-2014).xlsx'.

Stage 3 and Stage 4 implied from Option Four in 'Working Paper - Costing Summary for Options 6, 8, 9A, 4 - Revision (1.2).pdf'.

Light Rail

Staff costs per service hour	$49.20
Power costs per service km	$2.31
Other maintenance costs per service km	$1.10
Track maintenance costs per km pa	$65,815
Track renewals per km pa	$24,352

Track costs are flat values per km per annum across the analysis period as no phasing has been provided.
Network maintenance (both maintenance and renewals) are expensed as incurred (i.e., not capitalised)

Buses

Staff costs per service hour	$41.00
Other costs per service km	$2.10

Revenue

Farebox revenue	none
Funding - AT share	50%
Funding - NZTA share	50%

Financing

Interest rate on cash and debt	8% pa

Construction is 100% debt financed. Debt repayments begin with operations.
Rolling stock is 100% debt financed.
All debt fully repaid within the 40 year analysis period.
Debt is amortised on an equal payment basis.
No arranging or commitment fees have been included.

Capital expenditure by stage (for full analysis period)

Real $M	**Stage 1**			**Stage 2**			**Stage 3**	
Stage	**Queen Street (Fort to Ian Mkinnan Drive)**	**Wynyard section**	**Sub-Total**	**Dominion Road Don McKinnon to Mt Roskill**	**Stoddard & Depot**	**Sub-Total**	**Sandringham Road**	**Sub-Total**
Physical works	265	113	378	350	264	614	296	296
LRT purchases (twice within period)			109			204		204
LRT renewals			22			41		41
Physical works plus LRT			**508**			**859**		**541**
Peer reviewed physical works	404	-*	-*	441	332	774	373	373
Variance cf physical works	*140*			*91*	*68*	*159*	*77*	*77*

* No peer reviewed physical works cost provided for Wynyard section

Real $M	**Stage 4 & 5**					**All stages**
Stage	**Stage 4 Mt Eden Road (incl. upper Symonds Street)**	**Stage 5 Customs Street To New Market**	**Stage 5 New Market to Onehunga**	**Additional Stabling**	**Sub-Total**	**Total**
Physical works	338	600	436	20	1,395	**2,683**
LRT purchases (twice within period)					218	**734**
LRT renewals					44	**147**
Physical works plus LRT					**1,656**	**3,564**
Peer reviewed physical works	426	756	549	25	1,757	
Variance cf physical works	*88*	*156*	*113*	*5*	*362*	