MINISTRY OF TRANSPORT
TE MANATŪ WAKA

OC241373

18 December 2024

[redacted]

Tēnā koe [redacted]

I refer to your email dated 25 November 2024, requesting the following under the Official Information Act 1982 (the Act):

> *"a copy of all reports (including the foundation report) for 2016 ATAP."*

16 documents fall within the scope of your request and are enclosed. The documents are listed in the document schedule attached as Annex 1.

You have the right to seek an investigation and review of this response by the Ombudsman, in accordance with section 28(3) of the Act. The relevant details can be found on the Ombudsman's website **www.ombudsman.parliament.nz**

The Ministry publishes our Official Information Act responses and the information contained in our reply to you may be published on the Ministry website. Before publishing we will remove any personal or identifiable information.

Nāku noa, nā

Karen Lyons
Director Auckland

Annex 1: Title

Doc #	Document Title
1	ATAP ART Model Paper
2	ATAP Arterial Roads Report
3	ATAP Bus Reference Case Report
4	ATAP Demand Management Pricing Report
5	ATAP Evaluation Report
6	ATAP Final Report - 31 Aug 2016
7	ATAP Final Report Cover Letter
8	ATAP Foundation Report
9	ATAP Freight Report
10	ATAP Interim Report
11	ATAP MOR Report
12	ATAP Recommended Strategic Approach
13	ATAP Revenue and Expenditure report
14	ATAP Supporting Information
15	ATAP Technology Report
16	ATAP Update Report June 2016

Suitability of the ART model to support ATAP

Advice from the Independent Advisor

Suitability of the ART model to support ATAP

Advice from the Independent Advisor

Client: Auckland Council

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Quality Information

Document Suitability of the ART model to support ATAP

Ref

Date 22-Mar-2016

Prepared by Steven Kemp

Reviewed by Andrew Foy

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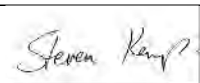
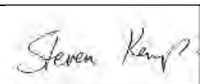
B	21-Sep-2016	Final Report Reformatted and minor amendments following feedback from JMAC	Steven Kemp Technical Director, Transport Advisory, Australia & New Zealand	
A	22 March 2016	Draft report	Steven Kemp Technical Director, Transport Advisory, Australia & New Zealand	

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1.0 ATAP needs

1.1 Modelling needs

The ATAP project needs to understand the impact of a range of potential transport interventions. A range of key performance metrics have been agreed between the organisations supporting ATAP and it is proposed to test and refine potential packages of transport interventions to determine their performance. A refinement process will progressively increase the complexity testing of packages against a rising number of performance metrics.

To determine to suitability of the ART model to support all or part of ATAP, the ART model testing and validation report has been reviewed and discussions held with John Davies (JD) and Jojo Valero (JV) to discuss the models suitability to inform the ATAP, and explore if there might be any alternative models available that address any limitation.

2.0 Differing types of model

NZTA has defined seven types of transport model that have differing purposes. These models are validated to differing levels of precision aligned to their purpose. The models may be developed using a range of modelling tools (software) that offer different capabilities that relate to the models intended purpose. Table 1 below describes the different types of model and their purpose.

The ATAP project is considering a range of multimodal interventions that include large roading and public transport projects, changes to land use and population are also being considered. This suggests that models in the range of A-D would be suitable for understanding feasibility and allow option testing at high level.

Table 1 NZTA model categories and suitability for differing purposes

PROJECT APPLICATION	MODEL CATEGORY						
	A: REGIONAL	B: STRATEGIC NETWORK	C: URBAN AREA	D: NZ TRANSPORT AGENCY LARGE PROJECT	E: SMALL AREA /CORRIDOR	F: INTERSECTION /SHORT CORRIDOR	G: HIGH FLOW, SPEED, MULTI LANE
AREA DEMAND RESPONSES, LAND-USE/TRANSPORT PLANNING, POLICY INVESTIGATION	S	U	U	U	U	U	U
LARGER TRANSPORT SCHEME FEASIBILITY, SCOPING STUDY	S	S	P	P	U	U	S[5]
LOCAL AUTHORITY TRANSPORT INTERVENTION & LAND-USE PLANNING	S	S	S	P	P	P	U
OPTION TESTING, DESIGN REFINEMENT, ECONOMICS	P	P	P	S	S	S	S
DEVELOPMENT FORECASTINGS AND/OR IMPACTS	P	P	P	S	S	S	S
DETAILED DESIGN, TRAFFIC MANAGEMENT	U	U	P	P	S	S	S
ITS, INCIDENT MANAGEMENT, ACTIVE MODE DESIGN AND IMPACT	U	U	P	P	S	S	S

S GENERALLY SUITABLE

P PARTIALLY SUITABLE

U GENERALLY UNSUITABLE

Source: NZTA Transport model development Guidelines July 2014

3.0 Background to the ART model

JD described that the ART model's background and purpose. The model was developed in 2006 with a primary purpose of testing policy. The ART model is therefore a 'Type A' model and has proved a useful and capable tool.

We discussed the key metrics described in the ART3 Model Testing and Validation report (SKM 2008). The report shows that the model performs within the usual parameters for trip production, trip ends, mode share by purpose, trips by time of day. This indicates that the model generates an acceptable number of trips, during the correct periods of the day and for the correct purposes.

4.0 ATAP performance metrics

As part of the development of the ART model a number of differing calibration criteria were evaluated, details are provided below. The model performs well for its purpose and meets the validation criteria for its type and that were applied at the time of its development.

The ATAP project is seeking to test a number of differing transport projects and draw conclusions relating to a range of performance metrics. Typically these types of metrics would be drawn from a project specific model. ATAP is therefore seeking a level of precision from the ART model it was not built to support. To assess how well it might perform in supporting ATAP, several validation metrics for the ART model were considered. These are summarised in Tables 2 and 3 and described in the following sections.

The ATAP performance metrics sought from the model are in the main related to travel time and levels of congestion represented by the model. Table 3 below displays the ATAP metrics and the issues related to those metrics.

Table 2 ATAP metrics and ART capability

Metrics	ATAP requirements
Jobs accessible by car within a 30-minute trip in the AM peak	Requires: - The model to represent relative differences in delays and travel time in congested conditions for vehicles and passenger transport. The ART validation report shows that it responds poorly to this metric due to level of calibration of journey times. Representation of the choice of mode. The ART validation report shows that it responds well providing mode splits. - Geographic coverage that extends to the majority of employment centres ART responds well covering the entire region. Suitability for use: - There no other model available that covers the whole region and could provide this information. Caution should be used in interpreting results. The ART is suitable to provide a comparison of journey times between two different interventions/packages but not suitable for assessing absolute journey times.
Jobs accessible by public transport within a 45-minute trip in AM peak	
Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter- peak	
Per capita annual delay (compared to maximum throughput)	Requires: - The model to capture relative delays between options at a regional level - ART provides representation of full network and operation throughout the day. However there is concern over the extent to which ART provides relativity of different options and delays. Suitability for use: - For small differences in model results care is needed and a small difference in delay shouldn't be used as a sole reason for preferring one package over another

Metrics	ATAP requirements
Proportion of travel time in severe congestion in the AM peak and inter-peak Proportion of business and freight travel time spent in severe congestion (in the AM peak and inter-peak)	Requires: - The model to represent relative differences in delays and travel time in congested conditions for vehicles and passenger transport. ART responds poorly to this metric due to level of validation of journey times. - The model to provide representative forecasts of business and freight as a proportion of total travel ART responds poorly and does not represent freight. It does provide information on Heavy Commercial Vehicle's (HCV's). - A geographic coverage that extends to the majority of the network likely to be congested ART responds well covering the entire region. Suitability for use: - In the absence of a model that covers the whole region the ART can be used to provide a comparison of journey times between two different interventions/packages but not suitable for assessing absolute journey times. A small difference in travel time shouldn't be used as a sole reason for preferring one package over another.
Average vehicle occupancy	Requires: - The model to represent the split between public and private travel and between car driver and passenger. ART provides for mode and sub mode splits. Suitability for use: - Vehicle occupancy is fixed within the model. To test differing scenarios the value in the model needs to be manually altered.
Proportion of vehicular total trips in the AM peak made by public transport Proportion of vehicular trips over 10km in the AM peak made by public transport	Requires: - Representation of the choice of mode. ART responds well providing mode split included in the model by origin and destination. - A geographic coverage that extends to the majority of the network ART includes entire region Suitability for use: - Whilst the validation report indicates that the ART responds well to these metrics the APT is recognised within AT providing better public transport information. Therefore APT should be used.
Increase in financial cost per trip compared to savings in travel time and vehicle operating cost Package benefits and costs	Requires: - The ability to assess the cost components of each trip ART provides cost components, however costs of congestion are NOT modelled accurately due to poor representation of journey time and poor assignment validation at link level. - The ability to provide region wide benefits and costs for variable trip matrices. ART includes entire region and existing processes provide a consistent set of outputs. Costs of congestion are NOT modelled accurately due to poor representation of journey time and poor assignment validation at link level. Suitability for use: - In the absence of a model that covers the whole region the ART can be used to provide a comparison of journey times between two different interventions/packages but not suitable for assessing absolute journey times and benefits arising from journey time savings.

5.0 ART model performance

5.1 Assignment of traffic

Traffic models assign traffic to links with differing precision dependent upon their purpose.

The ability of models to assign traffic to the network is considered in two ways, at a corridor level and at a link level. Table 3 shows the NZTA modelling guidance performance specification for traffic assignment.

Table 3 NZTA modelling guidance: Hourly GEH Count Comparison Criteria

COUNT COMPARISON	MODEL CATEGORY						
	A: REGIONAL	B: STRATEGIC NETWORK	C: URBAN AREA	D: NZ TRANSPORT AGENCY PROJECT	E: SMALL AREA /CORRIDOR	F: INTERSECTION /SHORT CORRIDOR	G: HIGH FLOW, SPEED, MULTI LANE
TOTAL DIRECTIONAL COUNT ACROSS SCREENLINE:							
GEH<5.0 (% OF SCREENLINES)	>60%	>75%	>85%	>90%	NA	NA	NA
GEH<7.5 (% OF SCREENLINES)	>75%	>85%	>90%	>95%	NA	NA	NA
GEH<10.0 (% OF SCREENLINES)	>90%	>95%	>95%	>100%	NA	NA	NA
INDIVIDUAL DIRECTIONAL LINK COUNT ON SCREENLINES:							
GEH<5.0 (% OF COUNTS)	>65%	>80%	>85%	>87.5%	NA	NA	>90%
GEH<7.5 (% OF COUNTS)	>75%	>85%	>90%	>92.5%	NA	NA	>95%
GEH<10.0 (% OF COUNTS)	>85%	>90%	>95%	>97.5%	NA	NA	100%
GEH<12.0 (% OF COUNTS)	>95%	>95%	>100%	>100%	NA	NA	100%
INDIVIDUAL TURNING MOVEMENTS AND / OR DIRECTIONAL LINK COUNTS:							
GEH<5.0 (% OF TURNS)	NA	>75%	>80%	>82.5%	>85%	>95%	>85%
GEH<7.5 (% OF TURNS)	NA	>80%	>85%	>87.5%	>90%	100%	>90%
GEH<10.0 (% OF TURNS)	NA	>85%	>90%	>92.5%	>95%	100%	>95%

Source: NZTA Transport model development Guidelines July 2014

In terms of assignment to the road network, at a screenline level the ART model performs well for a policy tool. Its performance in this regard is shown below.

Table 4 **ART model validation at Screenline level**

Statistic	AM	IP	PM	Guideline for Model type A	Guideline for Model type B
Proportion of screenlines with GEH<5	46%	61%	57%	>60%	>75%
Proportion of screenlines with GEH<10	71%	79%	89%	>90%	>95%
Proportion of screenlines with GEH<12	82%	89%	89%	-	-
Proportion of screenlines with % difference <10	81%	79%	93%	-	-
R^2	0.986	0.987	0.992	-	-

Source: ART3 Model Testing and Validation Report SKM 2008 and NZTA Transport model development Guidelines July 2014

Note: The lower the GEH value the better the modelled flow is comparing with observed. A value of 5 or less on an individual link is very good, between 5 and 10 is good, and 10 to 12 is reasonable. At the time of development the targets were that 60% links having a GEH of 5 or less and 100% having 12 or less. These target levels of validation have now changed.

Table 5 **ART model validation at Link level**

Statistic	AM	IP	PM	Guideline for Model type A	Guideline for Model type B
Proportion of links with GEH<5	35%	34%	34%	>65%	>80%
Proportion of links with GEH<10	61%	61%	64%	>85%	>90%
Proportion of links with GEH<12	69%	69%	70%	>95%	>95%
Proportion of links with % difference <10	61%	60%	64%	-	-
R^2	0.877	0.861	0.866	-	-

Source: ART3 Model Testing and Validation Report SKM 2008 and NZTA Transport model development Guidelines July 2014

As can be seen from tables 3 to 5 above, the assignment validation for ART model is reasonable at a screenline level and less well at link level.

This suggests that the model assigns demand acceptably at a corridor level but not for individual links. Project models are usually developed to provide a good representation of link flow. JD advised that AT usually uses or develops individual project models where appropriate.

The above assessment indicates that ART performs well for its intended purpose. It is not calibrated to a level where it represents link flows well and as a consequence caution is required in the use of its outputs when considering link metrics. The ART model can be used to produce comparative assessments of performance for differing projects but should NOT be used to inform design decisions.

5.2 Travel times

The ART's model travel time validation was tested for 3 periods of the day, AM peak, inter peak and PM peak. ***The EEM available at the time the model was calibrated provided no guidance as to acceptable calibration criteria***.

Table 6 below shows the journey time validation achieved in the ART model.

Table 6 ART model journey time validation

	No of Routes		
Diff from mean survey time	**Cumulative**	**%**	**Individuals**
AM Peak			
<5%	10	14%	10
<10%	25	36%	15
<20%	53	76%	28
>20%		24%	17
Within Range of survey times	47	67%	
Interpeak			
<5%	14	20%	14
<10%	33	47%	19
<20%	60	86%	27
>20%		14%	10
Within Rangeof survey times	44	63%	
PM Peak			
<5%	12	17%	12
<10%	20	29%	8
<20%	47	67%	27
>20%		33%	23
Within Range of survey times	31	44%	

Source: ART3 Model Testing and Validation Report SKM 2008

As can be seen from table 6, 76% of routes achieved a validation within 20% of the mean journey time in the AM Peak, and 67% of routes achieved a validation of within 20% of the mean journey time in the PM peak. The current NZTA guidance for journey time validation indicates 80% of modelled route journey times should fall within 15% of the mean observed journey time.

It should be noted that the ART model was last updated in 2006 and since this time the cost of travel time survey data collection has reduced significantly and the data variability improved dramatically.

The current NZTA guidance shown is shown in Table 7 below reflects this.

Table 7 Total journey time by route comparison criteria

Total Route Directional Peak Journey Time	Model Category						
	A: Regional	B: Strategic Network	C: Urban Area	D: NZ Transport Agency Project	E: Small area / Corridor	F: Intersection / Short Corridor	G: High Flow, Speed, Multi lane
Within 15% or 1 Minute (if higher) **(% of Routes)**	>80%	>85%	>85%	>87.5%	>90%	>90%	>90%

Source: NZTA Transport model development Guidelines July 2014

Having reviewed the Art model journey time validation data for the AM, PM and inter peak periods it was found not to reach the current validation required for any type model.

The ART model's journey time representation is poor during the AM and PM peaks. It is therefore NOT suitable to inform benefits associated with travel time saving, or business cases.

It should however be noted that in 2006 when the ART model survey data was collected, the technology to economically capture a large body of journey time data did not exist, and therefore data samples were small. High quality calibration of journey times in policy models would not have been sought.

5.3 Public Transport

The ART model validation for all PT trips is quite good within 3% in the AM peak and 1% in the PM peak. Assignment between different modes is less good. Across the region bus patronage is slightly over estimated in the peaks by about 5%, and under estimated inter-peak, by 11%.

At a regional level rail patronage is under estimated in the peaks by approximately 10% and overestimated in the inter-peak period by 27%.

At a sub-regional level, the calibration of bus patronage in the South is particularly poor. During the peak hours ART significantly over estimates bus patronage in the South (+ 47% AM, and +86% PM).

5.4 Heavy Commercial Vehicles (HCV's)

The ART 3 Model testing and Validation report provides some detail on the performance of the model at reflecting Heavy Commercial Vehicles at a screenline level. A review of the validation data for individual screen lines provided within the ART3 Model Testing and Validation Report (SKM 2008) suggests that the model underestimates HCV volumes to Auckland Port and overestimates HCV to offices and commercial – this is a future year issue.

5.5 Alternative models

JD advised that there are a number of different project models and that spatially these collectively would cover a substantial part of the Auckland region. However these are not multi-modal models and do not represent public transport.

There are several issues concerning the practicality of using multiple project models to inform ATAP. The most significant of these being calibration in differing years and to differing attained levels of calibration. This would give rise to a lack of consistency in ATAP project evaluation. The use of multiple differing project models to develop ATAP data is not recommended.

6.0 Conclusions and recommendations

The ART model is well suited to its purpose as a regional model developed to test policy. It represents regional performance to changes in population, employment and transport infrastructure well.

Regional models are not well suited to assessment of infrastructure at a link level and typically project specific models are developed when this data is needed.

ATAP needs a multimodal transport model to evaluate options for the future and ART3 is the only model in Auckland which has the capability..

Given the above and the importance of trip assignment at link level for the evaluation of public transport patronage, the use of the ART model is not recommended to test the impacts upon public transport patronage. The use of the APT model which was developed for this specific purpose is recommended.

ATAP will on occasions seek a precision of modelling beyond that which the ART model was created to provide. Persons evaluating ART model outputs therefore need to be cognisant of the limitations of using a regional model in the expectation of greater precision than is achievable for a model of this type.

The ART model's suitability to be used to test alternative transport projects is dependent upon what purpose its outputs are to be used for. Many of the agreed ATAP performance metrics are based upon journey time data which is a metric that regional models are not typically used to derive, nor are they usually well calibrated/validated for. However, since much of the work of ATAP is seeking to compare the performance of two similar sized intervention packages and in such circumstances the ART model is a suitable tool to produce comparative data. If comparative differences are small, the ART model outputs should not be used as a point of differentiation.

Investment decisions on individual projects will need to be supported by project specific business cases and for high value projects, it is recommended that individual projects models meeting NZTA modelling guidelines should be created.

The ART model is a strategic model developed to test policies and is not suitable to inform detailed design decisions, to develop bus service plans or to develop individual/detail project business cases.

When evaluating the ART model outputs, it would be beneficial to include JMAC staff who are familiar with the ART model (and its limitations) to help ensure that during evaluation of ATAP packages, that conclusions that cannot be supported by the level of calibration of the model are avoided.

It was noted that some of the outputs from the first round of ATAP evaluations contained results that appeared to be counter intuitive. E.g. modelling interventions that increased road capacity but the model reflecting poorer service (flow/speed). These instances need to be investigated to determine if this unexpected performance results from errors in coding which is perhaps a more likely cause that an issue with the model performance.

Auckland Transport Alignment Project

Arterial Roads Report

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Preface

This is one of a series of research reports that were prepared as inputs to the Auckland Transport Alignment Project (ATAP). It is one of a number of sources of information that have been considered as part of the project, and which have collectively contributed to the development of the recommended strategic approach. The content of this report may not be fully reflected in the recommended strategic approach, and does not necessarily reflect the views of the individuals involved in ATAP, or the organisations they represent. The material contained in this report should not be construed in any way as policy adopted by any of the ATAP parties. The full set of ATAP reports is available at www.transport.govt.nz/atap.

1. Executive Summary

Auckland's transport system faces a major challenge in coping with strong population growth. Arterial roads (as distinct from motorways and local/collector roads) are a vital part of the system, helping provide access to employment, education, hospitals and leisure destinations; and providing essential links for road freight. For these roads significant through-movement is of primary importance. Many arterial roads also have a variety of other, potentially competing uses, including providing access to local centres. Many Aucklanders live along these roads, which are the focus of substantial future growth.

Auckland's projected growth will place greater pressure on these networks, meaning that congestion will increase unless steps are taken to improve network efficiency and productivity. This report investigates the extent to which arterial road productivity (throughput of people and freight) can be increased while taking these other functions into account.

Currently, the main approaches to improving arterial road productivity are:

- Network planning through Corridor Management Plans (CMPs) to identify interventions necessary for arterial roads to deliver on their strategic requirements
- Network management through interventions such as optimising traffic signals, varying priorities at different times of the day, introducing bus and transit lanes to increase vehicle occupancy rates, and restricting on-street parking

  Network improvements ranging from minor intersection improvements through to large-scale grade separations

While these approaches often provide significant transport benefits, the extent to which they are pursued appears limited by challenging trade-offs on the arterial road network or resource constraints to investigate and deliver improvements.

Further recommended steps to improve arterial road productivity include:

- Better strategic network planning to identify and agree routes where through movement is of primary importance
- Better frameworks for resolving tensions between movement and place
- Evidence based decision-making on challenging interventions such as removing on-street parking, extending bus lane operating hours and improving pedestrian facilities
- Increased investment on arterial road improvements, to reflect the high proportion of travel that occurs on this network
- Maximising the benefits from demand management, such as smarter transport, and the application of new technologies (including intelligent transport systems, ridesharing and new vehicle technologies).

2. Background

Auckland's arterial road network represents 16% of the region's road network by length. The arterial network will have to cope with daily car trips increasing by an estimated 1 billion trips a year by 2046, from around 1.8 billion trips in 2013 to 2.8 billion in 2046.[1] There are always uncertainties about such long term projections but it is clearly important to improve the network's productivity and to find ways to reduce growth in demand.

Ongoing improvements to Auckland's public transport system are expected to result in continuing increases in public transport mode share, from around 7% of all peak time trips currently to 15% by 2046. . Despite this modal shift, car trips are still projected to predominate, accounting for an estimated 68% of all motorised trips in 2046. For parts of Auckland which are not well served by public transport services because of low demand or dispersed travel patterns, arterial road network productivity is particularly important.

The purpose of this paper is to outline the potential for improved productivity (movement of people and goods) on Auckland's arterial roads, so that this can be factored into future Auckland Transport Alignment Project (ATAP) assessment scenarios.

The ATAP objectives particularly relevant to this paper are:

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

The approach in this paper is outlined below:

- Defining productivity, how it can be measured and compared – including in the Auckland context
- Auckland Transport's current approach for identifying interventions on the arterial road network
- Recommended approach to improving arterial network productivity

[1] Auckland Transport Alignment Project Foundation Report, December 2015.

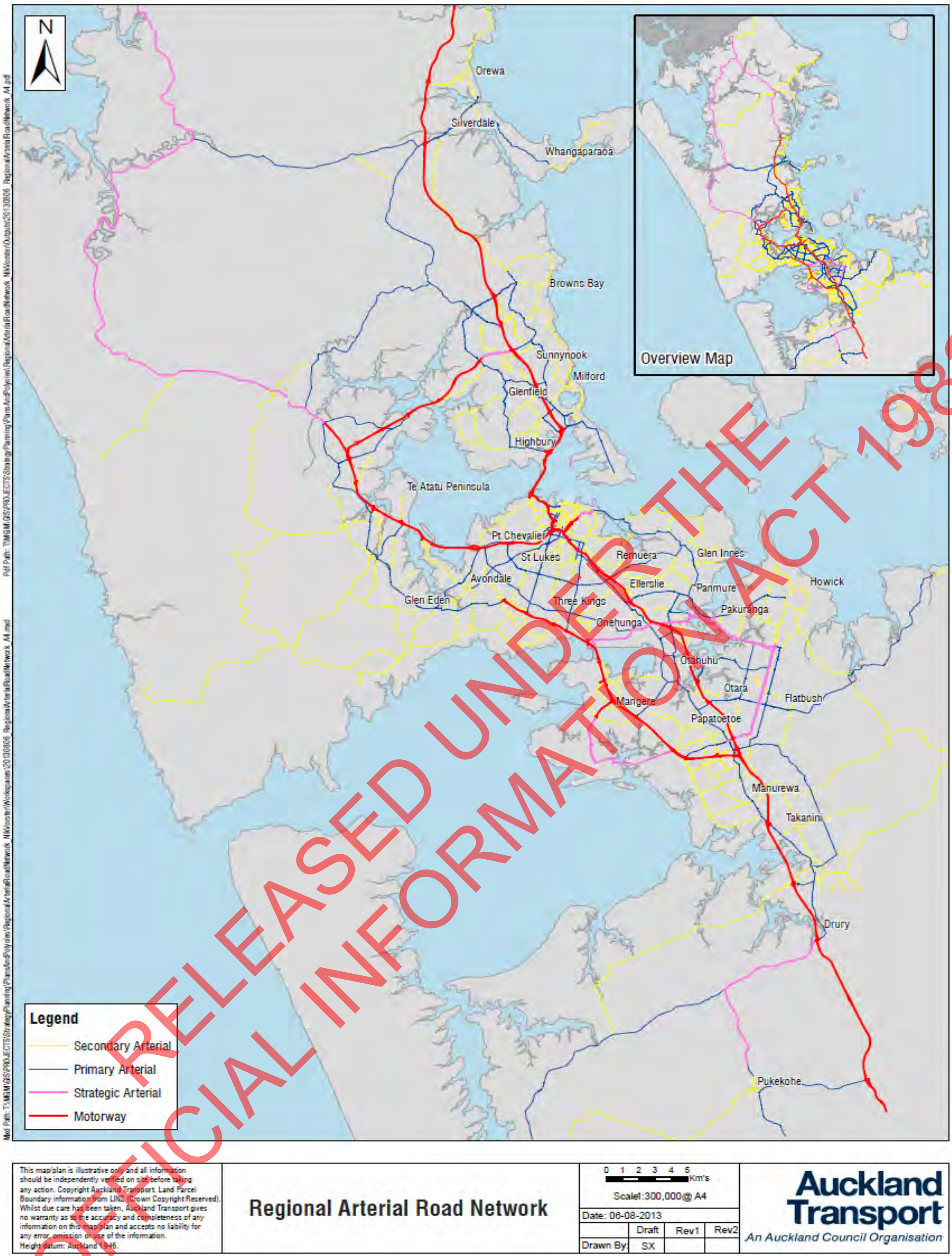


Figure 1. Auckland Arterial Road Network

3. Arterial Road Productivity

3.1. Defining Productivity

Productivity is about the volume of people and goods able to move through a transport corridor over time. There are two main components: the number of vehicles moving through a corridor (a product of travel speed and flow), and the people or goods in each of those vehicles. Pedestrians and cyclists also move in corridors and the management of vehicles can affect them and vice versa. The number of pedestrians or cyclists moving along a corridor is also a component of productivity.

The use of a productivity measure summarises the congestion levels and reliability of vehicle travel times on roads. Productivity can also be considered in terms of people and freight moving capacity and reliability, which may not be well captured within a vehicle movement assessment. For this reason, this paper also outlines the benefits of improving public transport mode share along arterials as an additional measure of productivity, and of improving freight movement.

The extent to which productivity is 'optimised' will depend on the situation. For example, optimal management of a main route that passes through a local business centre may involve different operational settings and arrangements at different times of the day. During periods of peak demand, the road may be configured with more emphasis on movement - with clearways, longer cycle times at intersections or even variable lane directions. During periods of low demand, the same section of corridor may be configured to give more priority to local access – with kerbside parking and longer pedestrian phases at lights.

Improving the productivity of a selection of arterial roads, and managing them as a network, is an important part of the response to Auckland's transport challenge.

3.2. Operational Performance Measurement and Target Setting

New Zealand uses Austroads guidelines to inform the way the network is managed and to measure the performance of the network and providers.

The Austroads guide to traffic management adopts a long established road hierarchy to determine how the trade-off between mobility and access is managed across the network. A road's position in the hierarchy determines whether mobility or access should be optimised. It can also inform land use policies applied to the land fronting the road, which should support the mobility function of arterial roads, the access function of local streets, and help resolve the tricky balance between access and mobility on the collector/distributor network.

However, in practice many Auckland (and indeed New Zealand) arterial roads pass through busy centres, where the movement and access functions heavily overlap – raising challenging trade-offs and the need to apply more sophisticated approaches to managing competing uses.

Austroads *National Performance Indicators for Network Operations* (AP-R305/07) recommends the use of five network performance indicators (NPI); namely:

- Traveller Efficiency: travel speed
- Traveller Efficiency: variation from posted speed
- Traveller Efficiency: arterial intersection performance
- Reliability: travel speed and variation
- Productivity: travel speed and flow.

The Government Policy Statement on Land Transport 2015 and the Auckland Long-term Plan 2015 use the Austroads 'productivity' performance indicator (travel speed and flow) as the key indicator of the results being achieved by investment in local roading.

3.3. Auckland context

Auckland Transport has primarily targeted two measures:

- Traveller Efficiency: travel speed, which in turn includes intersection performance
- Productivity: travel speed and flow

Travel time and variability is also used as an indicator for journey time reliability along key freight routes in the region.

The Highway Capacity Manual 2000 (HCM) lists urban street levels of service (LOS) criteria based on average speed and urban street class, translatable into percentage of posted speed limit as follows:

Level of Service	Average Travel Speed relative to Posted Speed limit
A	greater than 90%
B	70% - 90%
C	50% - 69%
D	35% - 49%
E	20% - 34%
F	less than 20%

The Auckland arterial network currently has on average between 20% and 25% performing at LOS D, E and F (defined as experiencing congestion). Within built-up areas and closely spaced intersections Auckland arterial routes at best perform at LOS E. Whilst an aspiration is to have the arterial network operate at LOS D and above, high growth makes achieving this challenging. Auckland Transport focuses on the productivity of a corridor as reflecting priorities of moving people and goods.

There is debate about the extent to which Australian and Auckland arterials are similar, whether or not Auckland arterials are more likely to have to serve multiple roles, and hence about the extent to which Auckland could move closer to the Australian benchmark levels through the types of intervention discussed in this paper. This debate highlights the key challenge for arterial roads: how vehicle-based objectives should be balanced against other objectives such as pedestrian amenity, local access, retail/parking and other types of "side friction".

The productivity challenge is brought out in the Auckland Regional Land Transport Plan (RLTP) 2015-25:

"An arterial road is "optimised" when... the number and/or speed of people movements are improving and approaching the standard of productivity defined for arterial roads by Austroads."…
"Arterial roads are often not able to cope with additional vehicle traffic. Widening roads and intersections is prohibitively expensive and can create problems for pedestrians and local residents as multi-lane roads are significant barriers to local trips, especially the young and elderly. Auckland's arterial roads are also the location of most of the city shops, schools and other important destinations. It becomes essential to set priorities... The order of priority of different road users will vary depending on the road, and may vary by time of day. " Source: A*uckland Regional Land Transport Plan 2015-25,* page 47

A significant proportion of Auckland's arterial corridors were not designed to perform at a 'highly productive' level for vehicles as measured by the Austroads standard; in Auckland Transport's view their form or location means that a lower level is appropriate.

For example, Broadway through Newmarket contains between four and six lanes and is heavily trafficked, but has a high density of intersections and crossings, friction of kerbside parking, manoeuvring of large volumes of buses and slower speeds inherent in a busy town centre. The corridor would therefore have a fairly low productivity rating, however efforts to increase this (such as by removing parking, fewer intersections or longer intersection cycle times, removing or restricting buses, etc.) would have detrimental effects on the town centre's economic performance or be unpalatable to the community. Instead, Auckland Transport has focussed on public transport improvements on connecting arterials to increase access the employment centre, and supportive pedestrian measures.

4. Current Approach to Improving Arterial Road Network Productivity

4.1. Arterial Network Planning

Auckland Transport's *Network Operating Plan* outlines six strategic principles for managing Auckland's arterials:

- Support "places" and activity centres
- Promote walking in high pedestrian areas
- Promote cycling links to activity centres and designated routes, reduce conflict
- Provide high priority for public transport on designated routes
- Promote freight on the freight network
- Promote general traffic on preferred traffic routes

The first three can conflict with providing for through traffic, but may result in higher people-moving capacity and more vibrant employment centres. Sometimes, competing objectives can be addressed by having different priorities at different times of the day, as discussed further in later sections.[2]

4.2. Corridor Management Plans

Corridor Management Plans (CMPs) are the main tool that Auckland Transport has used since 2012 to help identify the interventions necessary to allow critical sections of the arterial road network to deliver on their strategic requirements, which include productivity and other aims. The CMPs cover only some of the arterial network and other processes (including Network Operating Plans) are used to manage the rest of the network.

34 CMPs were developed between 2012 and 2015, covering approximately 25% of the arterial network, as shown in Figures 2 and 3. These were selected using an Arterial Network Deficiency Analysis (ANDA) covering issues such as predicted traffic and congestion levels, safety, public transport demands and operations, freight function and operations, active modes, urban realm, and relevant regional and local plans.

[2] As an example, operating arterial routes for commuting modes during commuting periods, except where they pass through town centres where there are other needs... An arterial in the suburbs is therefore expected to have a better experience for drivers than one the CBD or a town centre.

Figure 2. Auckland Corridor Management Plan - North

Figure 3. Auckland Corridor Management Plan - South

CMPs evaluate future population and employment growth projections and changes in land use. They also take into account known land use development and confirmed transport projects around corridor.

The aims of the CMPs are to:

- create a long term strategic vision for a corridor
- identify areas of change, future land use and transport demands, operational challenges and opportunities
- integrate transport, land use planning, economic development, community and open space development and infrastructure service interests
- create robust plans of prioritised projects to address future issues – in effect create Auckland Transport's forward programme for arterial road development
- inform Network Operating Plans and other Auckland Transport projects and operations

- provide justification/rationale for projects and allocation of scarce road space, including road widening if needed
- provide local implementation of regional planning
- provide longer-term strategic vision but also actions over short, medium and long-term
- enable inter- and intra-organisational buy-in and co-ordination (e.g. New Zealand Transport Agency, Auckland Council, key stakeholders)
- assist in a wider understanding of the strategic context within the wider transport system.

CMPs do not necessarily result in an increase in the corridor's measured vehicle-moving productivity. Often they recommend some form of public transport improvement which may increase the corridor's Public Transport patronage and bus service reliability. CMPs also often recommend walking or cycling improvements, or improvements to the urban amenity of a corridor if it is in an important people-centred location.

CMPs evaluate and balance a corridor's movement-based requirements – for drivers, public transport, freight, cycling and walking – with other considerations, such as slower speeds or reduced traffic movements for safety or amenity reasons, improving pedestrian crossing provision, etc. A corridor's measured productivity may be deliberately lower than its theoretical maximum. This is most clearly observed wherever an arterial passes through a town centre, and traffic often slows to allow for greater pedestrian safety and amenity.

These conflicting roles can result in congestion and unreliable journey times. Specifying which routes are of particular importance for through-movement would help in addressing some of these conflicts.

4.3. Network Management

4.3.1. Optimisation

Arterial road optimisation aims to address deficiencies and gaps identified in the local Network Operating Plan. These performance gaps rely on input data detailing current operational performance of the network from a multi-modal perspective. For general traffic, bus travel and freight, the primary basic performance measure is travel time (or level of service as defined in the Highway Capacity Manual), which enables Auckland Transport to identify deficiencies. Operational performance for pedestrian and cycle performance is also included, although the information for these modes is still relatively limited, but improving.

This deficiency analysis is supported by a "SmartRoads" tool which highlights the extent of the deficiency by factoring in volume (and people movement), user performance and strategic significance/priority.

Improvements are then pursued, for example

- dynamic lanes proposed on Whangaparaoa Road to enhance general traffic movement, and productivity.
- transit lanes on Manukau Road to enable higher occupancy vehicles to travel through the route at more reliable and higher average speeds, increasing corridor productivity

- freight lanes on the strategic freight network to improve reliability and productivity.

These may resolve the issues being experienced or enable an interim solution until any major projects are implemented.

4.3.2. Traffic Signal Optimisation

Traffic signals throughout the city are monitored and controlled to optimise traffic flows for different times of the day. Incidents are monitored, emergency services and traffic contractors are advised, and information systems such as variable message boards and public information channels for drivers and other users are activated. The signals are run dynamically – both the intersection signals and the ramp signals respond to flows to determine their timings.

Currently all 830 traffic signals in the region are optimised on a four year programme, although Auckland Transport and the New Zealand Transport Agency are considering more frequent reviews for key centres and corridors.

The programme provides changes on the road corridor network that support increased network efficiency through greater corridor productivity, i.e. more movement of people and goods through the city. Operating to a plan provides clarity for infrastructure development and use of the network and its systems such as traffic signals and ITS to make the most of the network. It also enables a focus for communication to customers to make informed choices about their travel by mode, time of day and route choice. By way of example, the 2013-2014 Optimisation programme targeted the inner city for efficiency with increased access and safety improvements, and resulted in a Benefit Cost Ratio (BCR) of 14. For the same year routes in outlying areas achieved similar results with BCR of 13.4, largely achieved through improved operation of general traffic movement on these primarily general traffic movement-orientated routes.

There are numerous ways that traffic signals are being optimised and improved. These tactics and interventions have been further endorsed and supported by a recently released Austroads report *Research Report AP-R494-15 Signal Management Techniques to Support Network Operations.* This work developed guidance on how signal management and operation should be undertaken, providing a Signal Management Toolkit, including an indicative impact assessment for a range of signal timing and modal priority techniques. It is intended to assist signal operators in the identification and assessment of appropriate treatments in support of the Network Optimisation Programme.

4.3.3. Pedestrian/Vehicle Interface

Effectively managing the pedestrian/vehicle interface on the arterial road network is a challenging task. Unlike the motorway network or very low volume local roads, where conflict is generally avoided, arterial roads can have high volumes of both vehicles and pedestrians, requiring the same space and coming into frequent conflict. This has potentially major implications for safety, network efficiency and the place-value of areas the arterial network passes through.

To balance these competing requirements, some design elements that may improve corridor productivity are not pursued as they are perceived to negatively impact pedestrian amenity or safety. An example of this is the treatment of left turning vehicles at signalised intersections that are often removed for amenity reasons, which can result in more complex intersection phasing and vehicle delays.

Other design elements that may lead to improved intersection operation from a vehicle efficiency perspective and potentially improved productivity include the treatment of pedestrian crossings.

In some cases, traffic signal changes that have been adopted for amenity reasons within activity centres can affect traffic flows. Examples include:

- single long pedestrian crossings instead of a staggered pedestrian crossing
- "Barnes dance" crossings where there are few pedestrians

The level to which signal phasing favours pedestrians is a component of Route Optimisation and Network Operating Plans, so can be assessed and amended via that process.

4.3.4. On-Street Parking

The management of on-street parking affects corridor productivity but is a challenging issue, particularly as many local businesses highly value on-street parking on arterial roads. Most Auckland arterials have clearways during peak periods (some already have limited or no parking). Roadside parking at other times frequently acts as chokepoints on the busier arterials.

An example of this situation is along Mount Eden Road where the evening peak bus lane operating hours are limited to one hour instead of the normal two. Whilst roadside parking can constrain vehicle throughput, it can also be a vital part of local economic activity, so is sometimes retained for non-transport purposes. There are some opportunities to remove further parking at peak travel times. Auckland Transport's Parking Strategy sets out the way parking is managed on arterial roads by extending clearways or removing parking where it:

- inhibits the capacity of the road to carry more people (and goods) particularly in the peak periods, and/or
- causes significant delays to the speed and reliability of public transport on the Frequent Transport Network, and/or
- causes safety risks for cyclists or impedes quality improvements on the Auckland Cycle Network.

4.3.5. Increasing Vehicle Occupancy Levels

Increasing vehicle occupancy rates is a key way overall corridor productivity can be improved. Car occupancy can be increased by encouraging ride sharing, now made easier by specialised apps discussed in the technology workstream. Bus occupancy can be increased by improving services and priority levels to increase attractiveness. Both types of occupancy affect the trade-off between car, bus and mixed (T2 or T3) use of a lane.

A key intervention to increase vehicle occupancy levels is bus and transit lanes. (Auckland *Transport Code of Practice 2013* Chapter 5.1). These lanes aim to enhance person throughput levels along constrained corridors, while also have improving bus reliability, speed and service delivery efficiency. By reducing travel times and improving reliability, bus and transit lanes can play a major role in encouraging modal shift to public transport.

However, where bus or transit lanes are created by repurposing what was previously a general traffic lane, there are important trade-offs that need to be appropriately considered through the Auckland Transport Code of Practice. In general, this guidance highlights bus service frequency thresholds that would justify the implementation of a transit lane or a bus lane. In general, some special treatment (e.g. bus advance signals) are considered as necessary from 15 or more buses an hour while bus lanes are increasingly justifiable at more than 20 buses per hour and likely at 25 buses an hour or more.

Application of this approach is based on actual survey data of inner city bus lanes, with observed vehicle occupancies. These can vary by route, location and area across Auckland. Travel speeds by mode form key inputs in these assessments. Where necessary, traffic model information is used to help assess likely changes in alternative lane configurations (clearway, T2, T3 or bus lane). By way of example, the proposed upgrade of Lincoln Road had previously envisaged bus lanes along the route but the current proposal is to implement the special vehicle lane as a T3 lane on inception. This provides greater people movement efficiency along this corridor than a bus lane (and higher than a general traffic lane), based on currently planned bus frequency numbers. As bus occupancies increase, reverting to a bus lane will become the most efficient configuration.

The new bus network that is currently being implemented has higher frequencies, fewer routes, a focus on busy roads that suit buses, more interchanges, better real-time information and greater use of bus lanes. The improvements increase the relative competitiveness of buses compared with cars and should lead to substantially increased patronage. This increase should further increase the cases for bus or transit lanes as appropriate.

4.3.6. Prioritising Freight

In discussions with the Ministry of Transport, road freight operators said they had been able to improve their productivity substantially over most of New Zealand but had gone backwards in Auckland, making fewer trips per day than they used to because of congestion. Efforts to reduce general congestion, including those discussed in this paper and possibly new forms of road pricing, would have benefits for road freight productivity – and hence for the cost of doing business and of living in Auckland.

Auckland Transport data show that congestion and signal phasing add an average of 21% extra time to road freight journeys. The median travel speed on the Auckland freight network (including motorways) is 67 km/h, but it is an average of only 21km/hr at the 10 worst hotspots.[3]

Some of the hotspots are being addressed through truck bypasses of on-ramp metering lanes, through completion of the Waterview motorway and, later, construction of the East-West link near Neilson Street. Planning is under way to address some of the others. Increasing use is being made of the rail connection between the port and the freight precincts around Neilson Street and Wiri; it has ample spare capacity at night, albeit limited by noise sensitivity issues, and could eventually be expanded with a third line from the port. A third line to the south has also been suggested to relieve congestion between freight and passenger trains.

The ATAP freight workstream report considers freight demand, cost of delay, the economic contribution of freight, estimated increases in the "do nothing" freight delays and associated costs, estimated costs of such delay to the economy, and interventions to address key sources of delay (including the potential impact of tolled freight lanes). It aims to identify the need and type of new freight capacity.

4.4. Network Improvements

4.4.1. Minor Improvements

Auckland Transport has discretion to spend up to $300-700k on minor individual works that generate more than half their benefits from efficiency, but the annual budget for these types of projects is only $2.5 million. Larger scale interventions are usually identified through business case processes or out of Corridor Management Plans.

4.4.2. Projects identified in Corridor Management Plans

Auckland Transport has undertaken a prioritisation process to assess all projects/work packages (approximately 300 so far) identified in the existing CMPs to ascertain the top candidates to progress through an Indicative Business Case. The prioritisation process made use of a range of Auckland Plan, Integrated Transport Programme and New Zealand Transport Agency criteria to assess each project; the overall score then provides a priority profile.

An analysis of projects focussed on traffic improvements (i.e. excluding those with public transport, cycle, safety, etc. themes) showed that from the CMPs there were 20 solely traffic-focused projects/packages, coming to a total of $275 million.

The cost of these improvements range from $250,000 to $60 million. Each proposal sought to separate out and improve a particular traffic movement, through intersection widening, signal changes, additional turning lanes or other improvements. The variety of locations across Auckland meant each was quite different from the next, but they could all be considered to address localised traffic congestion in some way. The analysis was not able to determine exact benefit-cost ratios, but noted they were typically around 1.0.

[3] AT, Freight route performance, June 2015

In formulating the 2015 RLTP, few of these traffic-focused projects were highly ranked in the prioritisation process – possibly due to them being singularly focused on traffic movement and doing little for other modes or deficiencies, so having a limited range of benefits.

4.4.3. Grade separation

Whilst signal optimisation and minor widening can provide moderate relief from traffic congestion at intersections, often the vehicle demands on an intersection are so large as to trigger consideration of grade separation. This is typically avoided by Auckland Transport due to the significant cost and community impacts involved but is considered in certain locations. Grade separation of arterial roads can cost from $30m (for a solution similar to removal of a rail level crossing) up to $140m (for a major project like the planned Reeves Road flyover in Pakuranga) and is generally considered so expensive and intrusive that travel time savings alone would not justify such an intervention, and significant safety or urban regeneration benefits would likely be required. The grade separation currently being considered at Pakuranga would remove extremely large traffic volumes from passing through two congested intersections and free up space for a busway and urban regeneration.

4.5. Conclusions

As outlined in this section, a number of interventions are currently undertaken to improve arterial road network productivity. These range from optimisation activities right through to fairly major investments. At the moment, these interventions are guided by Corridor Management Plans and a Network Operating Plan.

Effectively delivering current activities appears constrained by difficulties in resolving a variety of challenging trade-offs between:

- different demands on the arterial road network from different transport modes
- competing movement and place functions
- competing regional and local priorities

It also appears as though resources for improving arterial road productivity are relatively limited, particularly for minor improvements. Large improvements appear to deliver modest benefit-cost ratios.

5. Recommended Approach

5.1. Introduction

The previous section highlighted various interventions being undertaken to improve arterial road productivity, as well as some of the challenges faced in delivering these interventions.

While these challenges are significant and need to be addressed, evidence from Sydney (detailed below) suggests that interventions focused on improving network productivity on arterial roads could deliver extremely high levels of benefit, relative to their cost.

New South Wales (NSW) interventions that worked best in improving productivity
Transport for NSW uses a range of interventions to improve the productivity on the state road network. These measures are applied to minimise congestion on the existing road network in Sydney in the NSW Government's Pinch Point Programme. The initiatives deliver efficiencies at relatively low cost and quickly to ensure benefits and congestion relief for customers. They include • widening of small sections of road • lengthening or widening of busy turn bays • installation of variable message signs and closed circuit television cameras • turning restrictions • installation of no stopping, no parking and clearway restrictions • other small modifications and additions to improve traffic flow, including new signage. Estimated benefit cost ratios are • 37 for an early phase of the programme • 7 for infrastructure interventions, the mainstay of the programme • 12 for Clearways, 10 for CCTV, and for vehicle message signs. Source: extracted from a letter from Roads & Maritime Services, Transport for New South Wales, to the Ministry of Transport. BCRs rounded.

This section outlines a recommended approach to arterial roads that can improve their productivity in a way that also recognises other, competing uses for this space. A large part of this approach is defining which parts of the current arterial road network should be prioritised for through-movement.

5.2. Better strategic network planning

The biggest challenge for the arterial roads network is how to achieve improvements in productivity (throughput of people, goods and services) while balancing different user requirements, and addressing conflicts between through-movement and amenity.

In order to tackle these challenges, Auckland Transport has developed a *Roads and Streets Framework* which provides the direction for Auckland's roads and streets and reassesses the way it designs and delivers road space based on movement and place. This framework for managing and developing Auckland's roads and streets will enable Auckland Transport and key stakeholders to:

- Identify user needs in different circumstances and set priorities/make trade-offs accordingly
- Provide strategic direction to help resolve road space priority between different groups of users and places, while maintaining network integrity and strategic function
- Identify the types of tools that may be appropriate locally
- Balance place-specific needs with the overall function of the network through the applications of road and street typologies, which describe their roles, priorities and service standards
- Understand the need for intervention at a strategic level.

The framework considers roads and streets, including arterial roads, in a matrix of nine broad categories. It considers their various characteristics and where the conflicts are, and prioritise modes appropriately. For example, some arterials could be prioritised for through traffic and freight, while others could be prioritised for public transport and cycling. In some circumstances, the focus will be on meeting the needs of local centres with priority for safe pedestrian movement and access for local businesses.

Defining which arterial roads should form part of the "Strategic Road Network" is a crucial early part of this work.

5.3. Evidence based decision-making

Giving effect to strategic network planning of the arterial road network often involves difficult and controversial decisions, such as the removal of on-street parking, extending bus lane operating hours, increasing capacity by addressing chokepoints, providing additional pedestrian facilities in high volume areas that might slow down traffic and so forth.

Where these decisions align with the strategy and 'stack up' they need to be implemented consistently and at a much faster pace than has occurred in the past. This may require Auckland Transport to establish new systems for decision-making, and will require the support of the Auckland Council through future governance documents, like the annual Statement of Intent.

5.4. Increasing funding for arterial roads

Only around 7% of the funding allocated in the 2015 RLTP went towards existing local roads, despite these roads carrying a large proportion of Auckland's travel. Even this 'local roads' investment covers a range of activities, not all of which would be expected to increase corridor productivity in the way that Austroads measures.

Areas of investment that appear likely to deliver significant benefits, for relatively little additional investment include:

- Small and medium capital expenditure opportunities that could improve arterial road productivity (intersection upgrades, minor bottleneck removals etc.).
- Network optimisation and traffic signal system upgrades
- Bus or transit lane extensions that benefit large numbers of passengers, particularly where the impact on general traffic will be minimal.

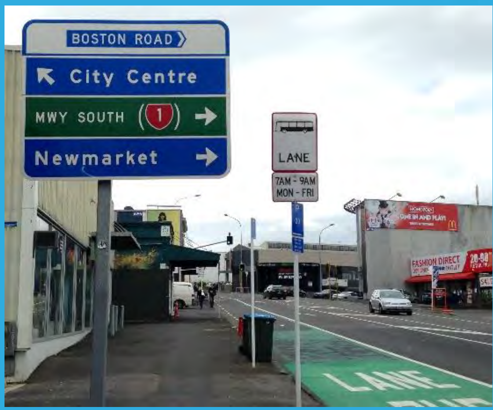
5.5. Maximising the benefits from demand management and new technologies

Developing vehicle and ridesharing technologies (as discussed further in the Technology Workstream Report) provide new opportunities to use existing transport networks far more efficiently in the future. These include:

- Connected and autonomous vehicles, which can enable higher throughput through closer following distances and much more efficient intersection operation through vehicle to infrastructure communication.
- Ridesharing applications, which can increase vehicle occupancy rates by making it much easier to carpool or rideshare with others.

Demand management, including smarter transport pricing, also has significant potential to improve network performance by varying the cost of travel to encourage time, route or mode shift that results in more efficient overall travel patterns. Pricing is discussed further in the Demand Management Pricing Workstream Report.

Under Peer Review



Final Report

City Centre Bus Reference Case

Auckland Transport

Prepared by:

MRCagney Pty Ltd

15 March 2016

MRCagney

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Note to Reader

As of March 2015, this document is under peer review. Note that some text, conclusions and/or figures may change following the review process.

These figures represent the final draft issue from 15 November 2015, with minor corrections to text.

Executive Summary

MRCagney was commissioned by Auckland Transport (AT) Metro Network Management to develop the *Bus Reference Case* to examine the required infrastructure for operation of the New Network in the City Centre. The purpose of this project was to review and consolidate existing plans and assumptions about City Centre bus networks and operations into a single “source of truth” or reference case. This reference case is intended to be used as a baseline scenario for public transport projects in the City Centre.

There have been public transport (PT) network design changes and infrastructure projects which have generally taken place separately, without consideration of the combined impacts of these projects on City Centre corridors and termini. This document is designed to look at the physical form that terminal facilities and major City Centre bus corridors will need to take in order to accommodate the New Network. The study utilises AT’s network and facility plans and is based on existing and projected bus volumes that were provided by AT.

Methodology

The study looked at the planned City Centre bus network for the following scenarios:

- 2018 after the completed rollout of the New Network;
- 2026 New Network with CRL; and
- 2036 New Network with CRL.

Key assumptions about bus service levels and frequencies for individual routes were provided by AT Metro Network Management and Bus Services. These were then compiled to develop a picture of the expected total bus volumes in the City Centre.

The Bus Reference Case considers what can be built in each corridor and at each terminal location, what the impacts are on capacity (including upper limits on certain corridors or at certain facilities), and provides some ideas on how to fit the network into the desired—or possible—infrastructure. Infrastructure assumptions were discussed and confirmed with AT Bus Services.

1 Introduction and Scenario Development

By 2018, it is anticipated that Auckland's New Network—a redesign of the city's bus network—will have been implemented. The New Network was designed to provide a clear hierarchy of routes, with frequent, all-day services providing access to as much of the city as possible, connector services providing additional passenger links, and coverage services ensuring the maximum number of Auckland residents have access to the network. The network was designed to achieve several goals, including the following:

- An easy to use, all-day frequent network;
- Improved network legibility;
- Improved service for counter peak, and suburb-to-suburb trips;
- Improved all-day and weekend service; and
- Minimal impacts on operating budget.

It is understood that currently, the network does not function well for many passengers making trips other than those for commutes during the peak period between residences in the suburbs and jobs in the City Centre. The New Network is intended to make such trips easier, by providing passengers with a network that is easier to understand and use, not only for commuting to work, but for casual and weekend trips as well.

The following report explores the spatial requirements associated with public transport services in the City Centre over the next 20 years. The New Network being rolled out across the city by 2018 fundamentally alters the way public transportation is delivered across the city and in particular in the CBD. In addition, the anticipated delivery of the City Rail Link (CRL) has impacts on planned bus service and projected patronage.

The volume of buses entering the City Centre, utilising major City Centre corridors and serving/terminating at City Centre bus transfer points and termini will greatly impact the infrastructure required to accommodate bus passengers and operations. This document seeks to provide guidance to Auckland Transport to determine what infrastructure will be required to accommodate bus service given several different scenarios.

This document assumes different scenarios regarding the implementation of the New Network and the City Rail Link (CRL). These scenarios are broken out into three "snapshots" of service at three different times:

- **2018** – In 2018, it is assumed that the New Network (bus network) will have been rolled out in all areas of Auckland, and that higher-capacity vehicles (e.g., double deckers) will be used on the all-day patterns of highest volume routes, but not the additional peak frequency. Key infrastructure improvements include:
    - New Network;
    - Revised Britomart Bus Terminal configuration (reinstatement post-CRL enabling works); and
    - Temporary Te Atatu Bus Interchange.

- **2026** – In 2026, the CRL is assumed to have been completed, and the rail network operating at full capacity, as well as extension of all three busways. In this scenario the bus network is adjusted to operate with CRL in place. Key infrastructure improvements include:
    - CRL in full operation with stations at Aotea Square and Karangahape Road;
    - Northern Busway expansion to Albany;
    - AMETI Busway expansion from Panmure to Pakuranga;
    - Delivery of the Northwestern Busway between Te Atatu and Westgate, with permanent interchanges constructed at both Te Atatu and Westgate; and
    - New bus termini at the Learning Quarter and Wynyard Quarter.
- **2036** – In 2036, it is assumed that rail service will be delivered to the airport, as well as further extension of the busways. Airport service could either be provided by heavy rail or light rail transit; however, the choice of mode has no difference in the impact on bus volumes in the City Centre. This scenario includes full build-out of the heavy rail network and busways.
    - Rail expansion to the airport;
    - AMETI Busway expansion from Pakuranga to Botany;
    - Northern Busway expansion from Albany to Silverdale; and
    - Northwestern Busway has NOT been completed between Pt. Chevalier and the City Centre.

2 City Centre Bus Corridors and Termini

This section investigates what major City Centre corridors will look like given the proposed New Network bus volumes and examines the specific requirements of each major City Centre bus terminal and transfer points at three different times: a 2018 network, assuming implementation of the New Network for buses; a 2026 network, assuming implementation of CRL; and a long-term 2036 network.

Peak volumes are compared to all-day volumes, with the assumption that AM and PM peak service will operate at the same frequency. In all likelihood, PM peak service will be somewhat less concentrated (e.g., fewer buses per hour) than the AM peak service, but will include longer dwell times with larger passenger volumes boarding and paying their fares.

The following table summarises peak and all-day bus volumes in each corridor. For Fanshawe Street and Wellesley Street, this is broken out into AM Eastbound/PM Westbound and AM Westbound/PM Eastbound, as due to proposed service patterns, these volumes differ. It is important to note that the below table includes only "in service" buses, and *does not show deadhead movements*. Note the City Link is not included in Karangahape Road, as it travels only on the segment east of Pitt Street, whereas all other buses travel only on the segment west of Pitt Street.

Table 1: Peak and All-Day Bus Volumes by City Centre Corridor

Corridor	Direction	2018	2026	2036
Albert Street	Peak Period	59	62	78
	All-Day	17	18	26
Fanshawe Street	AM Eastbound/ PM Westbound	164	178	196
	AM Westbound/ PM Eastbound	127	131	146
	All-Day	83	96	112
Karangahape Road	Peak Period	53	58	72
	All-Day	31	38	50
Symonds Street	Peak Period	120	112	123
	All-Day	46	48	50
Wellesley Street	AM Eastbound/ PM Westbound	110	122	136
	AM Westbound/ PM Eastbound	105	105	120
	All-Day	55	62	66

The termini and transfer points examined include the following:

- **Britomart Terminal** – this is currently the main City Centre terminal for most bus lines serving the City, all four rail lines, as well as ferry services in the adjacent Downtown Ferry Terminal on Queens Wharf. A proposed redesign of the bus facilities at Britomart, to be implemented with the New Network, effectively create two new termini: Britomart East, and Britomart West, each with different service groups. Britomart East will be served by routes from the east and south, while Britomart West will be served by routes from the north and west.
- **Learning Quarter Terminal** – this is a proposed terminus primarily for North Shore to University services traveling across Wellesley Street. It would be constructed either on-street or off-street at a location to be determined within the University precinct or Grafton Gully.

- **Wynyard Quarter Terminal** – this is a proposed terminus primarily for routes to/from the Isthmus and areas south and southeast of the City which travel across Wellesley Street, as well as for the Crosstown 5 and City Link.
- **Aotea Transfer Point** – this transfer point, to be located at and around the intersection of Albert and Wellesley Streets, would serve both as a destination for passengers traveling to the City and as a connection point between different routes and modes. It would include connections with the rail network at Aotea Station, bus service along Albert Street (routes to/from the west and northwest), and bus service along Wellesley Street (routes to/from the south, southeast and North Shore).
- **Karangahape Road Transfer Point** – this precinct will serve as a transfer point between bus and rail service at the proposed Karangahape Road Station on the CRL, to be located at the intersection of Pitt Street and Karangahape Road.

The following table shows the expected peak and all-day bus volumes for each terminal in 2018, 2026 and 2036, with Britomart split into "Britomart East" and "Britomart West". As discussed in Section 2, double deckers are assumed for use on several major routes, and CRL is assumed to be completed in 2026, resulting in a few changes to the bus network.

Table 2: Anticipated Peak Period and All-Day Bus Volumes at City Centre Termini

Terminal*	Time Period	2018	2026	2036
Britomart East	Peak Period	67	71	77
	All-Day	21	26	29
Britomart West	Peak Period	108	116	136
	All-Day	37	43	52
Learning Quarter	Peak Period	72	82	92
	All-Day	17	22	22
Wynyard Quarter	Peak Period	88	83	96
	All-Day	43	46	52

*Terminating (AM peak) / originating (PM peak) trips only - does not include trips travelling through.

The highest volumes are seen at Britomart West, which includes a number of peak-only routes from the North Shore and the west/northwest, meaning that a good portion of the capacity would be required only during the busiest hours. For example, in the 2018 New Network scenario, 108 buses will terminate (AM peak) or originate (PM peak) during the peak hour at Britomart West, while only 37 will terminate/originate there per hour throughout the day.

The Learning Quarter also sees high volumes, a large proportion of which are peak-only services. Upon implementation of the New Network in 2018, there would be 72 buses per hour terminating (AM peak) or originating (PM peak) at the Learning Quarter during the peak hour; all-day, only 17 trips would arrive and depart from the terminal each hour.

Wynyard Quarter sees higher volumes in the near term. Service at Wynyard Quarter is more even than at Britomart and the Learning Quarter, with 88 trips per hour terminating (AM peak) or originating (PM peak) during the peak and 43 trips per hour all-day, as most routes utilising this terminal operate all day.

The following table summarises the number of berths (or spaces) required to accommodate the bus volumes shown above at each of the termini. As with previous analyses, the table shows three scenarios: 2018, 2026 with CRL, and 2036 with CRL. All scenarios assume that the New Network has been fully-implemented by 2018. Note that this table shows the minimum number of spaces required to accommodate the expected volume of buses—this does not account for route groupings or other specific needs which would increase the total space required.

More specific analysis in subsequent sections considers other factors, such as additional time needed for activities such as staging, as well as the potential to reduce recovery times through the use of strategies such as headway-based scheduling and active line supervision. Headway-based scheduling means that buses are dispatched in order to maintain an "even spacing" (e.g., every five minutes), rather than according to a set timetable. This strategy is typically employed on frequent routes, and is currently used on the Link services in the City Centre. Active line supervision can aid in headway-based scheduling, as well as ensuring that service runs smoothly in the case of unusual circumstances such as special events, accidents or unusually heavy congestion. Off-board fare collection and rear door boarding was considered at several locations in order to decrease boarding times.

Table 3: Required Berths to Accommodate Proposed Peak Period and All-Day Bus Volumes

Terminal	Time Period	2018	2026	2036
Britomart East	Peak Period	8	9	9
	All-Day	3	4	4
Britomart West	Peak Period	13	14	16
	All-Day	5	6	7
Learning Quarter	Peak Period	9	10	11
	All-Day	2	3	3
Wynyard Quarter	Peak Period	11	10	12
	All-Day	6	6	7

It is important to note that the primary constraint in downtown terminal space is the PM peak period. During the PM peak, most (if not all) one-way, peak only services will originate from the downtown termini, requiring space for staging in addition to recovery and loading. During the AM peak, a large number of trips—particularly extra capacity and "short turns" operating on the all-day fixed routes, as well as peak period, peak direction-only services—will simply be able to discharge their loads and depart the terminal. Only those arrivals that are scheduled to depart from the same terminal for contra-peak trips, which can be assumed to be a similar number as those operating all day drips, will need to utilise the terminal for recovery or staging during the morning peak. Also, due to space constraints, additional driver layovers should be avoided at the downtown termini during the peak periods.

The following sections take a more detailed look at each of the termini, as well as the Aotea and Karangahape Road Transfer Points. Additional factors considered include:

- **Loading and unloading** time was assumed in the above section to take up to two minutes per terminating/originating trip. In the following sections, loading and unloading is assumed to take up to two minutes if taken in one location, but if loading and unloading take place in separate locations, each is assumed to take up to 90 seconds.
- **Recovery** time was assumed to be five minutes per trip, as specified in all PTOM contracts.
- **Layover** time includes driver breaks such as to eat or use the restroom. It is assumed that layovers would not take place in the City Centre during the peak periods.
- **Staging** refers to recovery time prior to trips departing from the City Centre, where the bus arrived at the terminal directly from the garage or via a deadhead movement from elsewhere. Staging time was assumed to be five minutes prior to departure for any service that is not bi-directional (e.g., peak-only routes and peak service on all-day routes).
- **Service groupings** impact capacity in the sense that each grouping was looked at separately, in order to maximise system legibility.
- **Headway-based scheduling** can reduce bunching, but may require active line supervision.
- **Boarding/transferring volumes** impact dwell times and major transfer points and termini.

2.1 Britomart Terminal and the *Downtown Bus Interchange Concept Design*

A new terminal is proposed for Britomart, and is assumed to be constructed in a manner that is consistent with the *Downtown Bus Interchange Concept Design (April 2015)*. This terminal will replace the existing terminal precinct, which currently encompasses 23 stops which can accommodate up to 41 buses at a time, as well as 13 additional layover spaces. The new terminal will be comprised of three sectors: Britomart East (Commerce, Gore and Tyler Streets), Britomart West (Lower Albert Street) and the "Link Zone", where City Link, Inner Link and Airbus Express services will stop as they pass through the area.

Britomart East would have three double stops, each with a separate designated drop-off space (referred to in the plan as "set-down" spaces), and would serve the Tamaki Drive, AMETI (Ellerslie/Botany) and Mt Eden Road (and Hospitals) route groups. Buses from Tamaki Drive would access stops on Tyler Street via Commerce Street, buses from Mount Eden Road would access stops on Galway Street from Lower Queen Street, and the AMETI group would access stops on Commerce Street via Quay Street.

Britomart West would be divided into two sectors: the North Shore services (on the western side of the street) and the west/northwest services (on the eastern side of the street). The North Shore services would have two triple stops, with the rear-most spaces of each considered "set-down" spaces. One of these would be reserved for the Northern Express, and the second for other North Shore services (primarily Glenfield Road and Birkenhead). The eastern side of the street would have three single stops, which would operate in concert with two "set-down" spaces on the western side of Albert Street just south of Customs Street. Northwest Express (Northwestern Busway services, including Te Atatu, Henderson, Massey and Westgate), Great North Road (New Lynn) service, and Richmond Road services would use these stops, as well as some peak express service from Titirangi, Glen Eden, Green Bay and Blockhouse Bay prior to the opening of the CRL. Additional recovery spaces would be available on Lower Hobson Street for west/northwest services to use during the afternoon peak period between dropping off passengers on Albert Street and picking up on Lower Albert Street.

Note that the Freemans Bay route (Route 106) which was initially proposed to follow the same pattern as the Richmond Road service within the City Centre (via Albert Street) has been realigned in the most recent New Network plan as a one way loop service to leave Britomart West via the Fanshawe Street corridor. Thus it is assumed to share a turnaround loop (and stops) with the Birkenhead and Glenfield Road services.

The Link Zone refers to City Link/Airbus Express and Inner Link stops placed at the intersection of Queen Street and Customs Street. The City Link and Airbus Express would share a pair of double stops on Queen Street just south of Customs Street; the Inner Link would utilise two double stops on opposite sides of Customs Street near the intersection with Queen Street.

Figure 1 shows the proposed Britomart Terminal, as shown in the *Downtown Bus Interchange Concept Design* report. The diagram in Figure 2 demonstrates potential travel alignments for each route group, as developed for the *Light Rail Project*.

The table below summarises each of the proposed stops/locations for the new Britomart Terminal.

Note: the Airbus Express service, which currently terminates on Queens Wharf, is not included in the Britomart plans.

Figure 1: Proposed Britomart Terminal

Figure 2: Potential Bus Alignments at Proposed Britomart Terminal

Table 4: Proposed Britomart Terminal Stop Locations

Stop	Sector	Stop Location	Route Group(s)	Spaces
Stop 1	Britomart East	Tyler Street	Tamaki Drive	2 stops, 1 set-down
Stop 2	Britomart East	Commerce Street	AMETI	2 stops, 1 set-down
Stop 3	Britomart East	Galway Street	Mt Eden Road	2 stops, 1 set-down
Stop 4	Lower Albert Street	Northbound (1)	North Shore	2 stops, 1 set-down
Stop 5	Lower Albert Street	Northbound (2)	NEX	2 stops, 1 set-down
Stop 6	Lower Albert Street	Southbound (1,2,3)	Northwest/West	3 stops, 2 set-down
Stop 7	Customs Street	at Queen Street	Inner Link	2 double stops
Stop 8	Queen Street	at Customs Street	City Link/Airbus Express	2 double stops

2.1.1 Britomart East

Britomart East is proposed to contain three double stops, each with a third “set down” space nearby. Each of these stops could comfortably accommodate 25 buses per hour (departures during the PM peak), which would nearly satisfy the requirement for the proposed levels of service through 2036. The Mt Eden Road/Hospitals group will exceed its stop capacity by 2026, and the Tamaki Drive group will exceed the capacity of the stop by 2036. Note that Papakura to City (Route 360x) service is discontinued with the implementation of CRL.

Table 5: Britomart East Peak Bus Volumes

Stop	Services	2018	2026	2036
Tyler Street	Tamaki Drive	19	22	28
Commerce Street	Ellerslie/Panmure Papakura	24	21	21
Galway Street	Mt Eden Road Hospitals	24	28	28
Total		67	71	77

2.1.2 Britomart West

Britomart West is divided into two sectors, each operating in opposite directions on Albert Street. Services to/from the West and Northwest will operate from the eastern side of Lower Albert Street, while services to/from the North Shore will operate from the western side of the street.

West and Northwest

The West and Northwest services will include routes operating between the City and Henderson, Te Atatu, Westgate and Massey (to be grouped into the West Express, or WEX, on the proposed Northwestern Busway); local services operating between New Lynn and the City via Great North Road; express services between the City and Blockhouse Bay, Green Bay, Glen Eden and Titirangi (to be discontinued upon the delivery of CRL); and local services between Britomart and Richmond Road. Following are volumes for those services in 2018, 2026 and 2036.

Table 6: Britomart West Peak Bus Volumes – West/Northwest Group

Stop	Services	2018	2026	2036
Albert Street (east side)	Northwest Motorway Services	26	44	58
	Great North Road	12	12	12
	West Auckland Expresses	15	-	-
	Richmond Road	6	6	8
Total		59	62	78

The West/Northwest group will share two “set-down” (drop-off) spaces on northbound Albert Street just south of Customs Street, then will turn left onto a newly two-way lower level of Customs Street West, followed by a right onto Lower Hobson Street, where staging/recovery spaces would be available. Buses would continue to turn right on Quay Street, then right onto Lower Albert Street, where they would serve three single stops to pick up passengers, returning to the south along Albert Street.

In 2018, there would be 59 buses per hour originating during the PM peak period. These could be accommodated with the proposed “set-down” spaces (2) and pick-up spaces (3), and would require five recovery/staging spaces on Lower Hobson Street. Five-minute recovery times per trip are specified in the PTOM contracts, and thus are considered mandatory for the purposes of this study.

Bus groupings at the pick-up stops would be as follows:

- Stop 1: Northwest Motorway services
- Stop 2: West Auckland Expresses (peak only) and Richmond Road services
- Stop 3: Great North Road service

The total number of buses per hour would grow to 62 by 2026, and 78 by 2036. The 2036 volume could be accommodated by expanding to a triple “set-down” stop on Albert Street. The triple drop-off stop was determined assuming the existing two-minute light cycles, which would mean that with evenly spaced buses, three buses would arrive at the stop nearly every light cycle. In addition, the number of layover spaces would need to be expanded to seven, in order to accommodate 5-minute recovery periods for all trips. Up to seven spaces could be accommodated on Lower Hobson Street.

However, note that the Albert Street corridor is constrained to carry a maximum of approximately 53 buses per hour with the proposed lane configuration.

The West Auckland Expresses group would be discontinued upon delivery of CRL, which is assumed to happen before the 2026 scenario. Upon the opening of the Northwestern Busway, the Northwest Motorway services would be consolidated into the West Express (WEX). Groupings in 2026 and 2036 would be as follows:

- Stops 1 and 2: West Express
- Stop 3: Great North Road and Richmond Road services

The expected all-day volume of 29 buses per hour maximum on Albert Street by 2036 could be accommodated with the two “set-down” spaces and three stops. However, one or two recovery/layover spaces should be retained all day to maintain flexibility in scheduling.

Note that these maximum volumes would apply to the PM peak, when the peak number of buses would be departing the terminal. During the AM peak, buses would arrive via Albert Street, drop off passengers at the “set-down” spaces, and likely turn left onto Fanshawe Street and left onto Hobson Street to access the SH-16 Motorway.

Infrastructure requirements in order to implement this circulation pattern include:

- Construction of a two-way roadway (busway) on the lower level of Customs Street West.
- Allowance for buses to make a right turn from Customs Street West onto Lower Hobson Street. This turn could be difficult during the peak period, and would disrupt heavy bus flows to/from the North Shore. Elimination of the Lower Hobson Street Viaduct and reconfiguration of the roadway space could ameliorate the problem.
- Nearly the entire block face on the west side of Lower Hobson Street would need to be available for recovery/staging during the PM peak period by 2036; perhaps one or two spaces should be maintained throughout the day in order to provide scheduling flexibility due to limited space on Lower Albert Street.

Note that without the provision of recovery spaces, each of the three stops could accommodate nine buses per hour, for a total of 27 buses per hour during the PM peak period, when five minutes of recovery/staging is assumed prior to each trip. Each recovery space adds capacity for roughly nine additional buses per hour.

North Shore

The North Shore Services, including the Northern Express, Glenfield Road to City and Birkenhead to City, as well as the Freemans Bay service would utilise the western side of Lower Albert Street. Two triple stops would be provided, with the rear space of each stop assumed to be used primarily for “set-down” or drop-off purposes. Buses would continue to turn left onto Quay Street, left onto Lower Hobson Street, and return to the North Shore via Fanshawe Street.

Following are the anticipated peak service volumes for the North Shore sector of Britomart West.

Table 7: Britomart West Peak Bus Volumes – North Shore Group

Stop	Services	2018	2026	2036
Albert Street (east side)	Northern Express	30	30	30
	Glenfield Road to City	9	10	12
	Birkenhead to City	8	10	12
	Freemans Bay	2	4	4
Total		49	54	58

It is envisioned that one stop would accommodate the Northern Express service, and one stop would accommodate the Glenfield Road and Birkenhead services. *Note that in the most recent plans for the New Network, the Freemans Bay route follows the same pattern as North Shore services out of the City Centre, and would thus likely share stops with the Glenfield Road and Birkenhead services.* Each stop would accommodate up to approximately 25 buses per hour without additional recovery space. The Britomart West North Shore service sector stop configuration would be as follows:

- Stop 1: Northern Express
- Stop 2: Glenfield Road, Birkenhead and Freemans Bay

The Northern Express service will include 30 buses per hour by 2018. The triple stop provided would be more than adequate to handle up to approximately 25 buses per hour, and thus would be sufficient for all-day service through 2036 and beyond. However, during the peak periods, recovery/staging spaces would be required to operate PM peak service—up to three spaces by 2036. The *Downtown Bus Interchange Concept Design* report shows these recovery spaces on the north side of Customs Street West just west of Lower Albert Street; however, there are some concerns regarding geometry at this location. This could be partially alleviated by starting some Northern Express (NEX 1) services at Victoria Park for the trip to the North Shore.

The Birkenhead and Glenfield Road services are anticipated to reach a peak volume of 24 buses per hour by 2036, and thus could be accommodated through that time in the triple stop provided (which will accommodate up to 25 buses per hour). However, the addition of the Freemans Bay service will put this stop over capacity during the peak by 2036.

2.1.3 Issues and Opportunities

Issue #1: Britomart East will reach capacity at the Mt Eden Road (Galway Street) stop by 2026, and the Tamaki Drive (Tyler Street) stop by 2036.

Issue #2: The large number of terminating buses at Britomart West will not improve with the implementation of CRL (as currently proposed). Britomart West serves the city's two major non-rail corridors, the North Shore and the North West, which are also two of Auckland's fastest growing areas. Both patronage and bus volumes can thus be expected to continue to increase.

Issue #3: The Freemans Bay route is included in the service pattern—and at the stop locations—of the North Shore services. The inclusion of this route at this stop location degrades system legibility as well as contributes to the North Shore group exceeding its terminal capacity by 2036.

Issue #4: The proposed Britomart Terminal was designed assuming some flexibility that does not exist. For example, assumptions were made that recovery times could be reduced below five minutes during the peak periods, but this is contrary to PTOM contracts. Thus additional recovery space will be needed than what is planned.

Issue #5: Stop legibility for west/northwest services could be improved. In the near term, four route groups would be consolidated into three stops: Northwest Motorway services, West Auckland expresses, Great North Road service and Richmond Road services. While the West Auckland expresses will be eliminated upon delivery of CRL, the West Express will likely require two of the stops.

Issue #6: No easy siting for Northern Express recovery spaces. The Lower Hobson Street viaduct prevents the use of the west side of Lower Hobson Street, while space constraints and need to provide a westbound travel lane (for the west/northwest group) on the lower level of Customs Street West limit the ability to provide space on that street. In addition, the Copthorne Hotel prevents the use of Quay Street for layover space.

Issue #7: The proposed turnaround loop for west/northwest services is not possible with today's street network. If a proposed two-way (bus only) roadway is constructed on the lower level of Customs Street West, this alignment will be physically possible; however, the right turn onto Lower Hobson Street will have the potential to disrupt inbound service from the North Shore.

2.2 Wellesley Street and the Learning Quarter Terminal

The Wellesley Street corridor crosses the Auckland City Centre at midtown, spanning between two proposed termini at Learning Quarter and Wynyard Quarter. This section summarises the Wellesley Street corridor and Learning Quarter Terminal; a subsequent section addresses the unique concerns regarding the Fanshawe Street end of the corridor (and associated transfer point) and the Wynyard Quarter terminal.

2.2.1 Corridor Description

The Wellesley Street corridor is the City Centre's busiest bus corridor under the New Network, providing direct, frequent, high capacity service with passenger distribution spanning from the University (Learning Quarter), through Midtown and Victoria Quarter to Victoria Park and Wynyard Quarter. This corridor is projected to carry significant volumes of buses, particularly during the peak periods, with major Isthmus bus routes traveling to/from a new terminus at Wynyard Quarter, North Shore services (including the Northern Express) traveling across midtown to a new terminus at the Learning Quarter, and additional Link and crosstown service between suburbs to the east and west of the City Centre.

Bus capacities included in this document for the Wellesley Street Corridor refer to the segment of Wellesley Street between Halsey Street (at Victoria Park) and Symonds Street. Some service options or alternative terminal configurations may reduce the 'common segment' of the corridor to the segment between Hobson Street and Princes Street.

2.2.2 Running Way Infrastructure and Service Groups

Wellesley Street will carry Buses from the North Shore and Isthmus, as well as the proposed "Crosstown 4" (Manukau Road – Jervois Road via Parnell). These groups can be broken down as follows:

- North Shore: NEX 2 Northern Busway to University, East Coast Road/Takapuna to University, Takapuna/Hillcrest to University, and North Shore (Hibiscus Coast, Belmont, Birkenhead/Glenfield) peak expresses
- Isthmus: Central Isthmus Corridors (New North, Sandringham and Dominion Roads) and South and East (Remuera Road, Abbott's Way, Gillies Avenue, Mangere to City)
- Crosstown Services: Crosstown 4 (Manukau Road – Parnell – Jervois Road), Manukau Road short runners, Pt Chevalier to University peak service

In the eastbound direction, buses would be grouped according to those terminating at the Learning Quarter (North Shore buses), those continuing to Isthmus destinations via Symonds Street (Isthmus buses), and those traveling via Parnell (Crosstown 4). In the westbound direction, buses would be grouped according to those travelling to the North Shore, those terminating at Wynyard Quarter (Isthmus buses), and those continuing up College Hill to Jervois Road (Crosstown 4). Thus the three groups cited above would hold true for both directions in this corridor.

Note that despite recent decisions to operate outbound Isthmus bus services on Victoria Street rather than Wellesley Street upon implementation of the New Network, this document continues to assume that all service will be on Wellesley Street in both directions. Appendix D outlines volumes and issues with the Victoria Street scenario. In this Victoria Street scenario, the eastbound Isthmus route group would be moved to Victoria Street, with all North Shore and Crosstown services and westbound Isthmus services remaining on Wellesley Street.

Bus stops would be designed to provide easy connections between services and to communicate common destinations, such as the University, Auckland Hospital and Wynyard Quarter. This is especially important near Albert Street where the core services of heavy rail (Aotea Station) and Albert Street bus services overlap.

Upon implementation of the New Network, Wellesley Street will carry 55 buses per hour in each direction throughout the day, with a peak volume of 105 buses per hour westbound in the morning and eastbound in the evening (primarily Isthmus services), and 110 buses eastbound in the morning and westbound in the evening (primarily North Shore services). These volumes are projected to grow to 136 and 120, respectively, by 2036.

To accommodate the projected 2018 bus volumes, Wellesley Street would require bus lanes in each direction, with two triple indented stops and one single indented stop at each stop location (e.g., Aotea and Victoria Quarter). However, while this stop configuration would accommodate the projected *volumes*, it does not account for the requisite route *groupings* (based on corridors/destinations served).

Wellesley Street is complicated by the fact that it has three distinct route groupings: North Shore services, Isthmus services and Crosstown services. Crosstown service volumes are generally consistent throughout the day, and could be accommodated in a single stop. The North Shore and Isthmus services, on the other hand, not only vary greatly in number between peak and all-day service, but also operate in opposing directions, with peak Isthmus service travelling westbound in the morning and eastbound in the afternoon, but peak North Shore service travelling eastbound in the morning and westbound in the afternoon. This results in similar volumes in each direction during both peaks, but complications regarding stop legibility.

Given the anticipated 2018 bus volumes, the Isthmus group would require a triple stop and a double stop at the outset of the New Network in order to accommodate anticipated peak service volumes. This could be most closely achieved if the Crosstown group were incorporated into the Isthmus group, and a pair of triple stops were provided to accommodate the two groups. In the off-peak direction, the Isthmus volumes could be accommodated in a triple stop (double stop in the near term), while Crosstown volumes could be accommodated in a single stop (growing to a double stop during the peak periods by 2036).

The North Shore route group, for which the peak direction is opposite that of the Isthmus Group, would require a double stop and a triple stop—the Northern Express, Takapuna and Hillcrest services could share a triple stop, with the North Shore Peak Expresses group utilising a double stop that would only need to be provided in the eastbound direction during the morning peak, and in the westbound direction during the afternoon peak.

Thus, the overall bus volumes on the Wellesley Street corridor would require the following stops in each direction:

- Triple stop to accommodate (most) Isthmus service;
- Triple stop to accommodate Crosstown service and remainder of Isthmus service (could be reduced to a double stop outside of the peak period/direction);
- Triple stop to accommodate the Northern Express, Takapuna and Hillcrest services (could be reduced to a double stop outside of the peak period/direction);
- Double stop to accommodate North Shore Peak Express services (only required during the peak period/direction).

Note that with the stop dimensions prescribed by AT, double stops are the maximum that can be provided on Wellesley Street, given the short block lengths through Midtown. Some compromise regarding these dimensions would be required in order to provide triple stops.

Table 8 below shows expected bus volumes in the Wellesley Street corridor in 2018, 2026 and 2036. It is important to note that projections show modest growth in all-day service levels, but moderate growth of peak volumes, particularly from the North Shore. Accommodation of future growth, particularly during the peak periods, will require the allocation of additional kerb space for buses—this may conflict with the need to provide convenient and legible transfers at locations such as Aotea Station, as well as may contribute to less desirable outcomes, such as bus stops along the entire kerb frontage of Wellesley Street from the University to Victoria Park.

Table 8: Wellesley Street Corridor Bus Volumes

Service Grouping	2018	2026	2036
AM Eastbound / PM Westbound			
NEX 2	30	30	30
Takapuna and Hillcrest to University	14	18	18
North Shore Peak Expresses	25	28	36
Isthmus	32	32	34
Crosstown 4 and Pt Chevalier	9	14	18
TOTAL	110	122	136
AM Westbound / PM Eastbound			
NEX 2	8	10	10
Takapuna and Hillcrest to University	9	12	12
North Shore Peak Expresses	-	-	-
Isthmus	76	67	78
Crosstown 4 and Pt Chevalier	12	16	20
TOTAL	105	105	120
All-Day			
NEX 2	8	10	10
Takapuna and Hillcrest to University	9	12	12
North Shore Peak Expresses	-	-	-
Isthmus	32	32	34
Crosstown 4 and Pt Chevalier	6	8	10
TOTAL	55	62	66

Note: New North Road is not included in the Isthmus group for 2026 or 2036, as it is assumed to be realigned to Newmarket (rather than Wynyard) following implementation of CRL.

2.2.3 Aotea Transfer Point

While designing the Wellesley Street corridor, it is important to consider the intent of the New Network—to provide frequent, all day service in key corridors—and how Wellesley Street will function within that context. Wellesley Street bus services will provide a critical component of passenger circulation within the City Centre—it will not only provide distribution for passengers traveling from Isthmus and North Shore bus routes to the City, but will also provide a transfer point between those services and the Albert Street bus services to the West and Northwest, and the City Rail Link at Aotea Station.

Aotea Station will be where heavy rail passengers transfer between rail and bus to access Wynyard or the University, thus legibility is important for this transfer location. In addition, passengers entering the city via bus service on Albert Street would also transfer at Aotea for bus service on Wellesley Street. Thus the following considerations would need to be made:

- University- and Wynyard-bound stops should be located right in front of the station entrance in order to facilitate transfers between rail and bus to reach City Centre destinations to the east and west.
- Bus to bus connections should be facilitated for similar reasons, particularly between the Albert Street corridor (Northwestern Busway) and the Wellesley Street corridor (Wynyard, University).
- In order to provide access and transfers between the multitude of transit services in this area pedestrian improvements including wider footpaths, shorter intersection crossings and improved signal timing will be required.

2.2.4 Learning Quarter Terminal

The Learning Quarter Terminal will predominately be built for North Shore services terminating in the University precinct, including the NEX 2 (Northern Busway to University), East Coast Road/Takapuna and Hillcrest to University services, and North Shore peak express services. In addition, Crosstown 4 will travel through the Learning Quarter connecting the Wellesley Street corridor with Parnell and short runs from Pt Chevalier will terminate there. Table 9 following shows the routes terminating at or travelling through the Learning Quarter in 2018, 2026 and 2036. While connections will need to be available between Symonds Street services, this table shows only those services terminating in the precinct or travelling through on Wellesley Street, and not those routes using Symonds Street.

Table 9: Learning Quarter Terminal Bus Volumes (Lower Level)

Service Grouping	2018	2026	2036
(PM) Peak			
NEX 2	30	30	30
Takapuna and Hillcrest to University	14	18	18
North Shore Peak Expresses	25	28	36
Pt Chevalier to University	3	6	8
Isthmus and Crosstown 4 (through)*	12	16	20
TOTAL (terminating)	72	82	92
All day			
NEX 2	8	10	10
Takapuna and Hillcrest to University	9	12	12
North Shore Peak Expresses	-	-	-
Pt Chevalier to University	-	-	-
Isthmus and Crosstown 4 (through)	6	8	10
TOTAL (terminating)	17	22	22

*Peak direction for the Isthmus and Crosstown 4 route groups (AM westbound; PM eastbound) is opposite from the North Shore and Pt Chevalier to University route groups (AM eastbound; PM westbound). All-day volumes would operate in the counter-peak direction. These buses do not terminate at the Learning Quarter.

For this terminal, it is likely that the actual terminal (turnaround, recovery) would need to be separated from the first/last stop functions. The stops would ideally be located along Wellesley Street adjacent to the University, with pedestrian infrastructure optimised to provide transfers between Wellesley Street services and Symonds Street services.

All services travelling between the Wellesley Street corridor and Parnell, and all services terminating at the Learning Quarter are assumed to travel underneath Symonds Street on Wellesley Street.

The projected volumes would require the following stop configurations:

Westbound:

- A triple stop for North Shore services, growing to a quad stop or two double stops (one for NEX, one for other) services in the long-term; and
- A single stop for Crosstown 4 service, as well as Manukau Road and Pt Chevalier to University short runners.

Eastbound:

- A double set-down space for North Shore services, for which this would be the last stop; and
- A single stop for Crosstown 4 service, as well as Manukau Road and Pt Chevalier to University short runners.

Due to issues regarding space, street network and steep grades, the turnaround and recovery functions may require construction of a separate facility along Wellesley Street near the SH-16 Motorway (likely on a platform), or at a location TBD within Grafton Gully. In the near term, approximately six spaces would be required to accommodate recovery/staging for North Shore and Pt Chevalier-bound services during the PM peak—this requirement would grow to approximately nine spaces in the long term.

Facility size is a concern for the Learning Quarter, which does not currently have an easy space to locate such a facility. All day bus volumes are low, and could be accommodated via the first/last stop configurations cited above, with recovery taking place in the stops, given volumes projected through 2036. During the morning peak period, few buses would need to take recovery at this facility, as most would be dropping off passengers and returning to the North Shore via the Motorway, either to the depot or to bring an additional load of passengers into the City Centre. Thus the primary need for this facility is to accommodate staging for North Shore services during the PM peak period. The other 21 or so hours of the day, the facility would be underutilised or empty.

Through running of Isthmus services could potentially reduce the total number of services originating at the Learning Quarter during the PM peak, and thus somewhat reduce the required terminal facility footprint.

2.2.5 Issues and Opportunities

Issue #1: Proposed peak period bus volumes exceed what can be accommodated upon implementation of the New Network in 2018, and are anticipated to continue to grow. Volumes will increase particularly on services to/from the North Shore, but also on Isthmus services. Growth in this corridor cannot be accommodated without compromising system legibility or desired urban outcomes.

Issue #2: Under the New Network, Wellesley Street will have uneven volumes between the AM and PM peak periods, which require larger stops for North Shore services and smaller stops for Isthmus services for one peak period in each direction, but larger stops for Isthmus services and smaller stops for North Shore services during the other peak period and in the other direction.

Issue #3: Peak vs. all-day volumes mean that a large terminal facility is required at the Learning Quarter for staging during the PM peak period, but a much smaller facility (e.g., three spaces) is required to accommodate all-day service. This means that if a large facility is constructed, it will not be used throughout most of the day.

Issue #4: Unclear siting for the Learning Quarter terminal facility.

Issue #5: Due to the large potential of transfers to bus services on Wellesley Street following implementation of the New Network, particularly at Aotea Square and the Learning Quarter, it is important that routes are grouped in a logical manner in order to facilitate transfers and maximise access for all passengers.

Issue #6: This assumes the relocation of New North Road service in the post-CRL network to serve Newmarket instead of the City Centre. If this relocation were not to be implemented (i.e., if direct access to the City Centre were to be maintained for the New North Road route) then the bus volumes would increase along Wellesley Street.

2.3 Fanshawe Street and Wynyard Quarter Terminal

Fanshawe Street is the main point of entry to the City Centre from the North Shore, providing direct access to the Harbour Bridge and Northern Motorway (SH-1). As such, nearly all service from the North Shore utilises Fanshawe Street. Services between the western City Fringe and Britomart or Wynyard Quarter that use College Hill (e.g., the Inner Link and Mt Eden Crosstown service) also have the option of utilising Fanshawe Street. In addition, Isthmus bus services travelling along Wellesley Street must cross—or use a short segment of—Fanshawe Street at Victoria Park, in order to access their proposed terminal in Wynyard Quarter. This by default creates a transfer point at Victoria Park, where North Shore, Isthmus and Link/Crosstown services intersect.

2.3.1 Fanshawe Street (Victoria Park) Transfer Point

As noted above, several bus service groups intersect at Fanshawe Street adjacent to Victoria Park: all service from the North Shore to Britomart and the University, as well as Isthmus services that use Wellesley Street and terminate at Wynyard Quarter, and several Link and Crosstown services (City Link, Inner Link and Crosstown 5 services). It is important to distinguish this *transfer point* from the Wynyard Quarter *terminal*, as transfers between services would take place on Fanshawe Street (and potentially adjacent Streets) at Victoria Park, whereas bus layover/recovery, staging and turnaround functions would take place at the Wynyard Quarter Terminal, within the Quarter to the north.

The transfer point at Victoria Park would serve a few different functions:

- Connect North Shore passengers with access farther into Wynyard Quarter via Isthmus (Wellesley corridor) services; and
- Connect (primarily) North Shore passengers with service to access other parts of the City—can connect to services to Britomart, Parnell, Midtown/University, Hospital/Newmarket, Ponsonby and Karangahape Road.

With the streamlining of service and elimination of many "special market" peak express routes upon implementation of the New Network, this transfer point will become more important, and should be designed to maximise the ease with which passengers can connect between services.

The Fanshawe Street transfer point at Victoria Park will require upwards of 12 bays in either direction to accommodate 2018 volumes (not accounting for growth, not including the Link services, and assuming some flexibility of use between morning and afternoon peak periods) if all of these route groups are to stop on Fanshawe Street—this is equivalent to the entire block face between Halsey and Daldy Streets. While this would potentially work on the south side of the street, adjacent to the park, the northern kerb is interrupted by numerous driveways.

The stop groups at the Fanshawe Street/Victoria Park transfer point include:

Eastbound:

- Britomart-bound service (NEX 1, Glenfield Road and Birkenhead) – 47 buses per hour during the morning peak, requiring a triple stop.
- University-bound service (NEX 2, Hibiscus Coast, East Coast Road/Takapuna and Hillcrest, and peak only services) – 69 buses per hour during the morning peak, requiring a quadruple stop.
- Isthmus services (Dominion and Sandringham and New North Roads, Remuera Road, Gillies Avenue, Mangere to City) – 76 buses per hour during the afternoon peak, requiring a pentuple stop. This pentuple stop could be divided further into two stops (one double and one triple), one for services utilising Upper Symonds Street, and one for services travelling via Auckland Hospital and Newmarket. In order to maximise the use of space, these stops could be shared with the peak period, peak direction North Shore services, as the two groups would see maximum volumes during opposing peak periods.

- These volumes will decline upon implementation of CRL, which would see New North Road service re-routed to Newmarket.
- Link services (City Link, Inner Link, and Crosstown 5) – the City Link will require single stops, as will the Inner Link. Crosstown 5 is assumed to utilise the Wynyard Quarter terminal, but preliminary network maps show it crossing Fanshawe Street on Beaumont Street, so it is not factored into the required stop infrastructure here.

Westbound:

- Northern Express (NEX 1 and 2) services – 60 buses per hour during the PM peak, requiring a quadruple stop.
- Other North Shore services – 56 buses per hour during the PM peak in 2018, requiring a quadruple stop at minimum. However, it would be most logical to divide this stop into two stops: one for services to East Coast Bays/Takapuna, and one for services to Birkenhead/Glenfield.
- Isthmus services to Wynyard Quarter – 76 buses during the morning peak period. As these services would be terminating at Wynyard and thus passengers would primarily be alighting, these services should be able to be accommodated with a quadruple bay.
- Link Services (City and Inner Links, Crosstown 5) – the Link and Crosstown services would require two stops—with the City Link terminating at Wynyard Quarter, its stop could be located away from the main transfer point if space is not available. The Inner Link and Mt Eden Crosstown (Crosstown 5) services should share a stop (particularly important in the direction toward Ponsonby).

Table 10 below shows expected bus volumes on Fanshawe Street at Victoria Park in 2018, 2026 and 2036. These volumes refer to the total number of buses projected to pass through the Victoria Park Transfer Point on any corridor, with initial assumptions that most if not all would travel (and likely stop) on the block between Halsey and Daldy Streets. Precise alignments will be determined in AT's upcoming *Fanshawe Street/Wynyard Quarter Study*, and will likely impact these volumes.

Table 10: Fanshawe Street Corridor Bus Volumes

Service Grouping	2018	2026	2036
Eastbound AM Peak			
North Shore to Britomart	47	50	54
North Shore to University	69	76	84
Isthmus	32	32	34
Link Services (1, 2/3)	16	20	24
TOTAL	164	178	196
Eastbound PM Peak			
North Shore to Britomart	18	22	22
North Shore to University	17	22	22
Isthmus	76	67	78
Link Services (1, 2/3)	16	20	24
TOTAL	127	131	146
Eastbound All-Day			
North Shore to Britomart	18	22	22
North Shore to University	17	22	22
Isthmus	32	35	37
Link Services (1, 2/3)	16	20	24
TOTAL	83	99	105
Westbound AM Peak			
Northern Express	16	20	20
North Shore All Day	19	24	24
North Shore Peak Expresses	-	-	-
Isthmus	76	67	78
Link Services (1, 2/3)	16	20	24
TOTAL	127	131	146
Westbound PM Peak			
Northern Express	60	60	60
North Shore All Day	31	38	42
North Shore Peak Expresses	25	28	36
Isthmus	32	35	37
Link Services (1, 2/3)	16	20	24
TOTAL	164	181	199
Westbound All-Day			
Northern Express	16	20	20
North Shore All Day	19	24	24
North Shore Peak Expresses	-	-	-
Isthmus	32	35	37
Link Services (1, 2/3)	16	20	24
TOTAL	83	99	105

**Note these volumes exclude the Freemans Bay route, which operates in the westbound direction only on Fanshawe Street according to the most recent City Centre consultation maps.*

2.3.2 Wynyard Quarter Terminal

As separate from the transfer point on Fanshawe Street adjacent to Victoria Park, the Wynyard Quarter Terminal would function as the first and last stop for Isthmus services that utilise Wellesley Street, as well as provide space for turnaround and recovery/staging/layover for those routes. Similar to the Learning Quarter Terminal, passenger functions would not necessarily need to take place at the same location as turnaround and/or recovery/staging/layover. It would function as the terminal for Isthmus, City Link, and Crosstown 5 services. In addition, Crosstown 4 short runners from Onehunga would terminate at Victoria Park, but likely on the opposite (Victoria Street) side of the park.

Table 11 below shows the anticipated volumes at the Wynyard Quarter Terminal in 2018, 2026 and 2036. In 2026, it is anticipated that New North Road service will be re-routed to Newmarket upon implementation of CRL.

Wynyard Quarter is a bit of a conundrum: development goals of creating a dense, urban neighbourhood preclude the use of large amounts of space for public transport terminal uses; meanwhile, the existing street grid and Council directives limit development if the Quarter does not achieve a 70 percent non-car mode share.

Table 11: Wynyard Quarter Terminal Bus Volumes

Service Grouping	2018	2026	2036
(PM) Peak			
Isthmus	76	67	78
City Link	8	10	12
Crosstown 5	4	6	6
TOTAL	88	83	96
All day			
Isthmus	32	32	34
City Link	8	10	12
Crosstown 5	3	4	6
TOTAL	43	46	52

If the maximum projected volumes (e.g., PM peak departures) are to be accommodated at Wynyard Quarter, assuming that boarding and alighting functions take place at stops that are separate from the turnaround/recovery space, eight recovery spaces would be required to accommodate 88 buses per hour in 2018. This volume is anticipated to grow to 96 by 2036, which is the maximum volume that can be accommodated by eight recovery spaces. Note that five minutes of recovery time per trip is specified in PTOM contracts and is not negotiable.

Outside of the peak periods, four recovery spaces would be required to accommodate bus volumes in 2018 increasing to five spaces by 2036.

A double or triple stop in each direction would likely suffice for the volumes within Wynyard Quarter, possibly served only by select Wellesley Street routes as well as the City Link and Crosstown 5 services. Limiting the number of routes utilising the stop could limit the requirement to a double stop in each direction.

While separating the stops from the turnaround and recovery functions improves design flexibility and would allow for a more compact recovery area, there is still a significant difference in the amount of infrastructure required to accommodate peak vs. all-day service. Ideally, no more than five recovery spaces would need to be provided at Wynyard Quarter—enough to handle up to 60 buses per hour (53 buses per hour would be the cap for triple passenger stops). Additional trips would need to be re-routed or take recovery elsewhere.

2.3.3 Issues and Opportunities

Issue #1: The volume of buses proposed to terminate and originate at Wynyard Quarter during the peak periods exceeds the amount needed to serve the internal requirements of the Quarter and may compromise urban amenity and require a large footprint facility.

Issue #2: Bus volumes exceed available space for a transfer point at Victoria Park if all stops are to be accommodated on Fanshawe Street. Stops on adjacent streets likely will require consideration.

Issue #3: North Shore bus volumes are quite high upon implementation of the New Network in 2018, and are projected to continue growing through 2036. These volumes will become increasingly difficult to accommodate in the City Centre, resulting in very long stops along Fanshawe Street that complicate passenger transfers between services at Victoria Park. Some of this may be mitigated by originating some NEX service at Victoria Park in the PM peak, reducing the number of NEX buses stopping at the park and ensuring that boarding passengers will indeed fit on the vehicle.

Issue #4: Wynyard Quarter is expected to achieve a 70 percent (minimum) non-car mode share in order for planned development to continue. Despite this requirement, developers and stakeholders generally find large volumes of buses to be “unacceptable”, and resist accommodating public transport. This may be mitigated by staging some PM peak (extra) service in Victoria Quarter and beginning some trips at Aotea Station, allowing for lower volumes to originate from Wynyard Quarter.

Issue #5: This assumes the relocation of New North Road service in the post-CRL network to serve Newmarket instead of the City Centre. If this relocation were not to be implemented (i.e., if direct access to the City Centre were to be maintained for the New North Road route) then the Wynyard Quarter Terminal would need to accommodate the additional service.

2.4 Albert Street

Albert Street is the main corridor for bus service from the west into the City Centre. With the New Network, all service on Albert Street will terminate at Britomart West. In addition, following implementation of CRL, rail service will travel under Albert Street with stations at Karangahape Road, Aotea and Britomart.

The bus volumes included in this section refer to the entirety of Albert Street, from Customs Street West to Mayoral Drive. Slightly lower volumes would exist on Vincent Street as express services are expected to access the motorway via Cook Street, though they may still run on Vincent St, albeit non-stop.

2.4.1 Running Way Infrastructure and Service Groups

Plans for Albert Street preclude much flexibility in the running way for this corridor—essentially, Albert Street will be equipped with a bus lane and a general travel lane in each direction, and due to a narrow street profile, in-line bus stops. This means that all buses will use the same stops (in each direction), regardless of route group. In the inbound direction, this is not a problem—all buses terminate at Britomart West anyway. However, in the outbound direction, this could complicate the boarding process somewhat for passengers.

Table 12 shows the route groupings and expected volumes for the Albert Street corridor in 2018, 2026 and 2036. Outbound route groups include the following:

- Northwest Express service (future Northwestern Busway WEX service), connecting the City Centre with Westgate, Massey, Te Atatu and Henderson. This service is expected to grow rapidly (from 26 buses per hour in 2018 to 58 buses per hour in 2036), as the area of West Auckland that it serves is anticipated to grow by 120,000 people over the next few decades. If accommodated separately, this service would require a double stop in the near term, growing to a quadruple stop in the long-term.
- Great North Road local service enters the City Centre via Karangahape Road and Albert Street. This major corridor will be upgraded to double decker buses in order to accommodate patronage growth, and could be accommodated by a single stop.
- West Auckland Expresses – currently, services from Blockhouse Bay, Green Bay, Titirangi and Glen Eden operate all the way into the City Centre. These will be discontinued with implementation of CRL, and passengers will transfer at Glen Eden, New Lynn and Avondale Stations to reach the City Centre.
- Richmond Road services use Albert Street, providing a connection between the City Centre and suburban fringe to the west. These services could be accommodated by a single stop, or could share a stop with the Great North Road service.

Note that the above are route groups/stop size requirements for locations where separate stops are possible. The proposed post-CRL cross-section of Albert Street is anticipated to only allow for in-line stops, meaning all routes/groups would have to stop at the same locations.

In addition, note that the West and Northwest express services utilise two different alignments to access the City Centre: routes denoted with an "x", including 125x from Westgate, 132x from Te Atatu, 133x from Henderson, 151x from Glen Eden, 171x/172x from Titirangi and the proposed service from Red Hills utilise the Northwest Motorway to the Nelson Street exit, then access Albert Street via Cook Street. Other services between the City Centre and the West and Northwest, including Routes 110 from Westgate, 129 from Massey West, 132 from Te Atatu, 133 and 134 from Henderson, 195 from Blockhouse Bay and 209 from Green Bay utilise Great North Road, Karangahape Road, Pitt Street and Vincent Street to access Albert Street.

Table 12: Albert Street Corridor Bus Volumes

Service Grouping	2018	2026	2036
Peak			
Northwest Expresses (WEX)	26	44	58
Great North Road	12	12	12
West Auckland Expresses	15	-	-
Richmond Road	6	6	8
TOTAL	59	62	78
All-Day			
Northwest Expresses (WEX)	6	8	12
Great North Road	6	6	8
West Auckland Expresses	2	-	-
Richmond Road	3	4	6
TOTAL	17	18	26

**Note these volumes exclude the Freemans Bay route, which operates in the northbound direction only according to the most recent City Centre consultation maps.*

With in-line stops, it is not recommended that volumes exceed 53 buses per hour at any time, the maximum that can be accommodated with triple stops. This is because the passenger experience is degraded with longer stops serving multiple route groups, as people must determine when their bus is arriving (it might be the third or fourth bus in line), and then move to the correct bus to board. Albert Street will have already reached this volume upon implementation of the New Network in 2018. Thus effort must be undertaken to avoid increases in service in this corridor.

It is also worth noting that the Albert Street corridor extends south to Karangahape Road via Mayoral Drive, Vincent Street and Pitt Street. Bus improvements are planned for Pitt Street in order to accommodate transfers between buses and the Karangahape Road Rail Station (to be constructed as a part of CRL) at Pitt Street and Beresford Square. Triple stops would be required to accommodate the Albert Street buses, as well as an additional single southbound stop for the City Link. However, the volumes on Vincent and Pitt Streets are somewhat lower than on Albert Street, as many of the West and Northwest Express services will utilise the Northwest Motorway between West Auckland and the Nelson Street/Hobson Street exit/entrance ramps. Thus these express services (those denoted by an "x" in the route number) are assumed not to use Pitt Street, Vincent Street or Karangahape Road (today, some of these services do, and others don't, at the discretion of the operator).

In addition, with an increasing density of residential development and businesses in the southern portion of the CBD, a set of stops would be desirable on Vincent Street, in the upper half of the street closer to Pitt Street. These stops would require some re-configuring of the street, which also include bicycle lanes and on-street parking. It may be necessary to provide clearways during the peak period. While boarding and alighting volumes will likely be lower at the Vincent Street stops than on Pitt Street, the improved legibility of the New Network will likely increase the use of the Albert Street buses for shorter trips.

2.4.2 Realignment of West Express Services with Delivery of CRL

Note: the West Auckland Expresses group (Blockhouse Bay, Green Bay, Titirangi and Glen Eden) is eliminated from the City Centre and re-aligned to provide connections to the rail network following implementation of CRL for several reasons:

- Prior to implementation of CRL, rail access from these areas to the City is slow and circuitous, and only provides access to the downtown portion of the City Centre. With CRL, transferring from bus to rail at New Lynn, Glen Eden or Avondale results in faster trip times than riding the bus all the way into the City, and new stations will provide direct access to the midtown and uptown areas of the City Centre as well.

- Operating these services between their local catchments and the nearest rail station allows for fewer resources to be used to provide more frequent service in the suburban catchment areas of these routes (e.g., frequent shuttles to the nearest rail station rather than infrequent bus service to the City).
- More frequent service on both the bus routes and the Western Rail Line mean connections between services will be short.
- Limited capacity on Albert Street coupled with high expected growth in the Northwest means that there will not be space to continue operating these services into the City Centre. Priority on Albert Street would go to high capacity buses to/from the Northwest (e.g., services on the proposed Northwestern Busway), where there is limited opportunity to connect to rail, and such connections result in longer, rather than shorter, travel times.
- Connections can be made at New Lynn or Avondale to Great North Road bus service.

2.4.3 Issues and Opportunities

Issue #1: The proposed street profile on Albert Street (CRL Enabling Works – Public Realm Reference Design, April 2015) is designed for bus lanes with in-line stops, which will make it impossible to group stops (skip-stops cannot be used, as buses will not be able to pass one another). Thus, if stop lengths exceed triple stops, it becomes difficult for passengers to get to the correct bus—quadruple stops would mean some passengers would have to run 50+ metres to catch the correct bus if standing at the front of the bus stop. Triple stops can accommodate up to 53 buses per hour in each direction, which effectively becomes the ceiling on the volume of buses that can operate in this corridor.

Issue #2: The volumes at the upper (Vincent Street/Pitt Street) end of the corridor are somewhat variable, as it is up to operator discretion as to whether to use the motorway or Vincent and Pitt Streets.

2.5 Symonds Street

Symonds Street carries Isthmus and southeast Auckland services to both the Wellesley Street corridor and to Britomart, with stops serving the University. Currently, a large number of buses use Symonds Street during the peak period—bus volumes following implementation of the New Network are expected to be reduced from current volumes on the street presenting an opportunity for improved public realm and walking and cycling access.

Bus volumes in this section refer to Symonds Street between Wellesley Street and Grafton Bridge, the common segment for all New Network routes utilising Symonds Street.

2.5.1 Running Way Infrastructure and Service Groups

Service groupings in this corridor would include the following:

Northbound:

- Britomart-bound buses would include the Mt Eden Road, Howick to City (AMETI), Papakura to City and Hospitals services. Triple stops would be required to accommodate this route group.
- Wynyard Quarter-bound buses would include Dominion, Sandringham and Remuera Road Services, Gillies Avenue service, Mangere to City service and, prior to the opening of CRL, New North Road service. Quintuple Stops would be required to accommodate this route group.

Southbound:

- South and East via Grafton Bridge and Auckland Hospital – this route group would be comprised of Remuera Road, Howick, Gillies Avenue, Hospitals (south of Grafton Road only), Papakura to City and Mangere to City services and would require triple stops.
- Central Isthmus via Upper Symonds Street – this route group would be comprised of bus service from New North, Sandringham, Dominion and Mt Eden Roads. New North Road service would be realigned to Newmarket upon completion of CRL. Quadruple bus stops would accommodate this route group; however, this configuration would accommodate very little growth.

Table 13 shows projected bus volumes on Symonds Street in 2018, 2026 and 2036. Transfers would need to be provided at the University between Symonds Street buses and North Shore and Crosstown 4 services on Wellesley Street below (it is assumed that Crosstown 4 would stop with the North Shore services on Wellesley Street, rather than utilising Symonds Street to Grafton Road). Pedestrian facilities and wayfinding need to be provided to facilitate transfers between services at this location. Stops should be sited so that transfers can be made as easily as possible.

At the Learning Quarter, southbound stops for all route groups would need to be located south of Wellesley Street, in order to accommodate buses turning onto/off of Wellesley Street. In the northbound direction, the Britomart-bound route group could stop north of Wellesley Street, while the Wynyard Quarter-bound route group would have to stop south of Wellesley Street.

This corridor has less "peak only" service, and is projected to remain much more stable in bus volumes over time, as most routes in this corridor serve already built-out (less rapidly growing) areas and some services are reduced due to CRL. The infrastructure needs along Symonds Street are more stable over time than in other corridors. Upon implementation of the New Network, bus volumes on Symonds Street will actually be slightly lower than they are with the current network.

Table 13: Symonds Street Corridor Bus Volumes

Service Grouping	2018	2026	2036
Inbound Peak			
Britomart East	44	45	45
Wynyard Quarter	76	67	78
TOTAL	120	112	123
Inbound All-Day			
Britomart East	14	16	16
Wynyard Quarter	32	32	34
TOTAL	46	48	50
Outbound Peak			
Via Hospital/Newmarket	46	46	51
Via Upper Symonds Street	74	66	72
TOTAL	120	112	123
Outbound All-Day			
Via Hospital/Newmarket	16	20	22
Via Upper Symonds Street	30	28	28
TOTAL	46	48	50

Note that the Hospitals route is assumed to utilise Grafton Road, and not Grafton Bridge. Thus it is included in the southern portion of the Symonds Street corridor, but not the northern (busier) portion, and is not included in the above table.

2.5.2 Issues and Opportunities

Issue #1: Volumes on Symonds Street south of Wellesley Street exceed the capacity of the corridor at the Wynyard Quarter-bound (northbound) and Upper Symonds Street-bound (southbound) stops.

Issue #2: This assumes the relocation of New North Road service in the post-CRL network to serve Newmarket instead of the City Centre. If this relocation were not to be implemented (i.e., if direct access to the City Centre were to be maintained for the New North Road route) then the bus volumes would increase along Symonds Street.

2.6 Karangahape Road

The Karangahape Road corridor carries the highest bus volumes west of Pitt Street, where service from Great North Road and West Auckland enters the CBD and connects to Albert Street via Pitt and Vincent Streets. In addition, the Inner Link (Link 2 and 3) and North Shore to Newmarket (NEX 3 and n93) services also use Karangahape Road. This section references bus volumes on Karangahape Road between Pitt Street and Newton Road, the common segment for all services except the City Link. The primary stop location on Karangahape Road will be at the Motorway Overbridge, as the existing stops at Pitt Street will be moved around the corner onto Pitt Street itself to facilitate transfers with rail service at Beresford Square (the proposed location of the Karangahape Road Station entrance).

2.6.1 Running Way Infrastructure and Service Groups

The main constraint in this corridor is the Motorway Overbridge bus facility, which has five stops in each direction. In addition, the existing stop at Pitt Street and Karangahape Road is currently at capacity (and will be moved upon the opening of CRL). However, due to constraints on Albert Street, volumes on Karangahape Road are unlikely to increase by much.

Table 14 shows expected bus volumes at the Motorway Overbridge; however, it should be noted that these volumes do not take into account constraints on Albert Street, and thus may not be achievable. This excludes the City Link service, which operates on Karangahape Road, but only between Pitt Street and Queen Street. Route groups on Karangahape Road include the following:

Eastbound:

- Service to Newmarket would require a double stop.
- Service to Britomart West including Great North Road, West and Northwest express service (including southern West Auckland service prior to the completion of CRL) and Richmond Road would require a triple stop. While projected volumes show this requirement increasing, constraints on Albert Street will limit expansion.

Westbound:

- Great North Road and Richmond Road services could share a single stop, upgraded to a double stop by 2036.
- West and Northwest express services would require a double stop—the Northwest express service would be upgraded to WEX (Northwestern Busway service) over time, while the West express services would be discontinued following delivery of CRL.
- Inner Link and North Shore services would require a double stop.

As stated previously, the West and Northwest express services utilise two different alignments to access the City Centre: routes denoted with an "x", such as 125x from Westgate, use the Northwest Motorway to the Nelson Street exit, then access Albert Street via Cook Street, while other services between the City Centre and the West and Northwest, including Route 110 from Westgate, utilise Great North Road, Karangahape Road, Pitt Street and Vincent Street to access Albert Street. AT notes that for the routes accessing Albert Street via the Nelson Street off-ramp, some drivers may opt to operate via Karangahape Road instead, meaning actual bus volumes could exceed those stated in the table.

The Motorway Overbridge is 60 metres long (up to five spaces), and could accommodate all the services noted above (up to about 74 buses per hour in quadruple stops). However, due to street redesign plans such as implementation of a cycleway, these buses would need to stop in line (all at the same stop). Thus it is desirable to limit the total volume of buses (and, more specifically, limit the total number of route groups) along Karangahape Road to triple stops, which can handle up to about 53 buses per hour.

During the peak periods, legibility and customer service will likely be compromised somewhat in order to allow for quadruple in-line stops on the overbridge. This concern is somewhat moderated by the greater relative importance of the Pitt Street stop following the delivery of CRL.

Table 14: Karangahape Road Corridor Bus Volumes at Motorway Overbridge

Service Grouping	2018	2026	2036
Peak			
Northwest Expresses (WEX)	10	16	22
Great North Road	12	12	12
West Auckland Expresses	7	-	-
Richmond Road	6	6	8
Inner Link	8	10	12
North Shore to Newmarket	10	14	18
TOTAL	53	58	72
All-Day			
Northwest Expresses (WEX)	6	8	12
Great North Road	6	6	8
West Auckland Expresses	2	-	-
Richmond Road	3	4	6
Inner Link	8	10	12
North Shore to Newmarket	6	10	12
TOTAL	31	38	50

**Note these volumes exclude the Freemans Bay Route, which operates in the eastbound direction only*

In addition to carrying a large volume of buses, Karangahape Road will also see heavy rail service upon completion of CRL, with a new station at the intersection of Pitt Street. Bus transfers will likely take place primarily at the Motorway Overbridge between North Shore/Link services and Great North Road/Northwest Express services. Rail transfers will take place at Pitt Street—a full set of bus stops will need to be constructed on Pitt Street outside the rail station entrance. The higher provision of transport access and passenger transfers will require a re-allocation of street space as well as improved pedestrian amenities.

2.6.2 Issues and Opportunities

Issue #1: The primary concern on Karangahape Road is the expected volume of buses combined with in-line stops, such as those on Albert Street. A large volume of buses from several different route groups could result in inefficient operations with buses causing delays and getting delayed at stops, poor legibility with all route groups serving a single stop, and poor customer service with customers having to scramble to get to the second or third bus in the stop at busy times. Space will be further constrained with cycle lanes proposed for this corridor.

Issue #2: The Western Express services may run via Karangahape Road, as the exact running pattern between the motorway and the Mayoral Drive stop is at the discretion of the operator. This creates a potential issue on Karanagahape Road, as bus volumes may increase by up to 31 in the peak hour in 2018. While this will should not create an issue with stop capacity (as buses should not stop), it may create issues with the interaction of the inline bus lanes.

3 Assumptions

This section summarises some of the key assumptions used for all calculations included in this document. Assumptions were made regarding expected rates of patronage growth throughout the system, as well as vehicle types for use on each route or service, and impacts on the bus network (e.g., route alignments) as a result of implementation of CRL.

It is important to note that the bus volumes included in this document reference only "in-service" vehicles, and do not include deadhead movements, such as buses travelling to or from the depot or repositioning between trips. All peak only volumes have been assumed to operate inbound to CBD in the morning, and outbound in the afternoon, and in the reverse direction these services will operate as repositioning movements.

3.1 Growth Rates

Steady growth has occurred throughout Auckland Transport's Public Transport (PT) network over the past several years as the region has grown in population and overall service has improved, particularly through electrification, service expansion and on-time performance improvements on the rail network, implementation of the Northern Busway, and streamlining of service in many parts of the city. It is anticipated that this growth will continue into the future as Auckland continues to expand in population, as well as in response to the delivery of major PT infrastructure projects and service improvements.

The assumed service frequencies for 2018, 2026 and 2036 for each route were provided by Auckland Transport Network Management and Bus Services. These frequencies were provided based largely on the following principles:

1) As demand for PT service grows, AT will invest in additional double-decker and other higher capacity vehicles in order to accommodate growth wherever possible. The use of higher-capacity vehicles will minimise increases in the number of buses operating to/from the City Centre, and will help to keep operating costs low.
2) The greatest amount of growth in bus patronage is anticipated along the three busway corridors (Northern, Northwestern and AMETI), in part due to anticipated development, and in part due to these areas not being served by the rail network (although much service on the AMETI Busway will terminate at the Panmure Rail Station).
3) Approximately 120,000 new residents are expected to be added to the Northwest Suburbs, resulting in an assumed demand of 4,000 passengers on the Northwestern Busway, west of Te Atatu for the peak two hours by 2026. It is expected that approximately 60 percent, or 2,400 people will need to use the Northwestern Busway service in this segment during the peak hour. This is generally consistent with modelling results for the Northwestern Busway.

Growth percentages have been calculated by keys corridor or route groupings based on the bus volumes and vehicle types provided by Auckland Transport. AT HOP data for a day in March 2015 was used to provide a comparison with the current capacity on key routes. Routes were generally allocated a vehicle capacity of 60 to account for the provision of mixed sizes of buses on many current routes, though on some routes (such as Northern Express) which used a standard bus size, then this capacity was used.

Most routes show a significant jump in capacity between 2015 and 2018, which relates to expected higher capacities in the New Network through simplification of routes and introduction of double-deckers on key routes. The exception to this rule is Sandringham Road. Currently this corridor is served by eight distinct services, several of which have low bus occupancies. This corridor is to be simplified to two key routes, which will allow passenger volumes to be handled by slightly reduced overall capacity.

Table 15: Projected Growth Rates by Corridor

Route Group	Capacity				Per Annum Capacity Growth			Per Annum Capacity Growth
	2015	2018	2026	2036	2015-2018	2018-2026	2026-2036	2015-2036
City & Inner Links	770	1376	2040	2448	21.4%	5.0%	1.8%	5.7%
Manukau Road	825	1500	1860	2220	22.1%	2.7%	1.8%	4.8%
Mt Eden Road	1260	1640	2480	2640	9.2%	5.3%	0.6%	3.6%
Dominion Road	1860	2160	2640	3080	5.1%	2.5%	1.6%	2.4%
Sandringham Road	1620	1500	1980	2200	-2.5%	3.5%	1.1%	1.5%
Other Isthmus	1240	2270	2720	3140	22.3%	2.3%	1.4%	4.5%
East Isthmus	1620	2170	2590	3220	10.2%	2.2%	2.2%	3.3%
East Auckland	1090	2070	2070	2070	23.8%	0.0%	0.0%	3.1%
NEX/Hibiscus Coast	4160	5820	8180	8540	11.8%	4.3%	0.4%	3.5%
North Shore (West)	1740	2920	3880	4880	18.8%	3.6%	2.3%	5.0%
North Shore (Other)	840	1090	1260	1260	9.1%	1.8%	0.0%	1.9%
North West Auckland	1560	2060	3640	4860	9.7%	7.4%	2.9%	5.6%

3.2 Vehicles

In order to increase capacity without greatly increasing operating costs, and to minimise the increase in buses in the City Centre, many major routes connecting core Isthmus neighbourhoods and some outlying suburbs (particularly routes utilising busways) will be upgraded to higher-capacity vehicles. For most such routes, double decker buses will be used, which have a carrying capacity of approximately 110 passengers, versus 55 to 70 on existing single decker buses on the same routes.

For consistency, five vehicle types were considered to be available (with categories defined by AT):

- Small buses, with approximately 25 seats each and capacity for 35 passengers including standees;
- Standard buses (e.g., existing ADLs) with approximately 37 seats and capacity for 55 passengers including standees;
- Large buses (e.g., existing 3-axle, single-deckers) with approximately 51 seats and capacity for up to 70 passengers including standees;
- Super large buses (e.g., double-decker or articulated) with approximately 85 seats and capacity for up to 110 passengers including standees; and
- High-capacity, single-decker buses, with 32 seats and total capacity for up to 102 passengers including standees.

Double deckers are initially provided on the all-day volumes, but will be expanded to additional peak services as the fleet ages and additional small buses are replaced with double deckers. It should be noted that one side effect of using double deckers is the potential for increased dwell/loading times, or increased dwell/loading time variability, particularly at busy stops and termini.

Both City Link and Inner Link buses are assumed to use three-door, three-axle vehicles with fewer seats and enhanced internal passenger flows. These buses will be able to carry approximately 70 passengers each (up to 102 in the model shown in Section 5.3 of this report), and are preferable to double deckers on these routes, which include high ridership and frequent passenger turnover, with many passengers traveling short distances. For these passengers, navigating the stairs on a double decker can result in increased dwell times and discomfort, as the lower level would likely be overcrowded with boarding and alighting passengers.

Double decker buses will be provided on many of the busier routes in order to reduce the number of vehicles entering the City Centre, as well as overall operating costs. The Northern Express currently utilises some double deckers—these will be rolled out further as follows:

- By 2018, double deckers will be in use on Great North Road (Route 18), New North Road (Route 22), Sandringham Road (Route 24), Dominion Road (Route 25 & 26), Mount Eden Road (Route 27), Manukau Road (Crosstown 4), the AMETI corridor (Route 55), Westgate to City (Route 110), all Northern Express buses on NEX 1 and NEX 2, Glenfield Road (Route n8), and Birkenhead to City (Route n9).
- By 2026, double deckers will be added to the Northern Express – Newmarket service (NEX 3) and the Westgate to City Express (Route 125x).
- Double deckers cannot be used on Tamaki Drive (Route 77) service due to low-hanging trees along the roadway.
- Double deckers cannot be used on Remuera Road (Route 70) due to a low underbridge at the Eastern Rail Line on Merton Road in Glen Innes.
- It is anticipated that in the post-CRL (2026 and 2036) scenarios, demand will be reduced along New North Road, and double deckers may no longer be needed on Route 22.

3.3 Impacts of Infrastructure Investments on Bus Network

This section summarises the assumptions made with regard to bus service in response to delivery of CRL.

Implementation of CRL allows for:

- New North Road (Route 22) service re-directed to Newmarket;
- Elimination of expresses from the West, including Blockhouse Bay to City (Route 195), Green Bay to City (Route 209), Glen Eden Express (Route 151x), and Titirangi Expresses (Routes 171x and 172x)—these routes would terminate at the Avondale, New Lynn, and Glen Eden rail stations instead;
- Expansion of service from the Northwest, specifically Routes 110 and 125x (WEX upon completion of the busway); and
- Elimination of expresses from the Southeast, including Mangere to City (Route 309x) and Papakura to City (Route 360x).

4 Infrastructure Requirements

This section summarises the assumptions made with regard to infrastructure *requirements*. While the previous section cited major PT infrastructure investments that are already planned for the City Centre, this section details the way in which infrastructure requirements for running ways, transfer points and termini will be determined in order to operate anticipated levels of bus service.

4.1 Constrained Environment

We believe the provision of abundant and effective transport is a key driver of vibrant and economically productive places.

The design of public transport facilities should support adjacent land uses and access to public transport services itself. Sometimes these elements are at odds requiring careful consideration of the implications of facility choices on urban outcomes. In the City Centre this is especially critical as the land available for facilities is highly constrained, expensive, and valuable for competing uses. Bus stop and layover requirements need to be scaled and located to support the best possible urban outcomes.

In most cases here the bus facility requirements are based on peak volumes. In reality, facilities should be scaled to serve volumes lower than the peak particularly when peak service loads require a next level of investment/scale. Using the peak volumes in this analysis is designed to highlight the implications of the proposed volumes while designing for "future proofing".

4.2 Bus Stops and Lanes

Bus lanes will be driven by the frequency of bus service in the corridor, and the desire to minimise bus travel times and the potential for delay. Bus lanes benefit both buses and general traffic, by allowing buses to bypass congested general traffic lanes while keeping general traffic from getting delayed by buses in stops.

Bus stops will primarily be driven by the interaction of corridor service frequency and traffic signal phasing. At high frequencies buses will be metered by traffic lights and form into platoons of vehicles travelling in unison. In simple terms the number of bus bays required at a stop is equal to the number of buses we might expect to arrive at each phase of the lights. For example, if there are sixty buses an hour on a corridor at peak times, and two minute signal phases at the lights on the corridor, we would expect two buses per phase to arrive at the bus stop at each phase.

Assuming that the buses would dwell at the stop for well less than two minutes, on average two buses would pass through the stop on each two minute cycle. If the buses are randomly distributed there is a small probability that three may arrive on one cycle, and a very small probability of four, etc. We would therefore need a stop two bays long to accommodate most conditions or a stop of three bays to accommodate almost all circumstances.

Closer to the core City Centre large platoons of buses will be broken apart either by design or by the very short signals required for pedestrian crossings. There is an opportunity to regulate bus stop arrivals by signal timing, special bus signals, and bus lane allocation. For example, buses travelling west bound on Wellesley Street near Queen Street might have allocated bus lanes at the intersection corresponding to the stop destination. In conjunction with signal timing this would ensure that the desired number of buses arrives at a particular stop at once. At the very busiest times buses may miss a signal cycle and stacking would occur in the bus lane.

Table 15 shows the spatial requirements for stop infrastructure in the City Centre. Auckland Transport's Bus Services group uses the following dimensions as guidelines for bus stop design:

- 15 metre long bus stops;
- 15 metre lead-in to bus stops;
- 9 metre lead-out of bus stops; and
- 9 metres between individual positions within double, triple (or longer) stops.

Stop lengths may be shortened somewhat by locating stops adjacent to intersections and using the intersection itself as the lead-in and/or lead-out; however, it is understood that these dimensions are limited by space constraints and the need for pedestrian access and crossings within the City Centre.

In addition, it should be noted that the upper threshold of the volumes in the table below could be accommodated with a 90 percent probability of working without causing congestion. This means that 10 percent of the time, assuming the existing two-minute light cycles, more buses would arrive simultaneously than could be accommodated in the stop, causing at least one trailing bus to contribute to congestion in the general traffic lanes. This equates to congestion occurring approximately three times per hour. Auckland Transport's Bus Services group has expressed a desire to further reduce the probability of congestion, which further reduces the number of vehicles that can be accommodated by stops.

Note that these stop capacities assume that all buses will serve the stop. At less busy stop locations, buses may pass by the stop if nobody signals the driver to exit the bus and nobody is waiting. These facilities can be sized smaller, according to the volume of buses that is actually expected to stop.

Table 15: Spatial Requirements for City Centre Stop Infrastructure

Buses per hour per direction	Number of bays required per stop per direction	Nominal lane and stop configuration
1 to 16	1	Bus lane not necessarily required, simple kerbside stop
17 to 33	2	Single bus lane required, buses can stop in lane
34 to 53	3	Single bus lane required, buses can stop in lane
54 to 74	4	Single bus lane required, buses can stop in lane
75 to 95	5	Single bus lane with indented bus stops required
96 to 118	6	Single bus lane with indented bus stops required, skip stop pattern required (2 x three-bay stops in each direction)
119 to 141	7	Single bus lane required with indented bus stops, skip stop pattern required (1x three-bay and 1x four-bay stop in each direction)
142 to 164	8	Single bus lane required with indented bus stops, skip stop pattern required (2x four-bay stop in each direction)
165 to 188	9	Double bus lane required with stopping in lane, triple skip stop pattern required (3x three-bay stops in each direction)
189 to 212	10	Double bus lane required with stopping in lane, triple skip stop pattern required (2x three-bay and 1x four-bay stop in each direction)
213 to 237	11	Double bus lane required with stopping in lane, triple skip stop pattern required (1x three-bay and 2x four-bay stop in each direction)

*This table considers that buses can just go to the first available position at any stop. However, when routes are combined into groups serving different stops, the capacity of the corridor is equivalent to the sum of the capacities of the stop locations serving each individual route group.

4.3 Pedestrian Facilities and Access

At all transfer points and in many bus stops across the City Centre a better provision of footpaths is required. At very busy transfer locations, namely Wellesley Street, Aotea Station, Symonds Street (Learning Quarter), and Fanshawe Street (Victoria Park), wide footpaths will be required to accommodate very large numbers of passengers waiting, boarding, alighting and moving between services. As a reference it is useful to consider the width of existing footpaths. On Queen Street outside of the CPO building, the footpaths are 10.8 metres wide. On Symonds Street near AUT the footpath is 4.5 metres. Currently the Symonds Street footpath does not provide enough space for comfortable pedestrian circulation. Also, the narrow space limits other street-side activity (e.g., seating) that may be desirable.

At busy bus stops and especially at transfer locations facilities must be provided for pedestrians to cross the street to access public transport services. This pedestrian trip needs to be as convenient and safe as possible. Ensuring the convenience of these trips requires consideration of crossing facilities, crossing distances, signal timing, lighting, etc.

4.4 Transfer Point/Terminal Requirements

Transfer points and termini provide specific functions which are sometimes combined in what is generically called an interchange. It is important to consider the unique requirements of both termini and transfer points as this has implications for the size, location and design of the infrastructure. In addition, transfer point and terminal functions do not need to happen in the same place—in fact, these functions can be spread over a few different locations, with passenger boarding/unloading, turnaround, and layover/recovery functions all occurring in separate places.

A terminal is a location where transit services end. For bus infrastructure a terminal consists of the following:

- Bus stops and/or bays;
- Passenger facilities (shelters, benches, ticket kiosks, rubbish bins, posted maps/schedules, etc.);
- Space to accommodate last stop/unloading of all passengers (this can occur in bus stops/bays);
- Ability for buses to turn around;
- Space for buses to take recovery time between trips, layover time (e.g., restroom or meal breaks) for drivers, and staging time for buses waiting to access stops; and
- Driver facilities (e.g., restrooms).

A transfer point is a location where transit users transfer between transit services or between travel modes. At transfer points it is important to consider the distance, composition and magnitude of expected transfers. A transfer point consists of the following:

- Bus stops and/or bays; and
- Passenger facilities (shelters, benches, ticket kiosks, rubbish bins, posted maps/schedules, etc.).

The Auckland City Centre will include termini at Britomart, Wynyard Quarter, and the Learning Quarter with additional major transfer points at Aotea Square and Karangahape Road.

Typically, bus termini are far more complicated than bus transfer points, as they must accommodate more types of activity. Larger bus termini go beyond the requirements cited above, and often include a staffed ticket office, public restrooms, indoor passenger waiting area, bus supervisor area or office, or even a small police station. While the Britomart facility includes many of these amenities, in part because it is collocated with the City Centre's main train station, this document focusses more specifically on the requirements for bus operations and passenger movements.

The amount of space required for bus operations at either a transfer point or a terminal is impacted primarily by the following:

- **Loading and Unloading** – It is typically assumed that a bus needs approximately two minutes to pull into a stop, open its doors, unload, load, close its doors, and pull back into traffic. However, this time varies greatly, dependent on volumes of boarding and alighting passengers, fare collection method (off-board fare collection being fastest), or whether boarding and alighting take place separately at different locations.
- **Recovery** – For the purpose of this analysis, "recovery time" refers to the schedule time between trips to allow each individual bus to keep to timetable, even if the previous trip arrives a few minutes late. It is understood that the PTOM contracts include a recovery period of five minutes between trips. Therefore, the calculations in this document have assumed a recovery period of five minutes for each trip.
- **Staging and First Stop** – Often additional time is required at the beginning of a route, to allow for "staging", or queueing up at a separate location before entering the bus stop and picking up passengers. This is particularly crucial for peak-only services, as routes operating in one direction may have a greater likelihood of arriving at the terminal further ahead of their scheduled departure times than all day, bi-directional routes. This would come into play more often during the peak periods, when higher bus volumes mean stops would be more likely to be occupied when subsequent buses arrive.

- **Driver Layovers –** Layover time allows for drivers to take breaks, use the restroom, get refreshments, etc. The amount of time provided for layovers is determined based on run cuts/driver shifts, the length of a route, as well as labour contracts. Generally, layover time would be focussed outside of the peak periods or taken at the opposite (non-City Centre) end of the route. In the case of Britomart, terminal development plans include separate "layover" locations for each service group.
- **Service Grouping** – Discussed in further detail in the following section, services are typically grouped according to destination in order to improve passengers' ability to find the appropriate bus route to reach their destination. Service grouping is particularly important at a terminal or transfer point where there are a large number of boarding passengers going to a variety of different locations. Grouping can also be used to facilitate popular transfers by located stops close to one another. However, it should be noted that service grouping can limit the capacity of a terminal, as it may not be possible to group routes such that all stop locations are fully utilized. In order to maximise stop utilisation, "dynamic berthing" should be pursued (whereby arriving buses are assigned to a specific stop or berth upon arrival, rather than always serving the same stop). This strategy is likely to reduce system legibility, and is unlikely to be recommended for any of the Auckland termini.

Terminal capacity is generally constrained by the number of trips originating at the terminal during the peak of peak service. Thus for termini located within the City Centre, the capacity would be determined by the trips departing during the pm peak period. The reason for looking at departures, rather than arrivals, is that departures typically would include a short "recovery period" beforehand, in order to ensure that the trips operate on schedule.

While there may in fact be more arrivals during the morning peak than departures in the afternoon peak, unless the service is perfectly symmetrical (e.g., same number of trips operating in each direction on each route), many of the trips arriving during the AM peak would be returning to the depot, and thus would not include any recovery time at the terminal.

It is important to note that while terminal requirements can be adjusted by modifying the basic assumptions, such as providing less recovery time or altering the percentage of buses taking recovery and/or layover at each location, such adjustments can adversely impact on-time performance, leading to a decline in patronage. A rule of thumb is typically that recovery time should equal "10 percent of running time", but this varies between PT networks depending on traffic variability, on-time performance KPIs, service contracts, and other factors. Another option would be to move all layovers and recovery time to the outer (non-City Centre) end of the route in order to reduce the time each bus spends at the terminal, and therefore increase capacity; however, this strategy would have impacts on the on-time performance of trips originating in the City Centre.

4.5 Service Grouping

Grouping services at bus stops is required for spatial efficiency as well as legibility for users. Legibility assists users in understanding and navigating the network.

The New Network design combines similar services on common corridors to improve legibility. For example, most Isthmus services use Wellesley Street in the City Centre. This allows these services to be grouped at stops along the corridor which provides a simple, legible structure where users can take any bus from the group to access City Centre locations.

Grouping services also avoids the situation of having all services turn up at very long bus stops, where passengers are required to run up and down to find their particular service amongst many of arrivals and departures. It also allows the required number of bus stops to be located with better spatial efficiency relative to each other. Groupings where many passengers are likely to transfer between should be located in close proximity, such as alongside or on adjacent sides of a corner.

5 Notes on Infrastructure and Service

5.1 Peak Spreading

As a city grows, so does its workforce, and as such, so does demand for peak period travel on public transport. In Auckland, both the total number of jobs in the City Centre, and the PT mode share for City Centre commutes is growing. According to Stats NZ, City Centre employment grew from 80,000 to 100,000 over the period from 2001 to 2014. Meanwhile, according to the *2014 Screenline Survey*, the PT mode share increased from 26 to 48 percent. When active modes are considered, the non-car mode share exceeds 50 percent. In fact, over that same period, the total number of commuters driving alone to work in the City Centre decreased, even though the number of jobs in the City Centre increased by 25 percent. Thus the increase in commutes to City Centre jobs has been entirely absorbed by PT and active modes.

While this rapid uptake of PT usage is in line with policy-maker objectives for the Auckland region, this places a tremendous amount of pressure on the PT network. Given the large number of "nine-to-five" type jobs in the City Centre, the demand for service is highly peaked, with large numbers of people wanting to travel inbound between 7:00 and 9:00 AM, and outbound between 4:00 and 6:00 PM. The demand throughout the remainder of the day, and in the opposite (counter-peak) direction is much lower.

As discussed previously in this document, building infrastructure to accommodate these peak volumes would require a massive amount of investment for facilities that would take up a large amount of space, degrade the environment of the streets that they occupy, and would see little use outside these two peak periods. Thus it is does not make sense to construct infrastructure for such limited (temporally) use. Crowding during peak periods should be expected—just as congestion on major roadways occurs during the peak. Over time, passengers recognise that travelling during the peak period takes longer, and is less comfortable, and will adjust their travel accordingly. Many people, particularly those with flexible work schedules or making discretionary trips (e.g., shopping, visiting friends, etc.) will begin travelling on the shoulders of the peak period, or travel outside of the peak altogether. This phenomenon, known as "peak spreading", can be seen in cities across the globe.

In this report, it is recommended that infrastructure is built with a focus on desired outcomes, rather than to accommodate an infinitely increasing volume of buses. This way, large facilities are not built to be used only four to six hours of the day. In addition, this strategy is in line with the principles of the New Network, which seek to ensure that Auckland's public transport network functions for travel throughout the day between all parts of the city, not just during the peak period, in the peak direction. Thus rather than simply accommodate all demand for peak travel, it is recommended that Auckland expect—and encourage—some peak spreading.

Encouraging peak spreading, rather than accommodating infinite growth comes with numerous benefits:

- It reduces the differential between peak and all-day volumes;
- It allows for better service provision with all-day frequent service rather than a majority of service concentrated into a few hours of the day;
- It allows for a smaller total fleet size with by reducing the peak vehicle requirement; and
- It results in improved operations and happier drivers with a need for fewer split shifts.

There are several options for encouraging peak spreading:

- Encourage employers to adopt staggered work schedules;
- Implement peak period pricing schemes, whereby higher fares are charged for passengers wishing to travel during the peak period, in the peak direction; and

- Simply do not accommodate the peak demand, but improve peak shoulder and all-day service so that passengers can choose to travel at other times.

5.2 Off-Board Fare Collection and All-Door Boarding

Off-board fare collection is a strategy that many cities employ for speeding up bus service in busy corridors. Often a key component of Bus Rapid Transit systems, off-board fare collection speeds up service by allowing passengers to pay for their trips before boarding the vehicle, similar to how fare payments work on Auckland's rail network. This means that in addition to simply being able to "hop on" the bus without stopping to pay a fare, passengers can also board at any door—including the rear doors—because it is unnecessary for the driver to see whether they have paid. This strategy can greatly reduce dwell times at stops with large numbers of boarding passengers, such as will be expected at Aotea Station on both the Wellesley Street and Albert Street corridors. Reducing dwell times effectively increases the capacity of the stop, allowing more buses per hour to use the same space. It is recommended that off-board fare collection and all-door boarding is implemented at the Aotea Station bus stops on Wellesley Street and Albert Street, as well as at Britomart West. If successful, this strategy may be rolled out at additional busy locations in the City Centre (e.g., Karangahape Road, Learning Quarter, Victoria Park transfer point, etc.)

The down side of off-board fare collection / rear door boarding is that fare inspectors will be required, either to ride buses or to monitor boarding passengers.

5.3 Vehicle Capacity

Following analysis of the major City Centre bus corridors in the previous sections, the conclusion can be drawn that *the New Network cannot be delivered without high-capacity vehicles*. Projected bus volumes are simply too large to fit in the City Centre without using high-capacity vehicles wherever possible. By 2036, it would be advisable to avoid any routes into the City Centre that do not have patronage to support all day, frequent service on high-capacity vehicles.

Note that double-deckers may increase dwell times and/or additional variability in boarding times at some stops, particularly busier stops and terminals. This will need to be taken into account when considering the capacity of a corridor or stop in terms of buses per hour.

The following table summarises the double-deckers expected in use by 2018. Double deckers would be used on major Isthmus corridors (Mt Eden Road, Manukau Road, Great North Road, Dominion Road, Sandringham Road and New North Road), as well as the Northern Express (NEX 1 and 2) services, Glenfield and Birkenhead to City services, Howick to City service, and Westgate to City services. High-volume single-deckers would be in use on the City and Inner Link services.

While in 2018, double-deckers would only be used for all-day service volumes, by 2026, they would be rolled out to additional peak services as well, as older vehicles are retired and more double-deckers added to the fleet. Double-deckers would also be expanded to the NEX 3, and Remuera Road if a solution is found for the underbridge at Glen Innes, underneath which double deckers would not fit.

Table 16: High Capacity Vehicles on Major Corridors in the 2018 Scenario

Corridor	Peak				All-Day			
	Double-Decker	Single-Decker High Capacity	Single-Decker	Percent High Capacity	Double-Decker	Single-Decker High Capacity	Single Decker	Percent High Capacity
Albert Street	12	-	47	20%	12	-	5	71%
Fanshawe Street (EB AM/WB PM)	50	8	104	35%	50	8	25	70%
Fanshawe Street (WB AM/EB PM)	50	8	71	46%	50	8	25	70%
Karangahape Road*	12	4	37	30%	12	4	15	52%
Wellesley Street (EB AM/WB PM)	38	-	72	35%	38	-	17	69%
Wellesley Street (WB AM/EB PM)	38	-	67	36%	38	-	17	69%
Symonds Street	45	-	75	38%	38	-	8	83%

*Karangahape Road between Pitt Street and Newton Road only (does not include City Link)

In contrast to the double deckers in use on major corridors, it is recommended that high-capacity vehicles are also pursued for the City and Inner Link services, which carry large volumes of passengers. However, as these two routes have much higher passenger turnover rates, and passengers typically travel shorter distances, double deckers do not necessarily make sense. Instead, the Link services could use high-capacity single decker vehicles, such as the Volvo 7900 Hybrid or MAN Lyon's City Hybrid. These buses are characterised by the following:

- Three wider doors to facilitate passenger boardings and alightings, accommodating high passenger turnover and large volumes of people.
- Modified interior space with fewer seats and improved passenger flow, allowing more standees and thus allowing the vehicle to carry more people overall.

An example of the MAN Lion's City Hybrid is shown below. The standard-length Volvo 7900 Hybrid is available in two models, a 10.6 metre, two-axle, low-floor vehicle with three double doors and 27 seats (plus one folded seat) and capacity for up to 90 passengers; and a 12.0 metre, two-axle, low-floor vehicle with 32 seats (plus one folded seat) and capacity for up to 102 passengers. Both Volvo vehicles are 2.55 metres wide and 3.28 metres high.

Opportunities for expansion of high-capacity vehicles include:

- Rollout of high-capacity, single decker vehicles on Link services, where high passenger volumes necessitate capacity enhancements, but high turnover rates preclude use of double deckers.
- All Northern, Northwest and AMETI Busway services.
- Consolidation of peak expresses on the North Shore into additional double decker busway service.
- Replacing the existing fleet with more double deckers as older vehicles are retired, allowing for expansion of double deckers to peak extra services on some routes.

It should be noted that while there are benefits to utilising high-capacity vehicles on frequent services carrying large volumes of passengers, namely (in the case of this study) the reduction in total vehicles required to enter the City Centre, it is not advisable to use high-capacity vehicles on lower frequency routes, as the capacity improvements will not have the same positive impact that frequency improvements would on patronage growth and perceived customer/service levels. It is recommended that double deckers are focussed on those services operating at least as frequent as every 10 minutes for all day service.

6 Conclusions and Recommendations

Review of expected bus volumes in the City Centre upon implementation of the New Network as currently proposed reveals the need to consider trade-offs between services provided and required infrastructure. Anticipated large volumes of buses, particularly from the North Shore, Northwest and Isthmus will be a challenge to accommodate given space constraints in the City Centre, particularly along key bus corridors (e.g., Wellesley Street and Albert Street) and at City Centre bus termini. Key findings and recommendations include:

- Staging for PM peak service is the single biggest constraint on terminal capacity.
- All three City Centre termini are constrained: the planned configuration of the Britomart Bus Terminal is smaller than the existing terminal, development pressures will constrain the amount of space available for a Wynyard Quarter terminal, and limited space near the University for a Learning Quarter terminal.
- Building infrastructure to accommodate peak volumes results in unused facilities throughout most of the day.
- Separating terminal functions, such as passenger loading/unloading, turnaround and recovery/layover into different locations can improve the flexibility of terminal design.
- Capacity constraints exist on Wellesley Street, Albert Street and Karangahape Road due to roadway width, available space for stops, and pedestrian and cyclist requirements.

In order to operate the New Network in the City Centre, the following needs to happen:

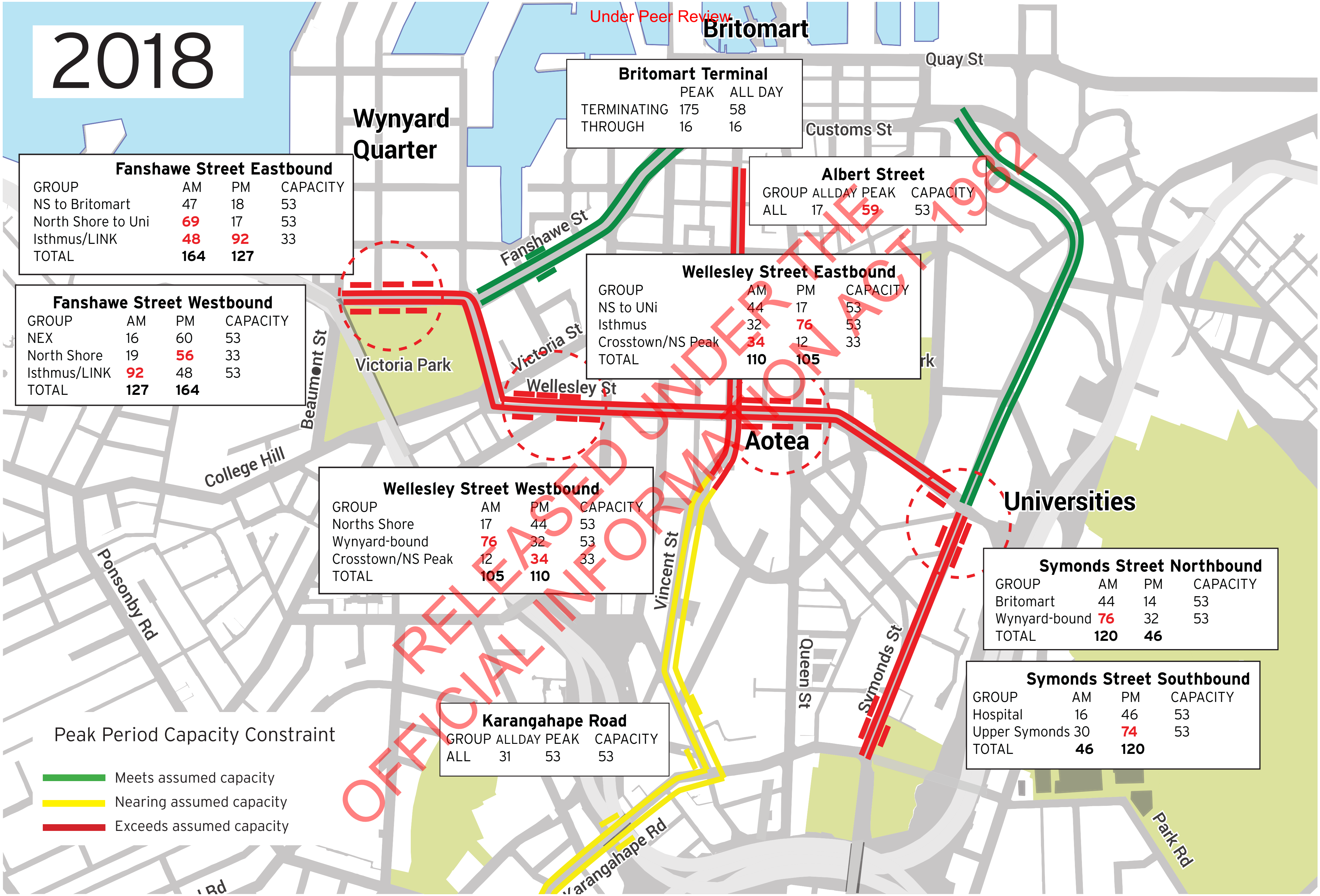
- A turnaround loop needs to be created for Albert Street service at Britomart West. Additionally, NEX and WEX staging areas need to be found. Removal of the Lower Hobson Street Viaduct would assist with these ends.
- Terminal facilities need to be constructed at Wynyard Quarter and Learning Quarter.
- Transfer points need to be designed at Fanshawe Street, Aotea and the University.
- Off-board fare collection needs to be pursued on Albert and Wellesley Streets.
- The use of high-capacity vehicles needs to be expanded, including to Link services.

Appendix A: Bus Volume Maps

Following are maps of the major City Centre corridors, highlighting the projected bus volumes during the peak periods. These maps include:

- 2018;
- 2018 (Victoria Street);
- 2026 (with CRL); and
- 2036 (with CRL).

2018



Britomart Terminal

	PEAK	ALL DAY
TERMINATING	175	58
THROUGH	16	16

Fanshawe Street Eastbound

GROUP	AM	PM	CAPACITY
NS to Britomart	47	18	53
North Shore to Uni	69	17	53
Isthmus/LINK	48	92	33
TOTAL	164	127	

Fanshawe Street Westbound

GROUP	AM	PM	CAPACITY
NEX	16	60	53
North Shore	19	56	33
Isthmus/LINK	92	48	53
TOTAL	127	164	

Albert Street

GROUP	ALLDAY	PEAK	CAPACITY
ALL	17	59	53

Wellesley Street Eastbound

GROUP	AM	PM	CAPACITY
NS to UNi	44	17	53
Isthmus	32	76	53
Crosstown/NS Peak	34	12	33
TOTAL	110	105	

Wellesley Street Westbound

GROUP	AM	PM	CAPACITY
Norths Shore	17	44	53
Wynyard-bound	76	32	53
Crosstown/NS Peak	12	34	33
TOTAL	105	110	

Symonds Street Northbound

GROUP	AM	PM	CAPACITY
Britomart	44	14	53
Wynyard-bound	76	32	53
TOTAL	120	46	

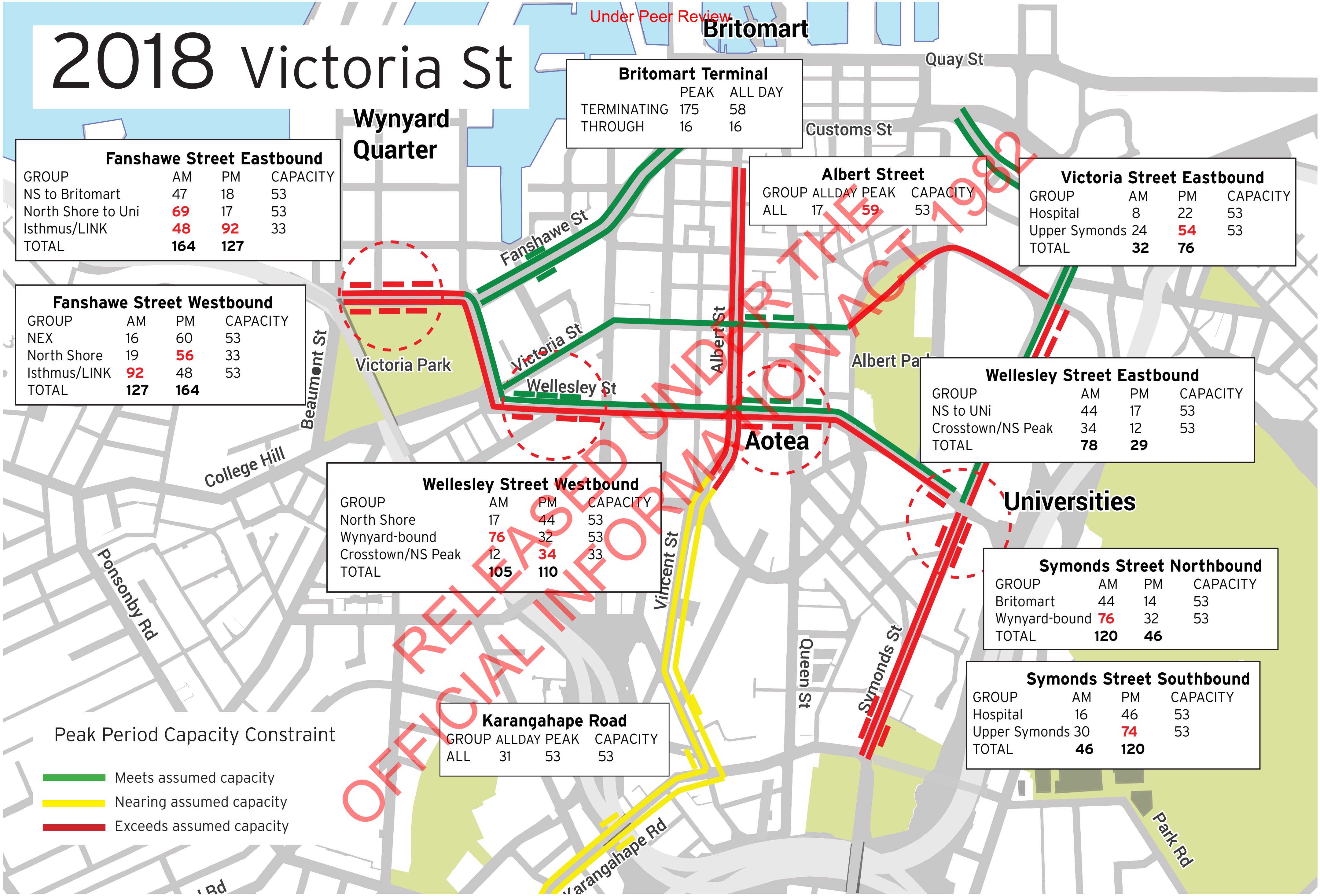
Symonds Street Southbound

GROUP	AM	PM	CAPACITY
Hospital	16	46	53
Upper Symonds	30	74	53
TOTAL	46	120	

Karangahape Road

GROUP	ALLDAY	PEAK	CAPACITY
ALL	31	53	53

2018 Victoria St



Britomart Terminal

	PEAK	ALL DAY
TERMINATING	175	58
THROUGH	16	16

Fanshawe Street Eastbound

GROUP	AM	PM	CAPACITY
NS to Britomart	47	18	53
North Shore to Uni	69	17	53
Isthmus/LINK	48	92	33
TOTAL	**164**	**127**	

Albert Street

GROUP	ALLDAY	PEAK	CAPACITY
ALL	17	59	53

Victoria Street Eastbound

GROUP	AM	PM	CAPACITY
Hospital	8	22	53
Upper Symonds	24	54	53
TOTAL	**32**	**76**	

Fanshawe Street Westbound

GROUP	AM	PM	CAPACITY
NEX	16	60	53
North Shore	19	56	33
Isthmus/LINK	92	48	53
TOTAL	**127**	**164**	

Wellesley Street Eastbound

GROUP	AM	PM	CAPACITY
NS to UNi	44	17	53
Crosstown/NS Peak	34	12	53
TOTAL	**78**	**29**	

Wellesley Street Westbound

GROUP	AM	PM	CAPACITY
North Shore	17	44	53
Wynyard-bound	76	32	53
Crosstown/NS Peak	12	34	33
TOTAL	**105**	**110**	

Symonds Street Northbound

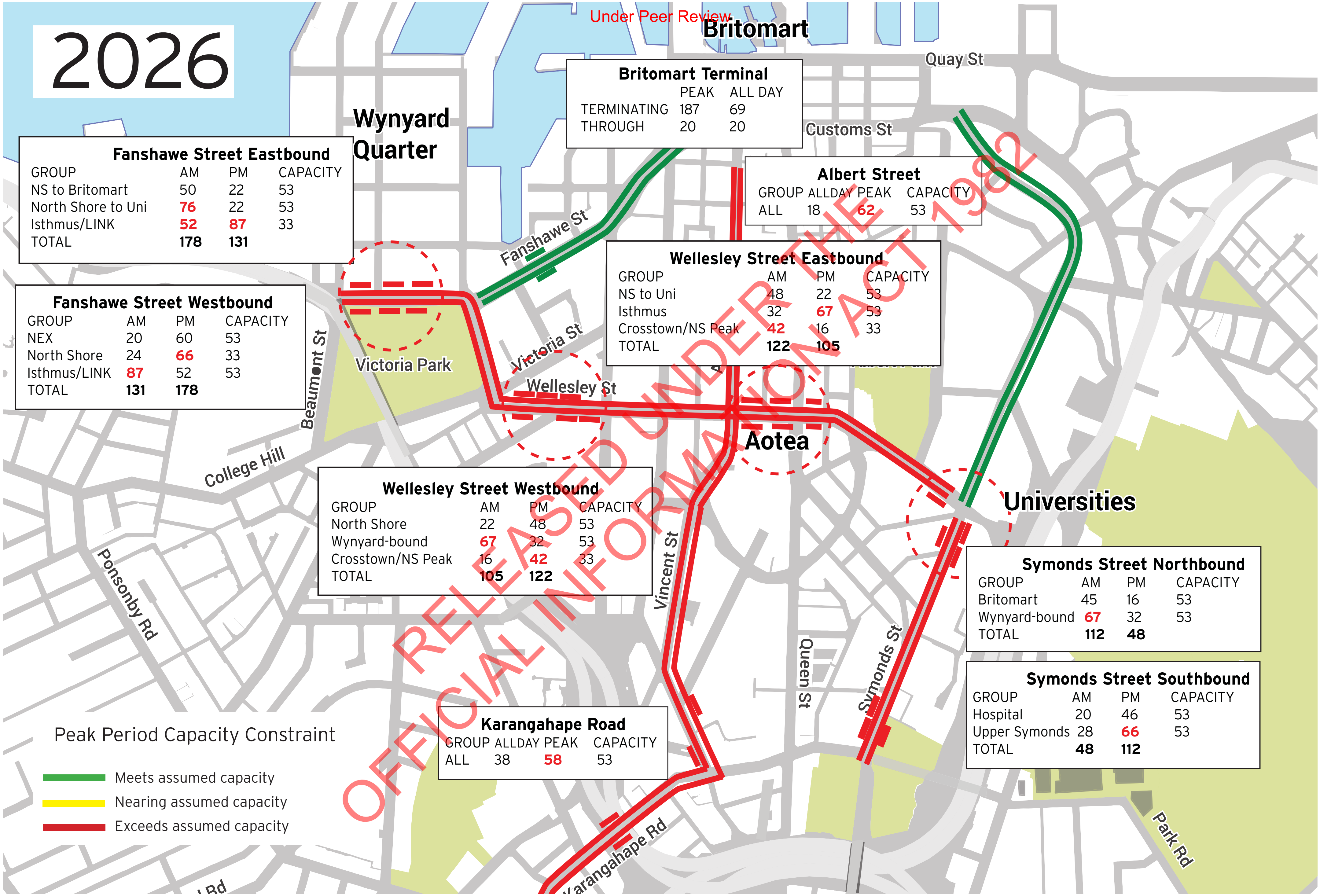
GROUP	AM	PM	CAPACITY
Britomart	44	14	53
Wynyard-bound	76	32	53
TOTAL	**120**	**46**	

Symonds Street Southbound

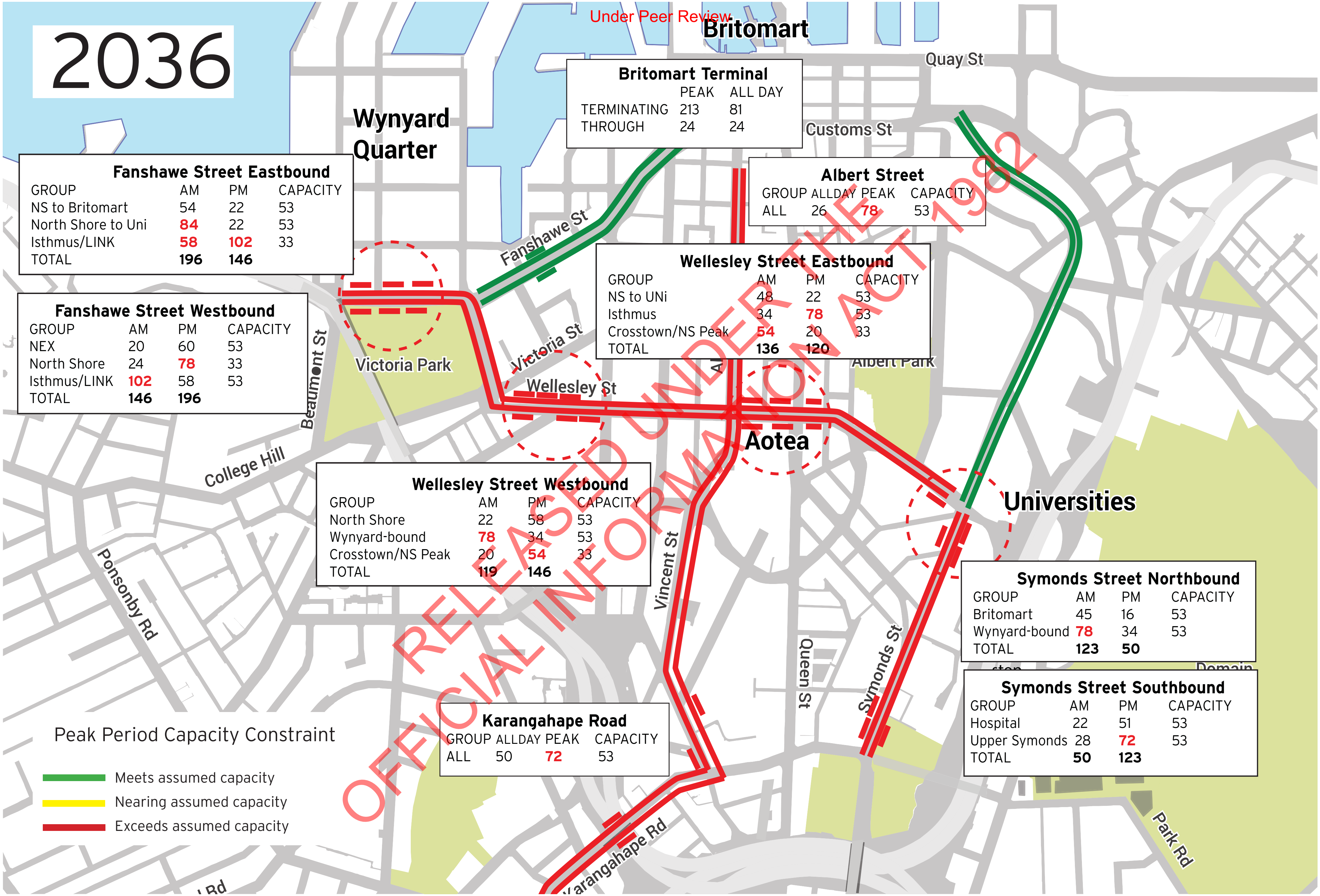
GROUP	AM	PM	CAPACITY
Hospital	16	46	53
Upper Symonds	30	74	53
TOTAL	**46**	**120**	

Karangahape Road

GROUP	ALLDAY	PEAK	CAPACITY
ALL	31	53	53


2026
Britomart
Wynyard Quarter
Britomart Terminal
PEAK ALL DAY
TERMINATING 187 69
THROUGH 20 20
Quay St
Customs St
Fanshawe Street Eastbound
GROUP AM PM CAPACITY
NS to Britomart 50 22 53
North Shore to Uni 76 22 53
Isthmus/LINK 52 87 33
TOTAL 178 131
Albert Street
GROUP ALLDAY PEAK CAPACITY
ALL 18 62 53
Fanshawe St
Wellesley Street Eastbound
GROUP AM PM CAPACITY
NS to Uni 48 22 53
Isthmus 32 67 53
Crosstown/NS Peak 42 16 33
TOTAL 122 105
Fanshawe Street Westbound
GROUP AM PM CAPACITY
NEX 20 60 53
North Shore 24 66 33
Isthmus/LINK 87 52 53
TOTAL 131 178
Victoria Park
Victoria St
Wellesley St
Beaumont St
Aotea
College Hill
Universities
Wellesley Street Westbound
GROUP AM PM CAPACITY
North Shore 22 48 53
Wynyard-bound 67 32 53
Crosstown/NS Peak 16 42 33
TOTAL 105 122
Vincent St
Ponsonby Rd
Symonds Street Northbound
GROUP AM PM CAPACITY
Britomart 45 16 53
Wynyard-bound 67 32 53
TOTAL 112 48
Queen St
Symonds St
Symonds Street Southbound
GROUP AM PM CAPACITY
Hospital 20 46 53
Upper Symonds 28 66 53
TOTAL 48 112
Peak Period Capacity Constraint
Meets assumed capacity
Nearing assumed capacity
Exceeds assumed capacity
Karangahape Road
GROUP ALLDAY PEAK CAPACITY
ALL 38 58 53
Karangahape Rd
Park Rd

2036



Britomart Terminal

	PEAK	ALL DAY
TERMINATING	213	81
THROUGH	24	24

Fanshawe Street Eastbound

GROUP	AM	PM	CAPACITY
NS to Britomart	54	22	53
North Shore to Uni	84	22	53
Isthmus/LINK	58	102	33
TOTAL	**196**	**146**	

Fanshawe Street Westbound

GROUP	AM	PM	CAPACITY
NEX	20	60	53
North Shore	24	78	33
Isthmus/LINK	102	58	53
TOTAL	**146**	**196**	

Albert Street

GROUP	ALLDAY	PEAK	CAPACITY
ALL	26	78	53

Wellesley Street Eastbound

GROUP	AM	PM	CAPACITY
NS to UNi	48	22	53
Isthmus	34	78	53
Crosstown/NS Peak	54	20	33
TOTAL	**136**	**120**	

Wellesley Street Westbound

GROUP	AM	PM	CAPACITY
North Shore	22	58	53
Wynyard-bound	78	34	53
Crosstown/NS Peak	20	54	33
TOTAL	**119**	**146**	

Symonds Street Northbound

GROUP	AM	PM	CAPACITY
Britomart	45	16	53
Wynyard-bound	78	34	53
TOTAL	**123**	**50**	

Symonds Street Southbound

GROUP	AM	PM	CAPACITY
Hospital	22	51	53
Upper Symonds	28	72	53
TOTAL	**50**	**123**	

Karangahape Road

GROUP	ALLDAY	PEAK	CAPACITY
ALL	50	72	53

Appendix B: Maximum Bus Volumes by Corridor/Terminus

The following table summarises the potential configurations at various corridors and termini throughout the City Centre. Each is broken out into the following:

- Initial Concept Design, which shows the bus volumes that could be accommodated given a configuration that maximises urban amenity and minimises negative impacts to surrounding properties; and
- Estimated Capacity of Existing Infrastructure, which shows the maximum number of buses that could be accommodated based on existing geometries and infrastructure (not necessarily what *does* exist today, but what conceivably *could* exist today).

In the case of the termini, the configurations for Britomart East and West are assumed to be as planned (Aurecon report). As there is currently no design (or site) specified for the Wynyard Quarter and Learning Quarter termini, the figures cited reflect smaller and larger options and capacities.

Table 17: Maximum Bus Volumes by Corridor

Corridor or Terminus	Major Constraint	Initial Concept Design		Estimated Capacity of Existing Infrastructure		Expected Bus Volumes	
		Stop Configura-tion	Bus Volume (bph)	Stop Configura-tion	Bus Volume (bph)	Current	Estimated 2018
Corridors							
Albert Street / Pitt Street	Narrow street profile post-CRL	Triple stop	53	Quad stop	74	53	59
Fanshawe Street Eastbound (Victoria Park)	Driveways on north side of street; operational challenges	2 triple stops + double stop	139	9 stops	188	125	164
Fanshawe Street Westbound (Victoria Park)	Turning movements at Beaumont Street and Motorway access	2 triple stops + double stop	139	12 stops	261	110	164
Karangahape Road	Narrow street profile, particularly at Pitt Street	Triple stop	53	Triple stop + double stop	86	48	53
Symonds Street	University stops (Mount St to St Paul St) and right turn from Grafton Bridge immediately into stops	2 triple stops	106	2 quad stops	148	154	120
Wellesley Street	Aotea Station; short block lengths	2 triple stops + double stop	139	4 double stops	132	45	110

*Initial Concept Design assumes 15 metres lead-in, 15 metres per space, nine metres between individual positions and nine metres lead-out; max vehicles assumes 90 percent confidence that all vehicles can be accommodated, with congestion anticipated 10 percent of the time.

In the case of the termini, the configurations for Britomart East and West are assumed to be as planned (Aurecon report). As there is currently no design (or site) specified for the Wynyard Quarter and Learning Quarter termini, the figures cited reflect smaller and larger options and capacities. The "expanded option" would provide larger termini at Wynyard Quarter and Learning Quarter. These are shown in the following table.

Table 18: Maximum Bus Volumes by Terminus

Corridor or Terminus	Major Constraint	Initial Concept Design		Expanded Option		Expected Bus Volumes	
		Stop Configuration	Bus Volume (bph)	Stop Configuration	Bus Volume (bph)	Current	Estimated 2018
Termini							
Britomart East	Narrow streets with short blocks	Three double stops + three layover spaces	72	N/A	N/A	N/A	67
Britomart West (West/ Northwest)	Driveways on Lower Albert Street	Two set-down stops + three single stops + five recovery spaces	74	N/A	N/A	N/A	59
Britomart West (North Shore)	Layover/recovery spaces	Two triple stops + three recovery spaces	77	N/A	N/A	N/A	49
Wynyard Quarter	Development/ limited space and high land values	Triple pickup stop + five layover spaces	53	Double the "best outcome" scenario	106	N/A	88
Learning Quarter	Lack of existing on or off-street space for a terminal	Triple pickup stop + five layover spaces	53	Double the "best outcome" scenario	106	N/A	75

*Assume 5 minutes recovery/staging time per trip, as per PTOM. In addition, two minutes per bus are assumed for drop off/pick up, or 1.5 minutes per bus for just drop-off or just pick-up.

*Current volumes are not relevant as Learning Quarter and Wynyard Quarter terminals do not exist yet, and Britomart will be significantly reconfigured due to local street changes and public space upgrades.

Note the following caveats and assumptions:

- The initial concept designs were developed based on the following New Network design principles:
  - Customers can easily understand where to catch services from. Not just for daily commute but for other purposes.
  - Minimising the need for customers to run long distances if bus stops are too long or parked too far away.
  - Minimising passengers scrambling from one stop to another if they are uncertain whether a bus will pull up.
- The initial concept designs were intended to develop an indication of how stop configurations impact on capacity. The designs will need to be refined, probably compromised as a result of expected bus volumes.
- Detailed assessments would be needed to refine / test these initial assumptions.

- The stop capacity assessments assumed that buses can be accommodated 90% of the time. This means that 10% of the time (2-3 times per hour, peak) there will be congestion, bus overflow.
- While the volumes shown for Fanshawe Street assume all buses would stop on the segment of Fanshawe Street between Halsey and Beaumont Streets, this is demonstrative—some routes (namely those which terminate at Wynyard Quarter) would likely stop on adjacent streets.
- Less busy stop locations would require less infrastructure if not all buses are expected to stop there.
- Theoretically, the Initial Concept Design for Wellesley Street would accommodate expected bus volumes; however, the bus route groupings required to provide legibility for the New Network create a challenge.
- Symonds Street currently functions with two very long stops in each direction. These sometimes result in a great deal of congestion, as well as passenger confusion, as large platoons of buses arrive and depart simultaneously.

The following maps summarise the initial assessment of bus stop capacity based the assumptions listed above. It is important to note that these capacities can be increased with changes to customer legibility and route allocations.

Appendix C: North Shore Peak Bus Occupancy

An analysis of HOP ticketing data (electronic and paper ticketing) was conducted on a selection of existing North Shore routes that are retained or have very similar alignments under the New Network. The period reviewed was the second week of March 2014, a week selected to represent a period of high usage and utilisation.

These routes included the core busway services of the NEX and the 881 (similar to the proposed NEX2/3), and local or express routes from Mairangi Bay (863X), Belmont (802X), Bayview (955), Windy Ridge (953) and Chatswood (971).

Hop data indicates where passengers board and exit each bus, and an analysis calculated the occupancy of each run of each route from the beginning of the route to the terminus in the city. From this, the occupancy distribution of each route across the morning peak was observed, and the average peak loading of the buses on each route was calculated crossing the harbour bridge (i.e. the peak load point approaching the City Centre in the morning peak).

This analysis revealed significant variation in the occupancy of buses arriving in the City Centre from the North Shore in the morning peak.

Trunk Rapid Transit Bus Services

The NEX is generally operated by conventional buses (triple axle, rigid body), except for two high capacity double deckers that operate selected peak runs. The observed average AM peak occupancy of the standard NEX crossing the harbour bridge to the City Centre was 50 passengers per bus, while the average occupancy of the double decker was 102 passengers per bus.

Similarly, the 881 (busway to university and hospital) service is operated by a mix of conventional buses and high capacity articulated buses. The average AM peak occupancy for the standard 881 services was 49 passengers per conventional bus, and 101 passengers per high capacity articulated bus.

Local Suburban and Peak-Only Services

Five routes that run through to the City Centre but largely do not operate one the busway were reviewed. Three of these operate all day, while two are peak-only expresses. All five routes are targeted at specific local suburban catchments, however all can also collect passengers from trunk corridors leading to the motorway and harbour bridge.

The average AM peak inbound occupancy for these suburban buses was 37 passengers per bus crossing the harbour bridge. These are all operated with conventional buses, typically smaller twin axle vehicles.

Summary

Overall, this indicates that conventional buses operating trunk service on the busway at peak times already achieve an average occupancy of 50 passengers per bus, while the variants operated using high capacity vehicles achieve slightly more than 100 passengers per bus.

By comparison, buses serving suburban catchments but providing direct service through to the City Centre only achieved an average occupancy of 37 people per bus inbound in the morning peak.

This indicates that local suburban buses operating across the harbour bridge to the City Centre achieve, on average, 74% of the observed occupancy of conventional busway services, and only 37% of the occupancy of high capacity busway services. In other words, it takes three suburban buses to move the same number of people to the City Centre as one high capacity busway bus, making busway buses three times more space efficient at city termini.

This indicates that, in the context of bus capacity constraints in the City Centre, a network model that avoids routing low-utilisation suburban buses through to the City Centre would be advisable. This suggests an alternative of serving suburban areas with shorter shuttle style services linking to busway stations or major centres, in order to connect to trunk services operated by high occupancy vehicles. A test case was developed simulating the removal of 30 low-utilisation suburban buses from the City Centre across the two hour peak and reallocating these as feeder services. Holding the passenger capacity to the City Centre constant required the addition of 11 high capacity buses on the trunk corridors, resulting in a net reduction of 19 buses across the peak, as well as approximately an 18% reduction in service delivery costs.

Appendix D: Victoria Street Eastbound Corridor

Upon the implementation of the New Network, the Victoria Street corridor is proposed to be used for eastbound Isthmus services. The long term plan is still for these services to use Wellesley Street, however the Wellesley Street busway will not be complete by 2018, and it is uncertain how buses will access Symonds Street from Wellesley Street.

The Victoria Street corridor referred to runs from Halsey Street in the west to Symonds Street in the east, and also includes Bowen Avenue and Waterloo Quadrant.

Table 20: 2018 Bus Volumes on Wellesley and Victoria Street corridors

	Service Grouping	AM	PM	All Day
Westbound	**Wellesley Street**			
	NEX 2	30	8	8
	Takapuna and Hillcrest to University	14	9	9
	North Shore Peak Expresses	25	0	-
	Isthmus	32	76	32
	Crosstown 4 and Pt Chevalier	9	12	6
	TOTAL	110	105	55
	Victoria Street			
	Isthmus	0	0	0
Eastbound	**Wellesley Street**			
	NEX 2	30	8	8
	Takapuna and Hillcrest to University	14	9	9
	North Shore Peak Expresses	25	0	-
	Crosstown 4 and Pt Chevalier	9	12	6
	TOTAL	78	29	23
	Victoria Street			
	Isthmus/Wynyard	32	76	32

The use of a Victoria Street as an alternative corridor reduces pressure on Wellesley Street by removing 76 eastbound buses in the PM peak. However this, is significantly higher than the 32 eastbound buses use that currently use Victoria Street in the peak. This volume of buses would require one triple stop (to handle buses heading to Upper Symonds Street), and one double stop (to handle buses heading to the Hospital and Newmarket). At the key stop between Albert and Queen Streets, there is sufficient on-street space to handle this volume, as there is space for a triple stop and a double stop between Queen and Albert Streets.

Issues and Opportunities

Issue #1: Stop capacity is severely limited at Waterloo Quadrant. The current stop is less than 25 metres long, which is shorter than the ideal infrastructure requirement for a double stop. The current stop already crosses two driveways, and driveways are present every 20 metres which make it undesirable to extend the current stop.

Issue #2: Use of the Victoria Street corridor means 120 buses per hour will be using Symonds Street southbound between Waterloo Quadrant and Wellesley Street. The bus stop along this section is located immediately to the south of Alten Road. This stop is less than 70 metres long and can accommodate two doubles stops, so could only handle up to 66 buses per hour. This stop cannot be extended to the north due to the Alten Road intersection, nor can it be extended to the south due to mature trees along the Symonds Street corridor.

Issue #3: Use of the Victoria Street corridor for eastbound service (only) creates problems regarding customer experience. For example, the use of separate corridors for inbound and outbound routes can cause confusion for customers. Bus networks are more legible when passengers know they can board the bus along the same route from which they alighted. These potential issues are exacerbated because North Shore buses bound for the Learning Quarter and the Crosstown 4 would continue to use Wellesley Street in both directions.

Issue #4: Using the Victoria Street corridor adds travel time and length versus using the Wellesley Street corridor, leading to higher operating costs and passenger dissatisfaction. Buses using this corridor would have to travel 2.0km, rather than 1.3km to use Wellesley Street. The route is also significantly slower, both because of increased length, and lack of bus priority, especially on the eastern end of the route. Bowen Avenue and Alten Road lead to a significant motorway on-ramp for the north-eastern part of the CBD so this area is regularly congested at peak times. There are fewer opportunities for bus priority due to the layout of intersections and competing uses for this corridor.

Issue #5: Use of the Victoria Street corridor limits the opportunities for passengers to connect between major bus services. Legible interchanges are an important part of the New Network concept as they allow people to easily travel from one part of the region to another, and to make discretionary trips that may currently be complicated on public transport. Aotea Station at Wellesley and Albert Streets would be a key interchange where transfers could take place between rail service and two major bus corridors; however routing outbound Isthmus services along Victoria Street removes a key grouping of services from this interchange. Transfers are still possible on Fanshawe Street near Victoria Park and on Symonds Street by Wellesley Street; however, these interchanges will offer a poorer customer experience as due to bus volumes. Further, these interchanges would be spread out of a wider physical space, and may involve grade changes and/or street crossings.

Issue #6: The use of Victoria Street as a key bus corridor conflicts with the strategic vision that Auckland Council and Auckland Transport have espoused for this corridor. The City Centre Masterplan identified Victoria Street as a linear park that would connect Albert Park in the east with Victoria Park and the Wynyard Quarter in the west, providing high quality public spaces in the city. The City Centre East-West Study confirmed that the Linear Park was appropriate, and traffic could be reduced to two low-speed lanes. Victoria Street would also be the major east-west cycleway, and has been identified as one of the City Centre Priority Routes, funded as part of the government-led Urban Cycleways fund. Operating buses (particularly a large volume of buses) in this corridor is incompatible with the vision set out in each of the above plans, as the other uses identified leave no space for bus lanes or the long stops necessary to handle significant volumes of buses at peak times.

Auckland Transport Alignment Project

Demand Management Pricing Report – Evaluation of three representative options

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Preface

This is one of a series of research reports that were prepared as inputs to the Auckland Transport Alignment Project (ATAP). It is one of a number of sources of information that have been considered as part of the project, and which have collectively contributed to the development of the recommended strategic approach. The content of the report may not be fully reflected in the recommended strategic approach, and does not necessarily reflect the views of the individuals involved in ATAP, or the organisations they represent. The material contained in this report should not be construed in any way as policy adopted by any of the ATAP parties.

1. Executive Summary

This report covers the first round Auckland Transport Alignment Project (ATAP) assessment of three representative road pricing options which could potentially be used for the purpose of demand management. The assessment considers the extent to which the options could contribute to the objectives of ATAP. The three options assessed are:

a) A Central Business District (CBD) cordon scheme similar to the option modelled in the Ministry of Transport's Auckland Road Pricing Evaluation Study (2007).
b) A motorway network charge, similar to the option modelled by Auckland Council during recent investigations.[1]
c) A comprehensive network charge applying to all journeys across the network.

The three options were compared to the Auckland Plan Transport Network (APTN) which does not include any time or location based road pricing except a toll on State Highway 1 (SH1) between Orewa and Puhoi.

Based on the initial testing and evaluation, the results indicate that pricing does have the potential to manage demand and improve network performance, compared to the un-priced APTN. This is in line with theoretical expectations, previous research carried out in Auckland and practical experience in other countries.

Of the three schemes, the CBD cordon charge makes the smallest difference from a regional, network wide perspective. However, the scheme performs well at a local level, encouraging a higher mode shift to public transport and reduction in car trips to the CBD.

Using a motorway charge for the purpose of demand management has the potential to cause large scale diversion of motorway traffic onto the local road network, with associated negative effects. In addition, public transport effects are small.

The option modelled, using a flat rate charge, tends to favour long distance motorway trips as the cost per kilometre to the user reduces with distance travelled on the motorway. A variation on this option, based on a per kilometre charge, was also tested. Appendix 3 reports the preliminary results for this variation, which indicates that although a distance based motorway charge is to be preferred over a flat rate charge, this option will still lead to a large displacement of trips onto the arterial network.

The comprehensive network charge has by far the greatest positive impact on the ATAP objectives, particularly for the operation of the network during the peak and for public transport use. The option includes a relatively simplistic charging structure of a fixed rate per kilometre at particular periods of time for trips made in all locations. A next step could include the development and assessment of a more graduated charging structure to mitigate the relatively high net-cost to users arising in non-congested, peripheral parts of the network and where access to employment and other facilities necessitates relatively long journeys.

[1] Subsequent to this assessment an alternative distance based motorway charge was also assessed and the results are summarised in Appendix 3. This assessment tended to confirm the conclusions reached in the assessment of the motorway network charge option.

The key findings from the initial evaluation are shown in the table below:

Table 1: Initial Evaluation Summary

	CBD	**Motorway**	**Network**
Positive Effects	• Performs well at a local level. • Encourages a higher mode shift to public transport and reduction in car trips for trips to the CBD. • Lowest cost scheme	• Has moderate to highly positive influence on regional congestion and accessibility indicators • Strongly positive reduction in proportion of congested travel time for heavy freight	• Substantially positive impact on regional accessibility, congestion and modal split, particularly in the peak and for public transport. • Strongly positive reduction in proportion of congested travel time for heavy freight
Negative Effects	• Small impact on indicators at regional level • Some diversion of traffic to local roads	• Creates negative effects on local roads, as trips divert from the motorway network	• Increased numbers of short distance trips by car
Suggested refinements	• Local mitigation to address increased congestion on outside of boundary e.g. Ponsonby Road • Consider additional CBD public transport capacity	• Develop mitigations for choke points on local roads • Investigate public transport alternatives	• Test a more graduated charging structure • Mitigation package designed to provide viable alternatives to vehicle trips

The Net Benefits to Users and Value for Money results for the three options using the agreed assessment approach are presented below:

Table 2: Results for Revised Assessing Approach for User Benefits and Value for Money (For 2036 in 2016$)

ATAP Objective	Objective description	Key indicator	CBD	Motorway	Network
Best possible value for money	Returns to society as a whole	Benefits and costs (EEM) BCR	2.1	1.3	1.6
Best possible outcomes for users of the transport system	Returns to people and businesses that make trips using the transport system	Generalised costs for system users (time, vehicle operating, safety)	$21.0m	$104.4m	$156.0m
Financial costs of using the transport system deliver net benefits to users of the system	Benefits arising from road charges exceed the financial cost of those charges to road users	1. Change in generalised costs *for those paying road charges* (time, vehicle operating, safety, road charges)	-$63.8m	-$167.1m	-$830.0m
		2. Change in generalised *costs for users of the transport system* charges (time, vehicle operating, safety, road charges)	$21.0m	$104.4m	$156.0m

This assessment approach confirms that the different interpretations of users makes a significant difference to the results. In addition, the treatment of the revenue raised is fundamental to the overall result. Excluding revenue obscures a potentially significant benefit.

Based on the initial analysis, it is recommended that:

- ATAP consider the use of road pricing for demand management in subsequent rounds of evaluation because of its potential contributions to the ATAP objectives;

- The next stage focuses on the development and refinement of the particular option(s) selected for the next round;
- The choice of road pricing scheme would depend on the approach to transport identified for round 2, noting that:
    - A CBD cordon charge would be suitable to encouraging public transport mode shift to the CBD;
    - A motorway network charge would be suitable to assisting the State highway network, and therefore most of the heavy freight network, to operate with less congestion, but other interventions would be needed to address impacts on the local network;
    - A comprehensive network charge would be suitable if widespread and significant changes in access, congestion and public transport mode share are sought across the network.

The next steps in the refinement of the options that could be progressed for further investigation should include:

- Review of the modelling approach
    - Investigating practical ways of incorporating the estimation of a distribution of values of time (e.g. by user groups) into modelling.
- Review of the approach to appraisal
    - Taking account of revenue (above reduction in vehicle operating costs) as a benefit.
    - Including other supporting key performance indicators in the evaluation framework for the next round.
    - This investigation should also consider whether pricing for demand management could reduce the level of investment required in the network to achieve a given level of performance, relative to the APTN.

The proposed way forward, based on the results from the first round of modelling, and taking into consideration the need to optimise the application of the available modelling resources, is to continue with testing of a road pricing option that is appropriate for the approaches to transport to be tested in the second round and to undertake the refinements listed above.

A key implication for package development in the second round that is emerging from the assessment of pricing options, is to analyse the scale of any potential opportunity to either re-prioritise current planned investment, or, reduce overall investment whilst balancing against a desired level of service for the network as a whole.

2. Background

Purpose of the report

The purpose of this report is to set out the development, assess and ultimately the recommendations made on the merits of three representative road pricing options for the purpose of managing demand and improving the operation of Auckland's transport system, as part of ATAP.

Objective of this assessment

The aim is to determine the extent to which the three proposed road pricing options developed for the purpose of demand management could contribute to the objectives of ATAP (relative to the APTN without pricing), and to determine whether road pricing is worthy of further consideration post ATAP.

As part of this, the investigation has also aimed to develop a view on whether pricing for demand management could reduce the level of investment required in the network to achieve a given level of performance, relative to the APTN. This was undertaken through a process of identifying a small number of representative schemes and testing these against the agreed ATAP objectives and the deficiency analysis.

This report summarises the assessment of the three pricing options and recommends that a road pricing option is considered for more detailed assessment in Stage 2. It also identifies useful modifications to the preferred option that might improve its performance against the ATAP objectives.

Limitations of the assessment

Investigating pricing as a revenue raising tool is not an objective of ATAP, but pricing will raise revenue. How this revenue might be used is an important question, as this will have some influence over the net benefit of pricing. However, resolving this question is beyond the scope of this investigation.

This evaluation is indicative at this stage and does not consider a complete range of economic and social impacts, which would be required for a more comprehensive road pricing study.

This evaluation has not considered the effects of optimising the transport network to reflect the demand management effects of a road pricing scheme.

The recommendations of this workstream are not intended to identify an actual pricing scheme for implementation. If the parties agree that road pricing is a useful tool for Auckland, then further work could be undertaken to determine an optimal road pricing scheme.

3. Narrative

3.1. Methodology and options for assessment

The evaluation approach adopted is broad based, using quantitative and qualitative information including:

- Data from the Auckland Regional Transport (ART3) model for all modes.
- Information from previous studies (to inform option development).
- Independent research (to inform the development of option costs).
- Relevant theory (to inform the evaluation of benefits and costs).

The specific intention for this round of the evaluation has been to test whether, at a high level, the pricing options could potentially be an effective tool for influencing traffic demand. This is demonstrated through testing for improved network performance (assessed against the ATAP objectives) relative to the APTN without pricing. Some of the assumptions used are intentionally towards the extreme (e.g. price is set at a relatively high level) in order to attempt to provoke a demand response.

The choice of representative pricing options was guided by a number of factors including:

- The desire for schemes to improve the operation of the transport network through managing demand, rather than maximising revenue.
- The desire to incentivise a change of time/mode of travel rather than removing trips.
- The need to keep schemes relatively simple at this early stage of investigation.
- The need for an assessment of schemes which covers a broad range of scenarios including:
  - small to large geographical/network coverage
  - with and without good public transport alternatives

In light of these considerations, the three pricing options chosen for assessment are intended to represent three different but potentially feasible approaches to pricing (see Appendix 1 for details and note: first round schemes are indicative concepts only and are based on relatively high charges so as to be able to assess the full potential effects of potential charging regimes):

- CBD cordon scheme: A small scale scheme to address issues in an area with high public transport provision and walk cycle options.
- A motorway network charge: Similar to the option modelled by Auckland Council during recent investigations by the Independent Advisory Board (IAB), but using a higher charge to reflect a demand management focus.
- A comprehensive network charge – prices all trips based on the distance travelled.

The extent of the effects of any scheme will depend on the price level. The prices were set at similar levels for each scheme, so that their effects could be comparable.

Some other pricing options considered at a high level by the Working Group but not taken forward for assessment:

Table 3: Options considered and not taken forward

Scheme	Reason for not progressing
Single Cordon:	Likely significant negative equity impacts, based on evidence from previous road pricing assessments in Auckland
Double Cordon	Same as for single cordon
Parking charge	Unlikely to make a significant difference to network performance, based on evidence from previous road pricing assessments in Auckland

3.2. Results of Analysis

The analysis of pricing options is reported at two levels:

- A summary of regional impacts based on the ATAP objectives and indicators.
- A more detailed analysis of:
  - Traffic flows
  - Travel time benefits
  - Access to employment
  - Change in costs and benefits to users
  - Average speeds.

Note: This is an early analysis to test initial responses and identify areas where an initial scheme could be modified to improve performance. It is important to interpret information carefully and recognise that while modelling results provide useful information to inform the decision making process, they are only one input and need to be weighed up carefully against other information.

3.2.1. Summary of Regional Impacts Assessment

The table below provides a summary of the performance of each option against the ATAP objectives.

Table 4: Regional Impacts Summary

Objective	Measure	Headline KPI	Metric	CBD	M/way	Network
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	Jobs accessible by car within a 30-minute trip in the AM peak	Number of jobs	✓	✓✓	✓✓✓
		Jobs accessible by public transport within a 45-minute trip in AM	Number of jobs	□	□	✓

Objective	Measure	Headline KPI	Metric	CBD	M/way	Network
		peak				
		Proportion of jobs accessible to other jobs by car within a 30 minute trip in the interpeak	%		✓	✓
Overall				□	□	✓
Improve congestion results	Impact on general traffic congestion	Per capita annual delay (compared to maximum throughput)	Hours per person	TBC	TBC	TBC
		Proportion of travel time in severe congestion in the AM peak and interpeak	% AM	✓	✓✓	✓✓✓
			% IP		✓✓	✓✓
	Impact on freight and goods (commercial traffic) congestion	Proportion of freight travel time spent in severe congestion (in the AM peak and interpeak)	% AM		✓✓✓	✓✓✓
			% IP		✓✓✓	✓✓✓
	Travel time reliability	Proportion of travel time in severe congestion in the AM peak and interpeak	% AM		✓✓	✓✓✓
			% IP		✓✓	✓✓
			% PM	TBC	TBC	TBC
	Increase vehicle occupancy	Average vehicle occupancy for road vehicles (cars and buses)	Number of people/car and bus AM peak			✓
Overall				□	□	✓✓
Increase public transport mode share	Public transport mode share	Proportion of total trips in the AM peak made by public transport	%			✓✓
	Increase public transport where it impacts on congestion	Proportion of vehicular trips over 9km in the AM peak made by public transport	%	□	✓	✓✓✓
Overall				□	□✓	□✓✓

Objective	Measure	Headline KPI	Metric	CBD	M/way	Networ k
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	Increase in financial cost per trip compared to savings in travel time and vehicle operating cost (Excludes benefit of toll revenue)	$ per trip/(TT+ VOC) - Base Value	-76.1	-193.5	-990.3
Overall				□	□	□
Ensure value for money	Value for money	Package benefits and costs (Net benefit = total benefits (inc toll revenue) – cost)	$ Net Benefit	11.0	25.4	59.0
Overall				□✓	□✓✓	□✓✓

✓✓✓	More than 35% in desirable direction
✓✓	15%-35% in desirable direction
✓	>5-15% in desirable direction
Blank	5% or less

The main finding of the regional impacts assessment is that all three charging options tested have the potential to improve the operation of Auckland's transport system, relative to the un-priced APTN through managing demand, but the scale and nature of effects differs significantly between the three schemes.

In general at network wide level compared to a position with APTN without charges:

- CBD charging has the least impact on regional accessibility, network performance and modal share. Several of the results are still positive, including reductions in AM and interpeak travel in congested conditions, improved access to jobs and increased public transport mode share. The small impact is to be expected due to the small geographical coverage of the CBD scheme.
- Motorway charges have a greater positive impact on regional accessibility and congestion indicators compared with CBD charging, although the impact on modal share is similar to the CBD charge. The negative effects on local roads, arising as a consequence of trips diverting from the motorway network to avoid being charged, are significant.

- Whole of network charging has a substantially more positive impact on regional accessibility (measured in terms of travel times) congestion and modal split, particularly in the peak and for public transport (although with the charges road users would face substantially increased total travel costs). One issue identified is that as currently formulated, this option is forecast to result in increased numbers of short distance trips by car, although this effect is more than counterbalanced by reduction in longer distance car travel and some shift to public transport. This results in a substantial reduction in the total numbers of trips made in the AM peak with some travellers diverted to other time periods and others simply discouraged from travelling

For most indicators the ART3 model is able to provide the outputs required to undertake the assessment of the options against the ATAP objectives. Where gaps exist input from the Evaluation Team will be necessary to complete an assessment against these indicators. However, it is not considered to be likely that completing the analysis for the three indicators where data was not available would materially change the conclusions reached. The assessment of pricing options did not consider the other ATAP KPIs but these will be included in the next stage of the evaluation.

3.2.2. Detailed Impacts Assessment

In order to provide a more informative assessment of performance and support the interpretation of the regional impacts assessment, the analysis against a number of indicators has been extended to a more local level.

Impact on Traffic Flows (AM Peak 2036)

Impacts on traffic flows are assessed to determine the parts of the network where flows will decrease or increase as a consequence of pricing.

- As expected, the impact of CBD charging is mainly focussed on CBD and immediate surrounds. Within the CBD traffic flows are reduced but links just outside the boundary, e.g. Ponsonby Road, experience increased flows.
- Motorway charging generally takes traffic away from the motorways (although very small effect on SH20) but moves substantial volumes on to local road network and increases congestion there.
- Network charging generally removes traffic from both motorways and local roads but with some minor increases on particular links as congestion levels and traffic patterns change.

Average Travel Time Benefits ($ per trip, 2036 AM Peak)

Travel time benefits (report in $s) are assessed for all trips, based on trip origins.

- CBD charging generally creates a small reduction in travel times for most trips, but there are some increases in travel times for trips originating from just outside the CBD cordon, as traffic diverts to avoid charges on CBD trips.

- Motorway charging has large impacts, reducing travel times for trips from further away from the CBD, but this option increases travel times for trips from closer in, primarily due to motorway traffic diverting to the local road network.
- Network charging reduces travel times for all origin zones across the network, as trip volumes are reduced on both motorways and local roads.

Change in Employment Access Car Trips (2036 AM Peak)

Accessibility to employment via a car trip is estimated by assessing the number of jobs accessible by car within a 30-minute trip in the AM peak:

- CBD charging generally has modest positive impact on accessibility to jobs, but it does lead to decreases in accessibility for trips originating close to but outside the CBD cordon, as travel times increase. There is a strong positive impact on the North Shore and in West Auckland, and also in Mangere and central Manukau.
- Motorway charging has significant positive impacts on accessibility to jobs for trips originating from the North Shore and West Auckland, but also leads to the creation of areas where access to employment reduces, due to increased local congestion.
- Network charging gives employment access benefits across almost all of the region with particularly large increases across the North Shore, West Auckland and central Manukau, and no significant reductions in access.

Figure 1 below depicts general access to employment based on the percentage of total jobs accessible via a 30 minute car trip or 45 minute trip using public transport.

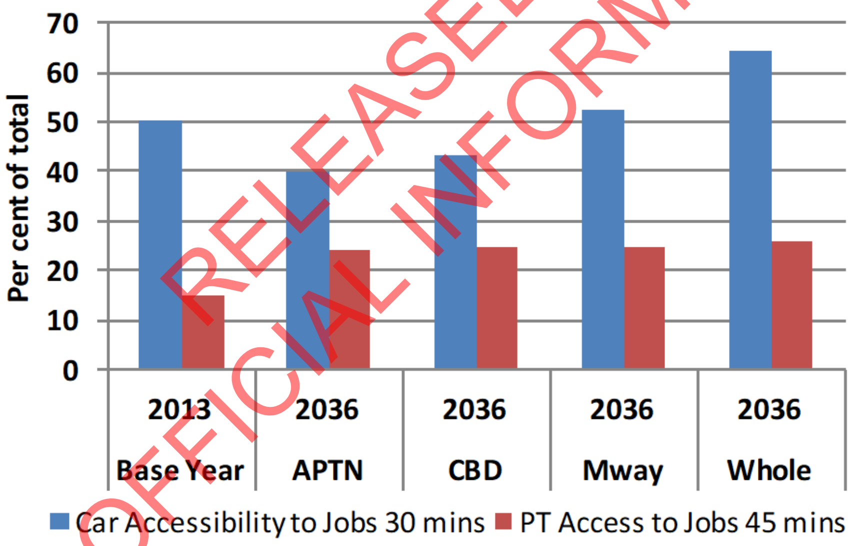

Figure 1: General access to employment

For the un-priced APTN, accessibility by car to employment declines from 2013 to 2036. With charging options accessibility gradually increases and with whole area charging it is significantly higher than 2013. Public transport accessibility increases roughly equally to 2036 for all options, including the un-priced APTN.

Net Benefits to Users – Initial Assessment

ATAP Objective 4 seeks to ensure that “any increases in the financial costs of using the transport system deliver net benefits to users of the system.”
This objective was assessed using ART3 outputs to determine the difference in the generalised cost of travel between the pricing options and the APTN for the 2036 AM peak. The generalised cost of travel combines the time and monetary costs (e.g. vehicle operating costs and pricing for demand management) of a trip into a single monetary measure. The result is an indication of the change in the financial cost per trip compared to the change in travel time and vehicle operating cost. The ‘net benefits to users’ takes no account of the potential benefit associated with any revenue generated.

The approach was adopted for this round of analysis as a practical way of determining the net effect of pricing on remaining road users, arising from the combination of improved network conditions and increased user charges.

The initial results from this assessment indicated that for all three pricing options the benefits to users (road users who continue to drive) are more than offset by the dis-benefits to those who change travel patterns as a consequence of pricing and by the cost of the charge to remaining users. The CBD Cordon has the smallest negative impact on benefits to users ($-76m in 2036) and the Network Charge the greatest (-$990.3m in 2036).

Table 5: Annual Net Benefit to Users for 2003 (2015$m)

	CBD Cordon	Motorway	Network
User Benefit from time and vehicle operating cost savings	35.3	130.7	316.2
Dis-benefit from trips discouraged by charging who have to divert to a less desirable alternative	-14.3	-26.4	-160.3
Net User Impact before charges on continuing users	21.0	104.4	156.0
Charging Revenue (User cost)	97.0	297.9	1146.2
Annual Net Benefits to Users	**-76.1**	**-193.5**	**-990.3**

However, on reflection this result raised a number of questions in relation to Objective 4 including:

- Ensuring net benefits to users could be argued to be an appropriate objective for a toll scheme, but is this actually an appropriate objective for a pricing scheme intended to manage demand?
- Is there a fundamental difference between road pricing to manage demand and road tolling to fund a network improvement?

A pricing scheme to manage demand is an example of using a corrective tax to increase price and reduce consumption in a situation where marginal social cost exceeds marginal private cost due to the presence of negative externalities e.g. congestion (See Appendix 2).

This is fundamentally different to the rationale underpinning a toll (revenue) scheme, where a user is asked to pay a toll in return for a travel time or reliability benefit, whilst those who choose not to pay are provided with a 'free' alternative route. Here it is clearly important for user benefits to exceed user costs, otherwise there would be no revenue.

Therefore, an important finding is not that the net costs to users exceed the benefits for all schemes, but that this result is, in fact, the most likely outcome where road pricing is being contemplated for demand management.

Value for Money – Initial Assessment

This assessment includes revenue within the benefits. The initial results are shown in the following table.

Table 6: Value for Money for 2036 (2015$m)

	CBD Cordon	**Motorway**	**Network**
User Benefit from time and vehicle operating cost savings	35.3	130.7	316.2
Dis-benefit from trips discouraged by charging who have to divert to a less desirable alternative	-14.3	-26.4	-160.3
Net User Impact before charges on continuing users	21.0	104.4	156.0
Charging Revenue	97.0	297.9	1146.2
User Impact Including charge	**-76.1**	**-193.5**	**-990.3**
Overall Benefit	**21.0**	**104.4**	**156.0**
Annual Opex	10	79	97
Surplus After Opex	**11**	**25**	**59**
Ratio of Annual Benefit (2036) to Annual Cost	2.1	1.3	1.6

These highlight:

- The benefits to users from reduced travel times and vehicle operating costs as levels of congestion are reduced.
- The dis-benefits to those users who with the toll either divert to less desirable uncharged alternatives or who cease to travel altogether.
- The combination of these first two elements which gives the net user impacts before the effects of pricing on those prepared to pay is assessed.
- The revenue generated. The way in which this additional revenue to the public sector is treated is not considered here.

Taking these factors into account, the key points that emerge from the analysis are:

- Overall welfare is improved under all three options, with the benefits from time and vehicle operating cost savings combined with revenue more than offsetting the loss of benefit to users who pay or switch to less attractive alternatives.
- The Network scheme generates the most benefit and the CBD scheme generates the lowest benefit.

As with Net Benefits to Users, this indicator is easier to interpret in conjunction with an understanding of the economics of road pricing[2]

Revised assessment of Net Benefits to Users and Value for Money

The initial assessment of Net Benefits to Users and Value for Money generated significant debate at the Working Group around the interpretation and way in which the options should be assessed for these two objectives.

For example, we can either look at "users" narrowly, as the group of road users that pay the charge; or more broadly, as the users of "the system": not only those that directly pay, but presumably also others who derive some benefit or experience the costs from the fact that the charging system is in place (eg congestion due to traffic diversion). As the ATAP objective refers to "users of the system". It would seem reasonable to accept the broader definition, although there will also be some interest in understanding the impacts on those who pay.

Another consideration is the understanding of what is meant by "net benefits". In the case of pricing, the treatment of revenue is an important factor. If the revenue is hypothecated to transport and spent in the general area (or part of the network) from which it is collected, then it seems reasonable to treat this as a benefit. This is consistent with the approach outlined by Goodwin (1997) for assessing the benefits of pricing for demand management.[3] Similarly, if the charging system enabled other transport charges (e.g. Fuel Excise Duty, Road User Charges, property rates) to be reduced or removed, then again, the "benefits" of this need to be taken into account.

As a result of this discussion, the following assessment framework was developed by the Working Group (see Appendix 4 for detail).

The results for the three options using the revised assessment approach are presented below:

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[2] See Appendix 2 for a discussion on the ART model and the economics of road pricing.

[3] Goodwin, P B (1997), Ibid.

Table 7: Results for Revised Assessing Approach for User Benefits and Value for Money (For 2036 in 2016$s)

ATAP Objective	Objective description	Key indicator	CBD	Motorway	Network
Best possible value for money	Returns to society (NZ Inc) as a whole	Benefits and costs (EEM) BCR	2.1	1.3	1.6
Financial costs of using the transport system deliver net benefits to users of the system	Benefits arising from road charges exceed the financial cost of those charges to road users	1. Change in generalised costs *for those paying road charges* (time, vehicle operating, safety, road charges)	-$63.8m	-$167.1m	-$830.0m
		2. Change in generalised costs *for users of the transport system* (time, vehicle operating, safety, road charges)	$21.0m	$104.4m	$156.0m

Caveat to the assessment of net benefit to users and value for money

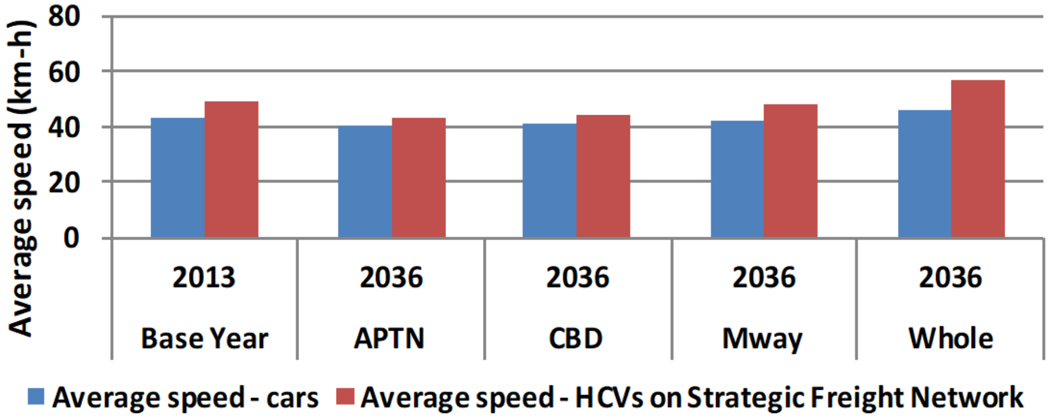
It is also important to be aware that the modelling carried out to date has applied a standard (equity) value of time to all trips. NZTA's Economic Evaluation Manual (EEM) generally requires the use of an "equity value of time" (EEM p4-117) for economic assessments and the ART3 model adopts this approach. However, in relation to the assessment of tolling schemes the EEM guidance states that an "equity value of time will substantially over-estimate the perceived dis-benefits of tolling." The assessment of toll schemes in NZ (e.g. Tauranga Eastern Link) has also confirmed that an equity value of time will underestimate the benefits to remaining users. The same would be true of a pricing scheme for demand management, suggesting that the estimated net benefits to users and value for money is understated in this round of the assessment.

If further analysis of the scenarios is to be undertaken it is recommended that consideration be given to the potential for the estimation of differing distributions of values of time, however, this is technically demanding within the ART3 model.

Average Speeds

With the unpriced APTN, average speeds in the 2036 AM peak are below the 2013 level. The CBD Charge and Motorway Charging options lead to an increase in speed over the unpriced APTN but still result in a slower speed in 2036 than 2013. Motorway Charging has more impact on average speeds than CBD charging. Whole Network charging has a more significant impact and results in speeds in 2036 which are faster than in 2013.

Figure 2: Average speeds AM peak.

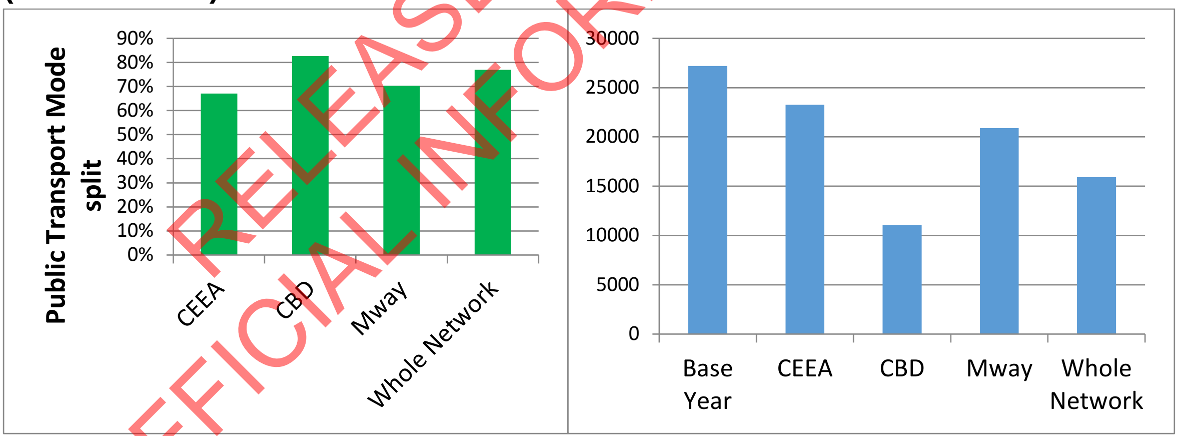


3.3. Summary of Results

3.3.1. CBD Cordon

Of the three schemes, the CBD cordon charge is the lowest scoring option from a regional, network wide perspective. However, the scheme performs particularly well at a local level, encouraging a higher mode shift to public transport and a corresponding reduction in car trips to the CBD.

Figure 3:
Public Transport Mode Split into CBD (2036 AM Peak) **Car Trips into CBD AM Peak**



3.3.2. Motorway Charge

A key observation from the analysis is that trying to achieve traffic demand management objectives using a motorway charge is likely to result in large scale diversion of motorway traffic onto the local road network, with associated negative effects. In addition, public transport effects are small.

The option modelled, using a flat rate charge, tends to favour long distance motorway trips as the cost per km to the user reduces with distance travelled on motorway. A variation on this option, based on a per kilometre charge, was also tested. Appendix 3 reports the preliminary results for this variation, which indicates that although a distance based motorway charge is to be preferred over a flat rate charge, this option will still lead to a large displacement of trips onto the arterial network.

3.3.3. Network Charge

The whole of network charge has by far the greatest positive impact on the objectives, particularly for the operation of the network during the peak and for public transport use. The option modelled includes a relatively simplistic charging structure and a next step could include the development and assessment of a more graduated charging structure, to mitigate the relatively high net-cost to users arising in non-congested, peripheral parts of the network.

4. Conclusions and Recommendations

4.1. Conclusions

4.1.1. Will pricing lead to an improvement in the performance of the transport network?

The first key question is whether road pricing for demand management will lead to an improvement in the performance of the transport network, relative to the APTN without pricing?

Based on the initial testing and evaluation, the results indicate that pricing does have the potential to manage demand and improve network performance, compared to the un-priced APTN. This is in line with theoretical expectations, previous research carried out in Auckland and practical experience in other countries.

4.1.2. Are the merits of road pricing sufficient to include as part of the findings of ATAP?

The second question is whether the merits of road pricing, for the purpose of managing demand, are sufficient to include this as a recommended intervention as part of the findings of ATAP.

At this point in the process, based on the generally positive results observed, but noting the issues raised, it is recommended that ATAP continue with the assessment of pricing for demand management. It is recommended that the next stage focuses on the development and refinement of a road pricing option that is suitable for the approaches to transport that are to be tested in the second round.

The next steps in the refinement of the options that could be progressed for further investigation will include:

- Modelling a more graduated network charge to mitigate user cost in non-congested parts of the network.
- Investigating practical ways of incorporating the estimation of a distribution of values of time (e.g. by user groups) into modelling.
- Taking account of revenue (above reduction in Vehicle Operating Costs) as a benefit.
- Including other supporting KPIs in evaluation framework for next round (e.g. safety), although may not be an important differentiator for pricing.
- This investigation should also consider whether pricing for demand management could reduce the level of investment required in the network to achieve a given level of performance, relative to the APTN.
- Modelling using Auckland Public Transport (APT) will need to use the crowding function to ensure that public transport capacity requirements are clearly identified.

4.1.3. Could pricing reduce the level of investment required in the network?

The investigation is also expected to develop a view on whether pricing for demand management could reduce the level of investment required in the network to achieve a given level of performance, relative to the APTN.

The initial testing indicates that this is likely to be the case, and supports the view that pricing for demand management provides an opportunity to move towards planning and providing the additional transport capacity required to meet a planned level of traffic demand.

4.2. Recommendations

Based on the results to date and taking into consideration the need to optimise the use of the available modelling resources, it is recommended that:

- ATAP consider the use of road pricing for demand management in subsequent rounds of evaluation because of its potential contributions to the ATAP objectives;
- The next stage focuses on the development and refinement of the particular option(s) selected for the next round;
- The choice of road pricing scheme would depend on the approach to transport identified for round 2, noting that:
    - A CBD cordon charge would be suitable to encouraging public transport mode shift to the CBD;
    - A motorway network charge would be suitable to assisting the State highway network and therefore most of the heavy freight network, to operate with less congestion, but other interventions would be needed to address impacts on the local network;
    - A whole of network charge would be suitable if widespread and significant changes in access, congestion and public transport mode share are sought across the network.

4.3. Implications for other workstreams

A key implication for package development in the second round that is emerging from the assessment of pricing options is to analyse the scale of any potential opportunity to either re-prioritise current planned investment, or reduce overall investment whilst balancing against a desired level of service for the network as a whole.

Appendix 1 Pricing Scheme Options

The key characteristics of each scheme are (note: first round schemes are indicative concepts only):

CBD Cordon

Concept / rationale

- Small geographical area,
- Good public transport and active mode alternatives

Scheme characteristics

- Cordon is inside the motorway corridor
- Charge is as close as possible to the point where vehicles enter CBD
- Not intended to capture through-trips on motorways
- Charges (2015 $s)
  - $10 AM Peak Inbound
  - $2.50 interpeak, PM Peak Inbound
- Relatively high charge to stimulate a demand response

Motorway Charge

Concept / rationale

- Represents a feasible larger-scale scheme with wide geographical coverage
- Captures a high volume of trips using a relatively short section of the regional roading network
- Also reflects recent proposal investigated by Auckland Council, but with charges increased to reflect TDM intent rather than revenue raising

Scheme characteristics

- Modelled in the same way as the IAB proposal.
- Single charge for each motorway trip
- Covers all of motorway network
- Charges (2015$s)
  - $5 AM/PM Peak
  - $1.25 interpeak
- Charge significantly higher than IAB scheme ($2) as purpose of this investigation is to test demand response. IAB scheme was focused on revenue raising and adopted lowest charge required to meet the revenue target.

Network Charge

Concept / rationale

- Represents a possible future scheme which allowed for full network coverage
- Captures all vehicle trips across regional network

Scheme characteristics

- Applies to whole region
- Per kilometre charge
- Charges (2015 $s)
  - 44 cents/km AM/PM Peak
  - 12 cents/km interpeak
  - partly offset by 6c/km reduction in VOC (RUC and FED).

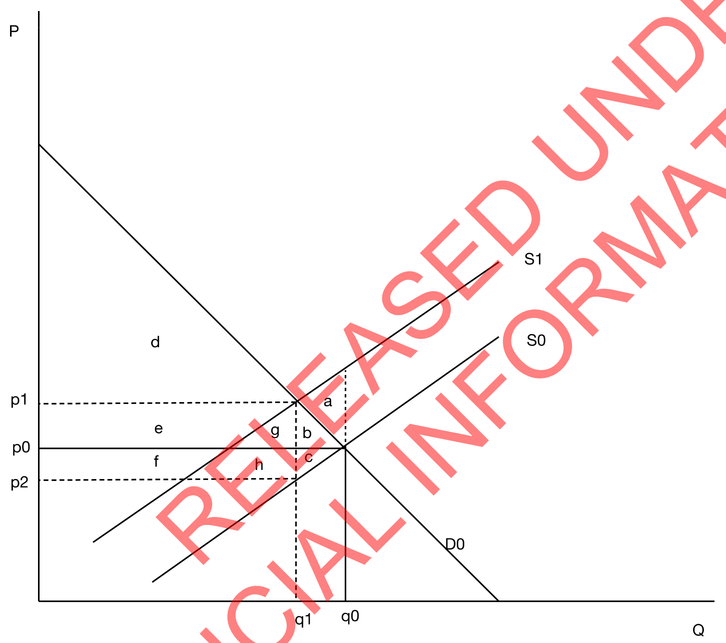
Appendix 2: Economic Aspects of Modelling Road Pricing

ATAP is assessing pricing options to manage demand and improve the operation of the transport network.

Pricing to correct for external costs

Currently, the costs faced by road users do not always fully reflect the resource costs associated with road use. For example, when travelling on a congested network individuals impose a time cost on others but do not take account of this cost when deciding whether to travel or not. In this situation the imposition of a corrective tax (pricing) can lead to an improvement in social welfare.
In economic terms the intersection of the supply (or marginal private cost) curve (S0) and demand curve (D0) shown on Figure 1 will not represent an efficient optimum from society's perspective when external costs are present. The efficiency loss to society is depicted by area a in Figure 4.

Figure 4: Tolling to correct for external costs.



Following the imposition of a toll (value p1-p2) and assuming the toll is efficient (e.g. it corrects for external costs not reflected in time cost to the individual[4]) then the following gains and losses can be observed:

- Reduction in deadweight loss to society = **a**
- Gain to government from toll revenue = **e + f + g + h**
- Gain to remaining road users from time saving = **f + h**
- Loss to remaining road users (toll payment) = **e + f + g + h**
- Loss to suppressed users for trips not made = **b**

The aggregate effects are:

[4] This is assumed to simplify the analysis. The toll level adopted for ATAP analysis is intended to correct for externalities but at this stage of investigation could be above or below the optimal price.

- Government gains **e + f + g + h**
- Remaining road users lose **e + g** **((e + f + g + h) – (f + h))**
- Suppressed users lose **b**
- Net change in overall welfare is **gain (f + h) – loss (b)**
- The net change in overall welfare is equivalent to area **a** the deadweight loss to society

An important observation from this analysis is that individual road users can potentially be made worse off whilst society is made better off following the imposition of a toll. Therefore, from a welfare perspective it is important to ensure that the economic analysis of pricing options (including ART model outputs) captures the full range of impacts (including the benefit of the revenue raised and external costs avoided).

A further complexity to bear in mind is that agglomeration effects are a positive externality and are positively related to accessibility. Pricing will increase the cost of accessing a given location thereby reducing accessibility. Where agglomeration effects are present (e.g. in Auckland) then the optimal price will need to reflect both the negative and positive externalities of road use.

To address these considerations it will be important to:

a) Include the user charge within the user benefits,
b) Include time savings and vehicle operating cost savings within the user benefits,
c) Include the lost surplus from suppressed trips within the user benefits
d) Ensure external cost reductions to non-users are recognised.
e) Take account of the positive externality of agglomeration.
f) Include the net revenue raised within the public costs and revenues.

The net effect to society can be calculated as follows:

Table 8: Losses and Gains from Pricing

Travel Time Benefits	Gain
Impact of Supressed Trips	Loss
User Charges	Loss
Environmental Benefits	Gain
Safety	Gain
Agglomeration Effects	Loss
Consumer Surplus	**= A**
Public Revenue and Costs	
User Charge	Gain
Operating Cost	Loss
Increased Public Transport Fares	Gain
Additional Public Transport Costs	Loss
Decreased Road User Revenue	Loss
Net Revenue	**= B**
Overall	**=A+B**

A final observation is that in the presence of externalities this analytical framework is enquiring into the optimal price to charge to road users. The fundamental premise of the analysis is that in the presence of external costs a corrective tax has the potential to lead to an improvement in overall welfare.

The Correct Value of Time to Apply to Pricing Scenarios

The EEM generally requires the use of an “equity value of time” (EEM p4-117). This is both a simplifying assumption and it avoids favouring road schemes used by higher income groups. The ATAP modelling is consistent with this approach and has relied on the use of an equity value of time.

However, in relation to the assessment of tolling schemes the EEM guidance states that an “equity value of time will substantially over-estimate the perceived dis-benefits of tolling.” The technical interpretation is that using an equity value of time will result in the area of loss to supressed users (area b in Figure 1) being significantly larger than would be the case in reality.

The use of specific values of time for unique users groups in the assessment of toll schemes in NZ (e.g. Tauranga Eastern Link) has also confirmed that an equity value of time will underestimate the benefits to remaining users, who have an above average value of time.

Therefore, it is suggested that consideration be given to the potential for the estimation of a distribution of values of time, (e.g. for disaggregated user groups) in order to avoid overestimating the dis-benefits to supressed users and underestimating of the benefits to remaining users from pricing.

Appendix 3: Motorway Distance Charge

Subsequent to the initial options assessment, and in response to the observed characteristics of the motorway network charge (MAC) an alternative distance based motorway charge was developed for assessment. Two options were examined, both based on a rate of 40c/km for peak travel and alternatives of either 30 c/km or 10c/km for interpeak travel. To ensure comparability with earlier work the analysis was undertaken for 2036 only.

The results of this assessment, including comparison with the initial MAC option are summarised in the table below:

Table 9: Alternative Distance Based Motorway Charge

MDC Option 1: 40c/km PK/10c/km IP	• Slightly worse network performance in terms of speeds than MAC for both peak and interpeak • Substantial switch of traffic away from motorways but impacts on other roads limited • Peak car accessibility slightly better for both travel time and generalised cost measures • Largely positive travel time benefits in both peak and interpeak in urban areas although some disbenefits to far north
MDC Option 2: 40c/km PK/30c/km IP	• Significantly worse network performance in interpeak than 40/10 and MAC and also APTN • Travel time benefits in interpeak largely negative across much of region • Substantial switch in interpeak from motorways onto other road types which may be slower or more congested

In terms of comparing the overall performance, both options are finely balanced. Option 1 (MDC 40/10) has worse network performance but higher benefits and higher accessibility compared to Option 2 (MDC40/30). Option 2 leads to poor performance in interpeak which suggests that a 30 c/km differential between peak and interpeak is too high. The results for Option 1 tend to suggest that a differential of around 10c/km is more reasonable.

Overall, this assessment tends to indicate that a distance based charge motorway charge is to be preferred over a flat rate charge. However, the assessment has also tended to confirm the main conclusions reached in the assessment of the motorway network charge option, that using pricing for demand management on just the motorway network will lead to a large displacement of trips onto the arterial network.

Appendix 4: Revised Approach to Assessing User Benefits and Value for Money

ATAP Objective	Objective description	Key indicator	Example (Motorway charging)	Example (Motorway widening)	Example (Busway)
Best possible value for money	Returns to society (NZ Inc) as a whole	Benefits and costs (EEM)	The full range of benefit and costs arising from a motorway charging scheme	The full range of benefit and costs arising from a motorway widening	The full range of benefit and costs arising from the busway
Financial costs of using the transport system deliver net benefits to users of the system	Benefits arising from road charges exceed the financial cost of those charges to road users	1. Change in generalised costs *for those paying road charges* (time, vehicle operating, safety, road charges)	The change in benefits and costs to motorway users who pay the charges	Not applicable	Not applicable
		2. Change in generalised costs *for users of the transport system* charges (time, vehicle operating, safety, road charges)	The change in benefits and costs to all transport system users, including those who use the motorway and those who don't	Not applicable	Not applicable

Auckland Transport Alignment Project

Evaluation Report

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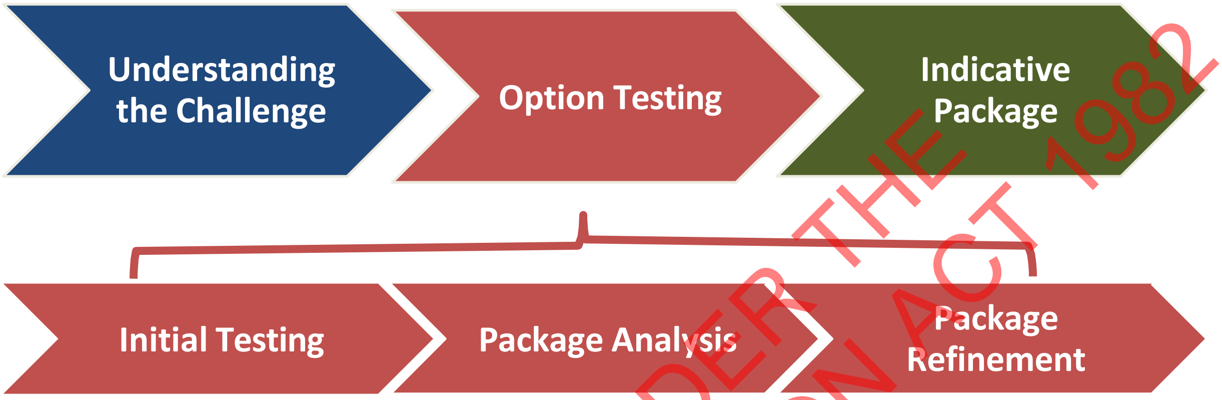
Preface

This is one of a series of research reports that were prepared as inputs to the Auckland Transport Alignment Project (ATAP). It is one of a number of sources of information that have been considered as part of the project, and which have collectively contributed to the development of the recommended strategic approach. The content of the report may not be fully reflected in the recommended strategic approach, and does not necessarily reflect the views of the individuals involved in ATAP, or the organisations they represent. The material contained in this report should not be construed in any way as policy adopted by any of the ATAP parties.

Introduction

i. Purpose of Report

The purpose of the Evaluation Report is to present the results obtained from the testing of the transport packages and tools that were prepared to achieve the objectives of the Auckland Transport Alignment Project ("the project"). In total three phases of assessment were undertaken:



- **Phase 1 (Understanding the Challenge)** comprises the evaluation of the Auckland Plan Transport Network (APTN).
- **Phase 2 (Option Testing)** comprises three main stages of analysis to progressively refine the intervention packages:
  - **Initial Testing** examined a wide range of interventions to compare performance against the project objectives.
  - **Package Analysis** took the best performing interventions and tested the effect of changing the mix of investment and the potential from new technology and moving to smarter pricing.
  - **Package Refinement** compared increasing investment with a pricing focused approach.
- **Phase 3 (Indicative Package)** comprises the development of the strategic approach outlined in The Recommended Strategic Approach and is informed by the three stages of option testing.

ii. Project Objectives

The project's terms of reference highlight that its focus is on whether better returns from transport investment can be achieved in the median and long-term, particularly in relation to the following objectives:

i. To support economic growth and increased productivity by ensuring **access to employment/labour** improves relative to current levels as Auckland's population grows

ii. To improve **congestion** results, relative to predicted levels, in particular travel time and reliability, in the peak period and to ensure congestion does not become widespread during working hours

iii. To improve **public transport's mode share**, relative to predicted results, where it will address congestion

iv. To ensure any increases in the financial costs of using the transport system deliver **net benefits to users** of the system

iii. Project Deliverables

Analysis included in this report provided evidence for the following deliverables.

The Foundation Report

The Foundation Report was published in February 2016. It summarises work undertaken in Phase 1 of the analysis. Within the Foundation Report is a more detailed assessment of the Auckland Plan Transport Network against the project objectives.

The Interim Findings Report

The Interim Findings Report was published in June 2016. It summarises work undertaken in Phase 2 of the analysis. Specifically, it provides initial advice reporting on the testing and evaluation of the broad intervention packages and seeks feedback to inform the next deliverable.

The Final Report

The Final Report was published in September 2016. It summarises work undertaken in Phase 3 of the analysis. Specifically, it details the best performing intervention packages, a preferred strategic approach and recommendations including necessary changes to achieve implementation.

iv. Evaluation Framework

An evaluation framework outlined in the Foundation Report was developed to test how the Auckland Plan Transport Network performs against the project objectives. This framework is also used to test how the different packages that are developed in the subsequent phases of the project perform against the project objectives, an overall requirement to achieve value for money, and other key outcomes. For further information on the evaluation framework, refer to Appendix A.

For each objective, measures and key performance indicators (KPIs) have been developed to enable evaluation. For each measure there are headline KPIs that will be reported on and secondary KPIs that will primarily be used for analysis but may be reported on where they significantly add value to informing key decisions and trade-offs.

The headline measures and KPIs are shown in the table below.

Objective	Measure	Headline KPI
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30 minute trip in the AM peak • Jobs accessible by public transport within a 45 minute trip in the AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak
	Impact on freight and goods (commercial traffic) congestion	• Proportion of business and freight trips spent in severe congestion in the AM peak and inter-peak
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, inter-peak and PM peak
Increase public transport mode share	Public transport mode share Increase public transport where it impacts on congestion	• Proportion of vehicular trips in the AM peak made by public transport • Proportion of vehicular trips over 9 km in the AM peak made by public transport
	Increase vehicle occupancy	• Average vehicle occupancy
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost
Ensure value for money	Value for money	• Package benefits and costs

In addition to the project objectives, a number of other key outcomes have been evaluated through the evaluation framework in the table below.

Other Key Outcomes	Measure	Headline Key Performance Indicator
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled
	Emissions	• Greenhouse gas emissions
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog

Other Key Outcomes	Measure	Headline Key Performance Indicator
Social inclusion and equity	Impacts on geographical areas	• Access employment in high deprivation areas • Distribution of impacts (costs and benefits) by area
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network

Where quantitative information is available, it has been used to undertake assessments of the identified measures. Where quantitative information is not available, qualitative assessments have been undertaken.

v. Evaluation Tools

Background

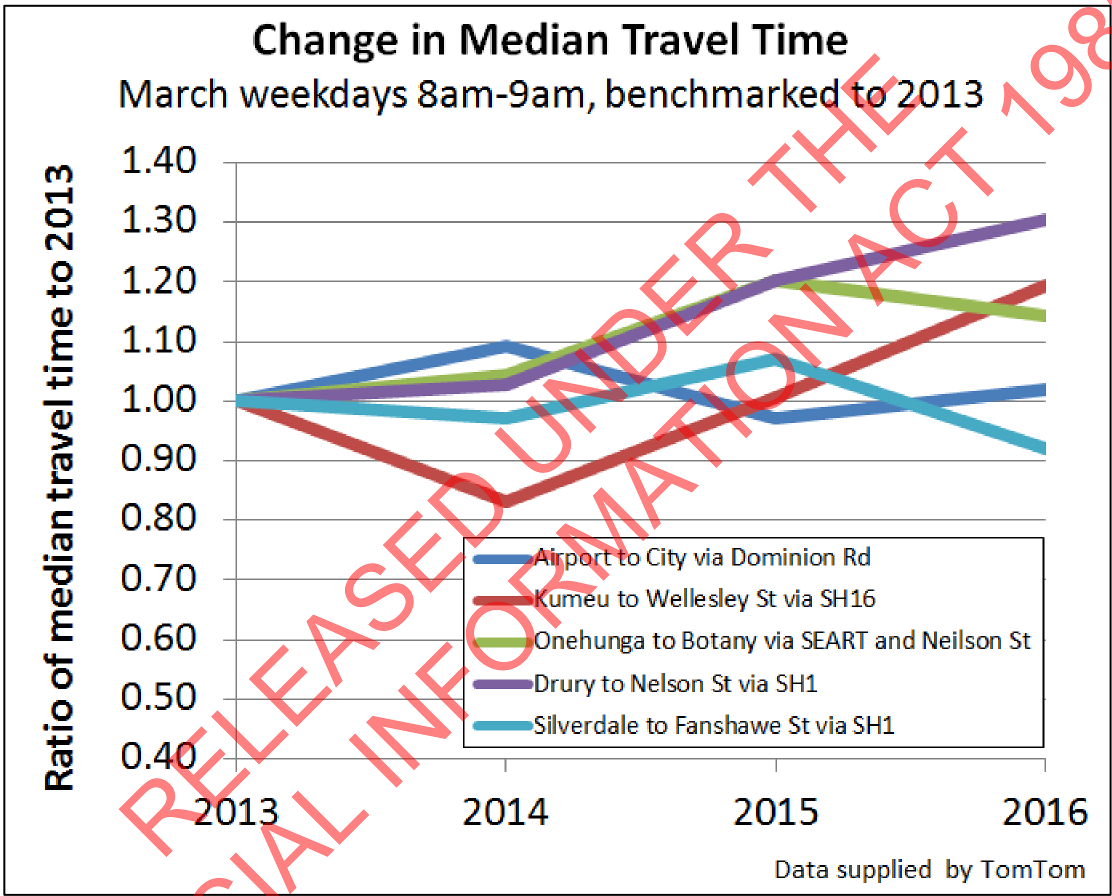
The Project uses the Auckland Regional Transport model (ART3) and Auckland Public Transport model (APT3) in its evaluation of projects and packages. Both models are regional scale demand models and have modelling strengths and limitations that need to be taken into consideration when selecting appropriate models for any test or forecast. These two models are linked but have different and largely independent model forms.

ART3	APT3
• Multimodal tool that includes private and public transport modes, daily trip generations and assignment of trips in the AM peak, inter-peak and PM peak periods. Multiple trip purposes are modelled. • Suited to test the regional effects of a major project on both road and public transport demand. It is also designed and has been used to test road pricing / tolling policies. • Limited when testing detailed, local network effects as it is based on a 2-hour average time period, average network capabilities, and does not include the effects of public transport crowding. • Splits private and public transport modes but the public transport modes are only split into rail, ferry and bus at the assignment stage.	• A more spatially detailed regional demand model than ART3 that only models passenger transport demands. • Only models the AM peak period. • Can be run with or without public transport crowding impacts. • Although there is an estimate of the effects of public transport projects on car trips, only demand changes are estimated (not actual road network effects). These demand changes can be fed back to the ART3 model to estimate road network responses; however this has not been undertaken in the project.

Both models utilise a land-use scenario, known as Scenario i9, which is based on the Auckland Plan's development strategy and reflects the likely location and timing of growth in newly urbanised areas (as outlined in the Future Urban Land Supply Strategy). Scenario i9's household and employment growth projections match reasonably well with the decision version of the Auckland Unitary Plan, with any significant differences being taken into consideration as part of the project.

Model results were produced for 2026, 2036 and 2046. The results for these years are indicative of the conditions that are expected to prevail towards the end of each of the three decades under review in this project (2018-28, 2028-38, and 2038-48).

Throughout the project we have used a base year of 2013 for our analysis, because the transport models are calibrated against Census information and travel patterns from this base year. It is important to note that since 2013 there has been a marked increase in travel demand, resulting in slower travel speeds and higher congestion (see graph below). Of the five routes examined, four showed increasing medium travel times, and three of these were significant (eg SH1 - Drury to Nelson Street travel times increased by 30%). This recent decline in performance on the Auckland road network needs to be taken into account when reviewing changes in performance between 2013 and 2026.



Model input assumptions

Model input assumptions were reviewed at the beginning of the project. Appendix B sets out the key input assumptions that were used, including how these were changed compared to modelling of previous strategic transport programmes in Auckland.

Application of the models to the evaluation

The table below shows the transport modelling tests undertaken at different stages of the project. In addition, various 'baselines' were used in each phase to help gain an understanding of the impact of the interventions tested.

Project Phase	Stage	Packages Tested	Pricing tests	Other tests
Understanding the Challenge		• Auckland Plan Transport Network (APTN)		
Option Testing	Initial Testing (Round 1)	• Individual project testing (particularly new ideas)	• CBD cordon • Motorway charge • Peak/off-peak network charge	
	Package Development (Round 2)	• 'Capacity Constraints' package • 'Employment Centres' package • 'Smarter Pricing' package	• "Smarter pricing" package tested a full network charge varying by time, location and route	• Scenario tests: effect of connected vehicles, and effect of higher vehicle occupancy • Test of new strategic corridor (eastern corridor)
	Refined Packages (Round 3)	• 'Higher Investment' package • 'Influence Demand' package	• Different pricing levels	• Scenario tests: effect of higher population growth rate
Refinement and Prioritisation	Final Indicative Package	• 'Indicative Package'		

The table below shows the transport modelling tests undertaken at different stages of the project. In addition, various 'baselines' were used in each phase to help gain an understanding of the impact of the interventions tested.

Package Description	ART results			APT results		
	2026	2036	2046	2026	2036	2046
Common Elements 1 (CE1)	Y	Y	Y			
Common Elements and Enhanced Interventions 1 (CEE1)	Y	Y	Y			Y
Common Elements and Enhanced Interventions 2 (CEE2)	Y	Y	Y			Y
Common Elements and Enhanced Interventions 3 (CEE3)	Y	Y	Y	Y	Y	Y
CEE3 with high population growth (2026 only)	Y					
Common Elements and Enhanced Interventions 4 (CEE4)	Y	Y	Y	Y	Y	Y
APTN i8b	Y	Y	Y			
APTN i9 without airport masterplan	Y	Y	Y			
APTN with updated input assumptions and airport masterplan	Y	Y	Y			Y
APTN with PT fare reduction			Y			Y
APTN with removal of bus lanes			Y			
APTN with bus step function and CEE4 bus services	Y	Y	Y	Y	Y	Y
Round 1 A group of interventions	Y	Y	Y			Y
Round 1 B group of interventions	Y	Y	Y			Y
Round 1 C group of interventions		Y	Y			Y
Round 1 D group of interventions	Y	Y	Y			Y
Round 2 Smarter Pricing	Y	Y	Y			Y
Round 2 Employment Centres	Y	Y	Y			Y
Round 2 Capacity Constraints	Y	Y	Y			Y
Round 3 Higher Investment	Y	Y	Y	Y	Y	Y
Round 3 Influence Demand	Y	Y	Y	Y	Y	Y
Pricing: CBD cordon		Y				
Pricing: Motorway tolls		Y				
Pricing: full network (flat rate)		Y				
Whole Motorway toll 40 30		Y				
Whole Motorway toll 40 10		Y				
Smarter Pricing (pricing 75%)		Y				
Smarter Pricing (pricing 50%)		Y				
Eastern Corridor: hybrid			Y			
Eastern Corridor: motorway			Y			
Technology Scenario: Med Occupancy		Y				
Technology Scenario: High Occupancy		Y				
Technology Scenario: Connected		Y				
Technology Scenario: Hi Occupancy + Connected		Y				
Round 4 Indicative Package	Y	Y	Y	Y	Y	Y
Indicative Package with high population growth (2046 only)			Y			
CEE4 with high population growth (2046 only)			Y			

Common baseline used for modelling purposes

A common baseline was established as a comparator to test the marginal effects of interventions and packages when compared to that baseline. The common baseline reflects projects either committed, generally agreed or needed for modelling tools to operate adequately (referred to as "Common Elements") as well as a number of minor projects/programmes whose benefits are unable to be measured through available strategic modelling tools.

The composition of the common baseline changed from Rounds 1 to 3 of the evaluation. After evaluating the Round 1 results and engaging with various project teams, the transport infrastructure in greenfield areas was refined. In Rounds 2 and 3, a core network of transport infrastructure in the greenfield area was retained in the common baseline. The Auckland Rail Development Programme[1] was also refined after Phase 1. These refinements have been carried through to Rounds 3 to 4 with minor exclusion of interventions perceived to have low value for money and inclusions if perceived to be required.

Suggestions for future detailed modelling evaluation

The strategic transport model is considered to be suitable for testing and comparing the packages that were developed in the project, as confirmed by peer review of the strategic transport model.

The following suggestions were raised during the project for future detailed modelling evaluation:

- It was recognised that consideration should be given to understanding more detailed effects of technology changes and ridesharing programmes and their dynamic impact on demand.
- It was also identified that consideration be given to understanding more detailed socio-economic segmentations in order to have more detailed economic and equity assessments of road pricing.

It is proposed that the next step is to develop models that will address these important issues. In addition, Auckland Transport and the NZ Transport Agency will develop detailed business cases for each of the capital projects in the Indicative package.

[1] The Auckland Rail Development Programme is a 30 year rail investment programme jointly prepared by Auckland Transport and KiwiRail to accommodate anticipated growth in rail passenger and freight demand. It assumes growth as reflected in the Auckland Plan and incorporates infrastructure capacity and resilience enhancements, station capacity, enhancements, additional passenger rolling stock, freight efficiency and capacity enhancements and level crossing removal. The programme excludes network extensions.

Phase 1 – Understanding the Challenge

1. The Auckland Plan Transport Network

1.1 Package Description

The project's first phase focused on understanding Auckland's current and future transport challenges in detail through assessing the Auckland Plan Transport Network (APTN). The Foundation Report provides an overview of the key transport challenges facing Auckland over the next 30 years.

Background

The APTN was developed by Auckland Transport, the NZ Transport Agency and Auckland Council to inform the 2015 Regional Land Transport Plan and Long-term Plan. It includes approximately $27.8 billion capital expenditure programme over 30 years (excluding renewals).

The APTN was assessed to represent 'current plans', as referred to in the project Terms of Reference. The term APTN is used throughout this report to refer to 'current plans'.

Key Interventions by Time Period

Table 1.1 below briefly outlines key components of the APTN and the timing of their completion (by decade).

Table 1.1: APTN key interventions by decade

First Decade (2015-25)	Second Decade (2025-35)	Third Decade (2035-45)
• City Rail Link • Accelerated Motorway Project Package • AMETI (Panmure to Pakuranga) • East West Link • Western Ring Route • Puhoi-Warkworth • Implementation of new public transport network • Infrastructure to support Special Housing Areas	• AMETI (Pakuranga to Botany) • Penlink • Northwestern Busway (Westgate and Te Atatu Road) • Rail electrification to Pukekohe • Warkworth-Wellsford • Major infrastructure to support future urban growth	• Additional Waitemata Harbour Crossing • Heavy rail to Auckland Airport • Widening of outer urban motorways • Major infrastructure to support future urban growth

1.2 Key Findings

Analysis of the APTN against key indicators shows mixed results. The following sections provide a summary of the key points and conclusion.

Region-wide Transport Challenges

Under the APTN, road and public transport networks come under increasing pressure over time, leading to increased congestion, more frequent overcrowding, and reduce reliability. Many of the issues currently experienced during morning and evening peak periods are projected to spread to other times of the day.

At a regional level, the APTN delivers mixed results: addressing some of the challenges posed by Auckland's projected growth but struggling with others. Overall employment access is projected to grow over time, but access to employment by car only increases after 2030 with the delivery of a substantial motorway widening programme. Furthermore, increasing congestion over the next 20 years means that access to employment by car does not keep up with total projected employment growth. This results in the proportion of Auckland jobs within a 30-minute peak time car commute declining until the mid-2030s (see Figure 1.1 below).

Access to employment by public transport is projected to perform much better, with a substantial increase in the number and proportion of jobs able to be reached within a 45-minute trip.

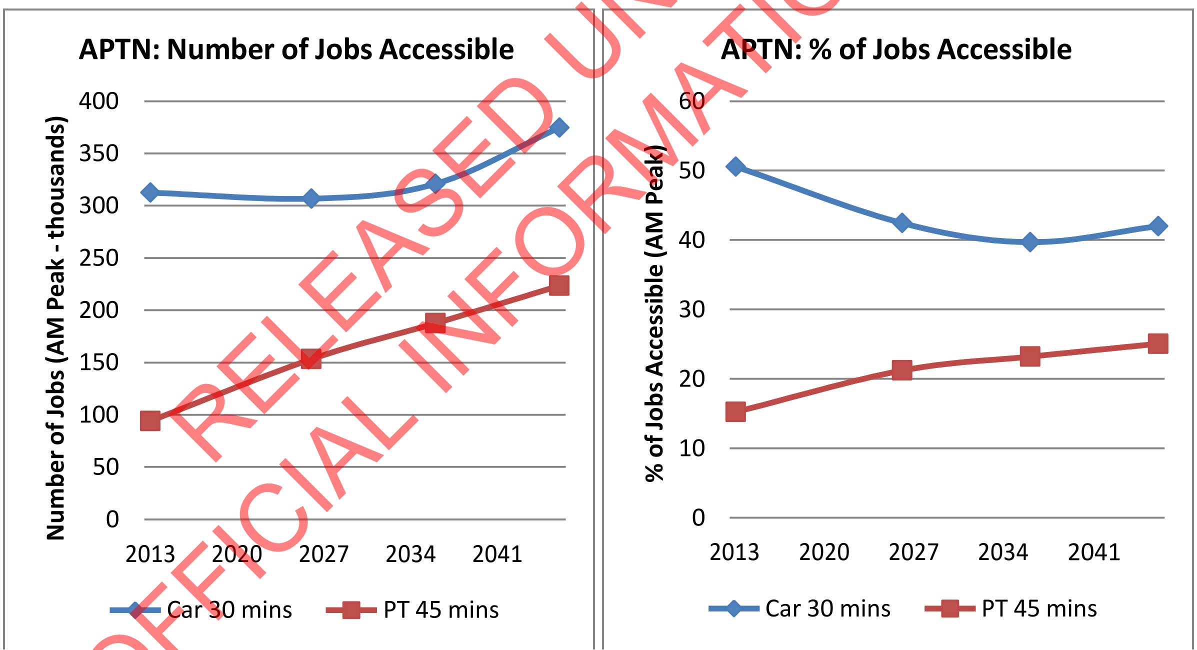


Figure 1.1: Accessibility to jobs for car and public transport in AM peak (APTN)

Under the APTN, congestion is projected to increase and spread as capacity is exceeded by growing demand (Figure 1.2). This crowding increasingly extends into the inter-peak, affecting travel throughout the business day, with particular impacts on high value commercial trips. Conditions are projected to improve in the longer term as investments increase capacity, but not sufficiently to get back to 2013 levels.

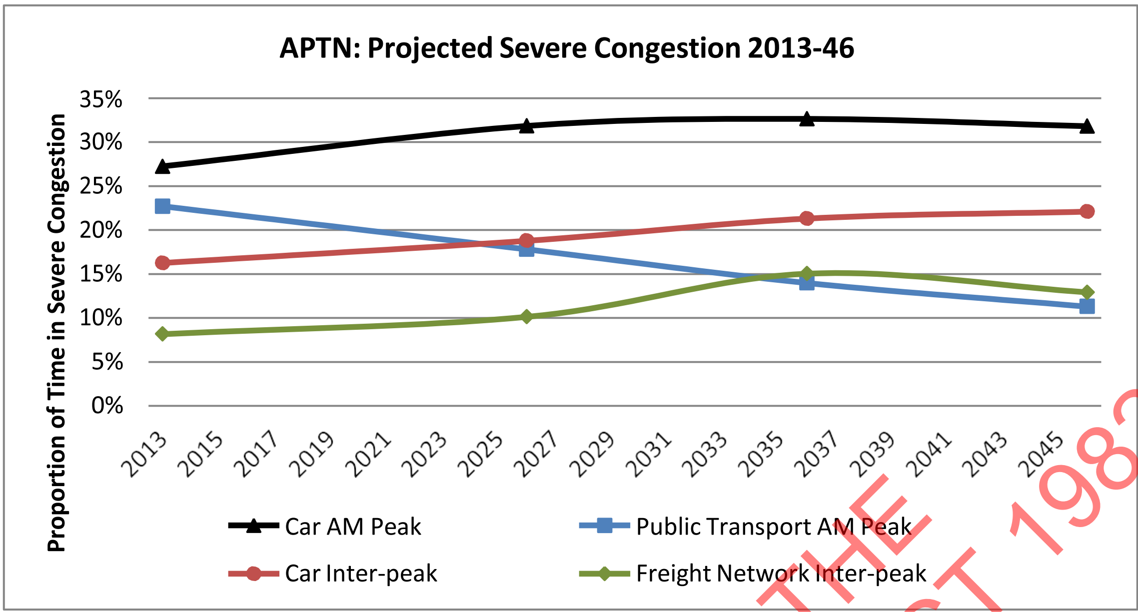


Figure 1.2: Projected severe congestion for car, public transport and freight (APTN)

Public transport mode share in the morning peak is projected to grow over time, more than doubling from 7% in 2013 to 15% by 2046 (Figure 1.3). For vehicular trips (i.e. excluding walking and cycling) to employment at peak times, public transport grows from 13% in 2013 to 29% by 2046.

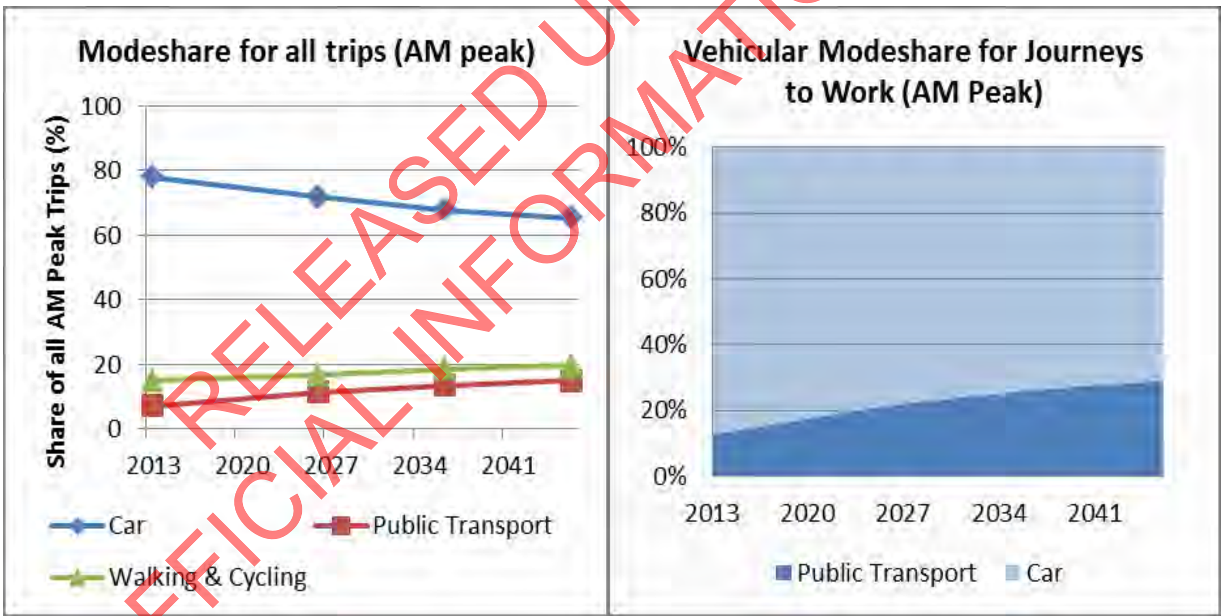


Figure 1.3: Projected mode share (APTN)

The Foundation Report concluded that future phases of the project needed to focus on addressing the following issues:

Access to Employment and Labour

- An overall decline in access to employment by car between 2013 and 2036, particularly in the west and south
- The slowing of public transport access improvements beyond 2026
- The extent to which transport interventions alone can improve access to employment

Congestion

- Increased levels of congestion between 2013 and 2036, particularly on the motorway network
- Key bottlenecks on the motorways and local road network which impact on overall accessibility and trip reliability

Public Transport Mode Share

- Investigation of options to increase public transport mode share, particularly attracting longer trips off the motorway network to reduce congestion
- The low level of public transport mode share growth in South Auckland, particularly in the first decade

Value for Money

- The APTN is the benchmark against which other packages or strategic approaches are assessed in terms of value for money. The parties to the project are seeking better performance in relation to the project objectives having regard to the cost to users and the amount of investment required for the 30 year programme.
- Overall, analysis of the APTN suggested that many of Auckland's most significant transport challenges appear to occur over the next 10 years, with planned investments beyond the next decade appearing to result in improvements. Auckland's significant growth since 2013, the base year for analysis, means that much of this challenge is likely to have already occurred.

Specific Transport Challenges

Accessibility in West and South Auckland

The accessibility projections in the Foundation Report highlight a significant unevenness to future employment accessibility and a growing polarisation of access to employment in the future. By 2046 more than a million people will be living in the western and southern parts of Auckland, nearly half the region's population. However these areas see relatively little improvement in their access to employment over time:

- In the west, car access sees a steep decline up to 2026. There are modest improvements after 2026 overall, with some areas seeing more significant gains. Public transport access improvements mostly occur after 2026 (Figures 1.4 and 1.5).
- In the south, there are widespread declines in car access up to 2026, with some subsequent improvement. Public transport improvements are generally modest throughout the whole 30 year period, with only isolated areas of significant increases (Figures 1.4 and 1.5).

The wider implications of these areas being at least partly excluded from the benefits of Auckland's expanding employment base over the next 30 years are potentially significant, particularly given they include parts of Auckland with higher levels of deprivation, as well as a number of key future urban growth areas. Overall the accessibility findings highlight the transport challenges in providing for increasingly concentrated employment growth coupled with widespread dispersed population growth.

Long-term solutions to these accessibility constraints potentially involve targeted capacity improvements as well as advancing the timing of interventions to better align with deficiencies.

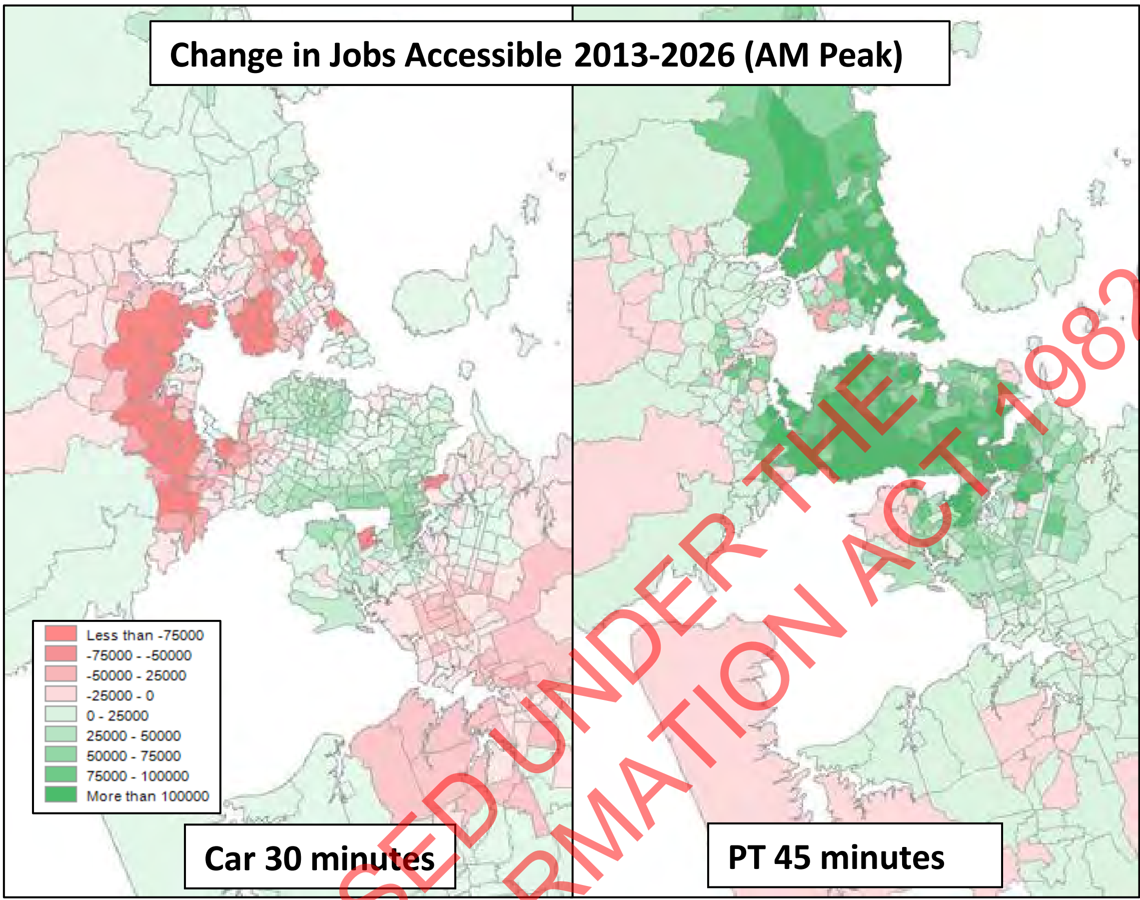


Figure 1.4: Change in accessibility to jobs 2013 vs 2026 (APTN)

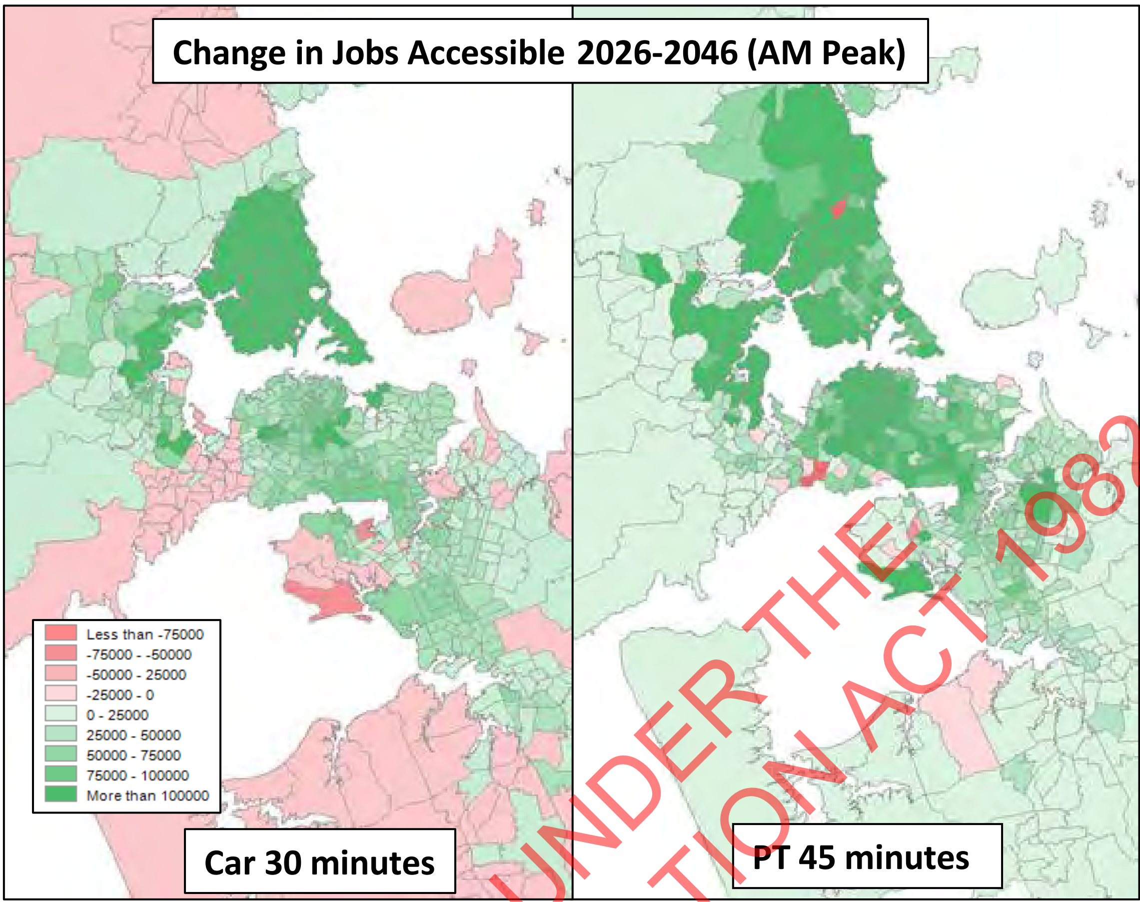


Figure 1.5: Change in accessibility to jobs 2026 vs 2046 (APTN)

1.3 Key Learnings

Analysis of the APTN highlighted a number of transport challenges expected to accompany Auckland's growth over the next three decades, even with the significant investments proposed in current transport plans. This relates particularly to increasing congestion in both the peak and inter-peak periods, and declining accessibility in the west and south.

A modest increase in public transport mode share occurs broadly over the next 30 years, although improvements are unevenly spread, with a particularly low level of mode share growth occurring in the south. For large parts of the overall transport task, particularly in outer areas of Auckland, public transport's role is not projected to notably increase under APTN.

Phase 2 – Option Testing

In this phase of the project, we progressively refined intervention packages in three main stages of analysis.

- **Initial Testing** examined a wide range of interventions to compare performance against the project objectives.
- **Package Analysis** took the best performing interventions and tested the effect of changing the mix of investment and the potential from new technology and moving to smarter transport pricing.
- **Package Refinement** compared increasing investment with a pricing focused approach

2. Initial Testing

Initial testing cast a wide net to look at different approaches to the APTN to see whether it was possible to achieve better performance against the project objectives.

A number of possible, new interventions were identified that could be applied either in addition to, or in place of, interventions in the current plans. The Supporting Information of the Final Report details these interventions.

Some of these interventions were tested without being brought forward into subsequent rounds of evaluation, including testing the current plans with reduced public transport fares or with bus lanes removed.

This section of the Evaluation Report provides information on two main interventions:

- Smarter Pricing: Initial Analysis (Section 2.1)
- Emerging Transport Technologies (Section 2.2)

2.1 Smarter Pricing: Initial Analysis

ATAP explored the potential to use variable road network pricing as a demand management tool to achieve better network performance against ATAP objectives. The goal of demand management pricing is to achieve better performance by pricing users to face a greater proportion of the true costs of their travel, including impacts on other users. Over time this can reduce the extent of investment required in the transport system.

In this initial phase, three approaches to varying the cost of private motor vehicle travel (we have called these interventions 'smarter road pricing' in the project) were tested[2] to understand their potential to improve performance against the project objectives:

- A city centre cordon scheme (a peak-time only charge for vehicles entering the city centre)
- A motorway network charge (a flat-rate charge for vehicles entering the motorway network, with a higher charge at peak times)
- A whole of network charge (a per kilometre charge across all parts of the road network, with a higher rate at peak times)

The options were assessed to understand their potential impact on the project's access, congestion, public transport mode share objectives. We also attempted to assess the options against the project's "net benefits to users" objective but the limitations of our analytical tools meant a robust assessment against this objective was not possible.

Initial testing and evaluation indicated all three approaches had the potential to improve congestion and increase public transport mode share, when compared to the unpriced APTN. Of the three schemes, the comprehensive network charge with its region-wide impact has by far the greatest impact on improving access (as measured by travel time), reducing congestion and increasing public transport mode-share.

However, as the initial option tested was a simplistic fixed-rate charge per kilometre for all trips across the network, analysis indicated poor net benefits to users. This was particularly the case for trips made in outer areas where there was little benefit from reduced congestion but a very high cost due to much longer average trip lengths and few realistic alternatives available to driving.

The city centre cordon charge had the smallest regional impact because of its narrow focus on the city centre, but it was effective at achieving modal shift to public transport and a corresponding reduction in car trips to the city centre. The main potential use of a city centre cordon charge could be as a transition to a broader scheme, but its relatively minor regional impacts means that other schemes were the focus of further analysis.

The motorway charge scheme improved regional congestion, particularly on the motorway network. However, the use of a 'flat-rate' and charging for the motorway network only, resulted in large scale diversion of motorway traffic onto local roads, with resulting congestion. A distance-based motorway charge was considered more likely to be successful in improving access and congestion so a higher per kilometre charge on the motorway network was incorporated into the network-wide system for the next phase of more detailed analysis.

[2] For detailed analysis, see ATAP Demand Management Pricing Report. Peak prices tested in this round were: CBD Cordon ($10 inbound); Motorway Charge ($5 per trip); Whole of Network Charge (44 cents per kilometre).

2.2 Emerging Transport Technologies

The potential future impacts of developing transport technologies are profound, but highly uncertain. We developed two 'what if' scenarios[3] to test the effects of:

- Increasing vehicle occupancy rates
- The uptake of connected vehicles

To understand the impact of technology changes in isolation from other interventions, the impact of connected vehicles and ridesharing were analysed using a common baseline of interventions.

Increases in car occupancy were analysed through directly modifying assumed occupancy rates in the strategic modelling tools. Vehicle occupancy rates convert car person trips into car vehicle trips by purpose. The modelling tools are not able to simulate trip diversion to 'pick up' passengers or reflect any changes in trip generation rates that may occur through greater use of ridesharing. This means the analysis is likely to over-estimate the impact of increased occupancy on reducing demand levels for travel by other means (e.g. drive-alone or use of public transport).

The uptake of ride sharing is expected to vary by trip purpose. Due to their recurrent and regular nature, coupled with low existing occupancy levels, the greatest increase in occupancy rates is expected to be in trips to and from work.

Two scenarios were developed, based around a 50% and a 100% increase in occupancy rates for work-related trips. Changes in occupancy for other trip types were adjusted accordingly, as shown in Table 6.1 below.

Table 2.1: Changes to car occupancy rate

Trip Purposes	Car occupancy rate increase
Work Related	50%-100%
Education Related	10% - 20%
Shopping Related	10% - 20%
Other Purposes	10% - 20%
Employer's Business	5% - 10%

The potential impacts of increasing connected vehicle use were tested in the strategic transport modelling tools by increasing road-lane capacity and reducing the extent of lost time per phase at signalised intersections (i.e. interventions which increase network productivity through improved vehicle throughput). Advancements in Intelligent Transport Systems (ITS) will also improve the operation of signalised intersections. A 75% uptake of connected vehicles by 2036 was assumed for the purpose of this test.

The modelling showed a reduction in public transport trips. In reality, greater use of ridesharing is more likely to replace public transport service in lower density areas than in higher capacity routes where public transport is more likely to offer a time advantage over cars.

[3] For detailed analysis, see ATAP Technology Report.

The main areas where connected vehicles and higher occupancy rates improve performance against the project objectives are in relation to congestion (Figure 2.1) and car accessibility (Figure 2.2).

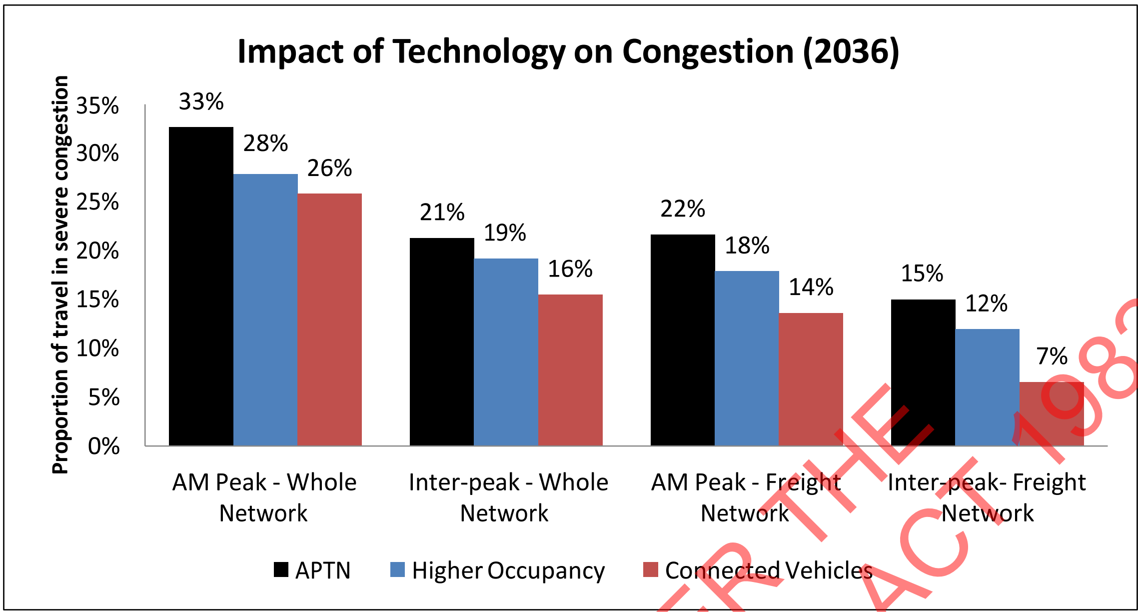


Figure 2.1: Impact of technology on congestion (2036)

Connected vehicles appear likely to have a larger effect on reducing congestion than increases in vehicle occupancy, although our analysis also showed that these impacts were independent and therefore cumulative if increased occupancy rates and connected vehicles occur simultaneously, as can be expected. Congestion reduction from connected vehicles was most significant on the motorway network, because this is where vehicle connectivity is projected to result in the greatest throughput increase due to fewer intersections and less interaction with pedestrians, cyclists and other vehicles.

Potential technology related congestion improvements translate directly into equivalent accessibility gains. The modelling indicates the accessibility gains could be greater than what could be achieved through infrastructure investments alone. This is likely to reflect the region-wide assumptions of technology improvements to Auckland's private motor vehicle fleet, road network and uptake of ride sharing.

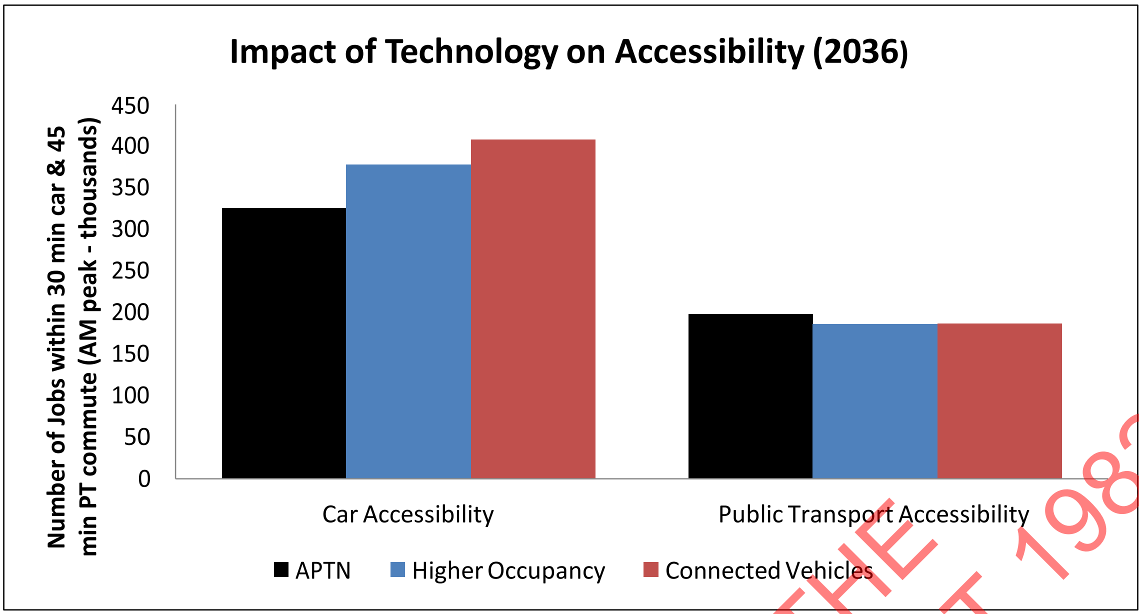


Figure 2.2: Impact of technology on accessibility (2036)

In contrast, public transport accessibility slightly reduced under the two technology scenarios when compared to the APTN. This suggests that neither technology development appears to result in faster public transport journeys. If public transport journeys did become faster, the improvement relative to car journey time is not significant.

As was the case for road pricing, it is important to recognise that with the technology scenario, the strategic modelling tools were being used for very different tasks than what they had been designed for. This was particularly the case for increased vehicle occupancy rates.

Given the level of uncertainty around the nature, scale and timing of technological innovation we decided not to build major technology assumptions into the later phases of technical modelling analysis. Some general conclusions were possible though:

- The benefits of developing vehicle technologies are likely to be substantial, and strongest on the motorway network.
- Increasing vehicle occupancy rates can help reduce congestion and improve car accessibility. Impacts on public transport are more complex, but seem more likely to affect demand in lower density areas more than along core strategic corridors.
- Ride sharing also has the potential to complement road pricing by offering practical alternatives for commuters where public transport is unlikely to be a realistic option under any of the packages we have analysed.

3. Package Analysis

Information from initial testing was used to develop full packages of interventions that could be compared against each other and current plans to assess performance against the project's objectives. This work informed our Interim Findings report that was released in June 2016.

To test whether a different mix of investment could deliver better returns, two intervention packages were developed using broadly similar decade-by-decade levels of investment to the existing plan – the APTN. Each package was built around a 'theme' to describe its focus:

- Focus on Addressing Capacity Constraints (Section 3.1)
- Focus on Access to Employment Centres (Section 3.2)

In addition, a refined version of the Smarter Pricing tool was analysed in Section 3.3, while a cross package review was also undertaken in Section 3.4.

A common baseline for the packages reflects out-of-scope projects and helps assist in identifying differences in performance arising from the different mix of large, strategic interventions in the packages. These differences occur mostly in the second and third decades, because a substantial proportion of the first decade is already agreed and committed.

In fact, compared to the APTN, the first decade already appears 'over-subscribed' even without the inclusion of any discretionary capex items. This is due to a number of investments being added to the common baseline since the APTN was constructed or where project information (including scope and cost) has changed compared with what was used for APTN.

The packages were evaluated against the evaluation framework to test their performance against the project objectives. The intention of the package analysis was not to pick a winner from the three packages, but to understand each package's strengths and weaknesses and the extent to which each package delivers better returns than the current plans.

3.1 Focus on Addressing Capacity Constraints

3.1.1 Package description

The Capacity Constraints package tests the hypothesis that the best approach for achieving the project objectives is through adding capacity in all locations where demand exceeded available capacity.

Projected growth in travel demand is expected to exceed available capacity in an increasing number of locations around Auckland over the next 30 years, leading to congestion and declines in accessibility.

Many of the areas projected to have the most significant access and network performance problems in the future are outer areas that rely on the strategic networks in particular to perform adequately.

This package prioritises interventions that address the most severe capacity constraints on the road and public transport networks, particularly in areas and on parts of these networks that will benefit the greatest number of users.

The total estimated 30-year cost of new capital improvements (excluding renewals) of the Capacity Constraints package is $29.5 billion (in 2016 dollars). Figure 3.1 below provides a breakdown of costs by decade and project type. In broad terms, the bulk of investment in this package goes towards motorway widening and the Additional Waitemata Harbour Crossing project. These costs were identified prior to the revision of project costs in ATAP.

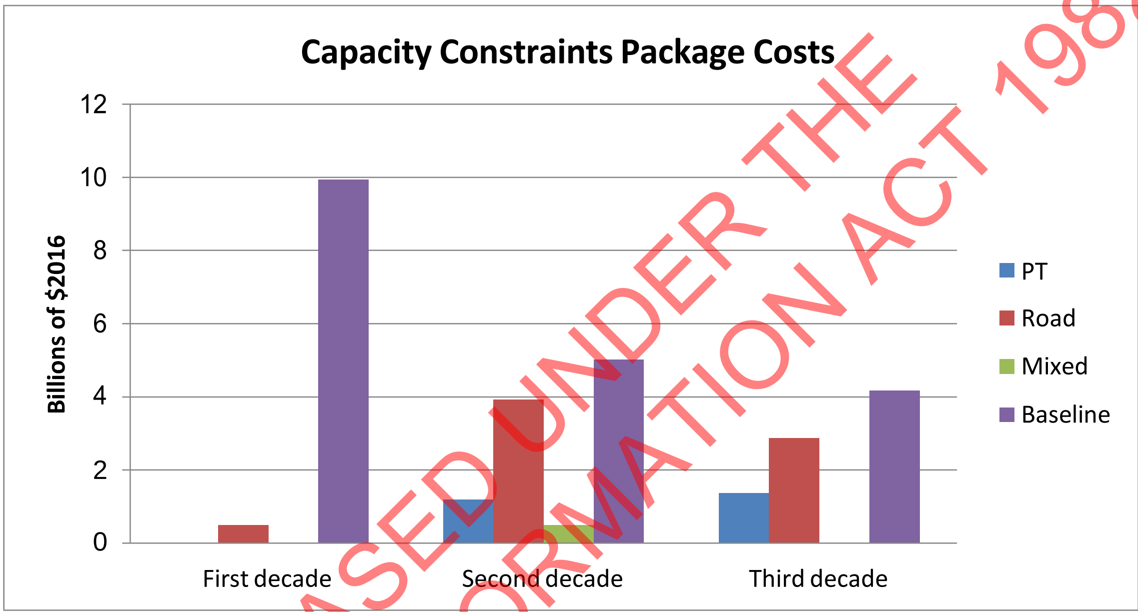


Figure 3.1: Estimated cost of new capital improvements (excluding renewals) of Capacity Constraints package (2018 – 2048)

Key interventions by time period

Key components of the package over and above the enhanced baseline are included in Table 3.1 below.

Table 3.1: Capacity Constraints key interventions by decade

First Decade (2015-25)	Second Decade (2025-35)	Third Decade (2035-45)
• Targeted SH20 widening	• Northwestern Busway (Point Chevalier to Newton) • Southern Motorway targeted widening and interchange upgrades • SH16 widening • AMETI Pakuranga to Botany	• Additional Waitemata Harbour Crossing (motorway tunnels) • City centre bus access improvements • Further SH20 widening • SH20A upgrade

3.1.2 Key Findings
Accessibility

Access to employment in the AM peak for car travel improves from 2026 onwards compared to the APTN, while public transport accessibility tracks very similarly to the APTN up until 2036, after which the APTN performs slightly better (Figure 3.2).

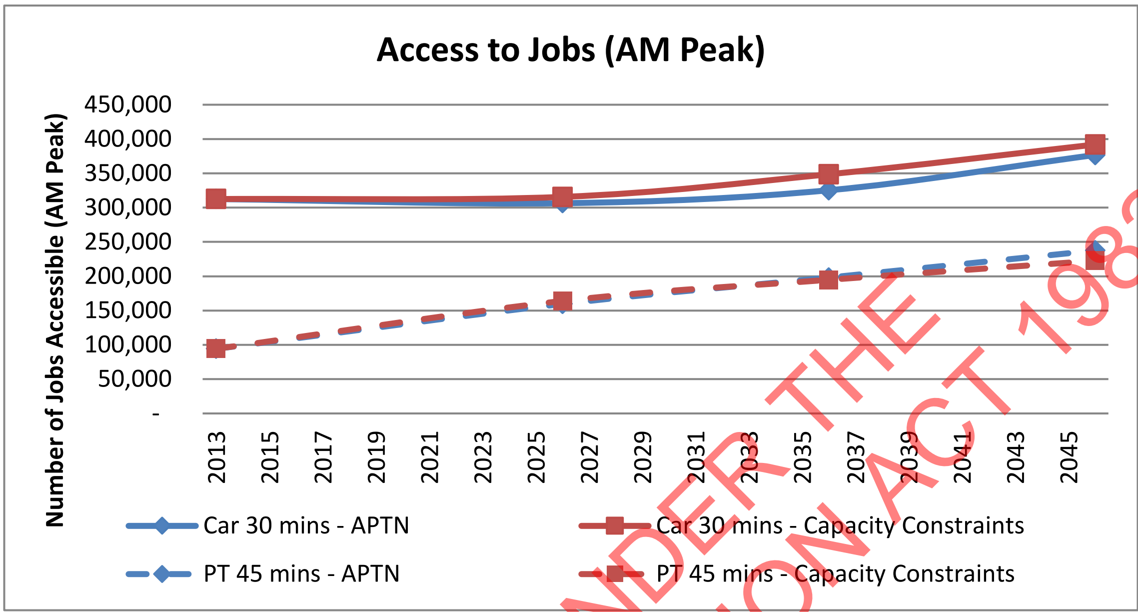


Figure 3.2: Access to jobs (Capacity Constraints and APTN)

Regional measures can mask sub-regional differences in performance, as shown in the accessibility maps below. At a sub-regional level, car accessibility declines in the west, northwest and parts of the North Shore under Capacity Constraints between 2013 and 2026 (Figure 3.3). However public transport accessibility increases significantly for most areas under the same period.

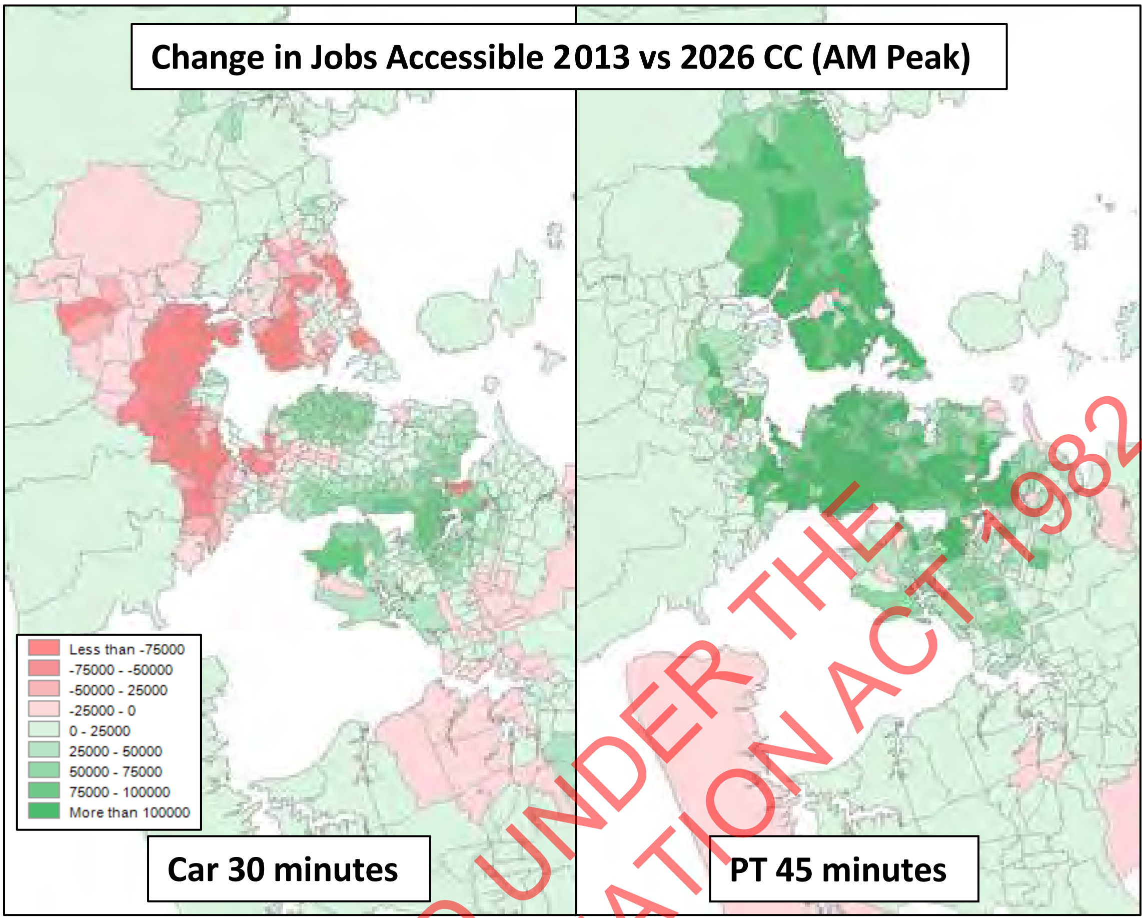


Figure 3.3: Change in accessibility to jobs 2013 vs 2026 (Capacity Constraints)

Between 2026 and 2046, car accessibility improves dramatically on the North Shore, northwest and parts of the isthmus under the Capacity Constraints package (Figure 3.4). However, accessibility declines in the west and around the Airport. Public transport accessibility improves across the region, especially in the isthmus and northwest.

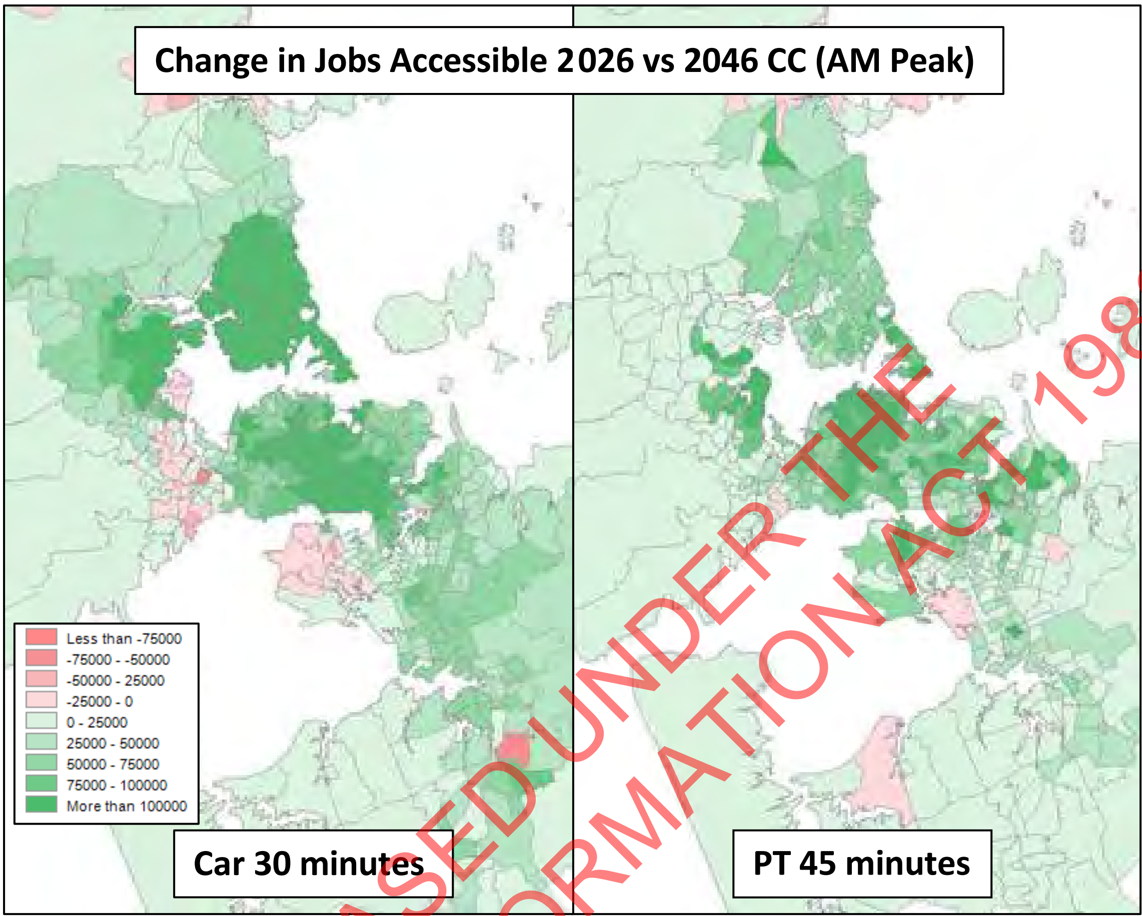


Figure 3.4: Change in accessibility to jobs 2026 vs 2046 (Capacity Constraints)

Compared to APTN, the Capacity Constraints package performs better for most of the isthmus, the inner west, parts of the northwest and the outer south (Figure 3.5). However, it performs worse for most of the lower North Shore, the outer west and the inner south. The reduction in accessibility for the North Shore may be due to the different improvements on SH1 in the area under APTN.

In terms of public transport, pockets of improvement can be seen around Howick and Mangere. However, accessibility declines for most of the region compared to APTN. Accessibility declines particularly for the northwest, likely due to the fact that this package provides for a busway from Point Chevalier to Newton Road, while APTN provides a busway corridor from Westgate to Te Atatu Road. Another reason may be that this package lacks the Upper Harbour strategic public transport route which runs between Henderson and Constellation.

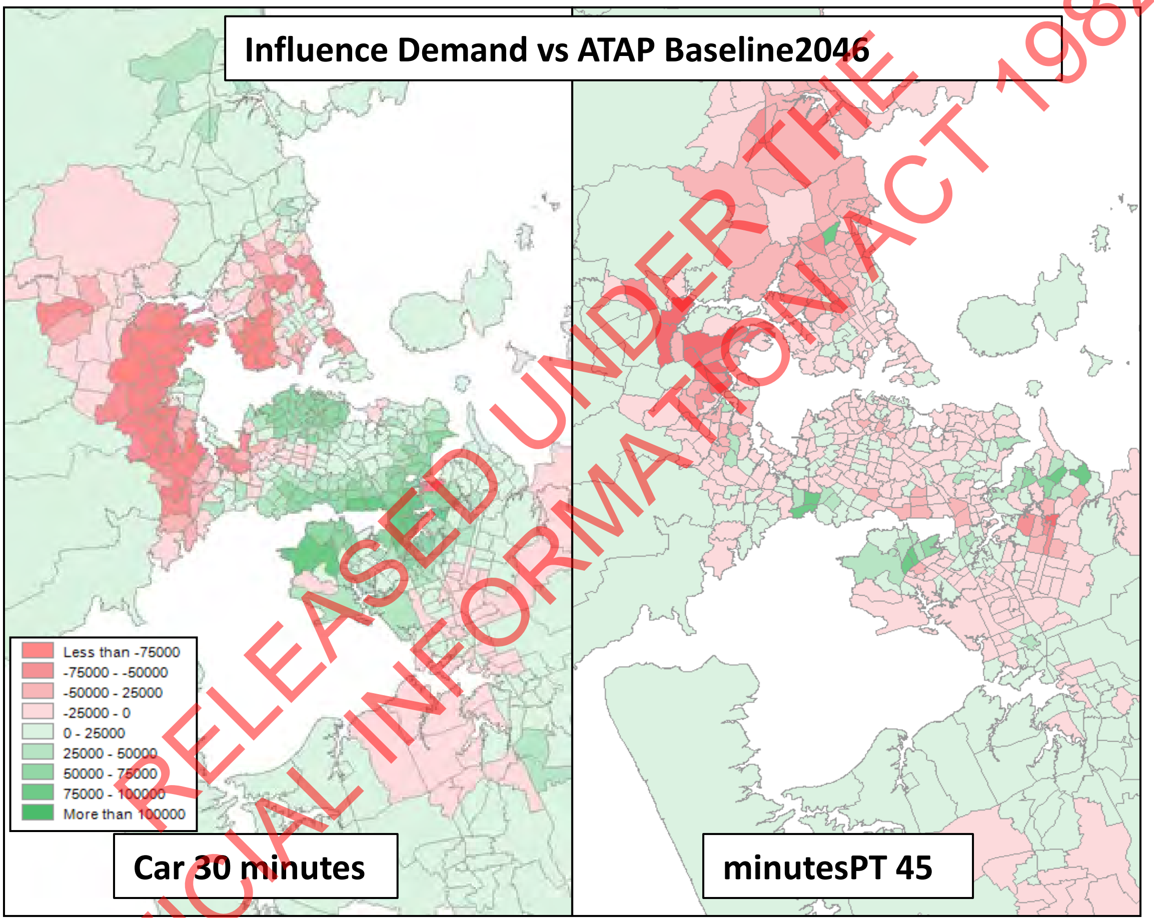


Figure 3.5: Accessibility to jobs (Capacity Constraints and APTN)

Congestion

Congestion levels in the AM peak and inter-peak improve moderately compared to APTN, with 2036 experiencing the greatest improvements (Figure 3.6)

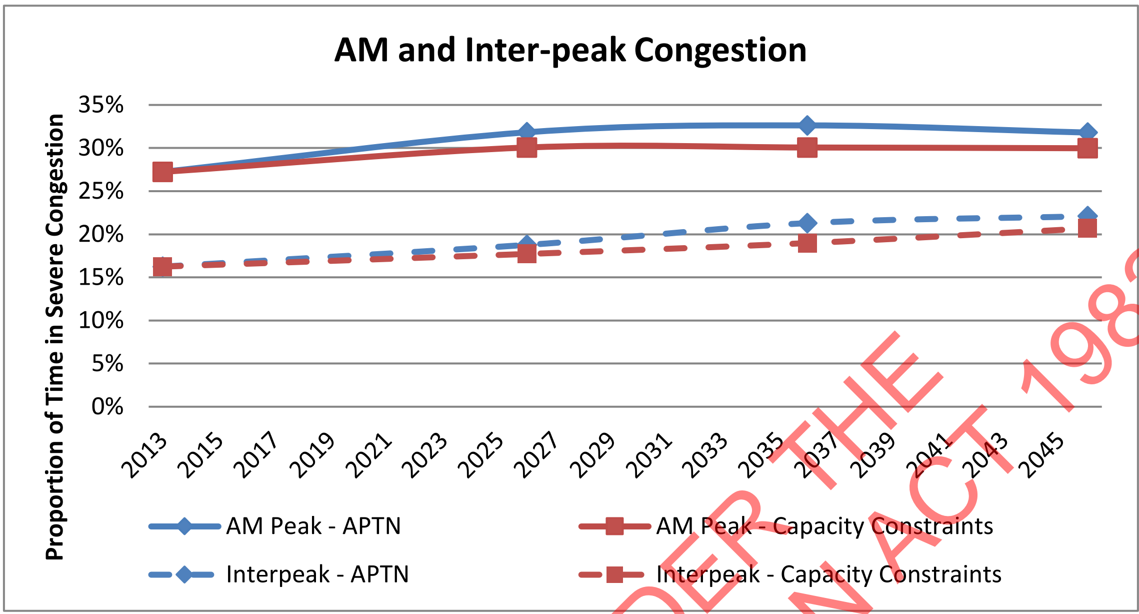


Figure 3.6: AM peak and inter-peak congestion (Capacity Constraints and APTN)

The freight network experiences greater congestion improvements compared to the road network, especially in the AM peak (Figure 3.7). A similar improvement to congestion is projected for the inter-peak. The year 2036 sees the greatest improvements to freight congestion.

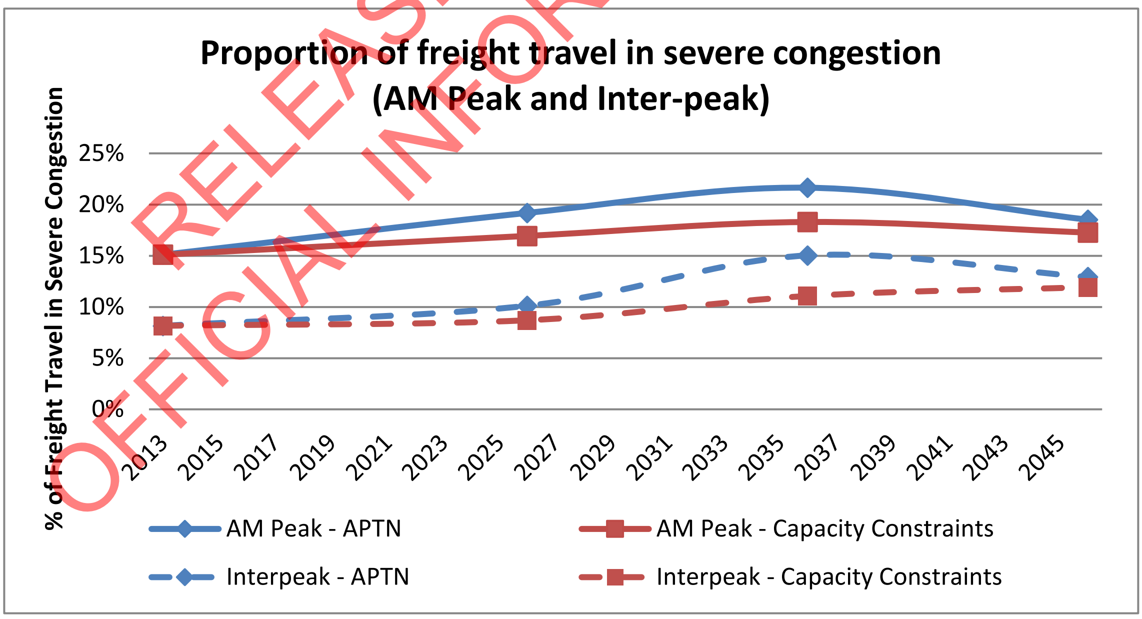


Figure 3.7: Proportion of freight travel in severe congestion (Capacity Constraints and APTN)

On a sub-regional level, the Capacity Constraints package alleviates some of the more severe congestion during the AM peak, in particular SH20A and parts of the Northern Motorway (Figure 3.8). However, severe pinch points remain on the motorway network.

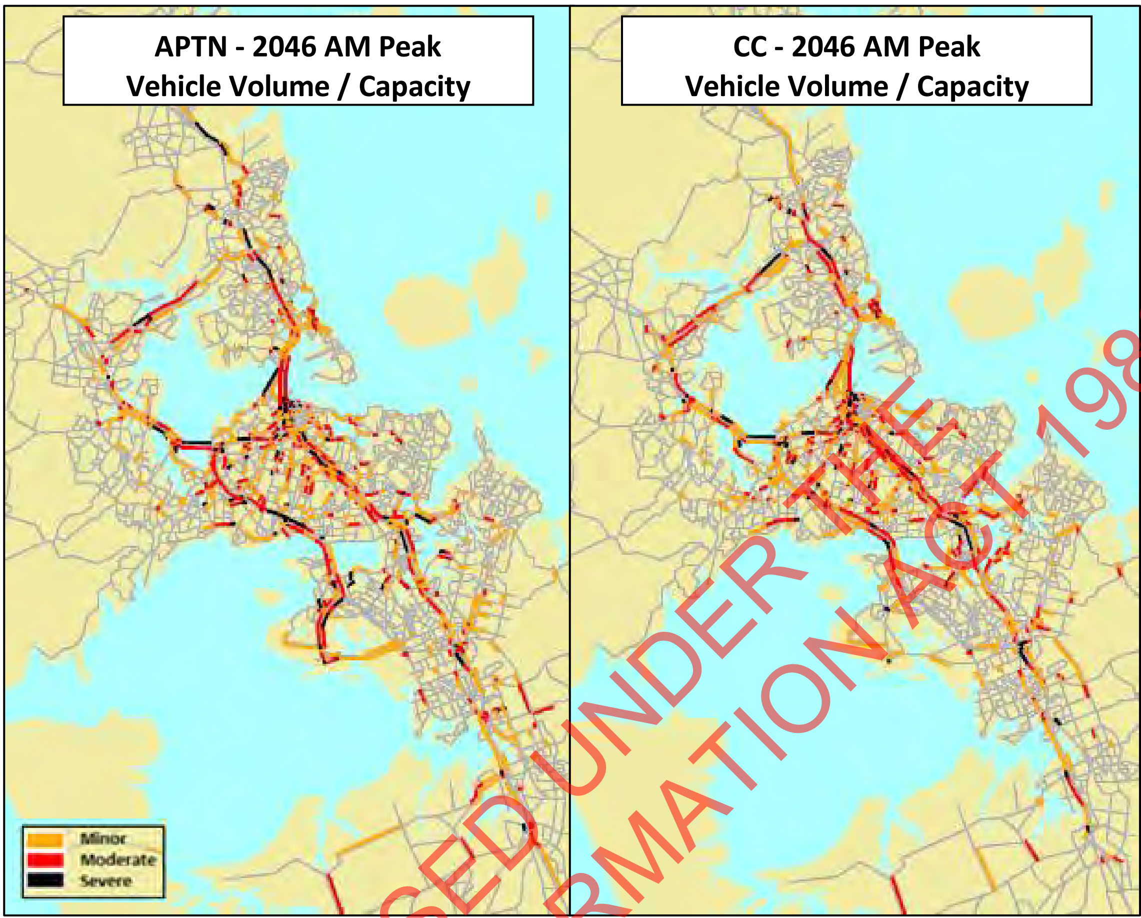


Figure 3.8: AM peak vehicle travel demand (Capacity Constraints and APTN)

The inter-peak experiences less severe congestion compared to the AM peak. The Capacity Constraints package continues to alleviate some of the more severe congestion on the motorway network, in particular SH20A and parts of the Northern Motorway (Figure 3.9). Limited severe congestion remains, particularly within the inner motorway network.

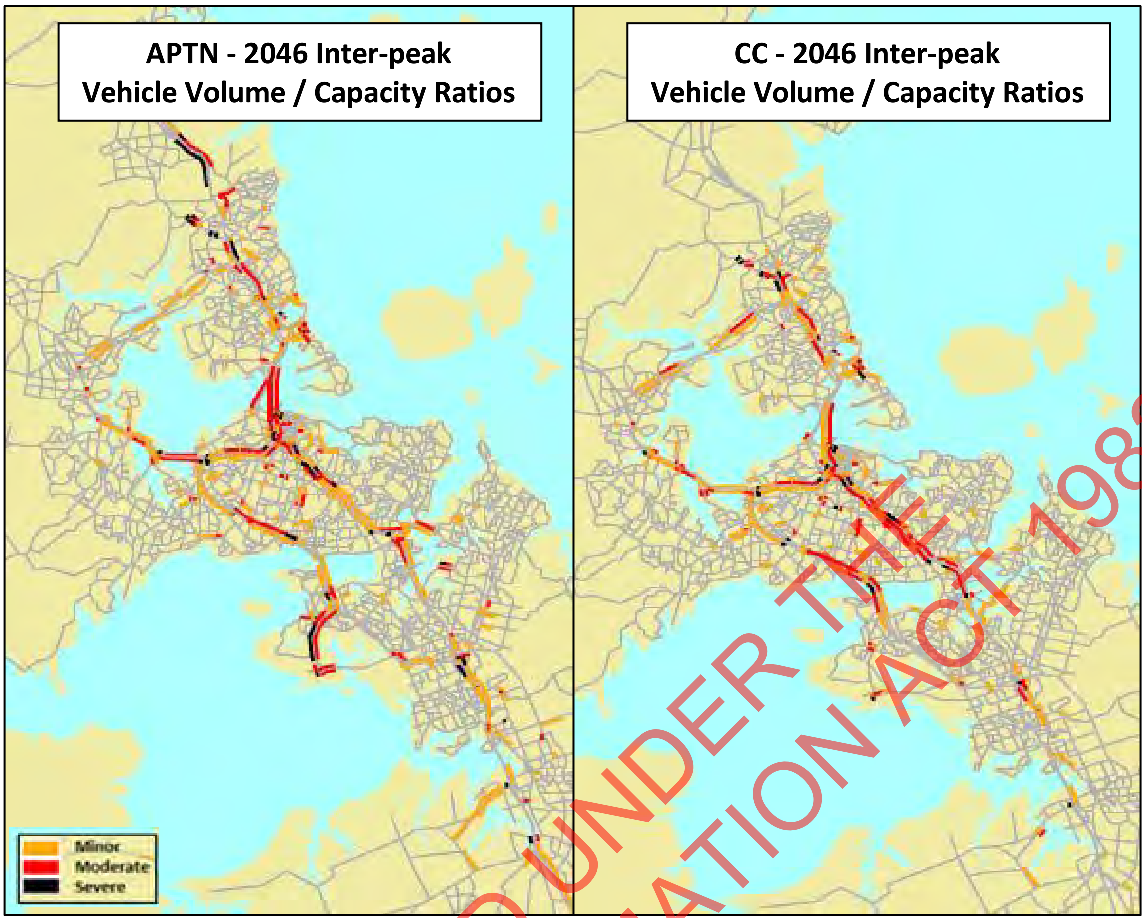


Figure 3.9: Inter-peak vehicle travel demand (Capacity Constraints and APTN)

Public Transport Mode Share

Public transport mode share remains virtually identical to APTN over the 30 year period (Figure 3.10).

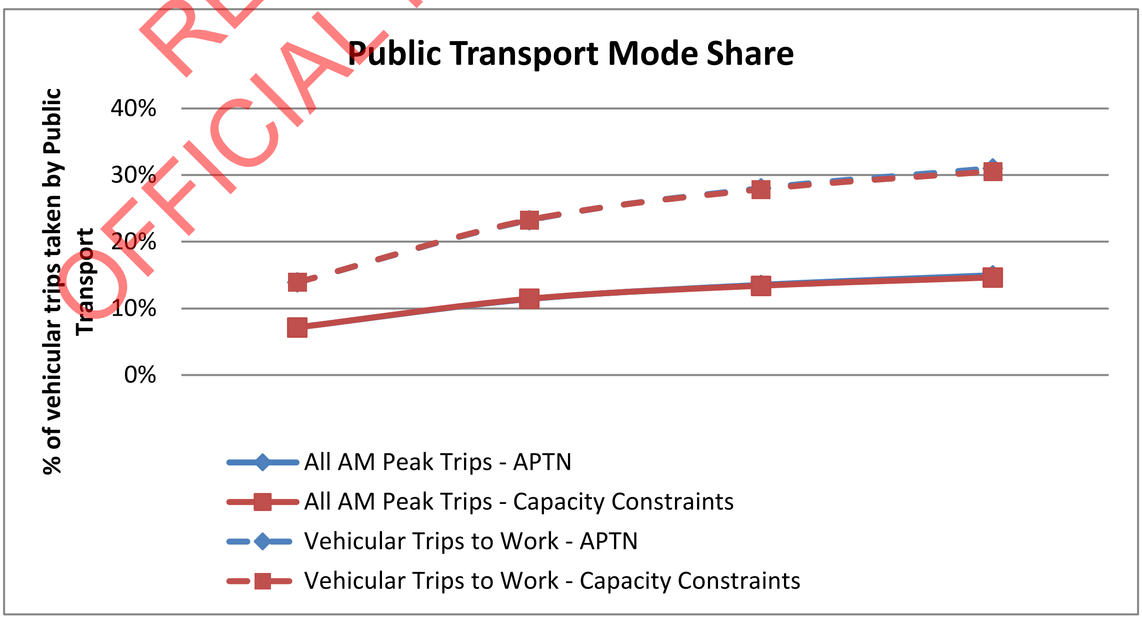


Figure 3.10: Public transport mode share (Capacity Constraints and APTN)

Bus demand continues to exceed capacity at parts of the network, broadly to a similar extent as APTN, with additional deficiencies to Panmure and Howick (Figure 3.11).

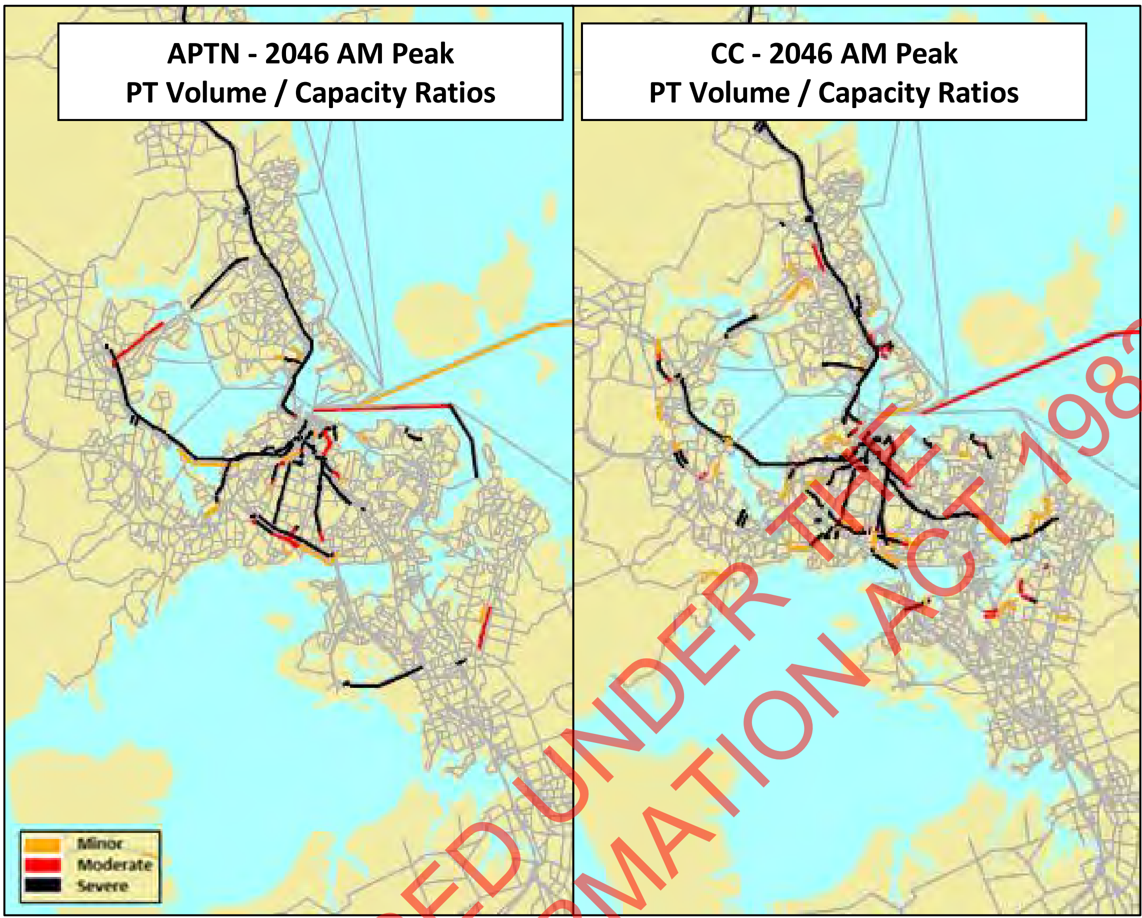


Figure 3.11: Public transport demand (Capacity Constraints and APTN)

Value for Money

Value for money assessments considered both network wide effects and isolating the contribution of projects at a sub-regional level, through an assessment of their impact on throughput and travel times relative to cost. These proxies for value for money were used to identify projects worth taking forward into the next round of evaluation.

The Capacity Constraints package has an estimated $29.5 billion capital expenditure programme over 30 years (excluding renewals) which is projected to have similar contributions to the ATAP objectives as the APTN. The package is projected to result in a higher proportion of jobs accessible by motorists of 44% (compared to 42% in the APTN), a slightly higher proportion of jobs accessible by public transport of 25% (compared to 27% in the APTN), a slightly lower proportion of travel time in severe congestion of 30% in severe congestion in AM peak (compared to 32% in the APTN) and a similar public transport mode share of 18.2% in the AM peak (compared to 18.6% in the APTN).

The Capacity Constraints package as a whole is projected to have a similar overall contribution to the ATAP objectives as the APTN package, with a similar sized capital improvement programme.

3.1.3 Key Learnings

Analysis of the Capacity Constraints package highlights some areas of strength, such as a significant improvement to congestion on the freight network, but also some areas of poor performance – particularly relating to congestion and car accessibility issues for parts of the west.

Targeted motorway widening, particularly on SH20 and parts outside the isthmus, improves car accessibility and provides marginal gains in congestion. Widening parts of the motorway network earlier also decreases the rate of deterioration.

While the package does not achieve a 'step-change' in regional performance, impacts at a sub-regional level are significant. In particular, improvements for the west and south appear possible through changes to the mix and timing of investment. In the south, whereas under the APTN access to employment by car declined and only increased strongly after 2036, the Capacity Constraints package shows better performance can be achieved in the south.

3.2 Focus on Employment Centres

3.2.1 Package Description

The Employment Centres package tests the hypothesis that because Auckland's employment growth is focused in a relatively small number of locations, the best approach to achieving the project objectives is by strongly focusing on improving access to locations with large numbers of jobs and where significant jobs growth is projected.

Auckland's employment is currently spread throughout the region, with a number of key centres forming important clusters. The key clusters are the central area (CBD), Auckland Airport, and Westgate. Employment growth in the future is projected to be highly focused on these clusters, reflecting an ongoing shift towards service-sector based jobs. Many of the areas projected to have the most significant access problems in the future are the parts of Auckland which are most distant from these clusters.

This package prioritises interventions that improve access to current and future major centres of employment (including the central area). Interventions that improve access to, from and between major employment centres will be prioritised in this package. The different characteristics and constraints of major employment areas need to be recognised in this process.

The total estimated 30-year cost of new capital improvements (excluding renewals) of the Employment Centres package is $29.6 billion (in 2016 dollars). Figure 3.12 below provides a breakdown of costs by decade and project type. In broad terms, the bulk of investment in this package is on light-rail and rapid transit, followed by motorway widening. These estimated costs were identified prior to the revision of project costs in ATAP.

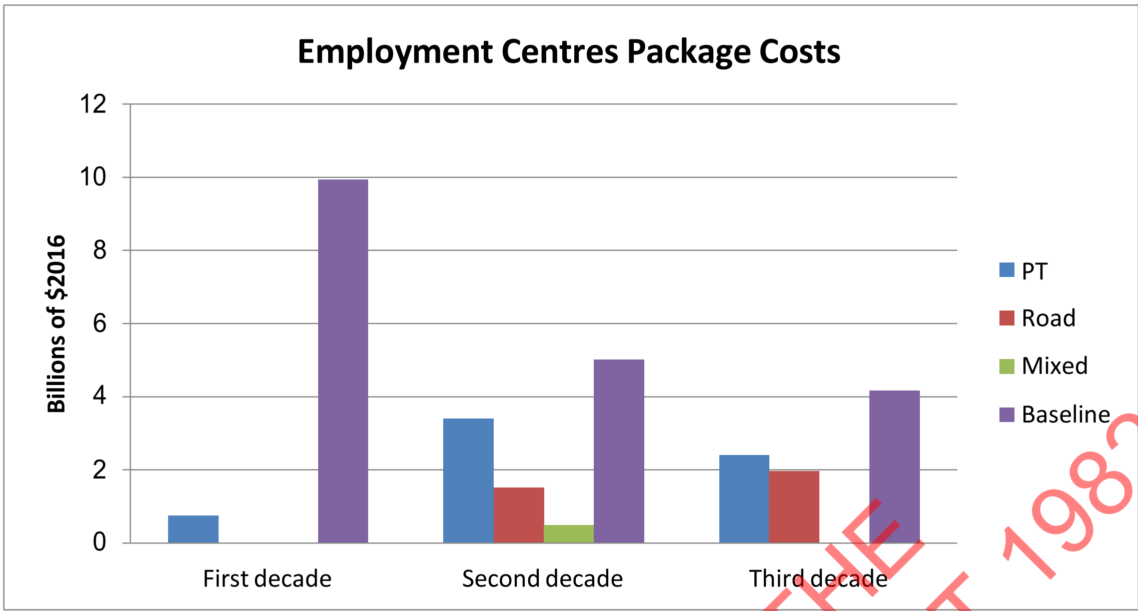


Figure 3.12: Estimated cost of new capital improvements (excluding renewals) of the Employment Centres package (2018 – 2048)

Key interventions by time period

Key components of the package over and above the enhanced baseline are outlined in Table 3.2 below.

Table 3.2: Employment Centres key interventions by decade

First Decade (2015-25)	Second Decade (2025-35)	Third Decade (2035-45)
• Northwestern Busway (Westgate to Newton)	• Targeted widening of Southern Motorway and SH20 • Isthmus light-rail • North Shore rapid transit (city centre to Takapuna) • Rail upgrades to enable Southern Line express trains • AMETI Pakuranga to Botany	• Extension of East-West Link east of SH1 • Targeted further Southern Motorway and SH20 widening • Upgrade to SH20A • Extension of light-rail to Airport from north • Extension of North Shore rapid transit to Albany

3.2.2 Key Findings
Accessibility

Access to employment in the AM peak tracks very similarly to APTN for car and public transport (Figure 3.13). Generally the Employment Centres package improves accessibility in 2026 and 2036, while APTN catches up in the final decade.

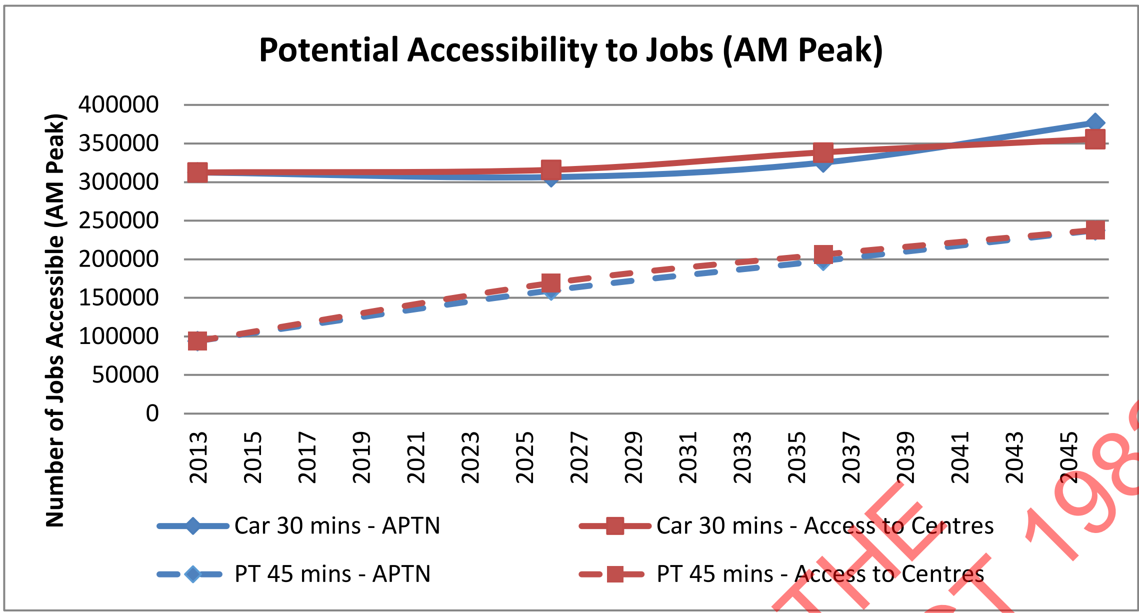


Figure 3.13: Potential accessibility to jobs (Employment Centres and APTN)

On a sub-regional level, car accessibility declines under the package in the west, northwest, and parts of the North Shore and outer south between 2013 and 2026 (Figure 3.14).

Public transport accessibility improves across the region over the same period. The decline in car accessibility in the northwest is offset by accelerating improvements of the Northwestern Busway into this timeframe.

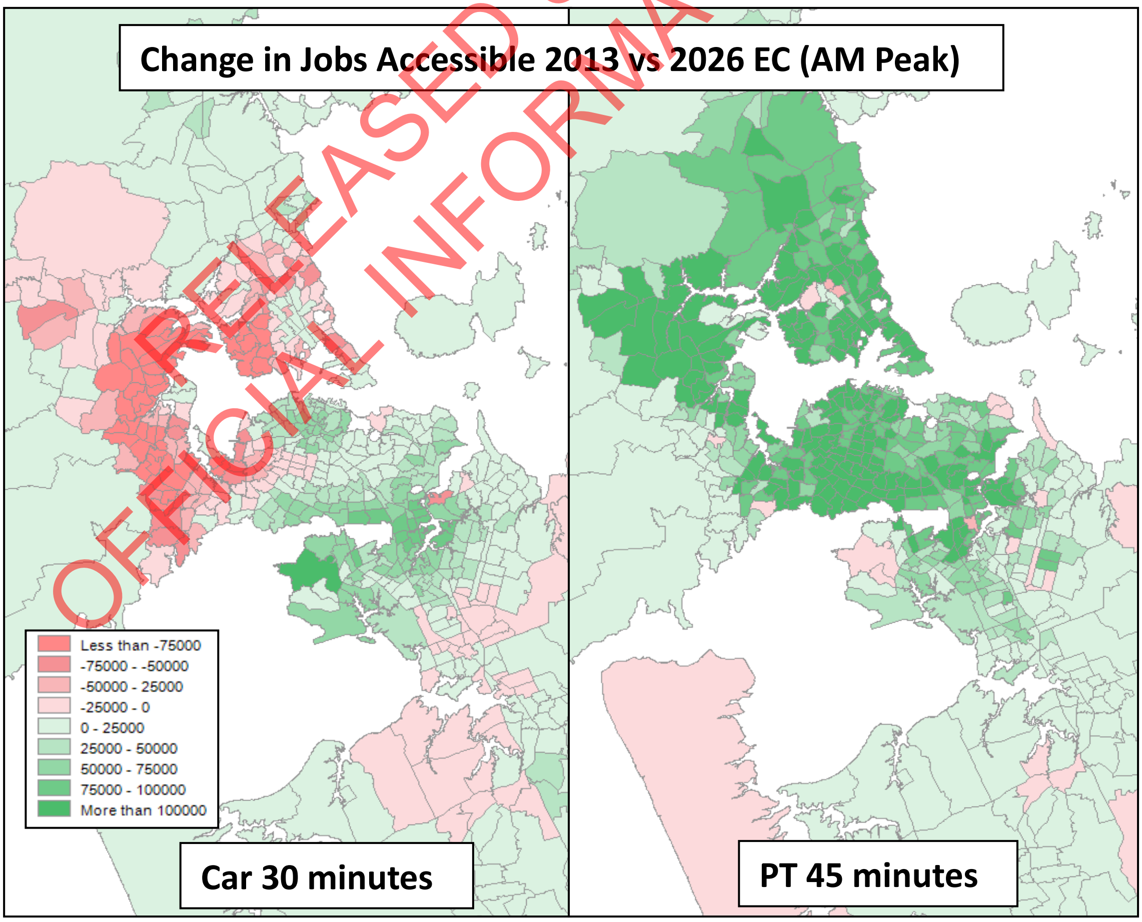


Figure 3.14: Change in accessibility to jobs 2013 vs 2026 (Employment Centres)

Between 2026 and 2046, there are generally better accessibility outcomes for both car and public transport (Figure 3.15). Some exceptions include car access from the Airport, northwest and parts of the North Shore. Even though this package does not include the Additional Waitemata Harbour Crossing, parts of the North Shore experience improvements in car accessibility.

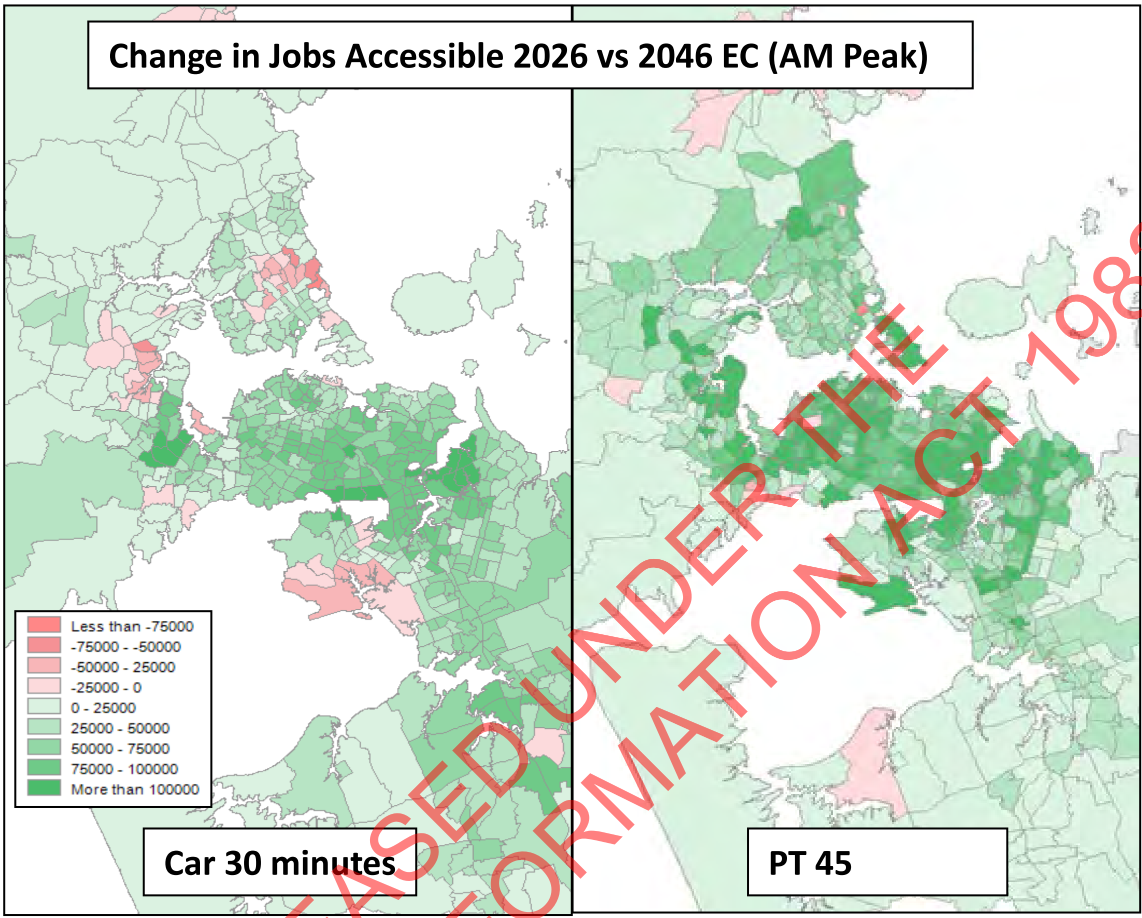


Figure 3.15: Change in accessibility to jobs 2026 vs 2046 (Employment Centres)

Compared to the APTN, the south and southeast areas generally perform better, likely due to the inclusion of a motorway connection from the East West Link to the Southeastern Highway (Figure 3.16). The North Shore on the other hand sees reduced accessibility – because it does not experience the significant access boost from the Additional Waitemata Harbour Crossing.

Public transport generally performs similarly except for the northwest, which performs better than APTN. This is likely to be due to the provision of a full grade Northwestern Busway corridor, as opposed to the combination of bus lanes and busway as specified in APTN.

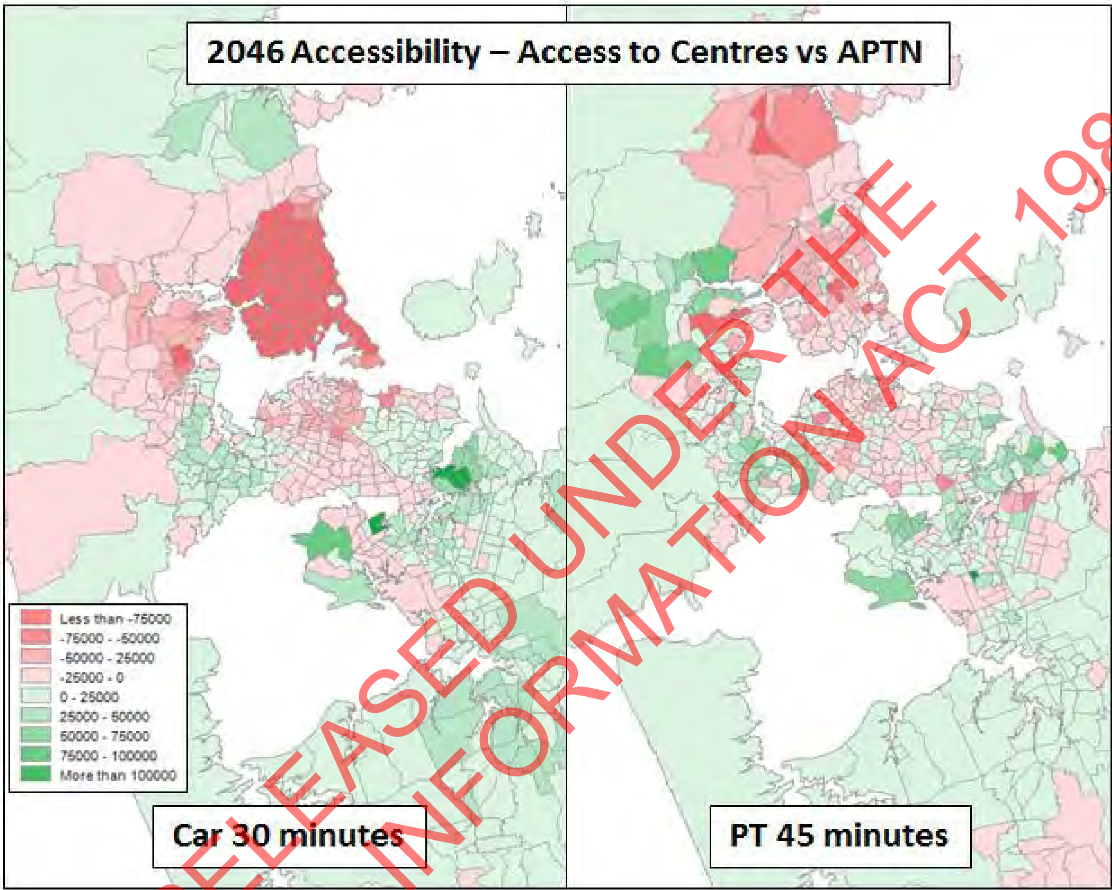


Figure 3.16: Access to jobs (Employment Centres and APTN)

Congestion

Congestion levels improve marginally under Employment Centres compared to the APTN, particularly between 2026 and 2036 (Figure 3.17). Both packages experience similar levels of congestion by 2046.

Similar levels of congestion improvements are seen for freight in the AM peak, although congestion worsens compared to APTN between 2036 and 2046 (Figure 3.18). Congestion levels improve to a lesser degree for the inter-peak, though similar to the AM peak, congestion increases slightly compared to APTN in the final decade.

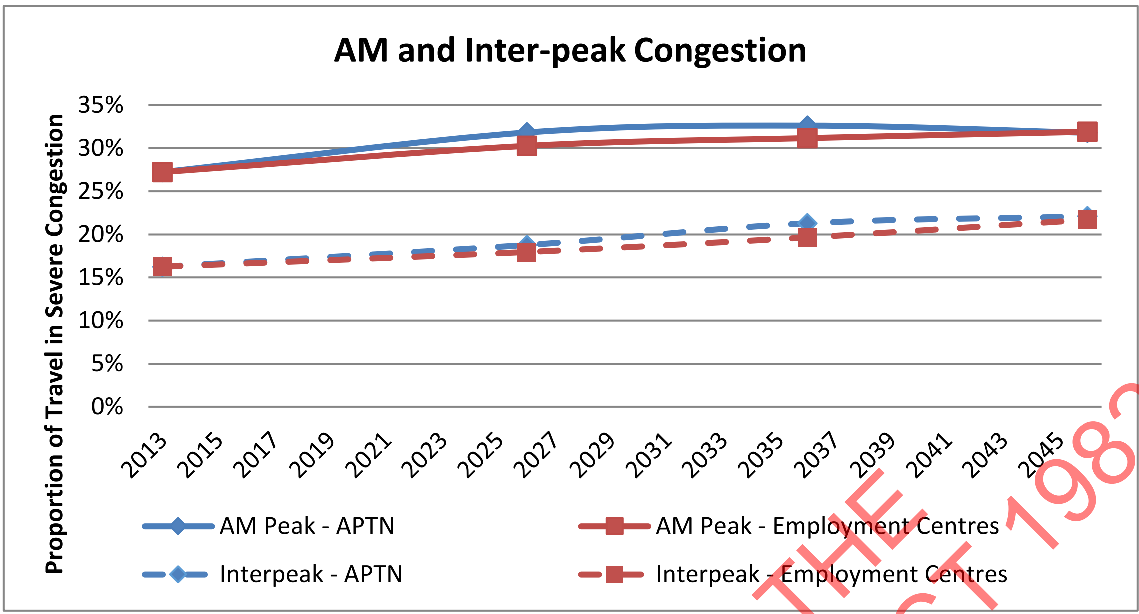


Figure 3.17: AM and inter-peak congestion (Employment Centres and APTN)

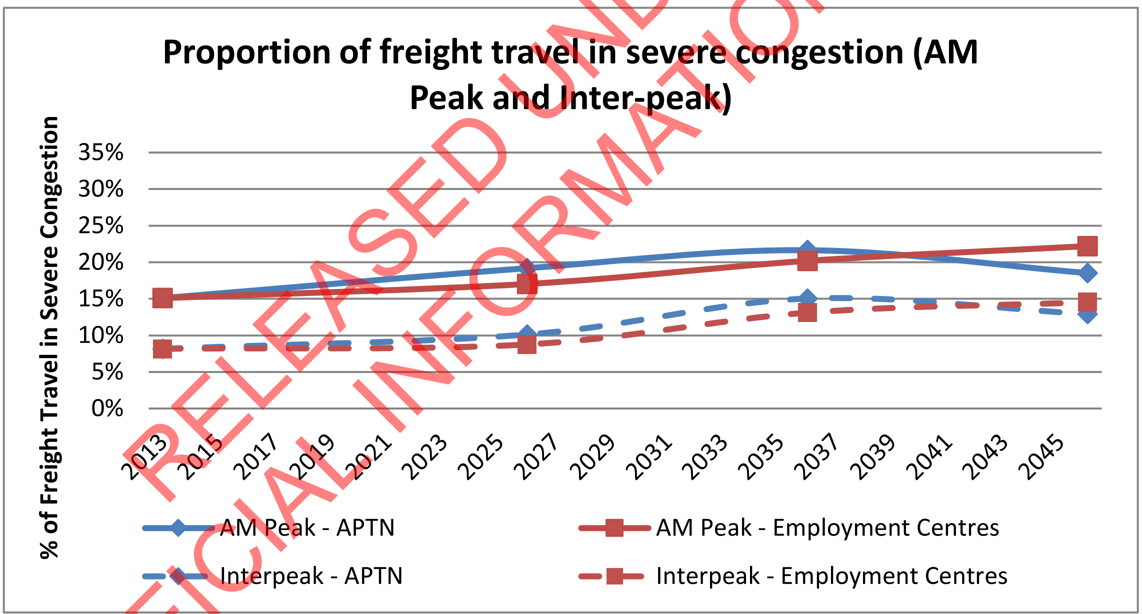


Figure 3.18: Proportion of freight travel in severe congestion (Employment Centres and APTN)

On a sub-regional level, the Employment Centres package alleviates some of the more severe congestion on the motorway network, most particularly on SH20A (Figure 3.19). However, severe congestion is extended along the Northern Motorway as well as parts of SH16 and SH18.

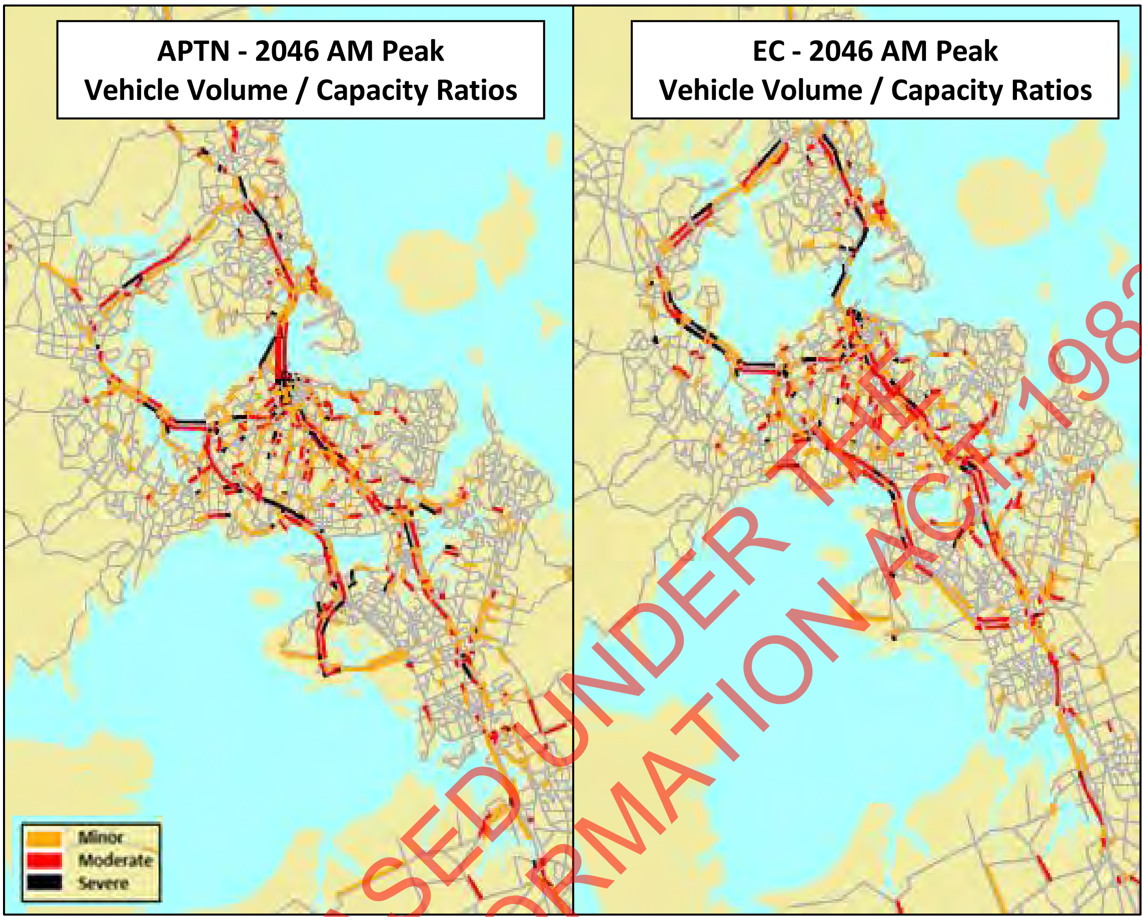


Figure 3.19: AM peak vehicle travel demand (Employment Centres and APTN)

The inter-peak experiences less severe congestion compared to the AM peak (Figure 3.20). The Employment Centres package continues to alleviate some of the more severe congestion on the motorway network, in particular SH20A and parts of the Northern Motorway. Limited severe congestion remains, particularly within the inner motorway network.

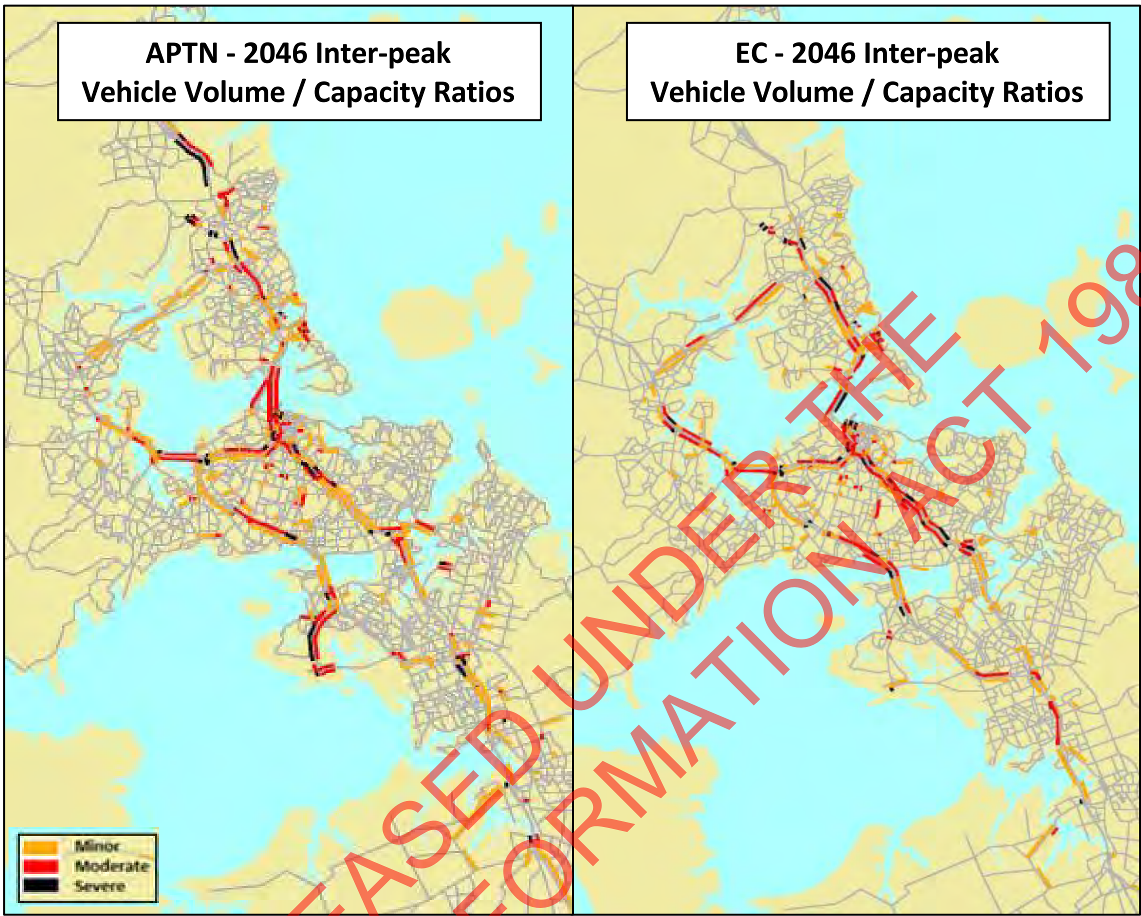


Figure 3.20: Inter-peak vehicle travel demand (Employment Centres and APTN)

Public Transport Mode Share

Public transport mode share is essentially identical to the APTN over the 30 year period (Figure 3.21).

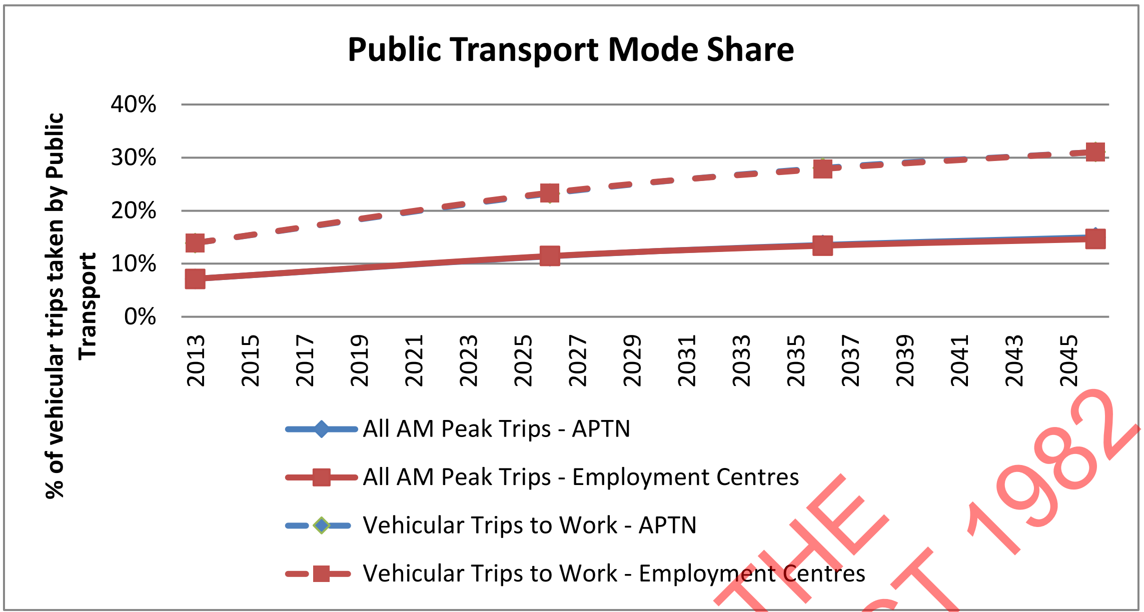


Figure 3.21: Public transport mode share (Employment Centres and APTN)

Mass transit on the North Shore and the isthmus removes the bus capacity issues faced under APTN for these routes (Figure 3.22). However bus demand continues to exceed capacity at parts of the network, to a much wider extent than the APTN, particularly in the east.

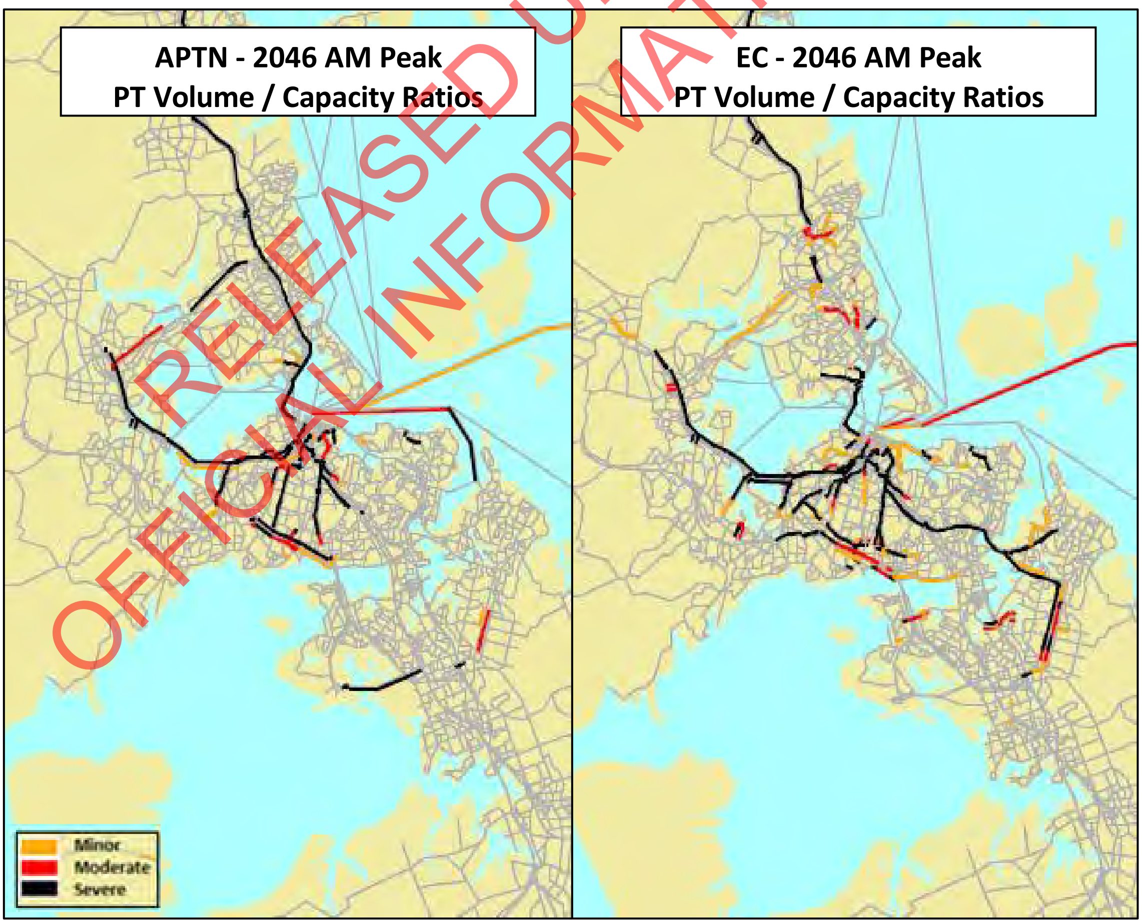


Figure 3.22: Public transport demand in 2046 (Employment Centres and APTN)

Value for Money

Value for money assessments considered both network wide effects and isolating the contribution of projects at a sub-regional level, through an assessment of their impact on throughput and travel times relative to cost. These proxies for value for money were used to identify projects worth taking forward into the next round of evaluation.

The Employment Centres package identified an estimated $29.6 billion capital expenditure programme over 30 years (excluding renewals) which is projected to have similar contributions to the ATAP objectives as the APTN. The Employment Centres package is projected to result in a slightly lower proportion of jobs accessible by motorists of 40% (compared to 42% in the APTN), the same proportion of jobs accessible by public transport of 27% (also 27% in the APTN), the same proportion of travel time in severe congestion of 32% in the AM peak (also 32% in the APTN) and a similar public transport mode share of 18.5% in the AM peak (compared to 18.6% in the APTN).

The Employment Centres package as a whole is projected to have similar overall contribution to the ATAP objectives as the APTN package, with a similar sized capital improvement programme.

3.2.3 Key Learnings

Analysis of the Employment Centres package highlights some areas of strength, such as improvements to accessibility for the south and west compared to the APTN, but also some areas of poor performance, such as declining accessibility for the North Shore and the isthmus. The package also sees a decrease in average travel time to work for most of the region and an increase in average trip length.

Although this package does not provide a step-change in regional performance, the impacts at the sub-regional level are significant. In particular, improvements for the west and south appear possible through changes to the mix and timing of investment.

In the south, this includes the extension of mass transit to the airport and the additional widening of SH1. In the northwest, the Northwestern Busway improves public transport accessibility. The extension of the East West Link appears to improve car accessibility to the east.

3.3 Smarter Pricing

3.3.1 Tool Description

As noted, the initial testing phase found that the whole of network pricing system had the greatest high-level potential for improving accessibility, congestion and public transport mode share.

The pricing scheme developed for this phase of analysis reflects these earlier findings by seeking to find balance between increasing the cost of travel to achieve mode, time or route shift that will improve network performance, while targeting this increase to areas where the greatest level of choice is available, average trip lengths are shorter and congestion is greatest.

Our analytical tools are not calibrated to assess the detail of a potential pricing system because of the following:

- They use fixed-trip matrices so are unable to show the extent to which the introduction of pricing may result in trip suppression (trips no longer being made).
- They are also not able to consider different values of time or vary prices at a more micro-level, so provide a very simplistic representation of what the impacts of a scheme might be.

Therefore, the pricing structure we developed for the second phase of the analysis should be considered very much 'hypothetical'.

Key interventions by time period

The pricing structure we developed for Smarter Pricing should be considered very much 'hypothetical'. The pricing structure used is summarised in Table 3.3 below, with prices varying between 3c/km and 40c/km depending on the time of day, location and type of network that the travel occurs within. We assumed that these prices would replace existing fuel excise and road user charges, which average approximately 6c/km.

Table 3.3: Hypothetical variable network-wide pricing system

Hypothetical price levels used for testing (c/km)				
Area	**Network**	**Peak**	**Inter-Peak**	**Off-Peak**
Inner Urban (isthmus)	Motorways	40	30	3
	Other Roads	30	20	3
Outer Urban	Motorways	30	20	3
	Other Roads	20	10	3
Rural	All Roads	3	3	3

The highest prices were targeted to areas with the most congestion and where travel alternatives are most available (e.g. the "inner urban" Auckland isthmus). In outer areas, prices were reduced from the levels used in the earlier round of testing.

The pricing system was tested with complementary infrastructure investment focused on providing improved public transport options and capacity to meet changing travel patterns. The pricing system was introduced for modelling purposes at 2026.

The total estimated 30-year cost of new capital improvements (excluding renewals) of the Smarter Pricing package is $28.7 billion (in 2016 dollars). Figure 3.23 below provides a breakdown of costs by decade and project type. These estimated costs were identified prior to the revision of project costs in ATAP.

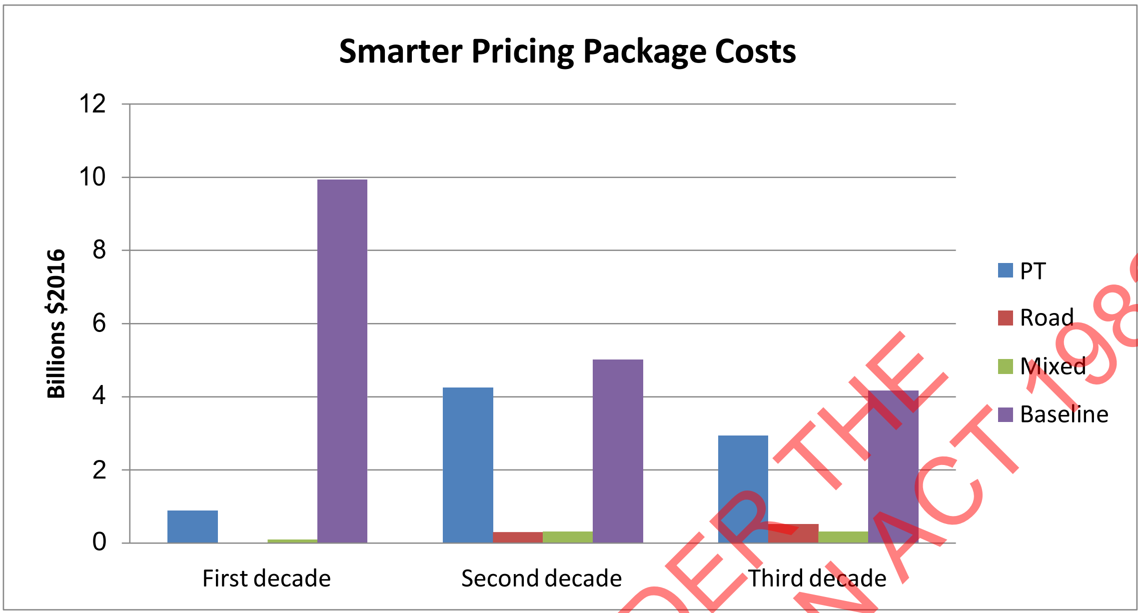


Figure 3.23: Estimated cost of new capital improvements (excluding renewals) of the Smarter Pricing package (2018 – 2048)

Key components of the package over and above the common baseline are outlined in Figure 3.4 below.

Table 3.4: Smarter Pricing key interventions by decade

First Decade (2015-25)	Second Decade (2025-35)	Third Decade (2035-45)
• Network wide pricing system • Northwestern Busway (Westgate to Point Chevalier)	• Penlink • Mt Roskill rail spur • Isthmus light-rail • North Shore rapid transit (city centre to Takapuna) • Rail upgrades to enable Southern Line express trains • AMETI Pakuranga to Botany • Northwestern Busway (Point Chevalier to Newton)	• Extension of isthmus light-rail • Extension of North Shore rapid transit to Albany and Birkenhead

3.3.2 Key Findings

The main effects of the pricing on travel patterns appear to be a slight reduction in trip length made by private vehicles and a mode shift from private vehicle to public transport. There were approximately 39,000 (6%) fewer private vehicle trips and around 16% less vehicle kilometres travelled at peak times in 2046 compared to current plans. These changes have a profound effect on the transport network's performance.

Accessibility

The number of jobs accessible within a 30 minute car journey during the AM peak increases substantially in this package compared to the APTN. This is due to the pricing system reducing the number of vehicle trips during the AM peak by approximately 6% and reducing average trip length by approximately 5%, thereby reducing congestion and increasing travel speeds (Figure 3.24). Public transport accessibility improves more modestly, potentially due to a more effective mix of interventions combined with bus services that mix in general traffic being able to travel at higher speeds due to lower congestion levels.

Car accessibility has a step change improvement through the introduction of smarter pricing in 2026. The trends in the subsequent decades mirror the projections for APTN.

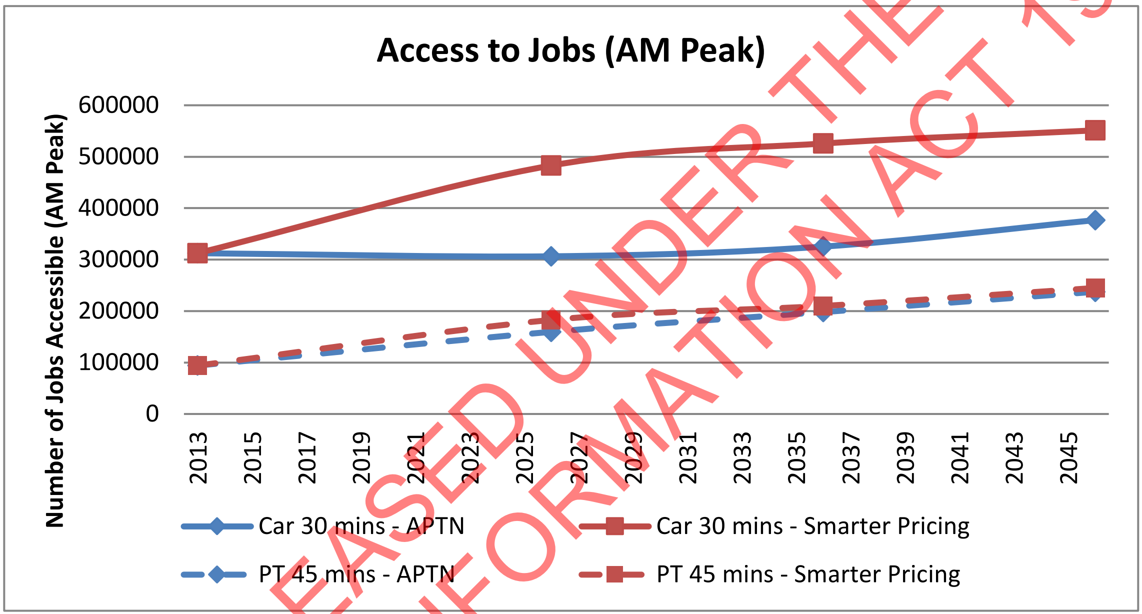


Figure 3.24: Access to jobs (Smarter Pricing and APTN)

On a sub-regional level, improvements in potential job accessibility by car are experienced in the isthmus and the east, as shown in Figure 3.25 below. Decreases in car access are experienced in the west, large parts of the North Shore, and the outer south.

On the other hand, public transport access increases significantly for most areas up to 2026.

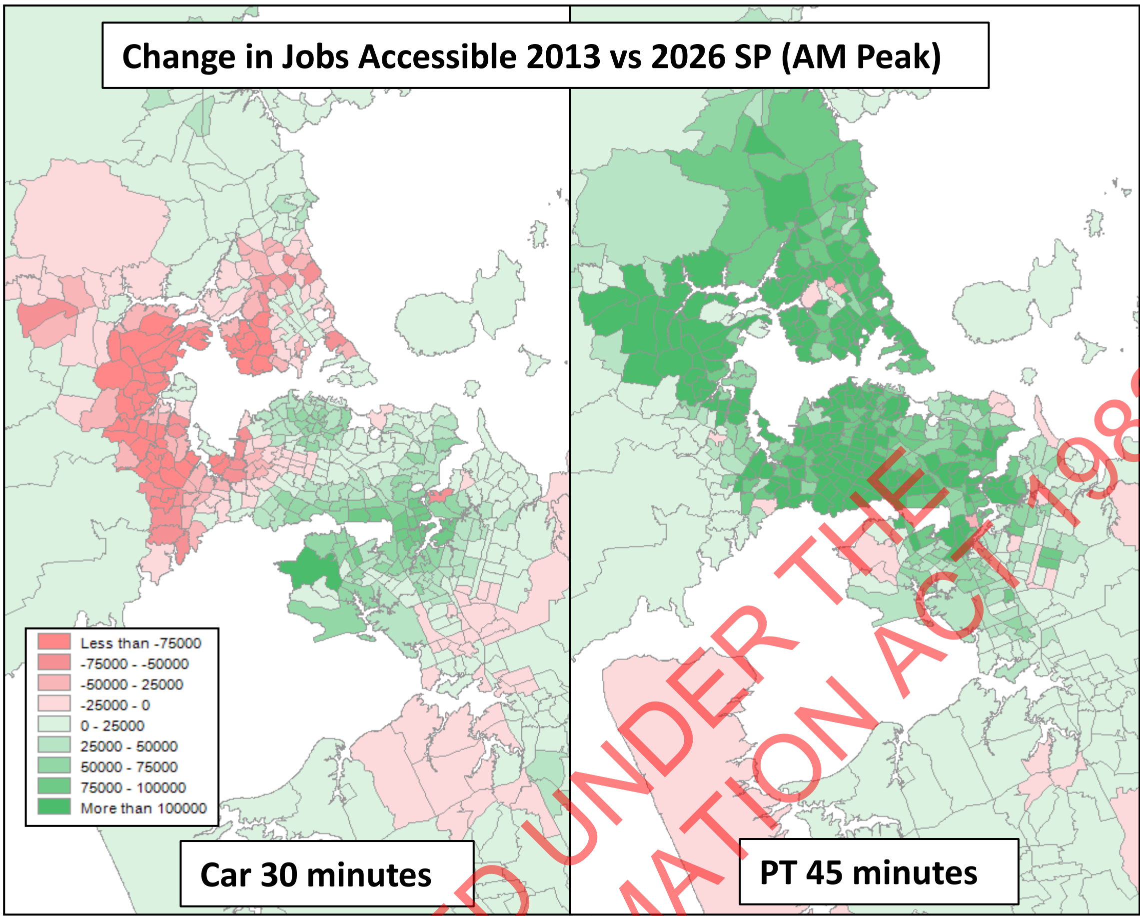


Figure 3.25: Change in jobs accessible 2013 vs 2026 (Smarter Pricing)

Improvements to accessibility continues after 2026 for car and public transport, particularly for the isthmus, northwest, and parts of the south (Figure 3.26). Car access declines for the outer north and the outer south.

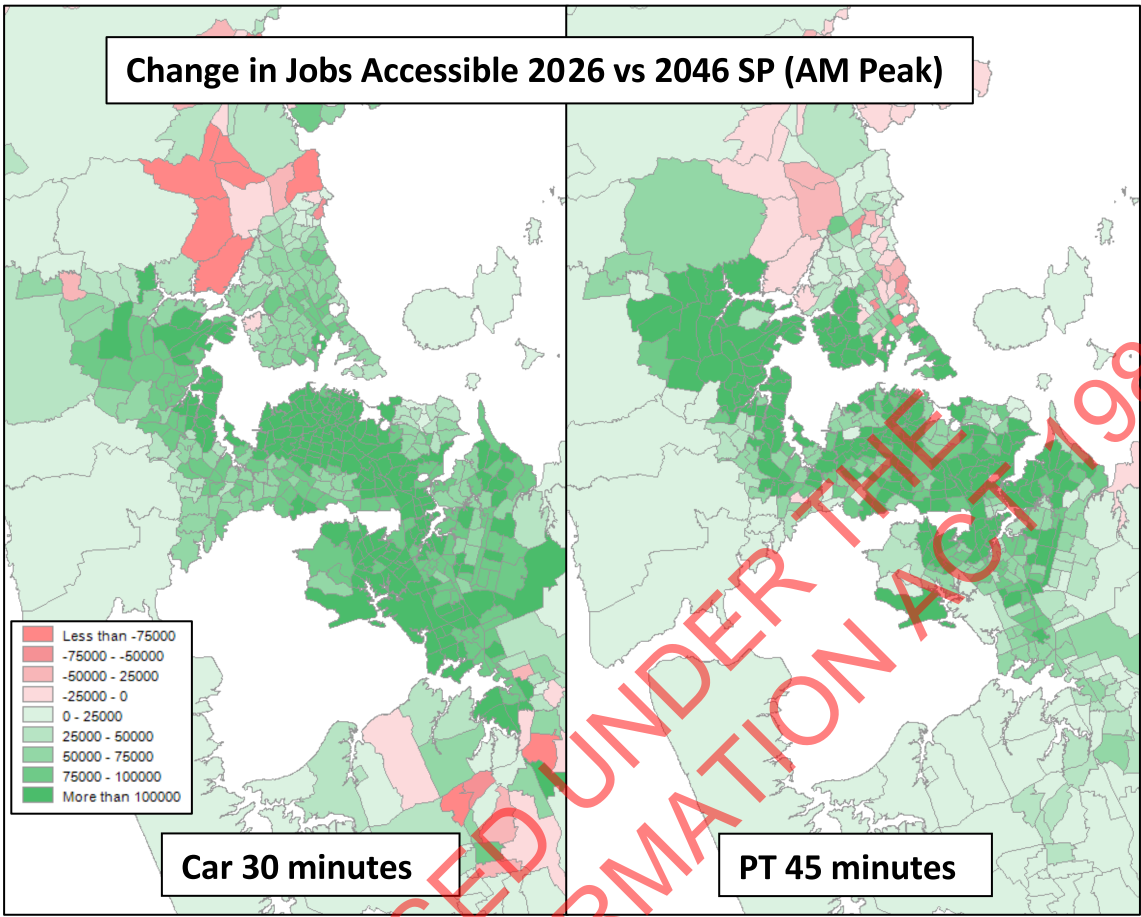


Figure 3.26: Change in jobs accessible 2026 vs 2046 (Smarter Pricing)

Compared to the APTN, car accessibility increases most strongly in the west and south – likely due to faster travel times in these areas bringing them within 30 minutes of the large concentration of jobs in the central area. Public transport accessibility results are more mixed, with the North Shore seeing a decline in access to employment. Upon investigating the reduction in public transport accessibility in the north in more detail, we found that it may have been caused by modelling methodology issues rather than representing a likely future (Figure 3.27).

The improvements in access to employment by car appear to be largely driven by road pricing – a reduction in car trips and shorter trip lengths compared to APTN enables faster travel speeds.

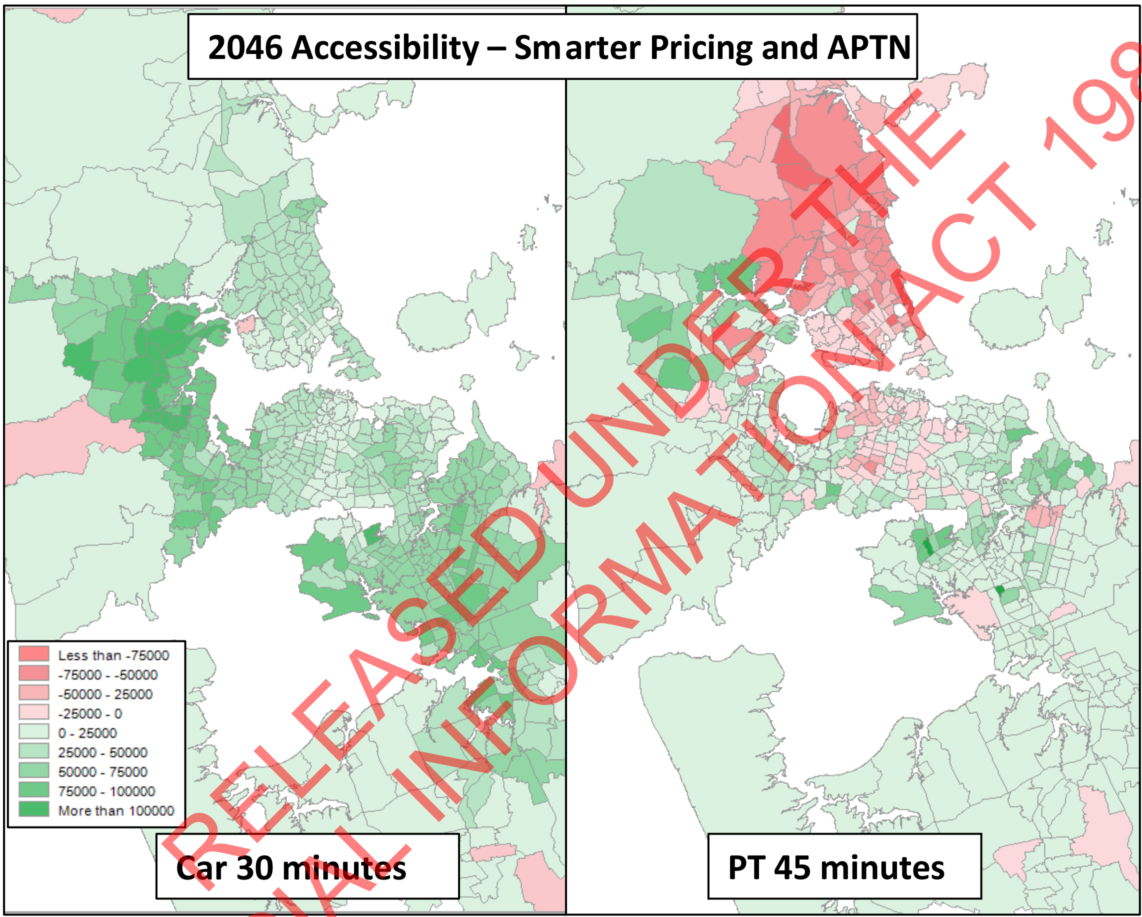


Figure 3.27: Access to jobs in 2046 (Smarter Pricing and APTN)

Congestion

Congestion in the AM peak reduces significantly from 2013 to 2026, due to the implementation of pricing (Figure 3.28). After 2026 there is a modest projected increase although congestion levels are still significantly lower than APTN projections.

Inter-peak congestion is projected to roughly remain at 2013 levels throughout the next 30 years under this package, substantially lower than the APTN projections, which indicate a steady increase over time.

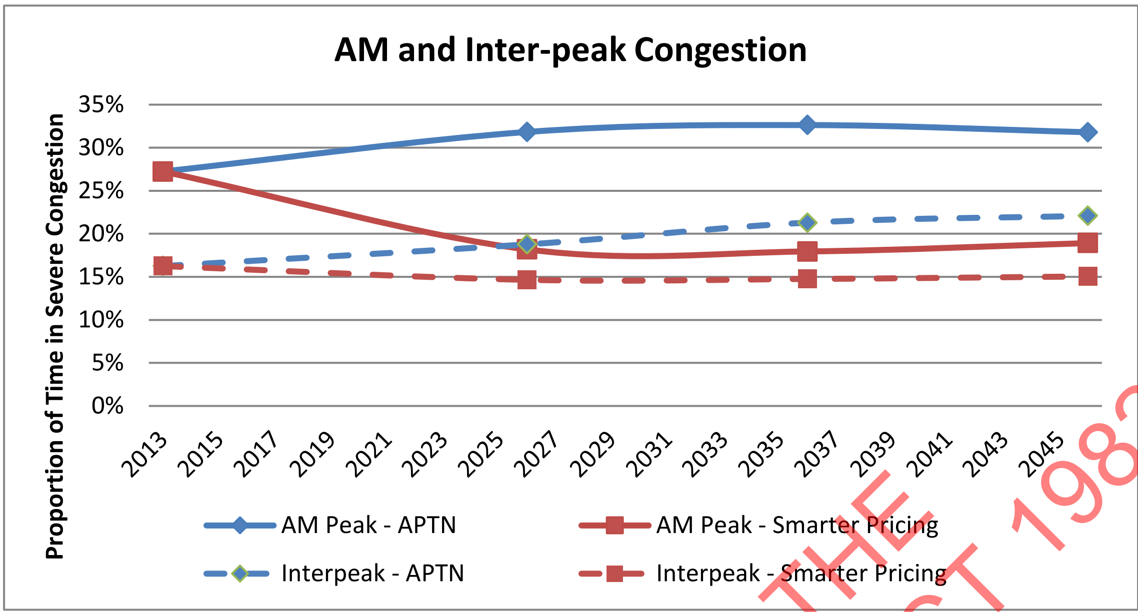


Figure 3.28: AM and inter-peak congestion (Smarter Pricing and APTN)

Freight travel sees similarly large reductions in AM peak compared to APTN (Figure 3.29). In the inter-peak, freight congestion decreases up until 2026, after which it remains constant until 2046. In comparison, inter-peak freight congestion under APTN keeps increasing until 2036, after which it declines slightly.

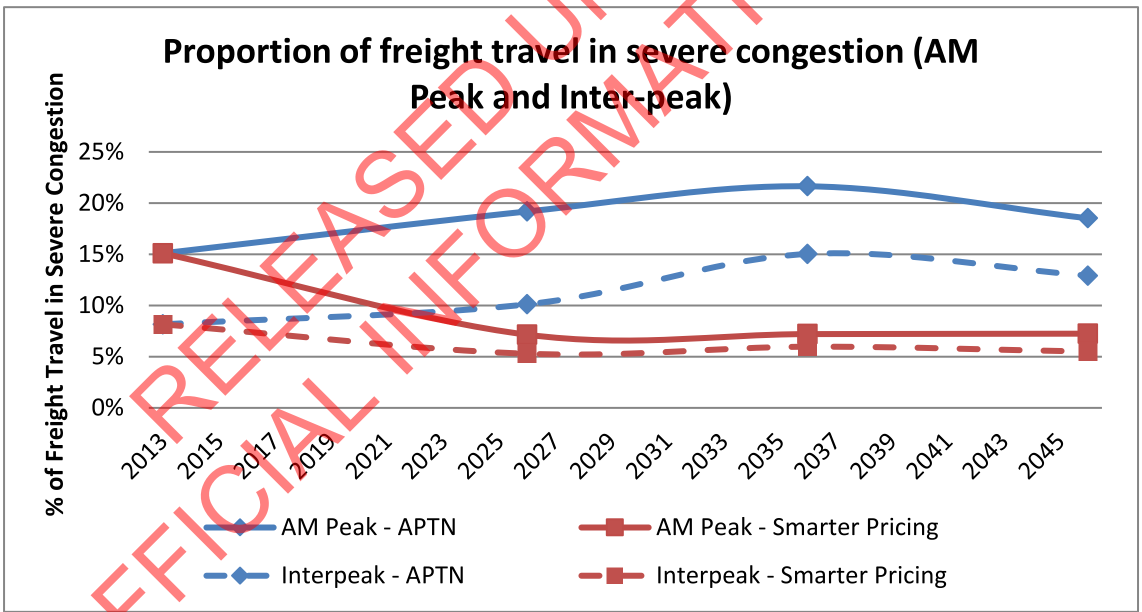


Figure 3.29: Proportion of freight travel in severe congestion (Smarter Pricing and APTN)

Some parts of the roading network still face severe congestion in the AM peak with the implementation of Smarter Pricing, although to a significantly lesser extent than the APTN (Figure 3.30). Severe congestion remains on the Auckland Harbour Bridge (with or without the Additional Waitemata Harbour Crossing) and sections of the Northern Motorway.

Focusing network improvements on areas that would still face congestion after the implementation of pricing provides a good indication of good value.

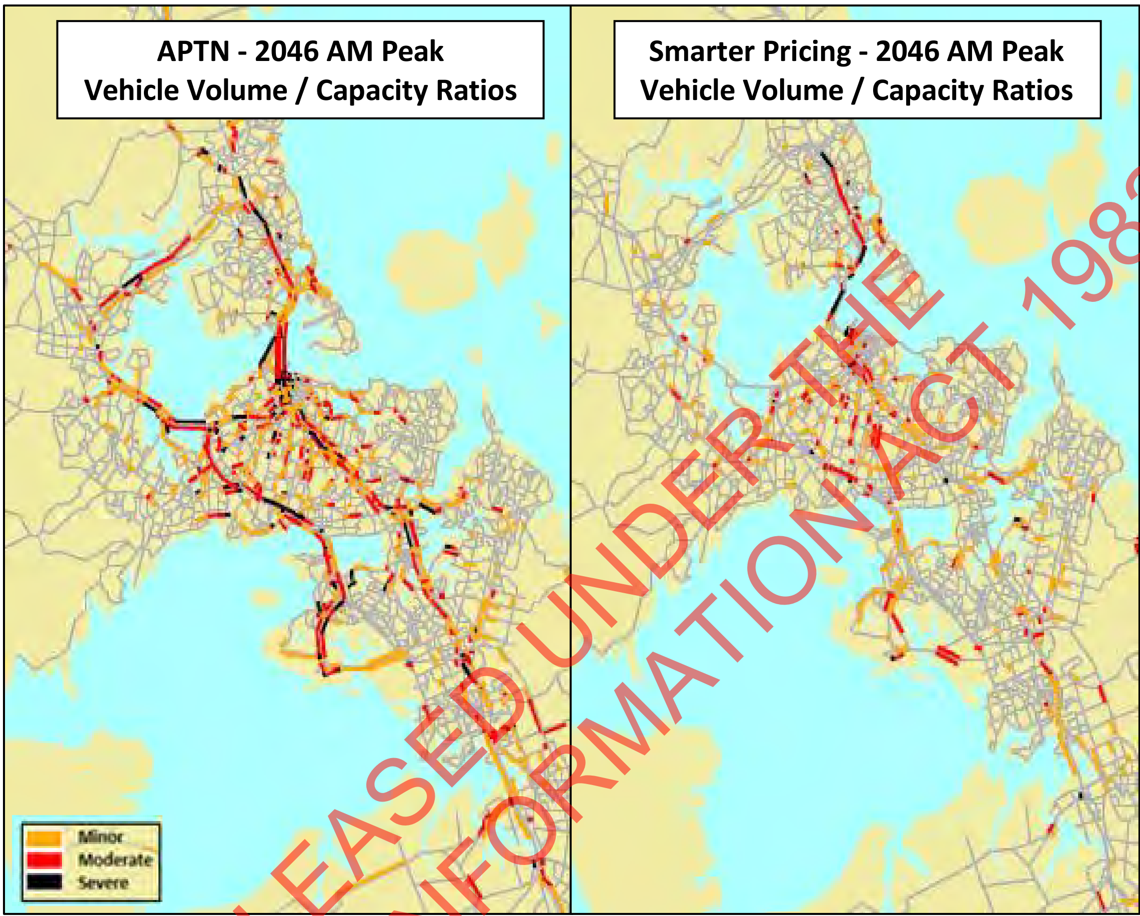


Figure 3.30: AM peak vehicle travel demand (Smarter Pricing and APTN)

Congestion is largely eliminated in the inter-peak under Smarter Pricing (Figure 3.31). While limited severe congestion remains at key pinch points on the network, the removal of even minor congestion suggests that pricing levels may be too high and the scheme applied too broadly.

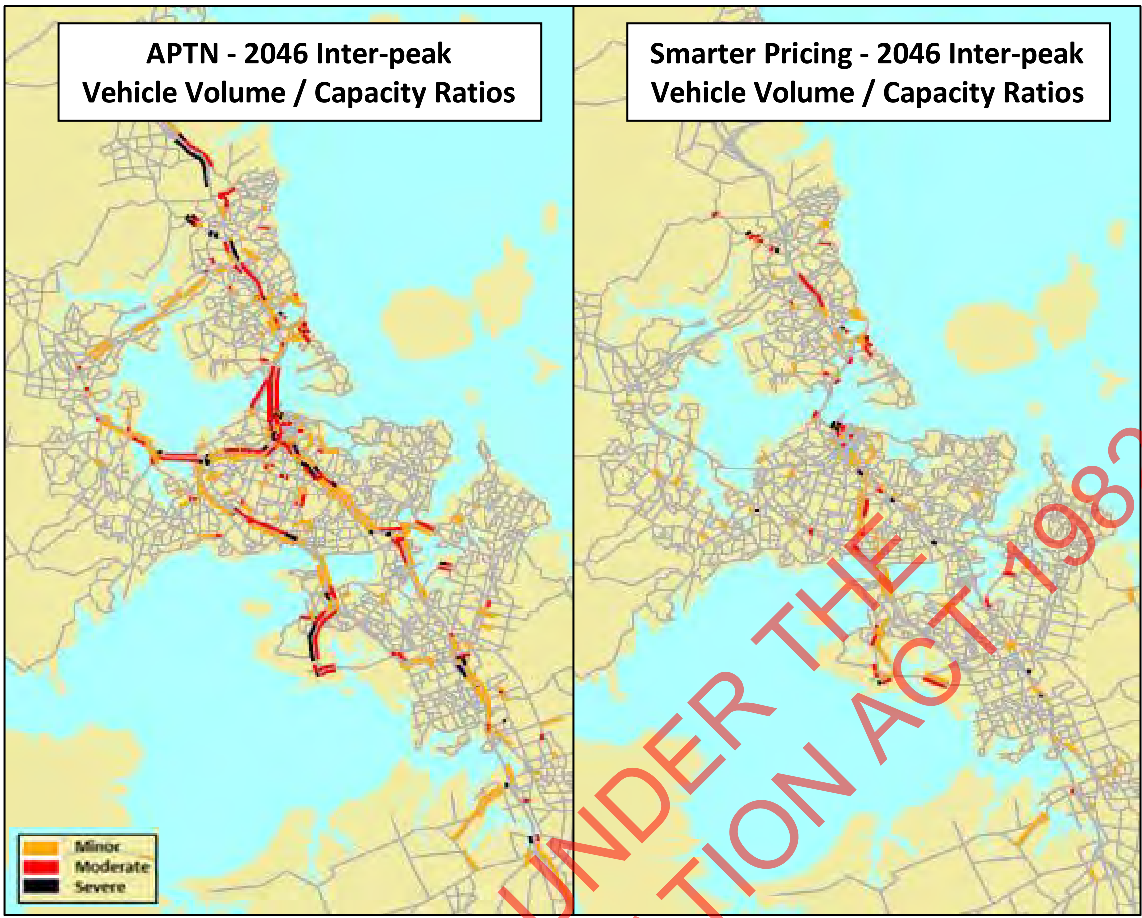


Figure 3.31: Inter-peak vehicle travel demand (Smarter Pricing and APTN)

Public Transport Mode Share

Compared to the APTN, public transport mode share increases substantially in this package, largely in areas where significant public transport investment has taken place (Figure 3.32).

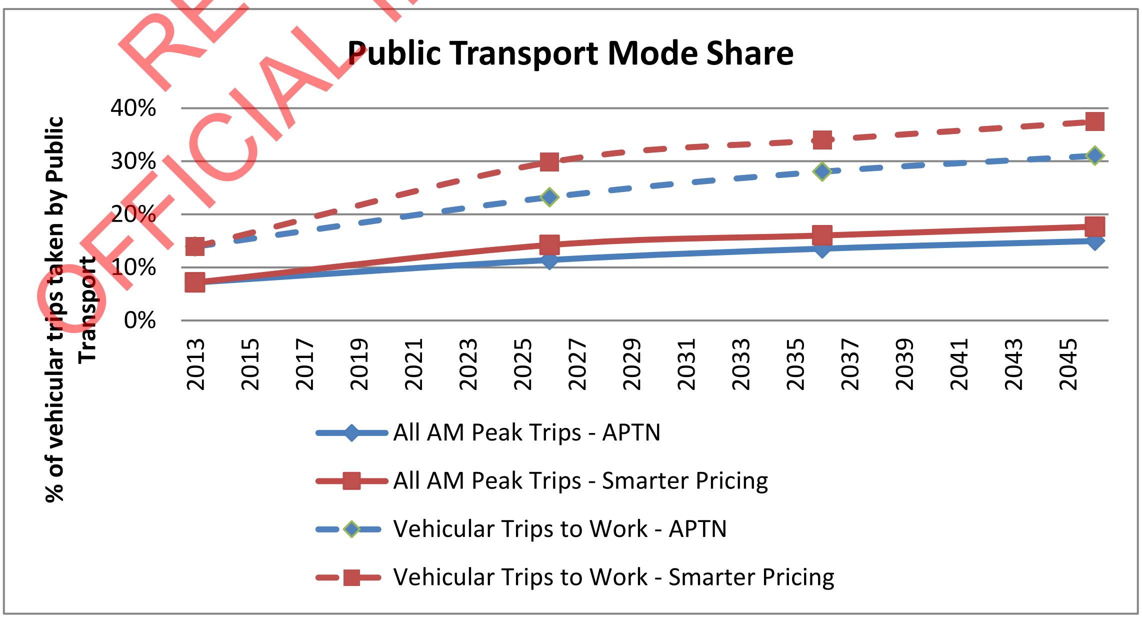


Figure 3.32: Public transport mode share (Smarter Pricing and APTN)

At a sub-regional level, the Smarter Pricing tool shows an increase in public transport mode share in parts of the region up until 2026 (Figure 3.33). By place of origin, this includes the city centre, isthmus, northwest and parts of the North Shore, partly due to the public transport investments occurring in those locations. By destination, the city centre and Westgate see the biggest increase in mode share.

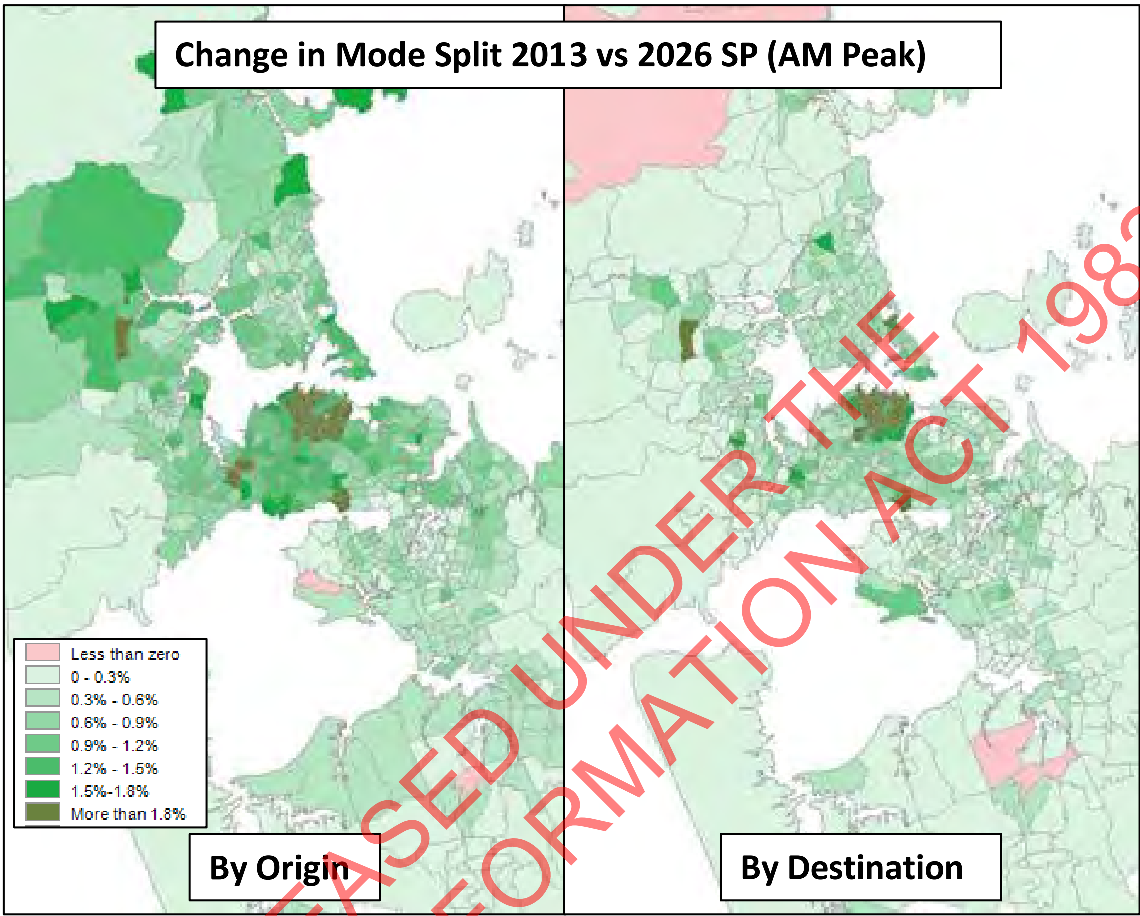


Figure 3.33: Change in mode split 2013 vs 2026 (Smarter Pricing)

Public transport mode share continues to increase after 2026 across the region, although at a lesser rate (Figure 3.34).

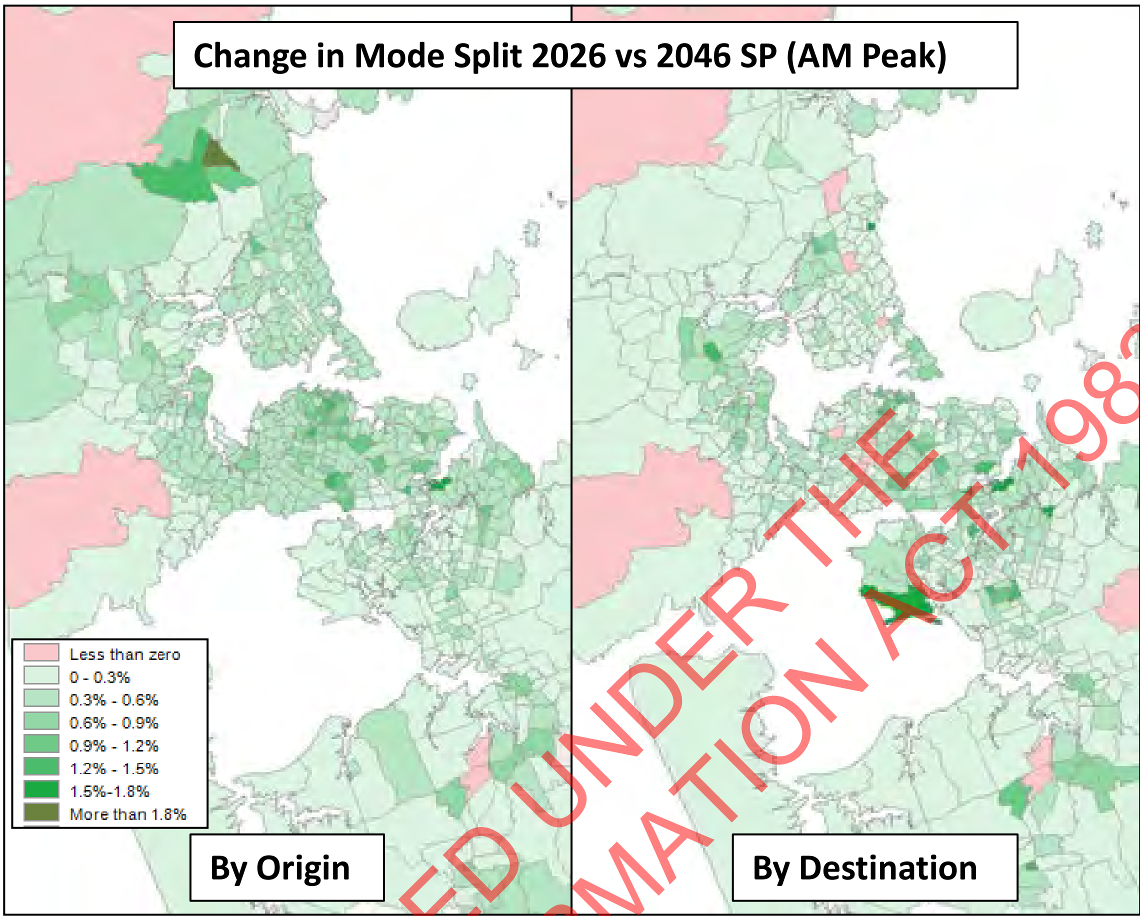


Figure 3.34: Change in mode split 2026 vs 2046 (Smarter Pricing)

While pricing has reduced demand for the roading network, it has substantially increased demand for the public transport network. The volume / capacity plots in Figure 3.35 show that under this pricing regime, much more public transport capacity is required.

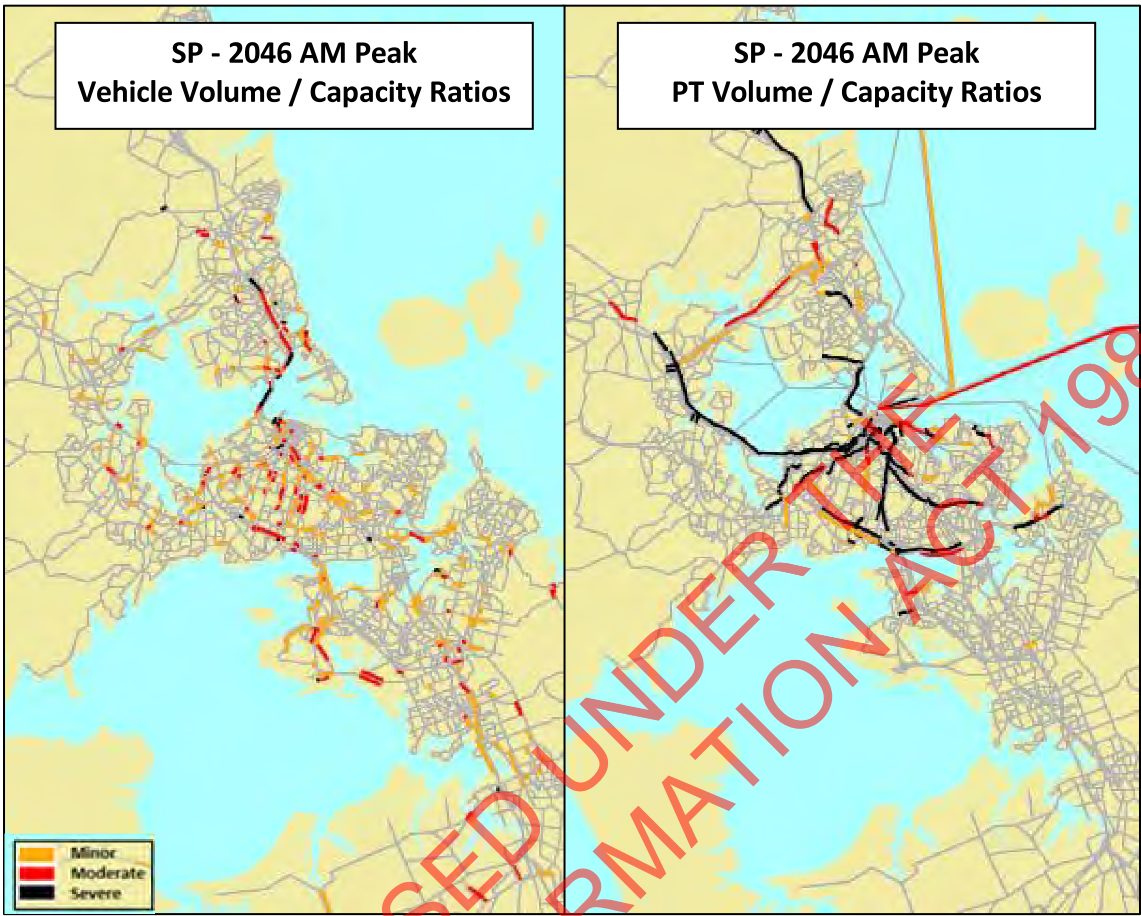


Figure 3.35: Vehicle and public transport demand (Smarter Pricing)

Net Benefits to Users

"Net benefits to users" was estimated because the Smarter Pricing package increases the financial costs of motorists using the transport system. Motorists receive a benefit from the improved network performance (in terms of shorter travel times and lower vehicle operating costs) but also face significantly increased costs from having to pay the network charges (Figure 3.36).

The following map shows the difference in projected generalised costs for motorists in different parts of Auckland in the morning peak in 2046 with Smarter Pricing, compared to the generalised costs in the APTN.

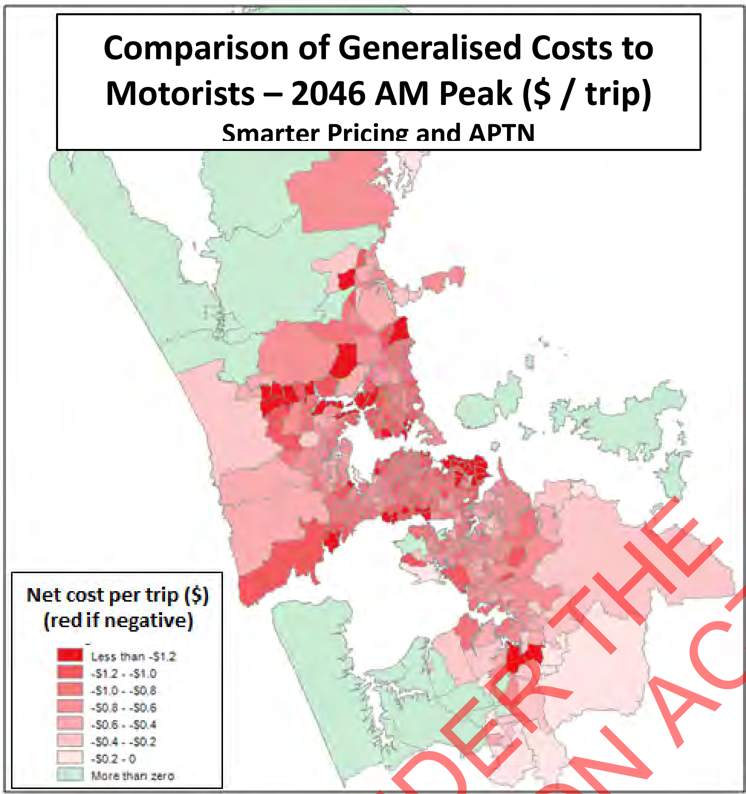


Figure 3.36: Generalised costs to road users - Smarter Pricing and APTN

This analysis balances the network charge that motorists pay against the savings in travel times and lower vehicle operating costs. However, the analysis does not take into account the wider benefits that users of the transport system would gain from increased accessibility and reduced congestion. The increases in net generalised costs above $1 per trip indicate that the price levels set in the morning peak may have been set too high. This assessment helps to inform a pricing level that provides desired demand management effects (i.e. increases in accessibility and reduction in congestion) at a lower financial cost to motorists.

Value for Money

Value for money assessments considered both network wide effects and isolating the contribution of projects at a sub-regional level, through an assessment of their impact on throughput and travel times relative to cost. These proxies for value for money were used to identify projects worth taking forward into the next round of evaluation.

The Smarter Pricing package has an estimated $28.7 billion capital expenditure programme over 30 years (excluding renewals) which is projected to result in significantly higher contributions to the ATAP objectives compared to the APTN. The package is projected to result in a higher proportion of jobs accessible by motorists of 62% (compared to 42% in the APTN), the same proportion of jobs accessible by public transport of 27% (also 27% in the APTN), a significantly lower proportion of travel time in severe congestion of 19% in severe congestion in the AM peak (compared to 32% in the APTN) and a higher public transport mode share of 22.1% in the AM peak (compared to 18.6% in the APTN).

3.3.3 Key Learnings

The Smarter Pricing package as a whole is projected to have significantly higher contributions to the project objectives than the APTN package, with a similar sized capital improvement programme, but at a higher average cost to motorists.

Our analysis of smarter pricing showed it offers the potential to achieve a step-change in transport network performance and should therefore form a core part of the strategic approach. However, setting prices at the right levels is extremely challenging as performance improvement, travel time savings and increased travel costs need to be carefully balanced.

3.4 Cross Package Review

3.4.1 Overview

The Capacity Constraints and Employment Centres packages as well as the Smarter Pricing packages were compared against the APTN to understand the extent to which they appear to deliver better returns than current plans. The main findings from the cross package review are listed below:

- Smarter Pricing shows significantly better travel time accessibility, congestion and public transport mode share results. However, at the price level it imposes significant financial costs on many users which may outweigh travel time reductions.
- The Capacity Constraints and Employment Centres packages show relatively similar regional results to APTN, despite a different mix of projects. However, regional results mask some sub-regional differences, with the impacts of most infrastructure investments seen at the sub-regional level.
- Bringing forward motorway widening provides some improvements to congestion in 2036, however only Smarter Pricing provides a major impact on congestion.
- A very large increase in projected bus passengers over the next 30 years is predicted, which will create capacity 'pinch points' with significant challenges to meet demand. It is unlikely that smarter transport pricing and technology will reduce this challenge.
- Care is needed in interpreting public transport results, as the ART model does not take account of crowding. In reality, public transport crowding would result in some users shifting to car, with increased congestion on the road network.
- The next phase of evaluation needs to test whether better results can be obtained by investing more in the first decade. Strategic choices appear to be between demand management and investing more on infrastructure.

3.4.2 Accessibility

Accessibility by Car

Both the Capacity Constraints and Employment Centres packages show slight to moderate improvements compared to the APTN up until 2036, after which accessibility provided under the Employment Centres package plateaus (Figure 3.37). However, Smarter Pricing produces the step-change in car access.

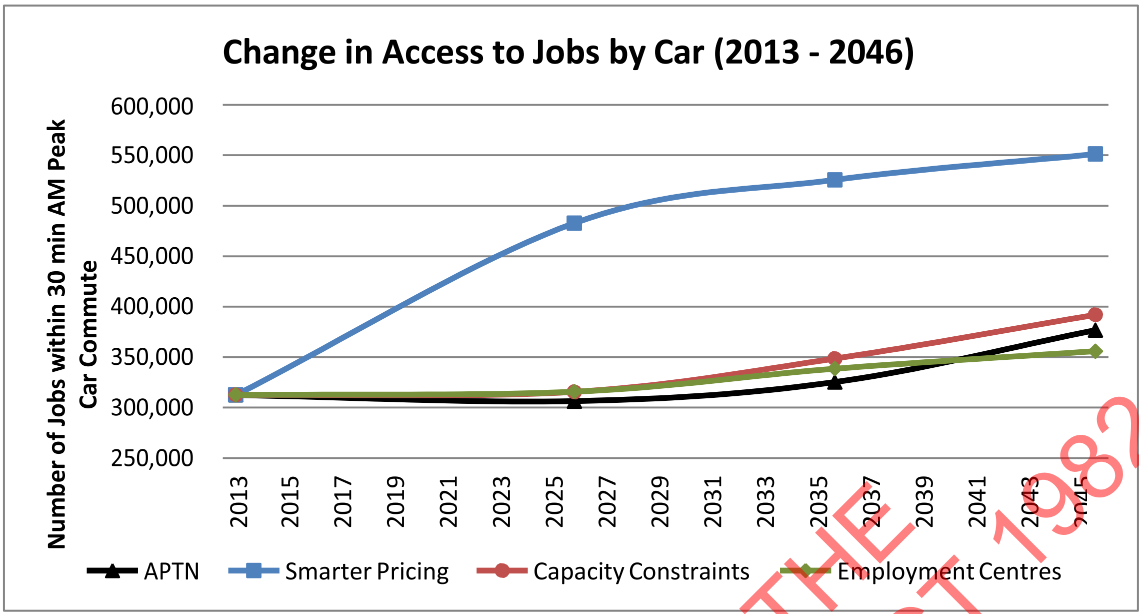


Figure 3.37: Change in number of jobs accessible within a 30 minute car commute AM peak (2013 – 2046)

In terms of public transport access, the Employment Centres package shows slight improvements compared to APTN (Figure 3.38). The Capacity Constraints package performs slightly better compared to APTN up until 2036. Smarter Pricing provides the highest level of public transport accessibility, particularly in the first and second decades, though at a more moderate scale compared to car access.

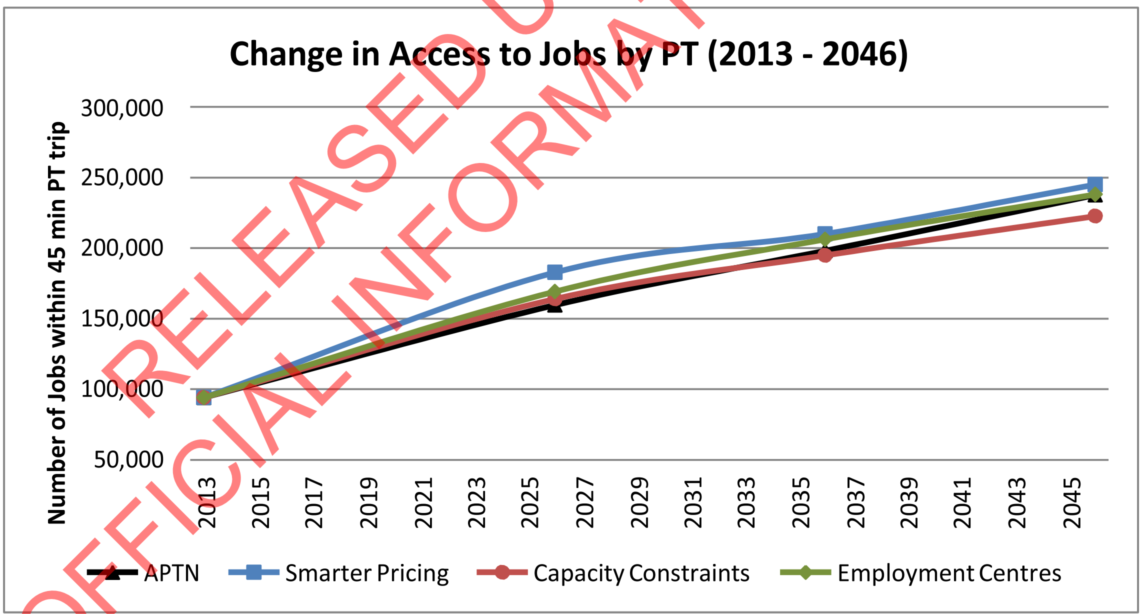


Figure 3.38: Change in number of jobs accessible within a 45 minute PT commute AM peak (2013 – 2046)

Despite having a very different mix of projects, the Capacity Constraints and Employment Centres packages show very similar results to the APTN on a regional level, particularly between 2013 and 2026.

Between 2026 and 2046, car accessibility improves across the region for Capacity Constraints, which has a motorway-widening theme, while public transport accessibility improves in certain parts of the region for Employment Centres, which focuses more on mass rapid transit.

Car accessibility by sub-region

The figures below show the potential accessibility to jobs by car for the four sub-regions. Calculating accessibility based on sub-region shows that smarter pricing provides the highest level of accessibility for all sub-regions.

While changing the mix of investment (through focusing on capacity constraints and employment centres) does not achieve a 'step-change' in regional performance, impacts at a sub-regional level are significant. In particular, improvements for the west and south appear possible through changes to the mix and timing of investment. This is important because these were areas where access challenges were found to be most significant in the first phase of the project.

West:

When assessing the change in car accessibility from 2013 in West Auckland, all three packages tested show better performance can be achieved, especially with Smarter Pricing (Figure 3.39). In comparison, access to employment by car under APTN declines in the first decade and only increases marginally after 2036.

Both Capacity Constraints and Employment Centres increase the number of jobs able to be reached within a 30 minute car commute from the west by around 20% in 2036 compared to the APTN.

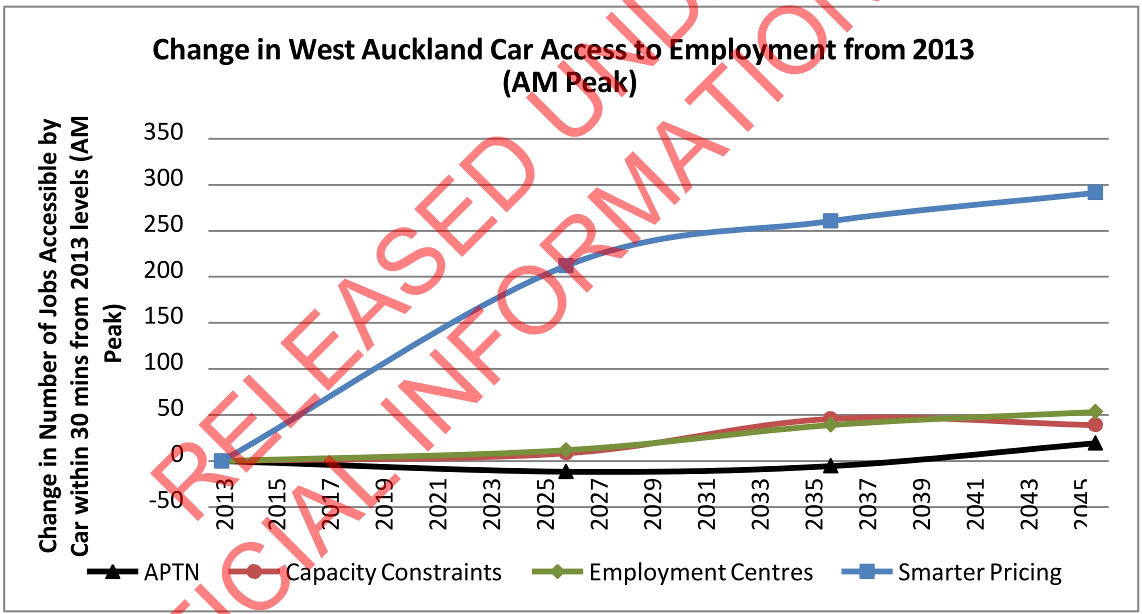


Figure 3.39: Change in West Auckland car accessibility AM peak from 2013

South:

In South Auckland, all three packages show improved performance on accessibility compared to APTN, which declines in the first decade and only improves strongly after 2036 (Figure 3.40). Some of the projects that may have had an impact include the selective widening of SH1, SH20A and SH20 in both the second and third decades.

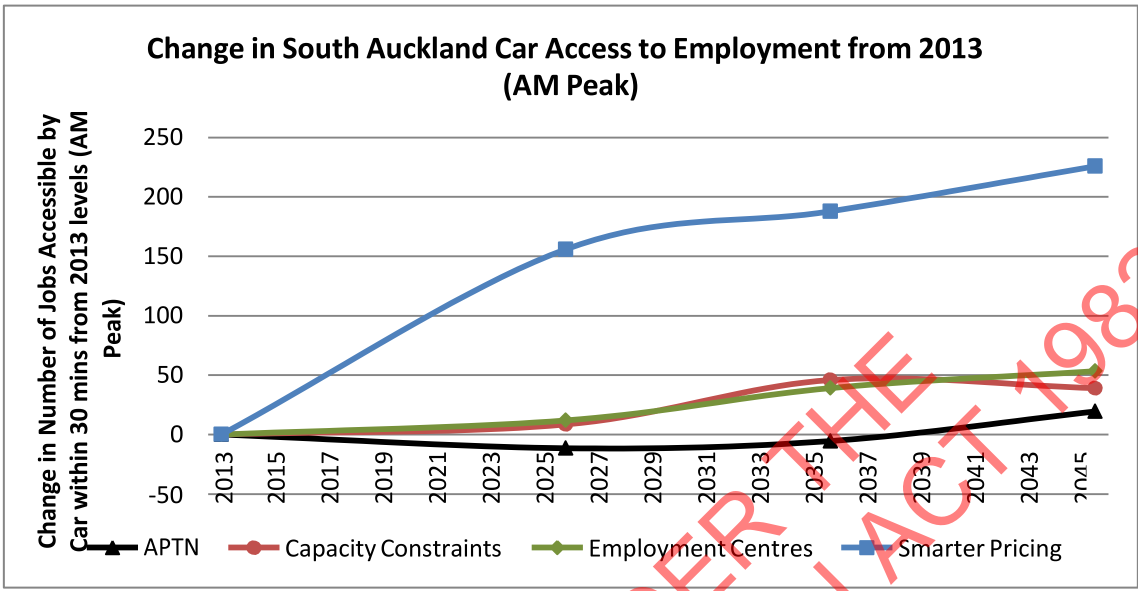


Figure 3.40: Change in South Auckland car accessibility AM peak from 2013

North:

Only Smarter Pricing brings a step-change to performance in accessibility for the north, despite the inclusion of the Additional Waitemata Harbour Crossing in both Capacity Constraints and APTN (Figure 3.41). Both Capacity Constraints and Employment Centres perform similarly to the APTN up until 2026, after which Employment Centres plateaus and Capacity Constraints perform similarly to APTN.

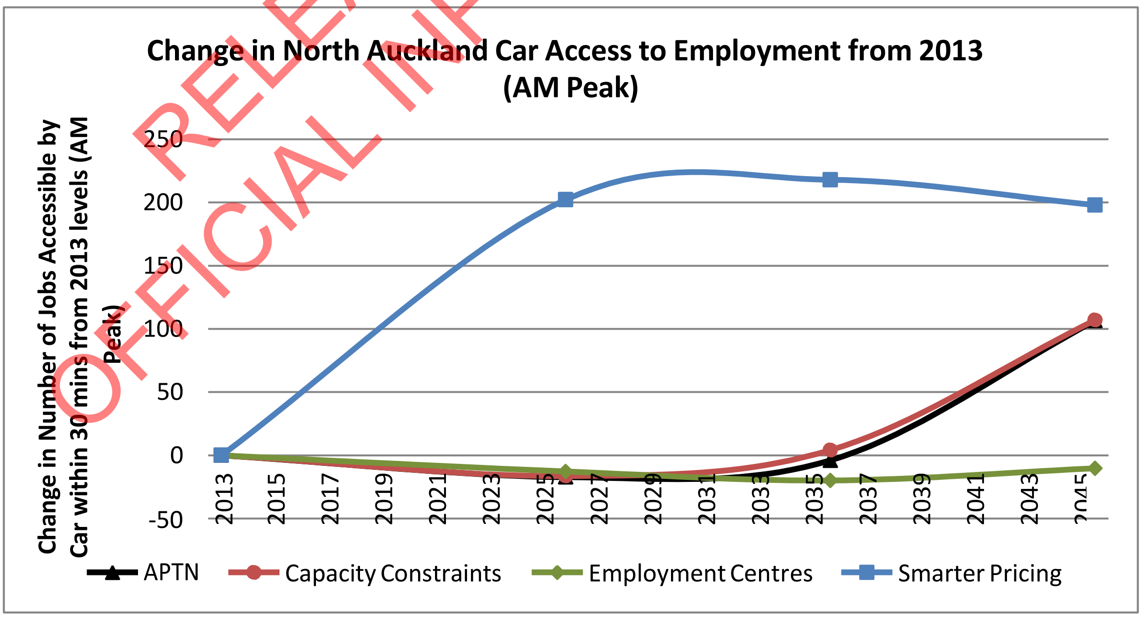


Figure 3.41: Change in North Auckland car accessibility AM peak from 2013

Central:

Central Auckland also sees Smarter Pricing providing the step-change in accessibility (Figure 3.42). Both Capacity Constraints and Employment Centres perform similarly to APTN up until 2026, after which both packages improve. Accessibility provided under Employment Centres plateaus after 2036.

Minor improvements in the central area such as the addition of a northbound lane at the Newmarket viaduct may have led to improved accessibility.

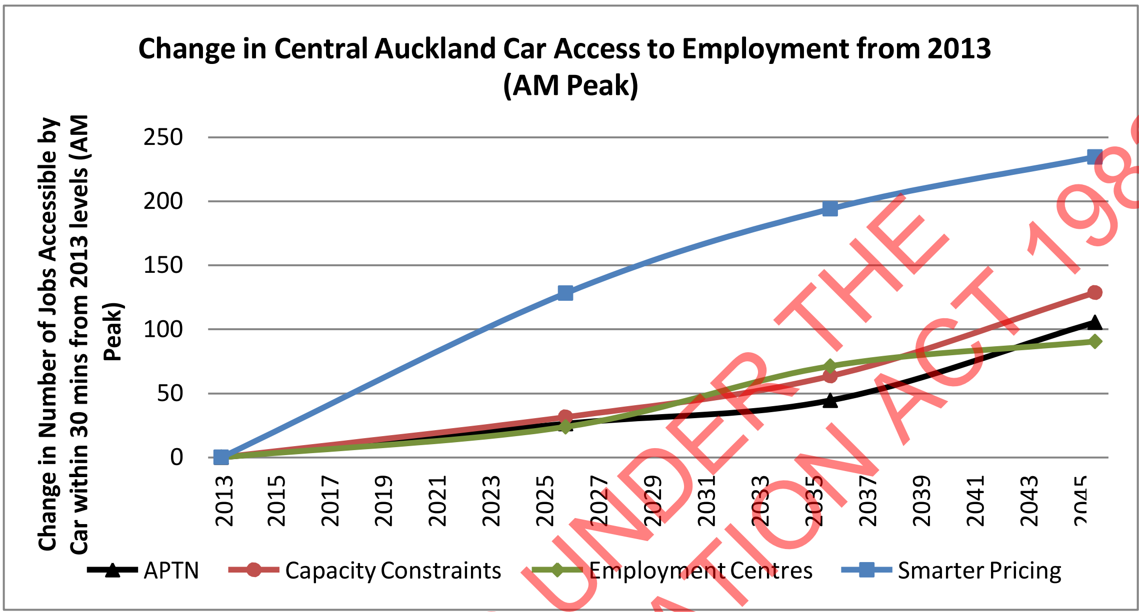


Figure 3.42: Change in Central Auckland car accessibility AM peak from 2013

Spatial analysis of car accessibility

Smarter Pricing increases car accessibility across the region between 2013 and 2026, whereas APTN, Employment Centres and Capacity Constraints largely show increased accessibility on the isthmus, inner south and outer north, and declining accessibility elsewhere (Figure 3.43).

Smarter Pricing continues to show increased car accessibility between 2026 and 2046, except for the area around Albany which sees a decline in accessibility (Figure 3.44). Both APTN and Capacity Constraints see improved accessibility for the North Shore due to the inclusion of the Additional Waitemata Harbour Crossing.

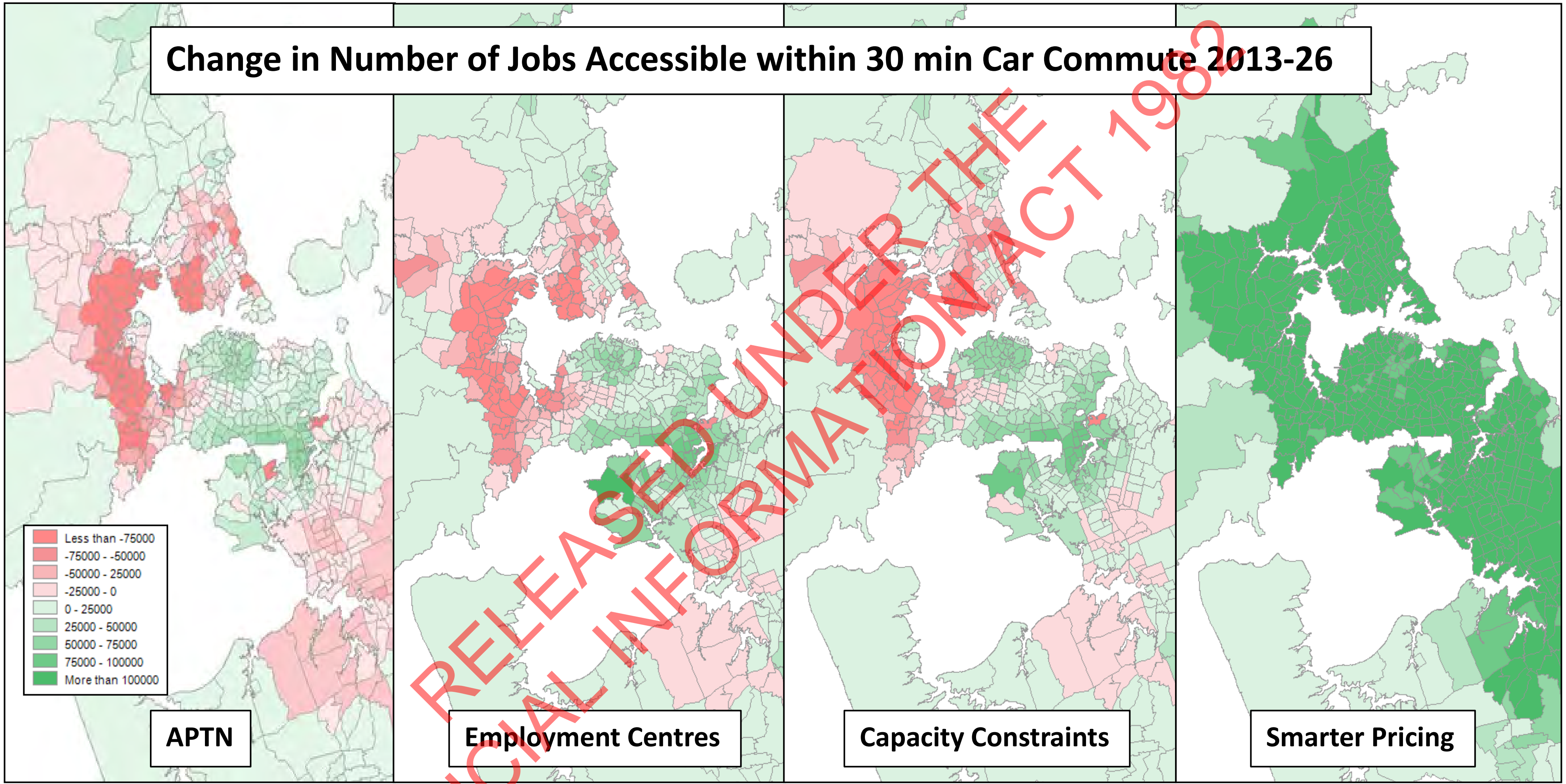


Figure 3.43: Change in number of jobs accessible within a 30 minute car commute AM peak (2013 – 2026)

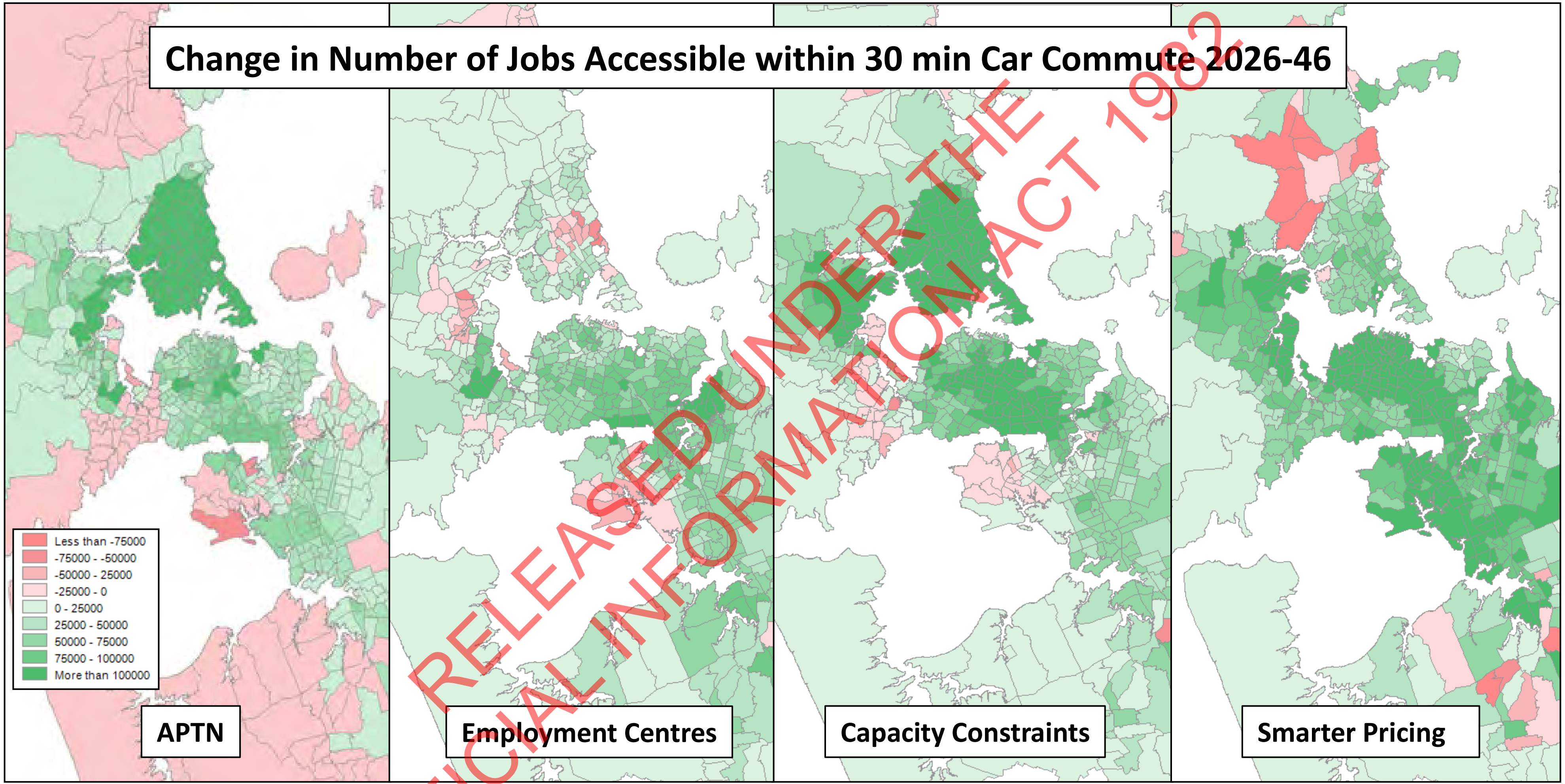


Figure 3.44: Change in number of jobs accessible within a 30 minute car commute AM peak (2026 – 2046)

Public transport accessibility

Public transport accessibility by sub-region

The figures below show the number of jobs able to be reached within a 45-minute public transport commute for each package on a sub-regional level.

The ART3 model is limited by the fact the capacity of public transport vehicles is not constrained.

West:

The west sees the greatest variation in public transport accessibility between the packages analysed (Figure 3.45). As mentioned before, Smarter Pricing and the Employment Centres package provided substantially higher public transport accessibility than the other packages, particularly in 2026 and 2036. Advancing the full Northwestern Busway from Kumeu to the city centre in this package is the main contributor to this improvement.

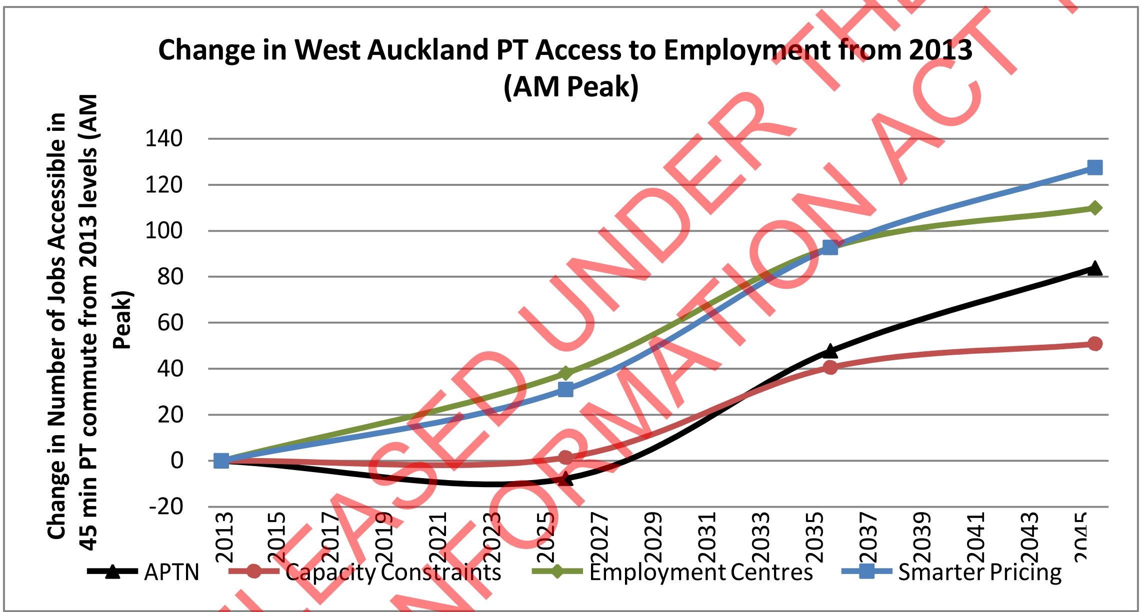


Figure 3.45: Change in West Auckland public transport accessibility AM peak from 2013

South:

In the south, both Capacity Constraints and Employment Centres provide similar levels of public transport access in the first decade compared to APTN (Figure 3.46). Smarter Pricing provides the highest level of accessibility, although the Employment Centres package catches up briefly in 2036. Rail upgrades to enable the Southern Line express trains are likely to be the main contributor to this improvement.

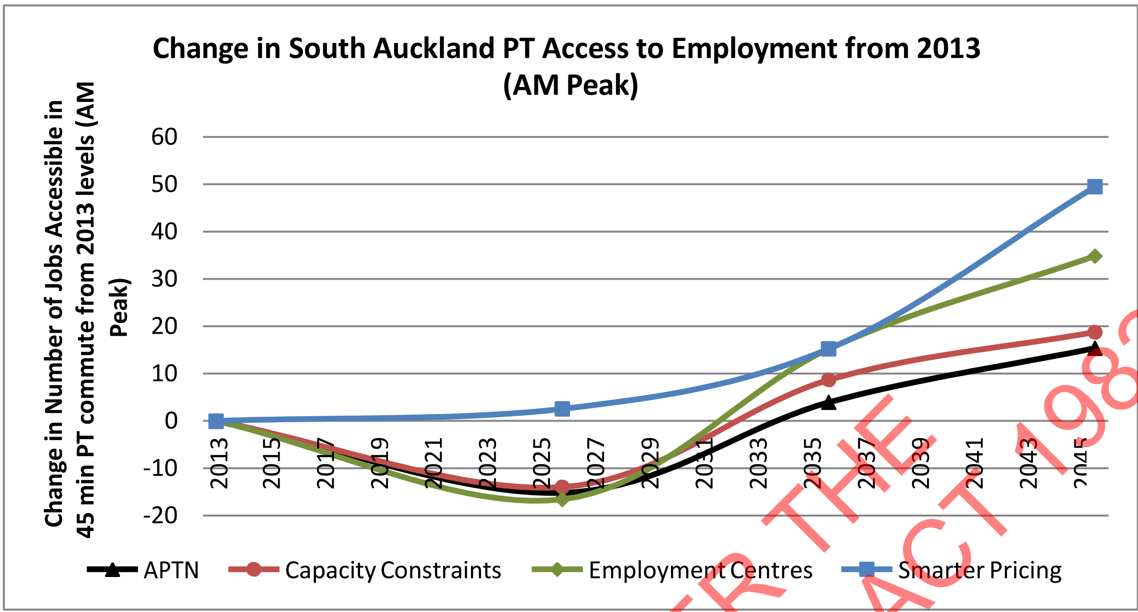


Figure 3.46: Change in West Auckland public transport accessibility AM peak from 2013

North:

In the north, all three packages tested perform better than APTN in the first decade, although the APTN catches up in the final decade (Figure 3.47).

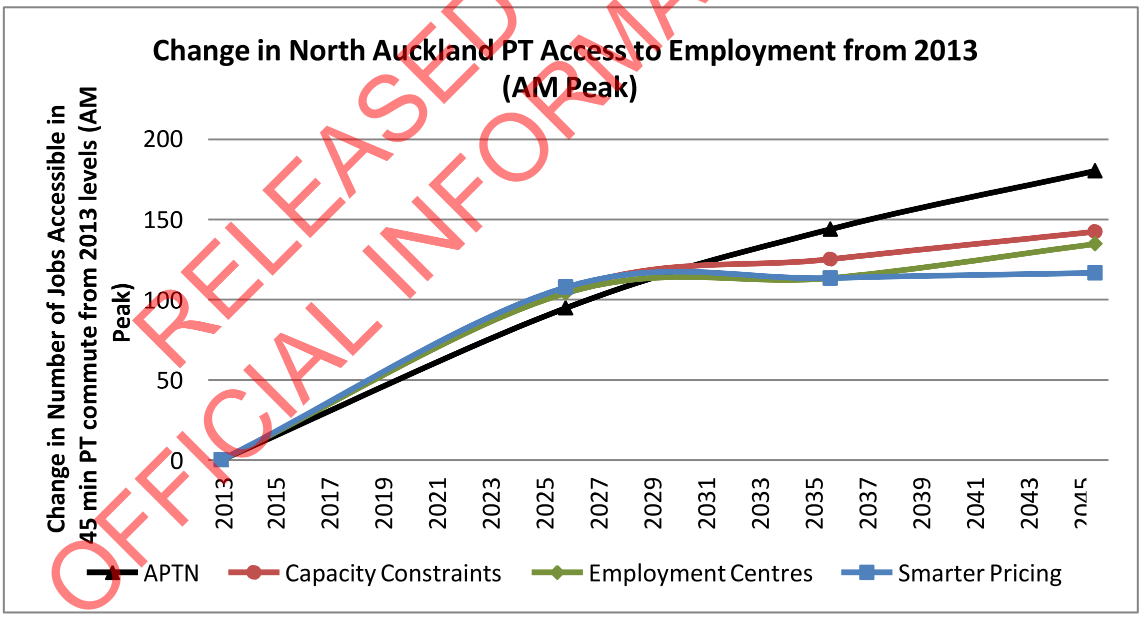


Figure 3.47: Change in North Auckland public transport accessibility AM peak from 2013

Central:

In the central area, Smarter Pricing sees the highest increase in public transport access between 2013 and 2036, largely due to the inclusion of both the isthmus mass transit and Mt Roskill rail spur (Figure 3.48). Capacity Constraints tracks similarly to APTN, while Employment Centres improves after 2026 to reach similar levels of accessibility as Smarter Pricing.

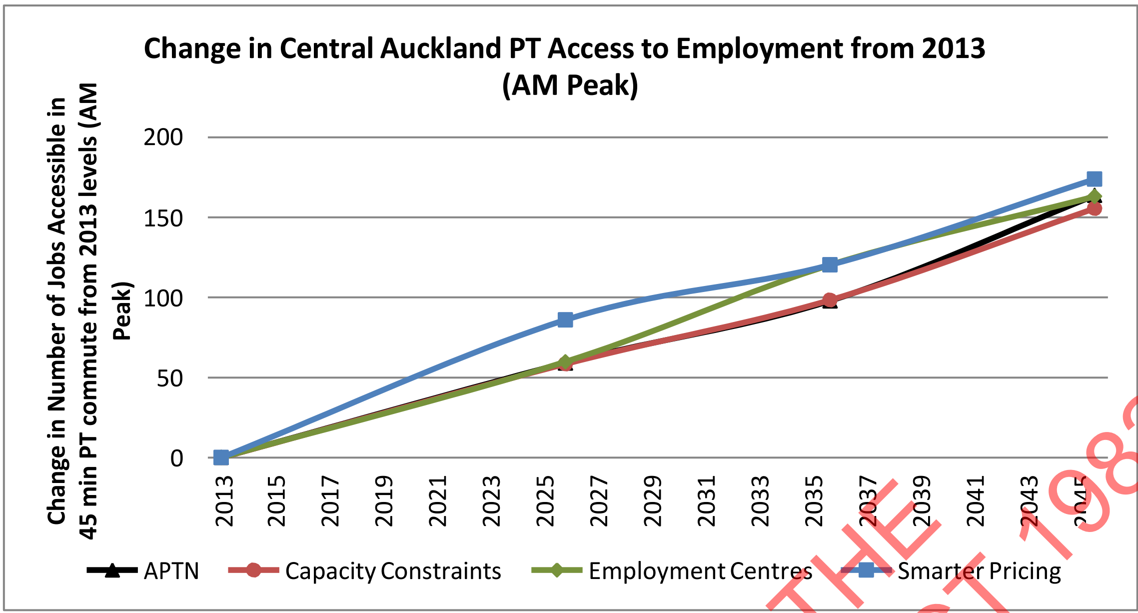


Figure 3.48: Change in Central Auckland public transport accessibility AM peak from 2013

Spatial analysis of public transport accessibility

APTN, Employment Centres, Capacity Constraints and Smarter Pricing all see increases to public transport accessibility across the region between 2013 and 2026, particularly around the isthmus and the North Shore (Figure 3.49). Employment Centres also see improved accessibility in the northwest as a result of the addition of the Northwestern Busway in the first decade.

Public transport accessibility improvements vary between the packages between 2026 and 2046 (Figure 3.50). Smarter Pricing sees the greatest improvement to public transport access, although it also sees decreases to accessibility on parts of the North Shore.

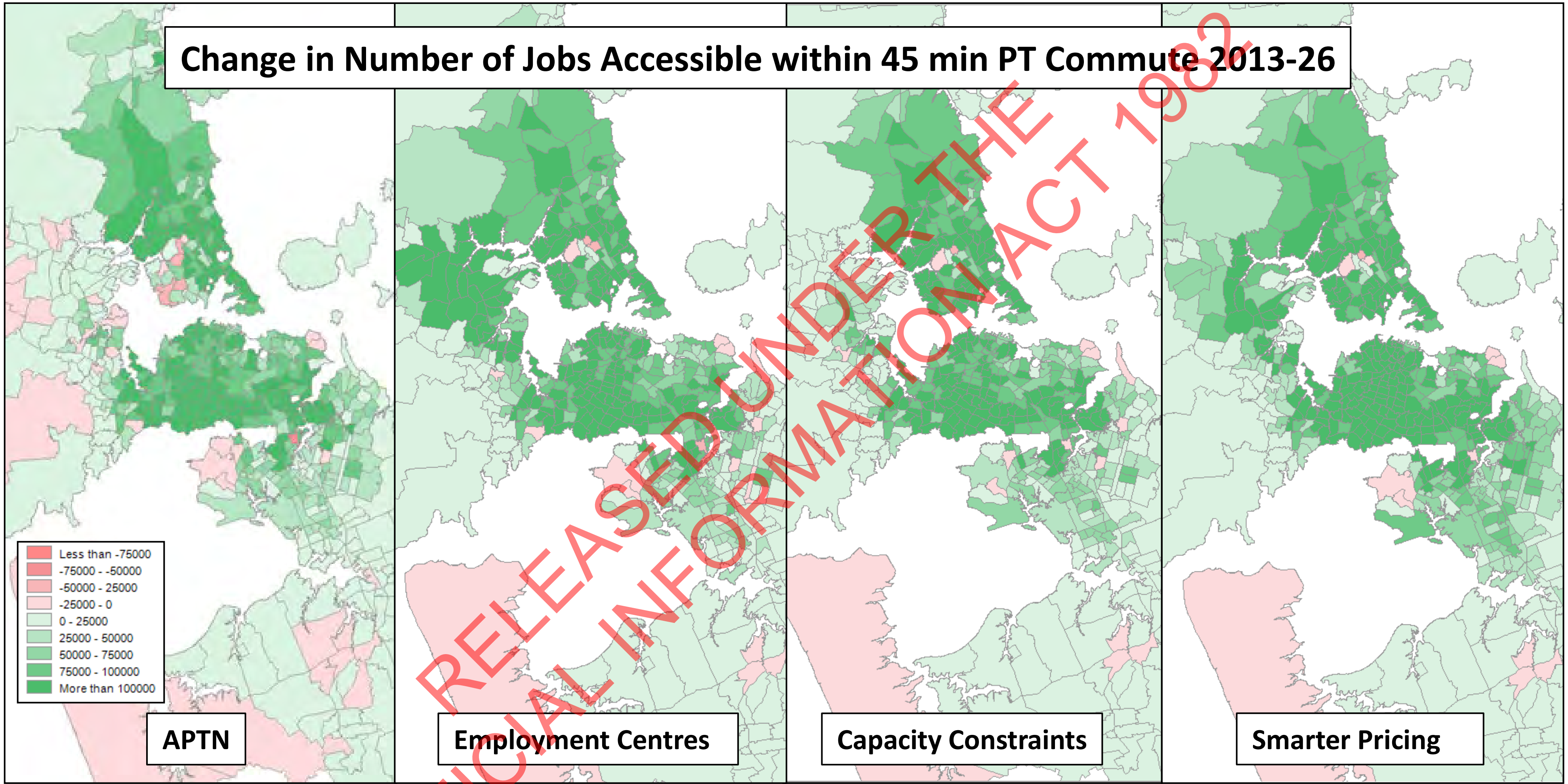


Figure 3.49: Change in number of jobs accessible within a 45 minute public transport commute AM peak (2013 – 2026)

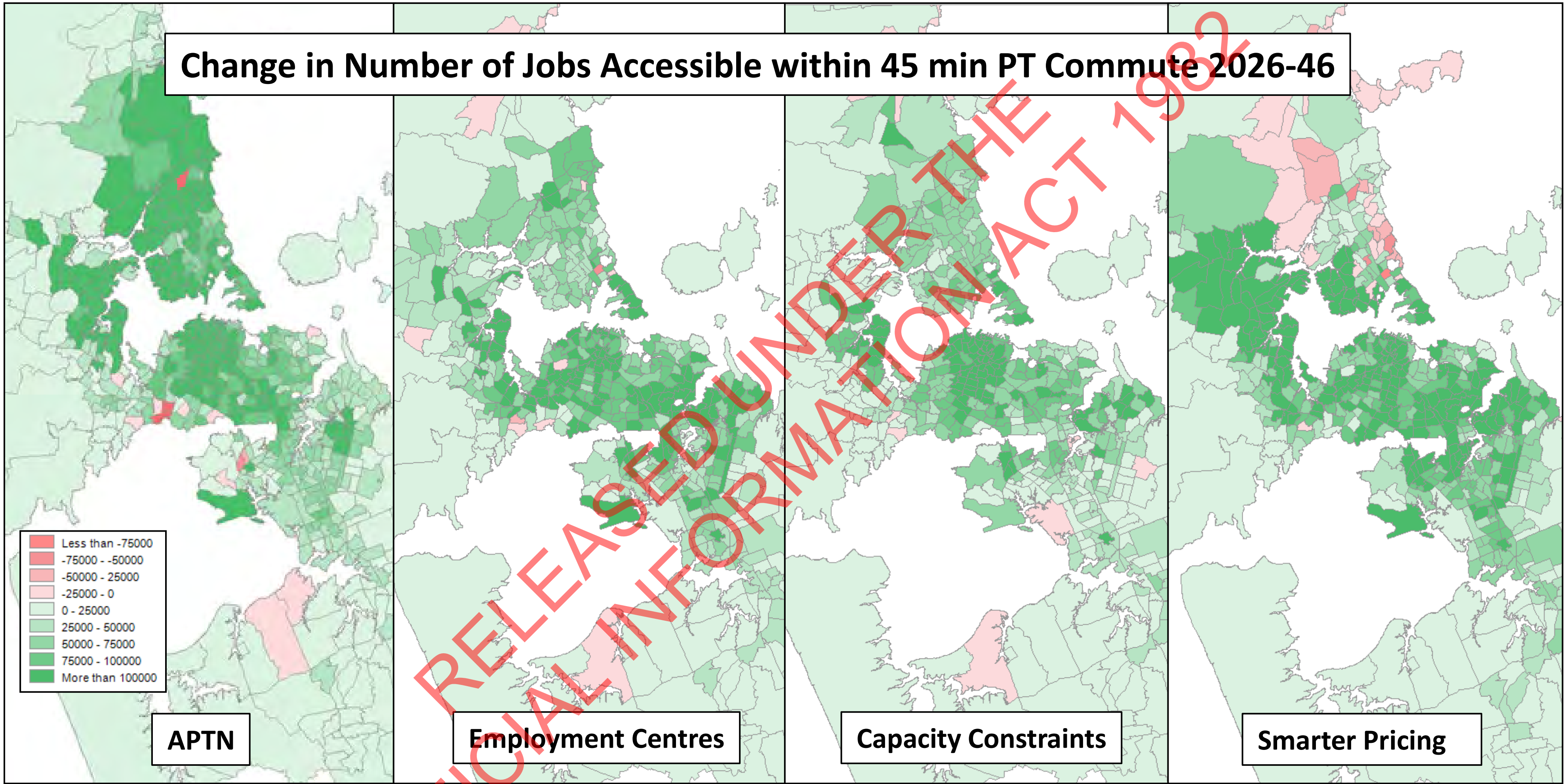


Figure 3.50: Change in number of jobs accessible within a 45 minute public transport commute AM peak (2026 – 2046)

3.4.3 Congestion

Both the Capacity Constraints and Employment Centres packages show small improvements compared to the APTN, particularly within the first decade (Figure 3.51). Congestion levels under Employment Centres gradually increase from 2026 until they reach the same level as APTN in 2046. Congestion levels remain the same under Capacity Constraints between 2026 and 2046. Smarter Pricing is the only option that shows a 'step-change' in congestion alleviation, with the biggest reduction taking effect in 2026.

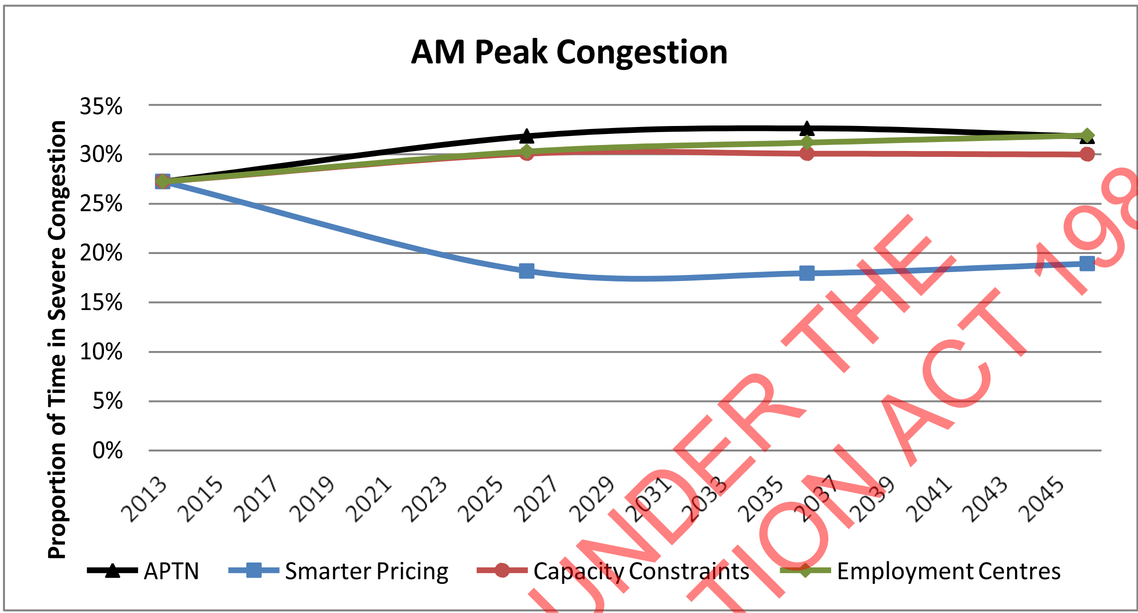


Figure 3.51: AM Peak Congestion (2013 – 2046)

Inter-peak congestion sees similar patterns to the AM peak, with Smarter Pricing showing the biggest reduction in congestion (Figure 3.52).

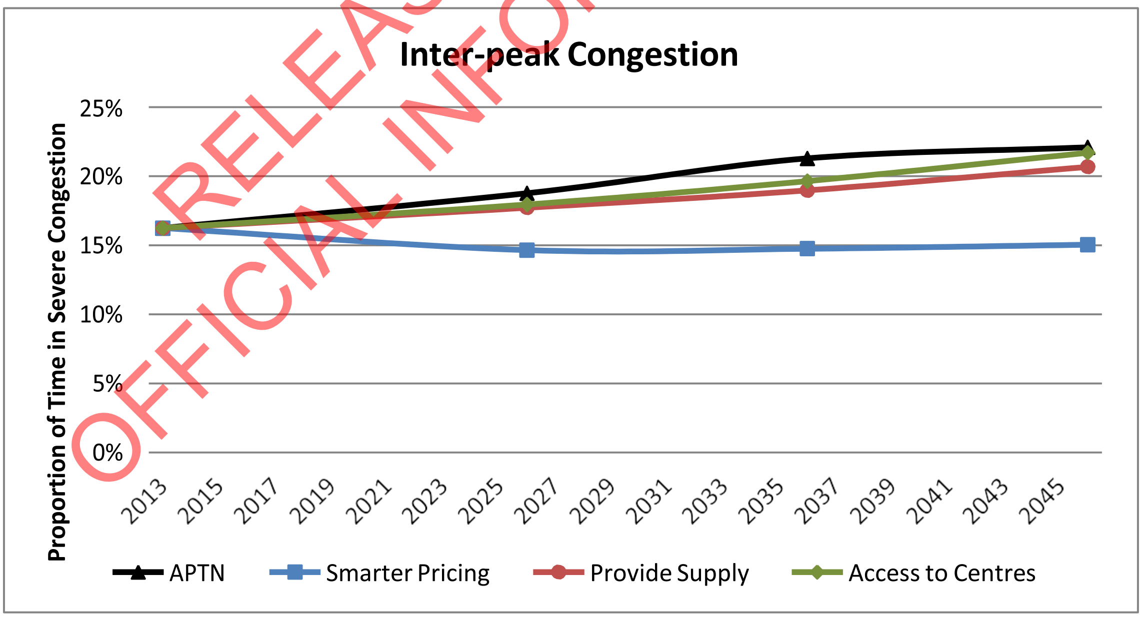


Figure 3.52: Inter-peak Congestion (2013 – 2046)

At a sub-regional level, congestion remains an issue in the 2046 AM peak under the Capacity Constraints package despite motorway widening being brought forward. Severe congestion is seen particularly on SH16, SH20, the Auckland Harbour Bridge and parts of the Northern Motorway (Figure 3.53). Only Smarter Pricing has any discernible impact on congestion, followed by the Employment Centres package.

The inter-peak sees less severe congestion on the network compared to the AM peak, although limited congestion remain on key pinch points (Figure 3.54). All packages see an improvement to inter-peak congestion compared to the APTN, particularly on SH20A and parts of the Northern Motorway. The removal of even minor congestion on the network under Smarter Pricing indicates that pricing levels may be too high.

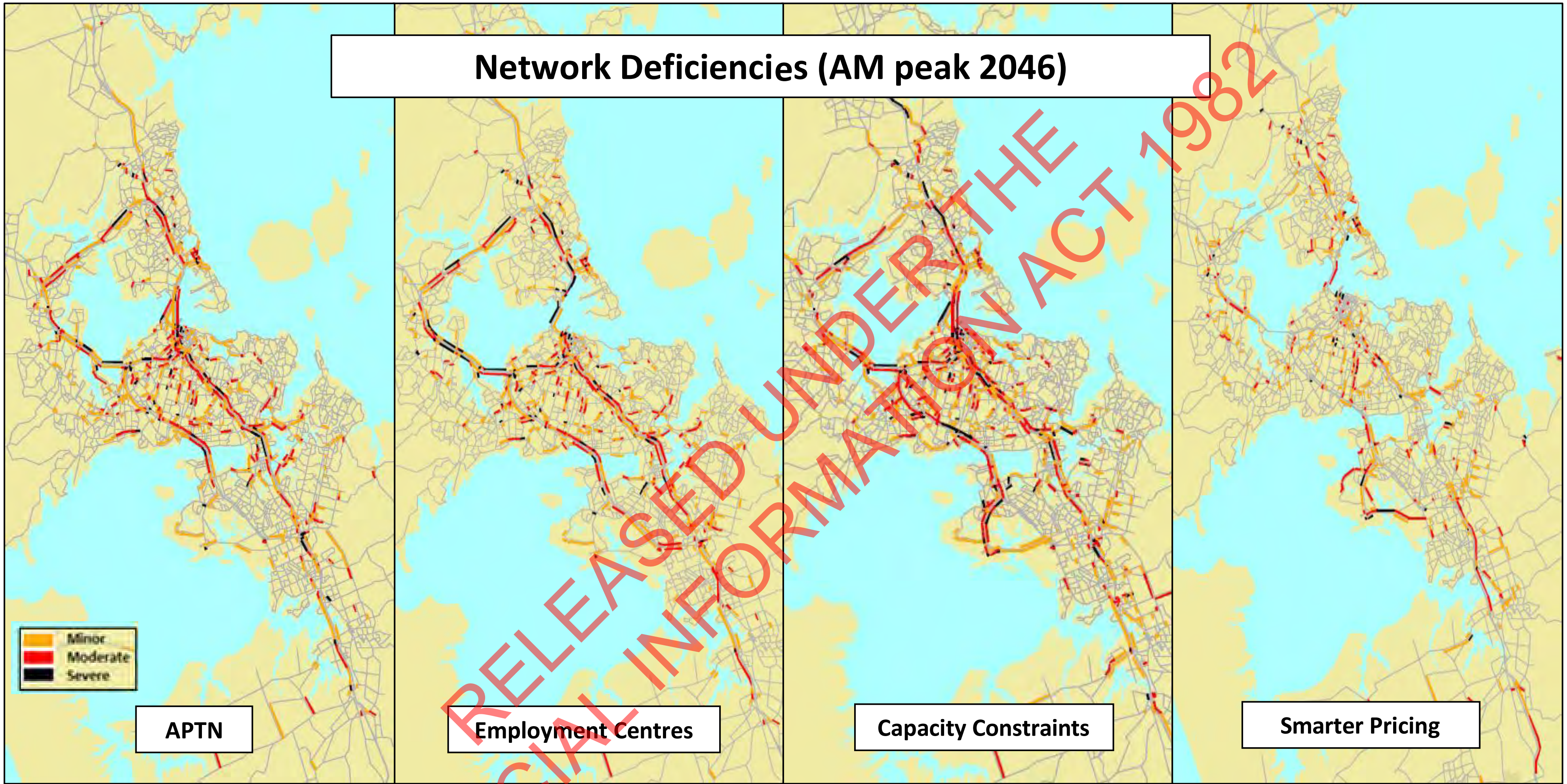


Figure 3.53: Network deficiencies in the AM Peak (2046)

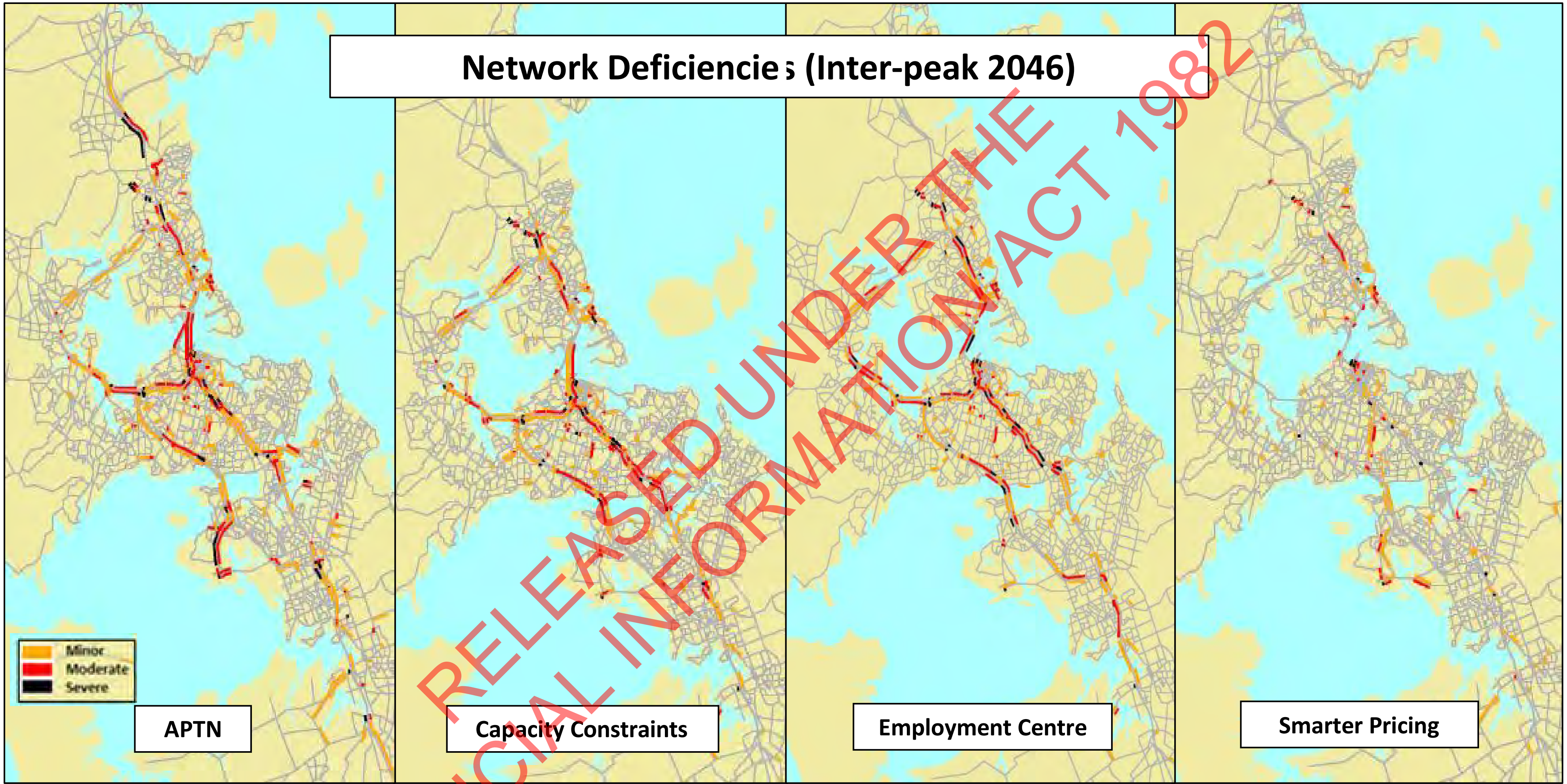


Figure 3.54: Network deficiencies in the Inter-peak (2046)

3.4.4 Public Transport Mode Share

Public transport mode share tracks similarly under APTN, Capacity Constraints and Employment Centres (Figure 3.55). Due to the increased cost of driving resulting from Smarter Pricing, public transport mode share shows moderate improvements.

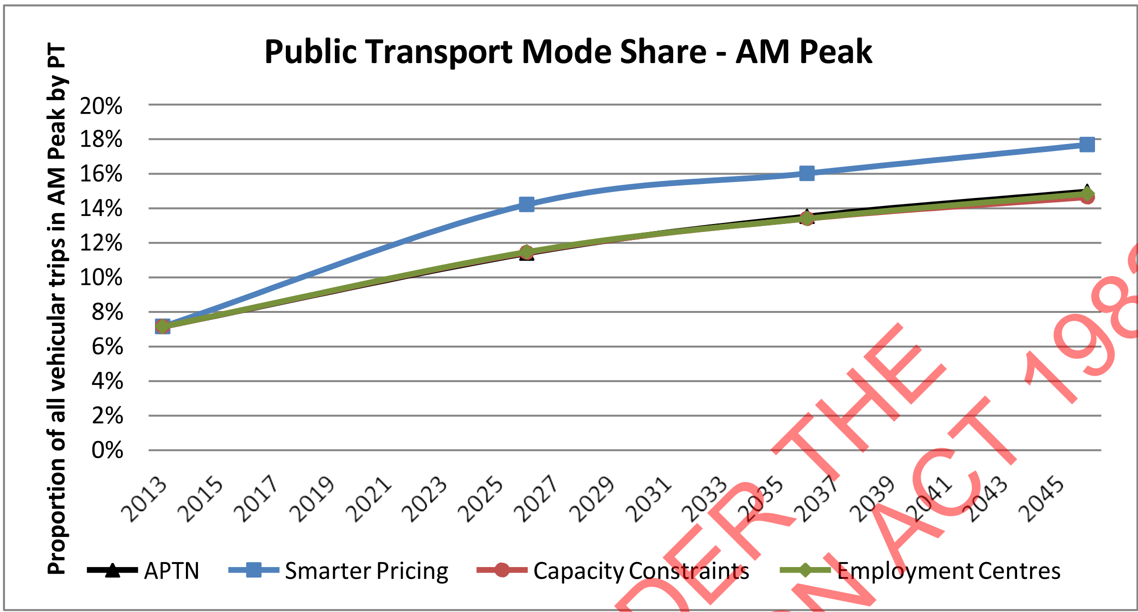


Figure 3.55: Public transport mode share in the AM peak (2013-2046)

Public transport constraints

A very large increase in projected bus passengers over the next 30 years is predicted, creating capacity 'pinch points' with significant challenges to meet demand.

Current bus demand for Symonds Street already exceeds medium capacity, and will exceed high capacity between 2018 and 2023 for all packages (Figure 3.56).[4]

[4] Medium capacity refers to a capacity of 120 buses per hour with 57 passengers per bus. High capacity refers to a capacity of 120 buses per hour with 80 passengers per bus. These are indicative corridor capacities and will vary according to specific circumstances.

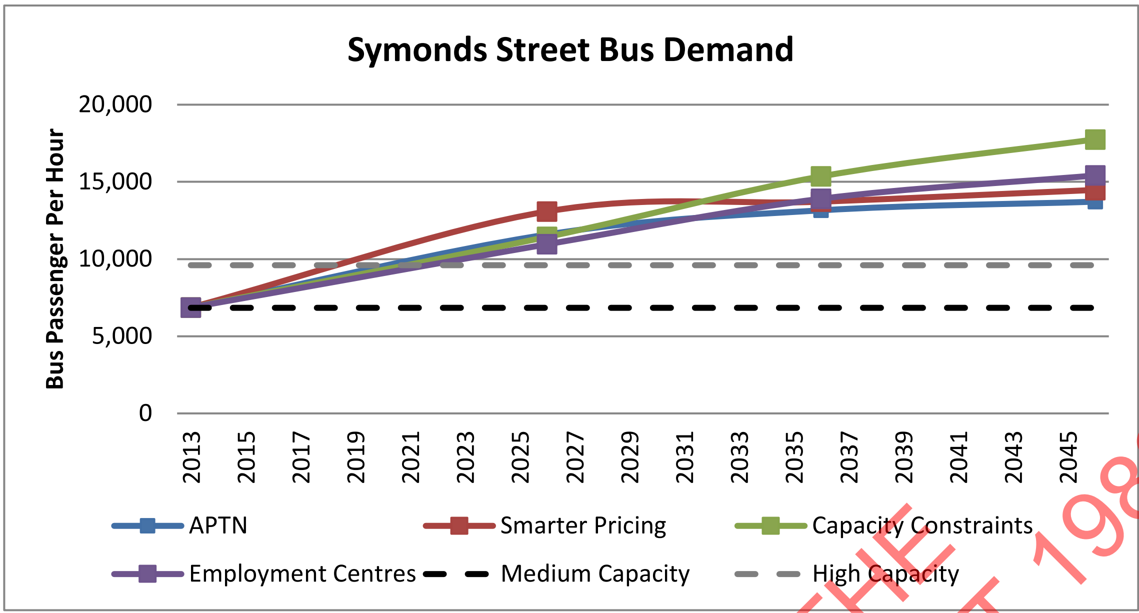


Figure 3.56: Symonds Street bus demand (2013-2046)

Bus demand for Fanshawe Street peaks at 2026 under the Employment Centres and Smarter Pricing packages, reaching medium capacity as a result of the introduction of the North Shore mass transit system (Figure 3.57). Without mass transit, bus demand continues to rise (as seen in the APTN and Capacity Constraints packages) until it exceeds high capacity at around 2036.

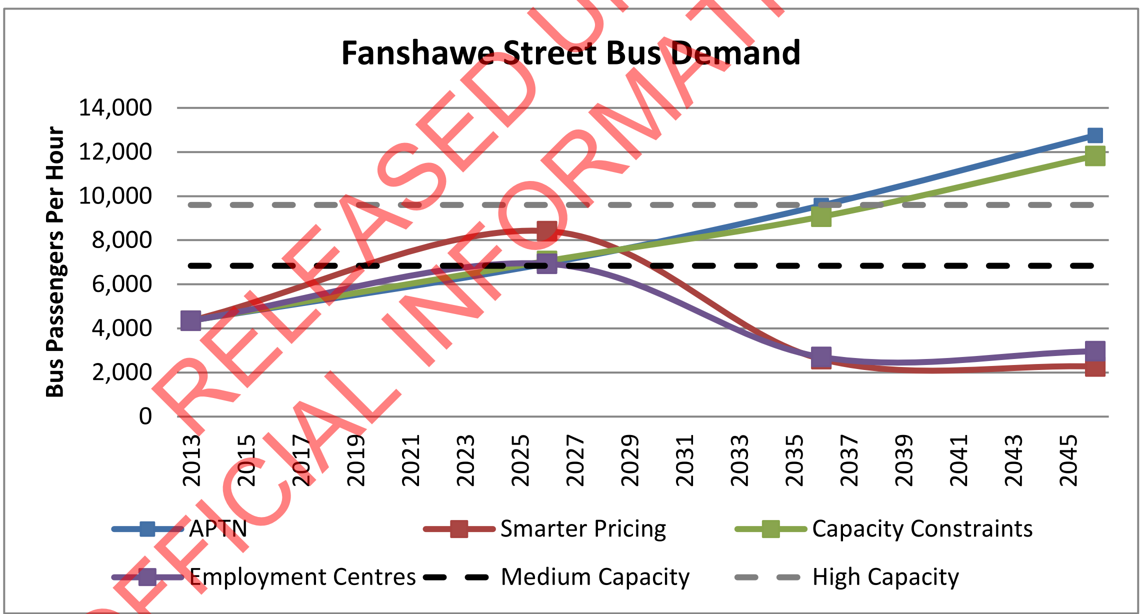


Figure 3.57: Fanshawe Street bus demand (2013-2046)

Bus demand for Karangahape Road reaches medium capacity in 2036 for both the Capacity Constraints and Employment Centres packages (Figure 3.58). High capacity is reached in 2046 with the smarter transport pricing tool.

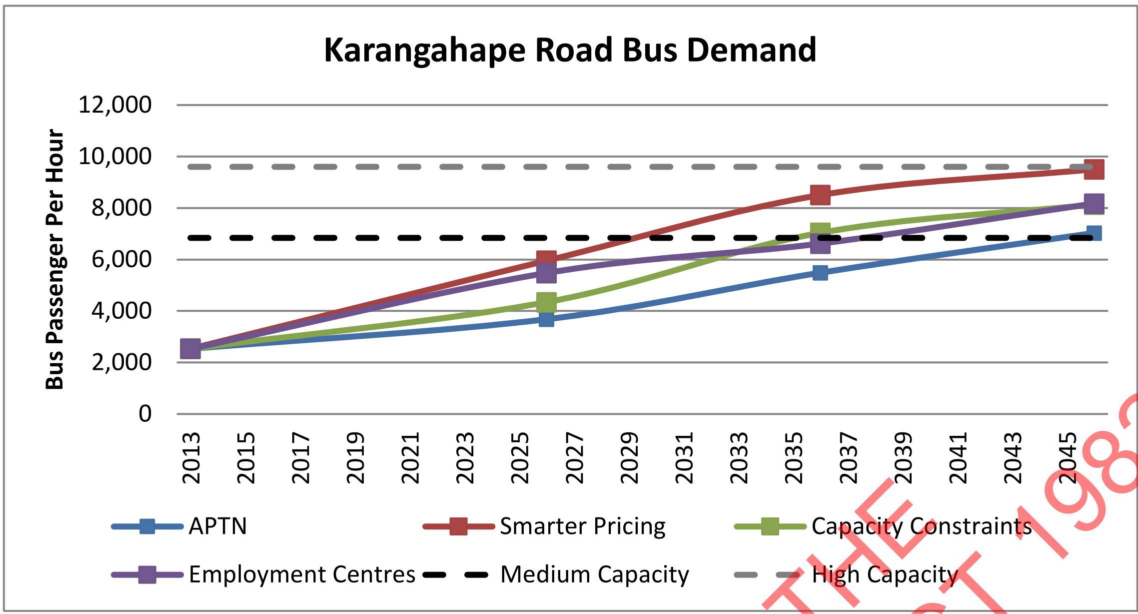


Figure 3.58: Karangahape Road bus demand (2013-2046)

Long-term solutions to these capacity constraints potentially involve substantial investments and have major network-wide implications. A network-wide approach to the planning, timing and funding of these interventions is therefore important to inform investment decisions.

It appears unlikely that smarter pricing and technology will reduce this challenge. Road pricing typically increases public transport demand, further increasing the challenge while any shift to ridesharing away from public transport in accessing the city centre is likely to increase, rather than reduce, congestion levels due to limited street-space.

However, care is needed in interpreting public transport results, as the ART3 model does not take into account the 'crowding off' of passengers from buses due to demand exceeding capacity. In reality, crowding would result in some users shifting to car, with increased congestion. When crowding is taken into account using the APT3 model, predicted bus demand is generally shown to be lower (Figure 3.59).

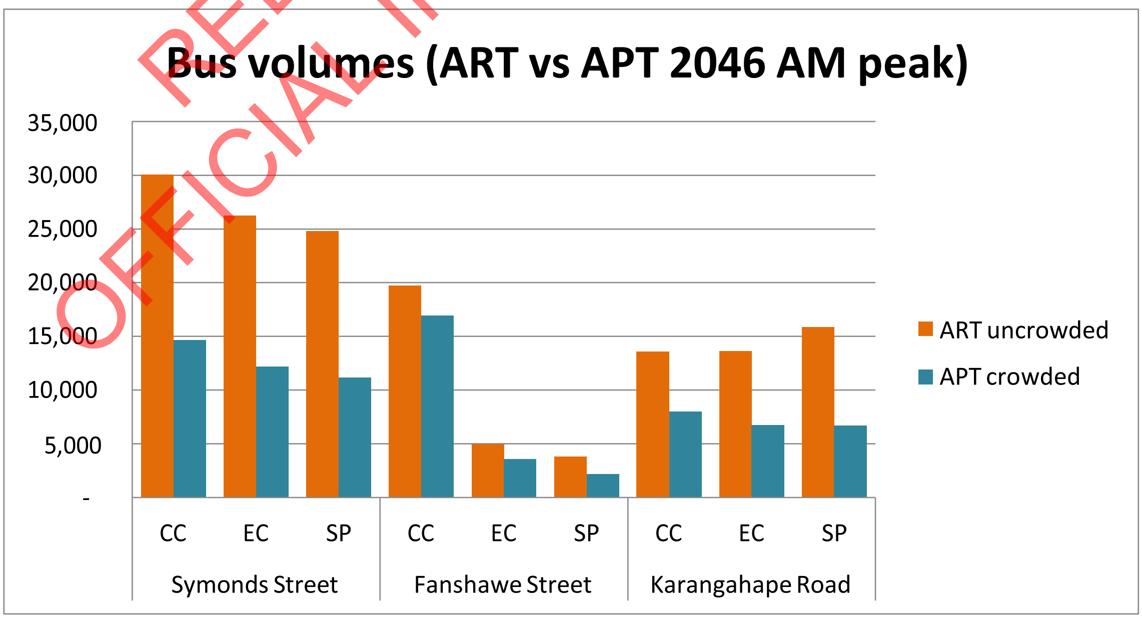


Figure 3.59: Isthmus bus demand ART uncrowded vs APT crowded (2013-2046)

3.4.5 Full Evaluation Results

The following table presents the results of our evaluation of the Capacity Constraints, Employment Centres and Smarter Pricing packages against the evaluation criteria established in the Foundation Report (Table 3.5). All results relate to the 2046 year unless otherwise specified.

Table 3.5: Evaluation framework – headline measures

Objective	Measure	Headline KPI	2013 comparison	Capacity Constraints 2046	Employment Centres 2046	Smarter Pricing 2046	APTN 2046	Comment
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30 minute trip in the AM peak • Jobs accessible by public transport within a 45 minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	312,000 i.e. 51% of available jobs 94,000 i.e. 15% of available jobs 467,000 i.e. 75 % of available jobs	392,000 i.e. 44% of available jobs 223,000 i.e. 25% of available jobs 599,000 i.e. 67% of available jobs	356,000 i.e. 40% of available jobs 238,000 i.e. 27% of available jobs 588,000 i.e. 66% of available jobs	551,000 i.e. 62% of available jobs 245,000 i.e. 27% of available jobs 678,000 i.e. 76% of available jobs	386,000 i.e.43% of available jobs 215,000 i.e. 24% of available jobs 590,000 i.e. 66% of available jobs	The Capacity Constraints and Employment Centres packages increases the number of jobs accessible by car and PT (mainly due to growth) but does not increase the proportion of jobs that could be accessed by car. The Smarter Pricing package significantly increases car and PT accessibility (measured only in relation to travel time, not financial cost) in the morning peak (7-9 am) in 2046, with a moderate increase in accessibility by public transport.
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak	7 hours 22 minutes per person per annum 27.3% AM peak 16.3% inter-peak	11 hours 53 minutes per person per annum 30.0% AM peak 20.7% inter-peak	13 hours 13 minutes per person per annum 31.9% AM peak 21.7% inter-peak	2 hours 49 minutes per person per annum 18.9% AM peak 15.4% inter-peak	13 hours 33 minutes per person per annum 31.9% AM peak 21.9% inter-peak	With Smarter Pricing, projected levels of congestion throughout the day are significantly better than the APTN. Projected levels of congestion for the Capacity Constraints and Employment Centres packages are expected to be similar to the APTN.
	Impact on freight and goods (commercial traffic) congestion	• Proportion of business and freight travel time spent in severe congestion on the strategic freight network (in the AM peak and inter-peak)	15.1% AM 8.3% inter-peak	17.3% AM 11.9% inter-peak	22.2% AM 14.5% inter-peak	7.2% AM 5.5% inter-peak	18.6% AM 12.9% inter-peak	Projected congestion on the strategic freight network varies considerably between the packages. With Smarter Pricing, projected congestion is significantly better throughout the day, compared to the APTN.
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, inter-peak and PM peak.	15% AM peak 6% inter-peak 16% PM peak	18% AM peak 12% inter-peak 24% PM peak	19% AM peak 14% inter-peak 24% PM peak	8% AM peak 5% inter-peak 10% PM peak	19% AM peak 13% inter-peak 23% PM peak	With Smarter Pricing, projected reliability of travel times for motor vehicle trips is expected to be significantly better throughout the day, compared to APTN. Projected reliability for the Capacity Constraints and Employment Centres packages is expected to be similar to the APTN.
Increase public transport mode-share	Public transport mode share	• Proportion of vehicular trips in the AM peak made by public transport	8.5%	18.2%	18.5%	22.1%	18.0%	With Smarter Pricing, projected PT mode share is slightly higher than APTN. Projected PT mode share for the Capacity Constraints and Employment Centres packages is expected to be similar to the APTN.
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 9 km in the AM peak made by public transport	18.3%	26%	27%	35%	31.7%	With Smarter Pricing, it is projected that a higher proportion of longer commute trips would be by PT, compared to the APTN. The proportion of longer commuter trips by PT is projected to be lower with the Capacity Constraints and Employment Centres packages, compared to the APTN.
	Increase vehicle occupancy	• Average vehicle occupancy	1.36 people per vehicle AM peak 1.25 people per vehicle inter-peak	-	-	-	-	It was not possible to model changes in vehicle occupancy. The input assumptions of an average of 1.36 people per vehicle in AM peak and an average of 1.25 people per vehicle in inter-peak remained constant for all packages and all model years.

Objective	Measure	Headline KPI	2013 comparison	Capacity Constraints 2046	Employment Centres 2046	Smarter Pricing 2046	APTN 2046	Comment
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	Not applicable	-	-	-	Not applicable	Financial costs from Smarter Pricing (see pricing schedule in Table 3.3) are assumed to replace road user charges and fuel excise duties. Savings in travel time and vehicle operating costs vary by trip. On average it is estimated that the financial costs exceed the savings in travel time and vehicle operating costs. Better model/tools are required to provide robust quantification of net benefits.
Ensure value for money	Value for money	• Package benefits and costs	-	-	-	-	-	Package benefits include the contributions to objectives as measured in this table. The costs of new capital expenditure (excluding renewals) for the 30 year programmes are estimated in billions of 2016 dollars as follows: Capacity Constraints: $29.5 b Employment Centres: $29.6 b Smarter Pricing: $28.7 b These cost estimates were identified prior to the revision of project costs in ATAP.

In addition to the project objectives, a number of other key outcomes have been evaluated through the evaluation framework in Table 3.6 below.

Table 3.6: Evaluation framework – other key outcomes

Other Key Outcomes	Measure	Headline Key Performance Indicator	2013 comparison	Capacity Constraints 2046	Employment Centres 2046	Smarter Pricing 2046	APTN	Comment
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	Existing transport infrastructure in greenfields is inadequate to support the growth required in the FULSS.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Does not meet timeframes of FULSS.	The same programme in greenfields has been assumed in all three packages.
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled	48 deaths and 3,487 injuries p.a. from motor vehicle crashes. 25 injuries per 10,000 population 28 injuries per 100 million vehicle kilometres travelled	-	-	-	-	Model forecasts can't accurately identify number of deaths and serious injuries.
	Emissions	• Greenhouse gas emissions	8.4 million kg of CO_2 per day	8.1 million kg of CO_2 per day	8.0 million kg of CO_2 per day	7.0 million kg of CO_2 per day	8.1 million kg of CO_2 per day	Model projects 12.5% fewer emissions in the Smarter Pricing package than APTN. This is mostly due to fewer trips and shorter distance of trips. Projected emissions for the Capacity

Other Key Outcomes	Measure	Headline Key Performance Indicator	2013 comparison	Capacity Constraints 2046	Employment Centres 2046	Smarter Pricing 2046	APTN	Comment
								Constraints and Employment Centres are similar to the APTN.
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog	In 2015, approximately 1% of the transport network was in a "very poor" condition. This is equivalent to $157 million of backlog. [Source: Auckland Transport's Asset Management Plan 2015-2018]	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog.	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog.	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog.	Similar to these packages	The same maintenance and renewals programme has been assumed in all three packages.
Social inclusion and equity	Impacts on geographical areas	• Access employment in high deprivation areas • Distribution of impacts (costs and benefits) by area	As identified in the Foundation report, high deprivation areas in the south and west have lower access to jobs than other parts of the region. People in the west rely on a congested motorway link to jobs in the isthmus and south. People in the south also experience congestion on motorway links to jobs.	Similar to the APTN, accessibility issues remain in Mangere and parts of the west.	Similar to the APTN, accessibility issues remain in Mangere and parts of the west. Accessibility from high deprivation areas in the North Shore is worse.	Compared to the APTN, accessibility improves for high deprivation areas, but access by motor vehicle is subject to pricing. Motor vehicle accessibility from high deprivation areas in the North Shore is worse than the APTN.	The Deficiency Analysis identified significantly lower levels of access in the south and west.	Accessibility from high deprivation areas is similar to the APTN, except with Smarter Pricing. Generalised costs generally increase as a result of Smarter Pricing.
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network	Vulnerable network due to incomplete State Highway, public transport and cycle networks and lack of capacity at peak times on the strategic road network to cope with disruptions.	Network resilience is similar to the APTN. This package improves resilience through additional roading links such as the Additional Waitemata Harbour Crossing.	Network resilience is similar to the APTN. This package improves resilience through additional roading links such as Penlink and the high capacity rapid transit network.	Network resilience is similar to the APTN. This package improves resilience through pricing of the road network. This reduces trips on the road network by about 10% which could result in less diversion and impact in the event of disruption to the road network. There is high capacity in the rapid transit network, which enables PT to take additional people in the case of disruption.	-	These packages have a similar level of network resilience to the APTN.

3.4.6 Package Analysis Conclusions

Overall, changing the mix of investments to reflect either a focus on addressing capacity constraints or accessing employment centres – with a similar overall level of investment – highlights the potential to achieve minor to moderate improvements in region-wide performance against the project objectives, but not a step-change. Sub-regional changes in performance suggested there was merit in continuing to optimise the timing and priority of investments. In particular, the analysis undertaken of different investment mixes suggests it would be possible to substantially improve employment accessibility in the south and west.

Analysis of smarter transport pricing showed it offers the potential to achieve a step-change in transport network performance and should therefore form a core part of the strategic approach. However, setting price levels is extremely challenging as performance improvement, travel time savings and increased travel costs need to be carefully balanced. While some further work was undertaken to assess different pricing levels, more sophisticated analytical tools will be required to undertake this work before a viable scheme could be developed.

4. Package Refinement

Drawing upon on the assessments undertaken in the package analysis phase, two refined packages were developed for the package refinement phase. These packages were developed differently to the initial ones, particularly because they did not have a “funding limit” placed on them. As the previous phase of analysis had highlighted, a step-change in performance was unlikely to be achieved through a different mix of investment. The refined packages focused on understanding the extent to which a step-change in performance could be achieved via two approaches:

- Focus on Higher Level of Investment (Section 4.1)
- Focus on Influencing Patterns of Travel Demand (Section 4.2)

A cross package review was undertaken in Section 4.3.

The common baseline for both packages was generally similar to that used for the previous packages. It is referred to interchangeably as the ATAP Baseline and the Base Network. The Base Network was refined and narrowed in greenfield growth areas to only include investments that were directly required to enable growth (i.e. local road networks). Other investments in greenfield areas were considered as part of one package or the other.

The common baseline has a capital cost of approximately $19 billion for new improvements (excluding renewals) over the 30-year period. Key components of the Base Network included committed projects (e.g. City Rail Link, East-West link, Puhoi-Warkworth etc.), the Auckland Rail Development Programme(because it cannot be effectively modelled using existing tools) and a variety of other minor investments either unable to be evaluated using current tools or would be expected to occur over the next 30 years (e.g. safety programmes, walking and cycling improvements, and minor road and public transport improvements).

4.1 Focus on Higher Level of Investment

4.1.1 Package description

This package tests the hypothesis that a higher level of investment (particularly in the first 10-20 years) could lead to a step-change in performance. The package tests a significantly higher and earlier level of investment. The focus is on ensuring the road and public transport networks keep up with growth so that levels of service are acceptable.

Compared with the previous packages, this package brings forward most infrastructure projects into the first two decades. It includes a substantial programme to improve the strategic roading network, targeting the most severe capacity issues in the first decade. The package also delivers a strategic public transport network.

The total estimated 30-year cost of new capital improvements (excluding renewals) of the Higher Investment package is $40.7 billion (in 2016 dollars). Figure 4.1 below provides a breakdown of costs by decade and project type.

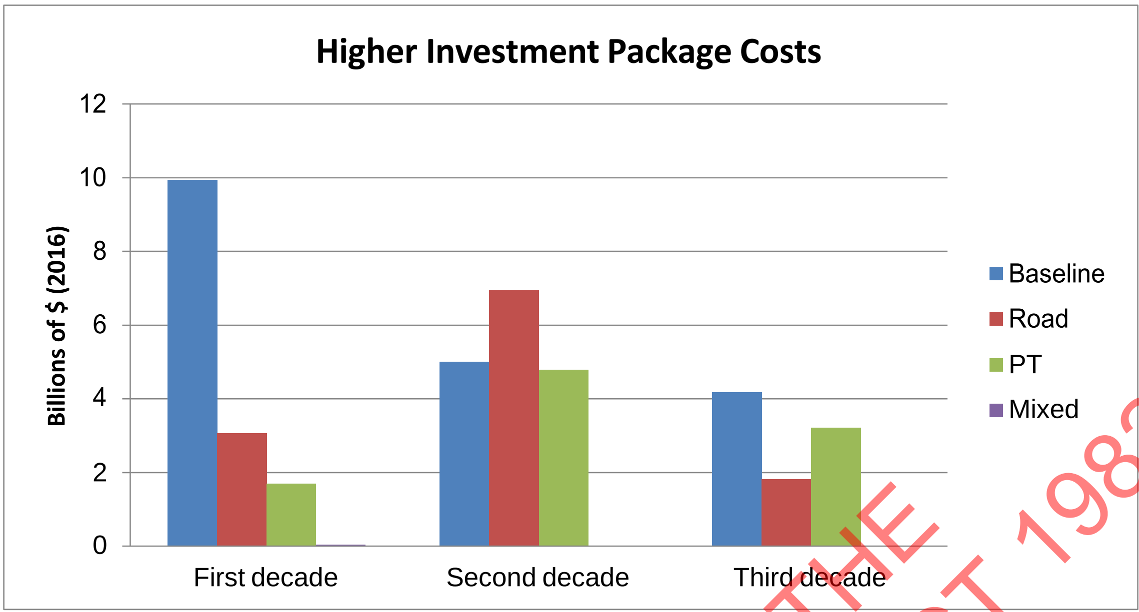


Figure 4.1: Estimated cost of new capital improvements (excluding renewals) of Higher Investment package (2018 – 2048)

Key interventions by time period

Key components of the package over and above the common baseline are included in Table 4.1 1 below:

Table 4.1: Higher Investment key interventions by decade

First Decade (2015-25)	Second Decade (2025-35)	Third Decade (2035-45)
• Northwestern Busway (Kumeu to Point Chevalier) • AMETI Pakuranga to Botany Busway • SH20 targeted widening • Southern Motorway targeted widening and interchange upgrades • Improved access to Port / Grafton Gully	• Northwestern Busway (Point Chevalier to Newton) • Additional Waitemata Harbour Crossing (motorway tunnels) • Isthmus mass transit • North Shore mass transit (city centre to Takapuna) • SH16 targeted widening • Cross isthmus mass transit • Southern Motorway further targeted widening	• City centre bus access improvements • Further SH20 widening • SH20A upgrade • Extension of isthmus mass transit • Extension of North Shore mass transit to Albany • Northern Motorway targeted widening and interchange upgrades • Extension of mass transit to Airport from north • SH20A targeted widening

4.1.2 Key Findings

The Higher Investment package in this phase was compared against both the APTN (to understand the extent to which they appear to deliver better returns than current plans) and the common baseline (to understand the value from additional investment above this baseline).

Accessibility

Access to employment in the AM peak for car travel improves from 2026 onwards compared to APTN and the Base Network, while public transport accessibility tracks very similarly to the APTN up until 2046 (Figure 4.2). Despite the higher level of investment in the first decade, the impacts on accessibility are not seen at a regional level until the 2036.

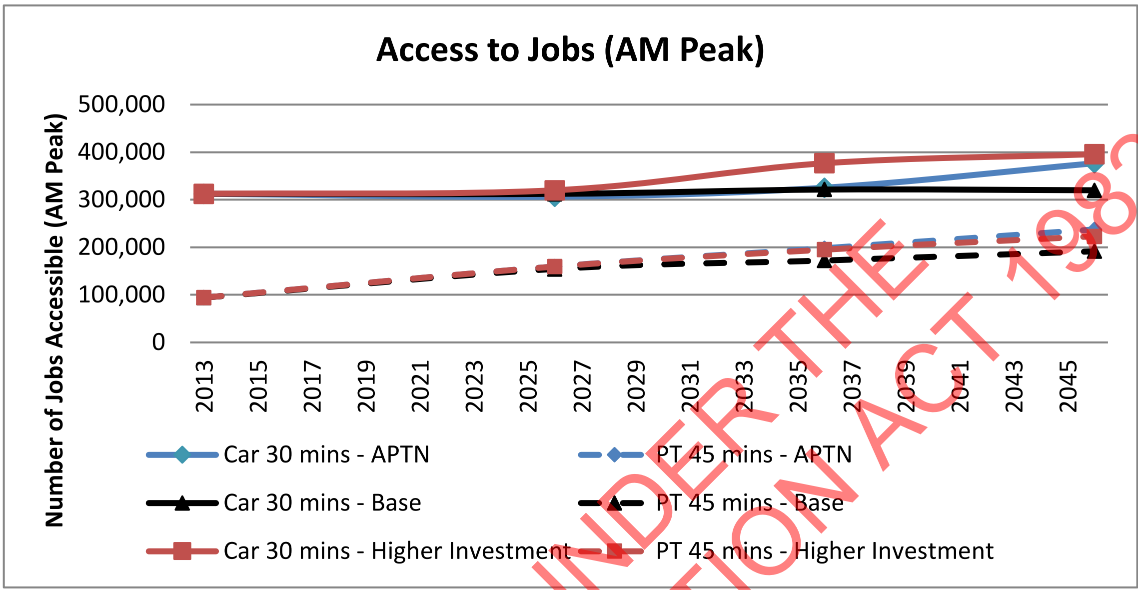


Figure 4.2: Access to jobs AM peak (Higher Investment, APTN and ATAP Baseline)

Regional measures can mask sub-regional differences in performance however, as shown in the accessibility maps below.

On a sub-regional level, car accessibility declines in the west, northwest and parts of the North Shore between 2013 and 2026 under the Higher Investment package (Figure 4.3). However, public transport accessibility increases significantly for most areas in the same period.

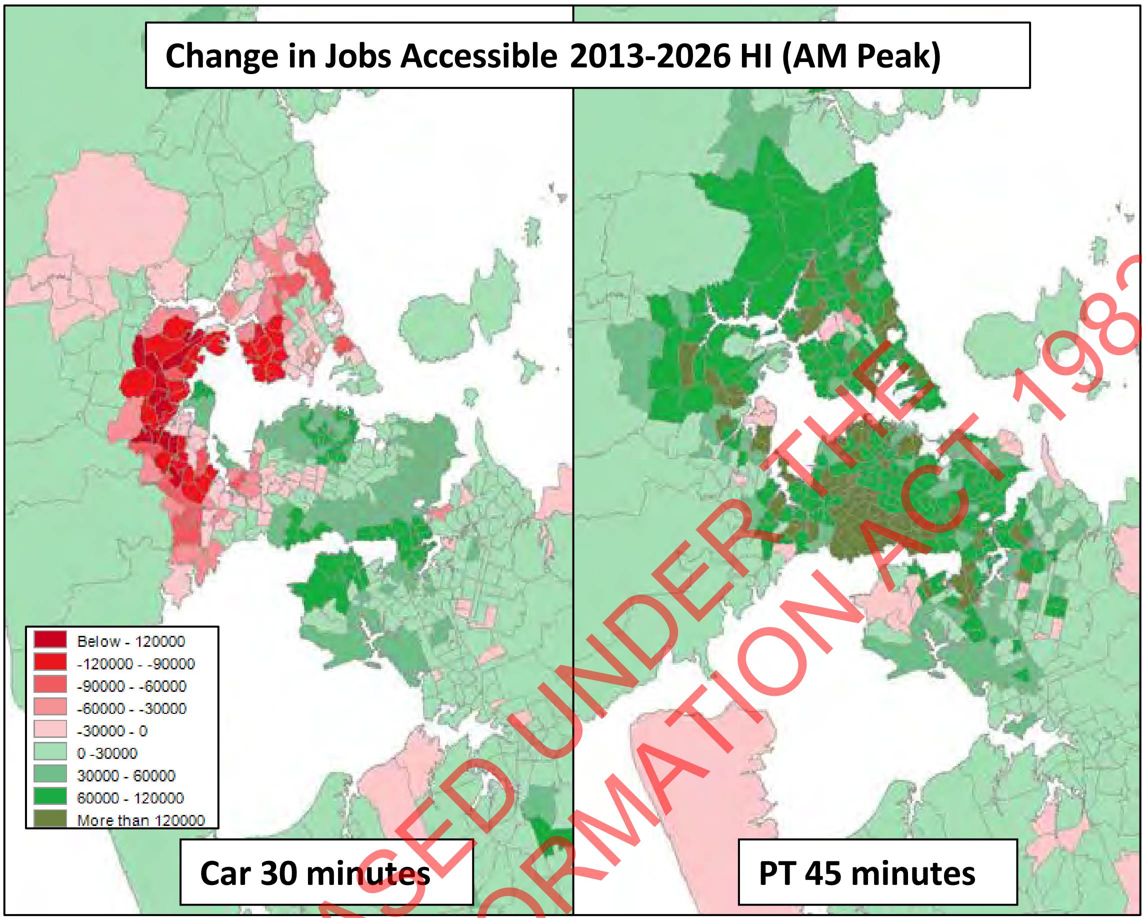


Figure 4.3: Change in accessibility to jobs AM peak 2013 vs 2026 (Higher Investment)

Between 2026 and 2046, car accessibility improves dramatically on the North Shore, northwest, as well as parts of the west and isthmus (Figure 4.4). However, accessibility declines within the inner south, particularly around Mangere and Otahuhu. The decline in accessibility occurs despite upgrades to SH20A and targeted widening of the Southern Motorway.

Public transport accessibility improves to a lesser extent across the region.

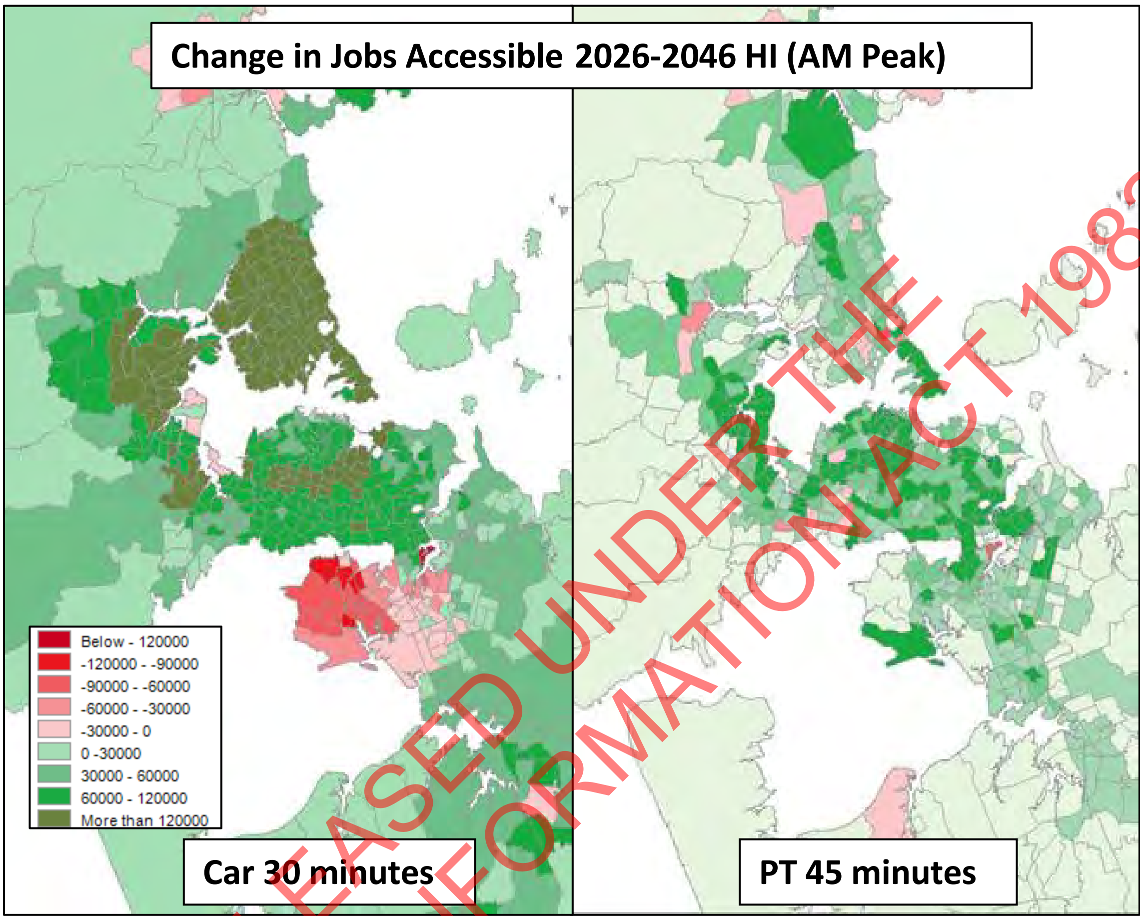


Figure 4.4: Change in accessibility to jobs AM peak 2026 vs 2046 (Higher Investment)

Compared to the Base Network, the Higher Investment package improves accessibility in 2026 for the northwest and parts of the west and outer south (Figure 4.5). These improvements indicate that the specific focus to improve accessibility in the west and south worked, to a certain extent. Accessibility declines in the inner south, despite upgrades to SH20A and targeted widening of the Southern Motorway between Manukau and Otahuhu.

The inner part of Auckland's motorway network falling inside the Western Ring Route currently experiences substantial capacity constraints and congestion, not only at peak times but also throughout the day. Our modelling of further widening in many parts of this network often showed very mixed results, by shifting around bottlenecks and congestion points rather than addressing them at a network level.

In terms of public transport, improvements are seen in largely in the northwest, as a result of the inclusion of a full grade separate right of way Northwestern Busway corridor (rather than the combination of bus lanes and busway as specified in APTN).

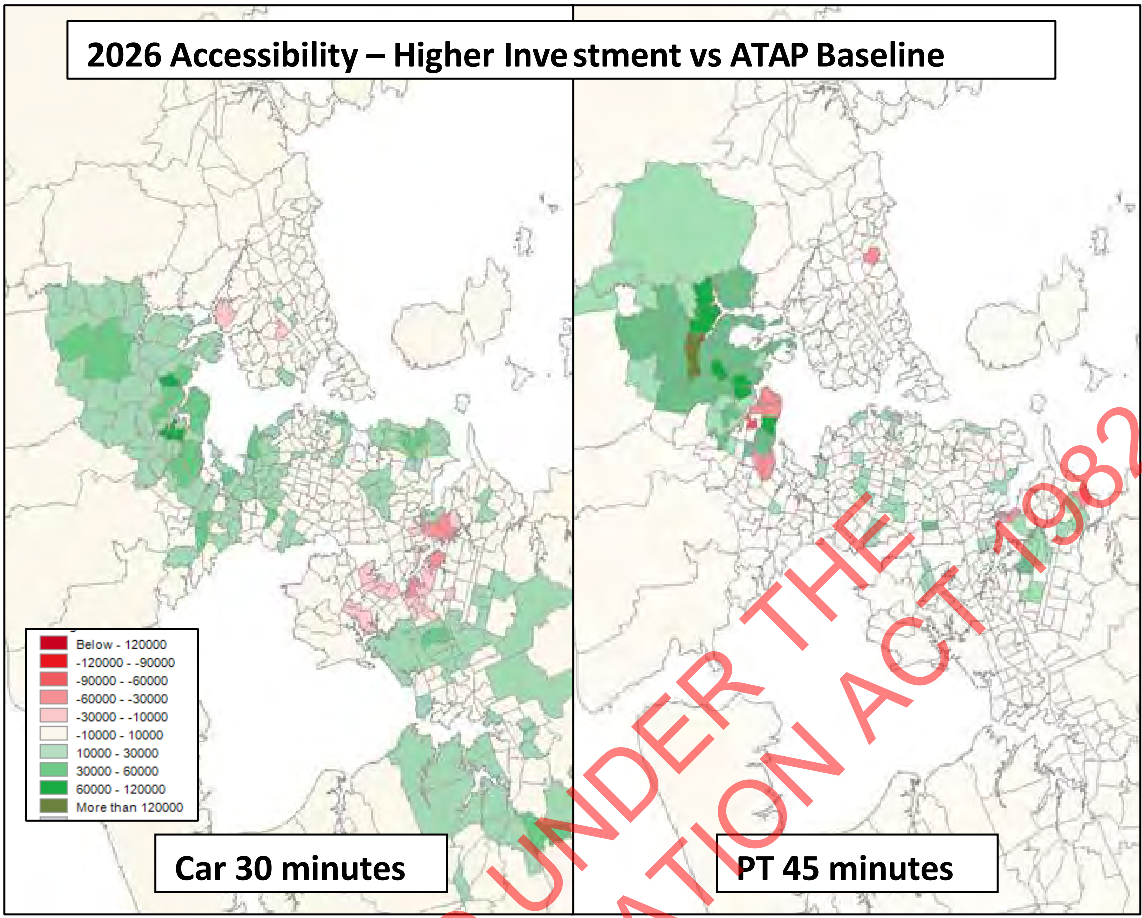


Figure 4.5: Accessibility to jobs AM peak 2026 (Higher Investment vs ATAP Baseline)

The improvements to accessibility in the northwest continue in 2046, spreading to the North Shore and parts of the west and isthmus (Figure 4.6). The inner south continues to experience declining accessibility.

For public transport, improvements to accessibility continue in the northwest and declines further on the North Shore.

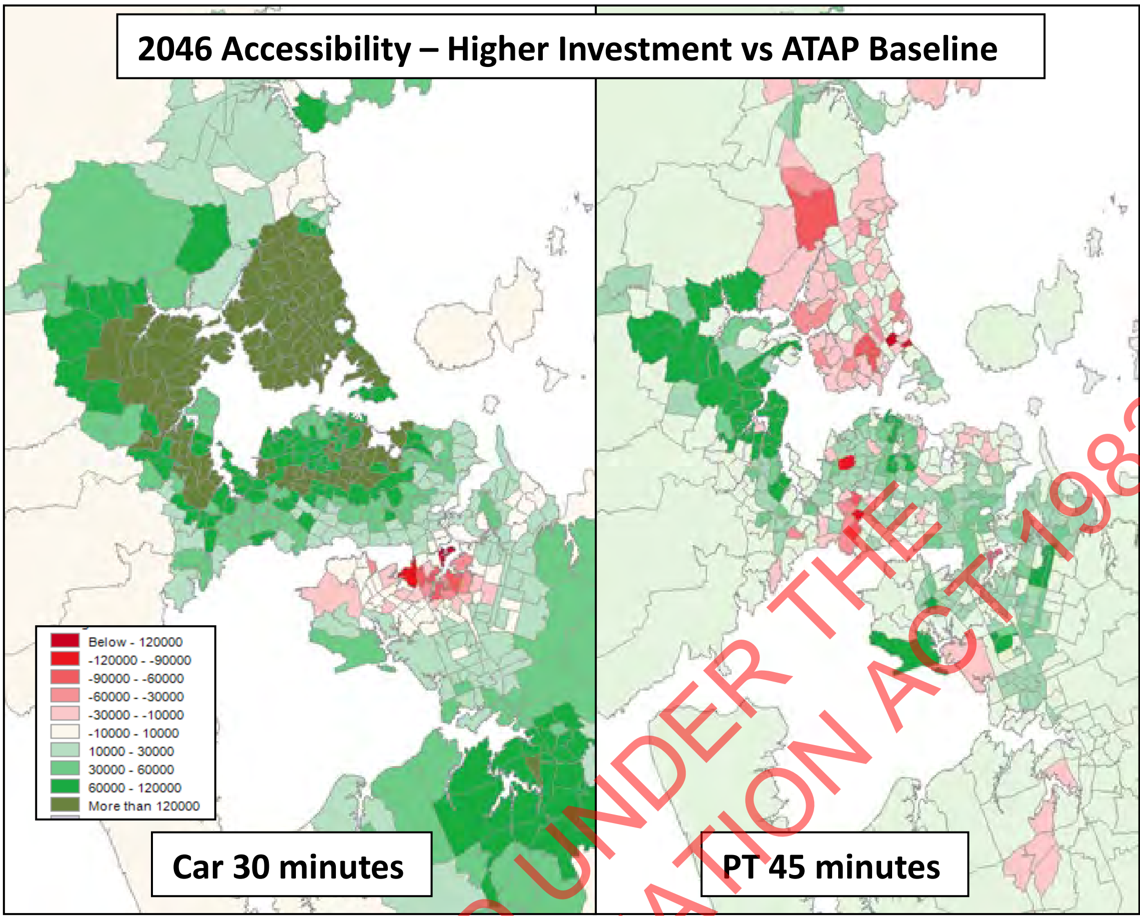


Figure 4.6: Accessibility to jobs AM peak 2046 (Higher Investment vs ATAP Baseline)

Two noteworthy findings are: Under the APTN and Higher Investment packages, people living near the airport area have limited access to employment as the motorways serving this area are congested in both directions at peak times, increasing travel times by car and public transport to jobs outside the airport area. Inclusion of the Additional Waitemata Harbour Crossing project into the second decade of the Higher Investment package creates a significant increase in car accessibility for the North Shore.

Congestion

Congestion levels in the AM peak and inter-peak reduce slightly compared to both APTN and the ATAP Baseline, particularly from 2036 onwards (Figure 4.7). This is considered to arise as a result of earlier investment in additional state highway capacity, compared to the APTN.

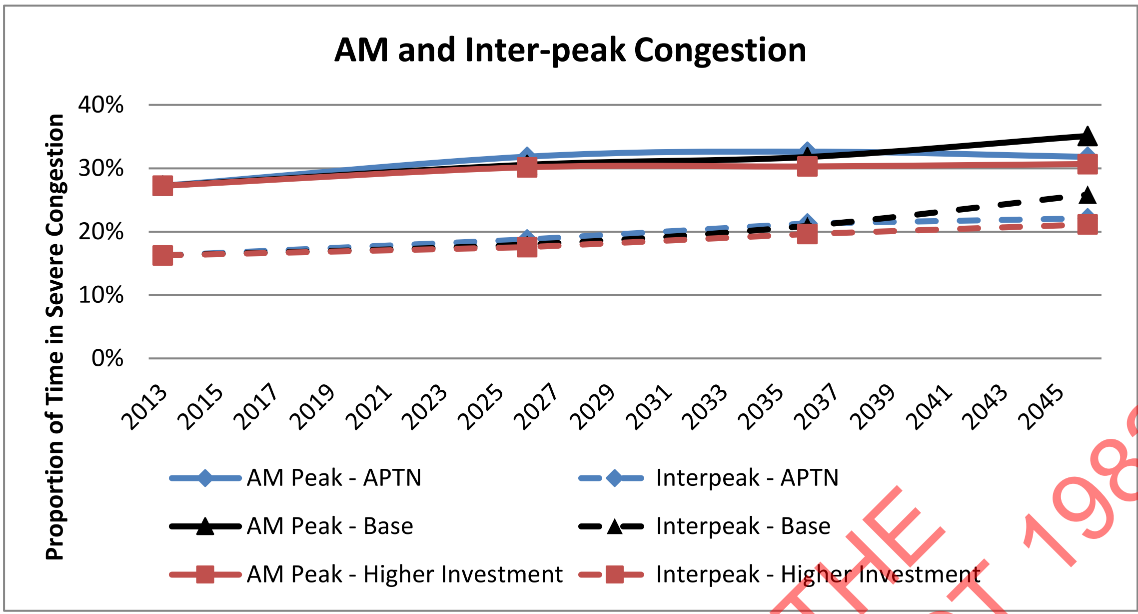


Figure 4.7: AM peak and inter-peak congestion (Higher Investment, APTN and ATAP Baseline)

The freight network under Higher Investment also experiences slight reductions in congestion compared to APTN and the Base Network, particularly in the first two decades (Figure 4.8).

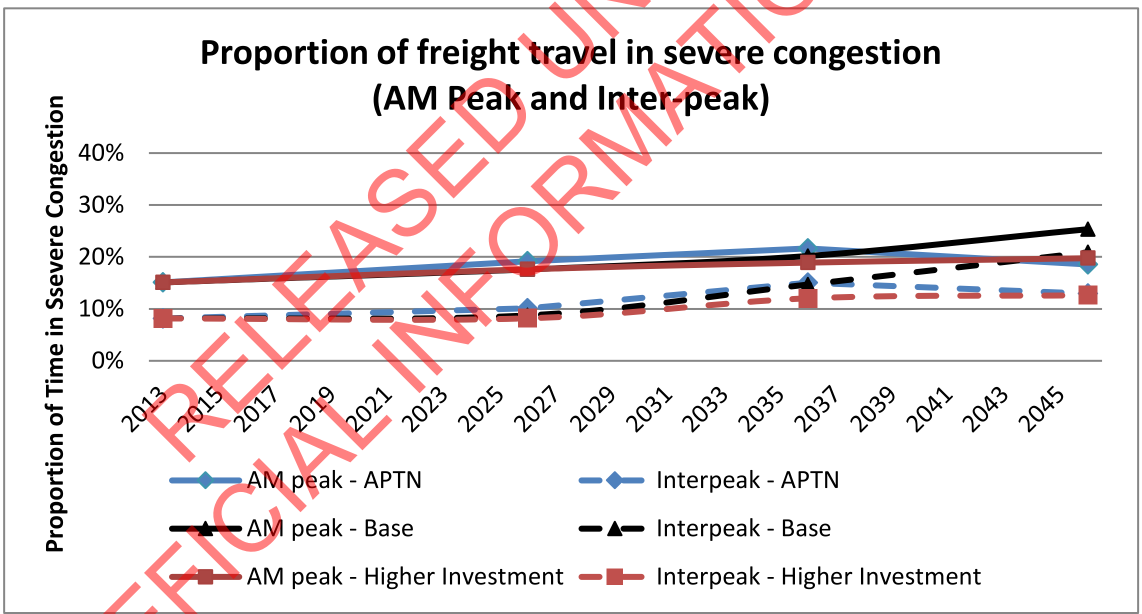


Figure 4.8: Proportion of freight travel in severe congestion (Higher Investment, APTN and ATAP Baseline)

At a sub-regional level, severe congestion is alleviated to a limited extent on parts of the network in the AM peak under Higher Investment, most particularly on SH20A and SH20 (Figure 4.9). However, the majority of constraints remain, most particularly on SH16 and parts of SH1 on the isthmus.

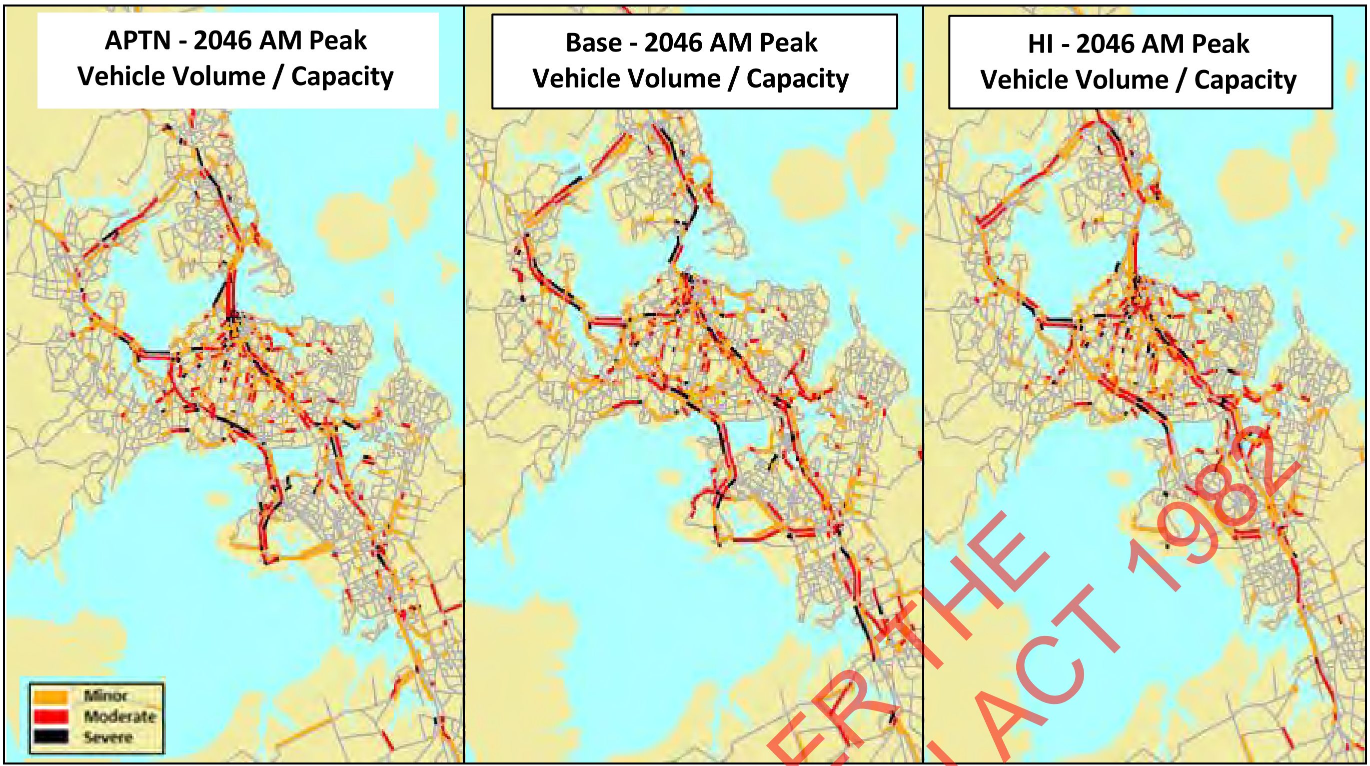


Figure 4.9: AM Peak vehicle volume to capacity (Higher Investment, APTN and ATAP Baseline)

During the inter-peak, severe congestion is eliminated on SH20A (Figure 4.10). However, on the whole, congestion under Higher Investment remains largely similar to APTN in 2046.

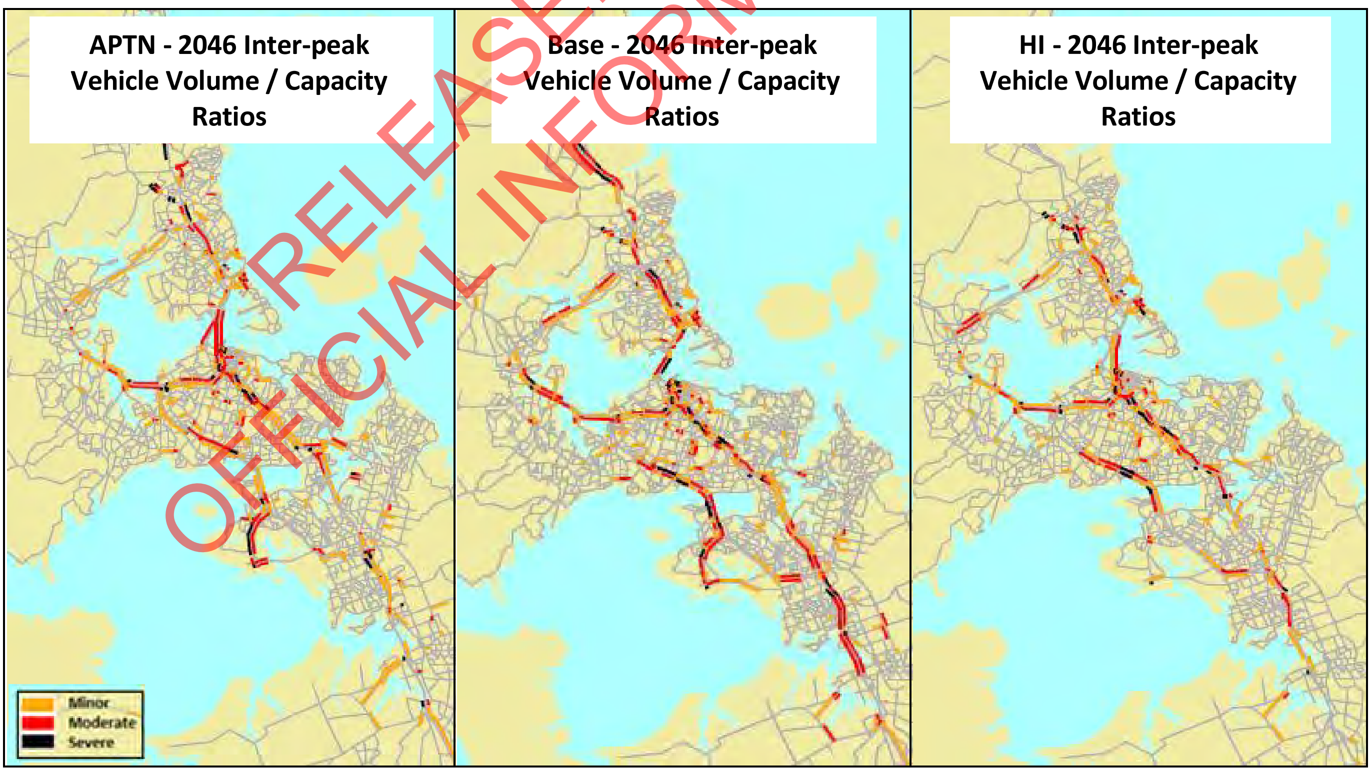


Figure 4.10: Inter-peak vehicle volume to capacity (Higher Investment, APTN and ATAP Baseline)

Public Transport Mode Share

Public transport mode share is virtually identical to the Base Network in 2026 (Figure 4.11). Mode share is slightly lower than under the APTN in the last two decades.

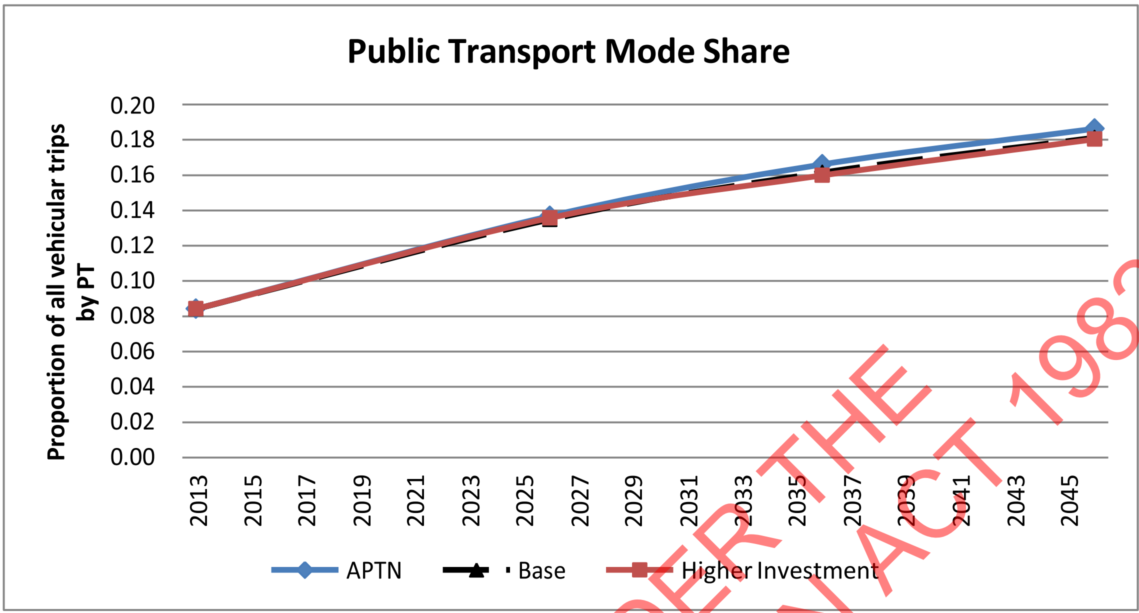


Figure 4.11: Public transport mode share AM peak (Higher Investment, APTN and ATAP Baseline)

Even though the Higher Investment package has a number of additional public transport investments, compared to the APTN, public transport patronage is slightly less than the APTN. Bus demand continues to exceed capacity at parts of the network, broadly to a similar extent as the APTN, although to a lesser extent compared to the Base Network (Figure 4.12). The North Shore mass transit in the Higher Investment package sees greater capacity compared to the Northern Busway under both APTN and the Base Network.

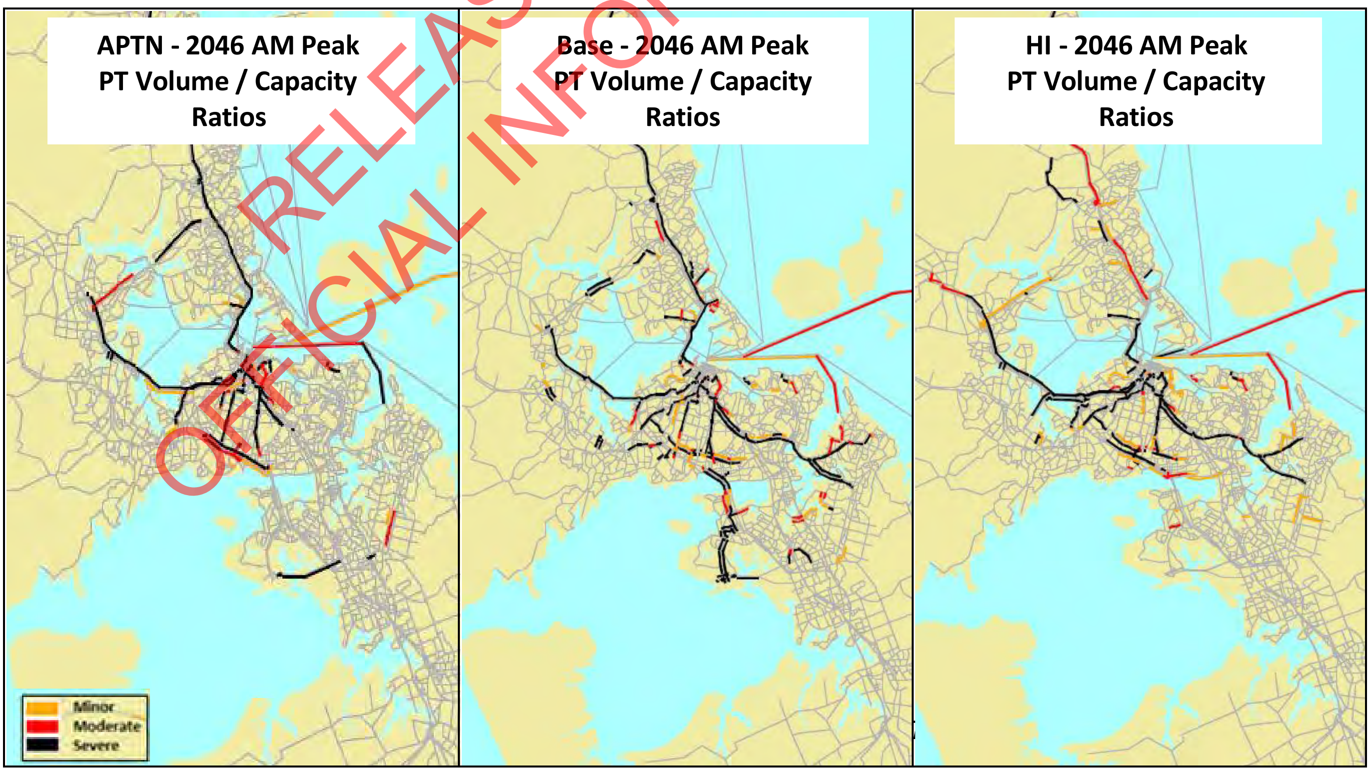


Figure 4.12: Public transport volume to capacity AM peak (Higher Investment, APTN and ATAP Baseline)

Value for Money

The Higher Investment package identified an estimated $40.7 billion capital expenditure programme over 30 years (excluding renewals) which is projected to have similar contributions to the ATAP objectives compared to the APTN. The package is projected to result in a slightly higher proportion of jobs accessible by motorists of 44% (compared to 43% in the APTN), a slightly higher proportion of jobs accessible by public transport of 25% (compared to 24% in the APTN), a slightly lower proportion of travel time in severe congestion of 31% in severe congestion in AM peak (compared to 32% in the APTN) and the same public transport mode share of 18.0% in the AM peak (compared to 18.0% in the APTN).

The Higher Investment package as a whole is projected to have a similar overall contribution to the project objectives as the APTN package, with a significantly larger capital improvement programme.

4.1.3 Key Learnings

Analysis of the Higher Investment package highlights a mix of performance levels, with car access improving compared to APTN. While congestion levels improve for car and freight compared to APTN, public transport mode share is slightly lower.

Additional investment in the first decade did not appear to improve performance against the project objectives at a regional level, but some of these extra investments did have some important sub-regional effects. For example, public transport access increases in the northwest as a result of the Northwestern Busway. Overall however, the Higher Investment package is likely to offer relatively poor value for money.

As such, the development of the Indicative Package in the next phase adopts a more targeted approach to identifying early priorities which both align with the project objectives and appear likely to deliver value for money.

4.2 Focus on Influencing Travel Demand Patterns

4.2.1 Package Description

The Influence Demand package tests the hypothesis that influencing patterns of demand could lead to a step-change in performance. This package tests the effect of variable road network pricing in 2036 and 2046. To support this, earlier investment in the strategic public transport network is provided, together with required improvements to the strategic road network to ensure that levels of service can be maintained.

Some significant road projects have been deferred or excluded. As a result, the Influence Demand package has a significantly lower level of total investment than the Higher Investment package.

The total estimated 30-year cost of new capital improvements (excluding renewals) of the Influence Demand package is $33.2 billion (in 2016 dollars). Figure 4.14 below provides a breakdown of costs by decade and project type.

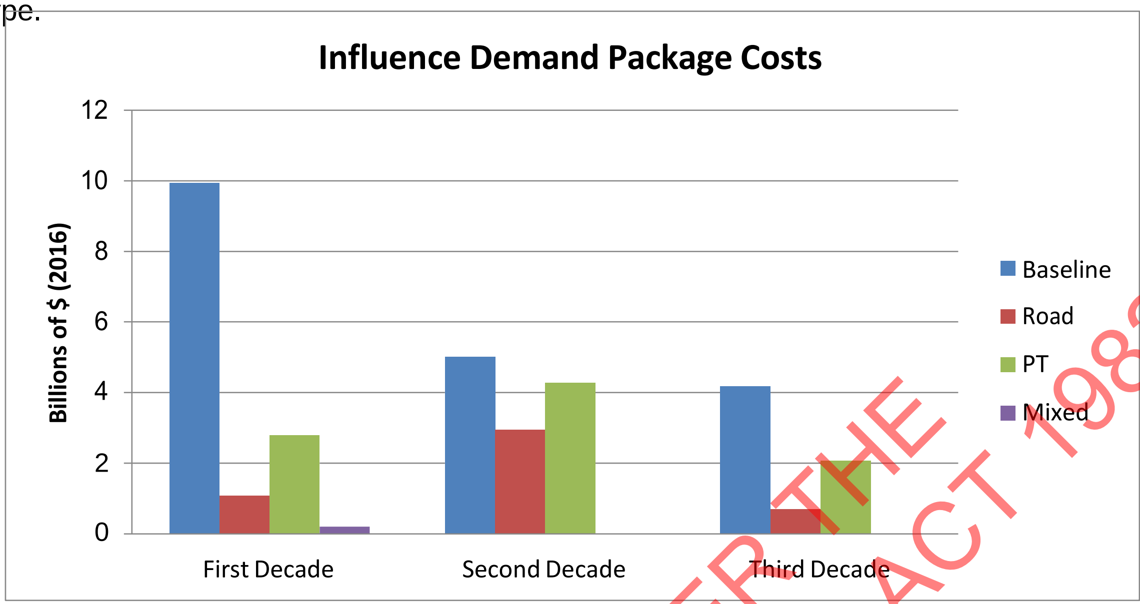


Figure 4.14: Estimated cost of new capital improvements (excluding renewals) of Influence Demand package (2018 – 2048)

Key interventions by time period

The hypothetical network-wide pricing system introduced in the package analysis phase was refined. In developing the Influence Demand package, different pricing levels were tested to better understand the relationship between the cost of travel and changed travel patterns. As a result of this analysis, price levels were reduced by 25% from what was tested in the previous stage. The refined network-wide pricing system maintains the variation in charges across different locations, parts of the network and time of travel (Table 4.2).

Table 4.2: Hypothetical smarter pricing system

Influence demand package: hypothetical price levels (c/km)				
Area	**Network**	**Peak**	**Inter-Peak**	**Off-Peak**
Inner Urban (isthmus)	Motorways	30	22.5	2.25
	Other Roads	22.5	15	2.25
Outer Urban	Motorways	22.5	15	2.25
	Other Roads	15	7.5	2.25
Rural	All Roads	2.25	2.25	2.25

The refined smarter pricing tool was tested with a complementary intervention package. Key components of the package over and above the common baseline are included in Table 4.3.

Table 4.3: Influence Demand key interventions by decade

First Decade (2015-25)	Second Decade (2025-35)	Third Decade (2035-45)
• Northwestern Busway (Kumeu to Point Chevalier)	• Implementation of smarter pricing • Northwestern Busway	• Continuation of Isthmus Mass Transit • Southern Motorway
• AMETI Pakuranga to Botany Busway • Cost to implement Road Pricing Infrastructure • Isthmus mass transit • SH20 targeted widening	(Point Chevalier to Newton) • Cross isthmus mass transit • Extension of mass transit to Airport from north • Additional Waitemata Harbour Crossing (PT only tunnel) • North Shore mass transit to Albany • Southern Motorway targeted widening • Upper Harbour strategic public transport route • TFUG projects*	further targeted widening • SH18 bus shoulder lanes • Extension of North Shore mass transit to Orewa • TFUG projects^

*Includes Mill Road upgrade and extension, Pukekohe expressway, SH1 widening from Papakura to Drury South, SH16 Kumeu bypass and SH16 to SH18 connection

^ Strategic public transport route from Oteha Valley Road to Grand Drive

4.2.2 Key Findings

Travel Patterns

Average trip time (Figure 4.15) and trip length (Figure 4.16) are projected to reduce under Influence Demand with the introduction of smarter pricing after 2026.

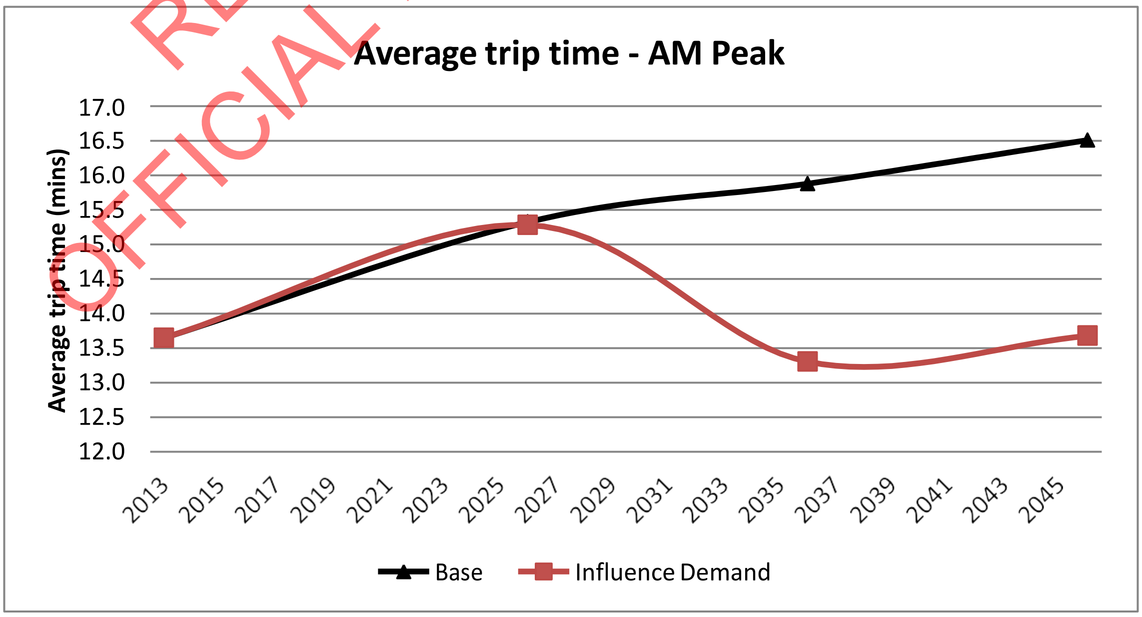


Figure 4.15: Average trip time during AM Peak (Influence Demand and ATAP Baseline)

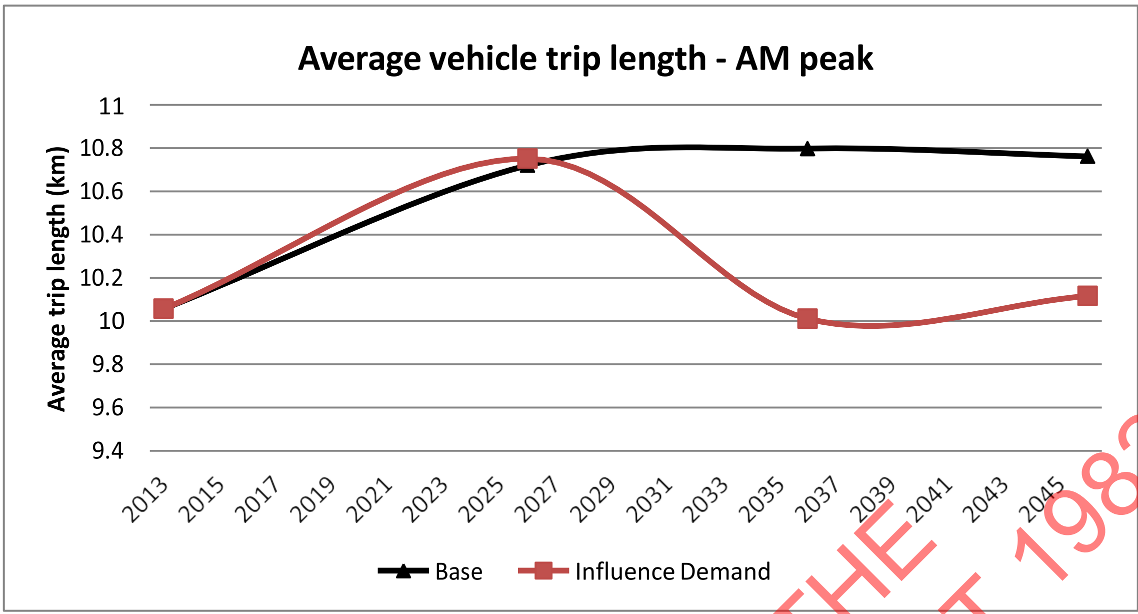


Figure 4.16: Average vehicle trip length during AM Peak (Influence Demand and ATAP Baseline)

Compared to the Base Network, there is a decrease in average travel time for trips originating from the northwest, and increases to the outer south and Howick in 2026 (Figure 4.17). The rest of the region is projected to experience a marginal change in average travel time.

In 2036 and 2046, average travel time is projected to decrease across the region. This is partly due to the reduced level of congestion and partly because travel distances are decreasing with the increased costs of travel.

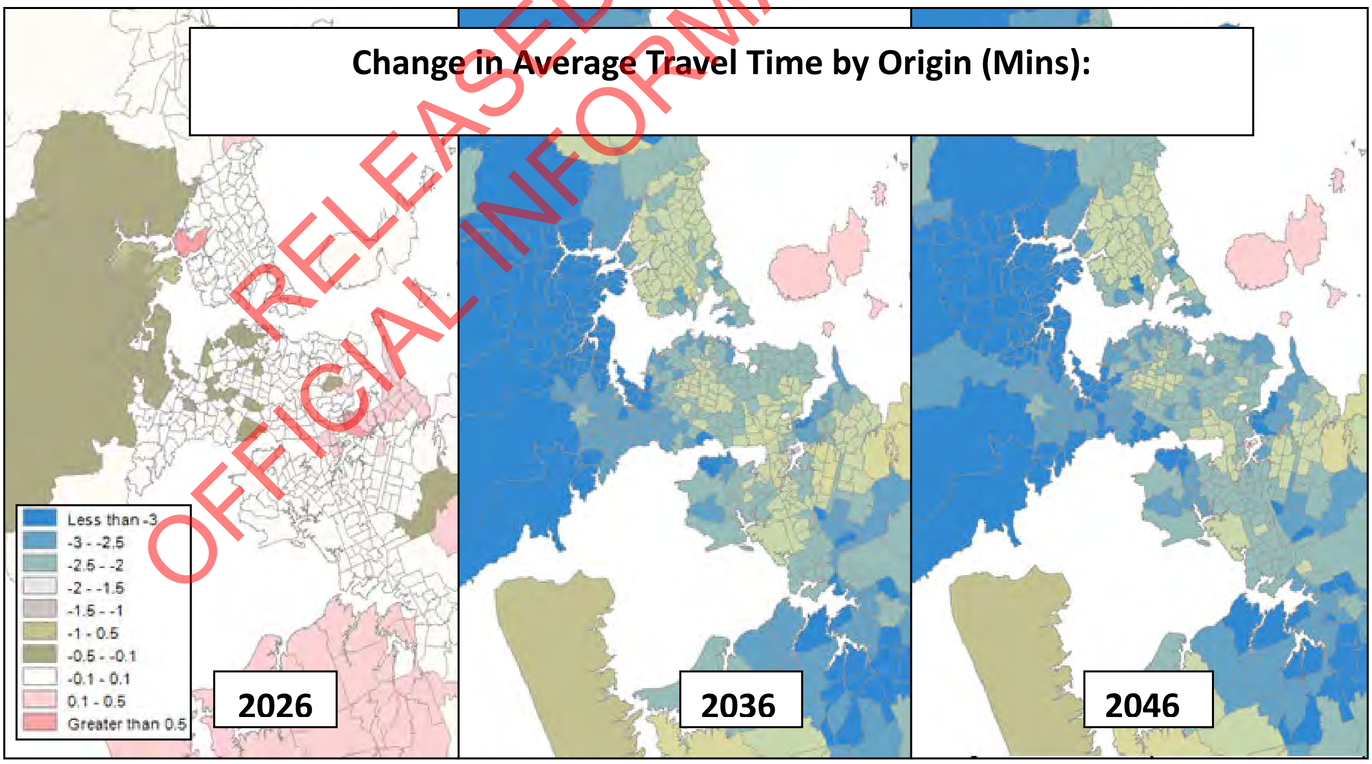


Figure 4.17: Change in Average Travel Time by origin during AM Peak (Influence Demand vs ATAP Baseline in three decades)

In 2026, trips from the isthmus and North Shore are getting shorter but trips from the west and other more peripheral areas are getting longer (Figure 4.18). With the increased costs of travel once smarter pricing is introduced, average trip length decreases across the region from between 2036 and 2046.

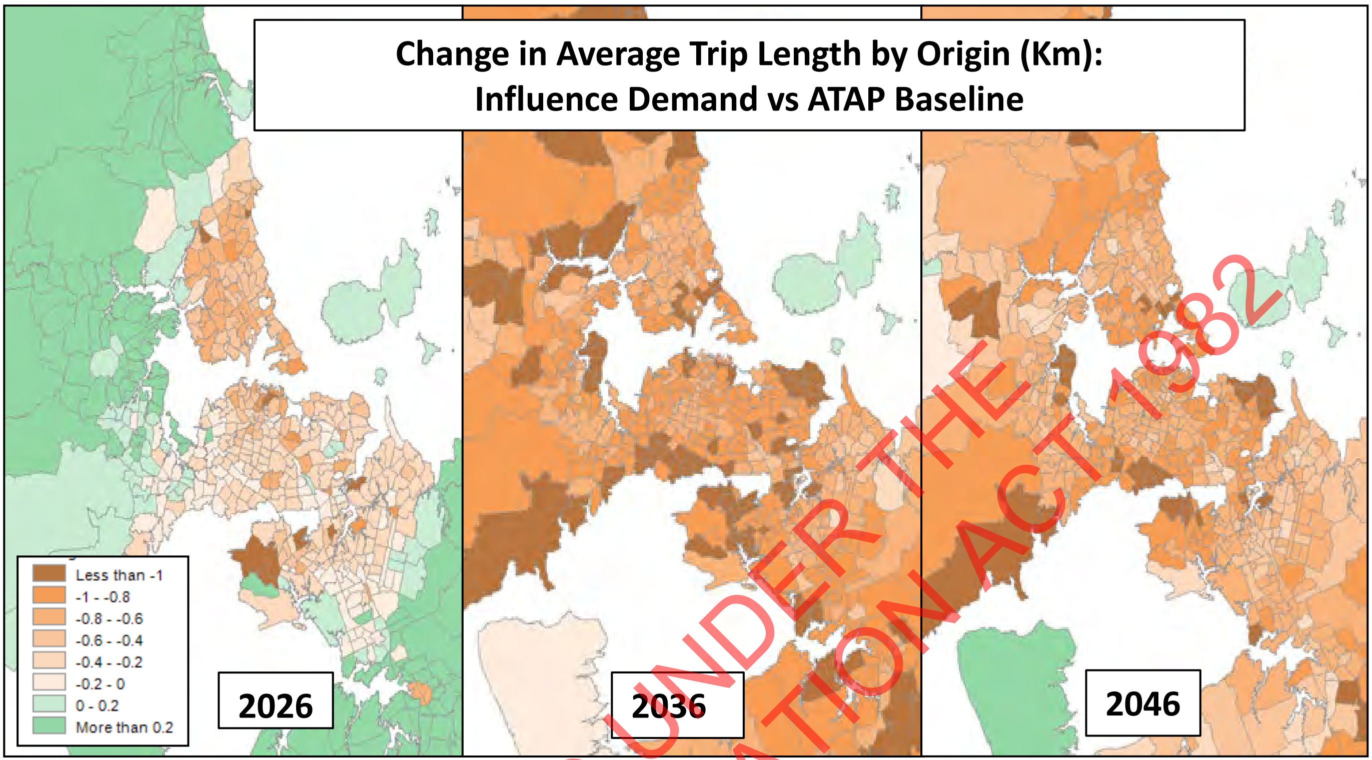


Figure 4.18: Change in Average Trip Length by origin during AM Peak (Influence Demand vs ATAP Baseline in three decades)

Accessibility

Between 2026 and 2036, the number of jobs accessible within a 30 minute car journey during the AM peak increases substantially under Influence Demand compared to APTN and the ATAP Baseline (Figure 4.19). This is due to the smarter pricing system reducing the number of vehicle trips during the AM peak, thereby reducing congestion and increasing travel speeds.

Public transport accessibility tracks very similarly to APTN for the entire duration of the evaluation. Despite the increase in public transport patronage and mode share under Influence Demand, the higher proportion of public transport investment ensures that public transport accessibility is maintained.

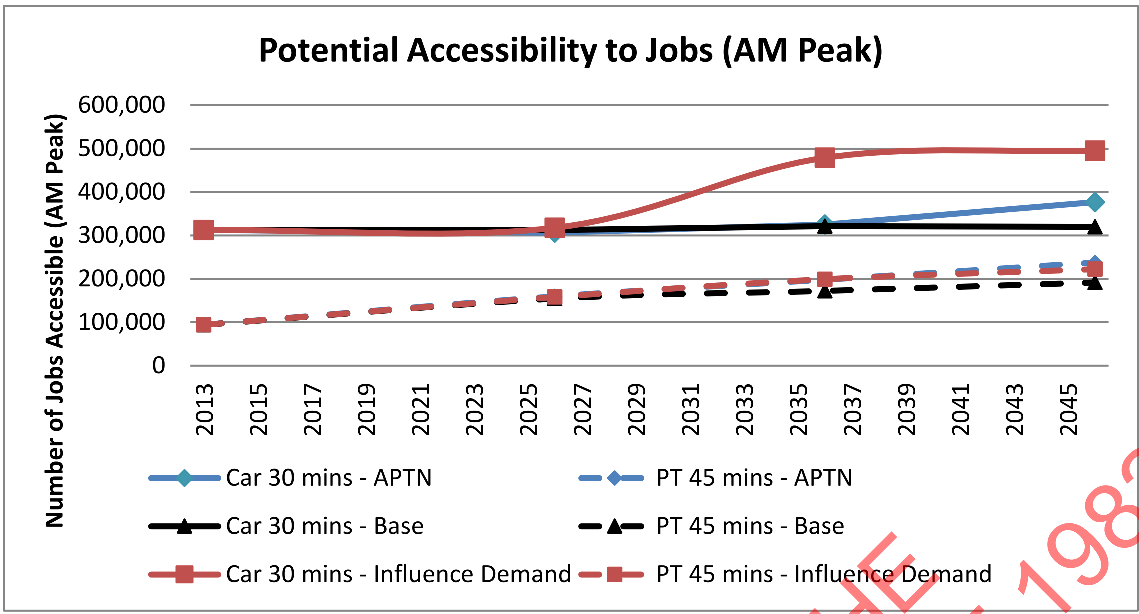


Figure 4.19: Potential accessibility to jobs AM peak (Influence Demand, APTN and ATAP Baseline)

At a sub-regional level, car accessibility improves in the south and the isthmus but declines in the west, northwest and parts of the North Shore between 2013 and 2026 under the Influence Demand package (Figure 4.20). However, public transport accessibility increases significantly for most areas under the same period.

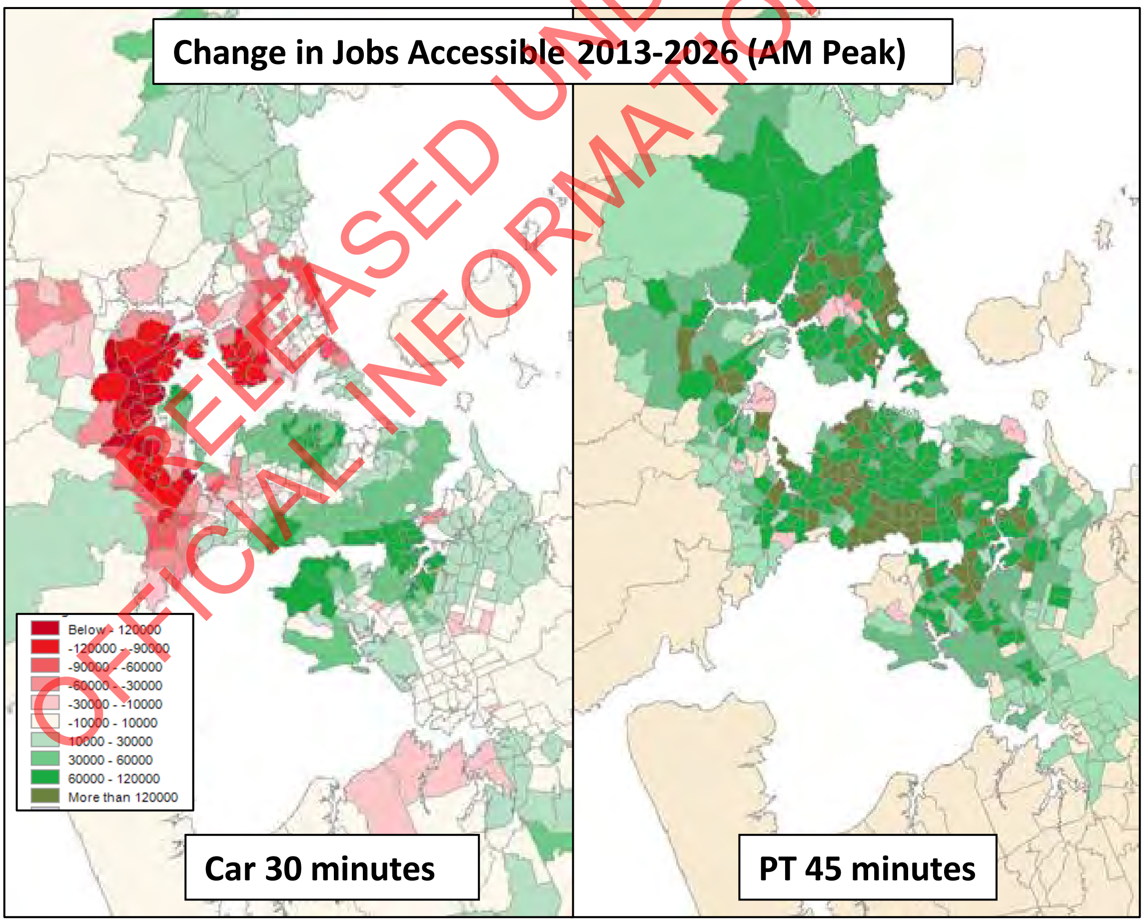


Figure 4.20: Change in accessibility to jobs AM peak 2013 vs 2026 (Influence Demand)

Between 2026 and 2046, as smarter pricing is implemented, car accessibility improves across the region, particularly for the northwest, North Shore and inner south (Figure 4.21). Public transport accessibility improves across most of the region.

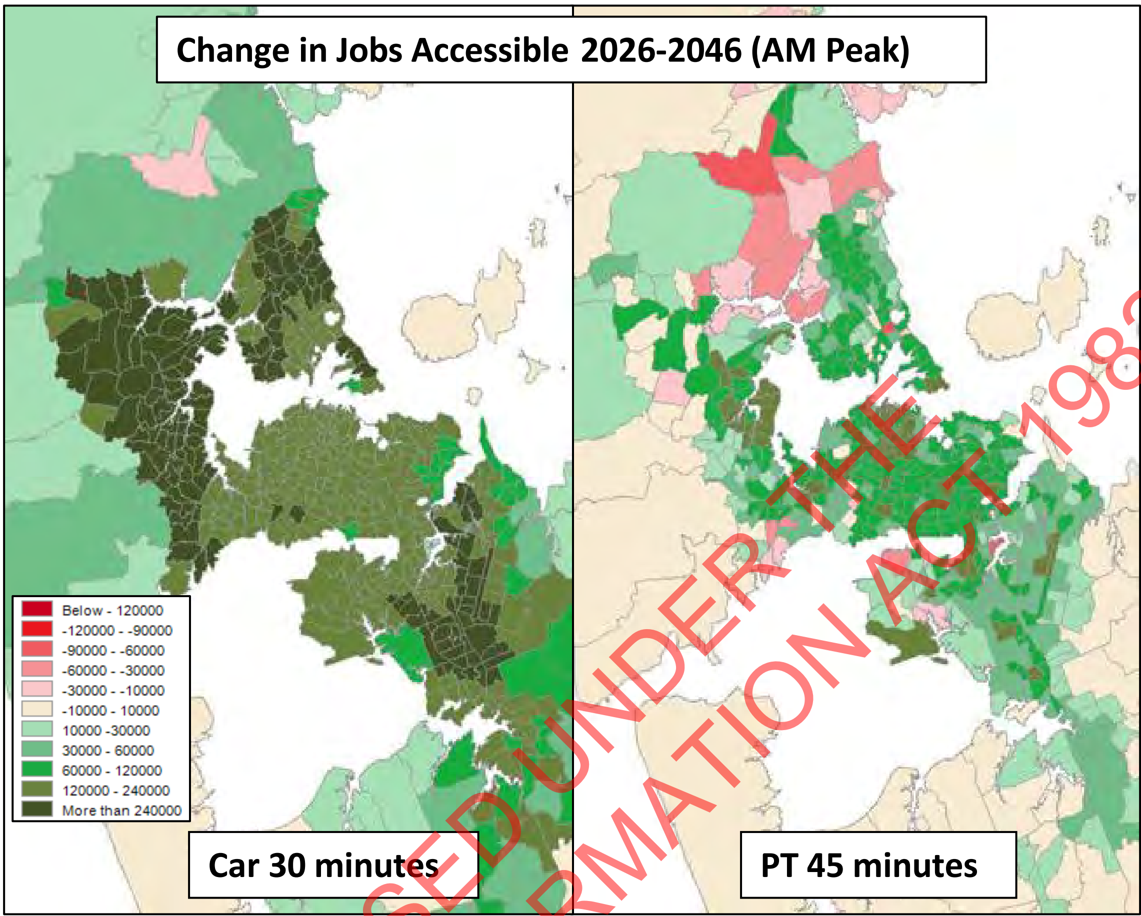


Figure 4.21: Change in accessibility to jobs AM peak 2026 vs 2046 (Influence Demand)

Compared to the Base Network, the Influence Demand package performs better for car accessibility in the northwest and parts of the west, while other parts of the region sees a slight reduction in accessibility, particularly the inner south (Figure 4.22). In terms of public transport, improvements in accessibility are largely seen in the northwest as a result of the inclusion of the Northwestern Busway, and the southeast as a result of the Pakuranga to Botany Busway.

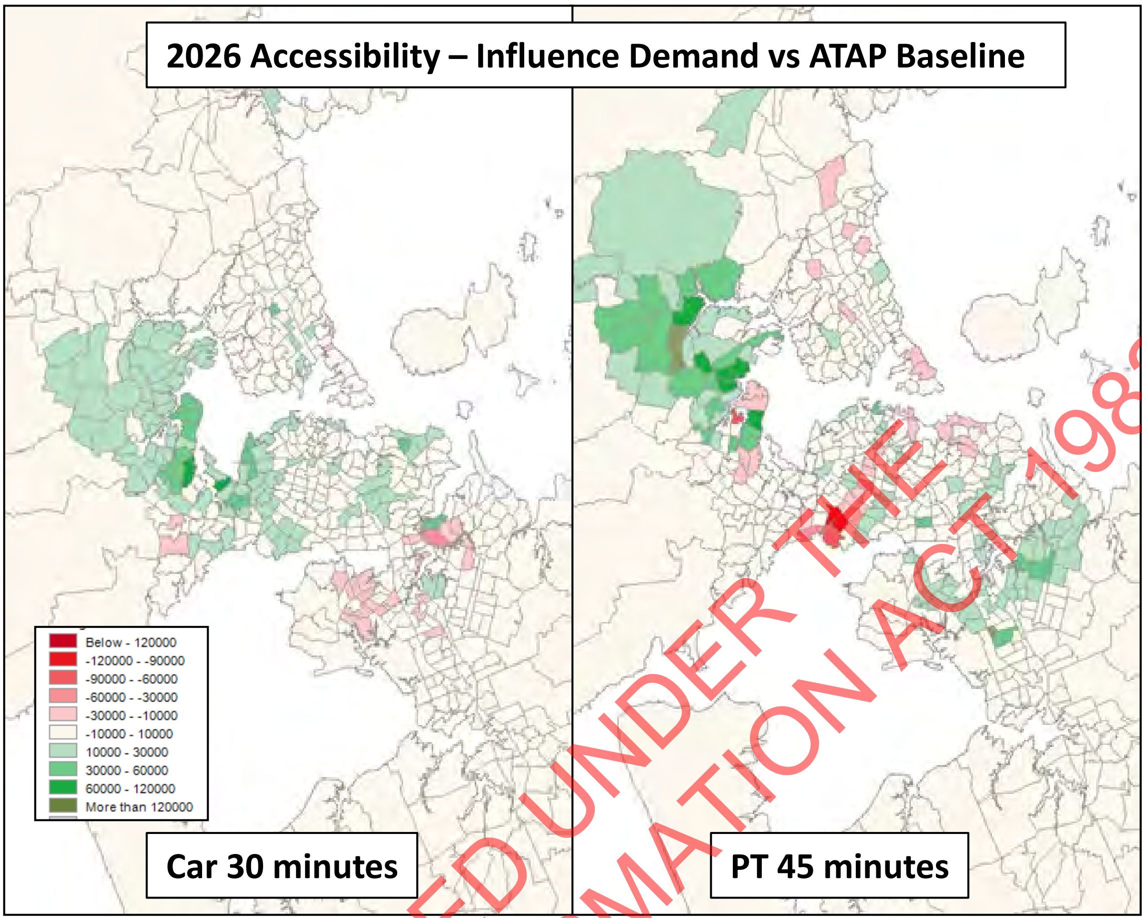


Figure 4.22: Accessibility to jobs AM peak 2026 (Influence Demand vs ATAP Baseline)

There is a dramatic improvement to car accessibility in 2046 compared to the Base Network (Figure 4.23). Virtually all of Auckland sees increased car accessibility, with the highest levels concentrated on the northwest and inner south. Apart from the targeted widening of the Southern Motorway and SH 20, most of the improvements to accessibility stem from the introduction of smarter pricing.

Public transport accessibility improvements are more uneven: improvements are seen in the northwest, and parts of the west, isthmus and inner south, while the upper North Shore sees a reduction in accessibility.

Two noteworthy findings are: Despite the exclusion of the roading element of an Additional Waitemata Harbour Crossing from the Influence Demand package, car accessibility for the North Shore is higher than under the APTN. The northwest and parts of the south appear to experience the greatest accessibility gains from the implementation of smarter pricing. This may be because pricing is particularly effective at reducing congestion along the routes serving these areas, bringing them back within a 30-minute travel time of the substantial employment opportunities in the central area. However, these travel time savings would need to be balanced against the increased direct travel costs from pricing to fully understand access impacts.

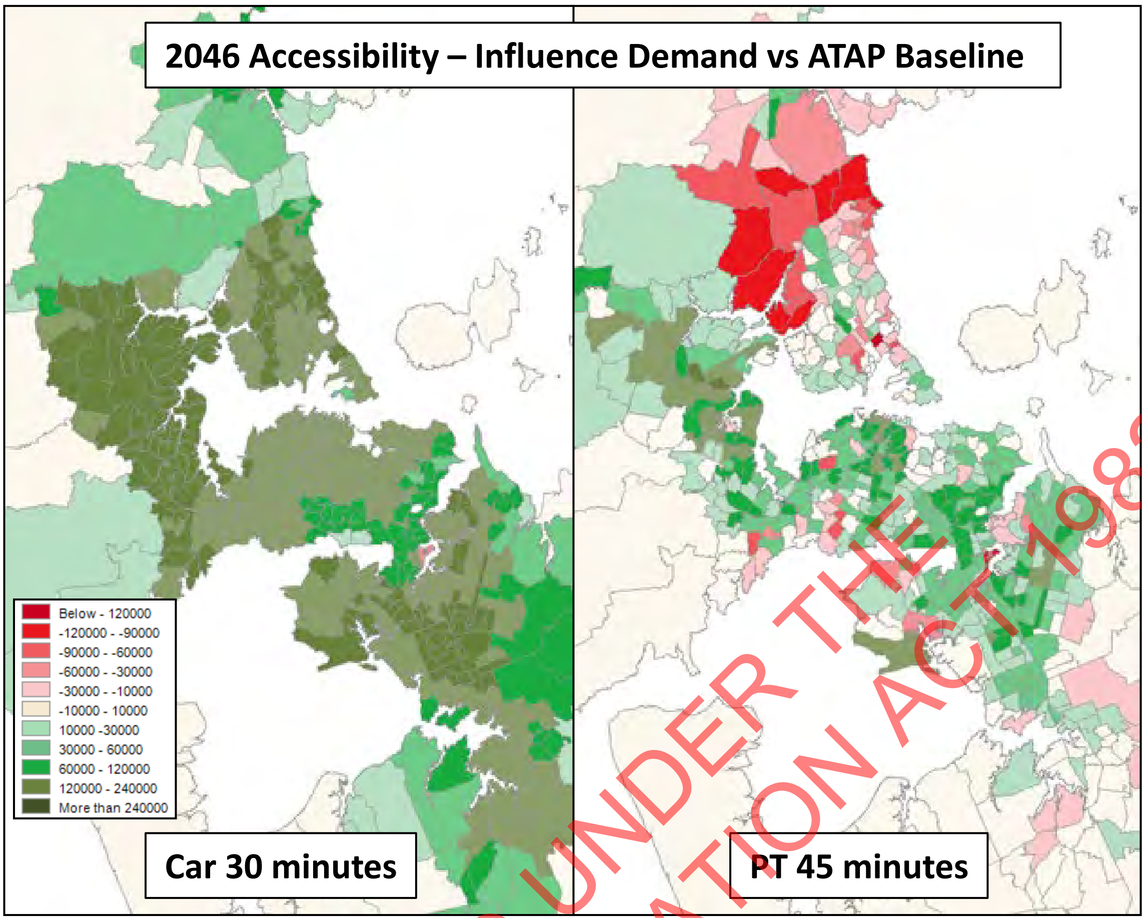


Figure 4.23: Accessibility to jobs AM peak 2046 (Influence Demand vs ATAP Baseline)

Congestion

The progressive introduction of smarter transport pricing in the Influence Demand package is projected to have a step change in reducing congestion levels. This is particularly apparent in the AM peak (Figure 4.24). Most of this change results from a combination of reduced trip lengths and a shift to public transport response to the increased cost of car travel. Inter-peak congestion is also projected to reduce under Influence Demand with smarter pricing. While some patches of congestion remain in the Influence Demand package at 2046, most of the inner motorway network is projected to operate below severe congestion levels in the inter-peak.

The Base Network and APTN perform similarly on congestion up until 2036, after which the Base Network sees an increase in both AM peak and inter-peak congestion while APTN remains largely flat.

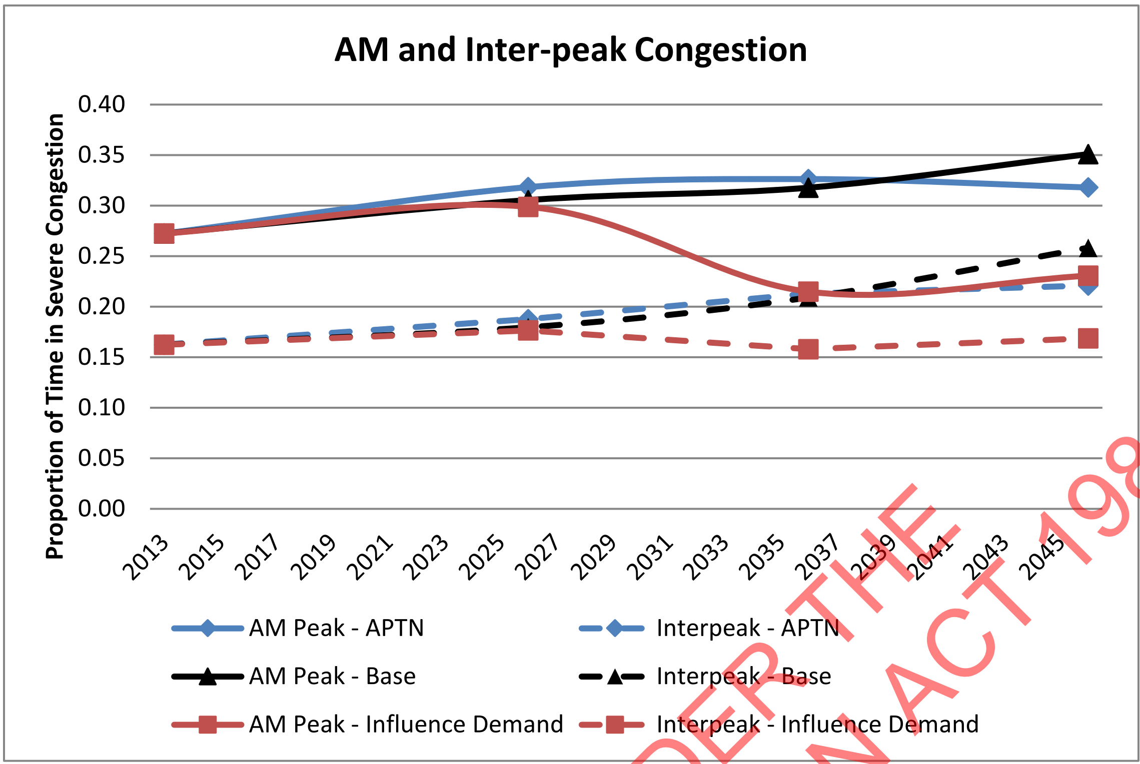


Figure 4.24: AM peak and inter-peak congestion (Influence Demand, APTN and Base Network)

Freight travel sees similar reductions in congestion for both AM peak and inter-peak (Figure 4.25). Inter-peak congestion levels rise significantly from 2026 under the APTN and the Base Network. Under the Influence Demand package however, inter-peak congestion is projected to decline after 2026 and remain below the 2013 congestion level.

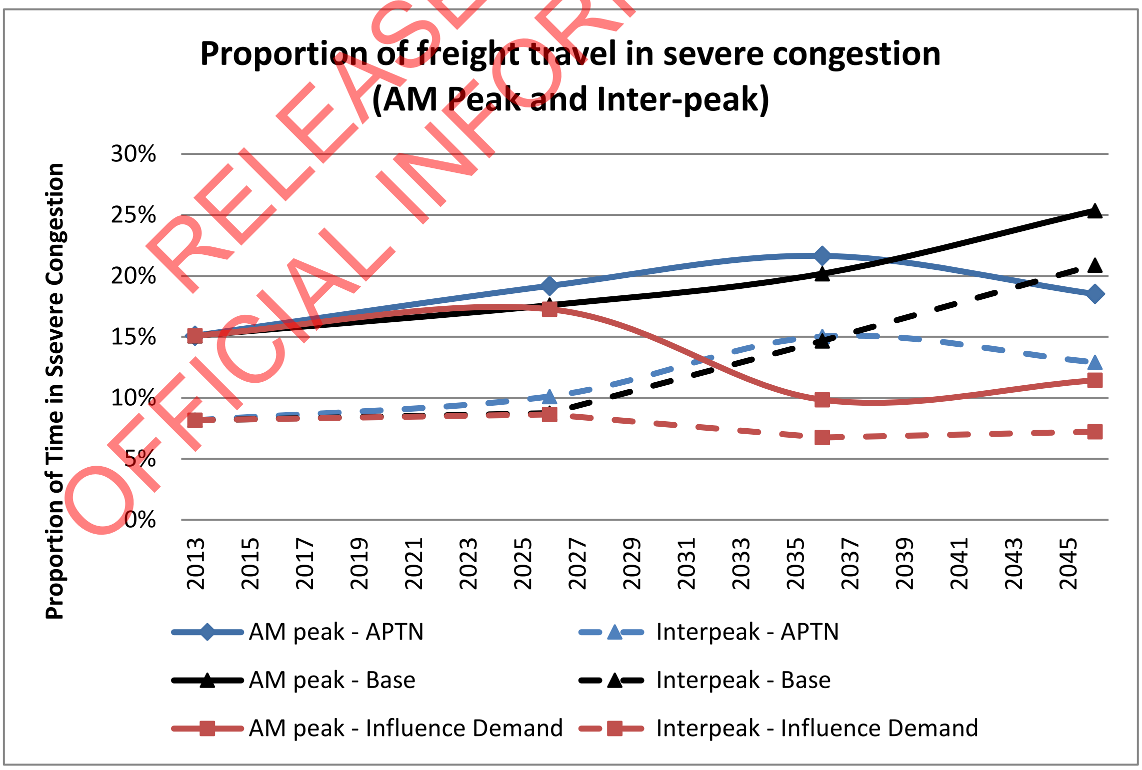


Figure 4.25: Proportion of freight travel in severe congestion (Influence Demand, APTN and Base Network)

At a sub-regional level, capacity constraints in the am peak in 2046 are projected to be alleviated on parts of the network, most particularly on SH20 and SH16 (Figure 4.26). However, constraints remain around the Airport as well as parts of SH1 on the isthmus.

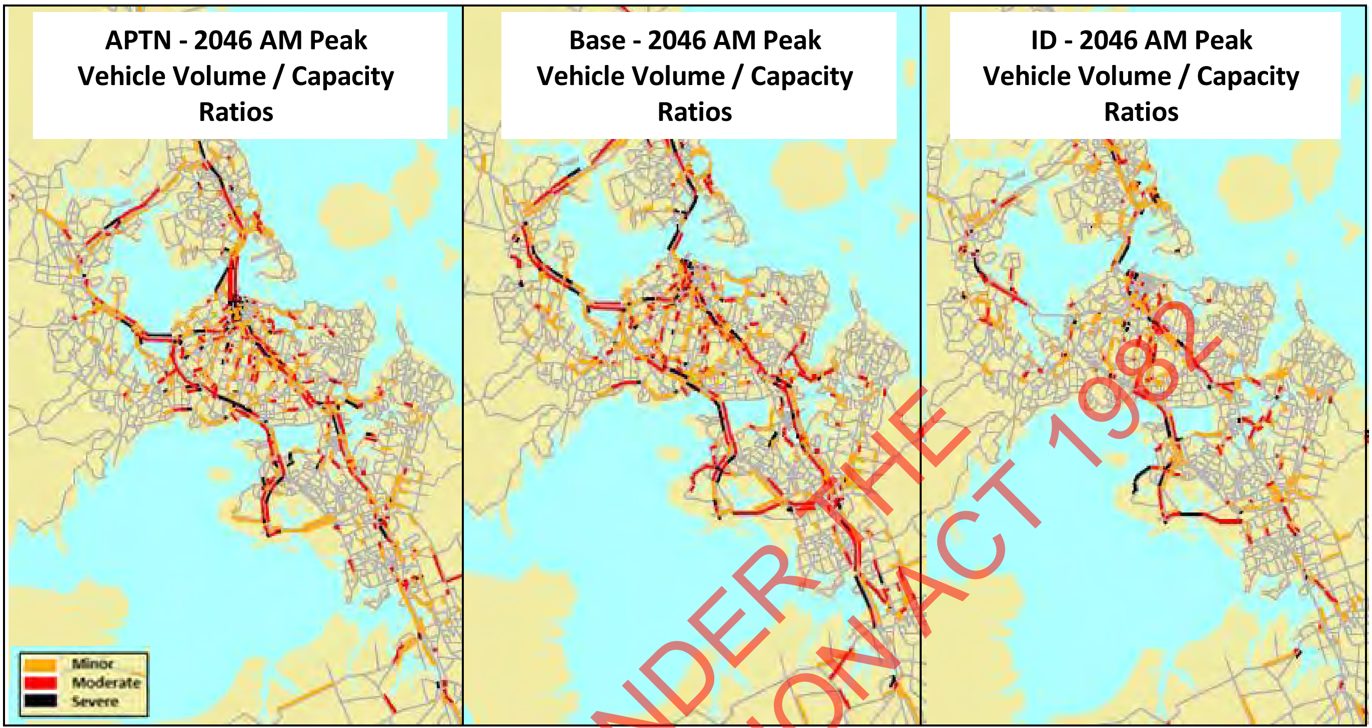


Figure 4.26: AM peak vehicle volume to capacity 2046 (Influence Demand, APTN and ATAP Baseline)

Inter-peak capacity constraints in the am peak are projected to dramatically reduce under Influence Demand, although limited severe congestion remains on the network in 2046 (Figure 4.27). The removal of most capacity constraints in the inter-peak shows that the pricing scheme may have been applied too broadly and that further analysis is required.

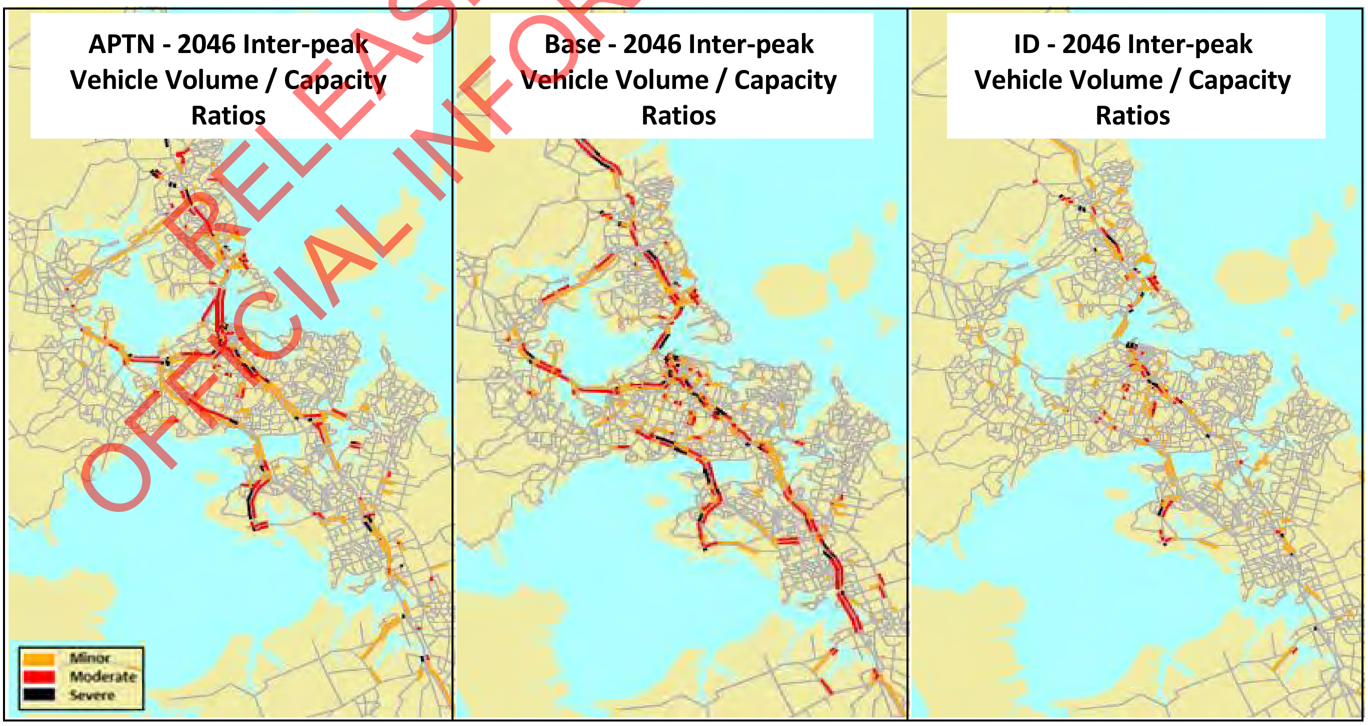


Figure 4.27: Inter-peak vehicle volume to capacity 2046 (Influence Demand, APTN and ATAP Baseline)

Public Transport Mode Share

Public transport mode share increases under Influence Demand as a result of the additional public transport expenditure and introduction of smarter pricing (Figure 4.28). Mode share for the ATAP Baseline and APTN remains largely similar over the 30 year period.

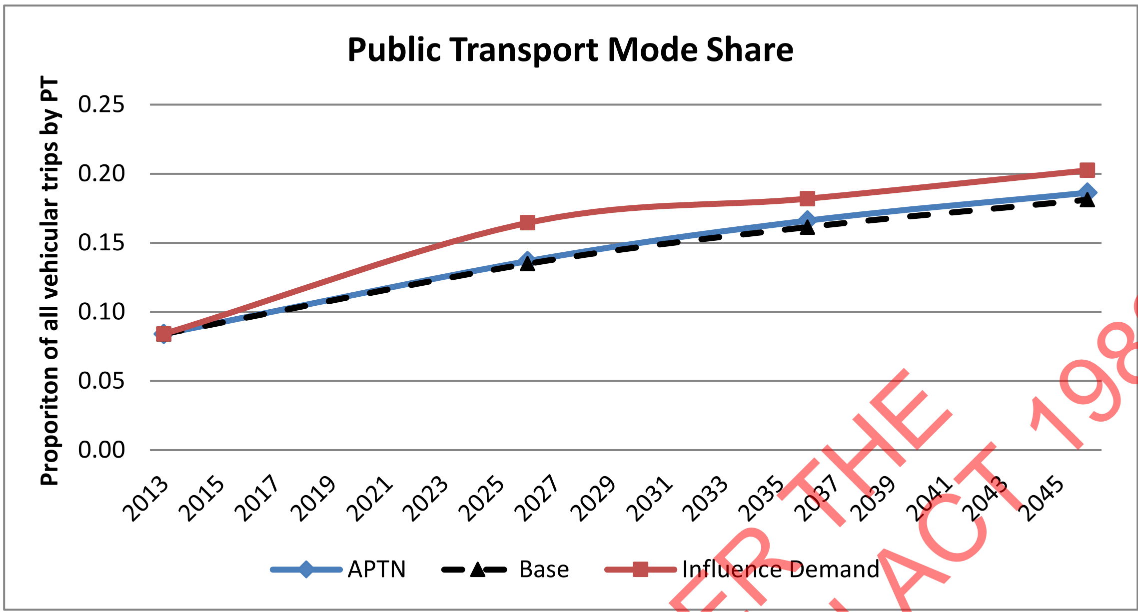


Figure 4.28: Public transport mode share AM peak (Influence Demand, APTN and ATAP Baseline)

While smarter pricing reduces demand for travel on the roading network, it substantially increases demand for the public transport network. Despite additional investments to public transport infrastructure, demand on the rapid transit network for bus continues to exceed capacity at parts of the network, particularly along the Northwestern and cross isthmus corridors, indicating the need for additional services or further investment (Figure 4.29).

Mass rapid transit to the Airport and North Shore, respectively, are projected to be operating within public transport capacity constraints under the Influence Demand package.

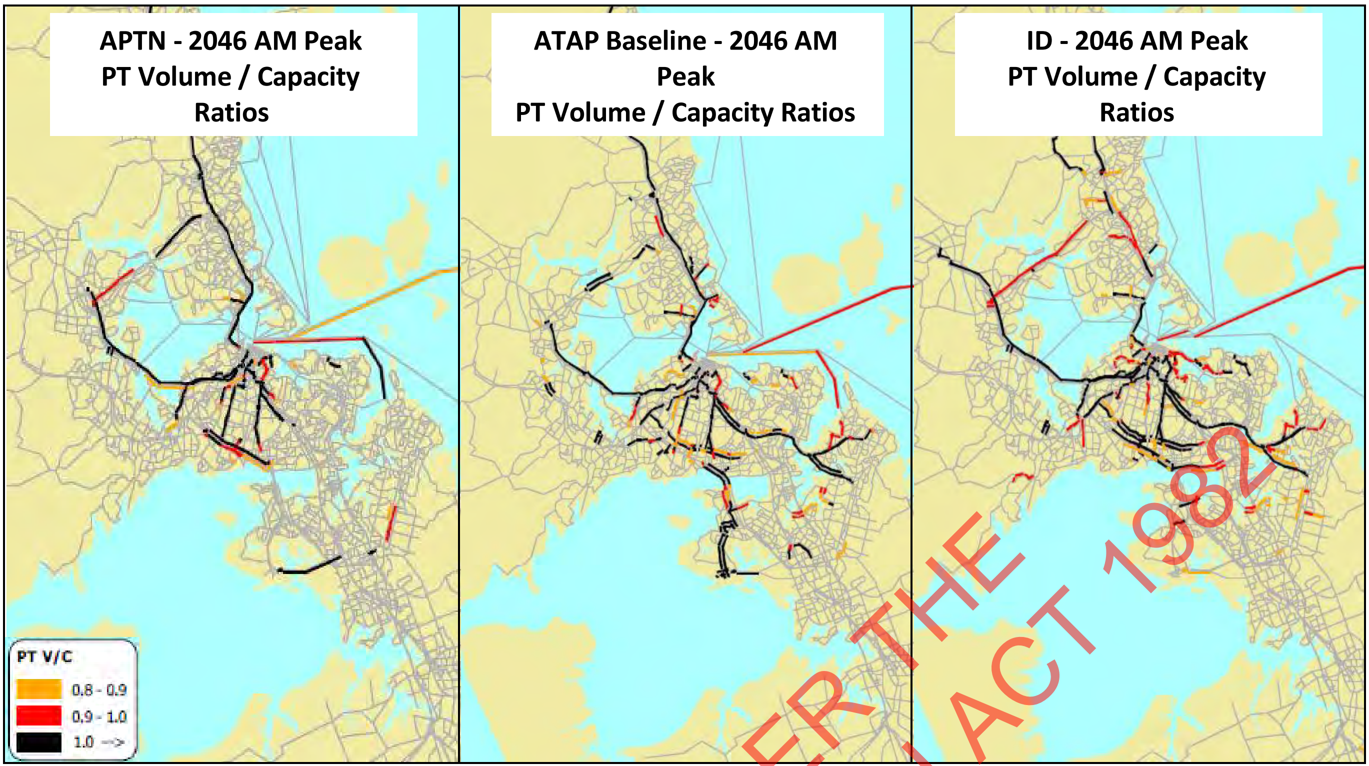


Figure 4.29: Public transport volume to capacity AM peak 2046 (Influence Demand, APTN and ATAP Baseline)

Net Benefits to Users

"Net benefits to users" was estimated because the Influence Demand package increases the financial costs of motorists using the transport system, depending on time of day and the route taken. While our analysis suggests moving to smarter transport pricing would deliver very material gains in travel times and a shift to public transport, it would impose additional cost on many road users. Motorists receive a benefit from the improved network performance (in terms of shorter travel times and lower vehicle operating costs) but also face increased costs from having to pay the network charges.

The following map (Figure 4.30) shows the difference in projected generalised costs for motorists in different parts of Auckland in the morning peak in 2046 with smarter pricing in the Influence Demand package, compared to the generalised costs in the APTN.

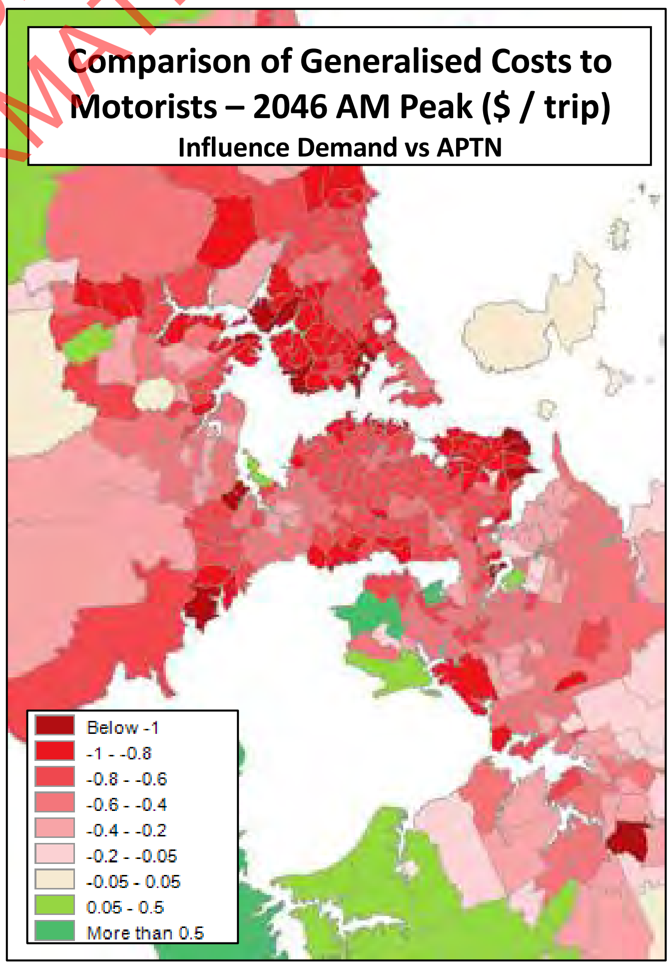


Figure 4.30: Generalised costs to road users AM peak 2046 (Influence Demand vs APTN)

Those generalised costs do not take into account the wider benefits that users of the transport system would gain from increased accessibility and reduced congestion.

Despite the reduction in pricing charges by 25% from the initial pricing scheme, this round of testing continues to impose additional financial costs on many road users, but to a much lesser extent than in the previous round. This analysis suggested that the prices charged would exceed the value of the time gained for the average road user, although for more peripheral regions where levels of congestion and the resulting charges are low, there would be net benefits to motorists.

These findings should be treated with caution. The analysis was a necessarily coarse approximation of how pricing might be applied, which means that some uncongested roads were subject to the same charge as congested routes. Furthermore, our analysis did not consider the likelihood that some users would place a much higher value on time savings than others. Further work, using much more detailed analytical tools, is required to identify efficient pricing levels which effectively address these issues.

We expect that more detailed development and analysis will go a long way towards ensuring overall net user benefits from the introduction of pricing, as prices could be adjusted to lower levels and a finer-grain (e.g. on uncongested counter-peak motorways) and would also be better information about the impacts on users with different values of time could be taken into account.

It will be important to understand where travel cost increases occur under a particular pricing structure so that equity impacts (including the affordability of travel to different groups, and the impact of pricing on access to jobs, education and services) can be assessed and any necessary mitigation can be developed.

Value for Money

The Influence Demand package has an estimated $33.2 billion capital expenditure programme over 30 years (excluding renewals) which is projected to result in significantly higher contributions to the ATAP objectives compared to the APTN. The package is projected to result in a higher proportion of jobs accessible by motorists of 55% (compared to 43% in the APTN), a similar proportion of jobs accessible by public transport of 25% (compared to 24% in the APTN), a significantly lower proportion of travel time in severe congestion of 23% in severe congestion in the morning peak (compared to 32% in the APTN) and a moderately higher public transport mode share of 20.2% in the morning peak (compared to 18.6% in the APTN).

The Influence Demand package as a whole is projected to have significantly higher contributions to the ATAP objectives than the APTN package, but with a larger capital improvement programme and a higher average cost to motorists.

4.2.3 Key Learnings

The Influence Demand package highlights significant improvements in potential accessibility, congestion and public transport mode share. These are counter-balanced by unclear net benefits to users that would require more detailed analysis.

Due to its significantly better performance against the project objectives, Influence Demand forms the base of the Indicative Package in the next phase of the project.

4.3 Cross Package Review

4.3.1 Overview

The Higher Investment and Influence Demand packages were compared against both the APTN (to understand the extent to which it appear to deliver better returns than current plans) and a common baseline (to understand the value from additional investment above this baseline). The main findings from the cross package review are listed below:

- Additional investment in the first decade did not appear to improve performance against the project objectives at regional level, but some of these extra investments did have some important sub-regional effects. Therefore, development of the Indicative Package in the next phase should adopt a more targeted approach to identifying early priorities which both align with the project objectives and appear likely to deliver value for money (refer to section 5).
- The introduction of smarter pricing in the Influence Demand package has the most significant impacts on the project objectives, but unclear net benefits to users that would require more detailed analysis.
- Because of its significantly better performance against the project objectives, Influence Demand should form the base of the Indicative Package in the next phase of the project.

4.3.2 Accessibility

Car accessibility outputs indicate a very similar situation between 2013 and 2026 across the packages, but with their differences subsequently growing (Figure 4.31). Additional investment before 2026 appears to have a very limited effect on car accessibility. After 2026, once the progressive implementation of a variable network charge has been introduced, car the Influence Demand package provides significantly higher car accessibility than any other package, despite containing around $8 billion less investment than the Higher Investment package.

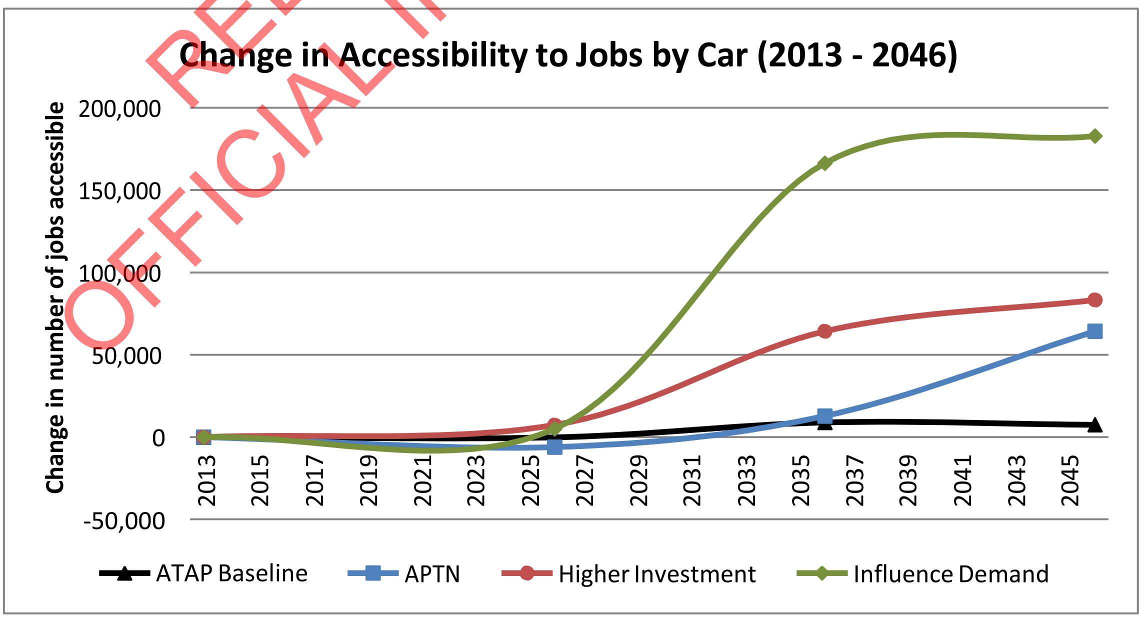


Figure 4.31: Change in number of jobs accessible within a 30 minute car commute AM peak (2013 – 2046)

Public transport accessibility modelling outputs hide some of the differences between packages, due to the limitations of the analytical tools. These limitations almost certainly mean performance of the ATAP baseline and the APTN are substantially over-stated. This is because capacity constraints arising from these packages being reliant on extremely high bus volumes along key corridors were not able to be assessed. The Higher Investment and Influence Demand packages perform very similarly over the 30 years, because the public transport investments in those packages are almost identical, with only the timing varying (Figure 4.32).

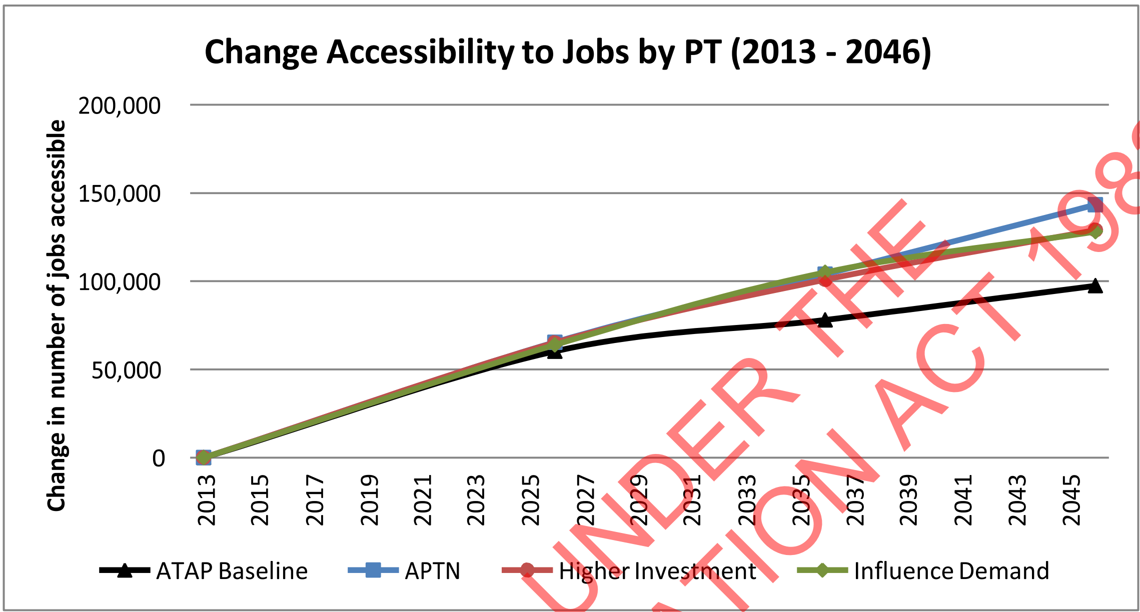


Figure 4.32: Change in number of jobs accessible within a 45 minute PT commute AM peak (2013 – 2046)

At a sub-regional level, all three packages show similar patterns in car access at 2026 (Figure 4.33). The isthmus sees a marginal increase in accessibility, while the northwest, west and North Shore see a reduction in accessibility. Higher Investment increases accessibility for most of the south, while Influence Demand sees relatively similar accessibility patterns to the APTN.

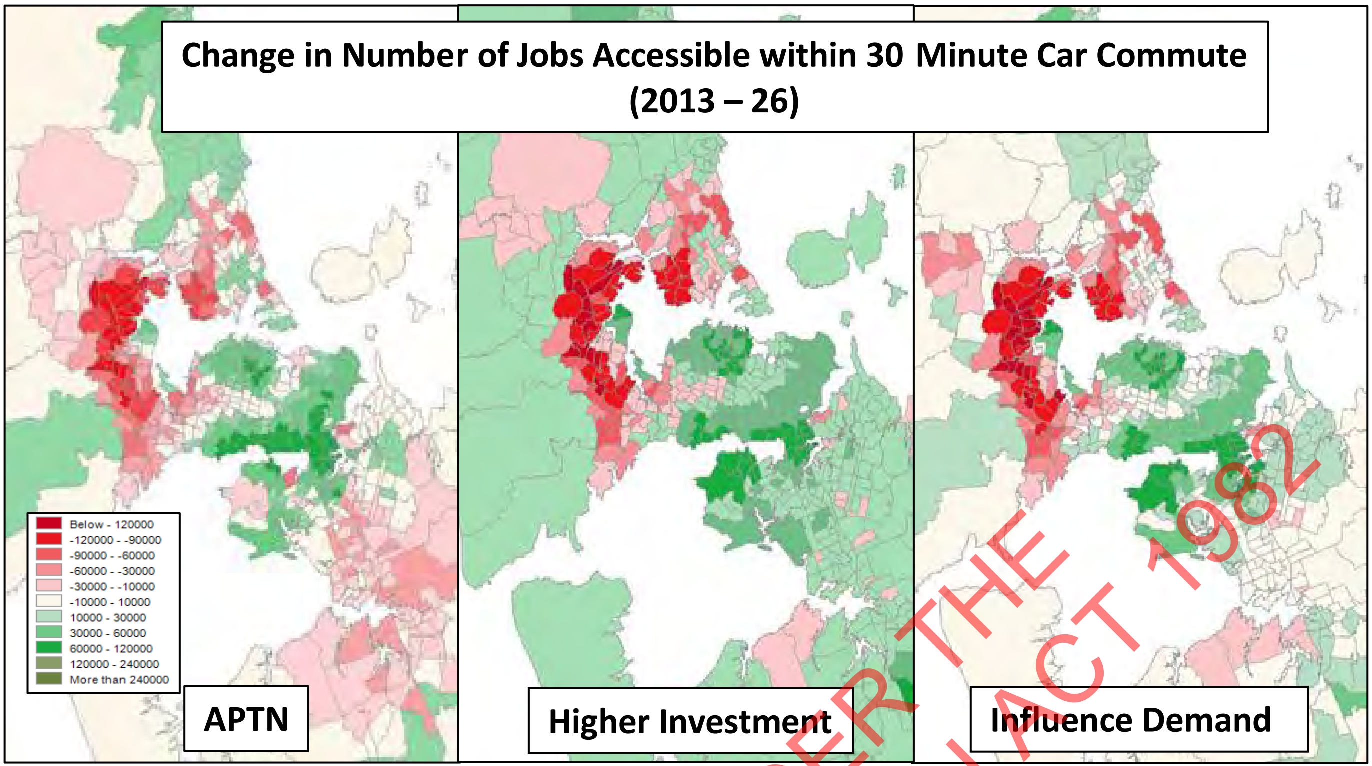


Figure 4.33: Change in number of jobs accessible within a 30 minute car commute AM peak (2013 – 2026)

Car accessibility improves dramatically under Influence Demand with the introduction of smarter pricing. This is reflected sub-regionally under Figure 4.34, with the northwest, North Shore and inner south seeing the greatest increase in accessibility. Higher Investment also experiences an increase in accessibility through most parts of Auckland, though at a smaller scale compared to Influence Demand. The inner south experiences declines in accessibility despite targeted widening in the Southern Motorway network.

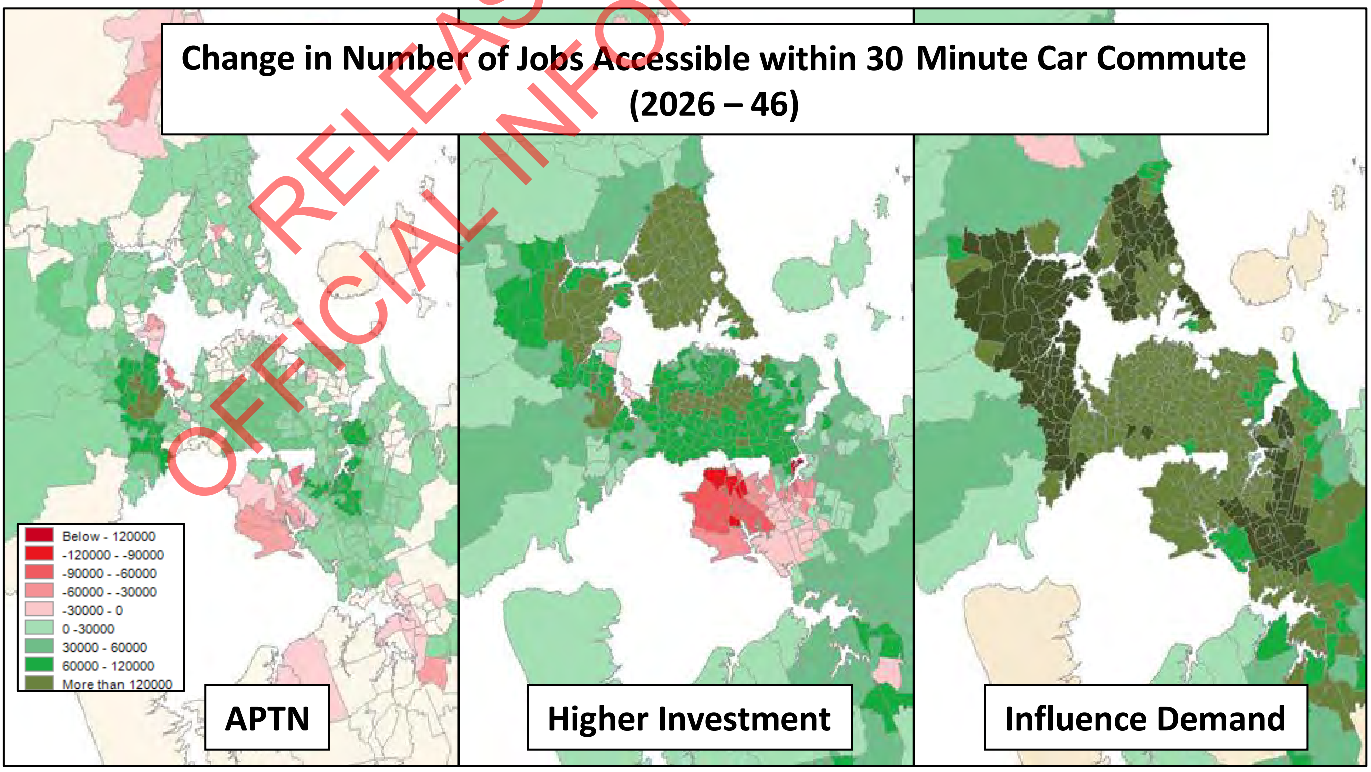


Figure 4.34: Change in number of jobs accessible within a 30 minute car commute AM peak (2026 – 2046)

At 2026, Influence Demand and Higher Investment are projected to have roughly similar patterns in public transport access improvements (Figure 4.35).

Between 2026 and 2046, improvements to public transport access are concentrated on the isthmus and northwest under Influence Demand (Figure 4.36). Accessibility declines on parts of the North Shore.

Higher Investment sees a more even distribution of public transport access improvements across the region, though the improvements are less dramatic compared to Influence Demand.

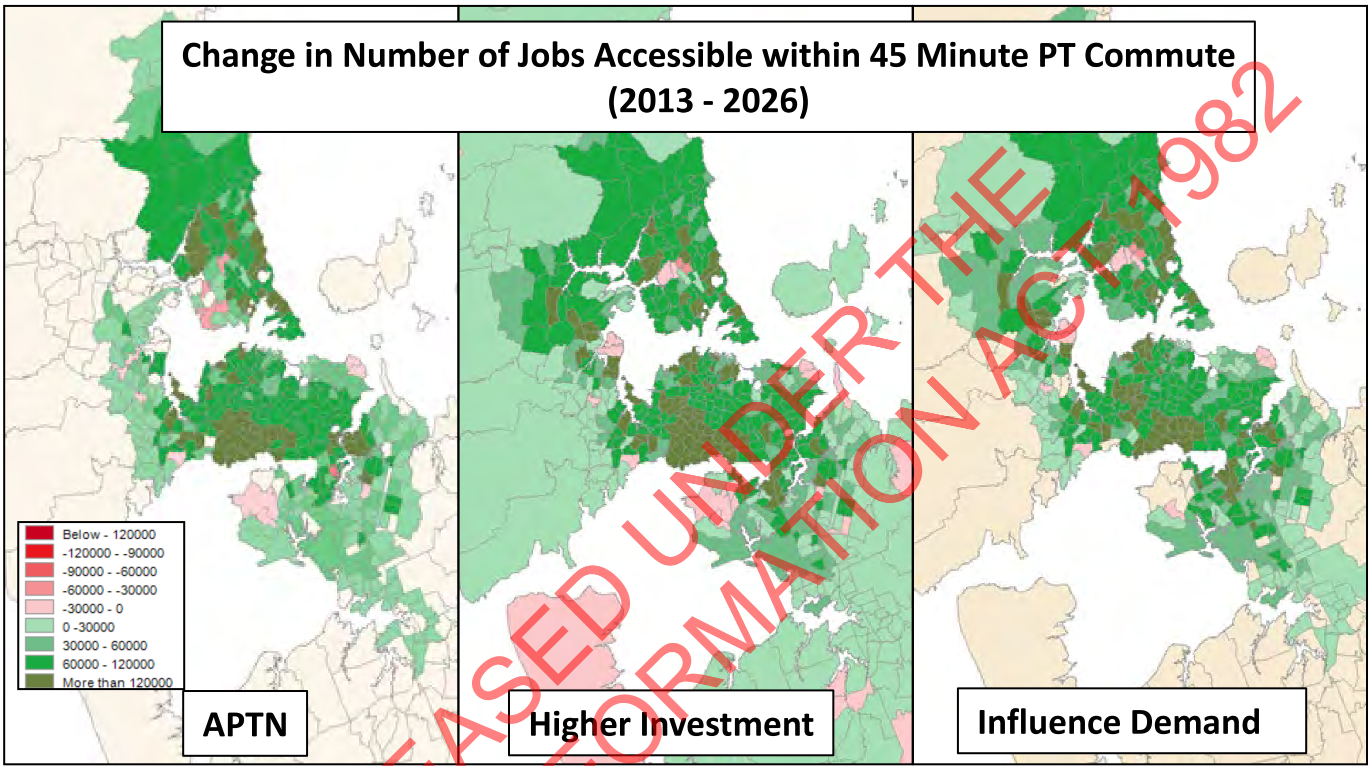


Figure 4.35: Change in number of jobs accessible within a 45 minute PT commute AM peak (2013 – 2026)

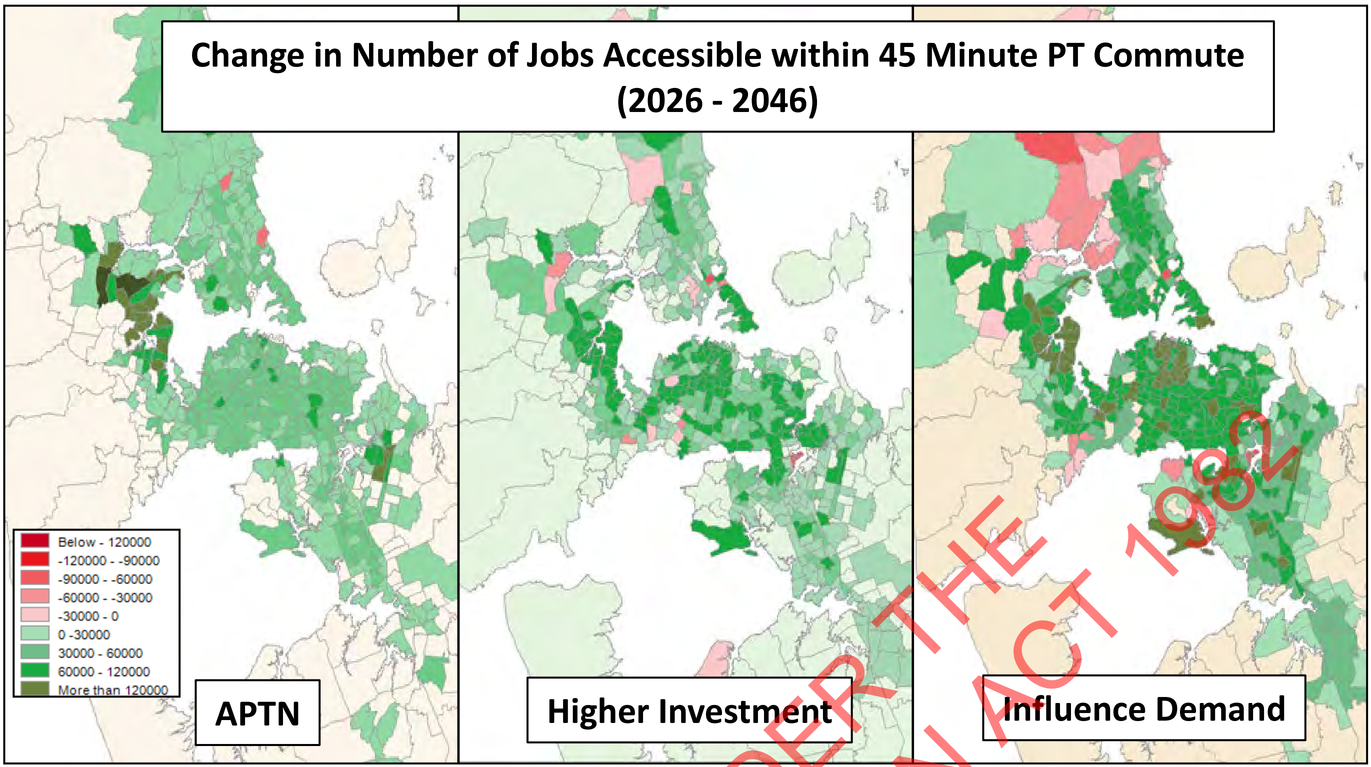


Figure 4.36: Change in number of jobs accessible within a 45 minute PT commute AM peak (2026 – 2046)

4.3.3 Congestion

Analysis of projected congestion levels mirrors the car accessibility outputs discussed above. While the Higher Investment package performs slightly better than the APTN (particularly in 2026 and 2036 as a result of earlier investment in additional highway capacity), it is only the progressive introduction of smarter transport pricing in the Influence Demand package that delivers a step-change impact on congestion levels (Figure 4.37).

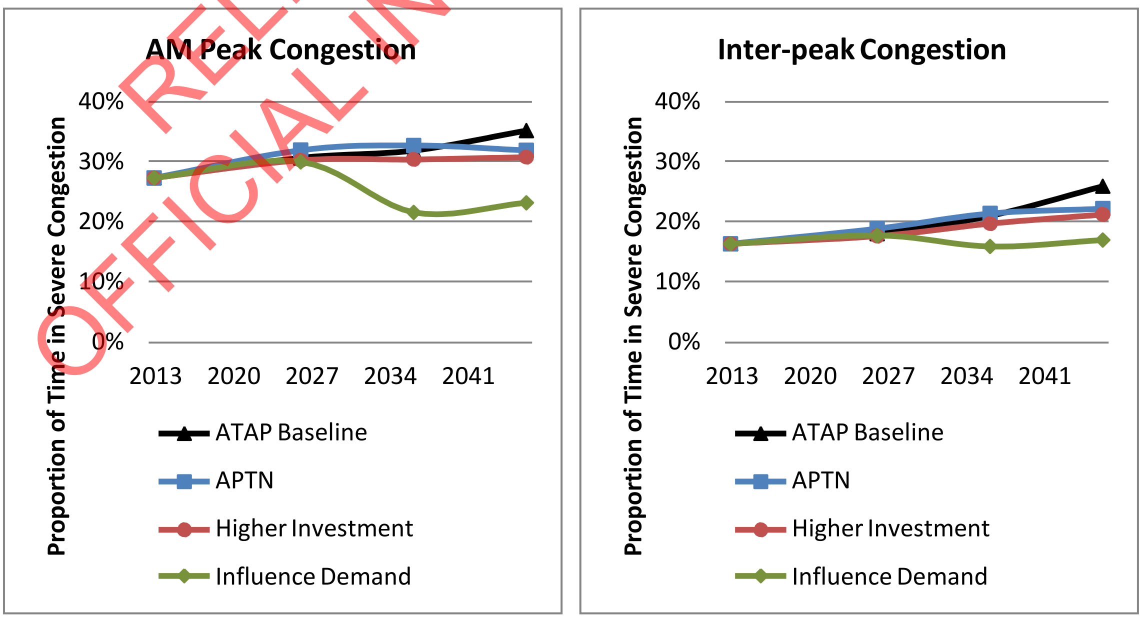


Figure 4.37: AM peak and Inter-peak Congestion (2013 – 2046)

Most of this change results from a combination of reduced trip lengths and a shift to public transport in response to the increased cost of car travel. The lower level of congestion for the Influence Demand package is reflected in the more detailed volume to capacity plots for 2046 (Figure 4.38). Under Higher Investment, key pinch points of the inner motorway network experience the highest levels of congestion.

These plots also indicate various areas of remnant congestion in the Influence Demand package, especially on the Northern Motorway and inner parts of the Southern Motorway. Addressing these areas of congestion informed the development of the Indicative Package, as well as the need to continue to refine the details of the pricing system over time, as changes to the pricing structure could also address these issues.

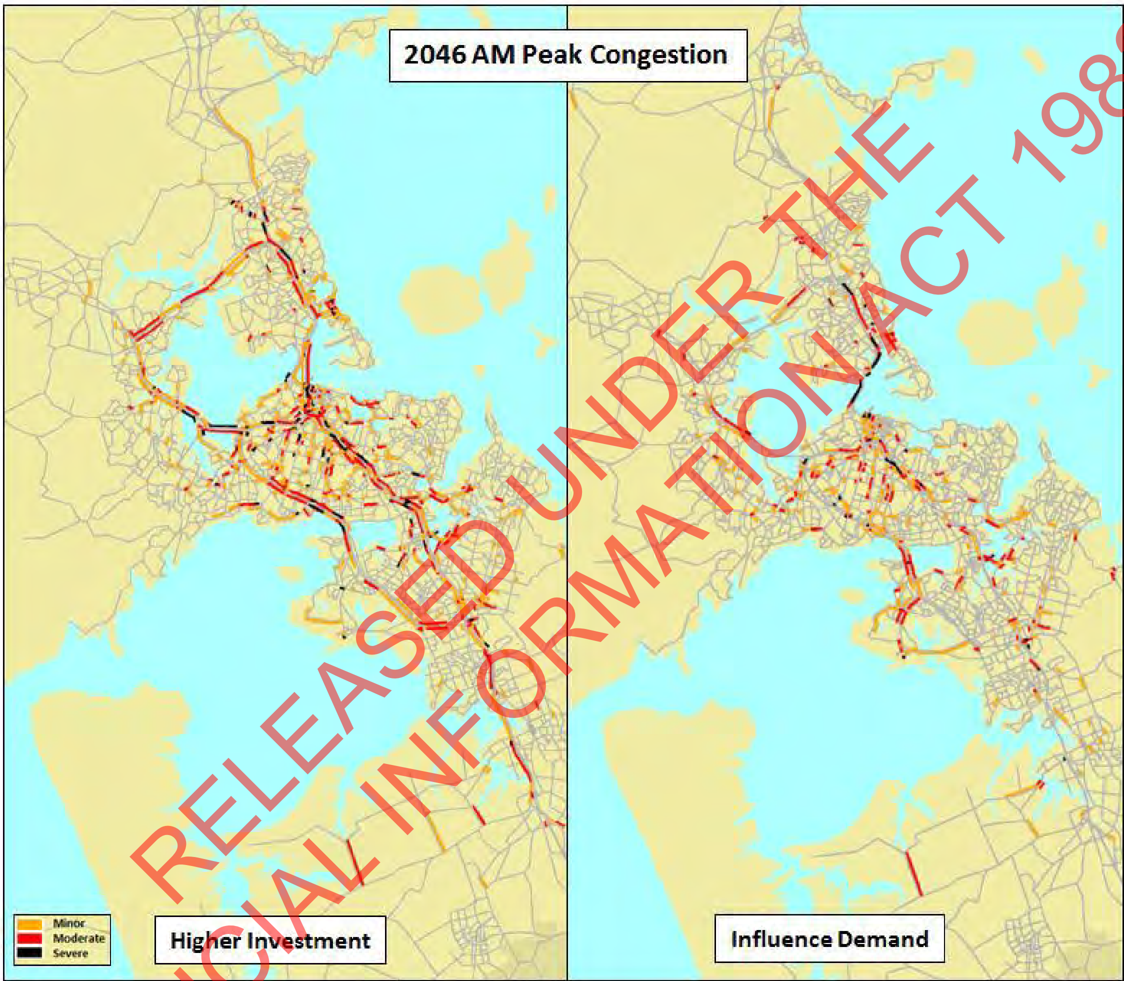


Figure 4.38: AM peak vehicle volume to capacity in 2046 (Higher Investment and Influence Demand)

Inter-peak congestion plots for the two packages also indicate a much lower level of congestion under Influence Demand (Figure 4.39). While some patches of congestion remain in the Influence Demand package, most of the inner motorway network is operating below moderate or severe congestion levels in 2046.

Moderate to severe congestion levels are found under Higher Investment, particularly within the inner motorway network.

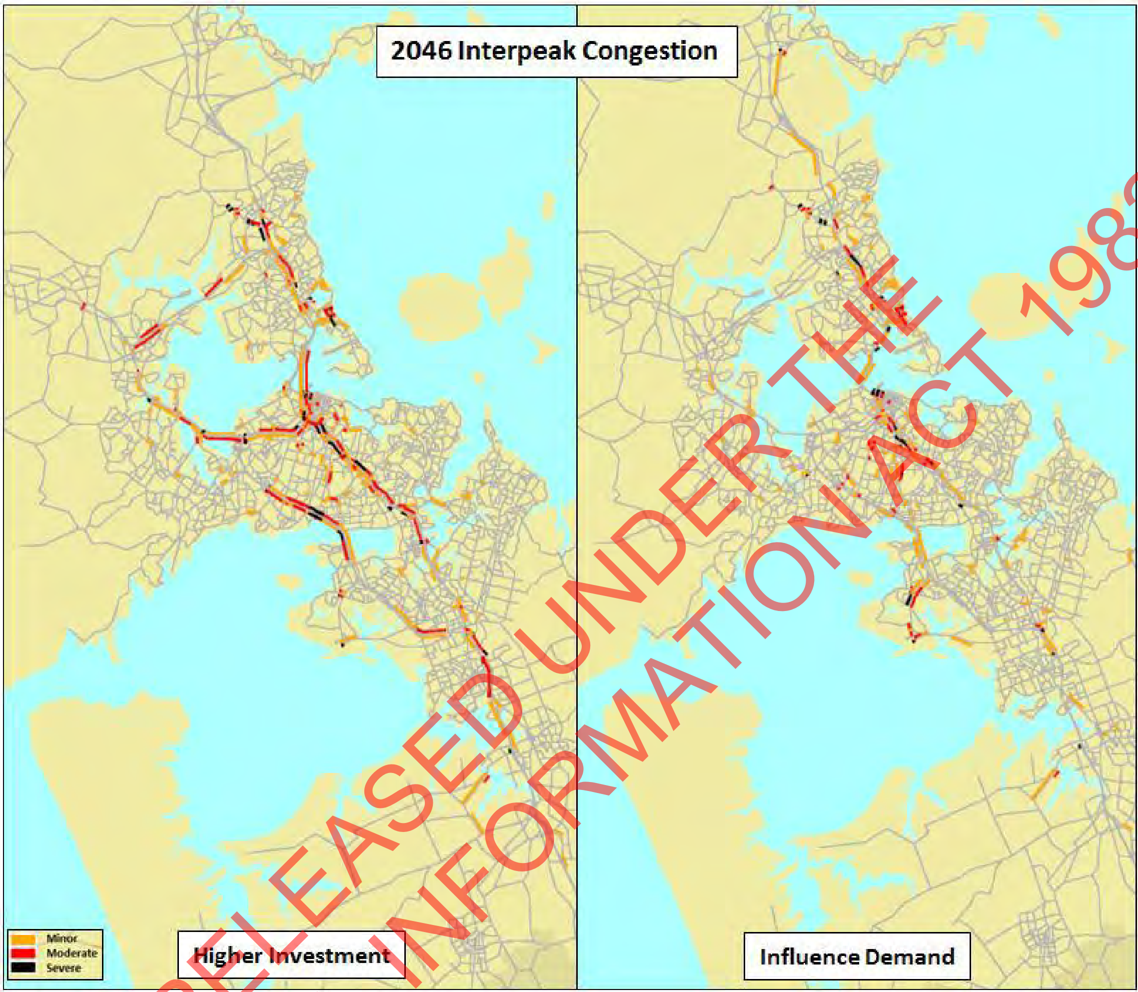


Figure 4.39: Inter-peak vehicle volume to capacity in 2046 (Higher Investment and Influence Demand)

4.3.4 Public Transport Mode Share

Public transport mode share tracks similarly for APTN, Higher Investment and the ATAP Baseline (Figure 4.40). Public transport mode share is projected to be higher under Influence Demand due to the increased cost of driving resulting from smarter pricing and further investment to the public transport network.

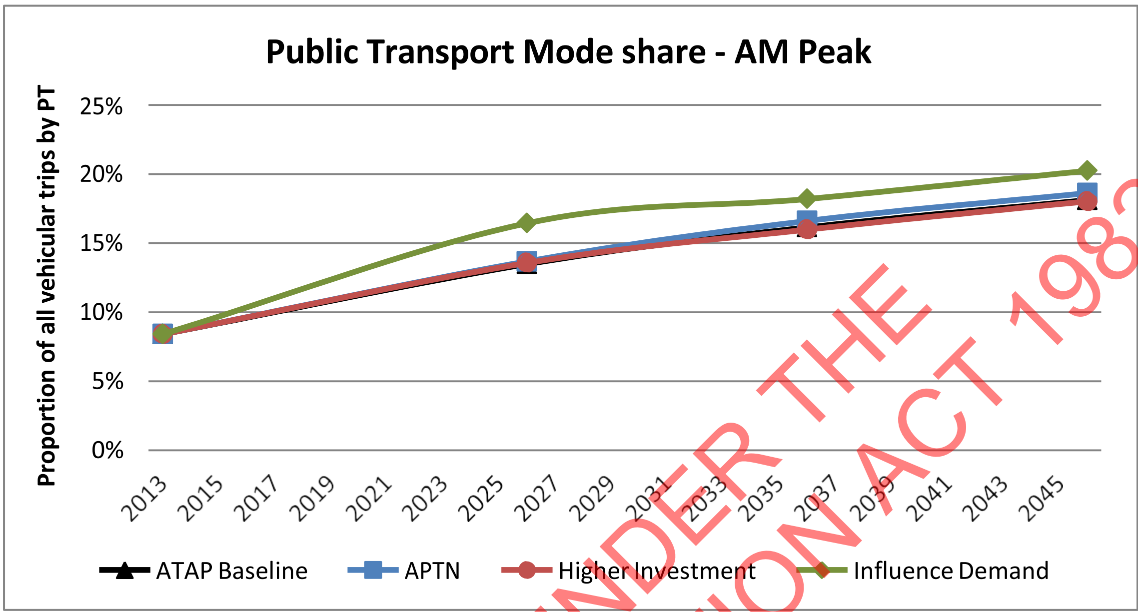


Figure 4.40: Public transport mode share in the AM peak (2013-2046)

4.3.5 *Full Evaluation Results*

The following table presents the results of our evaluation of the Higher Investment and Influence Demand packages against the evaluation criteria established in the Foundation Report (Table 4.4). All results relate to the 2046 year unless otherwise specified.

Table 4.4: Evaluation framework – headline measures

Objective	Measure	Headline KPI	2013 comparison	Higher Investment 2046	Influence Demand 2046	APTN 2046	Comment
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30 minute trip in the AM peak • Jobs accessible by public transport within a 45 minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	312,000 i.e. 51% of available jobs 94,000 i.e. 15% of available jobs 467,000 i.e. 75 % of available jobs	396,000 i.e. 44% of available jobs 223,000 i.e. 25% of available jobs 593,000 i.e. 67% of available jobs	495,000 i.e. 55% of available jobs 222,000 i.e. 25% of available jobs 655,000 i.e. 74% of available jobs	386,000 i.e.43% of available jobs 215,000 i.e. 24% of available jobs 590,000 i.e. 66% of available jobs	The Higher Investment package increases the number of jobs accessible by car and PT in the morning peak (7-9am) in 2046, but does not increase the proportion of jobs that could be accessed by car. The Influence Demand package increases car and PT accessibility (measured only in relation to travel time, not financial cost) in the morning peak (7-9 am) in 2046.
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak	7 hours 22 minutes per person per annum 27.3% AM peak 16.3% inter-peak	11 hours 58 minutes per person per annum 30.7% AM peak 21.1% inter-peak	4 hours 57 minutes per person per annum 23.1% AM peak 16.9% inter-peak	13 hours 33 minutes per person per annum 31.9% AM peak 21.9% inter-peak	Projected levels of congestion for the Higher Investment package are expected to be similar to the APTN. The Influence Demand package's projected levels of congestion throughout the day are significantly better than the APTN.
	Impact on freight and goods (commercial traffic) congestion	• Proportion of business and freight travel time spent in severe congestion on the strategic freight network (in the AM peak and inter-peak)	15.1% AM peak 8.3% inter-peak	19.8% AM peak 12.6% inter-peak	11.4% AM peak 7.2% inter-peak	18.6% AM peak 12.9% inter-peak	The Higher Investment package's projected congestion on the strategic freight network is similar to the APTN. The Influence Demand package's projected congestion is significantly better throughout the day, compared to the APTN.
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, inter-peak and PM peak.	15% AM peak 6% inter-peak 16% PM peak	19% AM peak 13% inter-peak 24% PM peak	10% AM peak 6% inter-peak 12% PM peak	19% AM peak 13% inter-peak 23% PM peak	Projected reliability of travel times for motor vehicle trips with the High Investment package are expected to be similar to the APTN. The Influence Demand package's projected reliability of travel times is expected to be significantly better throughout the day, compared to the APTN.
Increase public transport mode-share	Public transport mode share	• Proportion of vehicular trips in the AM peak made by public transport	8.5%	18.0%	20.2%	18.0%	Projected PT mode share for the Higher Investment package is expected to be similar to the APTN. The Influence demand package's projected PT mode share is slightly higher than the APTN.
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 9 km in the AM peak made by public transport	18.3%	31.7%	38.4%	31.7%	The proportion of longer commuter trips by PT with the Higher Investment Package is projected to be the same as the APTN. The Influence Demand package's projections shows a higher proportion of longer commute trips would be by PT, compared to the APTN.
	Increase vehicle occupancy	• Average vehicle occupancy	1.36 people per vehicle AM peak 1.25 people per vehicle inter-peak	-	-	-	It was not possible to model changes in vehicle occupancy. The input assumptions of an average of 1.36 people per vehicle in AM peak and an average of 1.25 in inter-peak remained constant for all packages and all model years.

Objective	Measure	Headline KPI	2013 comparison	Higher Investment 2046	Influence Demand 2046	APTN 2046	Comment
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	Not applicable	-	-	Not applicable	Financial costs from smarter pricing in the Influence Demand package (see pricing schedule in Table 4.2) are assumed to replace road user charges and fuel excise duties. Savings in travel time and vehicle operating costs vary by trip. On average it is estimated that the financial costs exceed the savings in travel time and vehicle operating costs. Better model/tools are required to provide robust quantification of net benefits.
Ensure value for money	Value for money	• Package benefits and costs	-	-	-	-	Package benefits include the contributions to Objectives as measured in this table. The costs of new capital expenditure (excluding renewals) for the 30 year programmes are estimated in billions of 2016 dollars as follows: Higher Investment: $40.7 b Influence Demand: $33.2 b These cost estimates were identified after the revision of project costs in ATAP. Better model/tools are required to provide robust quantification of net benefits.

In addition to the project objectives, a number of other key outcomes have been evaluated through the evaluation framework in Table 4.5 below.

Table 4.5: Evaluation framework – other key outcomes

Other Key Outcomes	Measure	Headline Key Performance Indicator	2013 comparison	Higher Investment 2046	Influence Demand 2046	APTN	Comment
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	Existing transport infrastructure in greenfields is inadequate to support the growth required in the FULSS.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	The transport infrastructure in greenfields programme does not meet timeframes of FULSS.	The same programme in greenfields has been assumed in both the Higher Investment and Influence Demand packages. The projects in the greenfields are needed to unlock housing capacity.
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled	48 deaths and 3,487 injuries p.a. from motor vehicle crashes. 25 injuries per 10,000 population 28 injuries per 100 million vehicle kilometres travelled	-	-	-	Model forecasts can't accurately identify number of deaths and serious injuries.
	Emissions	• Greenhouse gas emissions	8.4 million kg of CO_2 per day	8.1 million kg of CO_2 per day	7.3 million kg of CO_2 per day	8.1 million kg of CO_2 per day	Projected levels of greenhouse gas emissions for the High Investment package are expected to be similar to the APTN. The Influence Demand package projects 10%

Other Key Outcomes	Measure	Headline Key Performance Indicator	2013 comparison	Higher Investment 2046	Influence Demand 2046	APTN	Comment
							fewer emissions in the Influence Demand package than the APTN. This is mostly due to fewer trips and shorter distance of trips.
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog	In 2015, approximately 1% of the transport network was in a "very poor" condition. This is equivalent to $157 million of backlog. [Source: Auckland Transport's Asset Management Plan 2015-2018]	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog within 10 years.	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog within 10 years.	Similar to these packages.	The same maintenance and renewals programme has been assumed in both packages.
Social inclusion and equity	Impacts on geographical areas	• Access employment in high deprivation areas • Distribution of impacts (costs and benefits) by area	As identified in the Foundation report, high deprivation areas in the south and west have lower access to jobs than other parts of the region. People in the west rely on a congested motorway link to jobs in the isthmus and south. People in the south also experience congestion on motorway links to jobs.	Compared to the APTN, accessibility improves for high deprivation areas, but issues remain in Mangere.	Compared to the APTN, accessibility improves for high deprivation areas, but access by motor vehicle is subject to pricing. Motor vehicle accessibility from high deprivation areas in the North Shore is worse.	The Deficiency Analysis identified significantly lower levels of access in the south and west.	Accessibility from high deprivation areas is similar to the APTN, except with smarter pricing. Generalised costs generally increase as a result of smarter pricing.
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network	Vulnerable network due to incomplete State Highway, public transport and cycle networks and lack of capacity at peak times on the strategic road network to cope with disruptions.	Network resilience is similar to the APTN. This package improves resilience through additional roading links such as the Additional Waitemata Harbour Crossing.	Network resilience is similar to the APTN. This package improves resilience through pricing of the road network. This reduces vehicle kilometres travelled on the road network by about 10% which could result in less diversion and impact in the event of disruption to the road network. There is high capacity in the rapid transit network, which enables PT to take additional people in the case of disruption.	-	These packages have a similar level of network resilience to the APTN.

4.3.6 Growth Assumptions

Packages have been evaluated based on medium growth assumptions, as set out in Table 4.6 below.

Table 4.6: Population and employment medium growth forecast

	2013	2026	2036	2046
Population	1,471,108	1,871,614	2,064,205	2,279,341
Employment	618,152	722,932	808,839	892,457

A sensitivity test was done in respect of the Higher Investment and Influence Demand package. This was based on high growth assumptions for 2026 only, with a high growth forecast population of 1,889,795 and employment of 751,628 in 2026.

The projected results were similar to the 2026 results under medium growth assumptions, with only slightly worse performance in terms of accessibility and congestion. An additional 3.5% increase in vehicle kilometres travelled corresponds with an increase from 30% to 31% of cars in severe congestion in the AM peak in 2026 under both the Higher Investment and Influence Demand packages. Public transport mode share projections are virtually the same at 2026 under high growth and medium growth assumptions.

This limited analysis suggested that network performance in 2026 would not be unduly affected by high growth in the first decade under those packages.

4.3.7 Package Refinement Conclusions

Key findings from analysing the Higher Investment and Influence Demand packages that informed development of the final package were:

- Additional investment in the first decade did not appear to improve performance against the project objectives at the regional level, but some of these extra investments did have some important sub-regional effects. Therefore, development of the final package should adopt a more targeted approach to identifying early priorities which both align with the project objectives and appear likely to deliver value for money.
- The introduction of smarter pricing in the Influence Demand package has the most significant impacts on the project objectives, but unclear net benefits to users that would require more detailed analysis.
- Because of its significantly better performance against the project objectives, Influence Demand should form the base of the Indicative Package.

Phase 3 – Indicative Package

Drawing upon the analysis undertaken in the previous phase, a package of interventions was developed that is indicative of the project's recommended strategic approach. The Indicative Package was based on the Influence Demand package assessed in the previous phase, with the main focus of additional work on identifying early priority interventions to be progressed over the first decade.

The Indicative Package provides an indication of the types of investments, the overall scale of investment and gives an indication of possible sequencing. It is not an "investment programme" and all investments will need to go through existing statutory processes to proceed.

The APTN package has been updated to reflect changes to the bus network and an adjustment in the ART3 transport model to recognise the effects of bus congestion along bus corridors.

The common baseline (CEE4) in the Round 4 analysis was also refined. Referred to interchangeably as the ATAP Baseline and the Base Network, it is used in the evaluation as a low-cost comparator. CEE4 is broadly similar to CEE3, which was used in the previous phase of the evaluation. The main difference between CEE4 and CEE3 lies in the changes to the bus network. This involved updates to the bus network itself and bus frequencies to better reflect reality.

5. Indicative Package

5.1 Package Description

Key findings from analysing the Higher Investment and Influence Demand packages in Package Refinement phase (see previous section) informed the development of the Indicative Package in this phase. Although additional investment in the first decade did not appear to improve performance against the project objectives at regional level, some of these extra investments did have some important sub-regional effects. As such, the development of the Indicative Package adopted a more targeted approach to identifying early priorities.

Our prioritisation framework considered two broad factors:

- The extent to which investment targets the most significant first decade challenges
- The potential to deliver value for money in the first decade

Due to the stronger performance of the Influence Demand package against the project objectives, it forms the base of the Indicative Package. As discussed, more detailed analysis is required to understand the cost to users caused by the introduction of smarter pricing.

The total estimated 30-year cost of the Indicative Package is $84 billion (in 2016 dollars). Figure 5.1 below provides a breakdown of costs by decade and across major investment types. Unlike previous packages which focused only on capital costs, the estimated cost of this package includes asset maintenance, operations and renewals, net public transport operations and new investments.

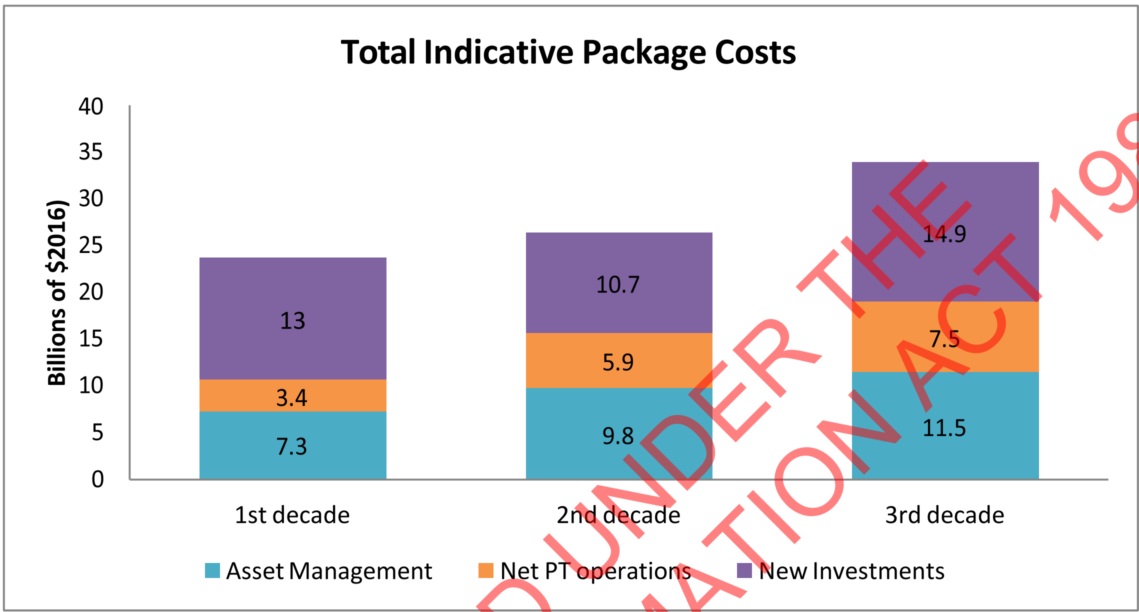


Figure 5.1: Estimated cost of new capital improvements (excluding renewals) of Indicative Package (2018 – 2048)

Of the total package, $38.6 billion (in 2016 dollars) is capital expenditure (excluding renewals). Figure 5.2 below provides a breakdown of those costs by decade and by broad type.

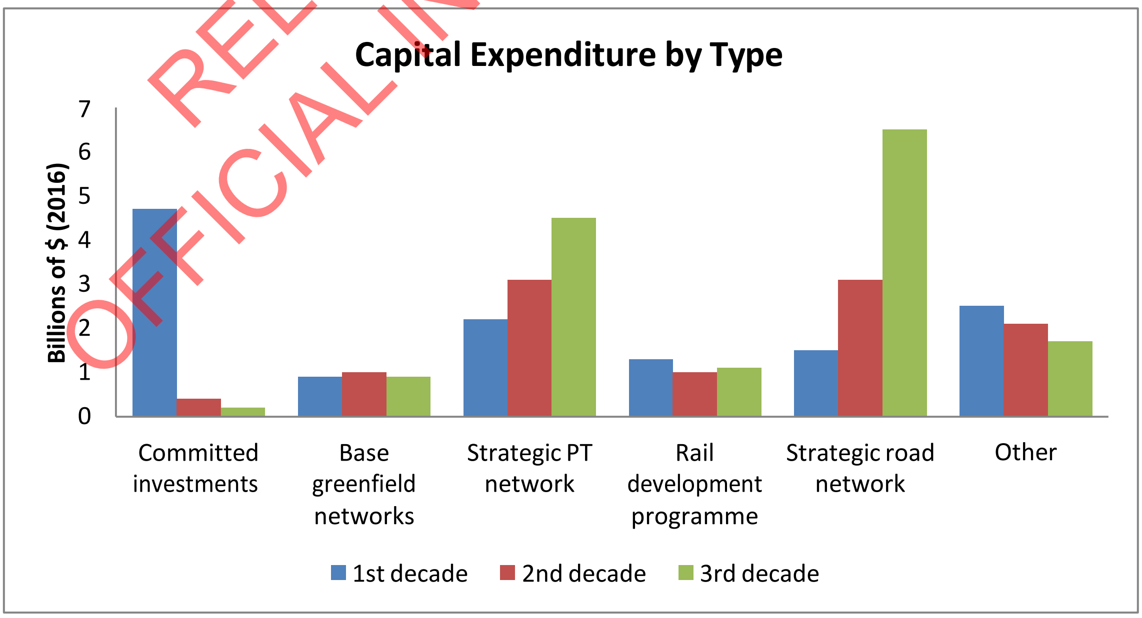


Figure 5.2: Capital expenditure of Indicative Package (2016 – 2046)

Key interventions by time period

Most investments likely to occur in the next decade are already committed or partly committed. This includes the City Rail Link, Accelerated Motorway Package, the Puhoi to Warkworth extension of the Northern Motorway, East West Link and a number of other, smaller projects. The indicative priority of investment additional to current commitments is outlined in Table 5.1 below.

Table 5.1: Indicative Package key interventions by time period

Indicative priorities for major new investments		
Early Priorities (completion in decade 1)	**Medium Term Priorities (completion in decade 2)**	**Longer Term Priorities (completion in decade 3)**
• Northwestern Busway (Westgate to Te Atatu section) • Address bottlenecks on Western Ring Route (SH20 Dominion Rd to Queenstown Rd) and Southern Motorway (Papakura to Drury) • New or upgraded arterial roads to enable greenfield growth in priority areas • Protect routes and acquire land for greenfield networks • Complete SH16 to SH18 connection • Early Rail Development Programme priorities • Upgraded eastern airport access (SH20B) • Investments to enable smarter pricing • Increased investment in Intelligent Network Management • Progress advance works on medium-term priorities	• Continued investment to enable greenfield growth • New strategic roads to Kumeu and Pukekohe • Implementation of mass transit on isthmus and then to the Airport • Bus improvements Airport – Manukau – Botany • Improved access to Port/Grafton Gully • Northwestern busway extensions • Improve connection between East-West Link and East Tamaki • Penlink • Medium-term Rail Development Programme priorities	• Continued investment to enable greenfield growth • Southern Motorway improvements south of Manukau • Southwest motorway (SH20) improvements and improved northern airport access • Northern motorway widening • Waitemata harbour crossing improvements, including mass transit upgrade of Northern Busway • Longer term Rail Development Programme priorities

These early investments were identified following a prioritization using a prioritization framework (Table 5.2).

Table 5.2: Prioritisation framework

ATAP Investment Prioritisation Framework

The purpose of this framework is to agree relative priority of investments for development of an indicative package for the final deliverable.

Items	**Investments**	- Interventions will be grouped by priority area / deficiency focus into future 'investments', which are then prioritised. - Investments will be grouped logically based on the the strategic networks and known deficiency areas.					
	Interventions	- All interventions above $200m will be included. - Interventions relating to the strategic approach will also be included, such as pricing programme, demand management (HOT lanes park and ride etc), technology programmes, optimisation.					
Alignment with objectives	**Objectives**	**First decade focus**	**Targets deficiencies against objectives <u>in first decade</u>**				
	Enable Auckland's growth	Enable housing growth; particularly SHAs and greenfield growth in the northwest and south.	✓✓✓ Direct requirement for new housing in priority greenfield areas (SHAs, Northwest and South).	✓✓ Enables and supports growth in priority greenfield areas (SHAs, Northwest and South).	✓ Enables and supports growth or intensification enabled by the unitary plan.	- Does not support areas identified.	× If an investment detracts from an objective.
	Employment accessibility	Improve employment accessibility; particularly from west and south.	✓✓✓ Addresses AM peak accessibility from the west.	✓✓ Addresses AM peak accessibility from the south, or to city centre, airport, or Westgate / Whenuapai.	✓ Addresses AM peak accessibility in other areas.		
	Congestion	Address severe congestion on the strategic road network, particularly in the interpeak period.	✓✓✓ Impacts areas with: - AM peak V/C ratios > 1.0 - Interpeak V/C ratios > 0.9	✓✓ Impacts areas with: - AM peak V/C ratios > 0.9 - Interpeak V/C ratios > 0.8	✓ Impacts areas with: - AM peak V/C ratios > 0.8	- Impacts areas with: - AM peak or interpeak V/C ratios < 0.8	
	Increase PT mode share	Increase peak person throughput on high volume corridors with targeted PT investment	✓✓✓ Increases PT capacity on corridors with 2-hour AM peak volumes > 10,000 persons.	✓✓ Increases PT capacity on corridors with 2-hour AM peak volumes > 5,000 persons.	✓ Increases PT capacity on corridors with 2-hour AM peak volumes > 2,000 persons.	- Does not increase PT capacity.	
	Overall alignment to objectives	**High** (total score more than ~8)		**Medium** (total score more than ~4)		**Low** (total score of less than or equal to ~4)	
Benefits Evaluation of potential investment benefits	**Measures of potential benefits**	**Indicator**		**Source**		**Method**	
	Amount of housing enabled	Expected growth in number of households		TFUG business case, modelling inputs and FULSS.		This measure applies only to base TFUG networks. Compare before and after housing figures in 2028 and 2048.	
	AM peak throughput	Expected change in AM peak person throughput (PT and road)		Evidence from package evaluation in ATAP Rounds 1, 2 and 3.		Agree key corridors for each investment. Compare forecast impact on key corridor(s) in 2026 between common elements and ATAP package tests.	
	Corridor AM peak speed	Expected change in AM road speeds		Evidence from Rounds 1, 2 and 3 package evaluation. Supplemented by information from projects.		Agree key corridors for each investment. Compare forecast impact on key corridor(s) in 2026 between common elements and ATAP package tests.	
	Corridor interpeak speeds	Expected change in interpeak road speeds		Evidence from Rounds 1, 2 and 3 package evaluation. Supplemented by information from projects.		Agree key corridors for each investment. Compare forecast impact on key corridor(s) in 2026 between common elements and ATAP package tests.	
Estimated cost	**Estimated range as developed for projects**	- Cost information will be sourced from projects where possible.					
	Overall relationship of potential benefit and costs	**High**		**Medium**		**Low**	
Strategic and project considerations	**Consistency with strategic approach**	Considerations include: - logical sequence to strengthen the strategic roading and public transport networks - whether this investment is sensitive to pricing or technology - sensitivity of an investment to potential changes in land use assumptions					
	Existing project evidence	Evidence on projects will be used including expected impact on deficiencies as well as other data on BCRs, effects on resilience, safety, freight, etc.					
Relative priority	**Reasons for recommendation**	This will be a statement outlining the assessment, based on the evidence presented on alignment with strategic objectives, potential benefits, costs, consistency with strategic approach and existing project evidence.					
	Priority	Bands of priority classified as high / medium / low					

5.2 Key Findings

Travel Patterns

The following is contextual information of projected travel patterns in relation to the Indicative Package, compared to the APTN.

Average trip time in the AM peak is projected to decrease from 2026 with the introduction of smarter pricing, and to plateau between 2036 and 2046 (Figure 5.3). In comparison, the APTN starts off with a lower average trip time which increases in 2026 to a higher level than the Indicative Package and plateaus between 2036 and 2046.

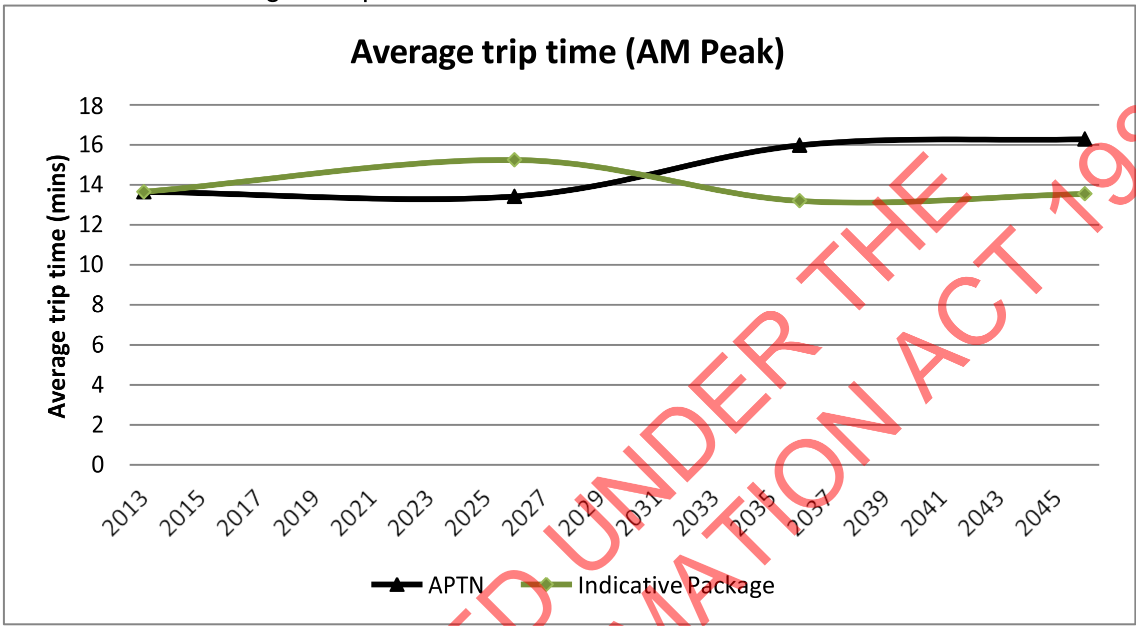


Figure 5.3: Average trip time during AM Peak (minutes)

A significant decrease in average trip length in the AM peak is projected under the Indicative Package, particularly between 2026 and 2036 (Figure 5.4). As smarter pricing is introduced, some trips during the peak period shift to other modes or other times. After 2026, average trip length evens out under the APTN and increases by 1km between 2036 and 2046.

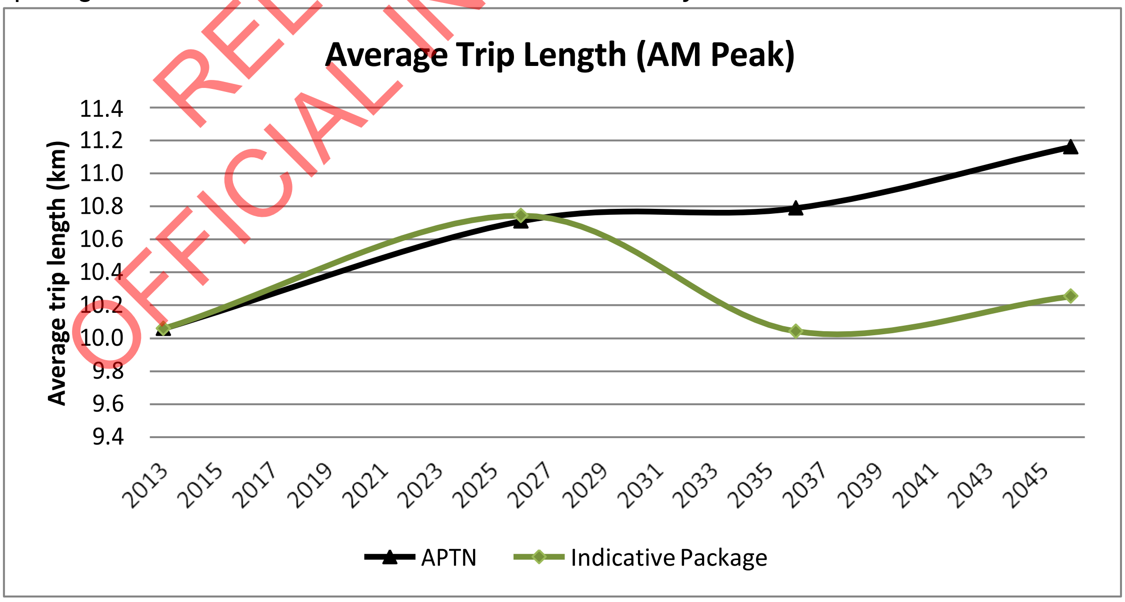


Figure 5.4: Average vehicle trip length during AM Peak (km)

A 3% reduction in the number of car trips taken in the AM peak is projected under the Indicative Package compared to the APTN, starting from 2036 when smarter pricing is in place (Figure 5.5). The number of public transport trips is projected to increase by 11% in 2036 under the Indicative Package.

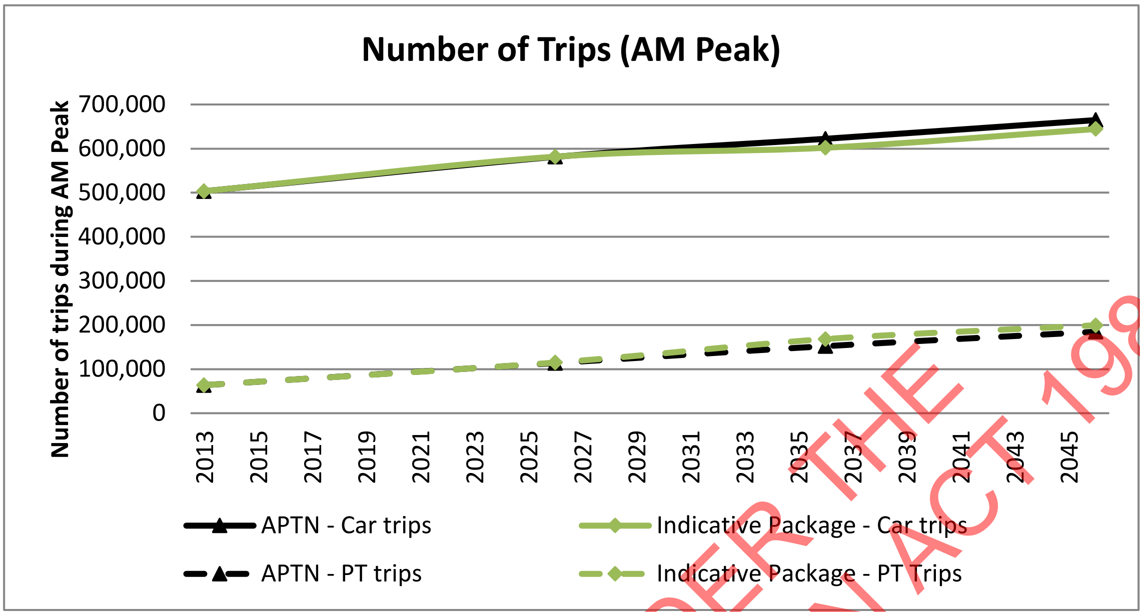


Figure 5.5: Number of trips during AM Peak by car and public transport (Indicative Package and APTN)

As a result of smarter pricing, there is a 10% decline in daily and peak vehicle kilometres travelled under the Indicative Demand compared to the APTN in 2036 (Figure 5.6).

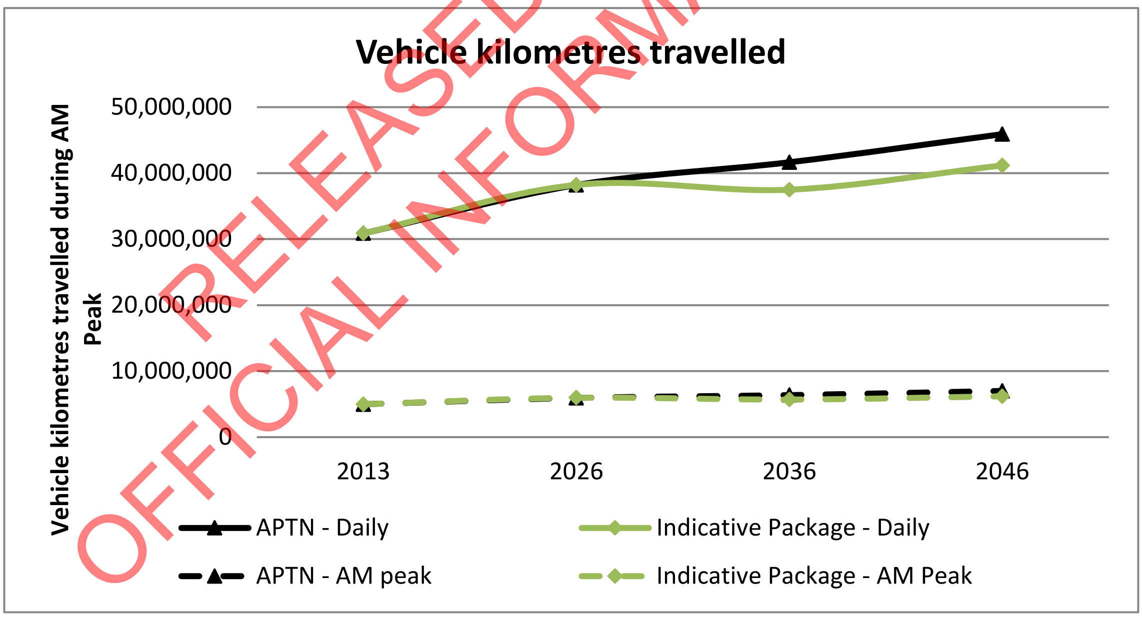


Figure 5.6: AM peak and daily vehicle kilometres travelled (km)
(Indicative Package and APTN)

Accessibility

Accessibility to employment by car under the Indicative Package is projected to significantly increase in the second decade in response to the implementation of smarter pricing. Additionally, third decade investment in the Indicative Package is projected to further increase car accessibility (Figure 5.7).

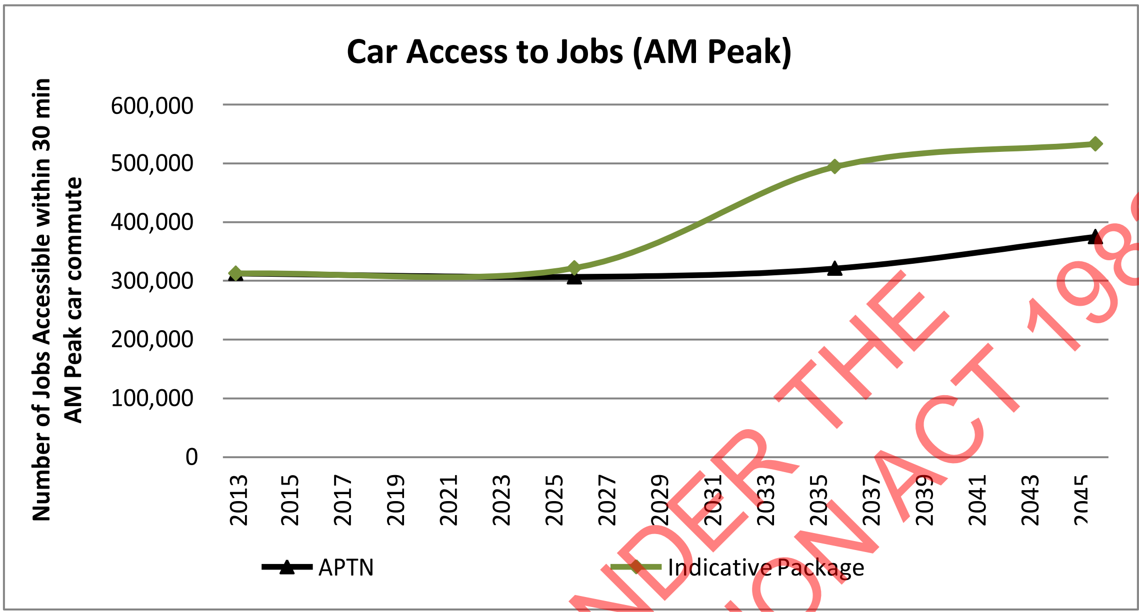


Figure 5.7 Car accessibility to jobs within a 30 minute car commute AM peak (Indicative Package and APTN)

Public transport accessibility is projected to be similar to the APTN (Figure 5.8). However, projections indicate slightly higher public transport accessibility than the APTN while providing for significant growth in public transport use.

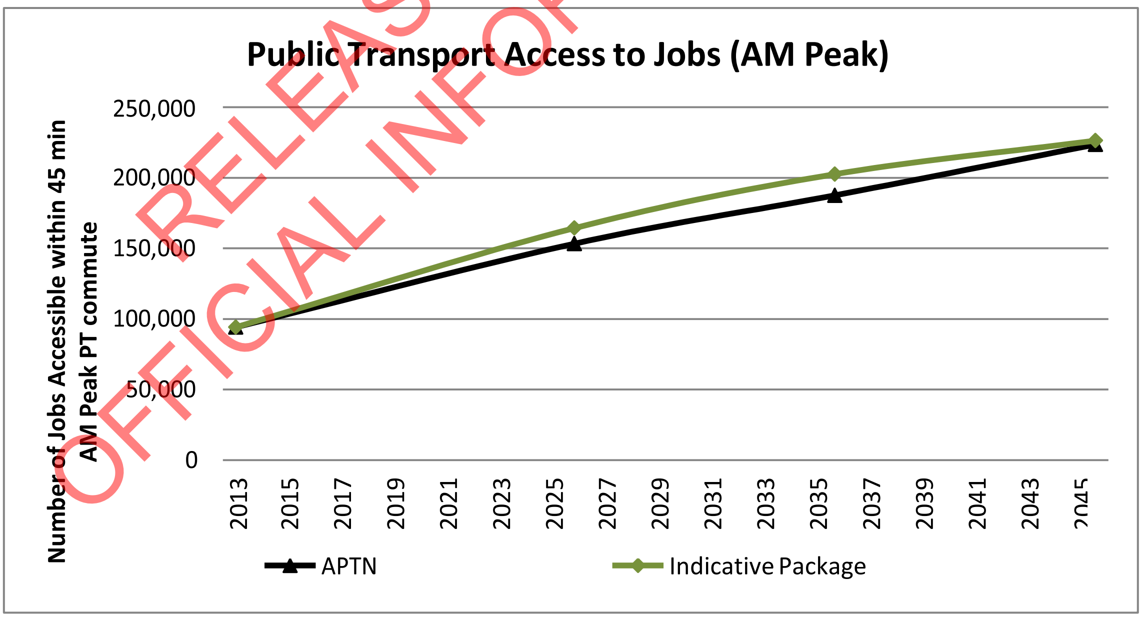


Figure 5.8: Public transport accessibility to jobs within a 45 minute PT commute AM peak (Indicative Package and APTN)

At a sub-regional level, there is a dramatic improvement to car access after 2026 under the Indicative Package as a result of the introduction of smarter pricing (Figure 5.9). Accessibility improves across the region, most particularly in the northwest, North Shore and parts of the south.

Car accessibility improves compared to the Base Network in 2026 particularly for areas outside of the isthmus. The Indicative Package highlights improved car accessibility from the peripheral areas of Auckland, due to motorway improvements to the outer motorway network.

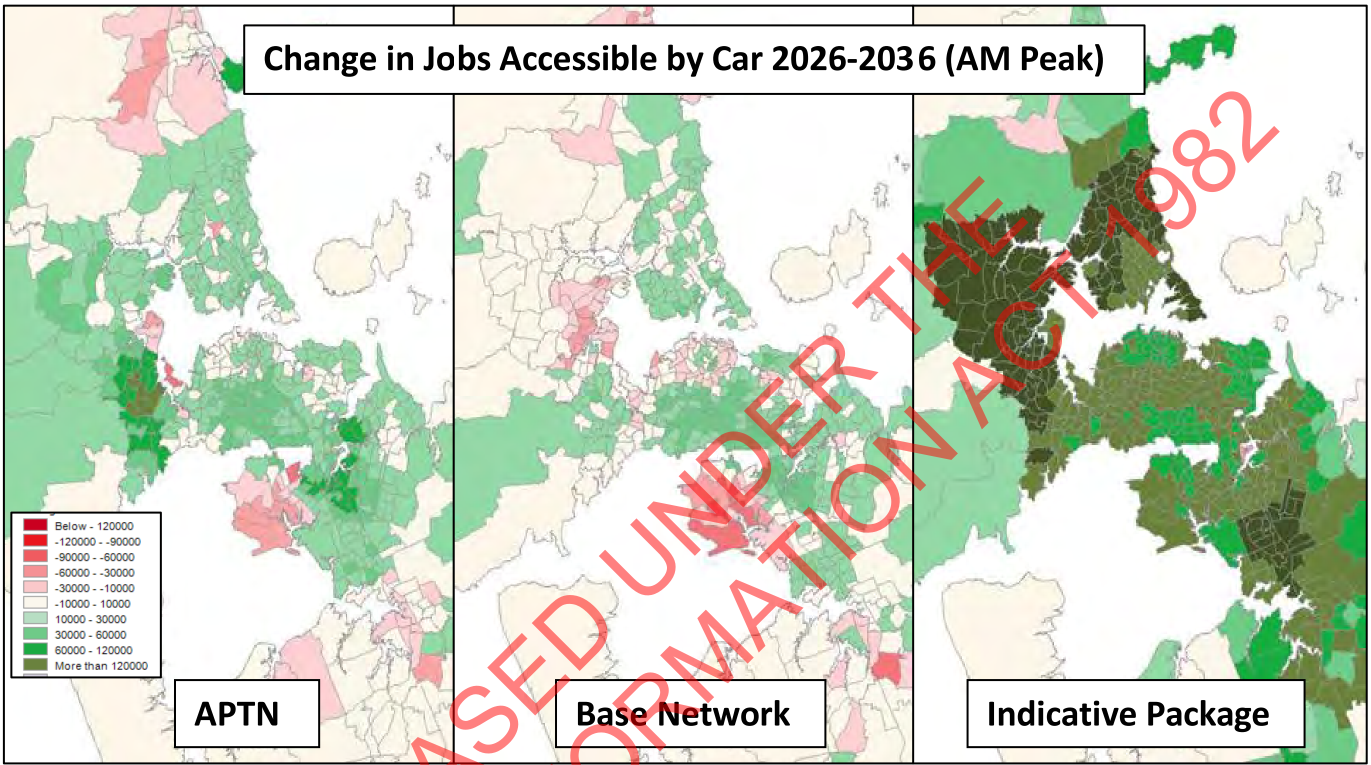


Figure 5.9: Change in car accessibility to jobs AM peak 2026 - 2036 (Indicative Package, APTN and Base)

Despite the increase in public transport use, public transport accessibility also improves in parts of Auckland after 2026 as a result of additional investments, although to a lesser extent compared to car accessibility (Figure 5.10). In particular, improvements are seen in the northwest, parts of the isthmus and parts of the southeast. Projects that would have improved travel times include extensions to the Northwestern Busway, mass transit from the Airport to the city centre, and bus improvements from Airport to Botany.

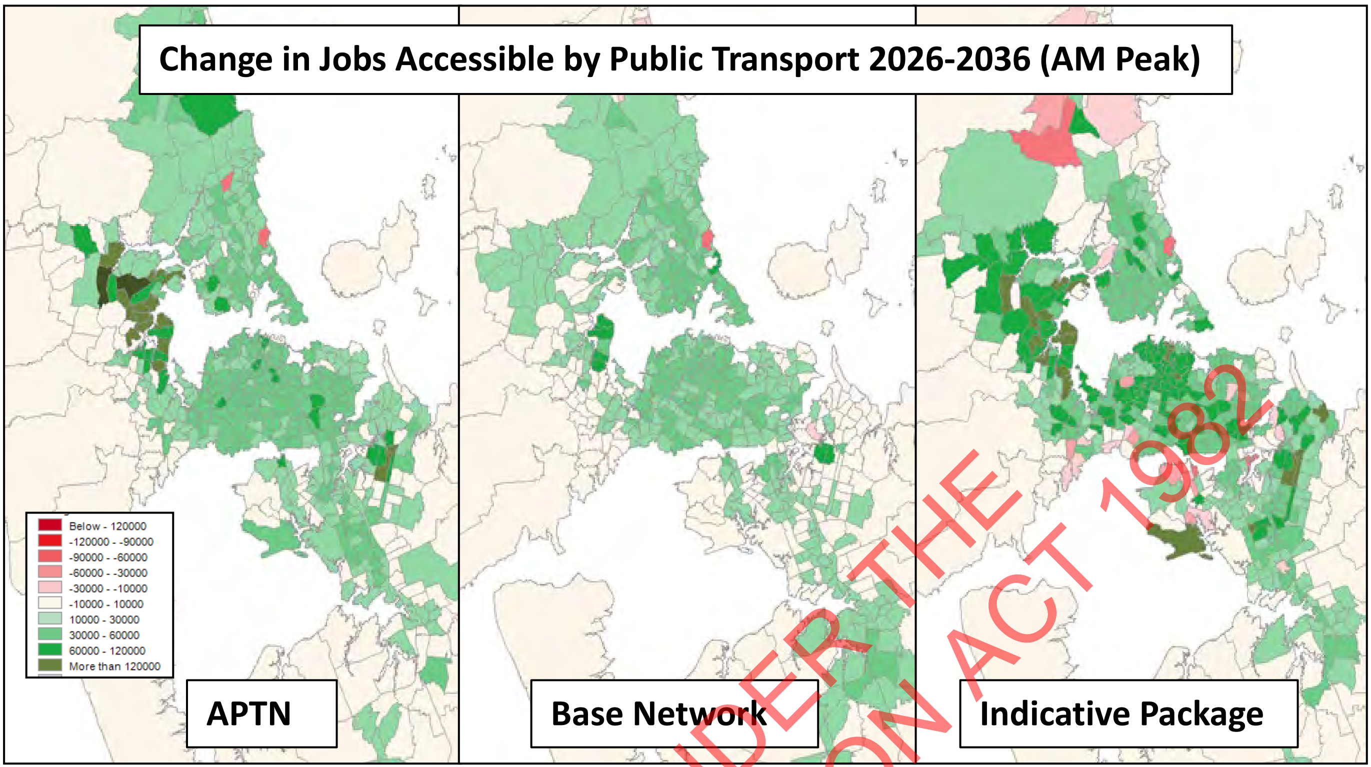


Figure 5.10: Change in PT accessibility to jobs AM peak 2026 - 2036 (Indicative Package, APTN and Base)

Accessibility by sub-region

West:

Car accessibility is projected to get worse in the first decade for both packages, and only just fully recovers by 2046 under the APTN (Figure 5.11). In the Indicative Package, the introduction of smarter pricing is very effective - bringing almost an additional 250,000 jobs within reach of a 30 minute car commute.

The Indicative Package provides noticeably higher public transport access in the first and second decades.

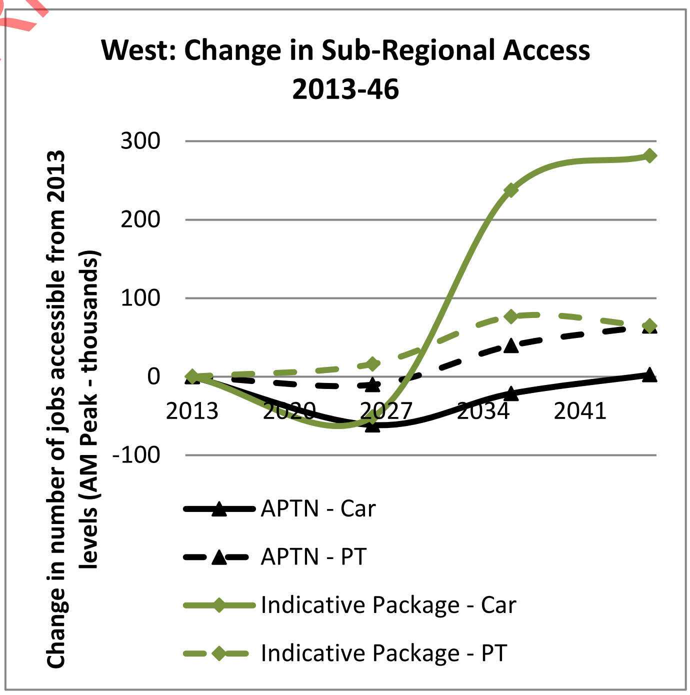


Figure 5.11: Change in sub-regional access to jobs from West Auckland AM peak (APTN and Indicative Package)

South:

The APTN results in poorer access over the first decade and minimal accessibility improvements over the next 30 years for either car or public transport (Figure 5.12).

Under the Indicative Package there is a marked improvement in car accessibility in the second decade, driven by the implementation of pricing. However, public transport access in the south remains low under the Indicative Package, barely increasing at all over time.

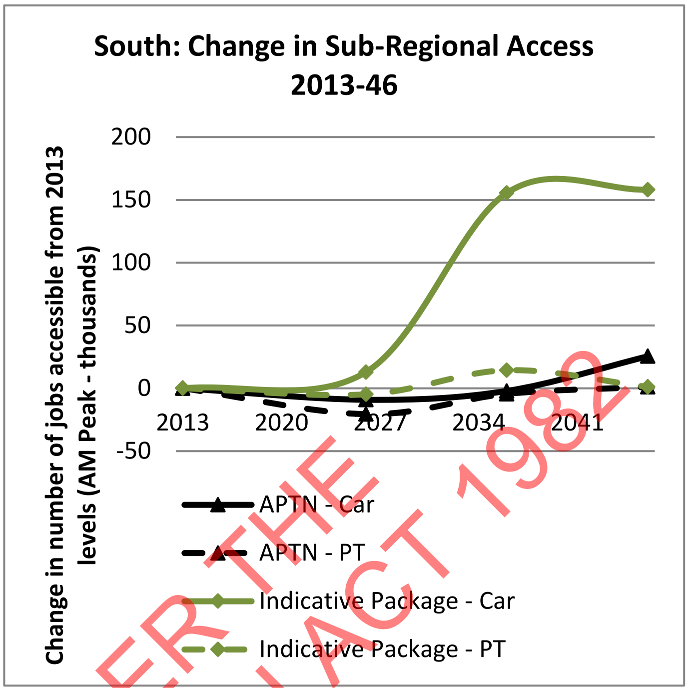


Figure 5.12: Change in sub-regional access to jobs from South Auckland AM peak (APTN and Indicative Package)

North:

Car accessibility for both packages does not improve in the first decade (Figure 5.13). Subsequently, the introduction of smarter pricing significantly improves car access, which is continued to a minor extent in the third decade by construction of a new harbour crossing.

Public transport access increases at a similar level for both packages throughout the next 30 years, with increases in the third decade driven by a major upgrade to a higher capacity mass transit option from the North Shore to the city centre.

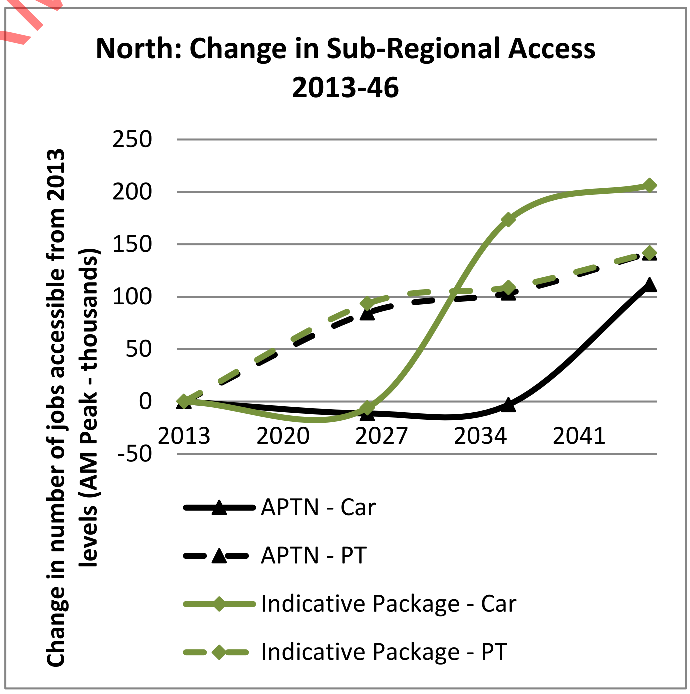


Figure 5.13: Change in sub-regional access to jobs from North Auckland AM peak (APTN and Indicative Package)

Central:

Both car and public transport accessibility steadily increase throughout the 30 year period under the APTN, reflecting the large growth in employment projected in central Auckland (Figure 5.14).

The Indicative Package provides a much greater increase in car accessibility in the last two decades.

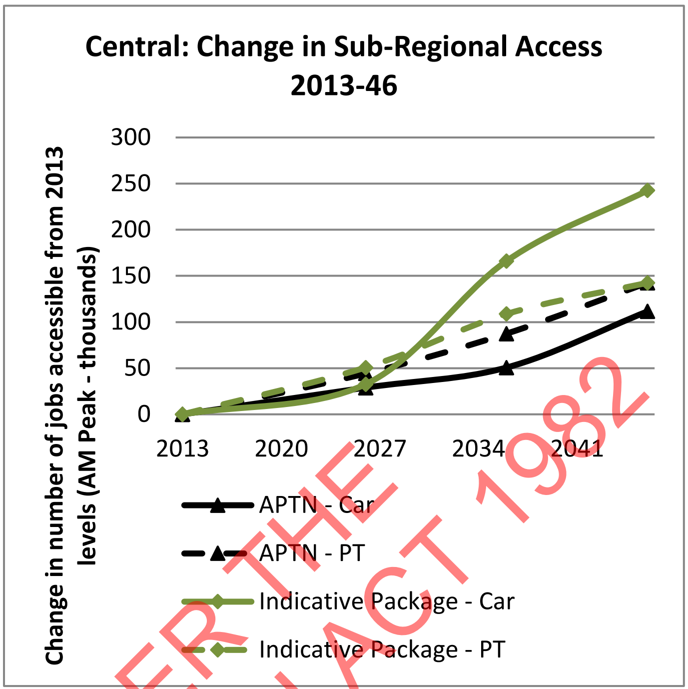


Figure 5.14: Change in sub-regional access to jobs from Central Auckland AM peak (APTN and Indicative Package)

Congestion

The Indicative Package addresses congestion to a greater extent than the APTN. The proportion of travel time in severe congestion during the morning peak, across the whole transport network, is projected to decline from 27% to 21% over the next 30 years (Figure 5.15). This mainly arises due to progressively implementing smarter pricing rather than increasing the level of investment in infrastructure.

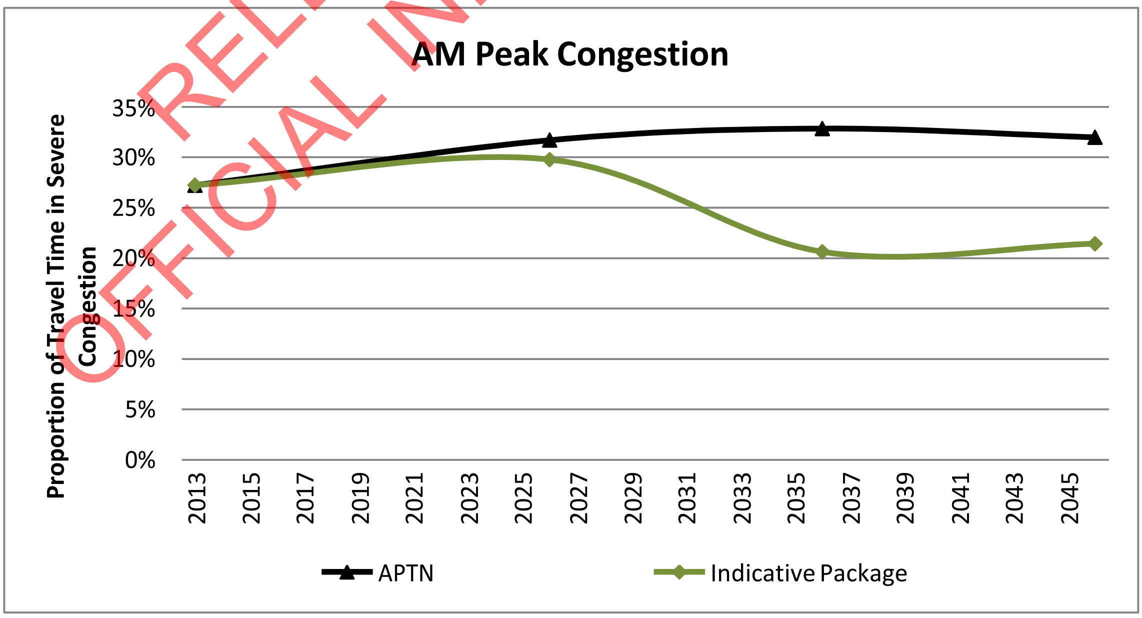


Figure 5.15: AM peak severe congestion (Indicative Package and APTN)

Projected inter-peak congestion shows similar trends, with the introduction of smarter pricing holding congestion at around 2013 levels over the next 30 years, despite population and employment growth (Figure 5.16).

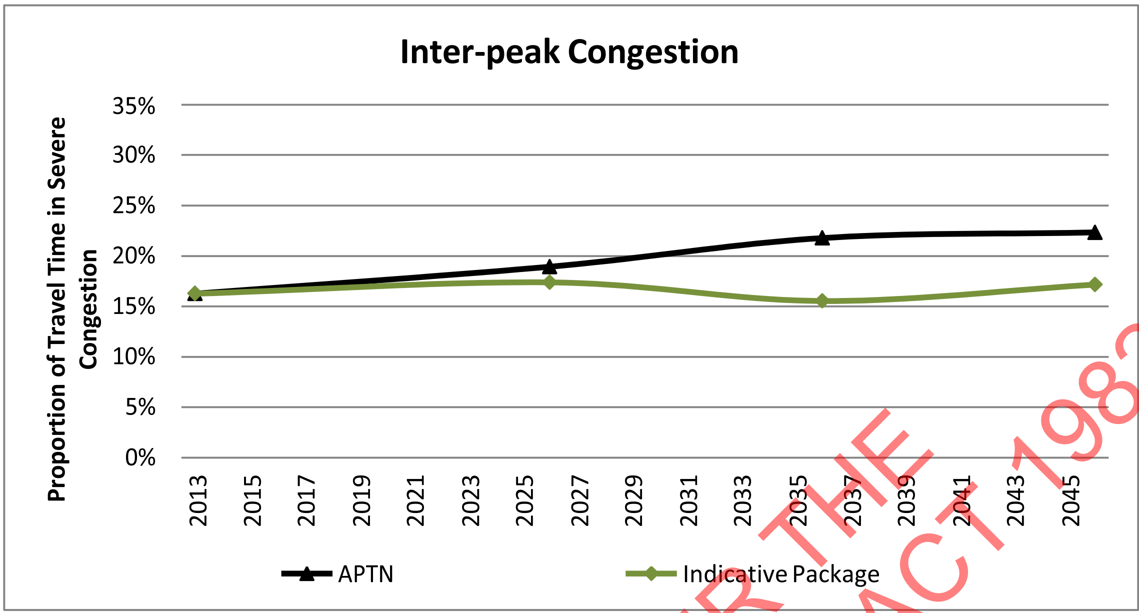


Figure 5.16: Inter-peak severe congestion (Indicative Package and APTN)

Freight congestion is projected to remain at similar levels between 2013 and 2026 under the Indicative Package, after which it reduces significantly between 2026 and 2036 before increasing slightly up until 2046 (Figure 5.17). In comparison, freight congestion increases steadily under APTN until 2036 before reducing, with congestion levels in 2046 remaining higher than 2013.

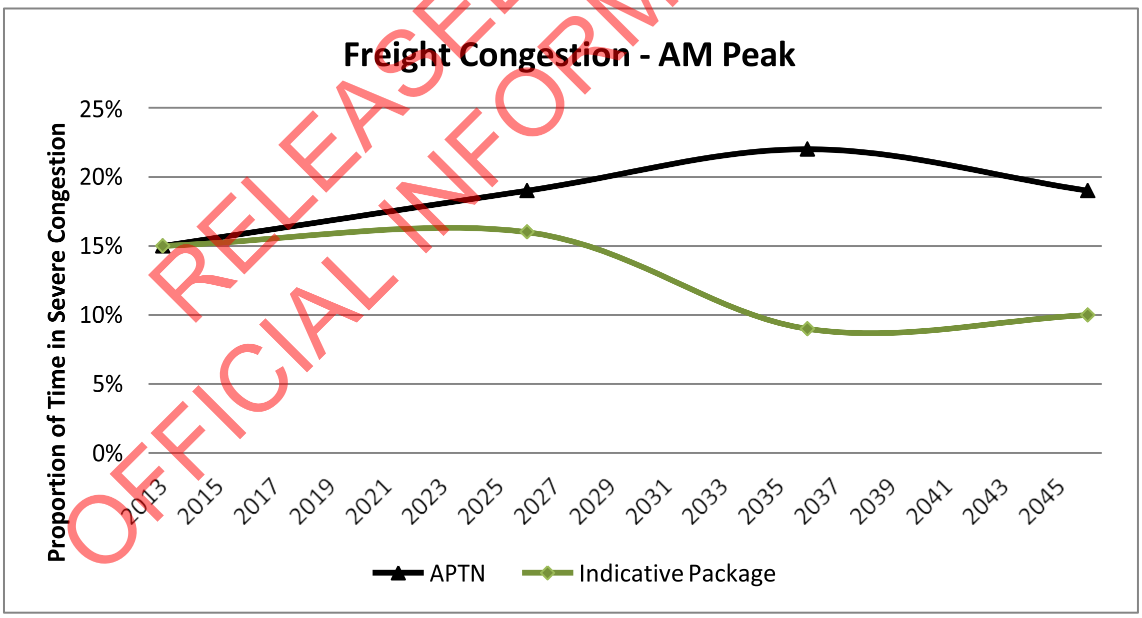


Figure 5.17: Freight AM peak severe congestion (Indicative Package and APTN)

The proportion of time spent in severe congestion for freight during the inter-peak remains significant, though lower compared to the AM peak. After 2026, congestion on the freight network reduces slightly under the Indicative Package and increases sharply under the APTN. After 2036, inter-peak freight congestion increases slightly under the Indicative Package and reduces under the APTN.

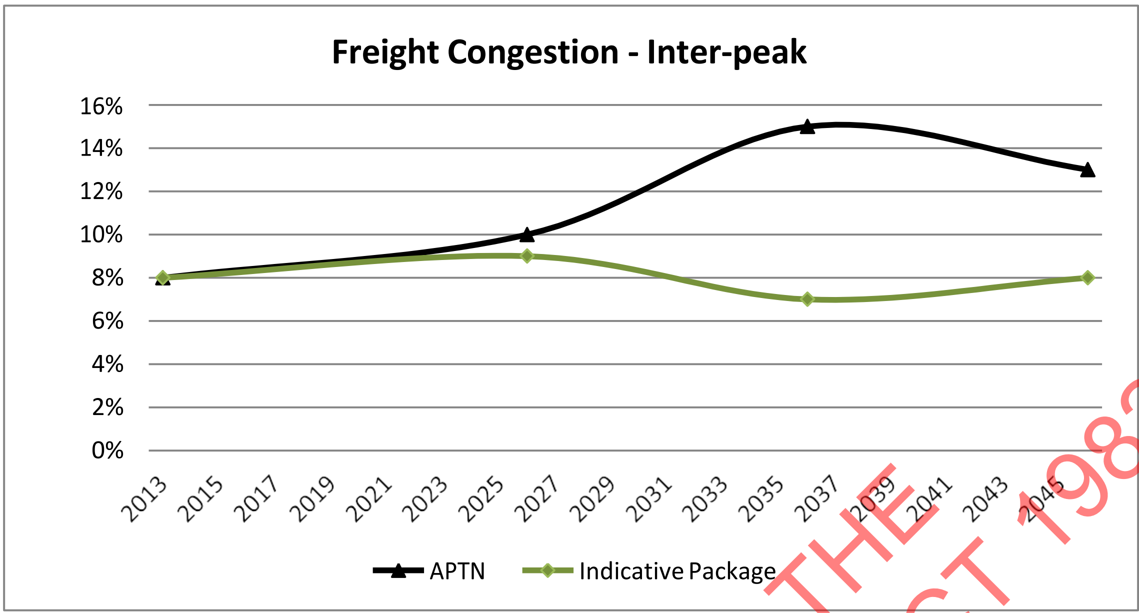


Figure 5.18: Freight inter-peak severe congestion (Indicative Package, APTN and ATAP Baseline)

At a sub-regional level, there are less capacity constraints during the AM peak in the Indicative Package network, compared to the APTN, as illustrated in more detail in the following volume to capacity plots (Figure 5.19).

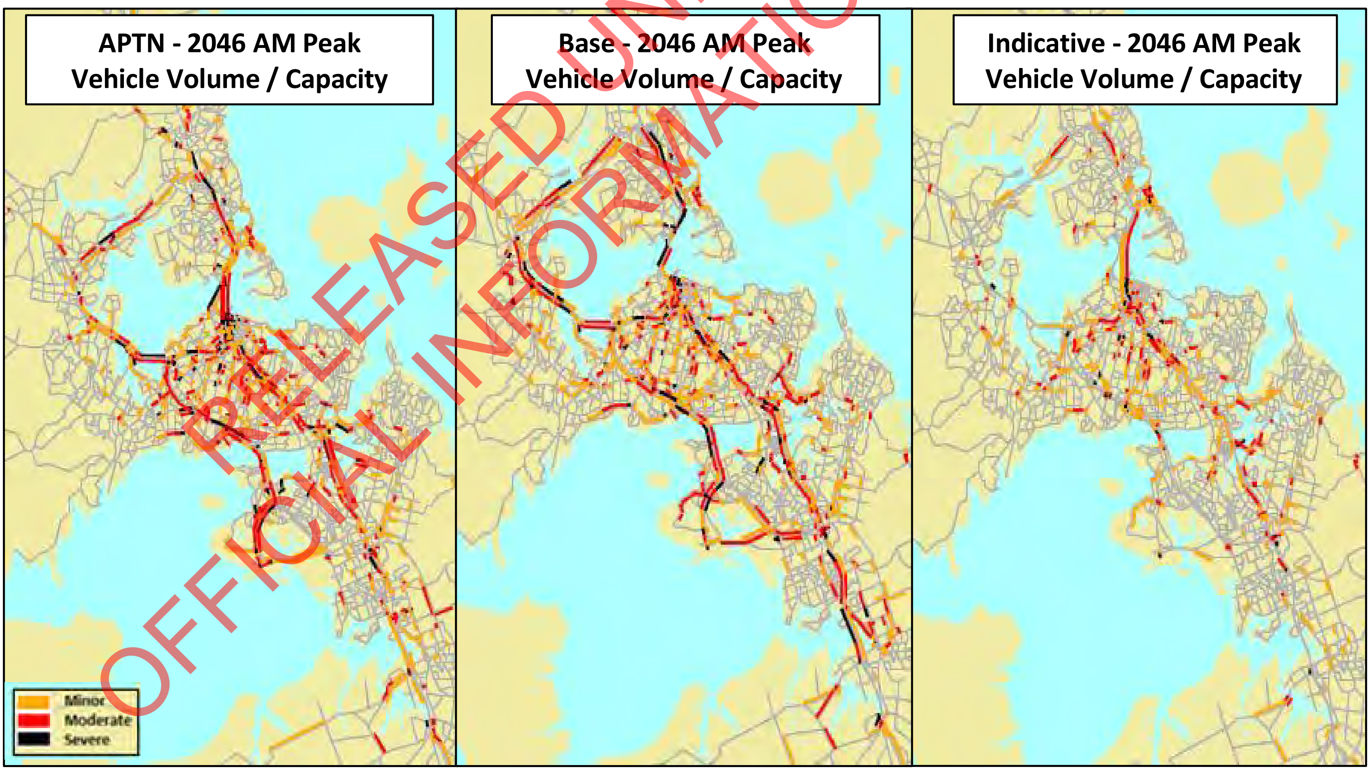


Figure 5.19: AM peak vehicle volume to capacity 2046 (Indicative Package, APTN and ATAP Baseline)

While some pinch points remain under the Indicative Package, most of the network is projected to operate below moderate or severe levels in 2046. In contrast, under the APTN much of the transport network, particularly the motorway network, is projected to experience moderate or severe congestion during peak periods (and increasingly during the inter-peak). With the Indicative Package severe congestion in the inter-peak is reduced to isolated pockets (Figure

5.20).

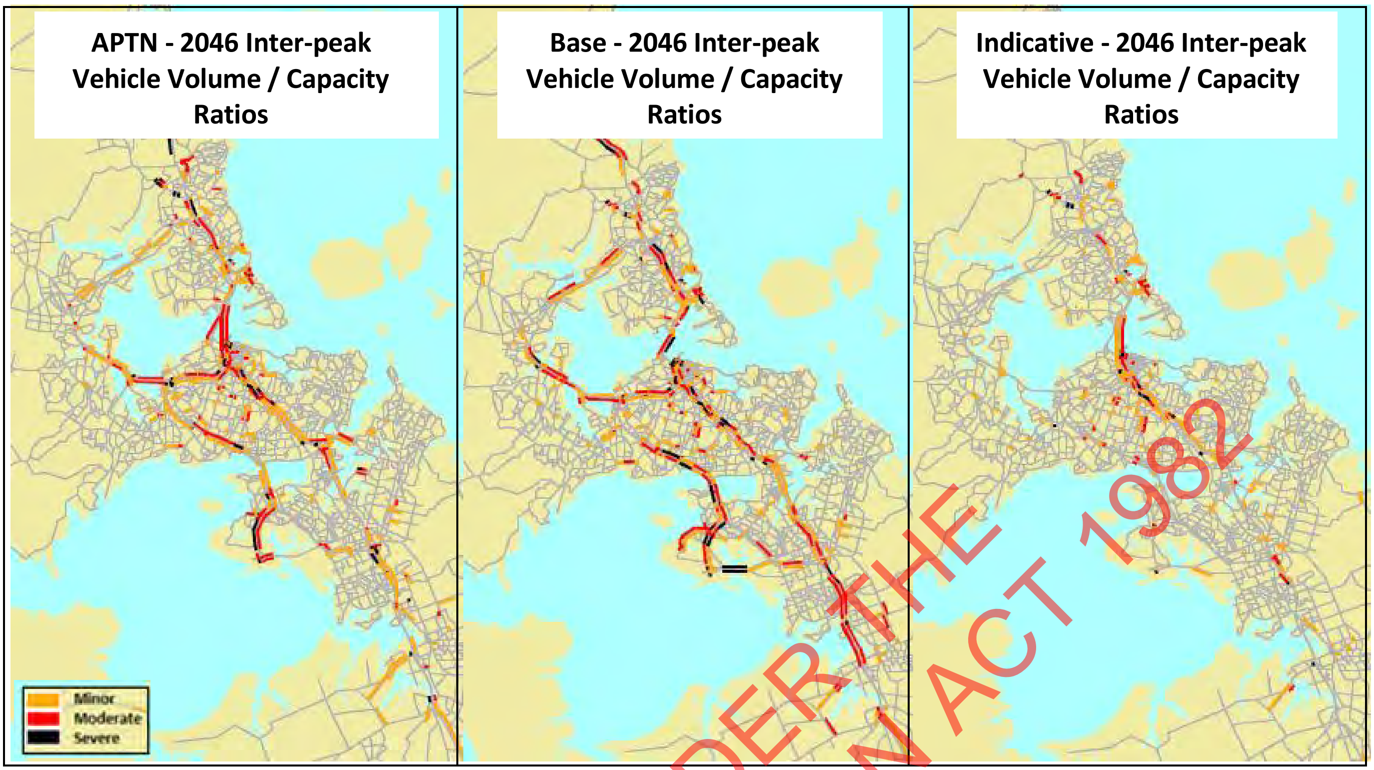


Figure 5.20: Inter-peak vehicle volume to capacity 2046 (Indicative Package, APTN and ATAP Baseline)

Public Transport Mode Share

The Indicative Package increases public transport mode share for all trips in the morning peak from what is projected to occur under the APTN. Between 2013 and 2026, the Indicative Package achieves similar levels of public transport mode share in the AM peak as APTN (Figure 5.21). After 2026, public transport mode share continues to increase under the Indicative Package. Mode share also increases under APTN, although at a slower rate.

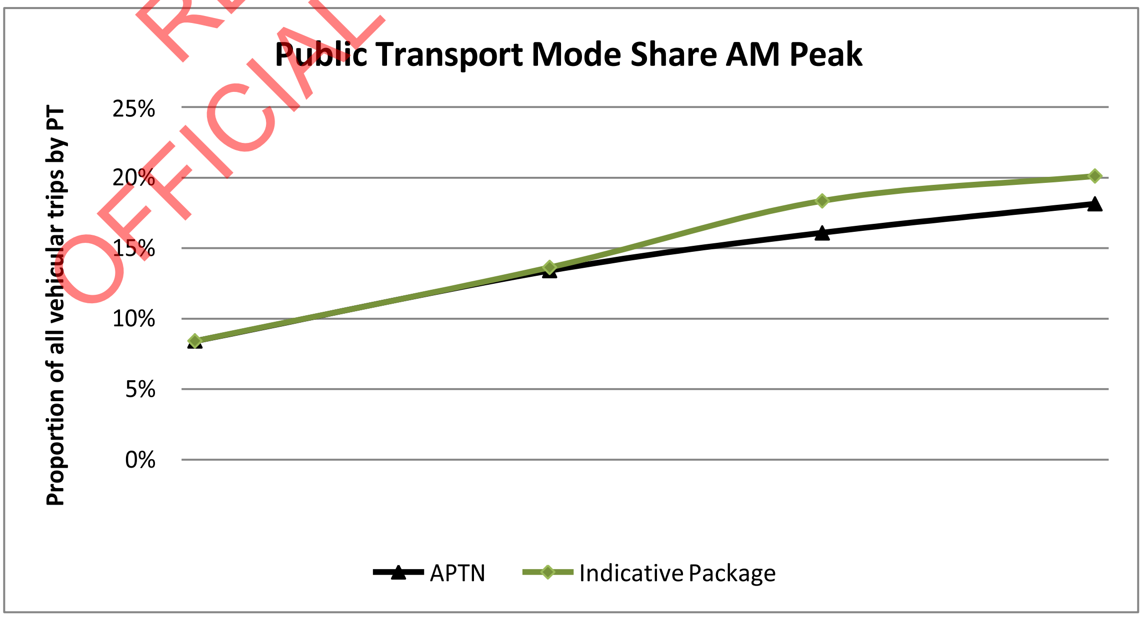


Figure 5.21: Public transport mode share AM peak (Indicative Package, APTN and ATAP Baseline)

Approximately a third of vehicular journeys to work (trips to employment either by public transport or private vehicle) in the morning peak are projected to be taken by public transport by 2046 under the Indicative Package, compared with 29% under the APTN. Combined with population growth, this growth in public transport mode share is projected to increase annual boardings from 83 million (in the year to July 2016) to around 265 million over the next 30 years.

While pricing has reduced demand for the roading network, it is projected to substantially increase demand for public transport services. The additional investment to public transport infrastructure over and beyond that allocated under Influencing Demand has reduced some constraints on the public transport network (Figure 5.22). However, demand on the bus RTN continues to exceed capacity at parts of the network, particularly along the Northwestern Busway and key isthmus corridors, indicating the need for further services or investment. On the other hand, capacity to the Airport, North Shore and southeast improves compared to the Base Network as a result of the inclusion of mass rapid transit in those areas.

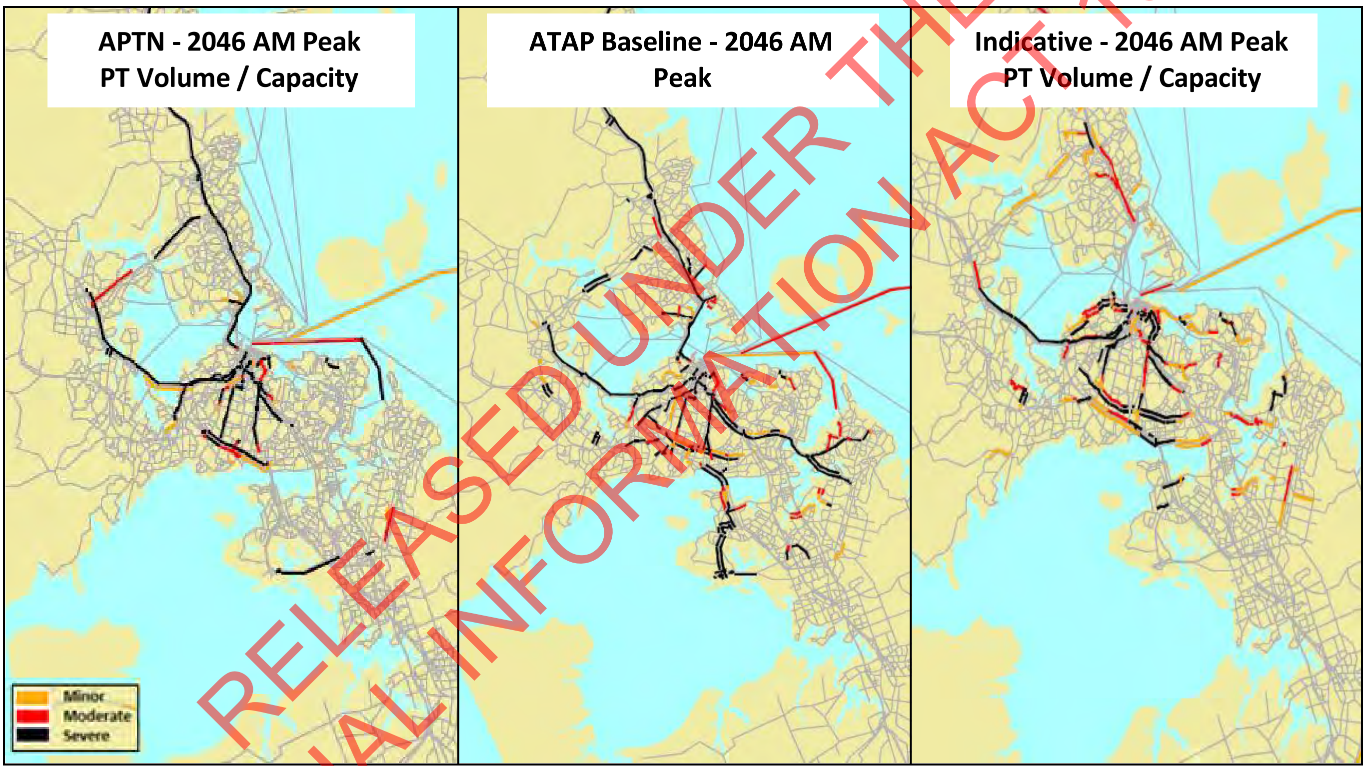


Figure 5.22: Public transport volume to capacity AM peak 2046 (Indicative Package, APTN and ATAP Baseline)

Net Benefits to Users

"Net benefits to users" was estimated because the Indicative Package increases the financial costs of motorists using the transport system, depending on time of day and the route taken. The same variable network pricing system was used in the Indicative Package as was used in the Influence Demand package (Table 4.2).

Motorists receive a benefit from the improved network performance (in terms of shorter travel times and lower vehicle operating costs) but also face increased costs from having to pay the smarter pricing. The estimated difference between those benefits received and the smarter pricing costs are set out in Figure 5.23 below.

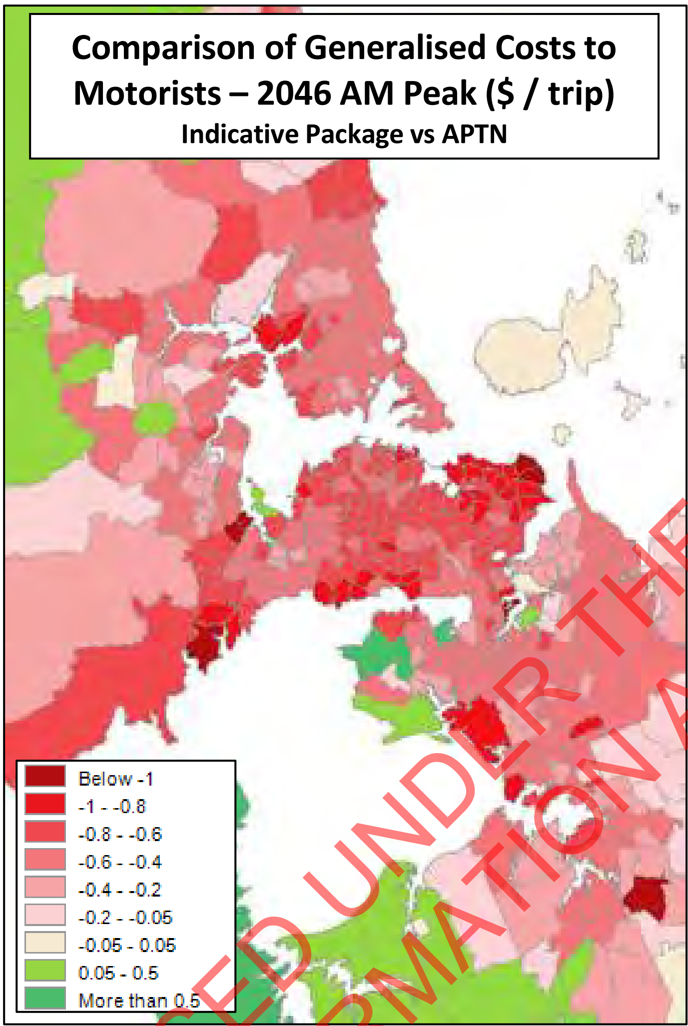


Figure 5.23: Generalised costs to road users AM peak 2046 (Indicative Package vs APTN)

The above calculations do not take into account the wider benefits that users of the transport system would gain from increased accessibility and reduced congestion. However, these findings should be treated with caution. This is a necessarily coarse approximation of how pricing might be applied, which means that some uncongested roads were subject to the same charge as congested routes. Furthermore, our analysis did not consider the likelihood that some users would place a much higher value on time savings than others. Further work, using much more detailed analytical tools, is required to identify efficient pricing levels which effectively address these issues.

As shown in the previous sections, our analysis suggests moving to smarter transport pricing would deliver very material gains in accessibility and reductions in severe congestion.

We expect that more detailed development and analysis will go a long way towards ensuring overall net user benefits from the introduction of pricing. Prices could be adjusted to lower levels and at a finer-grain (e.g. on uncongested counter-peak motorways). With better information, prices could also take into account the impacts on users with different values of time.

It will be important to understand where travel cost increases occur under a particular pricing structure so that equity impacts (including the affordability of travel to different groups, and the impact of pricing on access to jobs, education and services) can be assessed and any necessary mitigation can be developed.

Value for Money

The project's Terms of Reference require consideration of the costs and benefits of alternative combinations of interventions and whether better returns can be achieved from transport investment than current plans. Value for money is normally assessed through cost benefit analysis, which compares the level of benefits against the size of an investment.

The Indicative Package has an estimated $38.6 billion capital expenditure programme over 30 years (excluding renewals) which is projected to result in significantly higher contributions to the ATAP objectives compared to the APTN, but with a larger capital improvement programme and a higher average cost to motorists.

The Indicative Package is projected to result in a higher proportion of jobs accessible by motorists of 60% (compared to 43% in the APTN), a similar proportion of jobs accessible by public transport of 25% (compared to 24% in the APTN), a significantly lower proportion of travel time in severe congestion of 21% in severe congestion in the morning peak (compared to 32% in the APTN) and a moderately higher public transport mode share of 20% in the morning peak (compared to 18% in the APTN).

In assessing value for money, large differences between benefit-cost estimates at a 'package-wide' level and at a 'project' level became clear. In particular, more refined project level analysis appeared to capture project benefits to a much greater degree than the package-wide analysis. Table 5.3 below identifies the indicative benefit cost ratios of some of the key projects identified for the first decade which supports that conclusion.

Table 5.3: Indicative Benefit Cost Ratios of 1st Decade Projects

Project	BCR	Comments	Source
		Existing Commitments	
SH1 Northern Corridor Improvements	3.0	BCR includes busway extension to Albany	NZTA
SH1 Southern Corridor Improvements	6.0-9.0	BCR range depends on the growth scenario used	NZTA Board Paper – March 2015
East West Link	1.9		NZTA
Cycle sea path (AHB to Akoranga)	3.8		NZTA
Puhoi To Warkworth	1.1		NZTA
		Major Projects in Indicative Package	
SH20B	1.2	Overall Southwest Auckland and Airport Corridor programme	
TFUG South Northwest North Warkworth Total	 3.5-3.7 2.2-3.4 3.2-3.7 1.1 3.1-3.6	 Preferred Programme compared with Do Minimum	 TFUG draft Programme Business Case
North-western Busway	1.4	Westgate – City = 1.4 Westgate –Waterview = 1.2 Waterview – City = 1.9	NZTA
Mill Road (Northern section)	2.2	For northern section only	June 2013 Scheme Assessment Report
AMETI - Entire programme	1.5	Includes AMETI Link Road, Reeves Road flyover as well as busway from Panmure to Botany	June 2015 - AMETI Overall Package and Individual Component Economic Evaluation (2015)

Limitations of the strategic modelling tools were considered to be the likely cause of this difference and therefore we did not rely on package-wide benefit cost assessment based on modelling outputs. There are a number of uncertainties associated with a shift to smarter transport pricing that will require further more detailed analysis. Further understanding is required of how users will respond to the smarter pricing, and the social and economic consequences of those responses. Current analytical tools do not enable more detailed socio-economic segmentations in order to have more detailed economic and equity assessments of road pricing. Our analytical tools are not calibrated to assess the detail of a potential pricing system because of the following:

- They use fixed-trip matrices so are unable to show the extent to which the introduction of pricing may result in trip suppression (trips no longer being made).
- They are also not able to consider different values of time or vary prices at a more micro-level, so provide a very simplistic representation of what the impacts of a scheme might be.

Updated and more sophisticated analytical tools, with a particular focus on models that enable better testing of behavioural responses to pricing and technology changes, will be required to enable a more robust assessment of benefits and costs.

We focused on assessing the Indicative Package's value for money in the following ways:

- Ensuring identified 'early priorities' are likely to provide value for money if they are implemented over the next decade. Our prioritisation framework (Table 5.2) assessed the likely relative costs and benefits of major investments.
- A number of identified early priorities have existing value for money assessments indicating they deliver benefits that exceed their costs (Table 5.3).
- Analysis against our evaluation framework showed the Indicative Package will deliver better region-wide outcomes than current plans and significantly better results than a higher investment package that did not include smarter pricing (Table 5.4). This finding suggests that the inclusion of smarter pricing is key to achieving value for money.

Beyond these early priorities it becomes more challenging to assess value for money, as uncertainties relating to project costs, the location and quantum of growth, and the impacts of smarter pricing and new technologies become increasingly significant. Our most substantial uncertainty relates to large, longer-term infrastructure investments. The timing and scope of these investments should be monitored over time, particularly with regard to whether they provide value for money as we shift to a greater focus on influencing demand.

5.3 Full Evaluation Results

The following table presents the results of our evaluation of the Indicative Package against the evaluation criteria established in the Foundation Report (Table 5.4). All results relate to the 2046 year unless otherwise specified.

Table 5.4: Evaluation framework – headline measures

Objective	Measure	Headline KPI	Indicative Package	APTN	Comment in relation to Indicative Package
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30 minute trip in the AM peak • Jobs accessible by public transport within a 45 minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	533,000 i.e. 60% of available jobs 226,000 i.e. 25% of available jobs 656,000 i.e. 74% of available jobs	386,000 i.e.43% of available jobs 215,000 i.e. 24% of available jobs 590,000 i.e. 66% of available jobs	The Indicative Package significantly increases car accessibility (measured only in relation to travel time, not financial cost) in the morning peak (7-9 am) in 2046, with a moderate increase in accessibility by public transport. Car accessibility (measured only in relation to travel time, not financial cost) during the day is at similar levels in 2046 as in 2013.
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak	4 hours 8 minutes per person per annum 21.4% AM peak 17.2% inter-peak	13 hours 33 minutes per person per annum 31.9% AM peak 21.9% inter-peak	Forecast congestion on the road network is significantly better throughout the day, compared to the APTN.
	Impact on freight and goods (commercial traffic) congestion	Proportion of business and freight travel time spent in severe congestion on the strategic freight network (in the AM peak and inter-peak	10.1% AM peak 8.0% inter-peak	18.6% AM peak 12.9% inter-peak	Forecast congestion on the freight network is significantly better throughout the day, compared to the APTN.
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, inter-peak and PM peak.	9% AM peak 7% inter-peak 11% PM peak	19% AM peak 13% inter-peak 23% PM peak	Forecast reliability of travel times for motor vehicle trips is expected to be significantly better throughout the day, compared to APTN.
Increase public transport mode-share	Public transport mode share	Proportion of vehicular trips in the AM peak made by public transport	20.1%	18.0%	Forecast PT mode share is slightly higher than APTN.
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 9 km in the AM peak made by public transport	37.4%	31.7%	It is forecast that a higher proportion of longer commute trips would be by PT in the Indicative Package than APTN.
	Increase vehicle occupancy	• Average vehicle occupancy	-	-	It wasn't possible to model changes in vehicle occupancy. The input assumptions of 1.36 people per vehicle in the AM peak and 1.25 people per vehicle in the inter-peak remained constant for all packages and all model years. The Indicative Package includes programmes to increase vehicle occupancy.
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	-	Not applicable	Financial costs from a variable network charge (see pricing schedule in Table 4.2) are assumed to replace road user charges and fuel excise duties. Savings in travel time and vehicle operating costs vary by trip. This analysis requires better model/tools to provide robust quantification of benefits.
Ensure value for money	Value for money	Package benefits and costs	-	-	Package benefits include the improved contributions to objectives as measured in this table. The total cost of the 30 year programme is estimated as $84 billion (in 2016 dollars).

In addition to the project objectives, a number of other key outcomes have been evaluated through the evaluation framework in Table 5.5 below.

Table 5.5: Evaluation framework – other key outcomes

Other Key Outcomes	Measure	Headline Key Performance Indicator	Indicative Package	APTN	Comment in relation to Indicative Package
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Does not meet timeframes of FULSS.	Approximately half of major greenfield network projects are programmed to be in place in accordance with timeframes of the FULSS.
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled	-	-	Model forecasts can't accurately identify number of deaths and serious injuries.
	Emissions	• Greenhouse gas emissions	7.4 million kg of CO_2 per day	8.1 million kg of CO_2 per day	Model forecasts 9% fewer emissions in Indicative Package than APTN. This is mostly due to fewer trips and shorter distance of trips.
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog	The indicative package programme is expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears any renewals backlog.	Similar to indicative package	The maintenance and renewals programme aims to achieve service levels that reflect the ONRC and AT's goal of attaining a network 'steady state' and achieve consistent levels of service across legacy networks.
Social inclusion and equity	Impacts on geographical areas	• Access employment in high deprivation areas • Distribution of impacts (costs and benefits) by area	Lower levels of accessibility by car and PT are forecast from high deprivation areas in the south and west, compared to the rest of the region. Generalised costs generally increase as a result of road pricing.	The Deficiency Analysis identified significantly lower levels of access in the south and west.	The indicative package has prioritised investment in the first decade to improve access from the south and the west. The evaluation working paper contains graphs showing the geographic impacts of the indicative package.
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network	-	-	The Indicative Package network has a similar level of network resilience to the APTN. Resilience is improved in the Indicative Package in the following ways: Firstly, pricing of the road network reduces vehicle kilometres travelled on the road network by about 10% which could result in less diversion and impact in the event of disruption to the road network. Secondly, there is greater capacity in the PT network. This enables PT to take additional people in the case of disruption. Optimisation of technology provides choice and information during a disruption. There are a similar number of additional crossings in the Indicative Package compared to the APTN.

5.4 Growth Assumptions

The Indicative Package has been evaluated based on medium growth assumptions, as set out in Table 5.6 below.

Table 5.6: Medium growth forecast assumptions for population and employment growth

	2013	2026	2036	2046
Population	1,471,108	1,871,614	2,064,205	2,279,341
Employment	618,152	722,932	808,839	892,457

A sensitivity test was also done in respect of the Indicative Package based on high growth assumptions, as set out in Table 5.7 below.

Table 5.7: High growth forecast assumptions for population and employment growth

	2013	2026	2036	2046
Population	1,471,108	1,889,795	2,208,823	2,508,634
Employment	618,152	751,628	865,491	982,217

An evaluation of the Indicative Package based on high growth assumptions was done in relation to the 2046 model year only (building on the previous sensitivity testing which indicated similar results at 2026 for previous packages). The projected results indicated worse network performance in terms of accessibility and congestion. An additional 9.2% increase in vehicle kilometres travelled corresponds with an increase from 21% to 24% of the proportion of time that cars spend in severe congestion in the am peak in 2046 under the Indicative Package. The inter-peak results are projected to worsen from 17% to 19% in 2046. The proportion of jobs accessible by car within 30 minutes in the am peak in 2046 is projection to be 60% under medium growth assumptions and 56% under high growth assumptions. Public transport mode share projections are virtually the same at 2046 under high growth and medium growth assumptions.

This limited analysis suggested that high growth over the next 30 years would result in reduced accessibility to jobs and higher levels of congestion, compared with medium growth forecasts.

5.5 Indicative Package Conclusions

The Indicative Package is projected to deliver substantially better outcomes against the key project objectives of access to employment, congestion and public transport mode share, when compared to the APTN. The most significant gains are increases to accessibility by car and reductions in peak congestion levels.

The Indicative Package also addresses some of the key sub-regional challenges facing Auckland, although some of the challenges remain. The west achieves the greatest improvement in employment access, with around 280,000 more jobs being accessible compared to the APTN in 2046. However, car access in the west declines in the first decade. In the south, the Indicative Package provides access to around 130,000 more jobs within a 30-minute car ride in the AM peak than the APTN. However, there is little improvement to public transport access in the south.

It is important to emphasise that the step-change in performance against these objectives is largely driven by the introduction of smarter transport pricing, which is assumed to be fully implemented in the second decade. Further analysis is required to assess the impacts of pricing on net user benefits in greater detail. More sophisticated analytical tools will be required to undertake this work before a viable scheme could be developed.

Appendices

Appendix A – Evaluation Framework

1. Introduction

The purpose of this paper is to record and explain the framework used to evaluate transport packages in the Auckland Transport Alignment project to enable a robust and transparent analysis of different transport investments.

This paper outlines how the returns from transport investment over the next 30 years will be assessed. It identifies the objectives and other key transport outcomes (section 2) and key performance indicators (section 3) in relation to those objectives and outcomes.

A full list of key performance indicators is set out at the end of this Appendix.

The evaluation framework will be used for three key tasks:

- Assessing the existing transport programmes to understand where further performance improvements are required and where improved value for money could be obtained.
- Assisting with the initial round of intervention packages where the focus is on understanding the strengths and weaknesses of each intervention, rather than how the interventions compare to each other.
- Assessing refined intervention packages where the focus is on comparing the relative merits of the different packages in achieving the project objectives.

2. Project Objectives

The project's Terms of Reference outline its objectives, with the key focus being to test whether better returns from transport investment (i.e. value for money) can be achieved in the medium and long-term, particularly in relation to the following:

i. To support economic growth and increased productivity by ensuring access to employment/labour improves relative to current levels as Auckland's population grows

ii. To improve congestion results, relative to predicted levels, in particular travel time and reliability, in the peak period and to ensure congestion does not become widespread during working hours

iii. To improve public transport's mode share [relative to predicted results], where it will address congestion

iv. To ensure any increases in the financial costs of using the transport system deliver net benefits to users of the system.

The project objectives alone will not achieve all the broad outcomes sought from transport investment. A number of other key transport outcomes and demand on transport expenditure, such as maintaining existing assets and providing a basic level of infrastructure to enable growth, will require significant investment over the next 30 years and also need to be taken into account in the evaluation process.

The following is an explanation of the above objectives and other key transport outcomes that a transport system is expected to contribute to.

2.1. Improve access to employment and labour

Transport networks support the growth, productivity and success of urban areas and their catchments, by getting people to work, supporting deep, diverse and productive labour markets and allowing businesses within the area to reap the benefits of agglomeration.

This objective focuses on improving access to employment and labour in order to support the ultimate objective of achieving economic growth and increased productivity. The workforce should have access to an increasing number of jobs and proportion of the region's jobs, taking into account an increase in population and jobs over the next 30 years. Similarly, employers should have access to an increasing number of workers and proportion of the region's labour pool, taking into account an increase in population over the next 30 years. Access, in terms of a reasonable travel time and cost, is the important factor relating to this objective.

If people have a higher number of jobs within a reasonable commute time, this will increase their likelihood of finding the most suitable job, make it easier to build on their skills and reduce their vulnerability to long-term unemployment if they lose their job. Similarly, employers with larger labour pools (a greater number of people within reasonable commute time of their location) have a greater likelihood of finding the most suitable employees. For highly specialised employment types, where productivity levels are highest, accessing larger labour pools becomes particularly important.

This objective also focuses on access between business areas during the day to improve productivity and enable Auckland to carry out its freight and service functions efficiently.

2.2. Improve congestion results

This objective aims to achieve better congestion results, compared to the projected level of congestion from previously proposed programmes. The objective requires consideration of a different mix of interventions in the transport system, taking into account projected growth, value for money, and impacts of future changes in technology and travel behaviours.

Some level of congestion is a by-product of a successful city and generally cities with very low levels of congestion are either relatively small or in decline. However, congestion adds significant costs to doing business and moving freight, can reduce accessibility and quality of life and is a key concern for Auckland's travelling public. Congestion also impacts on the reliability of travel, adding costs by forcing travellers to add extra time to their journey to allow for the potential of delay. Therefore, congestion will be measured not only in terms of delay but also the reliability of travel times.

There are many different definitions of congestion. For the purposes of this project, congestion is defined as 'severe congestion', where the flow of traffic breaks down, speeds drop and stop-start-motoring begins[6]. This is also the point where traffic demand exceeds maximum practical capacity.

2.3. Improve public transport mode share where it will address congestion

This objective aims to achieve better public transport mode share from a transport package, compared to the projected public transport mode share from previously proposed programmes, where it will address congestion. The objective is focused on public transport use at times of the day and on parts of the network where there is congestion. The underlying assumption is that that people using public transport will not exacerbate congestion and therefore will have a positive impact on congested parts of the network.

Public transport carries a significant number of people efficiently along corridors of high demand, using space efficiently when compared to private vehicles. This attribute is particularly important in more intensive locations such as major centres where space is very valuable. Public transport trips are often focused at peak times to major centres of employment (especially the city centre) and are quite long – particularly trips on the rapid transit (rail and bus way) network.

Conversely, public transport often struggles as an attractive, cost-effective transport option in lower density areas, particularly when serving dispersed employment or low-intensity employment areas.

While the total mode share of public transport in Auckland is relatively small, this objective requires an examination of how public transport impacts on congestion.

2.4. Ensure increased financial costs deliver net user benefits

This objective assesses whether further charges to transport users in Auckland generate net benefits for those who will be paying the extra costs.

Policy interventions such as road pricing can achieve improved performance of the transport network through raising the financial cost of travelling, thereby influencing travel demand. It is important to weigh up the costs and benefits of pricing interventions to establish whether the additional costs of a road pricing charge are outweighed by the time savings benefit they provide.

2.5. Ensure value for money

The objective to ensure value for money relates to the overarching objective of the project to achieve better returns from transport investment, compared to forecast returns from current plans. Assessment of the intervention packages will need to demonstrate this outcome.

Developing, maintaining and operating the transport system has major costs – both public costs for Council and Government, and private costs for households and businesses. These costs have increased significantly over the last decade to address Auckland's growing transport demands. However, a decision to invest in upgrading Auckland's network imposes an opportunity cost for taxpayers, ratepayers and transport users. Investment made to

[6] In technical terms, this is Level of Service E, F or worse. It is assumed that reliability of travel times start to deteriorate on parts of the network where the volume to capacity ratio exceeds 0.9 (Source AECOM email 23/11/2015 and JMAC email 4/12/2015).

upgrade the network is money that cannot be invested to fund other government, council or individual priorities.

Assessing value for money will require understanding and measuring the total social benefits of a package of projects and ensuring they exceed the cost of the package. Achieving best possible value for money means that the package offers the greatest possible social benefits relative to its cost.

This project's objectives encompass the bulk of the social benefits that can be expected from transport projects. An understanding of how those objectives are met helps to understand the effects of a particular package of projects. This value for money measure reveals how the benefits stand in relation to the costs.

2.6. Other key outcomes

While the project is focused on the objectives outlined earlier, transport investment also contributes to a number of other important outcomes. These will be tracked to understand where achieving improved performance on the project's objectives may support or undermine achieving these other key outcomes. For example, it is important to ensure that interventions which may improve congestion or accessibility do not result in adverse safety impacts.

The following list of other key outcomes has been identified by the project team, based on long term outcomes contained in strategic planning documents such as the Government Policy Statement on Land Transport 2015 and the Auckland Plan. The Government Policy Statement highlights key focus areas of supporting economic growth and productivity, improved transport safety and ensuring value for money from investment. The Auckland Plan describes the key role of the transport system in facilitating liveability, economic growth and productivity is through creating better connections and accessibility within Auckland, across New Zealand and to the world.

- Support access to housing – Transport networks are expected to be in place to meet the demand for new housing in Auckland.
- Minimise harm – The transport programme is expected to avoid, reduce or mitigate the harmful impacts on people and the environment. Harm from the transport system includes risk of deaths and serious injuries, harmful emissions into the air, waterways and ecosystems, and negative impacts on heritage and communities.
- Maintain existing assets – It is expected that transport assets will be maintained and renewed at the optimal time to ensure a continued acceptable service to users of the transport system.
- Social inclusion and equity – The transport system is expected to be implemented with consideration of the fairness with which impacts (benefits and costs) are distributed and enable a cross-section of society to access everyday activities. This project will need to consider the distribution of benefits and costs arising from proposed interventions (not just those arising from an increase in financial costs as per the fourth project objective).
- Network resilience – The transport programme is expected to contribute to the resilience of the transport network in terms of its vulnerability to disruption and ability to adapt to disruption.

3. Evaluation criteria

This section outlines the indicators relating to the project objectives and other key outcomes. These form an evaluation framework which will be used to test existing and proposed transport intervention packages.

For each objective, measures and key performance indicators (KPIs) have been developed to enable evaluation. For each measure there are headline KPIs that will be reported on and will be used for analysis. Secondary KPIs are identified but may be reported on except where they significantly add value to informing key decisions. A small number of headline KPIs were identified in relation to each objective in order to provide meaningful and objective information that illustrates how well a package delivers on the objective.

Term	Working definition
Objective	What we want to achieve
Measure	How we will demonstrate achieving an objective
KPI	Extent to which we perform against a measure

The full evaluation framework comprises the headline KPIs and secondary KPIs is set out in Appendix A.

The project team will work through how the evaluation framework will be applied to the evaluation of packages. Broadly the intention is to use the information provided by the headline KPIs, and supporting KPIs where relevant, to inform judgements about how each package delivers against the objectives.

3.1. Improve access to employment and labour

This objective measures the extent to which Aucklanders have good access to employment opportunities, employers have good access to the labour pool and good access between businesses.

Measure 1: Access to employment and labour within a reasonable travel time	
Headline KPIs	**Explanation of how measured**
Jobs accessible by car within a 30 minute trip in the AM peak	This is calculated as the number of jobs that can be accessed from all different parts of Auckland within a 30 minute travel time by car in the AM peak. A 30 minute threshold for car trips has been used to broadly reflect existing average commute times in Auckland (approximately 25 minutes in the AM peak in 2014[7]) and a number of international cities as well as providing a good basis for comparing the impact of different interventions.
Jobs accessible by public transport within a 45 minute trip in AM peak	This is calculated as the number of jobs that can be accessed from all different parts of Auckland within a 45 minute travel time by public transport in the AM peak[8]. Travel time includes wait time and transfer penalties for transfers to a public transport service.

[7] MoT Household Travel Survey 2014

[8] It is commonly found in international research that the inclination to commute declines rapidly when commuting times exceed 45 minutes, regardless of gender, transport mode, and socio-economic factors (Sandow, E. and Westin, K Preferences for commuting in sparsely populated areas (2010) Journal of Transport and Land Use). Land use /employment patterns and transport are both expected to affect whether the current proportion of access to jobs across the region would remain the same or increase over time.

Measure 1: Access to employment and labour within a reasonable travel time	
Headline KPIs	**Explanation of how measured**
Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	This is calculated as an employment weighted average of jobs accessible from other jobs within a 30 minute car trip as a proportion of total jobs in the region. The inter-peak period is selected to differentiate commuter trips and to indicate the productivity of trips across the road network between business areas.
Supporting KPIs	**Explanation of how measured**
Proportion of jobs accessible within a 30 minute car trip in AM peak	This is calculated as a population weighted average of the number of jobs within a 30 minute travel time by car in the AM peak as a proportion of total jobs in the region.
Proportion of jobs accessible within a 45 minute public transport trip in AM peak	This is calculated as a population weighted average of the number of jobs within a 45 minute travel time by public transport in the AM peak as a proportion of total jobs in the region.
Average travel time by car or public transport in AM peak	This calculates the average travel time by car or public transport in the AM peak, which can be at the regional and sub-regional level. This helps to quantify the additional travel time to access jobs in the AM peak.
Access to specific origins and destinations e.g. City Centre and rest of region in AM peak	This uses the same calculation as the previous KPI, but differentiates access to/from the City Centre and the rest of the region. This could be further differentiated in terms of access to/from major centres and the rest of the region.

3.2. Improve congestion results

This objective measures the extent to which congestion results can be improved (relative to predicted levels of current plans) by different intervention packages. The measures and headline KPIs give strong consideration to travel time and reliability of travel time in the peak and inter-peak periods[9] as well as business trips caught in severe congestion on the network.

Measure 1: Impact on general traffic congestion	
Headline KPIs	**Explanation of how measured**
Per capita annual delay (compared to efficient throughput)	Annual per capita delay is calculated as the difference in travel time for motor vehicle trips on the road network throughout the day, compared to the travel time estimated if the network operates at an efficient throughput of vehicles (i.e. not free flow), for a year divided by the population. This represents the average time (in minutes) that a motorist is delayed in a year due to congestion. This is an indicator of the additional delay resulting from those parts of the network that are dealing with a throughput of vehicles greater than what is considered efficient (calculated in relation to Level of Service E).

[9] The transport model will not isolate the extent of the duration of peak traffic. The transport model does forecast volumes of traffic and level of congestion for different time periods: the am peak 7.00 to 9.00 am and an inter-peak period 9.00 am to 3.00 pm. The forecast volume of traffic and level of congestion in the inter-peak period may be affected to some extent by a spreading of the period of congestion in the morning. This information is indicative information about how widespread congestion is on the strategic road network. Interpretation is required to analyse the extent to which motorists are deferring trips (shopping, recreational, deliveries, etc) to the inter-peak period in order to avoid congestion in the am peak.

Measure 1: Impact on general traffic congestion	
Headline KPIs	**Explanation of how measured**
Proportion of travel time in severe congestion in the AM peak and inter-peak	This is calculated as the average time spent in severe traffic congestion as a proportion of total trip time travelled on the road network. This will be measured in the AM peak and inter peak periods. This KPI is an indicator of any increase in severe congestion for motor vehicle trips across the road network in the am and inter-peak periods of a working day[10].
Supporting KPIs	**Explanation of how measured**
Throughput of people at key parts of the network in the AM peak and inter-peak	This measures the volume of people travelling by any mode. This calculation will be done on routes to key employment areas including the City Centre and the airport, where there are screenlines at strategic parts of the network. This may be compared to the throughput to an industrial area (e.g. Highbrook). The selection of key parts of the network and routes will be done to help inform a sub-regional analysis of access to employment. This is an indicator of the productivity of corridors, which needs to be considered alongside indicators of congestion.
Proportion of the strategic road network (motorways, primarily arterials) in severe congestion during the AM peak and inter-peak	This measures vehicle kilometres travelled (VKT) in severe congestion as a proportion of total VKT on the strategic road network.
Proportion of VKT spent in severe congestion on state highways or regional arterials	This is a subset of the above KPI - the calculation would be done only in relation to state highways or arterial roads (that are part of the strategic road network).

Measure 2: Impact on freight and goods (commercial traffic) congestion	
Headline KPI	**Explanation of how measured**
Proportion of business and freight travel time spent in severe congestion on the strategic freight network in the AM peak and inter-peak	This is a specific calculation of the time spent by business trips in severe congestion as a proportion of total business trip time spent on the strategic freight network. This KPI is an indicator of any increase in severe congestion for business trips across the strategic freight network in the am and inter-peak periods of a working day.
Supporting KPIs	**Explanation of how measured**
Average travel times along strategic freight corridors	This is calculated as volume of vehicle trips x average speed / distance in relation to the following freight corridors: • Northern boundary to the port • Kumeu to the port • East Tamaki to the port • Metroport to the port

[10] Severe traffic congestion is characterised by slower speeds, longer trip times, unreliable trip times and increased vehicular queuing (i.e. a traffic jam). Austroads explains that traffic congestion is considered severe at Level of Service E (or worse) when the volume of traffic is at this effective capacity limit of the road. Austroads 2013, Guide to traffic management Part 3, Traffic studies and analysis. For modelling purposes, severe congestion is identified on parts of the network where the modelled speed is less than 67 kph on a motorway, expressway or rural highway or less than 25 kph on other roads [Source: JMAC email 4/12/15].

	• Airport to the port • Southern boundary to the airport • Southern boundary to the port. The model output of average travel times for these point to point routes could be calculated in the AM peak and inter-peak.
Proportion of VKT spent in severe congestion on the strategic freight network	This measures VKT in severe congestion as a proportion of total VKT on the strategic freight network.

Measure 3: Travel time reliability	
Headline KPI	**Explanation of how measured**
Proportion of travel time subject to volume to capacity ratio of greater than 0.9 during AM peak, PM peak and inter-peak	This calculates the distance travelled in severe congestion as a proportion of the total vehicle distance travelled. This KPI is an indicator of the proportion of distance travelled which could be subject to variable travel times. Severe congestion is identified as closely associated with the parts of the network where the volume to capacity ratio exceeds 0.9[11]. When traffic volumes are greater than 0.9 of the capacity of a road, travel times begin to become unreliable[12]. In these conditions extra time (buffer) is needed to ensure on-time arrival for trips and most trips are likely to experience variable travel times. This has been developed to reflect the significant monetary costs of congestion on commercial traffic which results in the scheduling of 'buffer' periods that add cost and time.
Supporting KPI	**Explanation of how measured**
Breakdown by motor vehicle and public transport	This measures the proportion of travel kilometres by motor vehicle only i.e. VKT (or by public transport only i.e. PTKT) subject to volume to capacity ratio of greater than 0.9 during AM peak, PM peak and inter-peak (refer to explanation of headline KPI above). This enables an understanding of travel time reliability for motor vehicle trips only or public transport trips only.

Measure 4: Increase vehicle occupancy	
Headline KPI	**Explanation of how measured**
Average vehicle occupancy in the AM peak and inter-peak	Average vehicle occupancy is the average number of people per vehicle for particular trip types and is an input to the model. Current input assumptions about vehicle occupancy vary by trip purpose and time of day[13].

[11] AECOM email 23/11/2015.

[12] Variability of travel times start to occur when the volume to capacity ratio is between 0.8 and 1.0 (equating to Level of Service E) due to day-to-day or unusual fluctuations in demand. Travel times become more variable when the volume to capacity ratio is greater than 1.0 (equating to Level of Service F).

[13] Home Based Trips

Purpose	Prod	AM	IP	SC	PM	OP	24 hr
HBW	From Home			1.10			1.10
	To Home			1.11			1.11
HBE	From Home	2.60	1.22	1.28	1.66	1.47	2.09
	To Home	2.30	1.63	3.35	2.30	1.78	2.57
HB Sh	From Home	1.27				1.63	1.31
	To Home	1.10	1.22	1.35			1.28
HBO	From Home	1.62	1.28	1.54	1.62	1.59	1.48
	To Home	1.09	1.25	2.03	1.69	1.64	1.50

Non-Home Based Trips

Purpose	AM	IP	SC	PM	OP	24 hr
EB	1.08				1.15	1.08
NHBO	1.62	1.32	1.75	1.51	1.66	1.49

Source: Sinclair Knight Merz TIME OF DAY AND VEHICLE DRIVER FACTORS Report 24 January 2007

Supporting KPIs	Explanation of how measured
Average vehicle occupancy in PM peak	This measures average vehicle occupancy in the PM peak only (refer to explanation of headline KPI above). This enables an understanding of travel time reliability at the worst part of the day (currently).
Breakdown of average vehicle occupancy of cars and public transport	This breaks down the measurement of average vehicle occupancy for motor vehicles only and separates the average vehicle occupancy in relation to public transport trips. Out-of-model information may assist in understanding how average vehicle occupancy may be affected by a new mode of mobility service – one that serves a similar function to taxis, but becomes more widespread through technology changes.

3.3. Improve public transport mode share where it will address congestion

This objective will be measured by two headline KPIs to assess the extent to which public transport is used and its contribution to easing congestion on the road network.

Measure 1: Public transport mode share	
Headline KPI	**Explanation of how measured**
Proportion of vehicular trips in the AM peak made by public transport	This calculates the proportion of total vehicular trips in the AM peak that are made by public transport. It is recognised that the ART3 strategic transport model only differentiates motor vehicle trips and public transport trips, because the number of walking and cycling trips is an input to the model.
Proportion of vehicular trips over 9 km in the AM peak made by public transport	This calculates the number of trips made by PT as a proportion of total vehicular trips (in the AM peak) 0-9 km.
Supporting KPIs	**Explanation of how measured**
Proportion of trips in the AM peak made by public transport	This measures PT trips as a proportion of total trips (i.e. vehicular trips and active mode trips) in the AM peak.
Proportion of trips/vehicular trips in the inter-peak made by public transport	This measures PT trips as a proportion of vehicular trips (or total trips) in the inter-peak period. This enables an understanding of the role of PT during the inter-peak period for general trips.
Measure 2: Increase public transport where it impacts on congestion	
Headline KPI	**Explanation of how measured**
Proportion of vehicular trips over 9 km in the AM peak made by public transport	This recognises that long trips on the road network in the AM peak contribute to congestion in multiple parts of the network. The number of long trips taken by public transport would have a direct impact of alleviating congestion. This is calculated as the number of PT trips greater than 9 km as a proportion of total vehicle trips greater than 9 km in the AM peak. The purpose of identifying long public transport trips is to understand the extent to which public transport could potentially be removing trips off several sections of the road network that would otherwise be subject to congestion.

Supporting KPIs	Explanation of how measured
Proportion of vehicular trips made by public transport (rather than contributing to congestion) along severely congested routes	This compares the number of PT trips with motor vehicle trips along congested routes (refer to map of screenlines). It is calculated as the number of trips using public transport at congested parts of the network as a proportion of total trips at those parts of the network in the AM peak and inter-peak. This enables an understanding of the number of public transport trips that are being taken instead of adding to severely congested routes. Selected routes would be those which are severely congested and with motor vehicle and PT connections to a key employment centre (e.g. City Centre, airport, etc). This relies on point to point information from the model (current list is Airport to CBD, Silverdale to CBD, Albany to Highbury, Westgate to CBD, Pukekohe to CBD, Manukau to CBD, Manukau to Airport, Howick to CBD, Howick to Manukau, Botany to Airport, St Lukes to St Johns, Waterview to Manukau).
Proportion of journey trips unaffected by severe congestion	This calculates the journey **time** unaffected by severe congestion as a proportion of the journey time of total trips (PT and motor vehicle) from point to point. This reflects the fact that most bus trips on busways and bus lanes will have some part of the trip on a road affected by traffic congestion. This calculation would be done in relation to a selection of routes where point to point information is available from the model (see list above).
Proportion of vehicular trips made by public transport to major employment centres e.g. City Centre (AM peak and inter-peak)	This is a mode share calculation which shows the proportion of PT trips to total PT and motor vehicle trips to a major employment centre. This provides another indicator of the proportion of public transport trips that are being taken instead of adding to severe congestion.
Proportion of public transport services in the AM peak which are over-crowded or have low use	This is an output from the APT model and indicates services which have low or high demand. This information may assist in understanding which parts of the network have demand for increased service or have a low contribution to easing congestion on the road network.

3.4. Ensure increased financial costs deliver net user benefits

This objective will be measured by the extent to which the cost of travel will vary under different intervention packages. This is particularly relevant to understanding the true costs and benefits from packages that involve pricing schemes for demand management purposes, as these policies improve network performance through increasing the financial cost of travel.

Measure 1: Changes in the cost of travel	
Headline KPI	**Explanation of how measured**
Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	This is calculated as the additional financial cost to users, isolated from financial costs that would be common to users under the different packages. The additional financial cost might be a congestion charge or an increase/reduction in PT fares of a package that is being tested. The total of the additional financial costs to users is divided by the number of trips by those users to calculate the increase in financial cost per trip. This is compared with the change in generalised cost of travel impacted by the proposed congestion charge or increase/reduction in PT fares. This helps to understand the net effects in terms of cost and time.

Supporting KPIs	Explanation of how measured
Total benefits and costs of a scheme as they apply to users	This provides a dollar value of total benefits to users and a dollar value of financial costs incurred by users. These benefits and costs to users are represented in the `generalised cost of travel'. This is the average monetary and non-monetary costs of all journeys. Monetary costs might include a fare on a public transport journey, or the costs of fuel, wear and tear, distance travelled and any parking charge, PT fare, or toll or congestion charge on a car journey. Non-monetary costs refer to the time spent undertaking a journey. Time is converted to a money value using a value of time figure, which in the model varies according to the purpose of the trip only.
Generalised cost of travel for specific trips (i.e. those being charged)	This calculates the generalised cost of travel (as per the first supporting KPI) applied to specific trips being charged e.g. business trips, journeys to work, etc.
Average cost of travel per capita	This calculates the average cost of travel, which is the total financial costs (including the charge) divided by the total population.

3.5. Ensure value for money

Better returns from investment, i.e. value for money, will be measured in a way that will highlight the overall benefits (to the extent that these can be effectively measured) and financial cost of a transport package or programme. Value is measured in the wider sense, in terms of the total societal benefits and impacts of a transport programme.

Measure 1: Value for money	
Headline KPI	**Explanation of how measured**
Package benefits and cost	This compares the financial cost of a package to the monetary value of potential benefits to both users and non-users in terms of: • Travel time savings • Vehicle operating cost savings • Impact on CO_2 emissions • Savings in accident costs • Improved reliability and greater throughout • Increased competition and agglomeration The calculation of benefits will be generally in accordance with NZ Transport Agency's Economic Evaluation Manual and using updated information e.g. value of time. This will enable a comparison of value for money between packages, rather than provide a definitive assessment of value for money.
Supporting KPIs	**Explanation of how measured**
Total cost of a package in current day dollars	30 year costs, both opex and capex, in $2016 values
Net present value of the total cost of a package	30 year costs, both opex and capex, in net present value
Average cost of travel for transport users (including time)	This is a calculation of the average generalised cost of travel for transport users (in terms of financial costs and time).

3.6. Other key transport outcomes

The measures and headline KPIs relate to outcomes outlined in the Government Policy Statement on Land Transport 2015 and the Auckland Plan. These headline KPIs enable consideration of contributions to outcomes that are not directly taken into account in relation to the project objectives discussed above.

Support access to housing

Measure 1: Transport infrastructure in place in future urban zones when required for new housing	
Headline KPI	**Explanation of how measured**
Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	This is calculated outside the model to measure the extent to which transport infrastructure is in place in future urban zones to support new housing in those areas. The timing of transport infrastructure is determined as an input to the model. The timing of these inputs is compared with the time frames identified in the Future Urban Land Supply Strategy. (Note that the Transport for future urban growth project is expected to identify the minimum transport networks required to enable housing to be established in future urban zones and the timing of those networks). The result can be calculated as a percentage of transport infrastructure that is provided within the timeframes. Because the common elements include the basic level of transport infrastructure and services supporting the future urban zones, this KPI would help to distinguish packages that apply different timing or amounts of additional transport infrastructure and services supporting the future urban zones. Another way to calculate this is a percentage of future urban zones that have transport infrastructure and services in place at the required time to support the future urban zones.
Supporting KPIs	**Explanation of how measured**
Cost of networks in future urban zones	This is calculated outside the model and comprises capital and operating costs relating to transport infrastructure and services that are modelled to service the future urban zones (residential and commercial). The costs could be calculated in current dollars and net present value to enable a comparison of packages.
Proportion of jobs accessible from future urban zones (30 minutes by motor vehicle, 45 minutes by public transport) in AM peak	This uses the same calculation as the headline KPI relating to access to employment. However, the calculation is applied to access from future urban zones only. The three future urban zones are in the southern, western and northern parts of Auckland as identified in the Future Urban Land Supply Strategy.

Reduce harm

Measure 1: Safety Emissions	
Headline KPI	**Explanation of how measured**
Deaths and serious injuries per capita and per distance travelled	This is a calculation made outside of the transport model, based on forecast data about travel speeds, vehicle kilometres travelled on different roads and the effects of the safety programme. The transport model provides a forecast estimate of future crashes (resulting in deaths or serious injuries) based on modelled travel speeds and total kilometres travelled on different road types. Two metrics are then calculated: per capita (usually per 100,000 population) and per vehicle kilometres travelled.

Supporting KPIs	**Explanation of how measured**
Number of deaths and serious injuries walking and cycling per capita and per distance travelled	This is a calculation made outside of the transport model, based on forecast data about travel speeds, number of trips by walking and cycling and the effects of the safety programme.
Cost of safety programme	This is a calculation of the total capital and operating costs of the safety programme.

Measure 2: Greenhouse gas emissions	
Headline KPIs	**Explanation of how measured**
Greenhouse gas emissions	The model provides a forecast estimate of greenhouse gas emissions based on vehicle kilometres travelled, changes in fuel efficiency and extent of travel in congested conditions. Emissions are largely dependent on the uptake of electric vehicles and improvements in vehicular efficiency and vehicle occupancy. This is a daily figure.

Maintain existing assets

Measure 1: Effects of maintenance and renewals programme	
Headline KPIs	**Explanation of how measured**
Asset condition levels of service	This is estimated outside of the model, based on the level of investment in maintenance and renewals and the level of service targeted in that programme.
Renewals backlog	This is estimated outside the model. The renewals backlog is calculated as the dollar value of the renewals programme that is deferred at the end of the 30 year period as a result of the level of investment in maintenance and renewals.
Supporting KPI	**Explanation of how measured**
Cost of maintenance and renewals programme	This is a calculation of the total capital and operating costs of the maintenance and renewals programme.

Social inclusion and equity

Measure 1: Fairness of distribution of impacts (benefits and costs)	
Headline KPIs	**Explanation of how measured**
Accessibility from high deprivation areas	This is a series of calculations of access from high deprivation areas to employment (AM peak) and employment areas (inter-peak) and the generalised cost of those trips. The following decile 10 areas have been selected to apply this calculation: West: Ranui; Central: Glen Innes; South: Mangere Central, Otara East, Rowandale, Papakura South. This provides a contrast to figures of accessibility at the regional level, which are calculated in relation to the headline KPI for access to employment. The generalised cost would be calculated and mapped across the region to identify differences.
Distribution of impacts (costs and benefits) by area	This draws from headline KPIs relating to other objectives and applies these to the four sub-regional areas i.e. north, west, central and south. This is expected to highlight any uneven distribution of costs and benefits of a transport programme. This geographical analysis will take into account a social deprivation index map to understand potential social impacts.

Supporting KPIs	Explanation of how measured
Impact on low deprivation areas	This uses the same method of calculation as the first headline KPI, but in relation to low deprivation areas (in the north and central areas) to provide a comparison of the range of access to employment and generalised costs between the low and high decile areas.
Access to important social services e.g. hospitals, education, shops	This calculates travel time by different modes to key destinations from high deprivation areas (as identified above).

Network Resilience

Measure 1: Network vulnerability and adaptability	
Headline KPI	**Explanation of how measured**
Impact in the event of disruption at vulnerable parts of the network	The headline KPI could be applied to key locations in the transport network where there is vulnerability to disruption. These locations would be on strategically significant routes and could be any mode. For example, Auckland Harbour Bridge, Crossings of Tamaki River, rail line, State Highway 1 at Drury. Travel times by an alternative route and volume of trips could be calculated to indicate the impact if a disruption occurs at a key location. The likelihood of a disruption could also be considered e.g. high likelihood of an accident or breakdown and low likelihood of a catastrophic failure. This KPI would enable packages to be compared to the extent that packages provide alternatives or ability to adapt to a disruption at these key locations. This could be calculated in different ways: using non-model information about travel times following incidents at these key locations; using modelled information about volumes and travel times on an alternative route; calculating travel time on an alternative route by switching off a key piece of infrastructure in the transport model.
Supporting KPI	**Explanation of how measured**
Composite index of economic and social indicators e.g. risk of disruption, transport choice (modes and routes), etc.	Research by NZ Transport Agency regarding measurement of economic and social impacts of resilience is underway and may add to the analysis as a supporting KPI. This research was not available for use during the ATAP.

Full list of key performance indicators

Objective	Measure	Headline KPI	Supporting KPI
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30 minute trip in the AM peak • Jobs accessible by public transport within a 45 minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	• Proportion of jobs accessible within a 30 minute car trip in AM peak • Proportion of jobs accessible within a 45 minute public transport trip in AM peak • Average travel time by car or public transport in AM peak • Access to specific origins and destinations e.g. City Centre and rest of region in AM peak
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak	• Throughput of people at key parts of the network in the AM peak and inter-peak • Proportion of travel time in severe congestion on the strategic road network during the AM peak and inter-peak • Proportion of VKT spent in severe congestion on state highways or regional arterials
	Impact on freight and goods (commercial traffic) congestion	• Proportion of time spent in severe congestion on the strategic freight network in the AM peak and inter-peak	• Average travel times along strategic freight corridors • Proportion of VKT spent in severe congestion on the strategic freight network
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, PM peak and inter-peak.	• Breakdown by motor vehicle and public transport
	Increase vehicle occupancy	• Average vehicle occupancy	• Breakdown of average vehicle occupancy of cars and public transport
Increase public transport mode share	Public transport mode share	• Proportion of vehicular trips in the AM peak made by public transport	• Proportion of trips in the AM peak made by public transport • Proportion of trips/vehicular trips in the inter-peak made by public transport • Proportion of kilometres travelled by public transport (peak and inter-peak) • Proportion of vehicular trips by journey length during the AM peak made by public transport
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 9 km in the AM peak made by public transport	• Proportion of vehicular trips made by public transport (rather than contributing to congestion) along severely congested routes during the AM peak • Proportion of vehicular trips made by public transport to major employment centres e.g. City Centre (peak and inter-peak) • Proportion of length of public transport trips unaffected by severe congestion • Proportion of public transport trips which are over-crowded or have low use
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	• Total benefits and costs of a scheme as they apply to users • Generalised cost of travel for specific trips (i.e. those being charged) • Average cost of travel per capita
Ensure value for money	Value for money	• Package benefits and costs	• Total cost of packages – 30 year costs, both opex and capex, in $2015 values and/or NPV • Average cost of travel for

			transport users (including time)
Other Outcomes	**Measure**	**Headline KPI**	
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	• Cost of networks in future urban zones • Proportion of jobs accessible from future urban zones (30 minutes by motor vehicle, 45 minutes by public transport) in AM peak
Mitigate harm	Safety	• Number of crashes per capita and per distance travelled	• Number of deaths and serious injuries walking and cycling per capita and per distance travelled • Cost of safety programme
	Emissions	• Greenhouse gas emissions	
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog	• Cost of maintenance and renewals programme
Social inclusion and equity	Distribution of impacts (costs and benefits) by area	• Accessibility from high deprivation areas • Distribution of impacts (costs and benefits) by area	• Impact on low deprivation areas • Access to important social services e.g. hospitals, education, shops
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network	• Composite index of economic and social indicators e.g. risk of disruption, transport choice (modes and routes), etc.

Appendix B – Model Input Assumptions

This memo outlines changes to ART3 input assumptions that have been considered by the ATAP project team and are being recommended to JMAC for implementation as at 24th November 2015.

Recommended changes to input assumptions are noted below – along with supporting evidence where input assumptions have been checked or changes are recommended.

ART input assumptions grouped under the following headings:

- Land Use Inputs
- Policy/Economic Inputs
- Transport Infrastructure and services
- TDM Assumptions
- Safety (factors added post ART model run)
- Emissions and fuel use (factors applied post ART model run)

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions For ATAP
Land Use Inputs			
Zonal land use inputs	Scenario H High growth	Scenario I8B Medium	Use land-use **i9 medium growth**.
Development of future 'Regional Growth Strategy' centres Affects the mode choice to access the identified centres. Relates to the TDM inputs listed below. Refer to ART3 User Manual – Feb 2009 (page 40) for details on how the trip end are effected with regard to RGS and non-RGS areas.	Scenario H	Auckland Plan Scenario I	Use existing assumptions.

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions for ATAP
Policy/Economic Inputs			
GDP/capita growth rate Affects the number of heavy vehicle trips, the value of time and future parking charges.	1.8% pa	1.8% pa	**Advice from MoT and Treasury:** Use 1.5% real GDP growth pa (from 2013 onwards). **2006 – 2013 GDP growth**: Use 0.5% real GDP growth pa (from 2006 – 2013).
Value of Time	Escalated wrt GDP/Capita growth (1.8% pa), with elasticity of 1 on work travel and 0.8 for non-work travel (Ref:UK DfT - TAG)	Escalated wrt GDP/Capita growth (1.8% pa), with elasticity of 1 on work travel and 0.8 for non-work travel (Ref:UK DfT - TAG)	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa
Private vehicle operating costs	Lower growth based on forecast fuel price and estimate of improved fuel efficiency (Ref:RLTS2010 WP5-Price Forecasts for Transport Fuels and other Delivered Energy Forms, MoT)	Lower growth based on forecast fuel price and estimate of improved fuel efficiency (Ref:RLTS2010 WP5-Price Forecasts for Transport Fuels and other Delivered Energy Forms, MoT)	Price updated based on NLTF revenue spreadsheet provided by MoT (based on VFEM and Fuel forecast)
Integrated ticketing – effect on speed of boarding	Assumed faster bus boarding times than 2006 base – as per RLTS (Assume 10% improvement in boarding time; net effect of Integrated Ticketing and increased loading)	Assumed faster bus boarding times than 2006 base – as per RLTS (Assume 10% improvement in boarding time; net effect of Integrated Ticketing and increased loading)	Use existing assumptions.
Public Transport Fares From ART3 Input Review work undertaken by Ian Wallis Associates Ltd May 2011. Refer “PE2” in report “ART3InputsReview-IWallis1328 May 1 Update Table 1.doc” attached below: Fare increase = $(GDP/Capita)^{0.25}$ *“With the GDP/cap forecast increase of 1.8%pa, this results in an average fare increase of c.0.45%pa: this is midway between the RLTS assumption and the NZTA”*	Increased wrt to GDP/Capita with elasticity of 0.25	Increased wrt to GDP/Capita with elasticity of 0.25	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa
PT fare system	Stage based (matches current system). Calculated based on a: • Boarding fare + • Distance based fare	Stage based (matches current system). Calculated based on a: • Boarding fare + • Distance based fare	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa

Integrated fares	Assumed removal of second boarding fare for transferring passengers but with 2c/km increase in all fares to retain same overall revenue and average fare	**Basic** Assumed removal of second boarding fare for transferring passengers but with 2c/km increase in all fares to retain same overall revenue and average fare **APTN** As above but no additional 2c/km	Use existing assumptions
Parking Costs	Escalation wrt GDP/Capita with elasticity of 1.2 for commuter travel and 1.0 for non-commuter travel. (Parking costs location and as per attached maps)	Escalation wrt GDP/Capita with elasticity of 1.2 for commuter travel and 1.0 for non-commuter travel. (Parking costs location and as per attached maps)	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa Update 2006 and 2013 costs based on CPI adjusted 2013 data
Toll and road pricing	Toll in ALPURT and in other projects as per the Auckland Plan scenarios. Toll values escalated at CPI.	Toll in ALPURT, Penlink. Toll values escalated at CPI. Specific network charges as per IAB specifications to be provided.	Use existing assumptions
External trips (to/from Waikato and Northland)	3% per annum increase in the number of trips per annum (increasing from 2006 observed figure)	3% per annum increase in number of trips (increasing from 2006 observed figure)	Use 1.3% pa increase for Auckland-Waikato and Auckland-Northland external trips. **Evidence base:** Projected growth in the Auckland region is downloaded from statistics NZ. Spreadsheet was downloaded 5th of November 2015.
Flight related trips Creates trips to and from Auckland Airport. Also affects interregional trips (i.e. from Northland and Waikato to AIAL).	Private vehicle model only based on vehicle counts at Airport in 2006.	Based on 2011 observed data and escalated over time based on the increase in the number of air passengers as advised by AIAL. Includes private vehicle, taxi, taxi shuttle and bus along with people who fly and associated "farewellers" and "greeters".	Use pre-existing assumptions **Evidence base:** Growth from January 2009 to August 2015 shows a cumulative increase of 3.6% per annum (Domestic: 3.4%, International: 3.8%). This aligns with pre-existing assumptions of 3 - 4% growth pa.
HCV Growth	Employment plus GDP multiplier (elasticity of 0.23) (Ref: NZTA - Additional Waitemata Harbour Crossing 2011)	Employment plus GDP multiplier (elasticity of 0.23) (Ref: NZTA - Additional Waitemata Harbour Crossing 2011)	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions for ATAP
Transport Infrastructure and services			
Rail, Bus and Ferry services	As agreed for each scenario	As per specification. Increased level of service in APTN compared to Basic.	To be specified for each modelling run
Road network	Auckland Plan	As agreed for Committed, Basic, APTN programmes.	To be specified for each modelling run
Interchange penalties (and quality of rail / busway stations)[14]	Assumed all upgraded to 'medium' quality	Assumed all upgraded to 'medium' quality (unless otherwise stated)	Specified for each model run

[14] The impact of having to interchange is modelled via 'time penalties' in ART. Penalties are modelled as follows:

1. A time penalty related to the quality of the interchange facility. This component of the penalty is modelled as follows:
    - 10 minute time penalty at low quality interchanges (and other places on the network where interchange is required between PT services)
    - 8 minute time penalty at designated medium quality interchanges
    - 5 minute interchange penalty at designated high quality interchanges
2. Plus a time penalty to reflect the waiting time required for the second service. This component of the penalty is calculated based on whether the interchange is planned or unplanned, and the frequency of the services.

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions for ATAP
TDM Assumptions			
Working from home	60% of RLTS 2010 assumptions *	**Basic** 60% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	Working group agrees to use existing assumptions and to include the basic investment package as part of 'common elements'. High investment TDM packages will be tested during refined packages stage.
Assumptions for behaviour change from Work Place Initiatives (WTI): Reduction in car trips to work – CBD	60% of RLTS 2010 assumptions*	**Basic** 30% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	
Assumptions for behaviour change from Work Place Initiatives (WTI): Reduction in car trips to work – RGS Centres	50% of RLTS 2010 assumptions*	**Basic** 25% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	
Assumptions for behaviour change from Work Place Initiatives (WTI): Reduction in car trips to work – Non-RGS Centres	60% of RLTS 2010 assumptions*	**Basic** 40% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	
Assumptions for behaviour change from Education TDM initiatives	100% of RLTS 2010 assumptions*	**Basic** 100% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	
Assumptions for behaviour change from Community TDM initiatives	25% of RLTS 2010 assumptions*	**Basic** 25% of RLTS 2010 assumptions **APTN** 100% of RLTS 2010 assumptions	

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions
Safety (factors added post ART model run)			
Crash rate Number of crashes are based on vkt on each road type x the crash rate for each road type	Injury crashes by road type (Urban Arterials, Rural Arterials & Motorways), based on VKT. Crash rates and associated rate reduction through time is based on NZTA Economic Evaluation Manual.	Injury crashes by road type (Urban Arterials, Rural Arterials & Motorways), based on VKT. Crash rates and associated rate reduction through time is based on NZTA Economic Evaluation Manual.	Use existing assumptions
Emissions and fuel use (factors applied post ART model run)			
Fuel use, NOX, CO2, PM10 particulate Assumption relating to engine efficiency improvements, take up of electric vehicle etc have been included as part of this work by UoA. Report attached: Model and spreadsheets available upon request (not included due to size)	Based on report titled “Vehicle Emission Prediction Model version 4” and associated spreadsheet model. Prepared for NZTA and AC by Energy & Fuels Research Unit, Department of Mechanical Engineering, The University of Auckland.	Based on report titled “Vehicle Emission Prediction Model version 4” and associated spreadsheet model. Prepared for NZTA and AC by Energy & Fuels Research Unit, Department of Mechanical Engineering, The University of Auckland.	Use existing assumptions

Hon Bill English Minister of Finance
Hon Simon Bridges Minister of Transport
Len Brown Mayor of Auckland
Councillor Bill Cashmore

31 August 2016

Dear Auckland Transport Alignment Project Parties

In accordance with the Terms of Reference for the Auckland Transport Alignment Project agreed by the Parties in August 2015, we are pleased to present our final deliverable, *Recommended Strategic Approach*.

The attached report will be laid out into a format suitable for publication in time for the public release of the report.

Peter Mersi
Secretary for Transport

Stephen Town
Chief Executive Auckland Council

Fergus Gammie
Chief Executive NZ Transport Agency

David Warburton
Chief Executive Auckland Transport

Cath Atkins
Deputy Secretary Treasury

Lewis Holden
Deputy Commissioner Auckland
State Services Commission

Ministry of Transport
TE MANATŪ WAKA

THE TREASURY
Kaitohutohu Kaupapa Rawa

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Auckland Transport

STATE SERVICES COMMISSION
Te Komihana O Ngā Tari Kāwanatanga

NZ TRANSPORT AGENCY
WAKA KOTAHI

Auckland Transport Alignment Project

Recommended Strategic Approach

August 2016

Ministry of Transport
TE MANATŪ WAKA

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Kaitohutohu Kaupapa Rawa

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NZ TRANSPORT AGENCY
WAKA KOTAHI

Executive Summary

i. As joint transport funders with a shared interest in a successful Auckland, the Government and Auckland Council have worked together to identify an aligned strategic approach for the development of Auckland's transport system. This report presents joint officials' recommended strategic approach. It builds on work reported in two previous documents: the *Foundation Report* (February 2016) and the *Interim Report* (June 2016).

ii. A sharp recent increase in Auckland's population is placing significant pressure on our transport networks, which will be compounded by substantial projected population growth over the next 30 years. While a very significant programme of infrastructure investment is underway and committed, to effectively address this challenge we will need to do things differently.

iii. We identified four critical challenges that need to be the focus of our efforts over the next decade:

- Enabling a faster rate of housing growth, particularly in new greenfield growth areas
- Addressing projected declines in access to jobs for people living in large parts of the west, and some parts of the south.
- Addressing growing congestion on the motorway and arterial road network, particularly at inter-peak times,
- Increasing public transport mode share on congested corridors

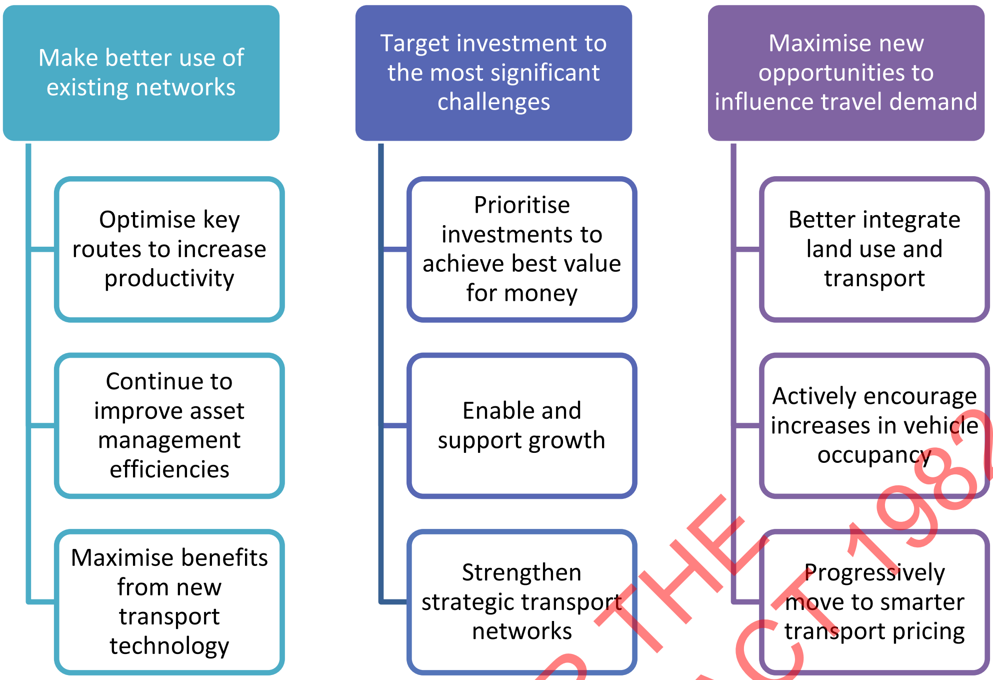
iv. We considered a range of options for addressing Auckland's transport challenges to see how we could get better returns than current plans.

v. Changing the mix of investment would deliver improvements in some areas, but it cannot deliver a step-change in performance across the region and would struggle to keep pace with projected demand growth.

vi. We also looked at options to substantially increase or bring forward new infrastructure investment, or to shift to a greater focus on influencing demand. We concluded that neither of these approaches alone is sufficient to address Auckland's transport challenges.

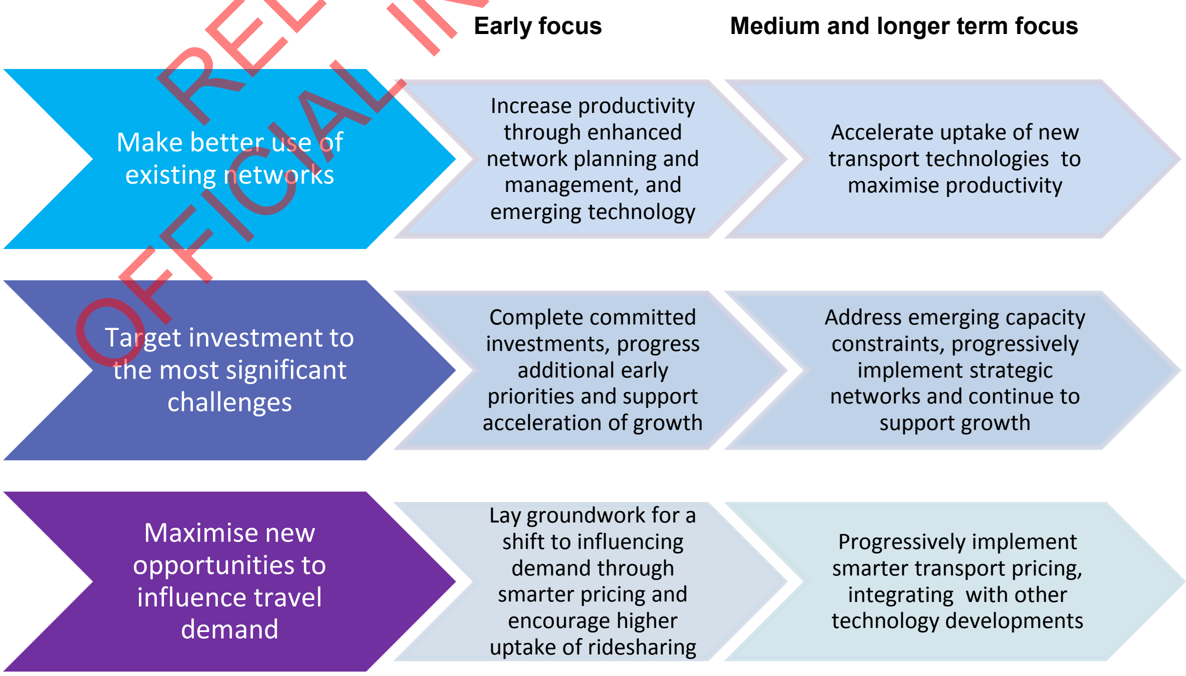
vii. Instead, we need to better balance transport demand with the capacity of our infrastructure and services. This requires a fundamental shift to a greater focus on influencing travel demand through smarter transport pricing and accelerating the uptake and implementation of new technologies, alongside substantial ongoing transport investment, and getting more out of our existing networks.

viii. Our recommended strategic approach therefore contains three integrated elements:



ix. Implementing this approach will provide much better returns than current plans, delivering better access to employment, reduced congestion, and increased public transport mode share. This does, however, rely on each of the three elements being progressed in an integrated manner. In particular, the main benefits will not be realised until we shift to smarter transport pricing.

x. The recommended strategic approach will need to be progressively delivered through infrastructure investment, policies and services over the next 30 years. To give an indication of how the approach could be applied, we developed an indicative package of the types of interventions likely to be needed, as well as the overall scale and sequencing of investment. Our broad approach is shown below.



xi. The indicative package is not an investment programme, as individual projects need to go through statutory processes to proceed. However, it provides an illustration of the type and quantum of investment that is likely to be required to implement the strategic approach.

xii. We have placed greater emphasis on the first 10 years because many of our current assumptions about the location of housing and employment growth and the timing and impacts of technological change become less accurate after this period. The estimated expenditure in the first decade, from 2018-2028, is around $24 billion. Over the 30-year period, estimated expenditure totals $83 billion, nearly half of which represents capital expenditure, with the remainder a combination of asset renewals, maintenance and operational costs.

xiii. The expenditure identified for the first decade exceeds the amount of funding expected to be available from current funding plans by around $4 billion. Auckland Council and the Government will need to consider options to address this gap ahead of the next round of statutory funding decisions in 2018.

xiv. The indicative package outlines interventions for the three decades from 2018. This does not mean that we can wait until 2018. A number of actions can be taken now to set us along the path towards our recommended strategic approach. The sooner we start, the sooner we can expect the benefits.

Recommendations

xv. We recommend the Government and Auckland Council adopt the recommended strategic approach, which contains the following key components:

a. Make better use of existing networks
b. Target investment to the most significant challenges
c. Maximise opportunities to influence travel demand

xvi. To implement the strategic approach, we also recommend:

a. Government, Auckland Council, Auckland Transport and the NZ Transport Agency incorporate the strategic approach into their statutory strategic documents
b. Government and Auckland Council work together to consider options and agree on an approach to address the funding gap by mid-2017, to inform statutory funding documents
c. Early establishment of a dedicated project to progress smarter transport pricing, with a view to implementation within the next 10 years
d. Review of investment processes to ensure they align with the strategic approach
e. Government and Auckland Council consider whether statutory changes are required to support ongoing joint strategic transport planning
f. Complete work on identified priority actions as soon as possible

The Auckland Transport Alignment Project

1. As joint transport funders with a shared interest in a successful Auckland, in August 2015 the Government and Auckland Council agreed to work together on the Auckland Transport Alignment Project, to identify an aligned strategic approach for the development of Auckland's transport system that delivers the best possible outcomes for Auckland and New Zealand.

Project Objectives

The focus of the Auckland Transport Alignment Project is to test whether better returns from transport investment can be achieved in the medium and long-term, particularly in relation to the following objectives:

i. To support economic growth and increased productivity by ensuring **access to employment/labour improves** relative to current levels as Auckland's population grows
ii. To **improve congestion results**, relative to predicted levels, in particular travel time and reliability, in the peak period and to ensure congestion does not become widespread during working hours
iii. To **improve public transport's mode share**, relative to predicted results, where it will address congestion
iv. To ensure any increases in the financial costs of using the transport system **deliver net benefits to users** of the system

2. This report has been jointly prepared by officials from the six agencies involved in the project[1], and presents our recommended strategic approach. It includes an indicative package of measures, covering the broad timing and scale of interventions, and estimates of costs and benefits, together with the nature, scale and timing of the funding gap for the recommended strategic approach. It also sets out recommended implementation actions.

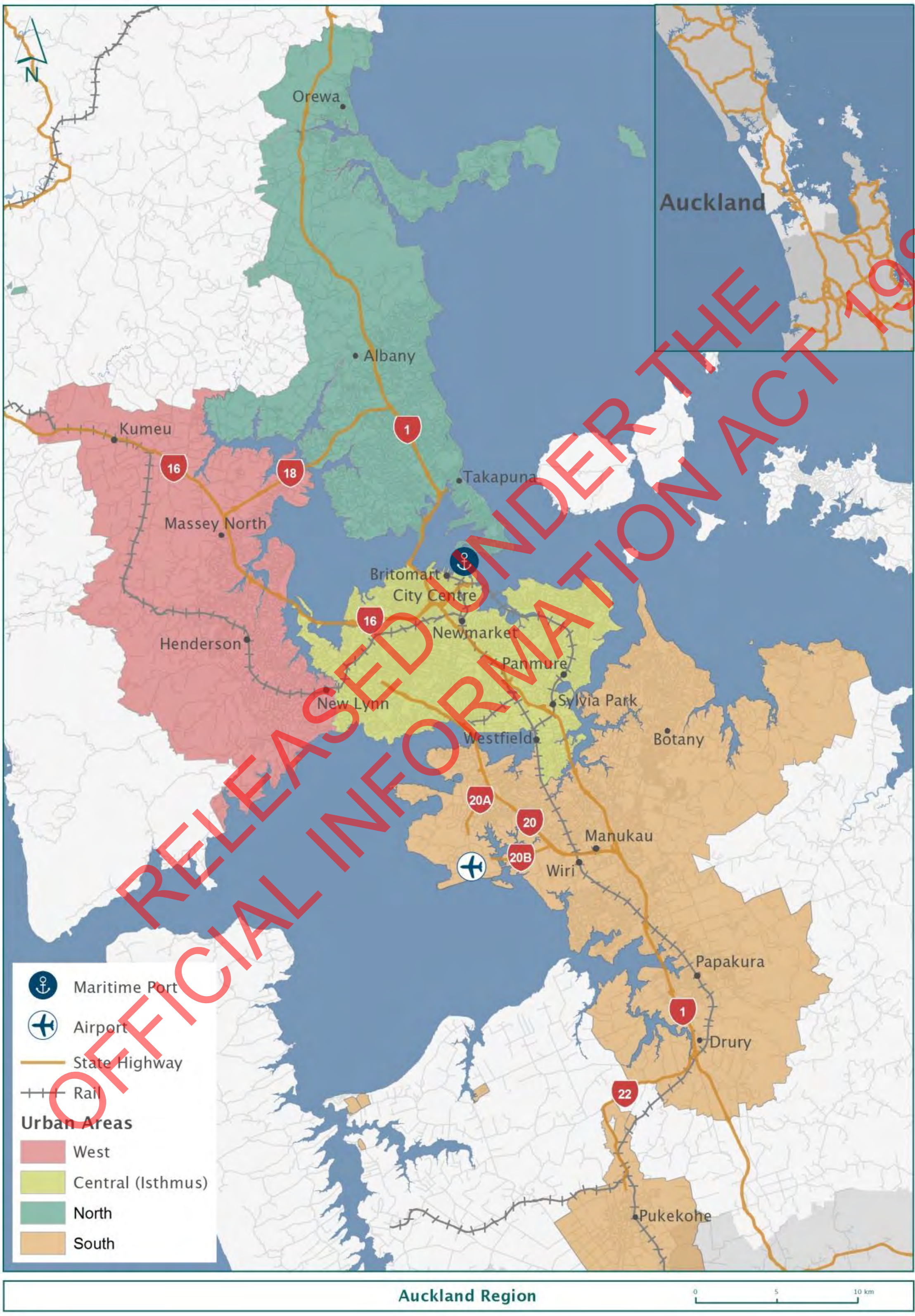
3. This report marks the completion of the Auckland Transport Alignment Project, and builds on the work reported in two previous documents: the *Foundation Report* (February 2016) and the *Interim Report* (June 2016). A companion document, *Auckland Transport Alignment Project: Supporting Information* presents the background information to support this report.

4. In a number of areas, including safety and active modes (walking and cycling), the views of the central and local government are already well aligned on the priorities and likely level of future funding. We have therefore taken as given the initiatives that are already underway in these areas, including the *Safer Journeys Action Plan*, the *Auckland Road Safety Plan*, and the *Urban Cycleways Programme*.

5. While the focus of this report is on the transport system within Auckland, it is important that this is considered within its broader inter-regional context, particularly the linkages between Auckland and the Upper North Island. We note and support

[1] Ministry of Transport, Auckland Council, NZ Transport Agency, Auckland Transport, The Treasury, and the State Services Commission

the initiatives that are currently underway to strengthen the strategic connections to Northland, Waikato and the Bay of Plenty, including the Auckland to Northland corridor initiatives ('Connecting Northland') and the Waikato Expressway.



Auckland's Transport Challenge

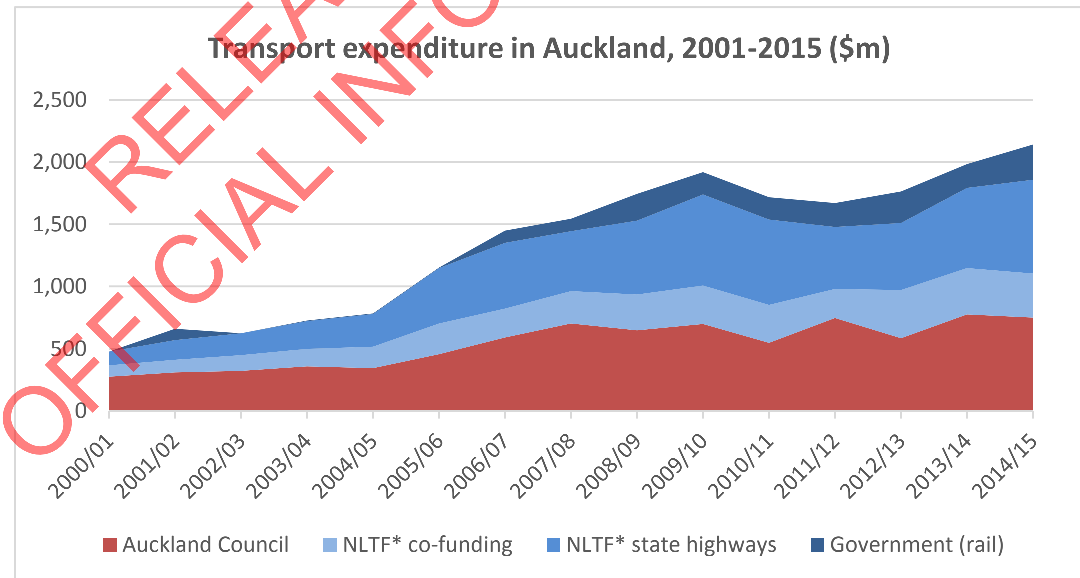
6. Auckland is growing quickly: the city's population is projected to increase by 45% to 2.2 million over the next 30 years, accompanied by a 40% increase in jobs to over 850,000. Continued strong growth in visitor numbers is also expected. This growth places pressure on transport networks, reducing performance and increasing congestion. Left unaddressed or without alternatives for travel, congestion will reduce the opportunities that Auckland's growth can provide.

7. The most significant projected transport challenges over the next decade are:

- The need to enable a faster rate of housing growth, particularly in Special Housing Areas and greenfield areas 'lived-zoned'[2] in the Auckland Unitary Plan
- Growing congestion on the strategic road network, not only during peak periods, but increasingly at other times of the day, which adversely affects the efficient movement of freight and services
- Declines in accessibility for large parts of the west, and some parts of the south.
- The need to increase public transport mode share, particularly along high volume, congested corridors.

8. In addition to these particular focus areas, there is a need to continue to make improvements to road safety and active modes (walking and cycling).

9. Transport is Auckland Council's largest and Central Government's fourth largest area of investment. A combination of catching up on past under-investment and accommodating Auckland's growth has resulted in transport expenditure in Auckland increasing from $500m per year in 2000 to $2.1 billion in 2015[3], as illustrated below.



[2] "Live-zoning" means a residential or business zone where development can occur, rather than a future urban zone where structure planning is required.
[3] includes all public expenditure on land transport, including capital and operations, but excludes debt servicing. *NLTF denotes funding from National Land Transport Fund

10. Overall, the challenge for Auckland’s transport system is to support the city’s growth in a way that is affordable and provides value for money, while also delivering benefits to Auckland and New Zealand as a whole.

Strategic Choices

11. In common with most cities in the world, the response to growing travel demand in Auckland has been to increase road capacity and to provide public transport, walking and cycling infrastructure and services, with relatively little attention paid to influencing that demand.

12. This has involved a substantial increase in investment over the past 15 years, which has delivered significant benefits as Auckland's motorway network has been substantially expanded, the rail network modernised and the Northern Busway constructed. This approach is continuing through a programme of committed and agreed investments in projects such as the Waterview Connection, the City Rail Link, the Auckland-Manukau Eastern Transport Initiative (AMETI), the Puhoi-Warkworth extension of the Northern Motorway, the Accelerated Motorway Package and the East-West Link.

13. While these investments will make a positive difference, our analysis has shown that Auckland's fast rate of growth and challenging physical geography mean congestion and access to employment are unlikely to improve from recent levels[4] in the next decade. In particular, access challenges are expected to become most significant in the west and some parts of the south due to lengthening travel times and a relative lack of local employment.

14. We examined options for changing the mix of what we invest in (spending the same amount as current plans but on different priorities) to consider whether this could achieve better returns. This would generate improvements in some areas, but not a step-change in performance across the region, and will struggle to keep pace with projected demand growth.

15. To achieve that step-change in performance we need a different approach. We looked at two future pathways:

Mainly focus on building more transport infrastructure	A greater focus on influencing transport demand
This pathway substantially increases or brings forward our investment in transport infrastructure to respond to demand and support growth.	This pathway shifts to a greater focus on influencing transport demand through taking advantage of new transport technologies, making full use of network capacity, and using a smarter transport pricing system.

16. Our analysis has shown we cannot solely rely on either approach.

17. Simply increasing investment to build our way out of the problem is unlikely to be cost-effective in the long run and will struggle to deliver significant access and

[4] Our base year for analysis is 2013. Since 2013 Auckland has experienced rapid population growth and increased congestion, with average peak time travel speeds on the State highway network declining by 9% (from 61 to 56 km/h).

congestion improvements. In part, this is because providing new transport infrastructure in existing urban areas is increasingly expensive to provide due to costly land acquisition or tunnelling. It can also have significant amenity impacts.

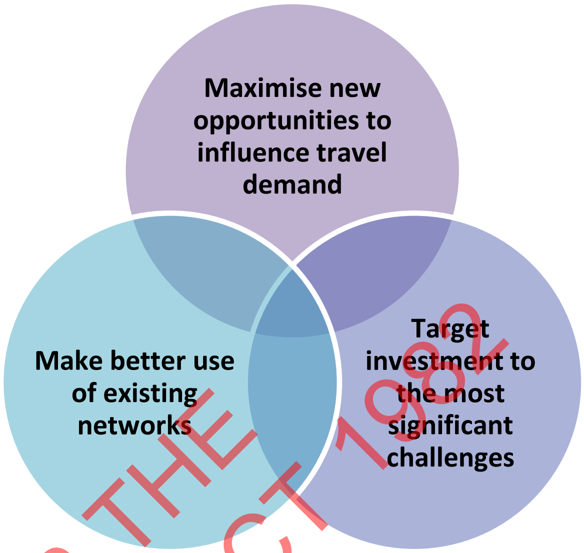
18. Conversely, Auckland's substantial projected growth, current challenges and uncertainties about the timing and effects of new technologies mean we cannot solely rely on influencing travel demand either.

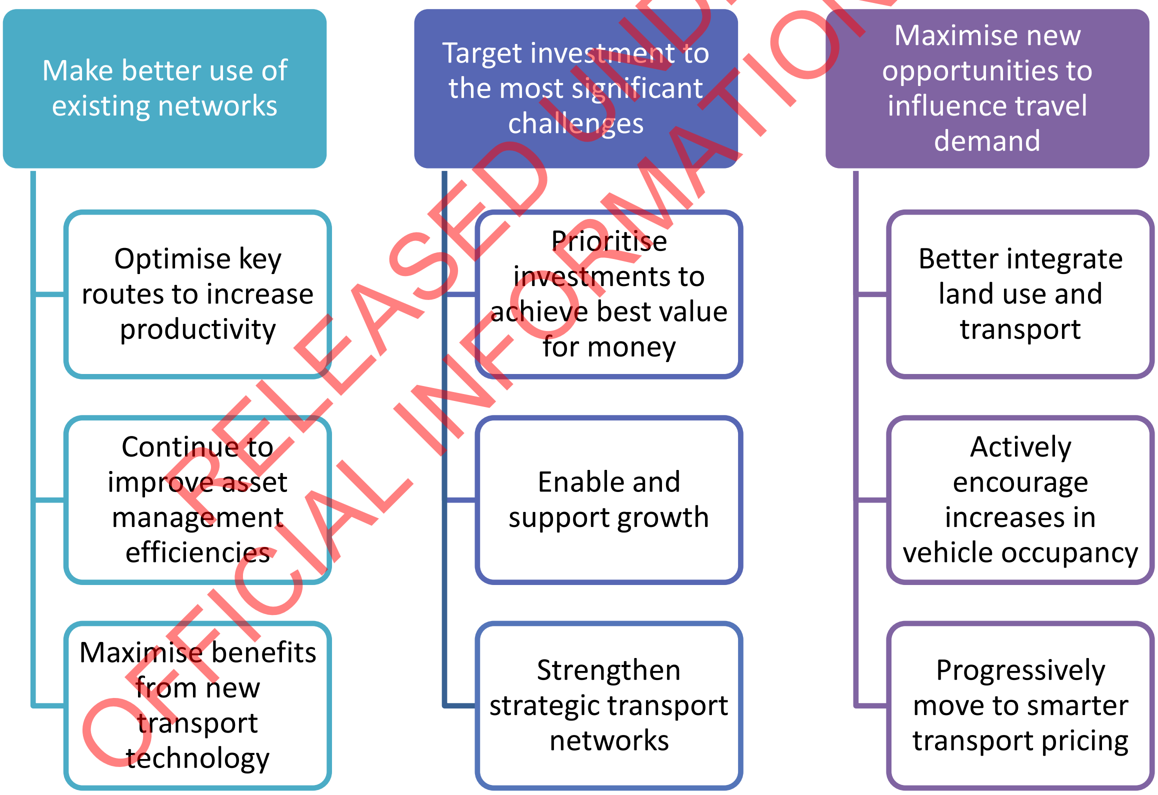
19. Instead, we need to better balance transport demand with the capacity of our infrastructure and services. This requires a fundamental shift to a greater focus on influencing travel demand through smarter transport pricing and accelerating the uptake and implementation of new technologies, alongside substantial ongoing transport investment, and getting more out of our existing networks.

Recommended Strategic Approach

20. To address Auckland's transport challenges and get better returns from the transport system, we need to better balance transport demand with the capacity of our infrastructure and services. Over time, this means influencing travel demand patterns through smarter transport pricing and accelerating the uptake and implementation of new technologies.

21. Our recommended strategic approach contains three integrated elements, each with three key components, as outlined below.





22. Our analysis shows that implementing this approach will provide better returns than current plans, and deliver positive results against the key objectives of access to employment, congestion, and public transport mode share. This does, however, rely on each of the three elements being progressed in an integrated manner. In

particular, the main benefits will not be realised until we shift to smarter transport pricing.

Make better use of existing networks

23. The vast majority of Auckland's future transport footprint already exists today. Most growth in travel demand will need to be accommodated on the existing networks, meaning we need to be much smarter about how we use them.

24. Developing transport technology provides exciting new opportunities to get more out of our existing networks by increasing vehicle throughput and occupancy levels. Maximising these benefits will require optimising key routes to increase their productivity.

Optimise key routes to increase productivity

25. Parts of Auckland's existing transport network have crucial national, city-wide and local functions to enable the efficient movement of people, goods and services.

26. Much of Auckland's motorway network carries significantly higher traffic volumes than anywhere else in New Zealand, and parts of the arterial network carry traffic volumes greater than most state highways elsewhere in New Zealand. For these roads significant through-movement is of primary importance.

27. Many arterial roads also have a variety of other, potentially competing uses, including providing access to local centres. Many Aucklanders live along these roads, which are the focus of substantial future growth.

28. We need a stronger focus on network-level strategic planning to identify and manage these routes. This includes clear criteria to help balance different user requirements, and to address conflicts between through-movement and amenity. While there has been substantial progress in identifying these key routes and developing a framework to help resolve competing issues, this work needs to be completed with urgency.

29. Once the framework has been finalised, some difficult decisions will need to be made to enable increased productivity, such as removing on-street parking, upgrading intersections, extending bus lane operating hours, or introducing freight priority measures. There will also need to be an increase in accompanying investment to enable these changes.

Continue to improve asset management efficiencies

30. Over half of Auckland's future transport investment will need to be spent on maintaining, operating and renewing existing and future assets. This has implications for the amount of funding available for investment in new transport infrastructure.

31. A relatively large proportion of local roads maintenance and renewals expenditure is not currently co-funded from the National Land Transport Fund. Agreement is needed

on appropriate levels of service and required funding for asset management. While progress has been made through the “One Network Roads Classification” process, it is important that this agreement is reached as soon as possible.

32. Our analysis has also highlighted the need for ongoing improvements in asset management efficiencies, including greater use of technology to remotely monitor assets which will help inform the optimal timing for intervention. We consider there are opportunities for further efficiency improvements in this area, with the potential for substantial overall savings.

Maximise benefits from new transport technology

33. We are on the cusp of a paradigm shift in transport technology. Emerging transport and related technology has the potential to significantly improve the performance of Auckland’s transport network over the next 30 years. The outcome could be much more efficient use of existing transport infrastructure, vehicles and services and better value for money from future infrastructure and service investments. However, it is unclear when new technologies can be implemented in Auckland and what their real-world impacts will be

34. In the short-term, increasing our use of intelligent network management presents significant opportunities to get more out of our transport networks through additional throughput. Focus areas include more comprehensive real-time understanding of network use, better data processing capability to support network management decisions and more effective travel demand management tools (e.g. adaptive traffic signals, dynamic lanes and traveller information provision). Specific funding provision for these types of activities in the next round of statutory funding plans would help to highlight their importance.

35. In the medium to longer-term, connected and autonomous vehicles, combined with ride-sharing, have the potential to help increase vehicle throughput (particularly on motorways), reduce traffic accidents, and improve travel time reliability. This could present opportunities to defer or avoid future investment in additional road capacity. These benefits will take some time to materialise, especially if there are institutional, regulatory or infrastructure barriers to their adoption. A coordinated work programme is needed to identify and remove unnecessary barriers and facilitate the uptake of connected and autonomous vehicles.

Target investment to the most significant challenges

36. To ensure the best possible returns from transport investment, we need to focus on addressing Auckland's most significant challenges in providing safe and efficient access to employment, addressing road and public transport congestion and supporting growth. We have identified strategic priorities for investment over the next 30 years, and where efforts should be focused in the short-term (early priorities).

Prioritise investments to achieve best value for money

37. Our framework for identifying early priorities is set out below. It provides a basis for assessing the extent to which different investment options will effectively target the most significant first decade challenges (as outlined in paragraph 7), and the extent to which an investment is likely to deliver value for money. The key assessment measures are the impact on throughput of people, goods and services, travel speeds, and enabling growth.

		Potential to deliver value for money in first decade		
		High	**Medium**	**Low**
Extent to which investment targets most significant first decade challenges	**High**	Highest priority to be progressed in the first decade	Secondary priority to be progressed in the first decade	Unlikely to be first decade priority
	Medium	Secondary priority to be progressed in the first decade	Unlikely to be first decade priority	Not a first decade priority
	Low	Unlikely to be first decade priority	Not a first decade priority	Not a first decade priority

38. Achieving best value for money requires identifying the right solution in the right part of the network at the right time. This means that investments should recognise the strengths of each part of the network:

- Public transport: access to concentrated activity centres (e.g. the city centre, major employment areas) where there is little or no capacity to take additional vehicle traffic.
- Roads: access for people, goods and services to wide transport catchments with diverse trip origins and destinations.
- Rail: providing a dual function of high capacity public transport backbone and strategic freight connections, especially to/from the Ports of Auckland and Tauranga
- Walking and cycling: serving higher intensity areas, short-to-medium length trips and extending the reach of strategic public transport corridors.

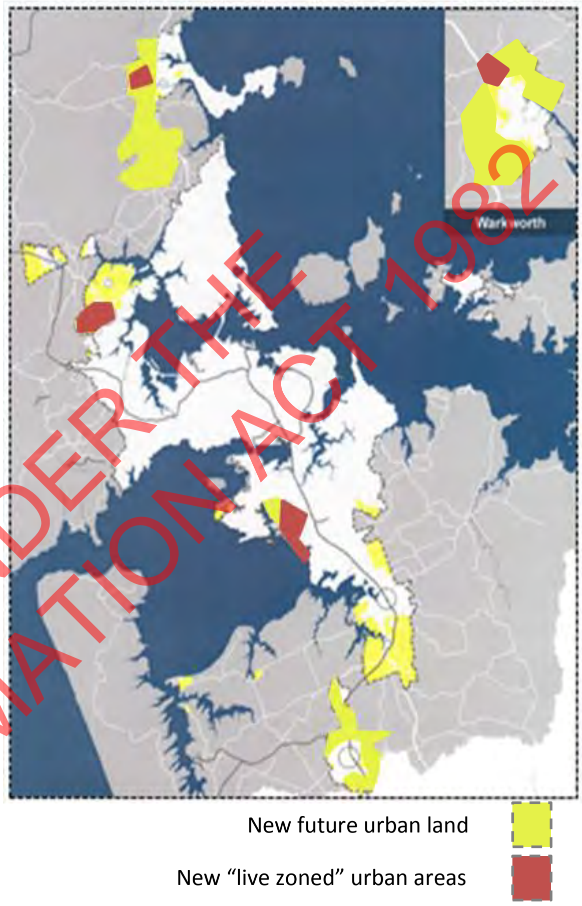
39. As we move towards a greater focus on influencing patterns of demand, investment will also be required to assist the take-up of new technologies that improve vehicle throughput and occupancy rates, and to support the implementation of smarter transport pricing. It will also be important to ensure that investments will continue to stack up in a future with much greater use of transport technology.

Enable and support growth

40. New urban growth areas in the north, west and south will need substantial investment in transport infrastructure before significant development can occur. Some of this investment is required to 'open up' land for development, alongside larger scale improvements are needed to better connect these areas to the rest of Auckland.

41. Transport investment within the existing urban area is also necessary to unlock growth, by improving access and making redevelopment more market attractive.

42. We have identified a number of potential transport investments to support and enable growth. Early investment is needed in areas 'live-zoned' by the Auckland Unitary Plan and through Special Housing Area processes, and to protect routes and secure land for longer-term networks.



Strengthen strategic transport networks

43. Auckland's strategic road, rail and public transport networks are the most critical elements of the city's transport system. Maintaining and developing strong, safe and resilient strategic networks that can cope with increased demand is essential.

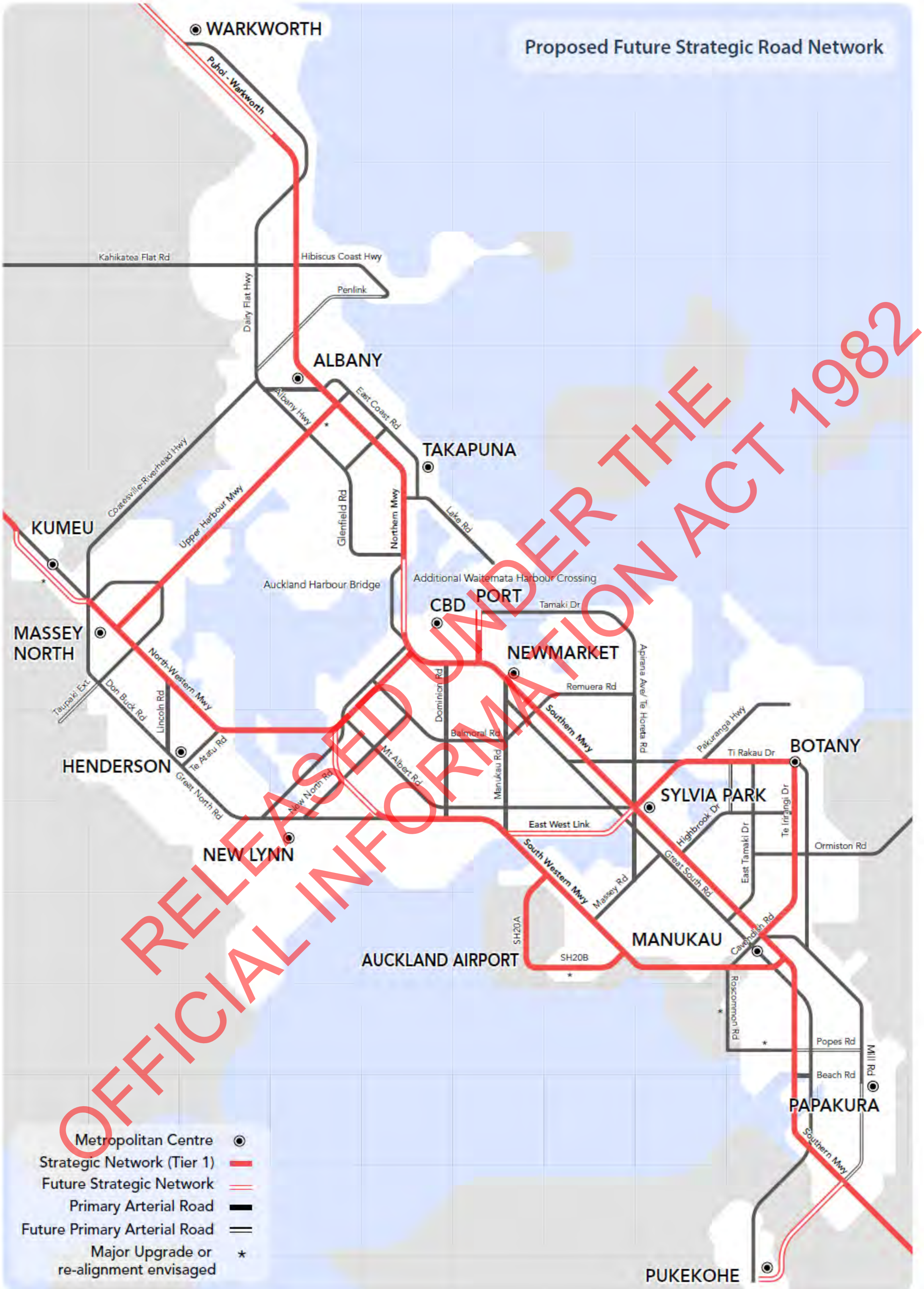
44. Although there are some opportunities to add new corridors, options are limited in existing urban areas. A targeted investment approach is required to address the impacts of growth and to ensure that these core parts of the network have sufficient capacity to operate effectively.

45. Our recommended approach to the development of the strategic road[5] and public transport networks is summarised below. The maps that follow illustrate our agreed view on how these networks will need to develop over the next 30 years.

	Strategic Road Network	Strategic Public Transport Network
Description	• Backbone of the road network, providing for a wide variety of travel and the highest traffic volumes. • Core links between major parts of Auckland and the rest of NZ, carries heaviest freight volumes and provides access to Port and Airport. • Through-movement of people and goods is primary consideration and access is limited or controlled.	• Backbone of the public transport network, providing for high volumes of travel to major employment centres, especially into the central area. • Frequent, high capacity services operating along corridors separated from private vehicles and unaffected by road congestion. • Passenger rail network shares corridor with freight

Approach	• Primarily focus on improving the efficiency of existing corridors by better balancing demand and capacity.
	• Provide new corridors in greenfield areas to support growth and improve connections to existing urban areas.
	• Focus additional capacity primarily on outer parts of the network, along the Western Ring Route and improving Port and Airport access.
	• Maximise benefits from new technology to increase vehicle throughput and occupancy levels.
		• Two key drivers for prioritising development of the strategic public transport network:
		  ○ Addressing emerging capacity constraints as demand increases
		  ○ Expanding the network to improve overall corridor efficiency and throughput
		• Mode choice for strategic network improvements should be driven by capacity requirements to meet forecast demand, integration with the wider network and achieving value for money.

[5] Further work is required to determine which parts of the Primary Arterial road network should have strategic functions.



Proposed Future Strategic Road Network
WARKWORTH
Puhoi - Warkworth
Kahikatea Flat Rd
Hibiscus Coast Hwy
Penlink
Dairy Flat Hwy
ALBANY
Albany Hwy
East Coast Rd
TAKAPUNA
Coatesville-Riverhead Hwy
Upper Harbour Mwy
Glenfield Rd
Northern Mwy
Lake Rd
KUMEU
Auckland Harbour Bridge
Additional Waitemata Harbour Crossing
CBD
PORT
Tamaki Dr
MASSEY NORTH
NEWMARKET
North-Western Mwy
Taupaki Ext.
Don Buck Rd
Lincoln Rd
Remuera Rd
Apirana Ave/ Te Horeta Rd
Southern Mwy
Dominion Rd
Balmoral Rd
Te Atatu Rd
HENDERSON
Great North Rd
Mt Albert Rd
New North Rd
Manukau Rd
Pakuranga Hwy
Ti Rakau Dr
BOTANY
SYLVIA PARK
Highbrook Dr
Te Irirangi Dr
East West Link
NEW LYNN
South Western Mwy
Great South Rd
East Tamaki Dr
Ormiston Rd
Massey Rd
SH20A
AUCKLAND AIRPORT
SH20B
MANUKAU
Cavendish Rd
Roscommon Rd
Popes Rd
Beach Rd
Mill Rd
PAPAKURA
Southern Mwy
PUKEKOHE
Metropolitan Centre
Strategic Network (Tier 1)
Future Strategic Network
Primary Arterial Road
Future Primary Arterial Road
Major Upgrade or re-alignment envisaged


Proposed Future Strategic Public Transport Network
Orewa
Albany
Constellation
Takapuna
Akoranga
Kumeu / Huapai
Devonport
Britomart
Wynyard
Aotea
Karangahape
Massey North
Newmarket
Lincoln Rd
Panmure
Botany
Ellerslie
Penrose
Sylvia Park
Swanson
Mt Roskill
Henderson
New Lynn
Otahuhu
Onehunga
Manukau
Puhinui
Auckland Airport
Papakura
Pukekohe
Metropolitan Centre
Major Interchange
Existing Strategic Public Transport (heavy rail)
Future Strategic Public Transport (heavy rail)
Existing Strategic Public Transport
Future Strategic Public Transport
Frequent Ferry

Maximise new opportunities to influence travel demand

46. A stronger focus on improving the balance between transport demand and the capacity of our infrastructure and services is critical to achieve a step-change in the performance of our transport system.

47. Stronger land-use and transport integration is required to reduce the need for longer trips during peak times. Auckland's rapid growth makes this challenging, but also presents opportunities to better match housing and employment locations to transport capacity and send more consistent signals to the market about the timing and location of development.

48. New and emerging technologies also provide opportunities to influence travel demand in ways that have not previously been possible. In particular, this includes moving over time to a smarter transport pricing system, which varies charges according to time and location. There are a number of challenges that will need to be addressed to take advantage of these opportunities, but the sooner we are able to start, the earlier we can expect to see the benefits.

Better integrate land use and transport

49. Land use lies at the heart of travel demand patterns. The location of Auckland's households, employment, education facilities, port, airport, factories, distribution centres, hospitals, shops and recreation opportunities determines trip origins and destinations. Imbalances between the location of household and employment growth will increase pressure on the transport system.

50. Integrating land use and transport is necessary to:

- Fully realise the economic benefits from population and employment growth
- Ensure the transport network can continue to operate effectively as Auckland grows
- Ensure value for money and good utilisation of new infrastructure and services

51. We can improve transport network efficiency through land use decisions. These decisions should aim to:

- Encourage housing growth in areas with better access to employment and more transport options, such as around the strategic public transport network and on the isthmus.
- Encourage employment growth where transport connections and options are strongest and where additional jobs would reduce reliance on long commutes across major transport bottlenecks, such as in the west and south.
- Enable the consolidation of freight movements, minimise amenity impacts and ensure efficient connections to the strategic network

52. The Auckland Unitary Plan, which was adopted in August 2016, provides the legal planning framework for enabling growth, including future changes in land use. The Unitary Plan provides sufficient development capacity to meet Auckland's growth

requirements for the next 30 years, enabling around 65% of future growth to be accommodated within the existing urban with greater intensification in and around centres, transport nodes and corridors. Significant capacity for employment growth is also provided, particularly in major centres.

53. The balance of growth enabled by the Unitary Plan between existing and future parts of Auckland matches the land-use assumptions that we have used in the project reasonably well. The main difference relates to the potential acceleration of some greenfield development in the north, but we have reflected this in our indicative early investment priorities.

54. Realising the Unitary Plan's capacity in a way that supports our desired land use and transport outcomes is an ongoing task that requires:

- A more flexible and responsive approach to the planning, funding and staging of infrastructure and services to better integrate with the location and timing of development. (This includes supporting the market attractiveness of residential development and successful centres through early investment in enabling infrastructure).
- Making sure that transport funding processes take account of the broader social and economic benefits of enabling growth.

Actively encourage increases in vehicle occupancy

55. Increasing private vehicle occupancy rates through ridesharing, carpooling and other emerging shared mobility opportunities such as shared taxis and taxi buses can help improve the transport system's performance.

56. Past efforts to increase private vehicle occupancy levels have had limited success. However, emerging technologies, particularly based around smartphone applications, provide new opportunities to overcome these challenges, by instantly connecting users with similar travel demands. When combined with the introduction of autonomous vehicles, shared mobility has the potential to fundamentally reshape the way transport is provided and consumed.

57. Most recent advances in this area have been led by the private sector, and we would expect this to continue in future. However, public sector agencies will need to continue to encourage these initiatives by better understanding barriers, ensuring regulation enables innovation in this area, promoting pilot schemes, ensuring open access to data, and exploring opportunities to allocate road space to encourage ridesharing where it will result in greater overall throughput.

Progressively move to smarter transport pricing

58. The use of our roads is not free. The current system of charging for motor vehicle use - through petrol taxes, road user charges and vehicle registration fees- is based on the cost of providing and maintaining roads, but does not reflect differences in the true cost of travel for the individual user by time, location and mode. This "flat-rate" approach under-prices some trips, resulting in congestion, while over-pricing others.

A progressive move to a pricing system that reflects the actual costs of each trip has the potential to result in much more efficient use of our existing road network, and provide better information on where investment in new capacity is needed.

59. Developing technologies enable more sophisticated pricing systems than currently exist. This includes whole of network dynamic systems - the focus of our analysis - that can vary the price of travel by time and location. A system that applies across Auckland's entire road network offers the greatest potential to influence demand in a way that delivers step-change improvements in accessibility, congestion and public transport mode share. Applying charges across the whole network also reduces the likelihood of unintended consequences resulting from diverting traffic, as prices can be fine-tuned across the network to support desired outcomes.

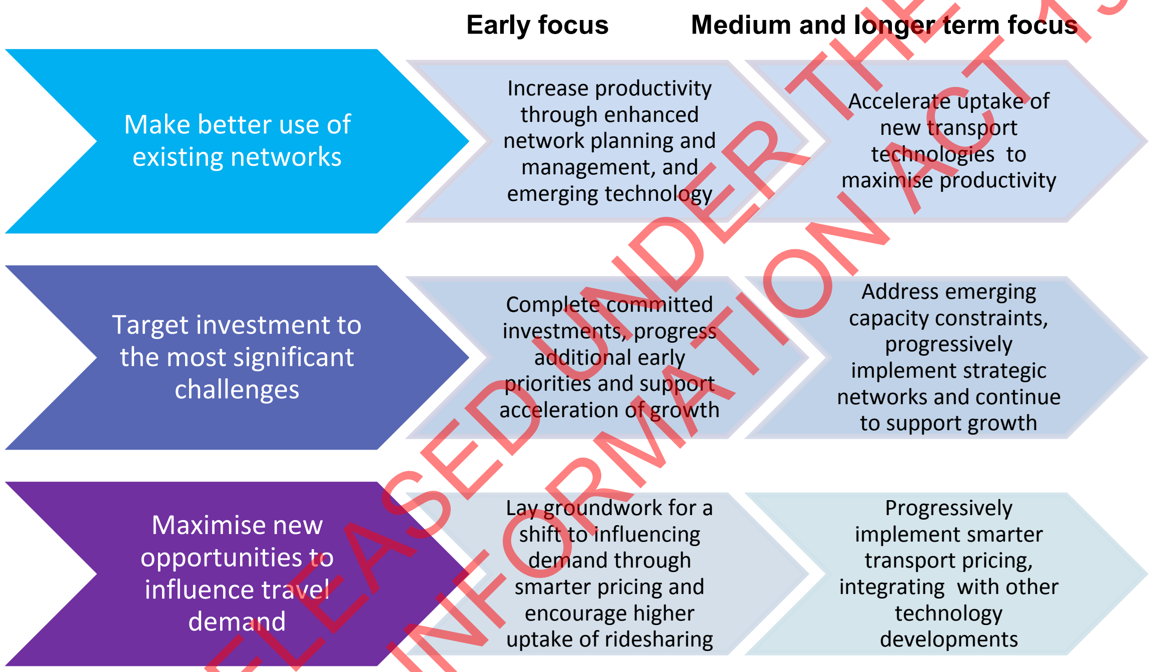
60. A shift to smarter transport pricing would increase the cost of travel for some and reduce it for others, depending on the time and location of travel. In further work to develop smarter pricing, it will be important to properly understand where travel cost increases occur so that equity impacts can be assessed. This will require consideration of the affordability of travel, the impact of pricing on access to jobs, education and services, and any necessary mitigation, particularly for lower income residents who face long commutes.

61. Our focus has been on smarter pricing as a means of influencing demand, rather than as a revenue-raising tool. Full implementation of such a system will take some time due to its complexities, the developing nature of its supporting technology, and the need to gain community awareness and support. However, as smarter pricing is key to delivering a step-change in Auckland's transport performance, we should start laying the groundwork now, with a view to implementation within the next decade.

Delivering the Strategic Approach

62. The strategic approach will need to be progressively delivered through infrastructure investment, policies and services over the next 30 years. To give an indication of how the approach could be applied, we have developed an indicative package of the types of interventions likely to be required, as well as the overall scale and sequencing of investment.

63. We have focused on identifying early priorities, which roughly correspond to the 10 years from 2018 onwards when new transport and Auckland Council funding plans need to be in place; and medium to longer term priorities, which would be delivered beyond the first decade. The broad approach of the package, showing earlier and medium/later interventions is outlined below:



Key focus areas

64. The indicative package includes a significant amount of investment in maintaining and operating the existing transport system, and in continuing to make improvements in safety and active modes through ongoing investments in these areas. In addition to these investments, we have identified six key areas where major interventions will be required to deliver the strategic approach. These are:

- Supporting greenfield growth
- Addressing motorway capacity constraints
- Strengthening central area access
- Improving airport access
- Enabling rail passenger and freight growth
- Shift to a greater focus on influencing demand

65. The following sections briefly outline the key drivers and potential timing of these major interventions. Early priorities (for the first 10 years) and medium to longer term priorities (beyond 10 years) are highlighted.

Supporting greenfield growth

66. Investment is needed to open up land for development and to address the impact of increased travel demands to and from new urban areas.

67. The Unitary Plan identifies over 12,000 hectares of "future urban" zoned land, as well as a number of locations where land currently used for rural activities has been "live zoned" to enable urbanisation in the near future. In total, the Unitary Plan enables around 150,000 dwellings of feasible capacity outside the existing urban area.

Early priorities	Medium and longer term priorities

• Early investment to enable growth in areas that have been 'live zoned' in the Unitary Plan, as well as in Special Housing Areas.
• Route protection, land purchase and early works to ensure future opportunities are not built out and to minimise land costs.
• Progress the Northwestern Busway to increase access to and from the northwest greenfield area and increase throughput along the congested north-western motorway corridor.
	• Progressive implementation of future transport networks in greenfield areas, depending on the timing and rate of development.
	    ○ Some investments may be needed 'up front' to unlock growth capacity, help shape land use and support the establishment of successful town centres.
	    ○ Other investments can be provided later, once growth has occurred, in response to capacity constraints.
	• Ongoing monitoring of the impacts of greenfield growth on travel patterns and refinement of when interventions are required.

Addressing motorway capacity constraints

68. Parts of Auckland's motorway network experience substantial congestion, both at peak times and increasingly throughout the day. Completion of the Western Ring Route, through the Waterview Connection and other committed motorway upgrades, will ease pressure on State Highway 1 and improve network resilience by providing an alternative north-south route. However, projected growth in travel means the motorway network will remain under significant pressure.

69. The inner part of Auckland's motorway network has the highest traffic volumes in the country, but is physically constrained – particularly along State Highway 1 between Takapuna and Mt Wellington where the motorway pushes up against high intensity and high value development, coastlines and other major infrastructure (such as railway lines). Limited capacity additions on this part of the network can provide some local benefits, but appear to shift bottlenecks and congestion points rather than address them. Conversely, increasing capacity along entire corridors involves significant land acquisition, extremely high costs and potentially major amenity impacts.

70. A major new eastern strategic corridor would provide significant access and congestion benefits, but extremely high costs suggest this will not be cost-effective in the next 30 years. However, given Auckland's ongoing growth it is prudent to retain existing route protection.

71. The Auckland Harbour Bridge forms a critical part of the motorway network as the main connection between the North Shore, the city centre and locations further south. Growth in freight, private vehicle and public transport use of the Bridge will create a number of future challenges, particularly as providing an additional harbour crossing will involve very high costs. It is important to continue the work currently underway to protect the route for a new harbour crossing in a way that integrates potential future road and public transport requirements.

Early priorities	Medium and longer term priorities
• Ensure maximum network-wide benefits from completion of the Western Ring Route by providing for capacity upgrades at each end to address bottlenecks, optimising its performance and ensuring it integrates with the East West Link. • Public transport investments, including the City Rail Link, extending the Northern Busway and accelerating the Northwestern Busway, to assist in taking pressure off the motorway network at peak times, especially for trips heading to the city centre. • Upgrades to outer parts of the motorway network, particularly to the northwest and the south, to enable and support growth.	• Ongoing targeted widening in outer parts of the network to enable and support growth. • Support developing vehicle technologies, increasing vehicle occupancy rates and smarter transport pricing to enable existing motorways to be used far more efficiently. • Progress cross-harbour improvements in a way that provides enduring benefits along the broader north-south corridor, integrates with public transport, and provides value for money. • Maintain existing route protection for an additional north-south corridor which may be needed beyond the 30-year timeframe.

Strengthening central area access

72. The city centre and its surrounds (including Newmarket) is New Zealand's largest employment hub and is projected to grow strongly over the next 30 years to reach nearly a quarter of a million jobs. This growth, expected to be largely driven by highly productive service-sector jobs, will be accompanied by a substantial projected increase in tertiary student numbers and continued household growth.

73. Access to this area is physically constrained, and there is competition for limited street-space between vehicles, pedestrians, cyclists and public amenity. This means it is imperative to move more people in fewer vehicles over time. This requires a continued modal shift towards public transport, walking and cycling.

74. Although bus efficiency improvements can help cope with increased demand in the short term, there are limits to the extent to which such improvements can continue to provide sufficient capacity, and a mass transit solution will be required in the medium term. Key criteria for determining the best long-term solution should be the ability to meet projected demand in a way that integrates with the broader strategic network, provides for and stimulates ongoing growth along these corridors and in the city centre, and delivers value for money.

75. The Port of Auckland is located in the edge of the central area and is a significant freight origin and destination including for high-value imports that travel by both road and rail to and from other parts of Auckland and New Zealand. Consistent with the conclusions from Auckland Council's recent Port Future Study, we have assumed the Port will remain in its current location within the 30-year period of this project. In the meantime, strong growth in freight demand which is competing with general traffic congestion, needs to be addressed. Connections between the Port and the strategic road network could be improved, and growth in demand for rail passenger and freight services will progressively impact on the efficient operation of the Port.

Early priorities	**Medium and longer term priorities**
• City Rail Link and associated further rail improvements will cater for a substantial proportion of increased trip demand into the central area over the next decade and beyond. • Bus efficiency improvements on city centre corridors serving the north, northwest and central isthmus will provide additional capacity to address growth demands over the next decade. • Port access improvements focused on improved efficiency between the Port and the motorway network. • Improvements to the core rail network to enable passenger and freight to operate reliably together.	• Invest in additional mass transit capacity to relieve demand pressures on bus corridors serving the isthmus; followed by those serving the North Shore. • Improvements to Port access from the motorway network

Improving airport access

76. The Airport area is nationally significant. It is New Zealand's primary international gateway, the country's third largest port by value of goods and a major and growing employment centre. Substantial employment growth in the broader Airport area, combined with growing passenger and freight flows, is projected to result in an increase in daily trips to and from the area from 63,000 currently to around 140,000 over the next 30 years.

77. Providing for this growth in travel demand is challenging due to the Airport's location in the southwest corner of Auckland's urban area, the limited number of access points, the dispersed nature of trip origins and destinations within the broader airport area, and the long average length of inbound and outbound trips.

78. Substantial access improvements are currently underway to extend the motorway from the north to the Airport's edge and future-proof the route for a higher capacity public transport mode. This is expected to ease congestion on the northern access corridor for some time. Capacity improvements are also required on the eastern access route, to address congestion and improve access from the east and south. These initiatives need to be supplemented with ongoing improvements in public transport services.

79. Over time, space constraints within the Airport area and capacity challenges on the broader road network make it increasingly difficult to serve the Airport area's transport demands through road and bus service improvements alone. This will require investment in mass transit, and route protection to enable this needs to be an early priority.

Early priorities	Medium and longer term priorities
• Complete access improvements from the north to extend the motorway to the Airport's edge • Increase capacity of the strategic road network from the east (including provision for public transport), which will also improve access from the south. • Increase bus services and frequencies (especially for employees in the area), and extend bus lanes to improve reliability • Protect the routes for future mass transit corridors linking the Airport with the north and the east	• Implement mass transit following consideration of: o Required capacity to meet demand generated by Airport passenger and employee growth o Integration with the strategic public transport network (especially isthmus mass transit to the north) o Timing of major improvements to the Airport's internal road network.

Enabling rail passenger and freight growth

80. Auckland's rail network, combined with the Northern Busway, forms the core of the city's strategic public transport network. Investment over the past 15 years has resulted in impressive growth in passenger numbers, with rail accounting for a growing proportion of public transport trips. The network also plays a key role in the movement of freight, particularly to and from the Ports of Auckland and Tauranga. Continued strong growth in passenger trips and freight carried by rail is forecast over the next 30 years.

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

Early priorities	Medium and longer term priorities

• The City Rail Link will provide benefits for rail passengers through significant reductions in travel times, particularly from the west, improved access to the city centre and increased capacity by removing the current Britomart bottleneck.
• Other key short term improvements likely to be required include:
  ○ Additional infrastructure including a third track to address key capacity constraints and enable passenger and freight services to operate reliably.
  ○ Additional trains to cater for growing passenger numbers
  ○ Removal of some road/rail level crossings to better manage safety risks and address road congestion
  ○ Extension of electrification to Pukekohe to serve growth in the south.
	• Depending on demand, longer term improvements are likely to include:
	  ○ Providing a fourth track between Wiri and Westfield
	  ○ Further extension of triple-tracking to Papakura and potentially Pukekohe
	  ○ Potential extension of the fourth main to Papakura
	  ○ Further tranches of additional trains and a second depot
	  ○ Ongoing level crossing removal programme.

Shift to a greater focus on influencing demand

82. Shifting to a greater focus on influencing travel demand should commence with an early work to develop a pathway for moving to smarter pricing. This includes developing a basis for assessing the potential impacts on different users of the transport system, including affordability and equity considerations, and how access to jobs, education and services could best be met under such a system.

83. Work will also be needed to address the implications for the current national system of charging for transport use, the case for legislative change to enable charging for use of existing roads, the technology options, and ultimately the development of a work programme for implementation.

Early priorities	Medium and longer term priorities
• More detailed assessment of the benefits and impacts of smarter pricing, particularly net user effects, affordability, equity and any necessary mitigation • Develop an implementation pathway that includes consideration of technology, national implications, legislative requirements, staging and trials; and progress priority actions • Investment in intelligent transport systems to enable increased productivity, and smarter pricing • Increased use of non-pricing demand management measures, such as high-occupancy lanes	• Full implementation of smarter transport pricing • Increased capacity of the public transport system where necessary to accommodate shifts in demand as a result of smarter pricing

Indicative investment Package

84. The indicative package illustrates how the strategic approach could be implemented over time. It is not an 'investment programme', as neither the Government nor Auckland Council are able to commit to funding over 30 years and all transport investments need to go through business case approval and statutory processes to proceed. We have placed greater emphasis on the first 10 years (2018 to 2028) because of considerable uncertainty about the rate and location of housing and employment growth and the timing and impacts of technological change beyond this period.

85. Committed infrastructure investments form a key part of the indicative package in the first decade. The largest committed investments are listed below, with estimated expenditure incurred during the 2018-2028 period[6]:

- City Rail Link ($2 billion)
- Puhoi to Warkworth extension of the Northern Motorway ($500 million)
- East West Link ($1,500 million)
- Accelerated motorway package ($500 million), which includes:
  - Northern corridor improvements and Northern Busway extension
  - Southern motorway improvements
  - Airport access (northern) improvements
- Mill Road northern section (partly committed, $290 million)
- Panmure-Botany busway and roading improvements (AMETI) (partly committed, $700 million)

86. We used the prioritisation framework in paragraph 37 to assess potential new investments beyond these current commitments (including the uncommitted elements of Mill Road and AMETI). This included an assessment of the extent to which they address the most significant early transport challenges, and may provide value for money in the next decade. The indicative sequencing of major new investments is outlined below:

[6] Does not include costs incurred up to 2018. Puhoi-Warkworth reflects estimated PPP costs during 2018-28

Indicative priorities for major new investments		
Early Priorities (completion in decade 1)	**Medium Term Priorities (completion in decade 2)**	**Longer Term Priorities (completion in decade 3)**
• Northwestern Busway (Westgate to Te Atatu section) • Address bottlenecks on Western Ring Route (SH20 Dominion Rd to Queenstown Rd) and Southern Motorway (Papakura to Drury) • New or upgraded arterial roads to enable greenfield growth in priority areas • Protect routes and acquire land for greenfield networks • Complete SH16 to SH18 connection • Early Rail Development Plan priorities (see paragraph 81) • Upgraded eastern airport access (SH20B) • Investments to enable smarter pricing • Increased investment in Intelligent Network Management • Progress advance works on medium-term priorities	• Continued investment to enable greenfield growth • New strategic roads to Kumeu and Pukekohe • Implementation of mass transit on isthmus and then to the Airport • Bus improvements Airport – Manukau – Botany • Improved access to Port/Grafton Gully • Northwestern busway extensions • Improve connection between East-West link and East Tamaki • Penlink • Medium-term Rail Development Plan priorities	• Continued investment to enable greenfield growth • Southern Motorway improvements south of Manukau • Southwest motorway (SH20) improvements and improved northern airport access • Northern motorway widening • Waitemata harbour crossing improvements, including mass transit upgrade of Northern Busway • Longer term Rail Development Plan priorities

87. The large scale of most of these investments means that they have long lead times (seven years or more for planning, design, procurement and construction). This highlights the need to commence work on these projects at an early stage. To reflect this, we have allocated 10% of the capital cost of projects listed as medium priorities to the first decade.

88. In addition to these major investments, the indicative package also includes a significant amount of expenditure on safety programmes, walking and cycling, and minor road and public transport improvements. It also includes provision for maintaining and operating the transport system and asset renewals, and an allowance for additional expenditure as a consequence of growth in the asset base and user demand.

Expected Outcomes

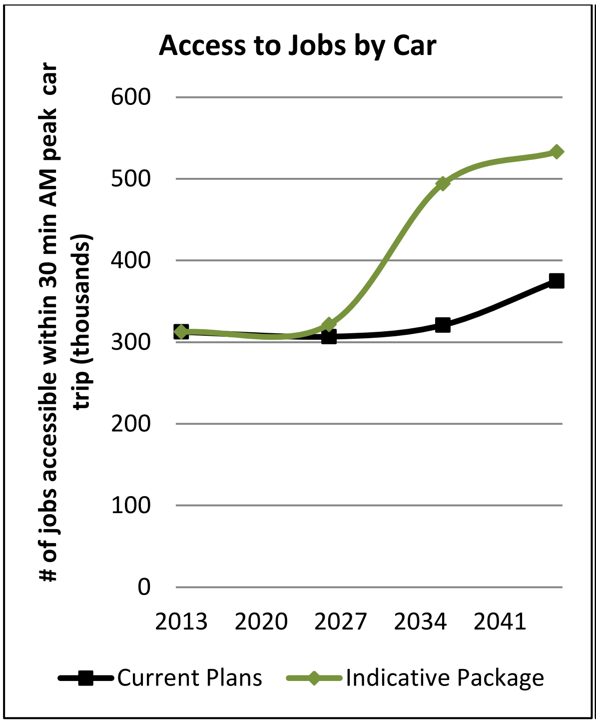
89. The indicative package is projected to deliver substantially better outcomes against the key project objectives of access to employment, congestion and public transport mode share, when compared to the current plan[7]. In combination, this will make a positive contribution to regional and national economic growth and productivity. The graphs below outline the projected performance of both the indicative package and the current plan, using strategic transport modelling outputs for 2013, 2026, 2036 and 2046.

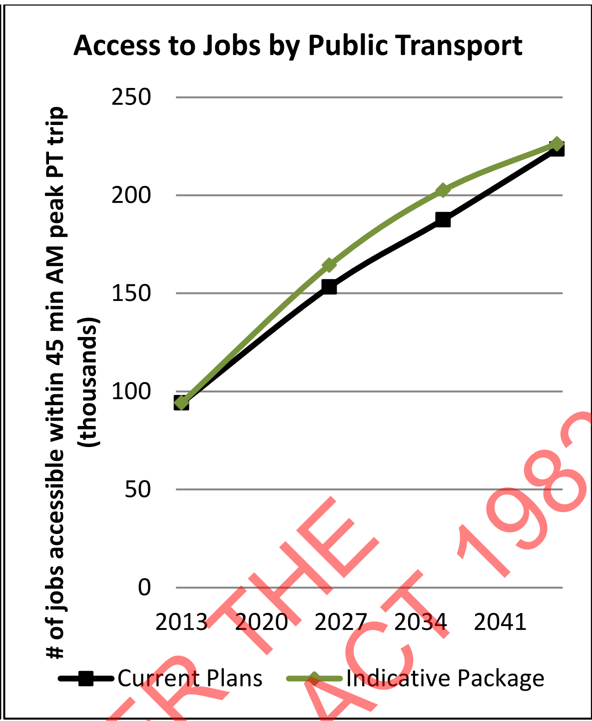
90. The use of a 2013 base year means that the model results need to be treated with some caution. Monitoring shows a significant recent increase in traffic volumes, and a decrease in average peak motorway speeds of 9% between 2013 and 2016. This suggests that the congestion and accessibility results in 2016 will already be significantly worse than indicated in the graphs below.

91. Our analysis shows that implementing this approach will provide better returns than the current plan. The most significant gains are increases to accessibility by car and reductions in peak congestion levels. It is important to emphasise that the 'step-change' in performance against these objectives is largely driven by the introduction of smarter transport pricing, which is assumed to be fully implemented in the second decade[8].

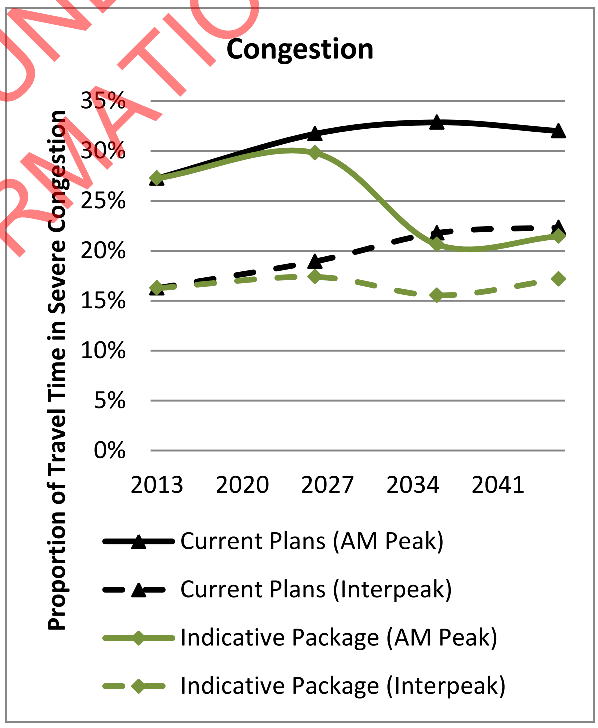
92. **Access to employment**[9]: The average number of jobs accessible within 30 minutes by car in the morning peak increases sharply between 2026 and 2036, reflecting the less congested network as a result of smarter pricing. Public transport accessibility improves under both the current plan and the indicative package, so that the number of jobs accessible within 45 minutes doubles by 2036. This reflects the stronger focus on the strategic public transport network under both the current plan and, more particularly, the indicative package.

[7] For the "current plan", we used the 30-year investment proposals that were developed for the 2015-25 Auckland Regional Land Transport Plan and Long-term Plan. This is referred to as the "Auckland Plan Transport Network", or APTN.
[8] For modelling purposes, we tested prices ranging from 2.25 cents to 30 cents per kilometre, depending on time period, location and road type. We assumed that these charges would replace existing fuel taxes and road user charges for light vehicles (approximately 6 cents per kilometre)
[9] Accessibility is measured as travel time rather than travel costs and therefore for this purpose does not assess the additional financial costs users face from pricing. A 30-minute car trip roughly corresponds to average journey to work time in Auckland. A 45-minute public transport trip includes walk and wait times.

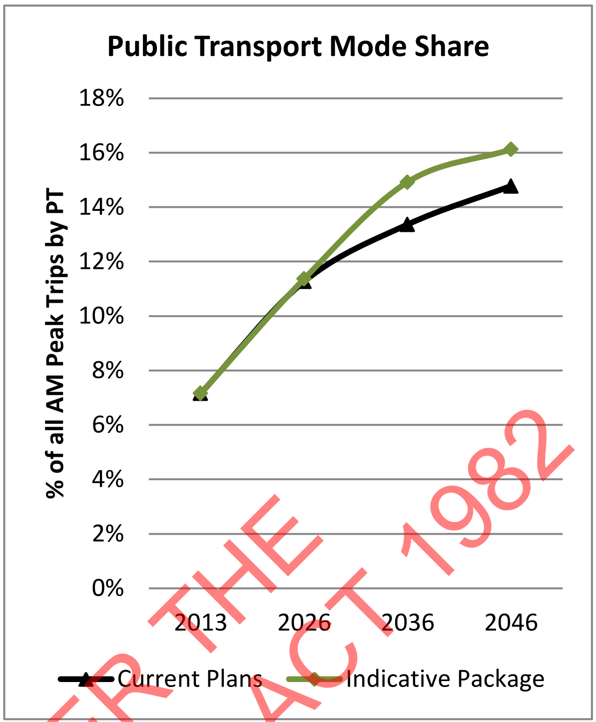




93. **Congestion**: The proportion of travel time spent in severe congestion during the morning peak period is projected to increase from 27% in 2013 under the current plan to 32% by 2026. The indicative package performs slightly better than the current plan over this period (30%), but congestion remains higher than 2013 levels until the introduction of smarter pricing, assumed to be in the second decade. By 2036, the time spent in peak congestion falls to 21%, which is significantly better than 2013. Inter-peak congestion also shows improvement.

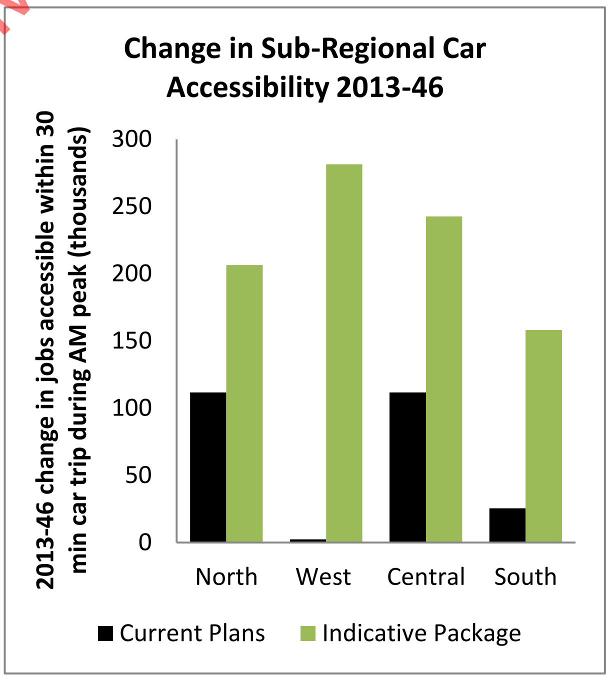


94. **Public transport mode share**: Both the current plan and the indicative package project a strong increase in public transport mode share, from 7% in 2013 to 11% by 2026. This equates to a doubling in annual public transport patronage over that period, to around 146 million by 2026. Further improvements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



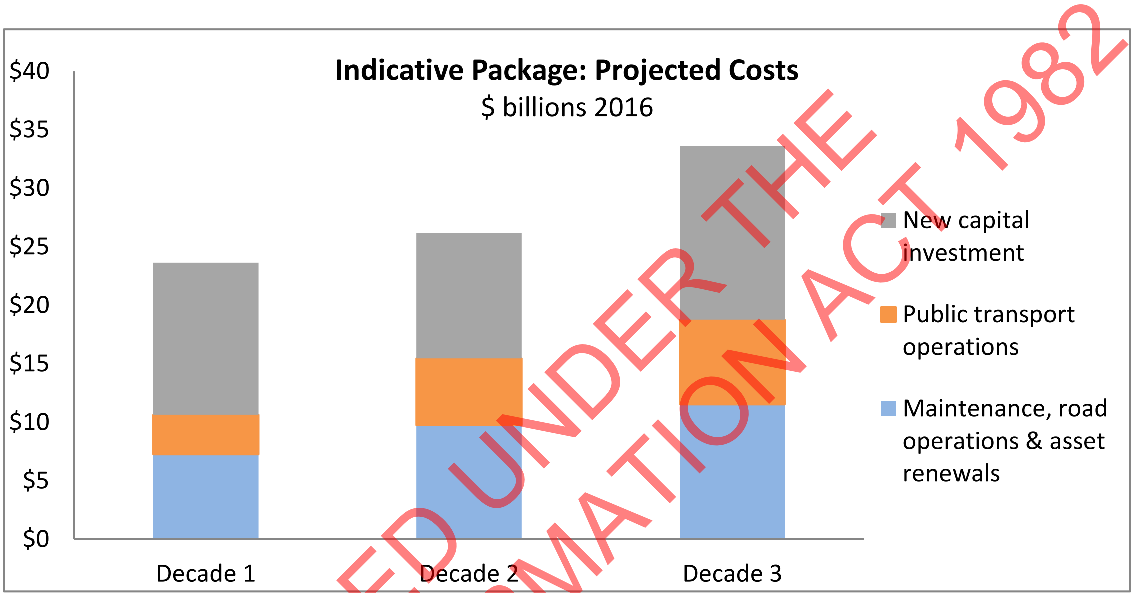
95. The indicative package also addresses some of the key sub-regional challenges facing Auckland, as illustrated in the graph below.

96. Under the current plan, access to employment from west Auckland by a 30-minute car trip is projected to barely change over the next 30 years, despite Auckland's employment growth. However, under the indicative package the west achieves the greatest improvement in employment access, with around 280,000 more jobs being accessible compared to the current plan in 2046. In the south the indicative package provides access to around 130,000 more jobs within a 30-minute peak trip by car than the current plan.



Cost Estimates

97. The estimated expenditure necessary to implement the indicative package in the first decade (2018 to 2028) is $23.6 billion (at 2016 prices). This includes $7.2 billion on maintenance, road operations and asset renewals, $3.4 billion on public transport operations (net of fare revenue), and $13.0 billion on new capital investment. The graph below summarises the cost estimates for these three components of the indicative package over the next three decades. A total of $83.4 billion of investment would be required over the 30-year period, of which $38.6 billion, or 46%, represents new capital expenditure.



98. The cost estimates show significant projected growth in expenditure on maintenance, operations and asset renewals. This reflects:

- the increased demands of a rapidly growing asset base
- a strong increase in projected expenditure on local road renewals in the first decade, targeted at achieving a consistent and appropriate level of service across the network[10]
- increased public transport operating costs as a result of additional services and projected growth in passenger volumes.

99. Given the strategic nature of the project, there has been limited opportunity to fully scrutinise these cost estimates, and they should be therefore treated with some caution. In some cases, there will be opportunities to make savings, but conversely, some investments may cost more than has been estimated here.

[10] Subject to review and agreement on appropriate levels of service and required funding

Value for Money

100. The project's terms of reference require consideration of the costs and benefits of alternative combinations of interventions and whether better returns can be achieved from transport investment than current plans. Value for money is normally assessed through cost benefit analysis, which measures society's willingness to pay for the various benefits that arise from an investment.

101. All transport investments require a rigorous investment process to demonstrate value for money based on robust value for money estimates as part of individual business cases before funding is committed.

102. We used Auckland's existing regional transport models to understand the differences in performance against our key objectives, as reported above. Our analysis has shown that the recommended strategic approach will deliver better region-wide outcomes than current plans. Furthermore, our analysis showed that the indicative package would deliver significantly better results than a higher investment package that did not include smarter pricing. This suggests that the inclusion of smarter pricing is key to achieving value for money.

103. The existing modelling tools have limitations in providing detailed information on all the economic benefits that would be expected from a mix of large and complex interventions, such as those tested the indicative package. For this reason, we have not relied on a package-wide benefit cost assessment based on modelling outputs.

104. Instead, we have focused on ensuring identified 'early priorities' are likely to provide value for money if they are implemented over the next decade. A number of these priorities have existing value for money assessments, which indicate they deliver benefits that exceed their costs.

105. Beyond these early priorities it becomes more challenging to assess value for money, as uncertainties relating to project costs and the impacts of smarter pricing and new technologies become increasingly significant. Our most substantial uncertainty relates to large, longer-term infrastructure investments. The timing and scope of these investments should be monitored over time, particularly with regard to whether they provide value for money as we shift to a greater focus on influencing demand.

106. These caveats emphasise the need to consider the package and the implied funding gap as 'indicative'.

Funding Implications

107. A key task for the project is to provide advice on “the nature, scale and timing of any funding gap for the recommended strategic approach and its alternatives”.

108. Funding for transport in Auckland comes from a variety of sources, most collected by either the Government or Auckland Council. These include fuel-excise duty, road-user charges, motor vehicle licensing, rates, taxpayers, public transport fares, parking charges, development contributions, and tolling. Under current funding policies, different types of projects have different funding sources. These are broadly outlined below:

- State highways are fully funded by the Government through the National Land Transport Fund (NLTF)
- Rail network infrastructure (tracks, signals, electrification etc.) is fully funded by the Government from general taxation (except the City Rail Link, which is subject to separate negotiations)
- Local roads, public transport operations (net of fares) and public transport infrastructure are jointly funded by Auckland Council and the Government, through the NLTF
- Some local roads and public transport infrastructure is solely funded by Auckland Council, either because it is not eligible for NLTF funding (e.g. street cleaning or footpath renewals) or is not prioritised for co-funding from the NLTF.

109. We estimated the amount of funding likely to be available in the first decade (2018-2028) under current funding plans (Auckland Transport’s 2015-25 Regional Land Transport Plan informed by Auckland’s Council’s 2015-25 Long-term Plan and NZTA’s 2015-18 National Land Transport Programme). These plans provided us with a seven-year funding estimate for 2018 to 2025. We extrapolated this out to 2028 to provide an estimate of funding from Auckland Council and the NLTF.

110. The estimate of total funding available also needs to include rail network funding. Our estimate is based on the expectation that the Government will fund half the City Rail Link, and that it will also continue to fund the network infrastructure component of future rail development in Auckland, subject to business cases. The indicative package includes an estimated cost of $470 million for rail network infrastructure in the first decade, which we assume is able to be funded by the Government and is therefore not included in funding gap calculations.

111. Based on these assumptions, we estimate that the total transport funding available to Auckland is likely to be around 19.8 billion in the first decade.

112. The difference between the $23.7 billion estimated cost of the indicative package and the funding available from current plans suggests a first decade funding gap in the order of $4 billion. The actual size of the gap, and the shares that can be attributed to the Council and the NLTF will vary depending on the assumptions made, especially in relation to:

- The total size of the investment programme, including the amount spent on maintenance, operations and asset renewals.
- Whether the share of investment between Auckland Council and the NLTF follows recent trends, or changes over time.

113. Further work will be needed to understand the implications of these different assumptions on the quantum of additional funding that will be needed from the Council and the NLTF, and to determine the options that are available for the Council and the Government to address the funding gap.

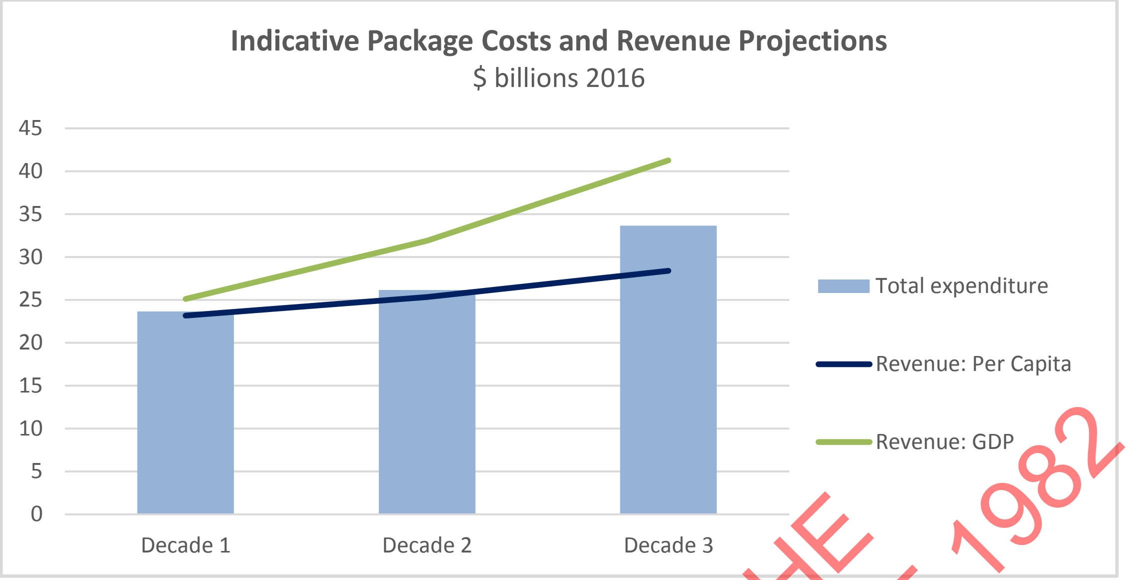
114. We have not calculated a funding gap beyond the first decade, due to greater uncertainty about the timing of longer-term interventions and the lack of any current funding plans to compare the package against. However, we developed two scenarios to understand the potential funding that could be available in the longer term to help understand the potential affordability of the indicative package.

115. Taking 2012-2015 expenditure levels as a baseline, our scenarios were:

a. A "Per Capita" scenario, where future transport expenditure increases in line with Auckland's population (i.e. the amount invested per Aucklander remains the same, but the total continues to increase in line with Auckland's population growth).
b. A "GDP" scenario, where future transport expenditure increases in line with Auckland's economic growth (i.e. transport investment as a proportion of the Auckland region's Gross Domestic Product, or GDP, is maintained over time by increasing investment in line with economic growth)

116. Under the "Per Capita" scenario approximately $75 billion would be available for transport investment over the next 30 years compared with approximately $96 billion under the "GDP" scenario. However, in the first decade the difference between the two scenarios is only approximately $2 billion.

117. The graph below compares total expenditure estimates for the indicative package across the three decades with the revenue available under the per capita and GDP scenarios. In each decade, total expenditure would be higher than the per capita revenue, but less than the share of GDP revenue.


Indicative Package Costs and Revenue Projections
$ billions 2016
45
40
35
30
25
20
15
10
5
0
Decade 1
Decade 2
Decade 3
Total expenditure
Revenue: Per Capita
Revenue: GDP

Implementing the Strategic Approach

118. Putting the strategic approach into practice will require a number of key decisions in the next few months. We recommend that the Government and Auckland Council:

1. ***Adopt the recommended strategic approach, which contains the following key components:***
   a. ***Make better use of existing networks***
   b. ***Target investment to the most significant challenges***
   c. ***Maximise opportunities to influence travel demand***

2. ***Implement the recommended strategic approach by:***
   a. ***Reflecting the strategic approach in statutory documents***
   b. ***Considering options for addressing the funding gap***
   c. ***Laying the groundwork for smarter transport pricing***
   d. ***Ensuring supportive investment processes***
   e. ***Taking steps to maintain ongoing alignment***
   f. ***Completing work on priority actions as soon as possible***

119. Reflecting the strategic approach in statutory strategic documents (the next Government Policy Statement for Land Transport Funding and the forthcoming refresh of the Auckland Plan) will ensure future policy and investment decisions are aligned with this approach, by giving guidance and a common starting point to statutory funding and planning documents (Auckland Transport's Regional Land Transport Plan and Regional Public Transport Plan, NZTA's National Land Transport Programme and Auckland Council's Long-term Plan).

We recommend the Government, Auckland Council, Auckland Transport and the NZ Transport Agency incorporate the strategic approach into their statutory strategic documents

120. Our estimates suggest an indicative funding gap of around $4 billion in the first decade. To implement the strategic approach, this gap needs to be bridged. A number of options are available.

121. Additional funding could be provided, by either increasing funding available for transport from current funding sources or through introducing new funding tools. The merits of these different options need to be jointly considered in a timely manner, so that clarity is provided to the 2018 funding plans.

122. Both the Council and Government will need to consider what this means for their current funding arrangements, and to identify future options for joint consideration.

We recommend the Government and Auckland Council work together to consider options and agree on an approach to address the funding gap by mid-2017, to inform statutory funding documents.

123. Progressively shifting to smarter transport pricing is crucial to achieve a step-change in the performance of Auckland's transport system. We believe that preparatory work on smarter pricing should be progressed with urgency, to develop an ambitious but feasible programme for implementation. The first key step along this pathway is to establish a dedicated smarter pricing project that leads:

- More detailed assessment of the benefits and impacts of smarter pricing, particularly net user effects, equity and any necessary mitigation
- Development of an implementation pathway that includes consideration of national implications, legislative requirements, technology, staging and trials

We recommend the early establishment of a dedicated project to progress smarter transport pricing with a view to implementation within the next 10 years

124. Transport investment processes need to ensure the best performing interventions are prioritised for funding, regardless of type. Funding arrangements would benefit from greater consistency, particularly across the strategic networks. This includes moving to consistent and integrated decision-making for rail.

We recommend investment processes are reviewed to ensure they align with the strategic approach

125. Achieving an aligned strategic approach through this project has demonstrated the value of establishing an agreed set of objectives, measures, problem definitions and assumptions. A continuation of this collaborative approach is recommended as ongoing review will be important as land use and population growth projections are adjusted.

126. The requirement for six-yearly reviews of the Auckland Plan provides a possible opportunity to incorporate a review of the strategic approach. The Government and Auckland Council should further consider how we review the strategic approach over time, including whether statutory changes are required.

We recommend the Government and Auckland Council consider whether statutory changes are required to support ongoing joint strategic transport planning

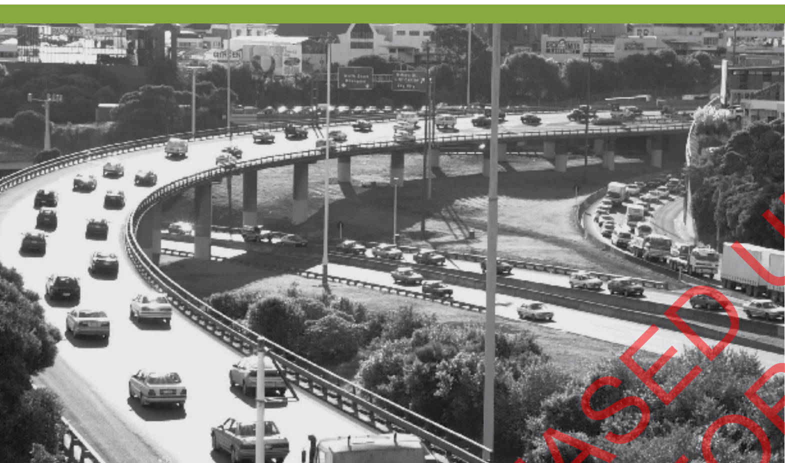
127. We have identified a number of high priority actions that should progress over the next 12 months to support the strategic approach. These are set out in the schedule below.

We recommend that the identified priority actions be completed as soon as possible

Action	Responsibility
• Agree the location of key routes where through-movement should be prioritised, as well as a target for improved productivity on these routes • Complete and implement a framework for managing competing uses on these routes, through traffic management actions and investment priorities	• Auckland Transport and NZTA (with Auckland Council)
• Agree appropriate asset management levels of service, associated funding requirements and provide improved visibility of the trade-offs from different levels of asset management investment	• Auckland Transport and NZTA
• Develop a shared work programme to facilitate the uptake of new transport technologies, including intelligent network management, connected and autonomous vehicles, and shared mobility; with a focus on enabling regulation, supporting infrastructure and trials.	• Ministry of Transport, NZTA and Auckland Transport
• Consider how government transport funding processes should reflect the benefits of enabling growth	• Ministry of Transport and NZTA (with Auckland Council and Auckland Transport)
• Complete business cases for each of the high priority interventions identified in this report, to enable early decisions on funding, timing and route protection to proceed as soon as possible	• Auckland Transport and NZTA

Auckland Transport Alignment Project

Foundation Report





Ministry of Transport
TE MANATŪ WAKA

THE TREASURY

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Auckland Transport

STATE SERVICES COMMISSION
Te Komihana O Ngā Tari Kāwanatanga

NZ TRANSPORT AGENCY
WAKA KOTAHI

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Executive Summary

The challenge in a nutshell

Auckland plays a critical role in New Zealand's current and future prosperity. It is the country's major centre of population and economic activity. Auckland's large and growing labour market provides opportunities to bring together complementary skills, enable specialisation of activities and a sharing of ideas that supports innovation and productivity.

Transport networks play a vital role in successful cities. It enables access to all the opportunities that the city can provide, including connections to overseas markets. Auckland requires a well-functioning transport system to make the most of its opportunities.

The scale and location of the population and employment growth creates a challenging transport future. Medium growth projections will see Auckland's population increase by over 700,000 over the next 30 years (approximately half again from current levels) and the number of jobs increase by over 270,000.

This growth offers a range of opportunities to improve productivity and prosperity. It adds vibrancy and diversity, which makes Auckland a more exciting and attractive place to live and invest. But growth also presents a host of challenges. The travel demands of a growing population places pressure on Auckland's transport networks. This lengthens travel times, increases variability and reduces access.

The challenge for transport is to identify opportunities and proactively respond to the pressures arising from growth, to deliver economic, cultural, environmental and social benefits to Auckland and New Zealand as a whole. However, this outcome cannot be achieved at any cost. Wise investment will be required to maximise the value from every dollar spent.

What is the Auckland Transport Alignment Project?

The Government and Auckland Council recognise the importance of Auckland's economic success to the national economy. As joint transport investors, they have a shared interest to ensure value for money from transport investments. To this end, the Government and Auckland Council have agreed on the need to improve alignment on a long-term strategic approach to transport in Auckland.

The Auckland Transport Alignment Project aims to align the strategic approach by testing whether better returns can be achieved from transport investment. This includes improvements in the areas of access to employment, congestion results, and public transport mode share. There would also need to be improvements to net benefits from any increase in financial costs.

This foundation report is the first of three project deliverables. It includes:

- An overview of the strategic context for the project and the current transport situation in Auckland
- An outline of future trends and agreed assumptions for the project
- The evaluation framework used to test how different options support the project objectives
- An assessment of future transport challenges.

Where are we now?

Auckland's geography presents a number of major transport challenges and opportunities. Infrastructure and demand are focused into a small number of narrow corridors, leading to congested pinch points across the transport network. Auckland's relatively dispersed employment creates challenges for the efficient provision of public transport.

Over the past decade there has been a very significant increase in transport investment by Government and Auckland Council. Large parts of Auckland's motorway network have been expanded or improved and other major projects are nearing completion. Significant investment in public transport has also taken place, including electrification of the rail network supported by a new fleet of electric trains, substantial bus service improvements and the introduction of a single electronic ticketing system across the public transport network.

These investments have yielded positive results. Although Auckland's population has grown by nearly 300,000 since 2003, traffic surveys indicate that overall peak period congestion has not increased over that period, although inter-peak congestion has become a more serious issue. Public transport use has also increased substantially over the past decade, growing from 50 million to over 80 million annual boardings.

On some metrics, such as the level of inter-peak congestion and the use of walking and cycling, Auckland's transport performance compares well against major Australian cities. However, in other areas Auckland lags behind: particularly its travel time reliability, public transport mode share and overall labour pool access.

Recent transport investments have helped to avoid some of the negative transport consequences of Auckland's recent growth. Continuing on this path will not be easy, as many of the most obvious investments in Auckland's transport system are now complete. The next generation of transport investments will be more challenging, as they will need to be integrated with established uses and generally do not have available corridors set aside.

What does the future hold?

This project has a 30-year planning horizon and therefore relies on a number of assumptions about the future. Uncertainty about the assumptions and their impacts increases the further the project looks out.

The scale and location of population and employment growth is a critical factor influencing Auckland's future travel demand. Two key growth trends are at the heart of Auckland's future transport challenges:

1. Population growth is spread throughout Auckland's urban area and extends into major future urban growth areas to the north, northwest and south. Nearly a third of population growth is projected to occur in areas beyond 20km of the city centre.
2. Employment growth is highly concentrated in a few locations, particularly the city centre, the airport and other regional metropolitan centres. Over a third of employment growth is projected to occur within 5km of the city centre. The growth in service sector jobs, which tend to locate in major centres to benefit from agglomeration, is a key factor behind the projected concentration of employment growth.

Auckland's freight task is projected to increase by 78% over the next 30 years, with a significant majority of freight and commercial travel consisting of internal distribution within Auckland. Continued strong growth in travel demand to and from the port and airport will place pressure on Auckland's transport network connecting people and goods to the rest New Zealand and its overseas markets.

Transport and communications technologies are changing quickly. New vehicle technologies, big data applications, ride-sharing and car-sharing technologies have the potential to make far-reaching changes to the way in which we travel. These could have potentially significant impacts on future travel demand, and the safety, efficiency and capacity of our transport networks. However, there is considerable uncertainty attached to the nature and timing of technological developments in the New Zealand context, and the resulting impacts on the Auckland transport system.

A key challenge for the project is to identify strategic approaches that are able to respond to future opportunities, while maintaining the flexibility to adapt to potential changes in demand, technologies and behaviour as they emerge. Future stages of the project will seek to understand future sensitivity to these variables by testing alternative future scenarios. It will also consider how different transport interventions can retain sufficient flexibility to respond to changing circumstances.

Evaluating alternatives and measuring success

The project has arisen from a desire to achieve better returns from transport investment and deliver the best possible value for money, particularly in relation to four key objectives: accessibility to employment and labour, congestion, public transport mode share, and ensuring net benefits to transport users from increased financial costs. An evaluation framework has been developed to test how different intervention packages perform against these objectives.

The table below shows the objectives and measures that will be used to measure success. The measures are supported by a set of key performance indicators. The evaluation framework recognises the project objectives alone will not achieve all outcomes sought from transport investment and therefore also includes measures relating to other important outcomes.

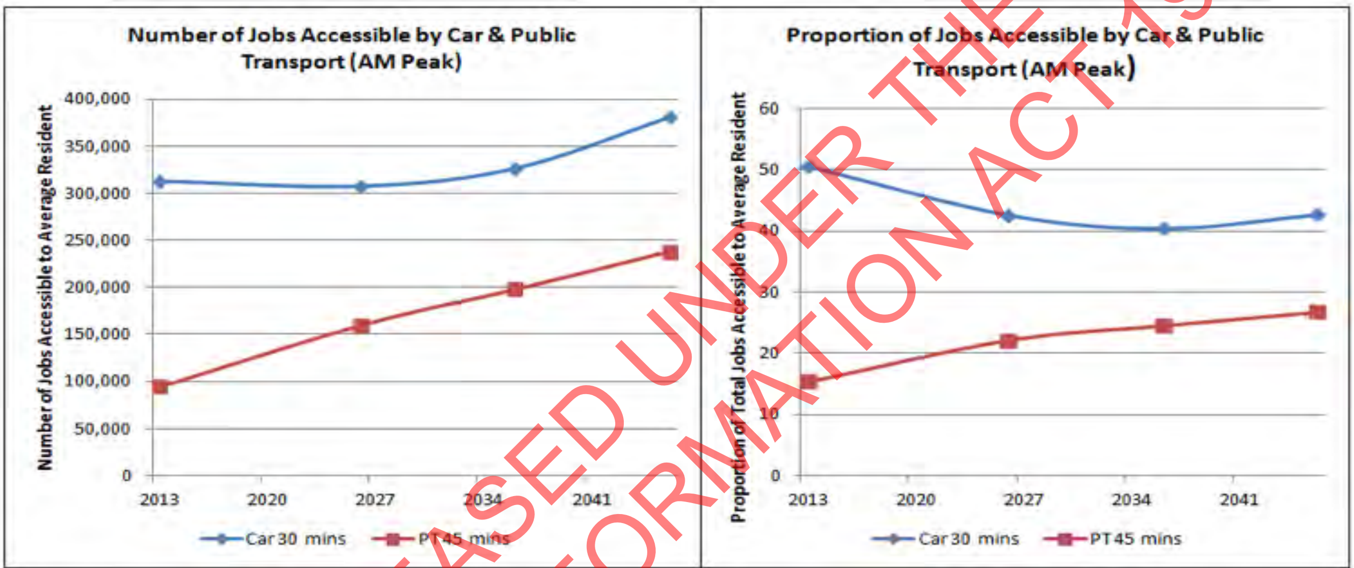
Objectives	Measures
Improve access to employment and labour	• Access to employment and labour within a reasonable travel time
Improve congestion results	• Impact on general traffic congestion • Impact on freight and goods (commercial traffic) congestion • Travel time reliability • Vehicle occupancy
Increase public transport mode share	• Public transport mode share • Public transport mode share where it impacts on congestion
Ensure net user benefits from transport investment	• Net benefits to users from additional transport expenditure
Ensure value for money	• Value for money
Achieve other key outcomes	• Enabling growth • Safety and greenhouse gas emissions • Asset condition • Distribution of costs and benefits by area • Network resilience

Understanding the problem

To gain a better understanding of the problems, an assessment of the future performance of the current 30-year transport plan (the Auckland Plan Transport Network - APTN) was undertaken. The assessment focused on the future performance in 2026, 2036 and 2046 against key project objectives.

Analysis of the APTN against key indicators shows mixed results. There is a projected deterioration in private vehicle accessibility and a related increase in congestion up to 2036. This leads to little overall growth in accessibility by private vehicle until the 2030's. The role of public transport in providing access to employment grows throughout the next 30 years, but with a slower rate of growth beyond the next decade.

These region-wide access trends are shown in the graphs below:



Within Auckland there are important sub-regional differences. Generally, the central (isthmus) area benefits the most while other parts of Auckland experience a much more mixed and patchy transport future. The west and south appear to face the greatest private vehicle access challenges into the future and are also the areas where public transport improvements appear most muted.

With more than a million people projected to be living in the western and southern parts of Auckland by 2046, higher levels of deprivation and a number of key future urban growth areas, the wider impacts of these areas being at least partly excluded from the benefits of Auckland's expanding employment base over the next 30 years are potentially significant.

Congestion is projected to become more widespread and severe over the next 30 years due to increasing travel demand. This is particularly evident on the motorway network and occurs at both weekday peak and inter-peak times. As congestion increases travel time variability is also likely to grow.

An increase in public transport mode share occurs broadly throughout Auckland over the next 30 years, reaching 15% of all peak-time trips by 2046. Improvements are unevenly spread, with a particularly low level of mode share growth occurring in the south. For large parts of the overall transport task, particularly in outer areas of Auckland, public transport's role is not projected to notably increase under the APTN.

Next Steps

The project's next phase will involve testing packages of interventions (including projects, services and policies) to understand how well they contribute to addressing the problems that have been identified. In addition to investments in infrastructure and services that increase system capacity, the project will also assess demand-side interventions that could improve the productivity of the existing transport system.

The analysis to date suggests a need to focus on addressing the following issues:

Access to employment and labour

- an overall decline in access to employment by car between 2013 and 2036, particularly in the west and south
- a low level of improvement in public transport access for people in the south and west, for accessing jobs in the south, and the slowing of public transport access improvements beyond 2026
- the extent to which transport interventions alone can improve access to employment

Congestion

- increased levels of congestion between 2013 and 2036, particularly on the motorway network
- key bottlenecks on the motorways and local road network which impact on overall accessibility and trip reliability

Public transport mode share

- investigation of options to increase public transport mode share, particularly attracting longer trips off the motorway network to reduce congestion
- the low level of public transport mode share growth in South Auckland, particularly in the first decade.

The project's next phases will also look how packages perform against providing value for money, net benefits to users and the other key outcomes identified in the evaluation framework.

Part 1
Introduction

1.1. Auckland's Transport Challenge

New Zealand's cities are homes to most of our population, centres of culture, recreation, social activity and education. They contain our key transport hubs, including those providing access to the rest of the world.

Fundamentally though, cities are centres of economic activity. Their large labour markets bring together complementary skills, enable specialisation of activities and a sharing of ideas that ultimately supports growth and innovation. As a consequence, larger cities with larger labour markets are generally more productive than smaller cities. Broadly speaking, as the effective density of a city doubles, the productivity of its working population increases by 3-8%[1,2].

Transport networks play a key role in cities, enabling access to all the opportunities that a city might provide. Developments in transport networks and technologies have been fundamental in ensuring cities continue to benefit from growth even as their physical size and intensity of demand for travel increases. However, enhancing transport networks and services generally requires significant public investment. Therefore, transport investments, policies and services need to carefully balance supporting a city's wider social, economic and environmental outcomes while delivering value for money.

The Auckland growth opportunity…

Auckland is growing rapidly in New Zealand terms. While population forecasts carry an inherent element of uncertainty, a medium growth rate over the next 30 years would see Auckland's population increase from 1.5 to 2.2 million (approximately 50%). The number of jobs is expected to increase from just under 600,000 to over 850,000 (approximately 40%).

This growth offers the opportunity to capitalise on the benefits of a larger and more diverse labour force, particularly the potential for greater productivity to help maintain and improve the prosperity of New Zealand relative to other major OECD nations. More widely, a growing population will add vibrancy to the city and a greater diversity of social and cultural opportunities, making Auckland a more exciting and attractive place to live.

….and challenges

Realising these benefits from growth is however not assured. Growth presents a host of challenges to a city's infrastructure and the lifestyle of its population. In the transport sector growing demand places pressure on transport networks, reducing performance and creating congestion. Left unchecked or without alternatives for travel, congestion may limit or even reduce the opportunities that a growing city can practically provide to its residents.

The challenge for Auckland's transport system is to at least keep pace with the city's growth, thereby delivering economic, cultural and social benefits to Auckland and New Zealand as a whole. This outcome cannot, however, be achieved at any cost. Wise investment will be required to maximise the value from every dollar spent and avoid simply transforming the costs of growth, such as congestion, directly into a fiscal cost to be borne by ratepayers and taxpayers.

1.2. Background

The Government and Auckland Council both recognise the importance of Auckland's economic success to the national economy. As joint transport investors, they also have a shared interest in ensuring value for money from transport investments. To this end, Government and Auckland Council have agreed on the need to develop an agreed strategic approach that delivers better returns from transport investment than current plans. This challenge has given rise to the Auckland Transport Alignment Project ("the project").

In early 2015 Auckland Council completed consultation on two transport networks: the 'Basic Transport Network' and the 'Auckland Plan Transport Network' as well as options for how the additional expenditure required to deliver the 30-year Auckland Plan Transport Network would be funded. From 2018, Auckland Council estimates that an additional $300 million per year would be required to deliver the Auckland Plan Transport Network.

The Government is committed to ensuring Auckland's transport system is able to meet the city's needs and recognises Auckland will likely need additional investment in transport infrastructure in the coming decades to provide for its significant forecast growth. Before considering additional funding or funding tools, however, the Government wishes to ensure that the future transport programme addresses Auckland's transport challenges and provides value for money.

The purpose of the project, therefore, is to improve alignment between the Council and Government over the way Auckland's transport system should develop.

Project Objectives

The focus of the project is to test whether better returns from transport investment can be achieved in the medium and long-term, particularly in relation to the following objectives:

i. To support economic growth and increased productivity by ensuring **access to employment/ labour improves** relative to current levels as Auckland's population grows

ii. To **improve congestion results**, relative to predicted levels, in particular travel time and reliability, in the peak period and to ensure congestion does not become widespread during working hours

iii. To **improve public transport's mode share**, relative to predicted results, where it will address congestion

iv. To ensure any increases in the financial costs of using the transport system **deliver net benefits to users** of the system

The project involves Auckland Council, Auckland Transport, the Ministry of Transport, the New Zealand Transport Agency, Treasury and the State Services Commission. It has three major deliverables:

First Deliverable

An overview of the context (including the impact of technology), problem definition, desired outcomes and measures

(This document)

→

Second Deliverable

Initial advice reporting on the testing and evaluation of the broad intervention packages, seeking feedback to inform the next deliverable

→

Third Deliverable

A final report detailing the best performing intervention packages, a preferred strategic approach and recommendations including necessary changes to achieve implementation

This foundation report comprises the first deliverable. It includes the following sections:

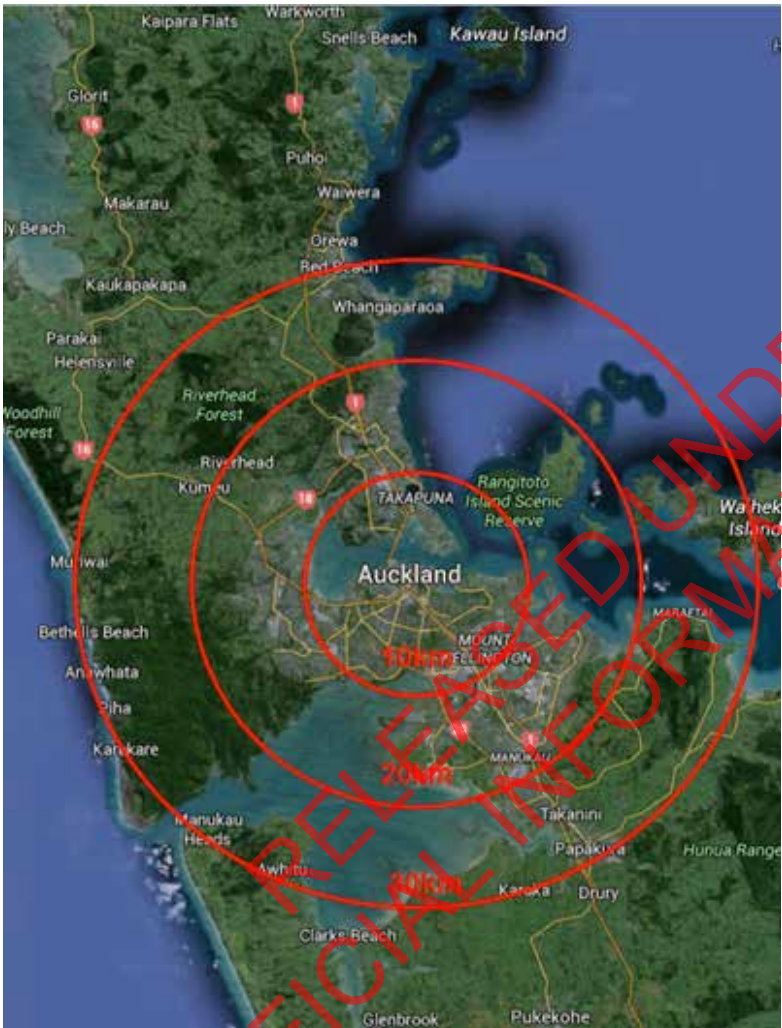
- A summary of Auckland's current transport situation, including recent trends and how Auckland compares with similar cities internationally.
- An outline of future trends that will impact on Auckland's transport system, including growth, changing land-use and travel trends. Uncertainties with future trends are also discussed, including from the impact of changing technology on transport.
- An evaluation framework to test an intervention's (or combination of interventions) contribution to desired outcomes
- A presentation and description of key problems for future stages of the project to focus on, through analysis of forecast results of the Auckland Plan Transport Network.

This report will guide the development and assessment of intervention packages (combinations of transport projects, services and policies) to inform the subsequent project deliverables.

Part 2
Auckland's Current Transport Situation

2.1. The Challenge of Geography

Auckland is a challenging city from a transport and urban growth perspective. Auckland's geography, particularly the location of its harbours, has constrained the city's growth in many directions – limiting opportunities for development in the centre. This has stretched the main urban area to nearly 50 kilometres north-south and over 30 kilometres east-west. A substantial proportion of the area within even 20 kilometres of the city centre is water, as shown below.



Auckland's north-south stretch gives the impression of a sprawling, low density city but this is only partly the case. Geographical constraints have concentrated development, particularly over the past 40 years. In comparing Auckland to Australasian cities, Melbourne has a similar density, with only Sydney being significantly denser than Auckland.[3]

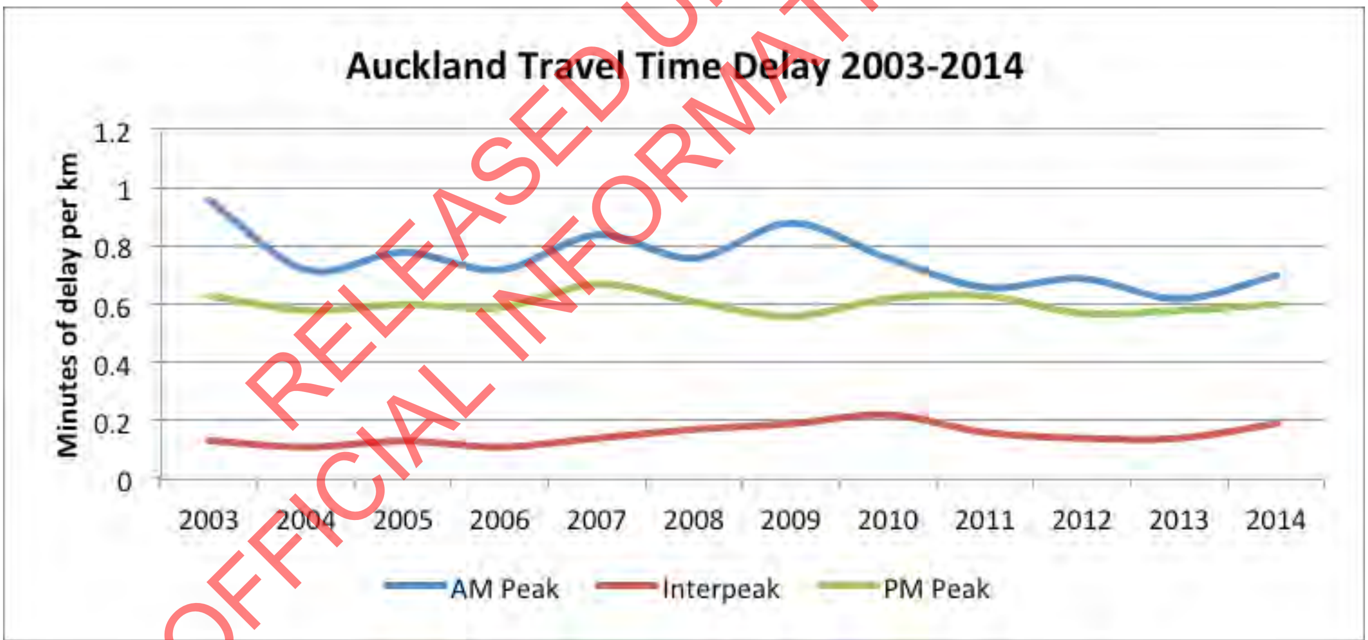
Auckland's geography presents a number of major transport challenges and opportunities. Infrastructure and demand are focused into a small number of narrow corridors, leading to congested pinch points across the transport network. Conversely, this concentration of demand should be well suited to supporting high capacity public transport systems – although Auckland's relatively dispersed employment creates challenges for the efficient provision of public transport.

2.2. Recent Progress

Over the past decade there has been a very significant increase in transport investment by Government and Auckland Council. Large parts of Auckland's motorway network have been expanded or improved and the imminent completion of the Western Ring Route will provide an alternative to State Highway 1 between Albany and Manukau. A number of major local roading improvements have also been progressed, including early stages of the Auckland Manukau Eastern Transport Initiative (AMETI) project, upgrades to many arterial routes and new connections such as Highbrook Drive in East Tamaki.

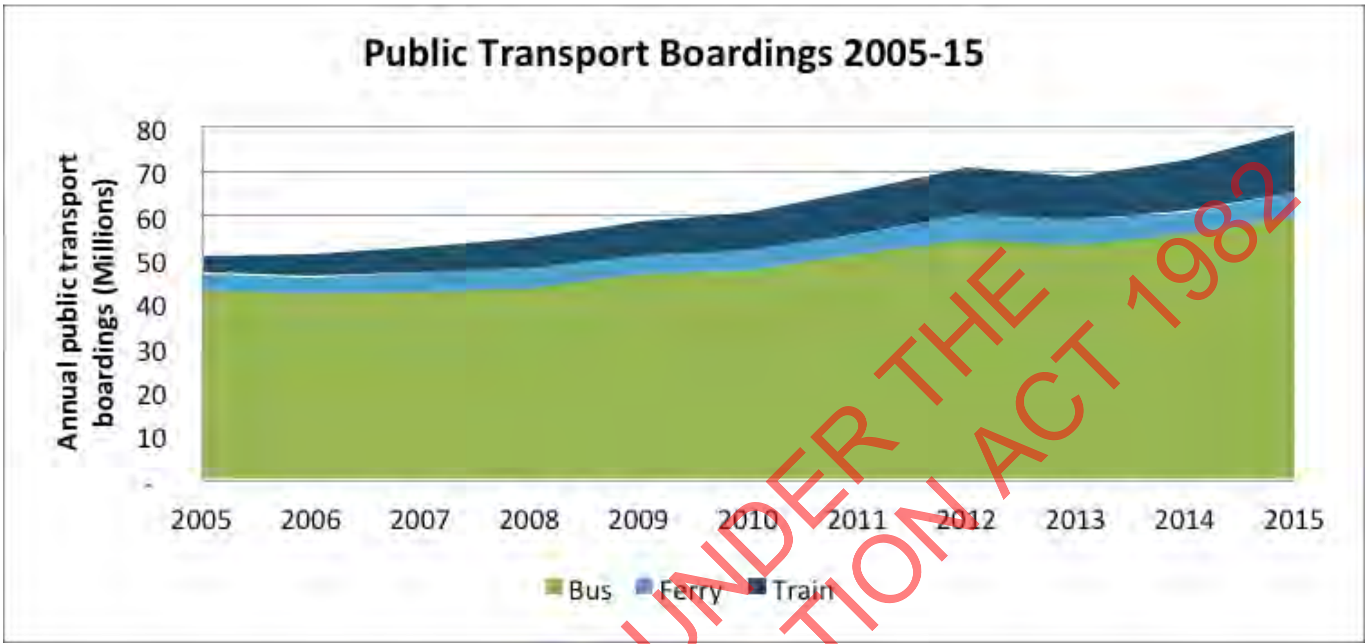
Significant investment in public transport has also taken place. The rail network has been electrified, upgraded and supported by a new fleet of electric trains. The Northern Busway has substantially improved bus operations from the North Shore; there has been expansion of the bus lane network, substantial service improvements and the introduction of a single electronic ticketing system across the public transport network.

These investments have yielded positive results. Although Auckland's population has grown by nearly 300,000 since 2003, traffic surveys have shown a general reduction in congestion during the morning peak and no increase in the evening peak[4]. However, Auckland-wide average measures such as these need to be treated with caution, as they can mask some significant variations between different locations and at different times. There is evidence that travel time variability has increased, especially during the evening peak; and inter-peak congestion has continued to increase over the past decade.



Source: NZTA/Beca Travel Time Surveys

Public transport use has also increased substantially over the past decade, growing from 50 million to over 80 million annual boardings. There has been an increase in public transport mode share for journeys to work (although the proportion of drivers has remained unchanged) and more people at peak times now enter the Auckland city centre by public transport than private vehicle.



Source: Auckland Transport monthly data

Growth in vehicular travel has slowed over the past 10 years, compared to decades of previous growth in both total and per capita travel. Since 2006 per capita annual travel has slightly declined. However, this decline in per capita travel has been outweighed by population growth and total annual travel has increased by approximately 980 million kilometres (8.4%) between 2006 and 2013, as shown below[5]:

Source: Ministry of Transport and NZTA travel demand data

Key Recent Progress Findings:

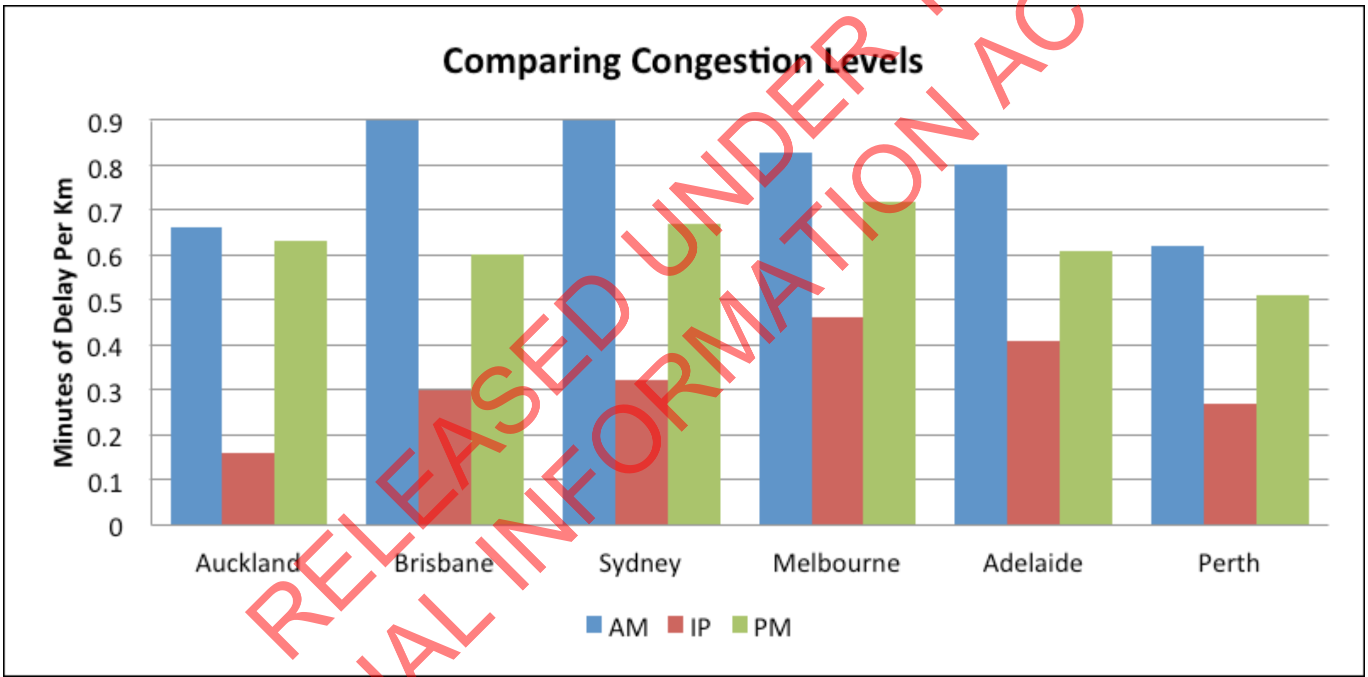
Despite strong population growth, transport investments over the past decade have generally yielded positive results, with improvements in overall peak period congestion results and increased public transport patronage. Continuing on this path will not be easy, however, as many of the most obvious investments in Auckland's transport system are now complete. Most transport corridors set aside in the past have been used and many long planned transport improvements, such as the Western Ring Route, are nearing completion. The next generation of transport investments will be more challenging as they will need to be integrated with established uses and generally do not have available corridors set aside for them.

2.3. International Comparisons

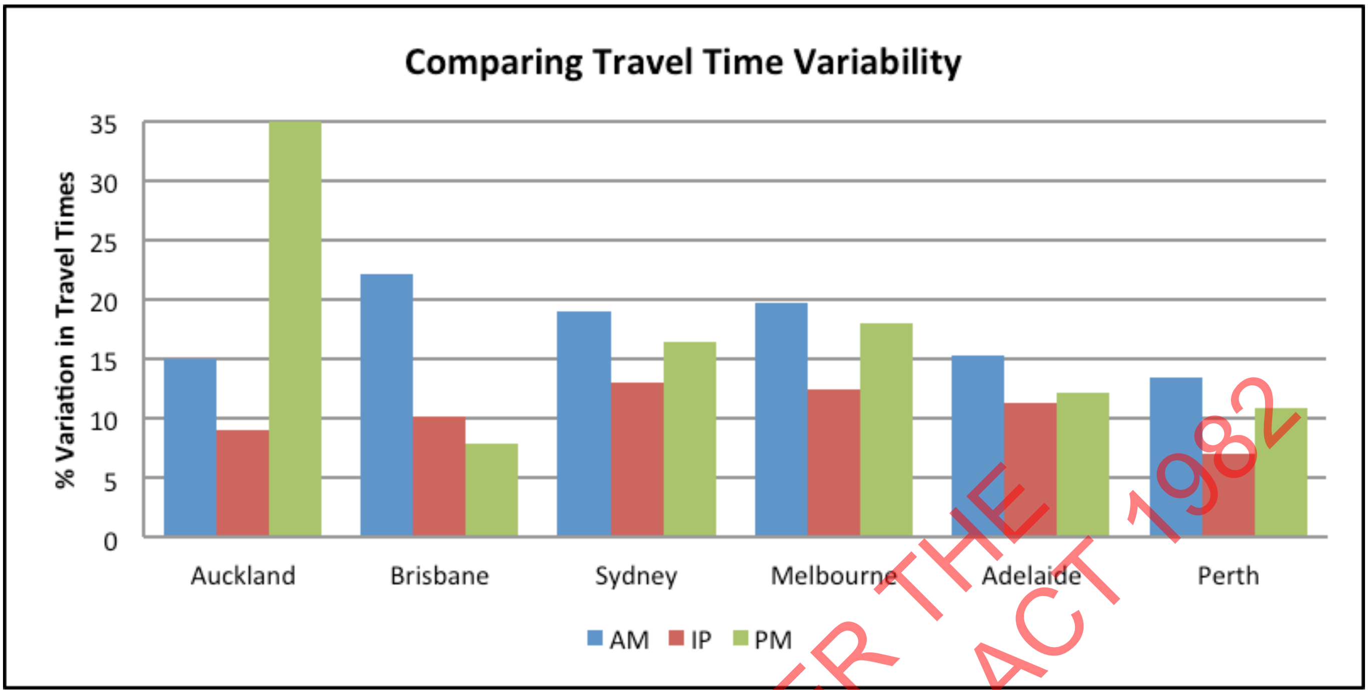
Studies have been undertaken to compare Auckland's transport performance with that of similar cities in Australia and also with Vancouver. Auckland's population is less than Perth, Brisbane, Sydney, Melbourne or Vancouver. On the other hand, it arguably has a more difficult geography, with the urban area less able to spread out evenly in all directions. All these factors impact on travel perceptions and performance.

Comparisons between cities are challenging because of the variety of geographical and social factors that impact on travel experience, as well as the difficulties of measuring performance in a consistent manner. The available analyses must therefore be interpreted with caution.

The charts below suggest that Auckland's transport network is, on average, less congested than in Brisbane, Sydney, Melbourne and Adelaide, but more congested than in Perth[6]. Travel surveys also indicate travel time variability is comparable to that of the Australian cities, except in the evening peak, when Auckland's performance is relatively poor.



Source: NZTA/Beca Travel Time Surveys & Austroads



Source: NZTA/Beca Travel Time Surveys & Austroads

Auckland has significantly lower public transport mode share than major Australian cities, the impact of which is partially mitigated by generally higher rates of working at home, walking and cycling. As a result, Auckland's share of private vehicle commuting is similar to that of Melbourne and Brisbane, lower than Perth's but higher than in Sydney[7].

Access to employment is a critical task for a large city's transport system and on average Auckland compares reasonably well to Sydney and Brisbane, but is behind Perth and Vancouver in terms of the share of total jobs available within a reasonable travel time[8]. Auckland's smaller population, combined with its access challenges, results in a significantly smaller accessible labour pool than all other cities analysed.

Furthermore, access to employment in Auckland varies significantly by location and declines comparatively rapidly beyond the central area. For example, the proportion of Aucklanders who can access more than 20% of the city's jobs within a 45-minute public transport commute is lower than any of the other cities analysed.

Key International Comparison Findings:

Available evidence suggests that while Auckland compares well in some areas with other cities analysed (e.g. congestion, use of active transport modes), it lags behind in other areas such as travel time reliability, public transport mode share and the overall size of its accessible labour pool. Auckland faces challenges to improve performance in these areas in the face of significant growth over the next 30 years

Part 3

Future Trends

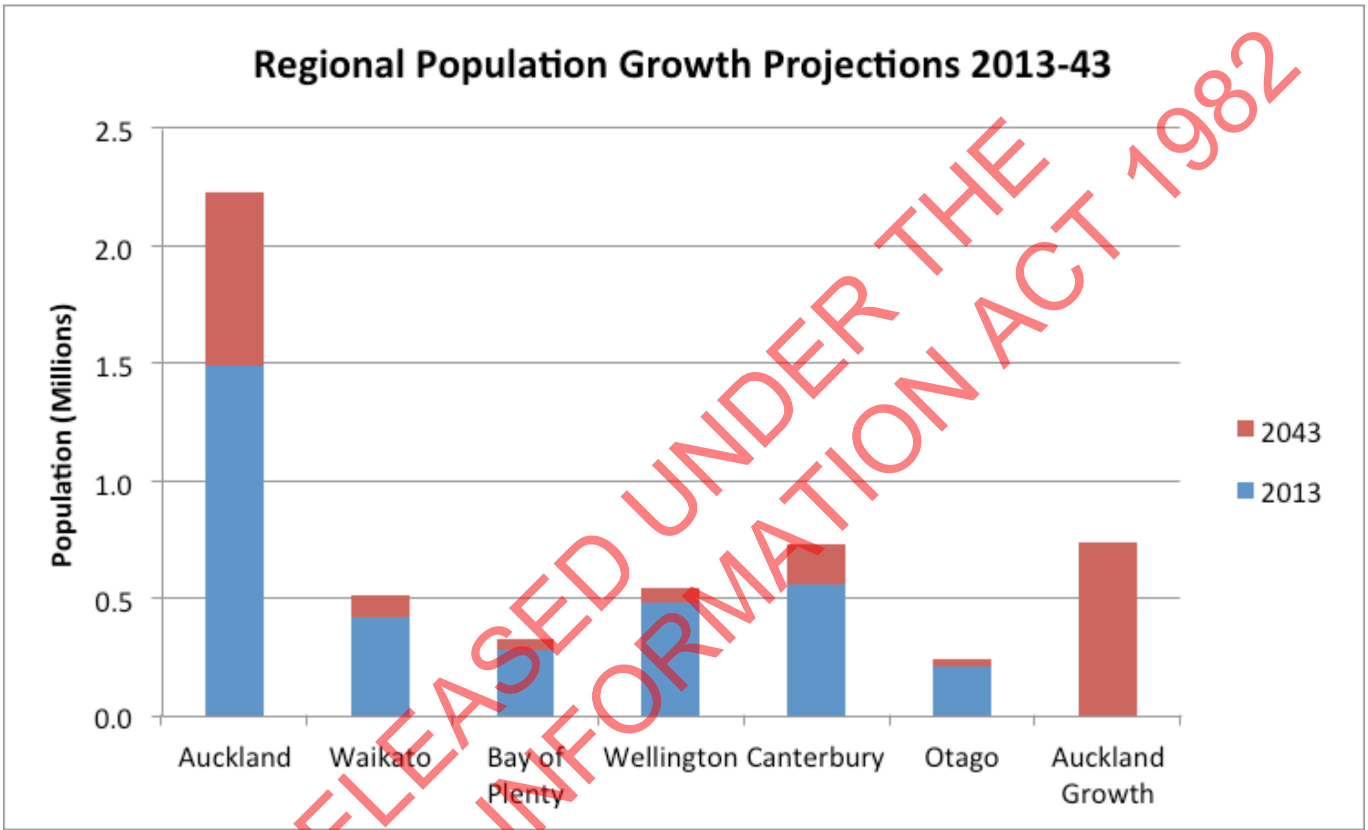
3.1. Introduction

Undertaking long-term strategic transport planning relies upon making a large number of assumptions about the future. Uncertainty about these assumptions and their impact on future transport trends increases as future time horizons for the analysis extend. This section outlines a number of the assumptions, including uncertainties, and their resulting trends that form the baseline for the problem definition in section 5 of this report.

A number of these assumptions may be tested in later stages of the project to develop a better understanding of how different packages of interventions would perform in a range of future scenarios.

3.2. Population and Employment Growth

The key factor increasing travel demand in Auckland over the next 30 years will be population growth. Over the last 30 years, the combination of natural growth and net immigration has increased Auckland's resident population by almost 700,000, and a similar level of growth is projected over the next three decades under a medium population growth scenario. The addition of 700,000 people will take Auckland's population to 2.2 million by 2043.

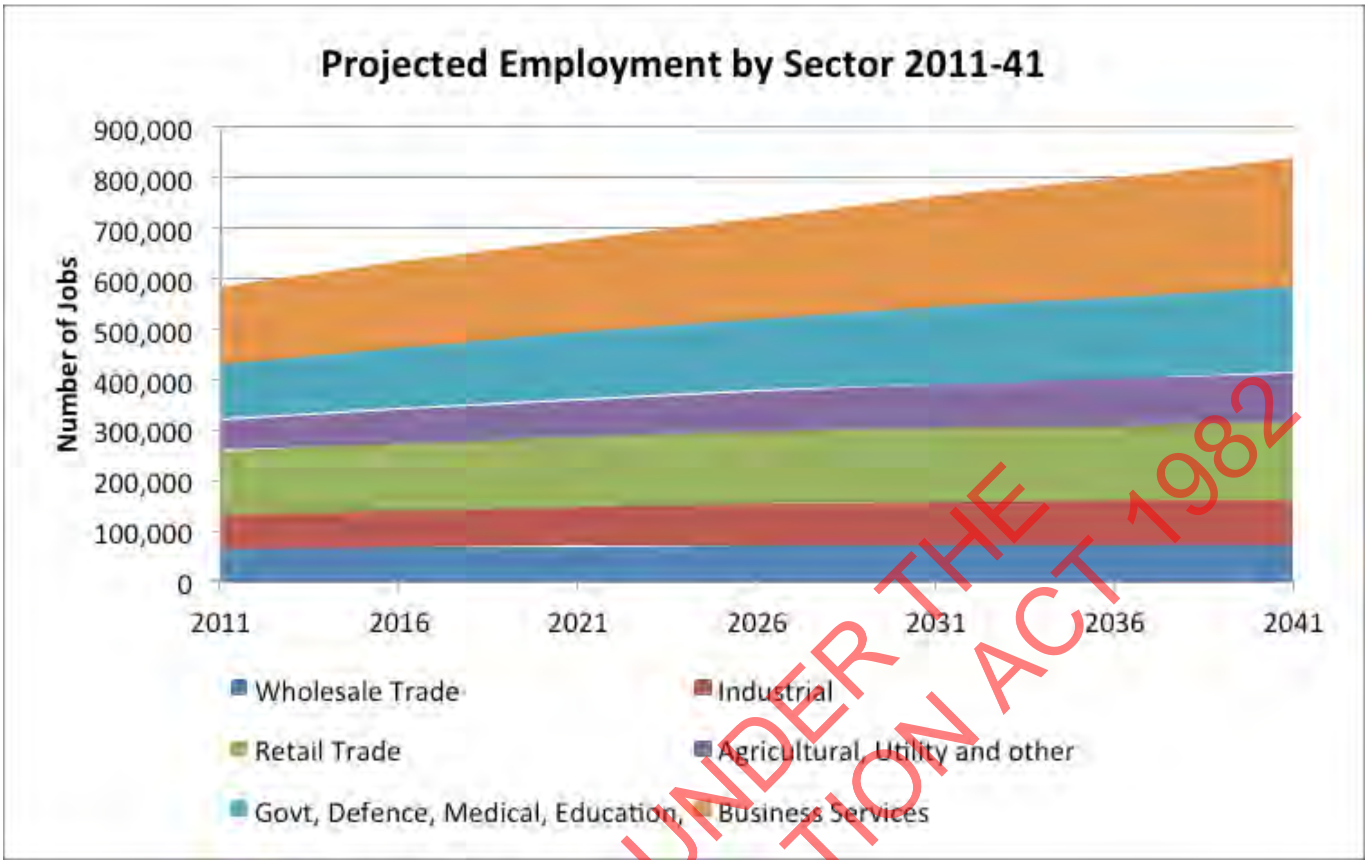


Source: Statistics New Zealand medium population growth projections

Auckland's growth and economic success will be increasingly important to New Zealand's overall economy. Over the next 30 years 60% of New Zealand's population growth is expected to occur in Auckland[9]. However, a lower average age means that the vast majority (over 80%) of the growth in New Zealand's working age population is projected to occur in Auckland.

The number of jobs in Auckland is projected to increase from just under 600,000 to more than 850,000 over the next 30 years. Changes to the structure of Auckland's economy in the future also drive changing transport demands. Auckland is New Zealand's dominant commercial centre, leading the finance, insurance, transport and logistics, and business services industries. The productivity of high skilled service sector jobs that cluster in Auckland is highly dependent upon agglomeration (the clustering of economic activity) and large labour markets.

The pattern of economic growth in Auckland is continuing to compound its structural differences with the rest of the New Zealand economy. The service sector has dominated the city's employment growth over the past decade[10] and this trend is projected to continue, with business services being the largest driver of employment growth, as shown below.[11]



Source: Auckland Council land-use projections

These projections assume that population and employment growth occurs at a reasonably steady rate. In practice, short term population growth can fluctuate significantly based on trends in net-migration. For example, Auckland's population growth rate between 2006 and 2013 was lower than between previous censuses while over the past two years a significant increase in net migration has boosted population growth to near-record levels, with Auckland's population increasing by over 75,000 since 2013.[12,13]

Longer-term population growth could occur at a lower or higher rate than projected by Statistics New Zealand. Past population projections for Auckland have tended to under-estimate the rate of growth; for example, projections in 1996 expected Auckland's population to reach two million around 2060 whereas most recent projections expect that to occur 30 years earlier.

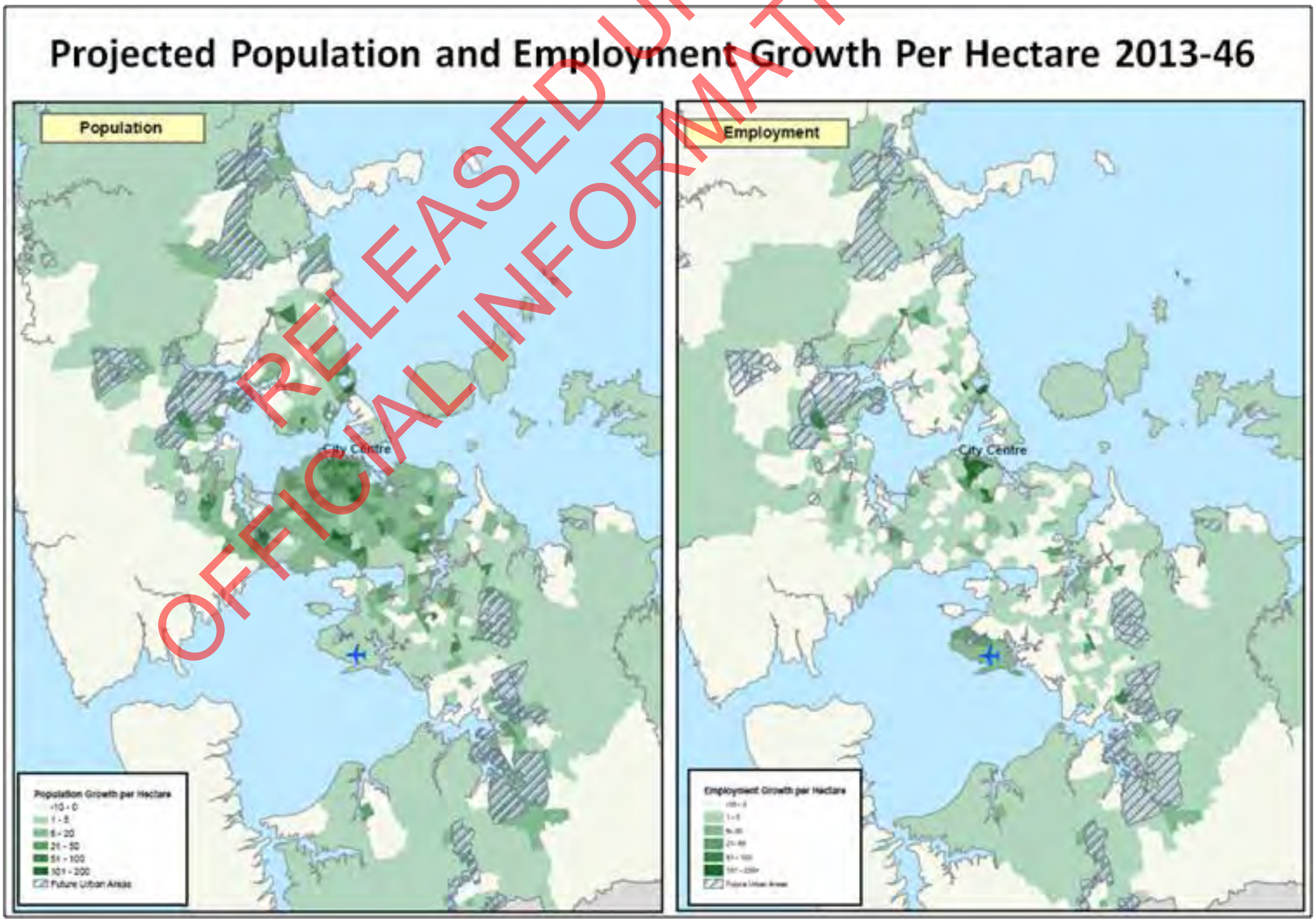
3.3. Location of Population and Employment Growth

The location of population and employment growth across Auckland over the next 30 years will have a significant impact on the transport network's future requirements and performance. The location and timing of growth will be driven by a number of factors including:

- The level of development provided for by statutory land-use planning documents (e.g. the Proposed Auckland Unitary Plan)
- The market attractiveness of development
- The provision of infrastructure and services to support and enable growth (e.g. water and transport infrastructure, schools etc.)
- The locational demands of businesses and how these may change over time

Auckland Council undertakes research and modelling to enable an understanding of where and when future growth is expected to occur. The scenario being used by the project is based off a medium population growth rate and reflects the direction of the Auckland Plan by projecting an approximate split of future household growth of 60% inside the current urban area and 40% through urban expansion[14].

The location of projected household and employment growth in Auckland over the next 30 years is shown in the maps below, as well as the location of future urban growth areas (shaded).

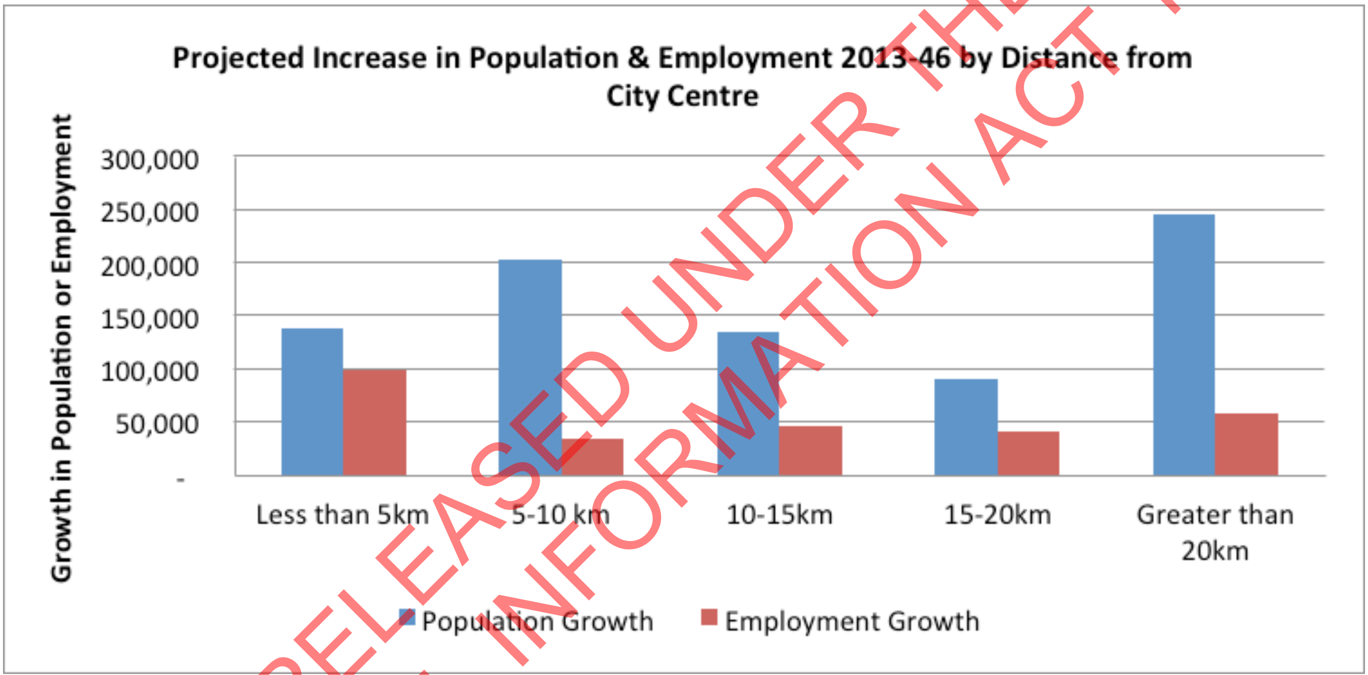


Source: Auckland Council land-use projections

Two key growth distribution trends are highlighted in the maps above.

- Population growth is spread throughout the Auckland urban area and extends into major future urban growth areas to the north, northwest and south of the existing city. Nearly a third of population growth is projected to occur in areas beyond 20 km of the city centre.
- Employment growth is highly concentrated in a few locations, particularly the city centre, the Airport and other major metropolitan centres. Over a third of employment growth is projected to occur within 5km of the city centre. The growth in service sector jobs, which often prefer to locate in major centres to benefit from agglomeration, is a key force behind the projected concentration of employment growth.

The trends are further illustrated in the graph below by comparing the level of population and employment growth over the next 30 years occurring in 5 km bands from the city centre.



Source: Auckland Council land-use projections

These projected household and employment growth trends will place significant pressure on the transport network through longer trip lengths, especially to major centres. The low level of growth in local employment is also likely to make improvements in employment access by car more challenging, as trips lengthen and become relatively more focused towards major centres with constrained access. Furthermore, the high value of land in major centres presents a key challenge of providing significant people-moving capacity without using extensive amounts of space.

There are a number of uncertainties about the rate and location of household and employment growth in the future, particularly because the Auckland Unitary Plan, which has a significant impact on the amount of development possible within an area, is still under development. Furthermore, the projected location of employment growth represents a significant centralisation of employment, largely based on assumptions about the extent of growth expected in business services jobs in the future.

3.4. Freight Demand

As New Zealand's largest city Auckland has nationally significant freight logistics function in the production and distribution of freight to the rest of New Zealand. Around 22 million tonnes of New Zealand's freight task moves to and from Auckland each year[15]. Recent analysis projects a 78% increase in the size of the future freight task for Auckland over the next 30 years with a significant majority of freight travel being internal distribution within Auckland[16].

Source: Ministry of Transport freight demand study

International/inter-regional freight is likely to be larger scale (i.e. containers) and can be carried by road, rail and coastal shipping. Any consolidation of movements on and off rail and coastal shipping will also require road freight movements within Auckland. Northland, Auckland, Waikato and the Bay of Plenty together produce more than 50% of New Zealand's gross domestic product (GDP). Increased economic interaction between these regions through the establishment and strengthening of supply chains will drive economic growth in the Upper North Island and across the country.

Internal distribution and service trips make up the vast majority of commercial travel within Auckland, with 80% of the freight originating in Auckland being distributed within the region. Some of this internal demand is driven by international and inter-regional movements, with freight being moved initially within Auckland before it is sent on to its final destination. Furthermore, while less visible than heavy commercial vehicles, over 70% of freight kilometres travelled within Auckland are by light commercial vehicles such as couriers and local deliveries[17].

Auckland is New Zealand's main "gateway" to international trade and commerce, including tourism. Auckland International Airport has the highest number of passengers per year in New Zealand, with 14 million passenger movements in 2013, projected to rise to 40 million by 2044[18]. Auckland Airport also handles about 15 per cent of foreign trade by value and on this basis is New Zealand's third largest port behind Auckland seaport and Port of Tauranga[19]. Growth in passenger numbers and freight from the Airport will increase the demands on Auckland's transport network connecting people and goods to the rest of Auckland and New Zealand.

The Ports of Auckland is the country's largest import container port by volume and value. Approximately $26.4 billion of trade passes through Ports of Auckland each year, roughly 31% of New Zealand's total trade[20]. Around 800,000 containers are moved to and from the port every year, along with bulk imports and exports[21]. MetroPort, operated by the Port of Tauranga, is also an important international gateway for exports and imports. Around 170,000 containers move to and from the terminal by road within Auckland, with rail moving the freight to and from the Port of Tauranga. Currently trains carrying up to 104 containers run five to six times a day to and from this part of Auckland[22].

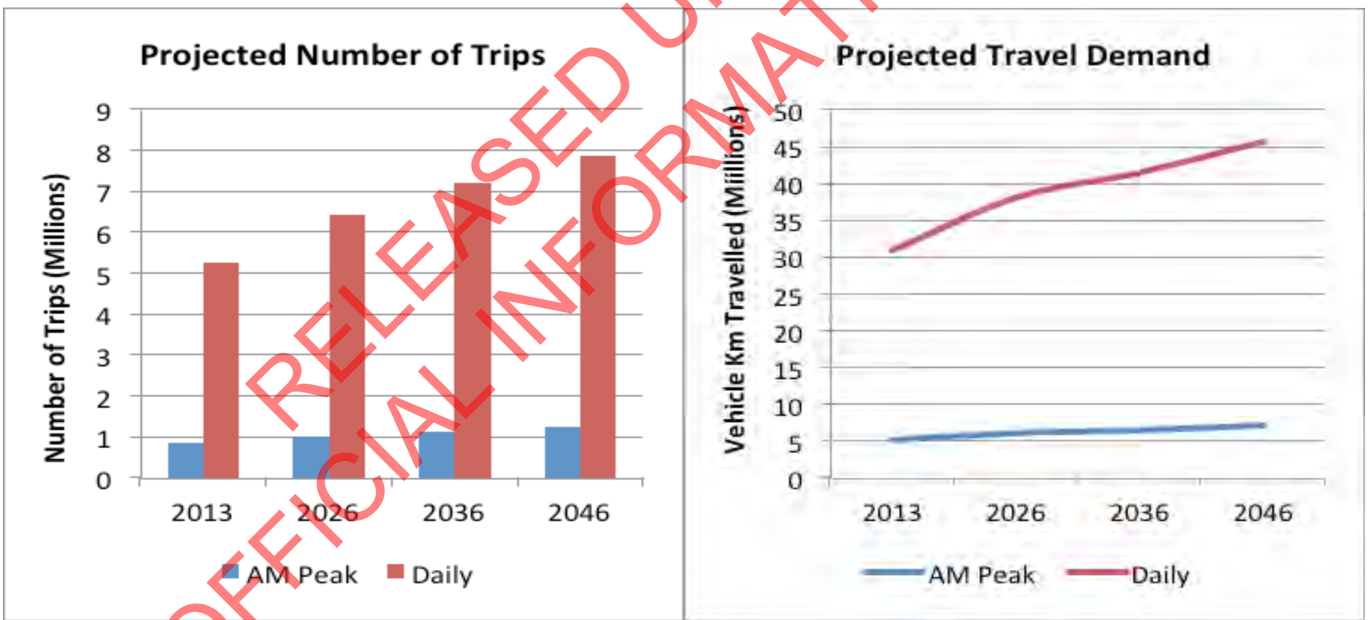
International trends towards bigger ships may result in more concentrated and consolidated import activity in Auckland and/or surrounding ports. The "Port Future Study" is taking place in parallel with the project, and will analyse the future of the Ports of Auckland. The findings of that study will feed into this project as required.

3.5. Projected Travel Demand

As discussed in section 2.2, a decline in per capita travel over the past decade in Auckland has been outweighed by population growth, leading to an overall increase in travel, albeit at slower rates than in earlier decades. This slowing of travel growth is likely to have been caused by a combination of economic variables and cultural and social factors that may be inducing structural change in driving habits and distance travelled. For example, studies both in New Zealand and internationally have highlighted changing travel requirements for 'Millennials' and an increasing age of driver's licence acquisition[23]. The observed plateauing of travel was not anticipated by past travel projections, which often over-estimated nationwide travel demand during the past decade.

Future travel demand projections made by the Auckland strategic transport model are based on a range of input assumptions such as the location and distribution of population and employment growth, the future price of fuel and assumed inter-regional trip growth rates. Many of these assumptions have been updated as part of this project to test their robustness and consistency.

These projections anticipate an increase in travel over the next 30 years, tracking close to population growth meaning per capita travel is projected to stay fairly constant over time. This rate of future growth is higher than what has occurred in recent years, when per capita travel in Auckland has marginally declined. Due to significant projected population growth, it would take a very substantial decline in per capita travel for the overall quantum of travel in Auckland to not continue to grow over the next 30 years.



Source: Auckland strategic transport model outputs (Scenario I9)

However, even small changes in per capita travel demand can result in much higher or lower future demand levels. Furthermore, when combined with the uncertain but potentially significant impacts of changing technologies and the rate of population growth, uncertainty around future travel behaviour and demand levels highlights the importance of Auckland's future transport investments being robust and flexible to changing future circumstances.

3.6. Impacts of Technology

Transport technology is changing quickly. Intelligent Transport Systems (ITS) as well as emerging vehicle and communication technologies have the potential to radically alter the way that transport is delivered in future, with significant impacts on demand and supply. Such changes have the potential to improve network productivity, as well as deliver significant improvements in congestion, safety and environmental outcomes.

Some transport technology developments, such as the uptake of electric vehicles, will impact significantly on some of the broader outcomes sought from transport (such as reducing greenhouse gas emissions) but are considered unlikely to have major effects on the core project objectives, travel demands or network capacity.

In other areas, however, developing transport and communications technologies have the ability to significantly change the nature of travel demand. This raises a number of important questions which will need to be addressed as part of the project, including:

- To what extent will emerging ride-sharing and car-sharing technologies replace individual vehicle ownership with a "mobility as a service" approach to transport; and what impacts is this likely to have on travel demand and the cost of transport?
- How will big data applications be used to help road users make better trip planning decisions, aided by dynamic management of the network?
- What impacts will the development of autonomous and communicating vehicles have on travel demand? Will they encourage new vehicle trips by increasing accessibility, particularly for the disabled and elderly which may be particularly important with an aging population? Will they increase overall travel through 're-positioning trips' or will their improved efficiencies reduce overall vehicle travel?
- How will autonomous vehicles and increased ride-sharing and car-sharing change the way public transport is provided in future, and how will this impact upon its cost-effectiveness and operating costs, and blur the distinction between public and private transportation?
- To what extent will technological change help to improve the performance of the transport network? For example, autonomous and communicating vehicles may increase the capacity or efficiency of Auckland's transport system by enabling vehicles to safely travel closer together, therefore reducing congestion and enabling far more efficient use of existing infrastructure and land by reducing the need for parking.
- When will new technologies become available, and to what extent will they be embraced by New Zealanders?

New technologies present an exciting range of opportunities for the transport sector, with the potential to fundamentally change the nature of transport demand and public sector interventions. However, there is considerable uncertainty attached to the nature and timing of technological developments in the New Zealand context, and the impacts of that they may have on the Auckland transport system. For example, increased travel demand and the financial, regulatory and on-road implications of transitioning to new technology could reduce or even offset any efficiency savings. The timing for uptake of new technologies to reach a point where it significantly improves network efficiency also remains unclear. Investment in transport infrastructure and services will be influenced by the direction of change brought about by technology trends.

The next stage of the project will include a more detailed assessment of the opportunities and uncertainties that technology change presents. This will include the identification of future scenarios which will allow the impacts of different technology futures to be sensitivity tested. A similar approach will be taken to address other key assumptions, such as future population growth and land use projections.

A key challenge for the project will be to identify strategic approaches that are able to respond to future opportunities, while maintaining the flexibility to adapt to potential changes in demand, technologies and behaviour as they emerge.


TOP TRANZ
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Part 4
Objectives and Evaluation Framework

4.1. Objectives for Auckland

Government and Auckland Council's broad objectives for transport nationally and in Auckland are set out in the Government Policy Statement and the Auckland Plan. The Government Policy Statement highlights key focus areas of supporting economic growth and productivity, improved transport safety and ensuring value for money from investment. The Auckland Plan describes the key role of the transport system in improving liveability and prosperity through creating better connections and accessibility within Auckland, across New Zealand and to the world.

Although there are differences in emphasis, both parties have a shared intention for transport investment to support and enable:

- Planned growth through delivering better access for people and goods to places of employment and businesses
- Improved living standards for people through enabling better connections and accessibility to participate in work and society
- Improved access to domestic and international markets
- Minimising harm (e.g. safety and environmental) from transport

The project's Terms of Reference articulate a desire to achieve better returns from transport investment and deliver the best possible value for money, particularly in relation to:

- Improving accessibility to employment and labour
- Improving congestion results
- Improving public transport mode share
- Ensuring net benefits to transport users from increased financial costs

The project objectives alone will not achieve all the broad outcomes sought from transport investment. A number of other key transport outcomes and demand on transport expenditure, such as maintaining existing assets and providing a basic level of infrastructure to enable growth, will require significant investment over the next 30 years and also need to be taken into account in the evaluation process.

The relationship of the project objectives to both interventions and the broad outcomes sought by Government and Auckland Council is shown in the diagram below.

Interventions:

- Infrastructure investments
- Service provision
- Policies

Project Objectives:

- Achieve better returns from investment & value for money
- Improve accessibilty
- Improve congestion results
- Improve public transport mode share
- Ensure net benefits to transport users

Other Key Outcomes

Broad Outcomes:

- Economic growth & productivity
- Improved quality of life & living standards
- Supporting growth
- Minimising harm

4.2. Evaluation Framework

An evaluation framework has been developed to test how the current 30-year transport plan and different packages perform against the objectives set out in the terms of reference, a broad overall requirement to achieve value for money and other key outcomes. The intention of the evaluation framework is to also reveal the impacts of choices between different packages.

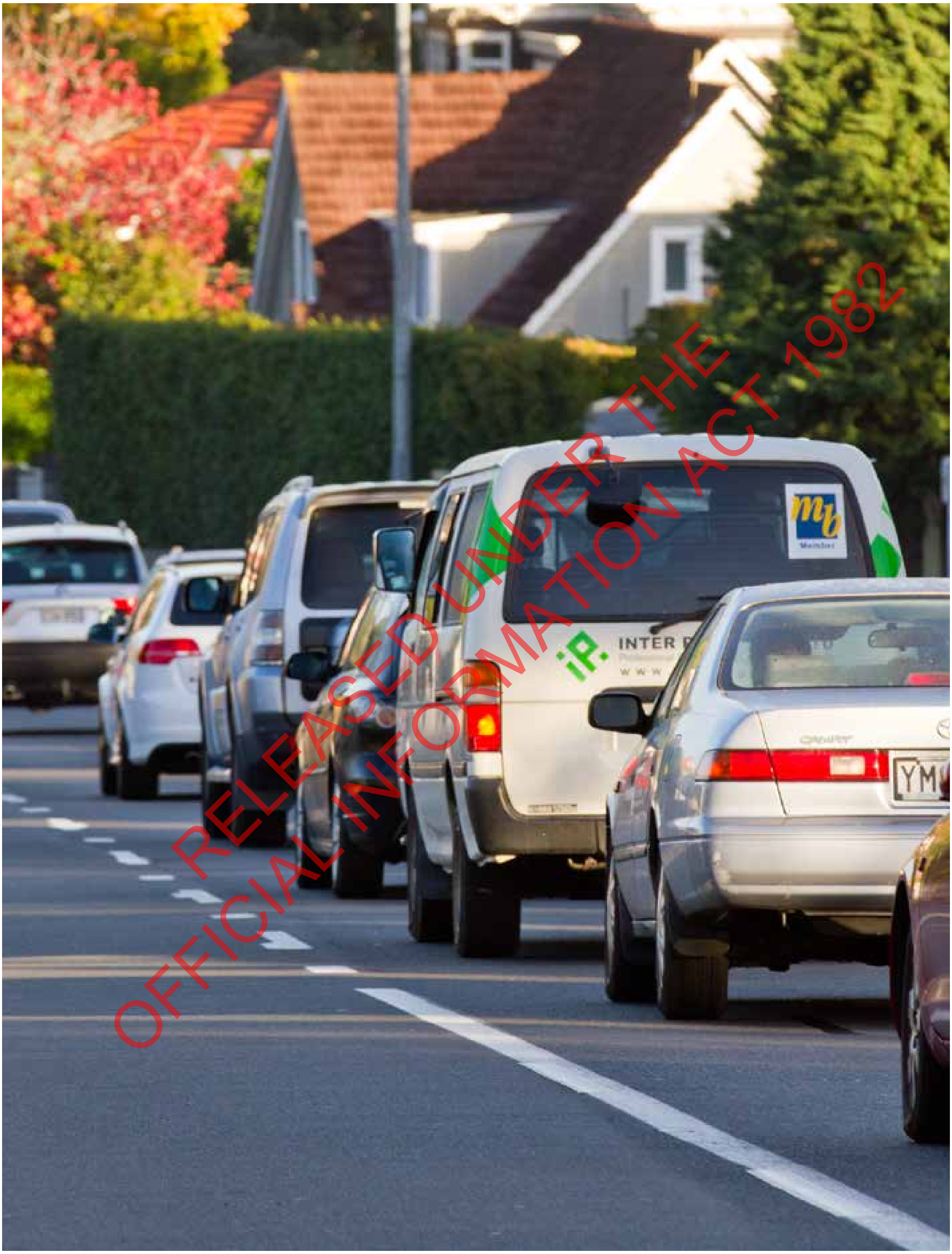
For each objective, measures and key performance indicators (KPIs) have been developed to enable evaluation. For each measure there are headline KPIs that will be reported on and secondary KPIs that will primarily be used for analysis but may be reported on where they significantly add value to informing key decisions and trade-offs.

Objective	Measure	Headline KPI
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30-minute trip in the AM peak • Jobs accessible by public transport within a 45-minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to maximum throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak
	Impact on freight and goods (commercial traffic) congestion	• Proportion of business and freight travel time spent in severe congestion (in the AM peak and inter-peak
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, PM peak and inter-peak.
	Increase vehicle occupancy	• Average vehicle occupancy
Increase public transport mode share	Public transport mode share	• Proportion of vehicular trips in the AM peak made by public transport
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 10km in the AM peak made by public transport

Objective	Measure	Headline KPI
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost
Ensure value for money	Value for money	• Package benefits and costs

In addition to the project objectives, a number of other key outcomes will be evaluated through the framework below:

Other Key Outcomes	Measure	Headline Key Performance Indicator
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy.
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled
	Emissions	• Greenhouse gas emissions
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog
Social inclusion and equity	Impacts on geographical areas	• Accessibility from high deprivation areas • Distribution of impacts (costs and benefits) by area
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network



Part 5
Understanding the Problem

5.1. Evaluating the Auckland Plan Transport Network

This section outlines the preliminary results of assessing the 'Auckland Plan Transport Network (APTN)' against the project objectives. The APTN was developed by Auckland Transport, the NZ Transport Agency and Auckland Council to inform the 2015 Regional Land Transport Plan and Long-term Plan.

This assessment is intended to highlight key areas where the transport strategy could be modified to achieve better returns from the planned transport investment. The assessment will also inform the development of intervention packages.

The table below briefly outlines key components of the APTN and the timing of their completion (by decade).

Completion date of Major Interventions in APTN		
2015-2025	**2025-2035**	**2035-2045**
• City Rail Link • Accelerated Motorway Project Package • AMETI (Panmure to Pakuranga) • East West Connections • Western Ring Route • Puhoi-Warkworth • Implementation of new public transport network • Infrastructure to support Special Housing Areas	• AMETI (Pakuranga to Botany) • Penlink • Northwestern Busway • Rail electrification to Pukekohe • Warkworth-Wellsford • Major infrastructure to support future urban growth	• Additional Waitemata Harbour Crossing • Rail to Auckland Airport • Widening of outer urban motorways • Major infrastructure to support future urban growth

The evaluation framework outlined above has been used to test how the APTN performs against the project objectives. This is an initial analysis using the Auckland strategic transport model and baseline assumptions, the results of which are summarised in the following sections.

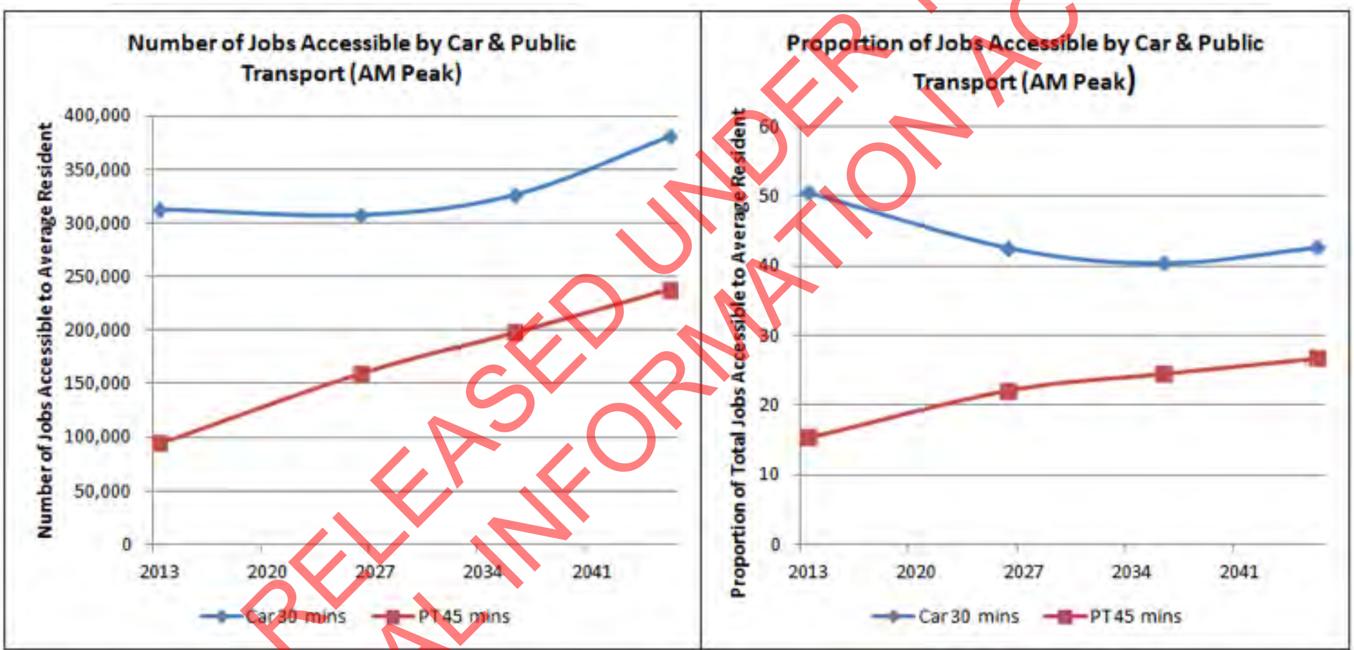
While the strategic transport model results provide a useful overview of future performance, some care is needed in interpreting region-wide average results, as they can mask some significant local variations. Furthermore, the model results do not paint a complete picture of all of the issues that need to be addressed. Further refinement incorporating additional information in areas such as freight, as well as testing different future scenarios that consider more significant changes in demand patterns that may arise from factors such as changing technology, will be undertaken in later stages of the project.

5.2. Access to Employment and Labour

Improving accessibility requires many aspects of the transport system to be operating effectively, to ensure the travel speeds are high enough, that wait times for public transport are short enough and that capacity of the system to cope with demand is sufficient. It also requires effective integration between land use and transport, principally to support effective access between residential areas and key employment areas.

While access to employment and labour are a critical measure of transport supporting desired economic outcomes, the location of employment is generally a good proxy for the location of other services (health, education, social support etc.), meaning that this measure can also be used to assess accessibility more broadly.

Analysis of how well the APTN provides for access to employment and labour during the morning peak period tells a mixed story over the next 30 years, with public transport improvements throughout the period (but slowing down over time) while improvements to car access occur mostly beyond 2030.



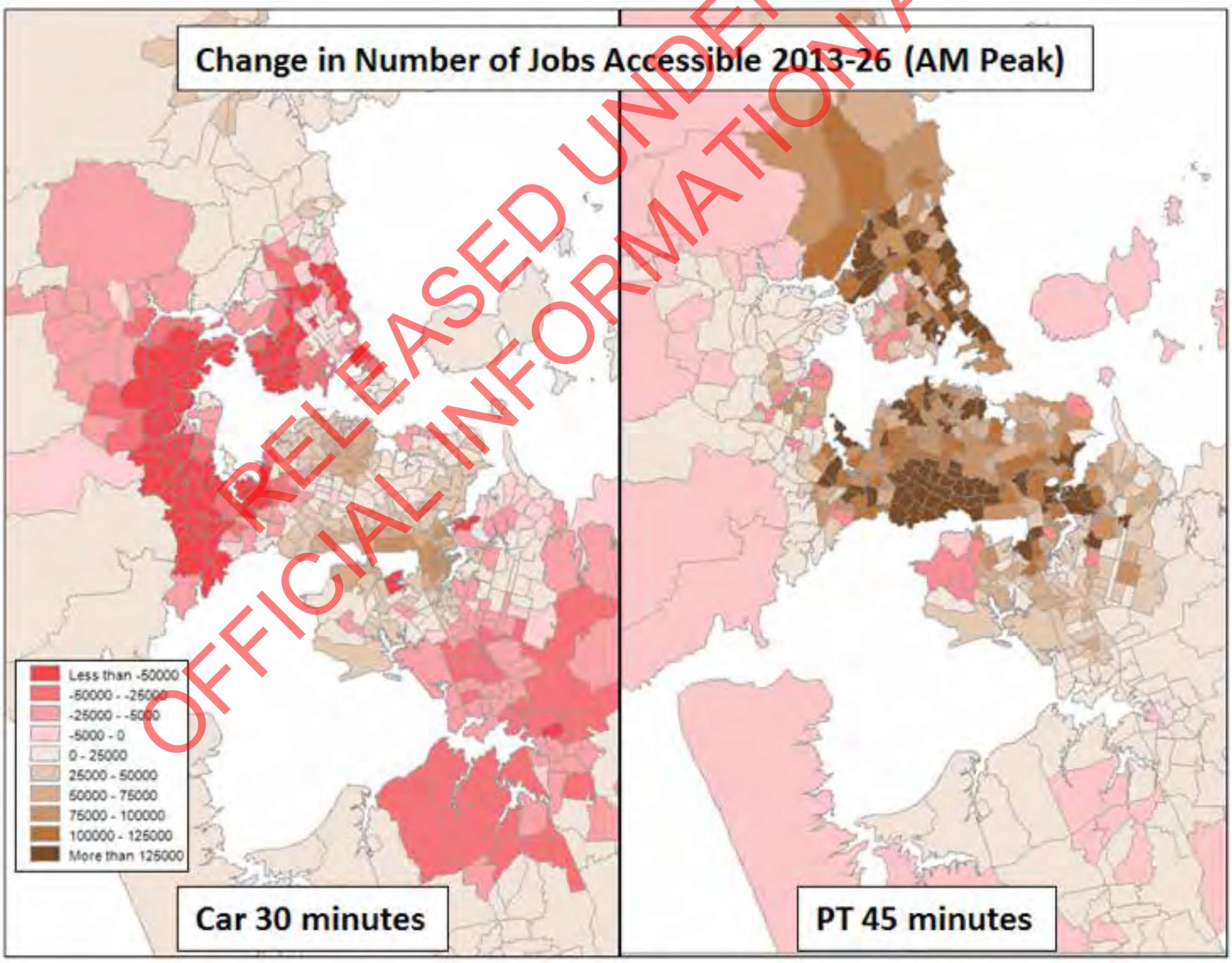
With private vehicles projected to account for around 75% of motorised journeys to work in 2036, the number of potential jobs available to the majority of travellers within an average commute time is not projected to increase until the 2030s (and actually marginally decreases up to 2026). This is despite the total number of jobs in the region increasing by around 30% over the same period. Essentially, longer trip times are offsetting the benefits of additional employment growth for the majority of commuters in the next 15 years.

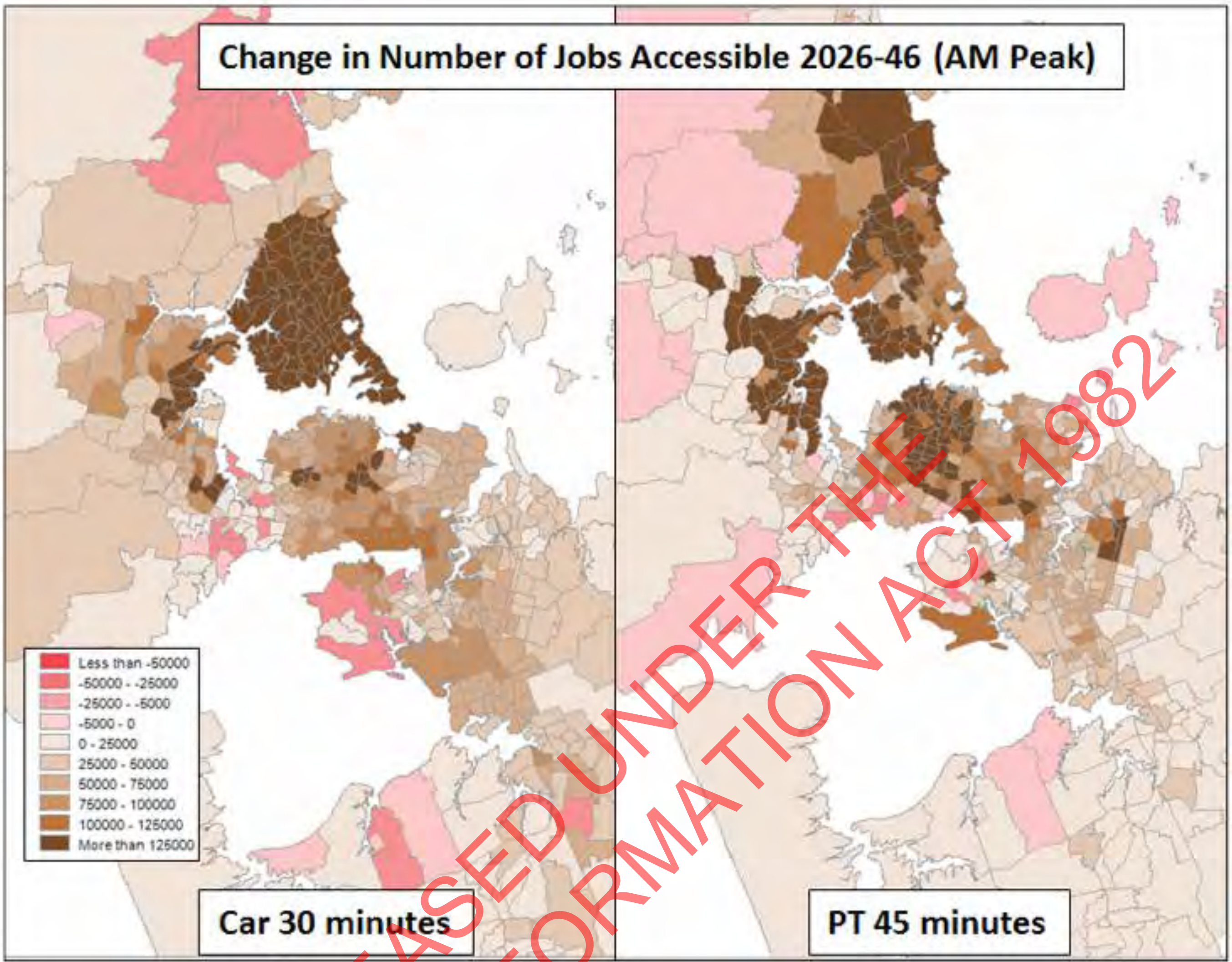
These regional figures mask some important variations between different parts of the region and over time. Access to employment by both car and public transport for those living in the central (isthmus) part of Auckland appears to improve throughout the next 30 years, reflecting the general growth in employment as well as its projected centralisation. However, increased congestion for cars and road-based public transport is likely to have a negative impact on access to some employment locations, such as the city centre. Further work will be needed to understand the extent of this problem, and how it should be addressed.

Access to employment from the north, west and south tells a much more mixed story:

- In parts of the north car access declines up to 2026 while the whole area sees a significant increase in car access after 2026. Public transport access for the area generally improves throughout the whole period, particularly after 2026.
- In the west car access sees a steep decline up to 2026, most likely the result of the area being 'pushed out' of being able to reach the city centre in a 30-minute trip. There are modest improvements after 2026 overall, with some areas seeing more significant gains. Public transport access improvements mostly occur after 2026.
- In the south there are widespread declines in car access up to 2026, with some subsequent improvement. Public transport improvements are generally modest throughout the whole 30-year period, with only isolated areas of significant increases.

These trends are illustrated in the maps below:

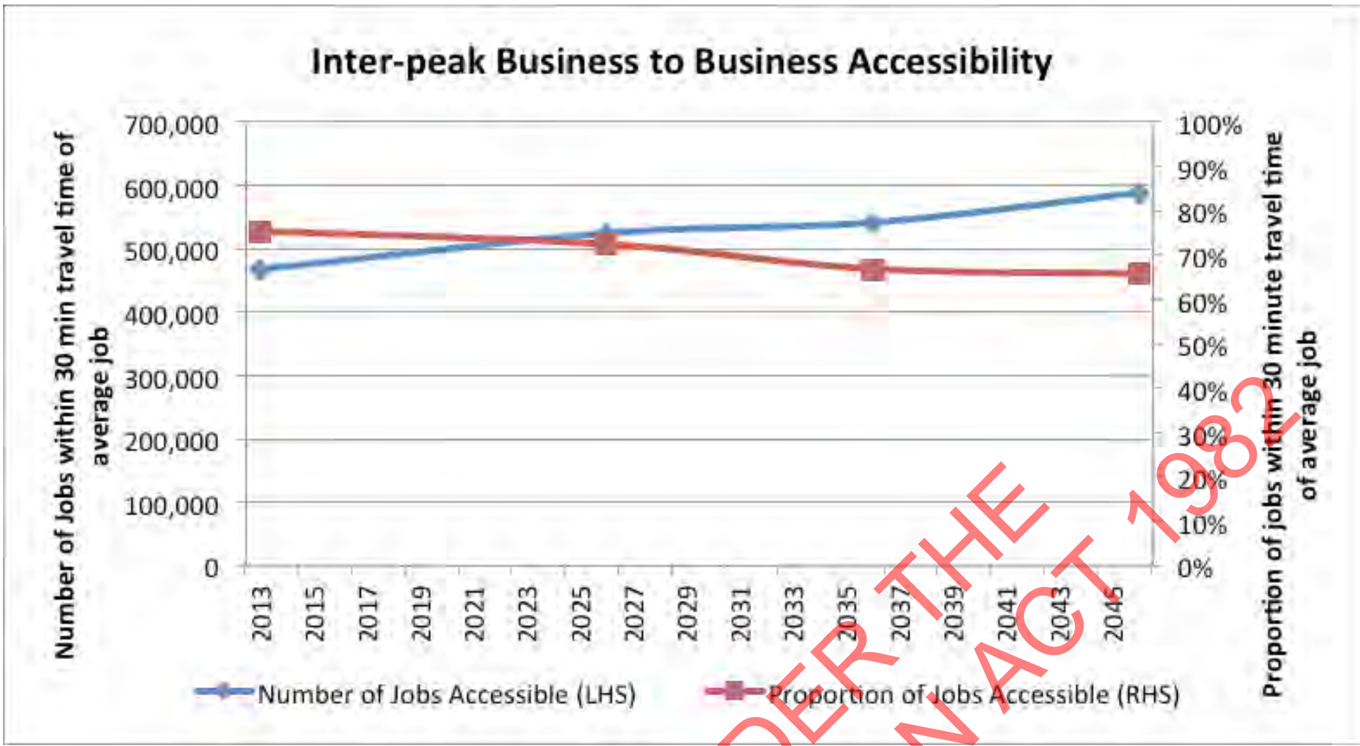




These accessibility projections highlight a significant unevenness to future employment accessibility and a growing polarisation of access to employment in the future. By 2046 more than a million people will be living in the western and southern parts of Auckland, nearly half the region's population. However, these areas see relatively little improvement in their access to employment over time, particularly by private vehicle. The wider implications of these areas being at least partly excluded from the benefits of Auckland's expanding employment base over the next 30 years are potentially significant, particularly given they include parts of Auckland with higher levels of deprivation, as well as a number of key future urban growth areas.

Part of the decline in access to employment by car is related to trips destined for the city centre and is not unexpected due to the significant constraints on increasing private vehicle access to this location. However, there are also major challenges for trips accessing jobs in the south, especially to the Airport area.

Accessibility between businesses is an important consideration for economic productivity and for the movement of services and freight – especially during the weekday inter-peak period when many of these 'on the clock' trips occur. The graph below tracks how the proportion and number of jobs within a 30-minute private vehicle travel time of the 'average job' changes over the next 30 years:



The number of jobs reachable between businesses in the inter-peak period grows at a moderate but steady rate over the next 30 years. This is due to overall employment growth outweighing the impacts of a steady increase in inter-peak congestion. Parts of Auckland seeing particular improvements include the Airport up to 2026 and for areas in the northwest after 2026. These localised improvements appear strongly linked to major projected employment growth in these locations.

Overall the accessibility findings highlight the transport challenges in providing for increasingly concentrated employment growth coupled with widespread dispersed population growth. This distribution of projected future growth appears particularly challenging to adequately provide for car accessibility in the south and west, yet it is in these same locations that public transport access improvements generally appear lowest. The extent to which these challenges can be addressed through transport interventions will need to be explored in the next stage of the project.

Key Accessibility Findings:

The development of intervention packages in the next stage of the project will need to focus on the following key issues:

- Addressing an overall decline in access to employment by car between 2013 and 2036, particularly in the west and south
- Addressing the low level of improvement in public transport access for people in the south and west, for accessing jobs in the south and the slowing of regional public transport access improvements beyond 2026.
- Investigate the extent to which accessibility challenges can be addressed by transport interventions

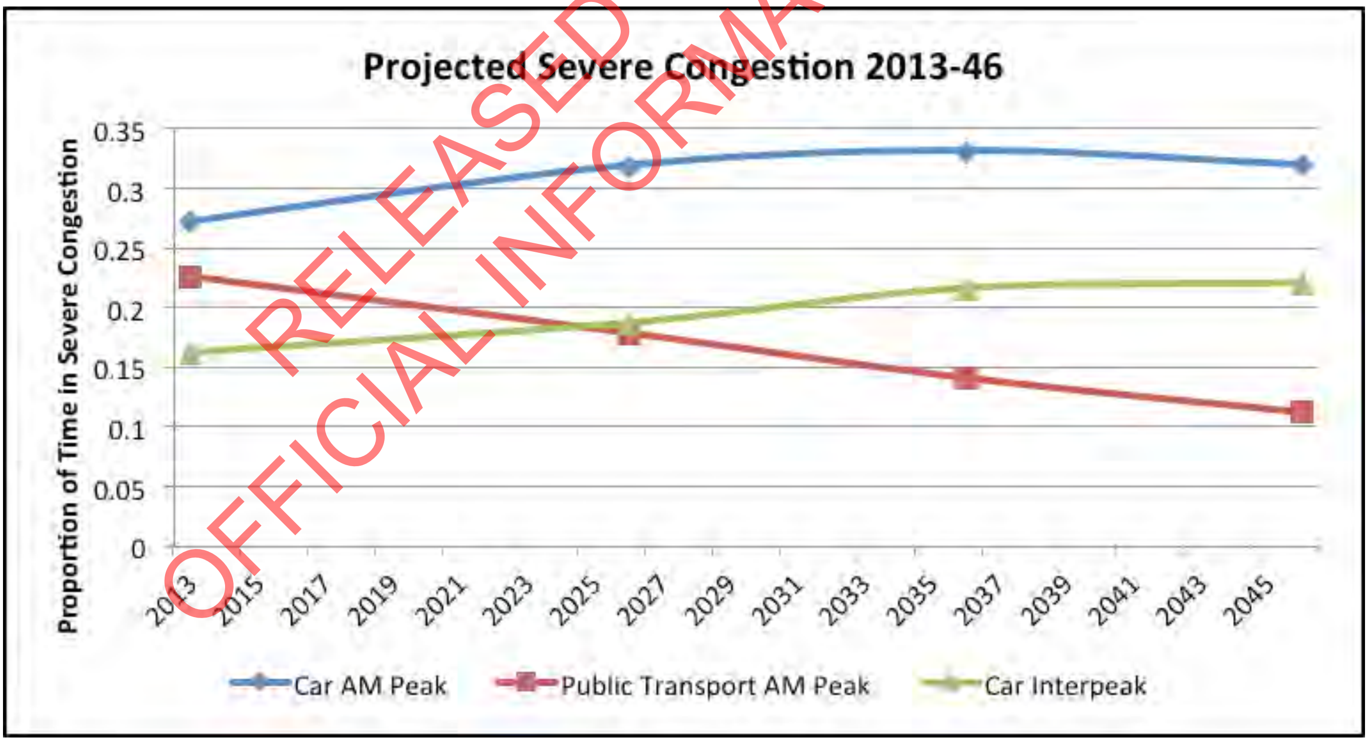
5.3. Congestion

Some level of congestion is a by-product of a successful city and generally cities with very low levels of congestion are either relatively small or in decline. However, congestion adds significant costs to doing business and moving freight, can reduce accessibility and quality of life and is a key concern for Auckland's travelling public. Congestion also impacts on the reliability of travel, adding costs by forcing travellers to add extra time to their journey to allow for the potential of delay.

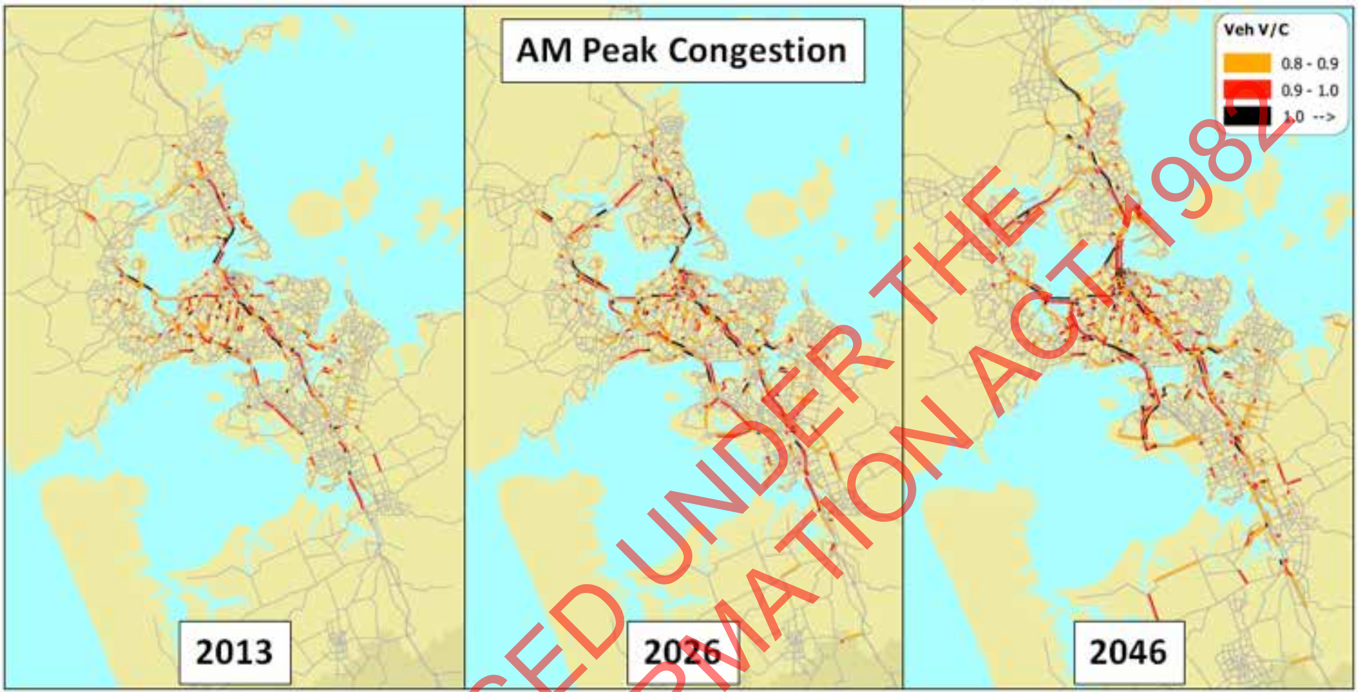
Analysis of the APTN highlights an increase in congestion over the next 20 years, with a subsequent reduction after 2036. In 2036 analysis suggests just under a third of travel time in the morning peak will be spent in congested conditions. While peak time congestion is projected to reduce from 2036 to 2046, inter-peak congestion continues to increase. By 2036, around 22% of inter-peak travel (an average of conditions between 9am and 3pm) is expected to be in congested conditions, influenced by a spreading of peak period conditions continuing later into the morning and beginning earlier in the afternoon.

Congestion is expected to particularly impact on the movement of freight. Time spent in congested conditions on the strategic freight network is forecast to increase by 45% by 2036. Inter-peak congestion on the strategic freight network is expected to double by 2036, reaching current peak period conditions.

In contrast, a key success of the APTN is that the impact of congestion on public transport at peak times is projected to decrease over time, due to an increased proportion of public transport trips being taken either on rapid transit services (e.g. rail and busways) or on bus services that utilise bus lanes. Projected congestion levels are shown in the graph below:

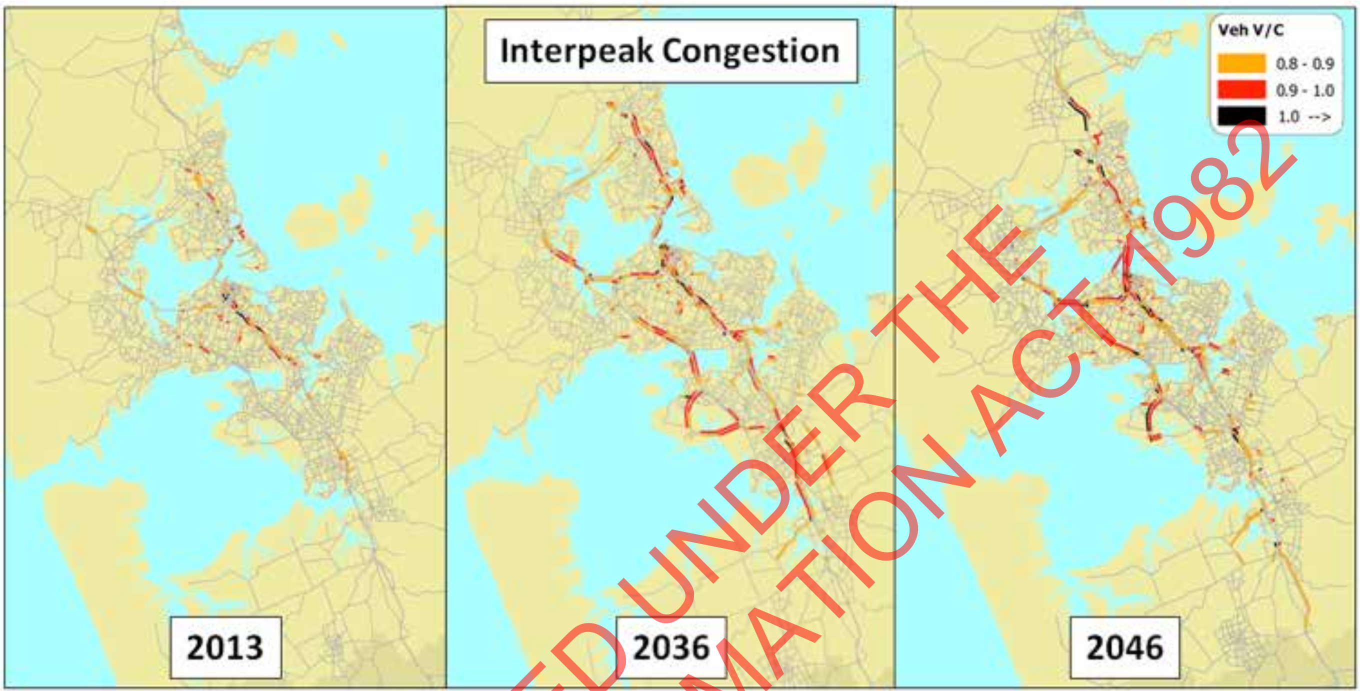


Modelling analysis of volume to capacity ratios, which provide a good indication of congestion levels, suggest that congestion problems will be experienced most on the motorway network. By 2046 in the AM peak, most of the motorway network is projected to experience some level of congestion (indicated by the coloured plots on the maps below) with some areas experiencing severe congestion (indicated by red and black). Much of the increase in peak congestion occurs before 2026 and either stabilises or improves towards the end of the 30-year period.



Outside the motorway network congestion is generally limited to specific locations during the AM peak, although it is important to note that the strategic modelling tools are likely to under-estimate localised congestion off the motorway network.

The projected increase in inter-peak congestion occurs almost exclusively on the motorway network. By 2036, inter-peak congestion is forecast to be as widespread on the motorway network as the current morning peak. Subsequent performance improvements do occur out to 2046.



The impact of congestion and unreliability is likely to be particularly pronounced for commercial and freight travel, which generally cannot rely on a public transport alternative and occurs mostly during the inter-peak period. Given the forecast congestion on the motorway network, unreliability will particularly impact on strategic freight movements, including freight to and from the ports and airports along with inter-regional freight movement.

Furthermore, with nearly three-quarters of daily trips in 2046 projected to be made by private vehicles, the impacts of congestion and poor reliability will continue to be felt by the majority of travelling Aucklanders

Key Congestion Findings:

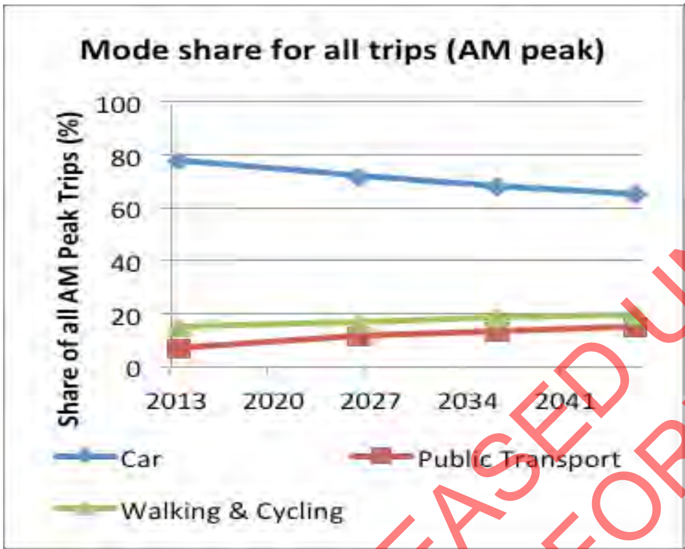
The development of intervention packages in the next stage of the project will need to focus on the following key issues:

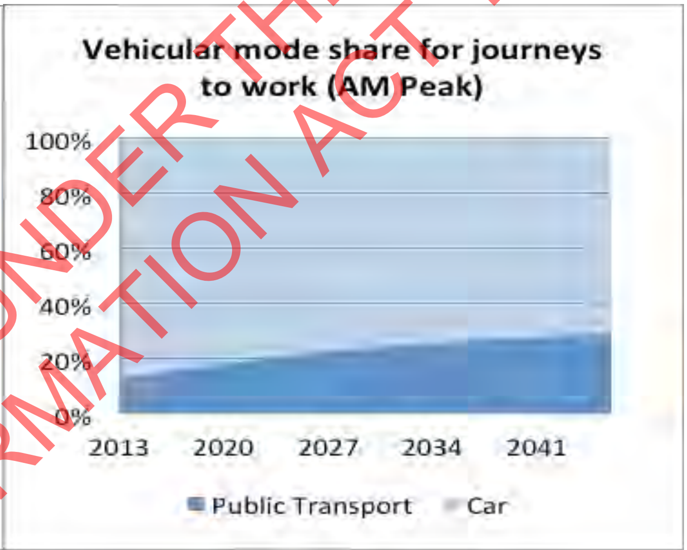
- Addressing a widespread increase in congestion between 2013 and 2036, particularly on the motorway network
- Addressing key bottlenecks on the motorways and local road network, particularly where they impact on overall accessibility and trip reliability

5.4. Public Transport Mode Share

Public transport carries a significant number of people efficiently along corridors of high demand, using space efficiently when compared to private vehicles. This attribute is particularly important in more intensive locations such as major centres where space is very valuable. Conversely, public transport often struggles as an attractive, cost-effective transport option in lower density areas, particularly when serving dispersed employment or low-intensity employment areas.

In the future, total mode share of public transport in Auckland is projected to remain relatively small compared to private vehicles. However, because public transport trips are focused at peak times, to major centres of employment (especially the city centre) and can be long (especially rail or busway trips), they play a critical role in supporting projected employment growth and reducing the impacts of congestion. Public transport is not projected to play such a significant role in the inter-peak period, as it is generally less attractive for the more dispersed travel occurring during this period.

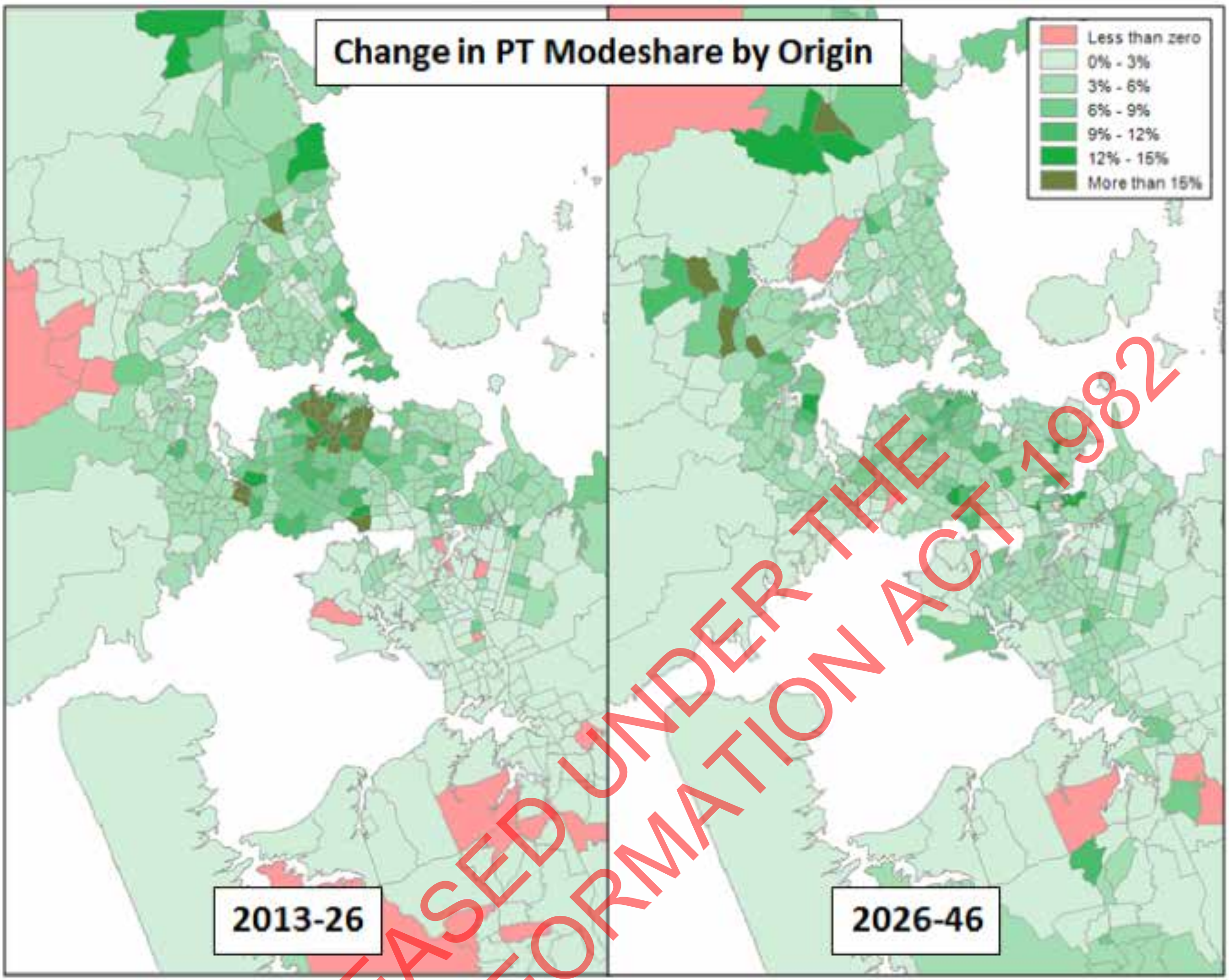


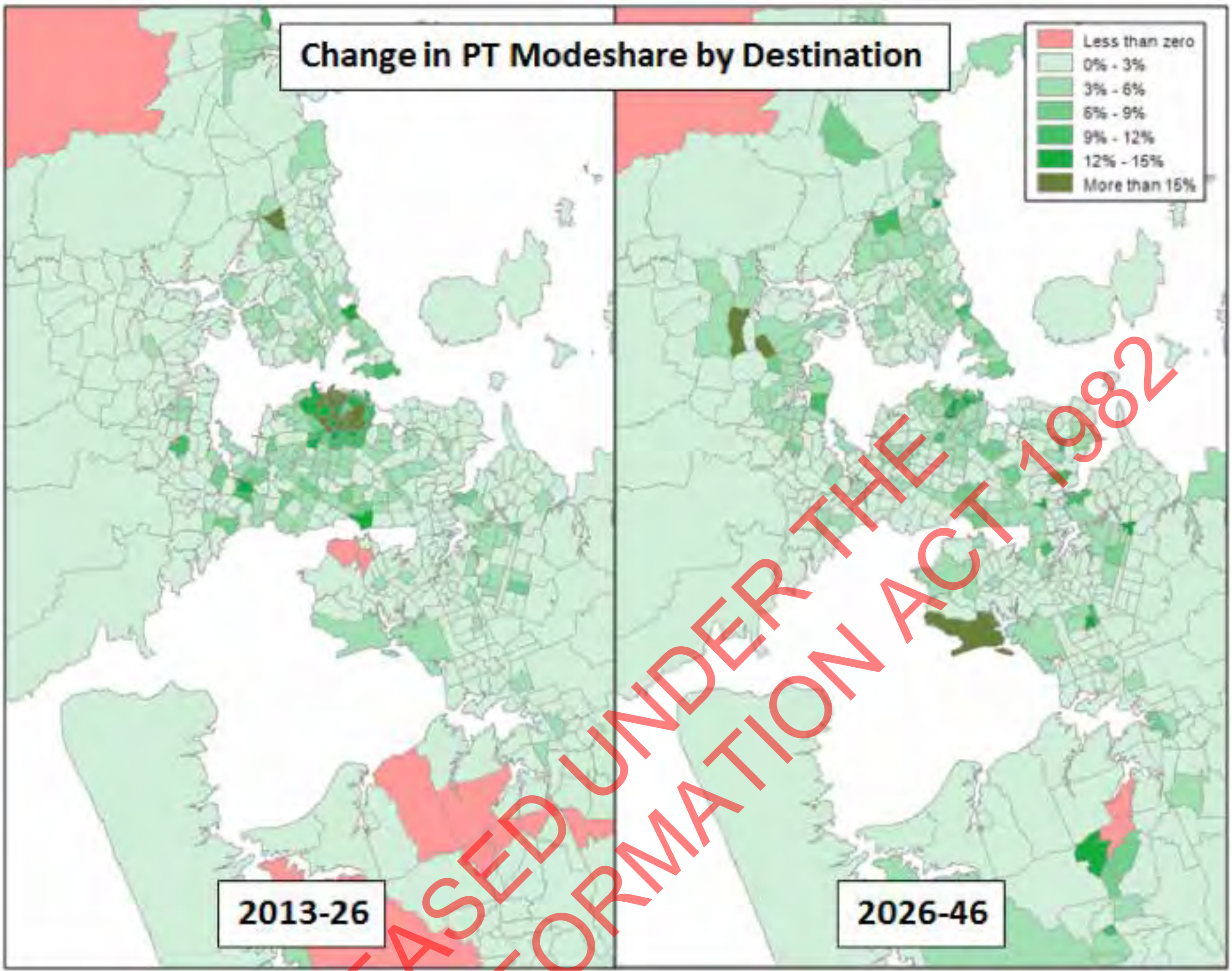


Public transport mode share is projected to increase steadily over time, with morning peak share lifting from 7% of all trips in 2013 to 15% by 2046. This would give Auckland a higher public transport mode share than Perth and Brisbane had in 2011, but lower than the mode shares of Sydney and Melbourne in 2011. For vehicular journeys to work in the AM peak, public transport has a higher share, growing from 13% in 2013 to 29% in 2046. It is notable that most of this increase occurs between 2013 and 2026, with a slower level of modal shift after 2026.

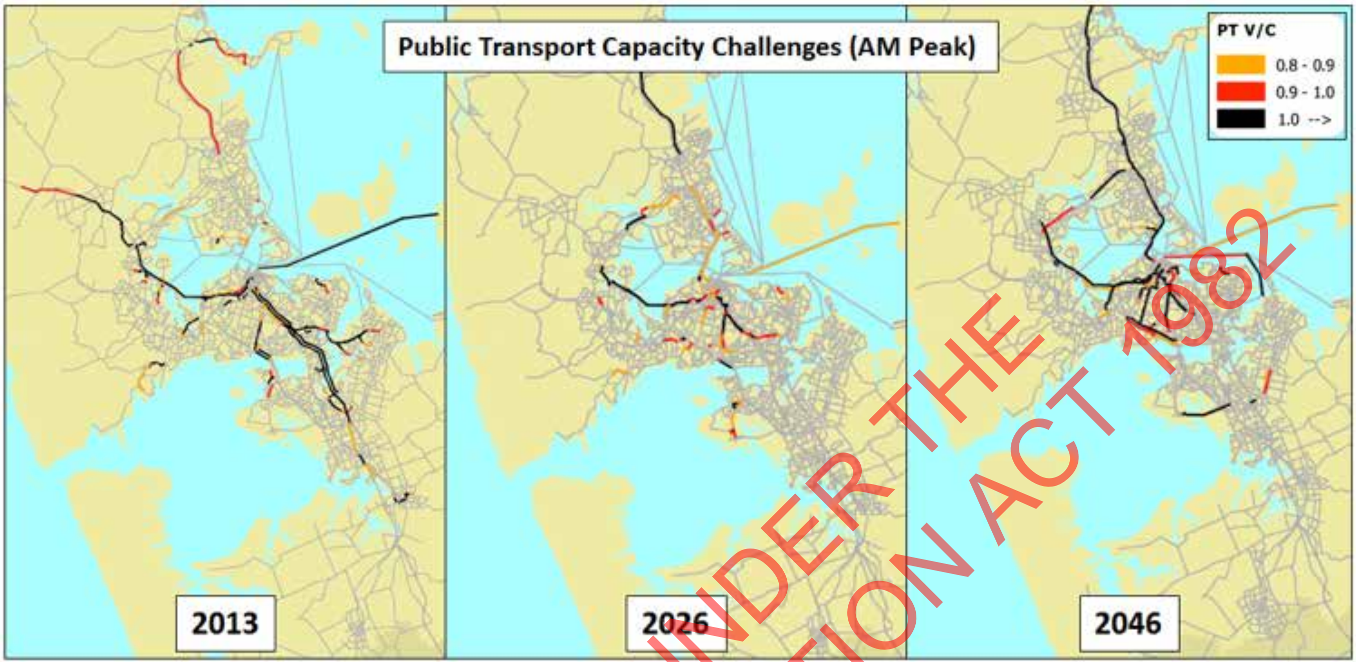
The importance of public transport in serving longer trips to major centres is further illustrated through the share of all personal distance travelled. In this case, public transport's share travelled increases from 11% in the 2013 morning peak to 19% in 2046. Due to their short distance, active modes account for around 1% of travel by distance.

Mode share growth up to 2026 appears to be focused on trips from the central area heading towards the city centre and its immediate surrounds. After 2026 the most significant growth is focused in the far north and northwest areas. Growth in the share of journeys taken by public transport to, from and within the south is limited throughout the 30-year period. Mode share growth for trips heading to the city centre and its surrounds slows down considerably after 2026, with the most significant growth by destination occurring for trips to the Airport and the northwest.


Change in PT Modeshare by Origin
Less than zero
0% - 3%
3% - 6%
6% - 9%
9% - 12%
12% - 15%
More than 15%
2013-26
2026-46


Change in PT Modeshare by Destination
Less than zero
0% - 3%
3% - 6%
6% - 9%
9% - 12%
12% - 15%
More than 15%
2013-26
2026-46

A key constraint on public transport mode share growth will be capacity constraints, where the level of demand cannot be provided for by the planned level of service. Projected public transport capacity constraints (indicated by situations where the volume of demand nears or exceeds service capacity) are highlighted in red and black below.



Typically, these constraints should be able to be resolved by providing additional services (i.e. operating more buses, trains or ferries) but in some cases this may be challenging due to infrastructural constraints such as the number of buses on particular corridors exceeding feasible levels. The main locations where simply providing more services may be challenging are on key approaches to the city centre from the north, west and south. The Auckland strategic transport model does not fully reflect the impacts of these capacity constraints, but more detailed analysis suggests a significant decline in bus speeds on busy routes over the next 30 years. If this is not addressed, it is likely to negatively impact on mode share growth.

Overall, the APTN analysis highlights that public transport mode share growth needs to make a greater contribution to reducing congestion, particularly for long trips where people using private vehicles are utilising highly congested motorway corridors. Notably, the analysis suggests that rail service levels included in the APTN do not appear to be a sufficiently attractive transport option to be driving major mode share change for areas served in the south and west.

Key Public Transport Mode Share Findings:

The development of intervention packages in the next stage of the project will need to focus on the following key issues:

- Investigate options for increasing public transport mode share, particularly attracting longer trips off the motorway network to reduce congestion
- Address the low level of public transport mode share growth in the south, particularly between 2013 and 2026

5.5. Net User Benefits

It is important to assess whether further increases to transport investment in Auckland generate net benefits for those who will be paying the extra costs. Policy interventions such as road pricing achieve improved performance of the transport network through raising the financial cost of travelling. It is important to weigh up the costs and benefits of pricing interventions to establish whether the additional financial costs of a road pricing charge are outweighed by the time savings benefit they provide to road users.

The APTN has not been assessed against this objective at this stage of the project. Intervention packages will however be compared against the APTN as part of later stages of the project.

Part 6
Next Steps

6.1. Testing Intervention Packages

The analysis in the previous section has highlighted a number of transport problems that are expected to accompany Auckland's growth over the next three decades, even with the significant investments proposed in current transport plans. Although the analysis did not specifically evaluate value for money, the results suggest that there are likely to be opportunities to deliver better outcomes by making some changes to the transport interventions that have been proposed.

The next phase of the project will examine these opportunities in more detail. This will involve the testing of different intervention packages (combinations of infrastructure investments, services and policies) to develop an understanding of the extent to which different interventions will contribute to the project objectives. In addition to investments in infrastructure and services that increase system capacity, the potential for demand-side interventions that improve the productivity of the existing transport system also needs to be assessed.

The next phase will be undertaken in two steps, which will inform the second deliverable:

1. Testing of specific interventions using a combination of transport modelling and analysis of previous work to understand the impact of major interventions
2. Using the findings from step one to create more realistic full 'packages of interventions' for comparative testing

The analysis to date has highlighted some key issues for the next phase of the project to examine in more detail:

Objective	Issues to address and investigate
Improve access to employment and labour	• An overall decline in access to employment by car between 2013 and 2036, particularly in the west and south • The low level of improvement in public transport access for people in the south and west, for accessing jobs in the south and the slowing of regional public transport access improvements beyond 2026. • The extent to which the accessibility issues faced in the west and south can be addressed by transport interventions
Improve access to employment and labour	• How widespread congestion becomes between 2013 and 2036, particularly on the motorway network • Key bottlenecks on the motorways and local road network, particularly where they will be impacting upon overall accessibility and trip reliability
Improve public transport mode share	• Options for increasing public transport mode share, particularly attracting longer trips off the motorway network to reduce congestion • The low level of public transport mode share growth in the south, particularly between 2013 and 2026

In addition to the issues outlined in section 5 above, there are some areas where the initial model-based analysis has not been sufficient to determine the full extent of future network problems. An example of this is freight transport, where further work will be needed in the next phase of the project to more clearly identify the issues and options that exist.

The next phase of the project will also include an assessment of the impact that different future scenarios for population growth, land use projections and technology futures may have on the project objectives.

6.2. Value for Money

The next phase of the project will test the intervention packages against all four project objectives, together with the other outcomes that form part of the evaluation framework in section 4.2. An important part of this next phase will be testing the extent to which transport interventions deliver value for money. The project's terms of reference outline a shared desire to achieve better value for money from transport investment in Auckland than will be achieved from current plans. Assessment of the intervention packages will need to demonstrate this outcome.

Developing, maintaining and operating the transport system has major costs – both public costs for Council and Government, and private costs for households and businesses. These costs have increased significantly over the last decade to address Auckland's growing transport demands. However, a decision to substantially increase investment in upgrading Auckland's network imposes an opportunity cost for taxpayers, ratepayers and transport users. Investment made to upgrade the network is money that cannot be invested to fund other government, council or individual priorities.

Assessing value for money will require understanding and measuring the total social benefits of a package of projects and ensuring they exceed the cost of the package. Achieving best possible value for money means that the package offers the greatest possible social benefits relative to its cost. Transport improvements create a wide variety of potential benefits to both users and non-users, including:

- Travel time savings
- Vehicle operating cost savings
- Impact on CO2 emissions
- Savings in accident costs
- Improved reliability and greater throughput
- Increased competition and agglomeration

This project's objectives encompass the bulk of the social benefits that can be expected from transport projects. An understanding of how those objectives are met helps to understand the effects of a particular package of projects. However, only a value for money measure reveals how the benefits stand in relation to the costs.

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[3] Nunns, P. (2014), Population weighted densities in New Zealand and Australian cities: a comparative data set.

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[8] MRCagney (2015), *Benchmarking public transport and car accessibility in Auckland*, Report for Auckland Council

[9] Medium growth population projections, Statistics New Zealand

[10] Infometrics and Auckland Council http://ecoprofile.infometrics.co.nz/Auckland

[11] Source: Scenario I9 land use

[12] Auckland Profile – initial results from the 2013 census (page 6), available online at: http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/reports/Documents/aucklandprofileinitialresults2013census201405.pdf

[13] In the June 2014 year Auckland's population grew by 34,000 (2.3 percent), in the June 2015 year population grew by 43,500 (2.9 percent), to reach 1.57 million - Subnational Population Estimates: At 30 June 2015, available online at: http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/SubnationalPopulationEstimates_HOTPAt30Jun15/Commentary.aspx

[14] This projection, known as "Scenario I9" has been developed by Auckland Council and Auckland Transport. It reflects the likely location and timing of growth in newly urbanised areas (as outlined in the Future Urban Land Supply Strategy). However, Scenario I9 does not reflect the Proposed Auckland Unitary Plan's zoning and development controls within the existing urban area as these are currently being decided upon as part of the independent hearings process for that Plan. Given this, the land use assumptions do not imply wider endorsement outside of the project.

[15] *National Freight Demands Study*, 2014, p.6

[16] Ministry of Transport (2014) ***National Freight Demand Study***, available online at http://www.transport.govt.nz/assets/Uploads/Research/Documents/National-Freight-Demand-Study-Mar-2014.pdf

[17] Ministry of Transport Fleet Profile 2012.

[18] Auckland Airport Master Plan http://www.aucklandairport.co.nz/downloads/aial-masterplan.pdf

[19] Richard Paling (2015)

[20] Richard Paling (2015)

[21] http://www.transport.govt.nz/assets/Uploads/Sea/Documents/FIGS-June-2015.pdf

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[23] Rive, G. (2015), ***Public transport and the next generation***. NZ Transport Agency research report 569. Available at: http://www.nzta.govt.nz/assets/resources/research/reports/569/docs/569.pdf

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Auckland Transport Alignment Project

Freight Report

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Preface

This is one of a series of research reports that were prepared as inputs to the Auckland Transport Alignment Project (ATAP). It is one of a number of sources of information that have been considered as part of the project, and which have collectively contributed to the development of the recommended strategic approach. The content of the report may not be fully reflected in the recommended strategic approach, and does not necessarily reflect the views of the individuals involved in ATAP, or the organisations they represent. The material contained in this report should not be construed in any way as policy adopted by any of the ATAP parties.

1.0 Executive Summary

This paper brings together what is known about freight performance in Auckland, discusses trends impacting the freight task and identifies a methodology for assessing freight delay. It largely concentrates on road freight as the primary freight mode in Auckland.

Auckland Freight Task

This investigation has confirmed the significance and importance of the Auckland region in the national freight task with currently around 25% of New Zealand's freight originating or terminating within the region, accounting for 28% of road transport related GDP in 2012. Looking ahead, forecasts from the Ministry of Transport (MoT) expect New Zealand freight volumes to grow by 58% by 2042 with a near doubling of existing flows experienced in Auckland. While rail and coastal shipping mode shares are expected to grow, in absolute terms road transport will continue to carry the vast majority of freight.

Road Freight Congestion

The belief that Auckland's congestion is having a negative impact on freight has been confirmed in recent meetings with the road freight industry where evidence of decreasing service offerings over time due to increasing congestion, both in terms of frequency and geography, was provided.

While general network wide congestion was noted by industry representatives, the areas of particular concern correlated, as would be expected, to access to and from major production or distribution hubs; namely access to Port of Auckland via the Strand, motorway access to and from Wiri, Onehunga / Southdown, Highbrook / East Tamaki and the Airport via 20A / 20B.

Looking forward, freight carriers expect congestion issues to spread south. This is tied to the development and/or intensification of industrial land at Manukau / Wiri followed by Takanini and in due course Drury. They also noted the size and scale of greenfield growth areas in terms of how freight will access the areas and the impact of the development and intensification that these routes will have on general traffic – for example the reliance on SH16 to serve the Kumeu / Huapai area.

Whilst there is uncertainty as to the impact of larger international ships visiting New Zealand and the subsequent role of rail as a shuttle to the inland ports and regions, road freight to and from Ports of Auckland Limited (PoAL) is expected to continue to increase. A review of available data has confirmed that approximately 80% of freight originating from PoAL travels via the motorway network, validating to some extent the Regional Freight Network.

Finally, industry representatives identified the lack of co-ordination and integration between PoAL and Port of Tauranga and their associated inland facilities. This was cited as contributing to double handling and back tracking.

Assessing Freight Demand

While both Auckland Transport (AT) and the New Zealand Transport Agency (NZTA) have monitoring programmes for their networks, there is no specific monitoring of freight. The lack of maintained representative data relating to freight movement and efficiency severely limits AT and NZTA's ability to plan for or improve the performance of freight movements. Ownership of freight function is shared across multiple parts of NZTA and AT with limited specific budget allocated for improving freight efficiency.

No assessment has been completed to determine if rail can accommodate the projected freight task on existing infrastructure and how this might change as demand for passenger rail increases. With growing demand for both freight and passenger transit it is likely that there will be a need to separate rail freight and transit, or expect freight to transfer from rail to road. The lack of freight data and a model hinders the determination of the date at which this separation / change of mode is required. A major driver will be the completion of the City Rail Link, expected in 2023, which will allow more passenger trains to operate on the network.

To understand the cost to the economy of delay and congestion impacting the freight fleet we need to understand both the cost of freight travel time and freight transport demand. The Economic Evaluation Manual (EEM) provides values for the former which have been reviewed against relevant international literature to confirm if they are appropriate or conservative. The latter item, namely an understanding of freight transport demand, is currently a significant gap.

To provide the Auckland Transport Alignment Project (ATAP) with an approach for testing and understanding the impacts of various transport infrastructure packages, a review of various datasets and methodologies was completed. There are numerous data sets that provide evidence of current freight movements, either in terms of volume, route choice or journey time. However, whilst these data sets all provide components of the quantified 'freight' demand, individually they don't provide a full picture of the pattern of current movements. They also fail to provide the future assessment that is required because they are 'observed' data.

Our assessment identifies an approach that compares output from the Auckland Regional Transport (ART) model with a range of datasets including eRUC (electronic Road User Charging), Bluetooth and classified vehicle counts. This methodology develops a base matrix of freight demand and of average journey times between areas of the Auckland network from the available observed data sets. This data can then be compared with the data in the ART model to provide an 'adjustment' matrix that can be used as a comparator for forecast changes.

It is considered unlikely that the above approach can be completed in time to align and provide insight to the ATAP project. It is also noted that NZTA has recently commissioned research looking at real-time monitoring of freight movements in Auckland (*TAR 15/24 Use of technology to measure and improve urban freight movements*) which is anticipated to be completed in 2017.

Key Findings

The findings of this report are not particularly new. Comparison with the Auckland Regional Council (ARC) Freight Strategy (2006) and the Upper North Island Strategic Alliance's Critical Issues (2013) shows little advancement on a number of common issues. This is in part due to a lack of organisational capability and focus on the freight task. Historically the Auckland Regional Transport Authority had a key focus on public transport, and local councils an emphasis on roads from an engineering perspective. As such there was and continues to be limited strategic planning relating to the freight task at the regional level.

Another key aspect that has previously held back understanding of the freight task has been the broad and diverse spectrum of the task and its participants which has made gathering of reliable and comprehensive data challenging. In recent years there have been significant advances in the industry's ability to gather data on freight traffic. While still not perfect or entirely complete in terms of coverage of the freight sector, this step change provides a vital enabler for transport agencies to plan for freight. As such, investing in data capture, monitoring and ultimately development of multi-modal freight demand and distribution tools, such as models, to assist strategic planning should be considered.

Recommendations

The majority of the recommendations identified in this report require investment beyond ATAP. Actions for immediate consideration in ATAP are:

- From the Round 2 Package Evaluation – Consider how the inclusion or omission of the AWHC and other significant strategic freight network improvements impact freight congestion and distribution.
- While recognising that eRUC data only represents a proportion of freight traffic, use regional eRUC data to verify current assumptions of the Strategic Freight Network. One approach would be to assess what areas the package is affecting and compare these with freight congestion data e.g. AT's freight monitoring and eRUC heat maps. Unitary Plan zoning maps would assist in identifying current and future commercial areas.

Recommendations that should be considered beyond the current ATAP scope:

- Address knowledge and data deficiencies
  - Develop and apply an adjusted freight matrix to assess future freight demand and enable quantification of delay and congestion costs.
  - Establish a consolidated accessible freight dataset for the Auckland region.
  - Develop a multi-modal regional freight model(s) to assist in the management and planning of freight movement and distribution.
  - Develop strategic freight planning capability. Engage further with PoAL, Port of Tauranga and KiwiRail to develop an enhanced understanding of capabilities, operations and future aspirations.
  - Develop organisational focus and capability in the freight sector to enable and enhance strategic planning of this significant transport sector.
  - Develop a stronger collaborative working relationship between public sector (NZTA and AT) and the freight sector beyond the regulatory relationship.

2.0 Background

2.1 Introduction

Efficient freight services by rail, large trucks and smaller delivery vehicles are important to Auckland, helping to keep the prices of goods and services down and ensuring prompt reliable service. Freight efficiency is also important to New Zealand as Auckland is the main import port. The higher cost of moving goods also restricts the competitiveness of manufacturers based in the region, resulting in constrained employment in the sector.

Auckland's congestion was thought to have a negative impact on freight and this has been confirmed in recent meetings with the freight industry where evidence of decreasing service offerings over time due to increasing congestion, both in terms of frequency and geography, was provided.

2.2 Scope

This paper brings together what is known about freight performance in Auckland, discusses trends impacting the freight task and identifies a methodology for evaluation of freight delay. The freight transport task covers a broad spectrum – this report primarily focuses on the heavy vehicle portion of this spectrum, with some limited discussion on the role of rail freight in Auckland. A significant gap in scope is consideration of the Light Commercial Vehicle and "man in van" business and commercial traffic sector which forms of a large part of the Auckland freight task. As became evident through the development of this report, there is a general lack of data and understanding of the freight task, and this sub-sector is typically proxied as being represented by general traffic when considered at a regional level. It would be useful to understand if these trips are concentrated in specific areas.
This workstream deliverable partially overlaps with both the Arterial Roads and the Rail Workstream reports.

2.3 Purpose

The focus of this workstream has been to develop an understanding of the current and future freight challenge in Auckland and the importance of freight in Auckland and New Zealand's productivity.

The findings, where applicable, will then be used to assist the development, testing and assessment of interventions and scenarios in the second and third stages of ATAP.

The approach to this task has been as follows:

a. Review published data in relation to Auckland and New Zealand freight research
b. Investigate readily available datasets to develop an understanding of freight demands and distribution.

2.4 Consultation and Engagement

A review of existing traffic data and monitoring sources was conducted and included meetings with the relevant teams at the Auckland Motorway Alliance (AMA) and AT. A workshop was also held with representatives from National Road Carriers (NRC) to assist with understanding key road freight issues and challenges.

It is recognised that a full freight supply chain view would require a much broader and triangulated consultation involving the likes of exporters, the port companies, KiwiRail and Air New Zealand. However due to the time constraints and the primary focus of this paper being on heavy vehicle freight on the Auckland network, external engagement was limited to NRC.

2.5 Structure

This working paper is presented as follows:

- Part A contains a thorough literature review of the existing and future freight network in Auckland and New Zealand as a whole.
  - Section 2 discusses the existing situation for freight on a nationwide level and then focuses on freight in Auckland
  - Section 3 looks at the factors which will influence the future freight task
  - Section 4 summarises the predicted future situation for freight. This includes the key challenges and opportunities.

- Part B explains the methods for quantifying freight delay in New Zealand.
  - Section 5 presents an approach for quantifying freight travel time
  - Section 6 presents an approach for forecasting future freight demand
  - Section 6 presents the conclusions and recommendations.

Part A - Characteristics of the Existing and Future Freight Network

3.0 Existing Situation

3.1 Economic Contribution of Freight

The Westpac Transport Industry Insight (2015) noted that the transport, logistics and distribution sector (including road, rail and shipping) produced around 5.4% of New Zealand's GDP in 2014, or $12.5 billion. This is in line with Australian and European Union GDP shares. Road transport (including freight and passenger services) employs the largest share of workers in the transport, logistics, and distribution sector, with 41,000 full time employees employed in 2014, generating $4.3 billion in GDP nationally. Auckland produced around $1.2 billion in road transport value in 2014, or 28% of the total sector.

The MoT and Lincoln University 2015 strategic study *Economic Development and Transport* noted the impact of transport on the location of economic activity (e.g. the Auckland port and the freight links to its hinterland). It discussed the importance of reducing the costs (including transport costs) of doing business and improving access to maintain relative competitiveness. It is noted that, while freight is no longer growing as fast as GDP, in part reflecting the increased share of service industries in the economy, the volume of freight moved within Auckland and New Zealand continues to grow at a substantial rate.

3.2 Freight Task

The Westpac Transport Industry Insight (2015) notes that the largest share of road transport value is added in Auckland, which accounts for around 28% of the national total.
A study in 2012 showed that 16.2% (by weight) of all freight movements around New Zealand were within Auckland (MoT, 2014a). Around 4.5% of nationwide freight movements were from destinations outside of Auckland to destinations within Auckland. Similarly, around 4.5% of nationwide freight movements were from Auckland to destinations outside of Auckland. Therefore around 25% of New Zealand's freight has an origin or destination of Auckland.

A further study conducted by Beca (2015) aimed to look at the current movements of freight from the PoAL. A cordon drawn around the Auckland Isthmus concluded that 20% of nationwide trips began or terminated within this cordon area, which is very similar to the conclusion reached by MoT (2014a).
Data from the MoT (2016) indicates that approximately 95% of freight originating from Auckland is transported by road to other regions. Rail makes up 4.6% and coastal shipping less than 1%.

As shown below, a significant proportion of Auckland's freight task is internal with just under 40% of estimated freight volumes being intra-regional.

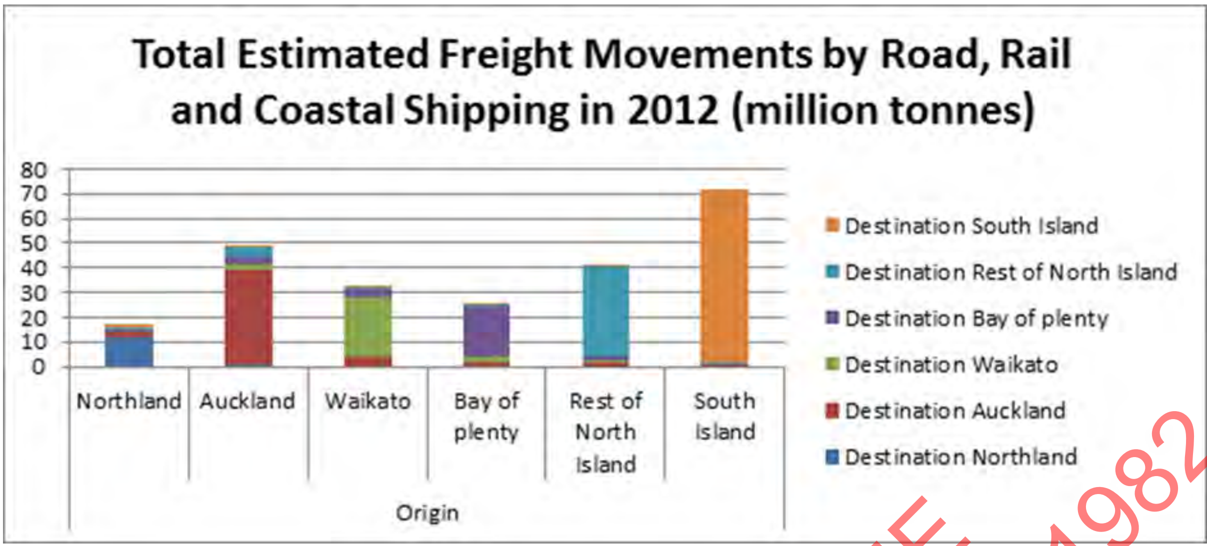


Figure 1: Freight movements by region for road, rail and coastal shipping in 2012 (MoT, 2016)

3.3 Regional Freight Network

The principle of a Regional Freight Network (RFN) based on the State Highway network and key regional arterials has existed in various forms for a number of years. Limited consultation with the freight sector has been undertaken to confirm the completeness of the routes covered. Anecdotal evidence from the workshop held with NRC is that the principles underpinning the network are sound as the network focuses on the "movement" orientated corridors in the region, the significant freight-generating hubs (manufacturing and distribution) and the metropolitan centres (receiving environments). The network is shown at Appendix B.

AT monitors Level of Service KPI's on a broader network which includes more of the arterial network than the RFN, but input data driving this dashboard is general traffic and this is not considered against Heavy Commercial Vehicle (HCV) volumes. This means the specific importance of each route to freight movement is not known or assessed. An example of this dashboard is included at Appendix C.

Supporting Evidence for the RFN - The Port Demand and Route Preference Study

The Port Demand and Route Preference Study completed in 2015 for the MoT used a sample of 122,000 vehicle trip movements from March 2015. These have been linked to census area units if a trip starts or finishes on the studied ports. The cordon for this study was the Auckland Isthmus and, as can be seen from the key findings, broadly supports the RFN.

Ports of Auckland

- The key sources of port freight traffic were as expected being the major freight hubs in the region; namely the Airport area, Onehunga, Penrose, Mt Wellington and Highbrook.
- 20% of trips started or finished within the Auckland Isthmus.
- Of those trips crossing the Isthmus cordon 20% travelled north or west – the remainder south.
- 80% of the Isthmus cordon crossing trips used the state highway with Great South Road the most significant local road.
- There is a bias for trips heading south from PoAL to use the Southern Motorway or Great South Road and for PoAL inbound trips to use SH20.

MetroPort

- Primary sources of MetroPort traffic are the industrial belt (Onehunga to Highbrook) and the Airport area.
- 80% of traffic crossed into the Auckland Isthmus on a state highway, with Great South Road taking over 50% of the non-state highway traffic.
- A noticeable asymmetry with a bias for south bound vehicles to use SH20 Mangere Harbour Crossing and return north bound on Great South Road or SH1 Southern Motorway. The significant cause for this is attributed to the lack of signals at the MetroPort gate.

Establishing the potential for this approach to be broadened to other major and minor freight nodes in the Auckland region could be explored as a cost effective way of developing a freight matrix for ATAP. This is discussed in more detail in section 6.

The RFN is essentially a form of classification or description – that is, a means of noting which roads are particularly important to freight and have a relatively high proportion of trucks in their traffic mix and are therefore significant contributors to national productivity. So far they have not been a basis for different policies compared with other roads. As noted above, the network focuses on the “movement” orientated corridors.

3.4 Current Network Pinch Points

When asked about specific locations of major freight congestion and delay on the current network, NRC representatives tended to speak of general congestion across the network and in particular the scale and duration of peak period congestion and how this impacted their scheduling.

While the benefits of encouraging public transport, active modes and increased vehicle occupancy were generally acknowledged, it was noted that the impact to freight of reassigning road space to these uses did not from the NRC’s perspective seem to be well considered. For example, the impact of dedicated bus lanes on key arterials results in a loss of general traffic lanes in peak periods. Conversely the potential for freight to use bus and other special vehicles lanes was raised as an opportunity to be explored. This has strong overlap with the Arterial Roads Workstream.

On further interrogation, locations of particular concern correlated, as would be expected, to access to and from major production or distribution hubs; namely the access to Port of Auckland via the Strand, motorway access to and from Wiri, Onehunga / Southdown, Highbrook / East Tamaki and the Airport via 20A / 20B. Projects addressing congestion and capacity, both for general traffic and freight have been identified as part of the Package Development Workstream. It is recommended that each of the projects is reviewed with respect to its contribution to addressing freight congestion.

Known capacity constraints such as Warkworth, the SH20/1 southbound merge at Manukau and the State Highway lane reductions at Mt Wellington and Takanini due to bridge widths were also noted. Priority freight lanes or ramps to and from the motorway at the above locations were noted as desirable.

At a local and very practical level, the quality of loading zones (both on and off-road) and the influence of development control rules on this were raised by NRC representatives. Developers, enabled by the rules, have long prioritised car parking over suitably sized loading zones resulting in inefficient deliveries. For example, a loading zone that enables access and unloading of an A or B Train will reduce the overall number of trips to a location if the same load is to be delivered by a medium goods vehicle. Similarly a loading area that enables optimal access to vehicles reduces time spent in the yard and would increase productivity.

3.5 The Use of Rail in Auckland

Rail does not usually suit operations within urban areas because of double handling costs (often trucks have to be used at one or both ends of the journey). The primary freight market served by rail in the Auckland region is the import / export of containerised cargo with perhaps the most important rail operation within Auckland being shuttle trains between the port and the freight precincts. Double handling costs are usually avoided because the trains go directly from sidings at the port to sidings in freight terminals. As noted above, road congestion deters some freight companies from using trucks for this journey.

Other significant rail freight operations in Auckland involve trains connecting Auckland with other regions, especially to/from the Port of Tauranga and on the main trunk south towards Wellington. Nationally this function is substantial in terms of access and volume, taking the equivalent of around 1000+, 50 tonne truck combinations per day.
Refer to the ATAP Rail Workstream for further detail on the use and anticipated future of rail in the Auckland context.

3.6 Monitoring & Data Sources

A review of existing traffic data and monitoring sources was conducted and included meetings with the relevant teams at the Auckland Motorway Alliance (AMA) and AT. A Workshop was also held with representatives from National Road Carriers (NRC) to assist with understanding key freight issues and challenges.

The key findings of this investigation are that, while both AT and NZTA have monitoring programmes for their networks, there is no specific monitoring of freight. The lack of maintained representative data relating to freight movement and efficiency severely limits AT and NZTA's ability to plan for or improve the performance of freight movements. Ownership of freight functions isn't clear within the organisations, with no budget allocation for improving freight efficiency. Similarly there isn't any specific tool available for the forecasting of future freight traffic demand and distribution.

While there are numerous data sets and sources ranging from fixed inductance loops through to in-vehicle journey tracking software such as SNITCH or TOMTOM; no single dataset is considered a complete picture of the freight sector – with the particular gap being an understanding of journey purpose and length. Many causes of this are issues common to the freight sector, especially the commercial sensitivity of information and breadth of contributing organisations. While eRUC, SNITCH and TOMTOM data are a marked improvement from traditional floating car surveys, the sample size and coverage of various vehicle classes is unclear.

AT have validated SNITCH data against floating car surveys and are satisfied that the data is statistically significant and representative of light and medium goods vehicles, but less certain for Heavy Commercial Vehicles (HCV's) – especially where gradients are significant. Commercial sensitivity and or privacy concerns are cited by both vehicle tracking service providers and freight haulage firms. If this barrier could be removed the consolidation of the various datasets – both physical and technology based – would be expected to provide a rich picture of the wider freight distribution and demand in Auckland.

As such, it is recommended that a consolidated freight data set is developed and maintained for the Auckland region. This would enable establishment of baseline travel patterns and the development and enabling of performance indicators. The sharing of this data within the industry could result in the optimisation of trips, in terms of both timing and consolidation of journeys between operators, and improved productivity.

Proactive engagement with the freight sector to discuss data availability and the potential data uses would be needed. The aim would be to develop an approach that is a compromise - with the potential benefits to the freight sector through greater understanding of the issues at an aggregate level exceeding any potential commercial sensitivity from the provision of that data by individual operators.

Both the AMA and AT agreed that in lieu of freight-specific matrices and data, general traffic congestion is considered an appropriate proxy for freight delay.

3.7 Organisational Focus

There is a lack of organisational capability and focus on the freight task. Historically the Auckland Regional Transport Authority had a key focus on public transport, and local councils an emphasis on roads from an engineering perspective. As such there was and continues to be limited strategic planning relating to the freight task, especially at the regional level.

One such example is the Auckland Regional Council's Freight Strategy (ARC, 2006) which identified a number of recommendations and tasks to support strategic planning of the Auckland freight task. Comparing the findings with that study with the Upper North Island Strategic Alliance discussed below shows little progress on many aspects over the past ten years.

3.8 Upper North Island Strategic Alliance

The Upper North Island Strategic Alliance (UNISA) is made up of the various councils in Northland, Auckland, Waikato and Bay of Plenty. This group is collaborating with AT, KiwiRail and NZTA on initiatives to reduce the cost of doing business in New Zealand, through an Upper North Island lens.

As part of this work the following have been identified as the seven critical issues, at an upper North Island scale, that are limiting economic productivity and New Zealand's ability to reduce the cost to do business. These issues are explained in Table 1.

Table 1: Seven Critical Issues limiting the North Island's Freight Productivity (NZTA, 2013)

No.	Critical Issue
1	**Strategic Road and Rail Network Constraints** There are a number of constraints on the upper North Island strategic freight road and rail network that are limiting our ability to enhance economic performance and reduce the cost to do business in New Zealand.
2	**Delivery of the High Productivity Motor Vehicle (HPMV) programme** There is a need to develop a more coordinated approach to the implementation and communication of the upper North Island HPMV programme. Freight operators require a fast and seamless permitting process, appropriate rules and enforcement, consistent coordination between agencies and regular communication on the status of routes ('whole of journey' network approach).
3	**Utilisation of industrial land** There is a need to understand the likely supply and demand for industrial land (amount, type and location) across the upper North Island so that land and public investment can be provided and staged at appropriate times.
4	**Lack of strategic, integrated land use and transport planning and investment** There is a lack of a comprehensive, integrated approach to current and future land use and land transport (road and rail) planning and investment at an upper North Island scale. A more strategic approach would increase certainty for industry and public sector agencies and support effective industry, local government and central government planning and investment.
5	**Lack of shared and accurate data** A lack of shared and accurate data (e.g. freight volume and value for both road and rail) means it is difficult for public agencies to make well-informed, collective decisions about land use and transport planning and investment that will increase efficiencies for business and public investment.
6	**Need to understand costs of freight supply chains for critical industries in the upper North Island** There is a need to better understand the costs of the freight supply chain for the upper North Island's key economic industries in order to support development / alignment of initiatives by industry and the public sector to reduce the cost to do business.
7	**Challenging local government and central government funding structures** The current range of central and local government funding structures and requirements (i.e. legislation, policy and application) are hindering 'smart investment' decisions due to their multitude and complexity.

The majority of these, particularly those focused on the transport element of the freight task, are confirmed as knowledge gaps or areas for further investigation by this work stream report. Similarly the Auckland-specific road and rail constraints relating to Critical Issue 1 are consistent with the locations identified in this study.

The relevant pages from the Upper North Island Freight Story – Shared Evidence Base (April 2013) are provided in Appendix D.

4.0 Factors Influencing the Future Freight Task

4.1 Trans-Pacific Partnership

The Trans-Pacific Partnership is predicted to accelerate growth in the freight industry. The freight industry is expected to grow in New Zealand by 58% by 2042, which is approximately 2% per annum assuming a linear increase (MoT, 2014a). The freight flows are predicted to increase in all regions across the country with increases of almost double the existing flow by 2042 in Auckland and Canterbury.

4.2 Congestion

Congestion is an increasingly serious problem for freight movements in Auckland. Attempts have been made to improve the issue, such as special lanes for commercial vehicles on the motorway onramps, however total delay times across the network due to congestion are increasing. Along with increasing travel time, travel unpredictability is also creating significant supply chain cost. There is currently limited understanding of the extent of this cost and how to reduce travel variability for freight.

4.3 Dead mileage

Underutilised or empty movements are reducing the productivity of freight operators. The clear imbalance between where imports are consumed and exports are generated is one cause of this problem. While Auckland is the dominant region for consuming imports, exports are principally produced in rural regions further south. This means that the transport system often requires the relocation of equipment, such as containers, from Auckland to other parts of the country (Beca, 2015).

Another prominent factor is the imbalance between the population in the North and South Island and between cities. This results in fewer goods being required in one location than another and consequently the movement of partially filled containers or trucks.

4.4 Larger Ships

Container ships have been growing in size since they first began use in the 1950s, with the 5,000 twenty-foot equivalent unit TEU class of ships that are now visiting New Zealand in increasing numbers having been in use since the late 1980s. The main factor driving this increase in larger ships visiting New Zealand is the post 2009 overcapacity in the Northern hemisphere which has made it more economical to send larger ships to the Southern hemisphere.

4.5 Logistical Services

Logistical services such as forwarding services, distribution centres and online inventory management are being utilized to help manage stock levels, reduce delivery costs and ensure that sufficient stock is held at all points in the distribution chain (MoT, 2014a). These logistical services utilise large trucks to move consolidated loads to distribution centres. Smaller vehicles are then used to deliver reduced loads to the urban area.
Although third party logistic services are being used in New Zealand, they are not as prominent as in overseas markets. New Zealand's large exporters have previously organized

their own transportation systems. The shift towards third party services is now becoming more noticeable with companies such as Fonterra and Carter Holt Harvey recently establishing independent businesses to look after their transportation requirements (MoT, 2014a).

4.6 Information Management and Scheduling

The freight sector is becoming more efficient in road transport as new technology enables more extensive information regarding traffic flows to be made available (MoT, 2014a). A greater proportion of movements are now being scheduled for off-peak periods, resulting in greater productivity, however after hours running has probably reached or is near its limits. There is limited scope for businesses to move freight after hours, due to staff availability at receiving sites, driver fatigue and the additional costs associated with having 24/7 operations.

Freight companies will continue to improve their efficiency as new technology becomes available to ensure that they remain competitive. A study of the road freight industry in Australia stated that Electronic Data Interchange (EDI) technology is becoming increasingly important (IBISWorld, 2011). These systems allow for communication within a company and more accurate information about the location of vehicles. As noted earlier, if the commercial concerns regarding aggregating and sharing this data could be overcome, the ability to understand traffic movements of the freight sector would take a great leap forward.

4.7 Online Services

The development of online communication and shopping services is changing the freight fleet composition.

Email and web based / cloud computing applications are causing a sharp decline in the number of document deliveries. Postal services are continuing to operate, however there is a shift from the traditional documents to parcels (Westpac, 2015). This will see a rise in the number of courier vans which are replacing the traditional postmen. In regards to the number of full time workers in the postal services sector, the decline in document deliveries has seen a reduction from 21,800 employees in the year 2000 to 7,000 in 2014.

The composition of trucks for shipping of retail goods is changing as online shopping becomes more prominent (MoT, 2014a). Traditionally containers of goods would be shipped to distribution centres, which would then be transported by large trucks to retail stores. The retail store is now being removed from the chain and replaced by a direct delivery from the distribution centre to the consumer's house. This presents a need for a larger number of small vans as opposed to a smaller number of large trucks. The same effect is occurring because of increasing pressure for just-in-time deliveries and manufacturers hold smaller inventories.

4.8 Regulation Changes

The rules governing the maximum weights and dimensions of heavy goods vehicles were amended in 2010 with the introduction of the concept of the High Productivity Motor Vehicle (HPMV). These vehicles can operate on specified routes at weights of up to 62 tonnes, depending on the number of axles on the vehicle and the capacity of bridges on the route. This allowed a greater freight task to be carried in one load which reduced the number of trucks and drivers required.

The use of HPMV's had been limited to specific routes because of the potential for damage to pavements and structures on some parts of the network. To address pavement wear concerns and bridge axle loading restrictions, the concept of a 50MAX HPMV was introduced in 2013. The 50MAX HPMV is a longer vehicle and has an extra axle which means that the truck's load is spread further resulting in the same amount of wear on the road surface as the conventional 44 tonne trucks. These vehicles are now able to drive on almost the entire State Highway network and on many local roads.

The introduction of HPMV's has seen an increase in the value added per worker as a result of larger tonnage vehicles being permitted. Many truck firms are switching to them as older trucks wear out. This may also increase the competitiveness of road transport against rail and coastal.

The NRC group were supportive of these changes but believe another incremental step change would come from an increase in truck lengths to 25m from the current maximum of 20-23m (depending on configuration). This would enable more flexibility in the possible container size configurations that can be carried in one trip. However, trials have found that despite the productivity benefits, these vehicles had problems tracking due to New Zealand's relatively tight road geometry.

4.9 Connected and Autonomous Vehicles (CAVs)

The potential for improvements arising from the digital revolution such as vehicle autonomy and platooning are seen by NRC representatives as having very limited impact in New Zealand in the short to mid-term. Several companies have conducted significant investigations and trialling of world leading innovations but to date have not (or at least are not willing to publicly discuss) invested in these. One innovation example cited was the driver assist provided by Volvo which had been trialled but found to currently be of limited value in the New Zealand road environment.

Many technology initiatives were seen as being of greater benefit to driving environments overseas such as motorways and freeways in Europe, Australia and the United States where distances are often longer, off-ramps less frequent and the topography less demanding.

5.0 Auckland's Freight Future – Key Challenges and Opportunities

5.1 Future Network Pinch Points

In considering where future problem locations might occur, the general consensus from NRC was an expectation of southward migration tied to the development and/or intensification of industrial land at Manukau / Wiri followed by Takanini and in due course Drury.

The quality of access to the proposed greenfield growth areas identified in the Unitary Plan and Future Urban Land Supply Strategy were also noted both from a construction and eventual servicing perspective. This was both about how freight will access the areas and the impact that the development and intensification of these routes will have on general traffic – for example the reliance on SH16 to serve the Kumeu / Huapai area.

Participants recognised the significance of good ground conditions as being an indicator of the potential for uptake of industrial land – seeing continued development of the Airport precinct and future development of the Drury South industrial park as likely prospects due to the ease of development of distribution and warehousing facilities.

There was strong support for Ara Tūhono – Pūhoi to Warkworth, East West Connections and the Waterview Connection. The opening of the Waterview tunnel will provide an alternative route for freight that would previously have had to cross the Harbour Bridge. Beca (2015) made a rough estimate that 15% of freight traffic currently crossing the Harbour Bridge would be diverted to the Western Ring Route once the Waterview Tunnel is opened. This figure is expected to increase to 30% with the opening of the East-West Connection.
NRC representatives anticipate an increase in congestion issues south of Manukau on completion of the Western Ring Route and SH20A/B upgrades (rerouting from PoAL to Wiri/Manukau) however the Southern Corridor Improvements project is expected to address this to some extent.

5.2 Growth by Mode

Future predictions for freight movement are for an increase across all of the modes of transport mentioned in Table 2 and Table 3 by 2042. The forecast increase in freight in tonne-kms over the next 30 years is consistent (48%) across rail, coastal shipping and road (16%, 13% and 71% respective current share of total freight tonne-kms). However, there is uncertainty around projects over such a long period, because of unknown economic, social and technical developments.

Table 2: Forecast Growth in Freight in New Zealand by Mode 2012-2042 in million tonnes (MoT, 2014a)

Year	Rail	Coastal Shipping	Road	Total
2012	16.1	4.2	216.0	236.3
2042	24.3	7.60	341.0	372.9
Growth to 2042	51%	81%	58%	58%

Table 3: Forecast Growth in Freight in New Zealand by Mode 2012-2042 in billion tonne-kms (MoT, 2014a)

Year	Rail	Coastal Shipping	Road	Total
2012	4.1	3.5	18.6	26.3
2042	5.9	5.1	27.6	38.8
Growth to 2042	44%	46%	48%	48%

It should be noted that no assessment has been completed to determine if rail can accommodate this task on existing infrastructure, particularly in Auckland where the network is shared with passenger trains.

5.3 The Role of Rail

The use of rail is expected to continue increasing gradually as companies look for more efficient and productive ways to transport freight domestically. Evidence from the Port of Tauranga[1] showed that where a new uncongested road route is available there is the potential for existing rail movements to be replaced by additional road movements. Freight movements are much more sensitive to the cost of travel. Mode and route choice react rapidly to changes in relative cost.

This was a view supported by the NRC workshop attendees who were sceptical when asked about the potential for rail to deliver more of the freight task, with the consensus being that rail had a role to play but that it would remain of limited significance in Auckland. The reasons given for this were numerous but in summary appear to be driven by:

1. a lack of responsiveness to scheduling and distribution requirements, and
2. reliability issues arising from the state and capability of assets (both tracks and rolling stock).

Auckland is a shared network catering for both passenger and freight demands. The ability to cater for additional services (both passenger and freight) will be limited without further investment. Refer to the ATAP Rail workstream for more detailed information.

5.4 Coastal Shipping

The largest increase in freight in tonnes is expected to occur in the coastal shipping industry, with a predicted increase of 81%. Coastal shipping was only briefly discussed with NRC but, due to the duration and speed of journeys, it was not seen as having significant potential in contribution to Auckland's freight task.

5.5 Consequences of Larger Ships

The increase in ship sizes require ports to upgrade their services to cater for larger ships. These upgrades include inland port development, deeper channels and larger quay cranes.

[1] Following the completion of the second harbour bridge and the removal of tolls for the crossing there was a marked increase in the HCV movements across the Harbour Link. Investigations showed that the growth was related to the replacement of rail based transfers of empty containers to road based.

Only some of New Zealand's ports will be able to make the required upgrades due to monetary and spatial constraints. Companies with larger ships may choose to make fewer New Zealand port calls. Thus the number of international container ports in New Zealand may decrease. This could lead to an increase in freight costs and increase in competition as the average distance that freight must travel domestically to reach its final destination increases. There is expected to be port consolidation and alliances as the ports become more competitive (MoT, 2014b).

The pattern of freight movement is expected to become more tidal with a higher quantity of trucks required to unload shipping freight while these vessels are in port, followed by a lull while the port waits for the next large vessel to arrive. Overall there are cost pressures working in opposite directions: larger ships that offer lower costs per tonne kilometre and higher landside freight costs. The net impacts on different New Zealand ports is not known, but it is expected that Auckland and Tauranga will retain or even increase their importance, with consequences for truck and train movements in the Auckland region. This is evident from current trends towards consolidation of shipments in the Upper North Island, and in particular at the South Auckland inland ports.

A capacity analysis performed by MoT (2014b) found that the current transport network generally had sufficient capacity to cater for larger vessels. However insufficient capacity was noted to occur on the road and rail routes around the ports of Auckland and Tauranga. These areas will require upgrading to provide sufficient capacity and travel time reliability for the time sensitive requirements of large vessels.

5.6 Freight Scheduling

It is believed that a greater proportion of freight movements will have to occur at night in response to Auckland's congestion. Representatives from NRC believed that this is already taking place, with freight scheduling prioritising movements in the inter peak and at night. However, there are labour supply issues and consent conditions associated with night working and current literature suggests that this approach is only used in the transportation of containers from ports to intermediate holding areas.

5.7 Logistical Services

Growth in the logistical services industry is expected to steadily increase for the foreseeable future but at a slower pace than in the past ten years. The reduction in positive growth rate is due to two main factors; China becoming more developed and therefore requiring less imported goods, and a large number of international trade barriers that have already been removed (Westpac, 2015).

Part B - Quantifying Freight Delay

The ATAP terms of reference require a methodology that can:

1. Understand the current freight delay cost;
2. Forecast future freight delay cost; and
3. Test the effectiveness of investments on key freight routes.
4.

To understand the freight cost (current or future), two pieces of information are needed:

1. An estimate of the cost ($ per unit) of freight travel time;
2. The quantum of freight transport demand.
3.

The following sections first consider elements contributing to the cost of freight travel time before outlining a methodology for assessing and forecasting freight transport demand.

6.0 Valuing Freight Travel Time

6.1 Components of freight travel time cost

Gillett (2001) noted that there are three components of the supply chain which impact the value of freight travel time. These are listed below:

- Direct costs – The cost directly associated with moving goods from one location to another, and can include costs such as fuel, driver wages, and the cost of the truck.
- Direct inventory costs – The cost associated with inventory, e.g. warehousing costs and the cost of holding additional inventory as a result of higher travel times.
- Obsolescence costs - A subset of inventory costs. Obsolescence costs are the costs associated with the risk of inventory depreciating while in transit.

Gillett (2001) also noted that obsolescence costs would be the most relevant component for accounting for the value of the commodity. In a separate study aimed at investigating freight delay costs for railroads, Lovett (2014) noted that it is common practice in North America for goods suppliers to charge railroad companies a negotiated penalty for late delivery, representing lost revenues or increased costs. These discount rates range from 15% a day for perishable goods to 5% a day for bulk goods.

6.2 Values of direct freight travel time

Utilising values from NZTA's Economic Evaluation Manual (EEM) reveals a combined driver, passenger and freight travel time for a weekday Urban Arterial traffic mix of $61.10 per hour in 2015 dollars. This excludes vehicle operating costs. The calculation is included in Appendix E.

A comparable Australian figure of $77.18 (2015 NZ$) was generated from the 'Austroads – Guide to Project Evaluation Part 4: Project Evaluation Data'. It should be noted that the value of 'commuting' and 'other' driver costs were kept in the same proportion to the values provided by the EEM. The major factor leading to the higher cost per hour is that the freight time component is valued highly in Austroads. The calculation is included in Appendix E.

Internationally estimated costs per hour of freight travel time vary considerably, through the different basis of estimation (resource cost versus 'willingness to pay'). Table 4 shows an estimated cost per hour of travel time between $55.29 and $128.97 (2015 NZD$). It is recognised by the Federal Highway Administration FHWA that the valuation of travel time is an unsettled aspect of benefit-cost analysis, hence the range of costs.

Table 4: Cost per hour of freight travel time from overseas studies.

Location	Author	Cost Per Hour (2015 adjusted $NZD)
USA (FHWA)	FHWA (2008)	$55.29
Texas (Texas A&M Transport Institute - TTI)	Urban Mobility Report (2015)	$128.97
Australia	Austroads (2012)	$77.18
USA	American Transportation Research Institution (ATRI) (2014)	$89.83

*The 10 year average NZD$-USD$ exchange rate of 0.73NZD$ per USD$ has been used for currency conversion

The NZTA EEM's value of freight travel time of $61.10 is below the average of the range provided by the four international studies shown in Table 4. It is noted that New Zealand costs are not directly comparable to international costs due to differences in cost of living, legislative environments, fleet composition, and a host of local factors. The next section has a comparison to remove some of these differences.

6.3 Valuation of New Zealand freight travel times

To remove some of the local cost factors from the comparison, scale factors have been developed between freight travel time costs and general traffic costs. This is intended to remove variations due to international income differences, inflation, GDP, and legislative environments. However, legislative requirements specific to the freight industry and differences in fleet composition cannot be removed.

Table 5 adjusts values of time for inflation for the studies above and calculates the scale factor between freight travel time valuations and general traffic costs. Due to the coarse nature and small sample size, this is an indicative study only and would need additional international evidence to provide additional confidence.

Table 5: Hourly value of freight travel time for New Zealand and international studies after adjusting values into a New Zealand context.

All costs are in 2015 $NZD	Hourly Value of Time (Composite)	Value of Freight Travel Time	Scale Factor
NZTA EEM (2014)	$32.49	$61.10	1.9
FHWA (2008)	$17.80	$55.29	3.1
Urban Mobility Scorecard (TTI, 2015)	$24.21	$128.97	5.3
Austroads (2012)	$28.85	$77.18	2.7
ATRI Study (2014)	$29.78	$89.83	3.0

The EEM scale factor value at 1.9 is the lowest of international estimates. If the highest of the international scale factors of 5.3 was utilised on the EEM value of time, the value of freight travel time would be approximately $170 per hour. The scale factors and ranges could be used to develop sensitivity tests in freight valuation assessments. However, it is noted that the composite value of time from the EEM is higher than all the overseas data and higher by some 30% than the TTI data. As such, this $170 could be considered to be the upper end extrapolation of all the data sets reviewed.

Methodologies aimed at developing an Auckland-specific freight value of time were investigated but ultimately discarded. Valuation of freight travel time using land use areas and commodity production with mass balancing were considered (and were used in a similar study for Southland), however mass balancing would not be an appropriate technique for Auckland.

6.4 Basic delay and the value of reliability

Lovett (2014) noted that holding costs are primarily affected by the variability of delivery rather than absolute travel time. Under ordinary circumstances where there is no serious time constraint, travel time reliability is valued at 80-100% of the value of time. In the presence of a significant non-flexible arrival or departure constraint, travel time reliability is valued at up to three times the basic value of time. A separate FHWA study notes that, depending on the product carried, unexpected delays can increase the value of travel time by 50% to 250%.

The NZTA EEM (Appendix A4.5) utilises a value of 90% as the value of reliability. This is based on a typical urban mix (NZTA, 2014). Cars utilise a value of 80% and commercial vehicles utilise a value of 120%. The EEM does not calculate reliability benefits based on travel time reduction (captured as travel time savings), but on the reduction in journey time variability (for which journeys with highly congested links exceeding capacity are likely to have more than the average travel time reductions).

Kruger (2013) addressed the value of reducing freight time volatility. The Swedish government guidelines for cost-benefit analysis recommend factoring travel time reductions by a value of two. This is intended to reflect the likely improvement in reliability, where their researchers derived values of reliability at approximately 90% of the value of travel time. This study also referenced studies from Denmark and the Netherlands which found that the value of reliability for freight was between 90% and 130% of travel time value.

It should be noted that the type of goods being transferred will result in a wide variance in the value of reliability. At the lower end of the reliability value are goods that are non-perishable and are intended for storage for a period far in excess of any variability. An example of this is warehousing and distribution of non-perishable goods where the reliability element of the costs relates to the number of vehicles required to move a given quantity of goods daily. With uncertain journey times an operator may need to run an additional vehicle to provide the capacity. At the other end of the spectrum is the movement of perishable goods to the port for export, where storage space is constrained precluding early arrival, and failure to arrive in time means that goods miss an export sailing and lose the majority of their value.

In summary, the majority of studies value the reliability of freight travel time at between 80% and 130% of travel time value, and using a value of 90% of travel time for reliability appears reasonable on aggregate. As a future aspiration, it would be beneficial to acquire data and consider methodologies for considering different reliability rates for particular sub-sets of freight vehicles or between specific origin and destination pairs where land uses lead to higher or lower sensitivity for journey time reliability.

7.0 An Approach to Assessing Freight Demand

7.1 Overview

The quantification for freight movements is generally of a lower quality than private vehicle movements in urban transport models. There are several reasons for this, including:

- Freight movements are a relatively small minority of vehicle movements during the peak periods;
- First order economic benefits for private vehicle congestion are an order of magnitude higher than freight related benefits;
- Data for individual journeys (private vehicles) is readily available from data sets including the census and household travel surveys; and
- Design is often focussed on alleviating a peak hour congestion issue which requires a solution to address a pattern of demands driven predominately by private commuter movements.

To be able to provide the ATAP Freight workstream with adequate tools for quantitative assessment of freight movement there is need to understand the following:

- Number of freight vehicles travelling on the network;
- The routes used by the freight vehicles;
- The delay experienced by those freight vehicles;
- The likely changes in journey time as a result of potential future network and demand changes.

The key consideration for this workstream is not just the ability to quantify the network today, but more importantly to forecast future conditions and be able to provide comparable quantification of the benefits (or disbenefits) to freight from potential interventions. As a result, a methodology that is aligned to a forecasting tool was considered essential.

7.2 The Role of the Auckland Regional Transport Model

NZTA and AT have heavily invested in a hierarchy of models over many years. Whilst these models are likely to evolve in the medium to long term future, for the purposes of this workstream it was considered that the existing strategic transport models, most notably the Auckland Regional Transport (ART) model, should be used to provide the data for the effects of forecast changes. Whilst the ART model has very limited freight data as input, the use of the model for the assessment of other ATAP workstream interventions means that there are logical and practical efficiencies that arise from using this tool as a consistent means for forecasts.

However, whilst this approach offers consistency, it is understood that there are significant shortcomings in the direct application of the ART model to freight movements. It is important to understand that this is not a particular failing of the current model, only that the specific focussed application of the tool when applied to freight movements is outside the purpose for which the model was initially developed.

7.3 Available Datasets

There are numerous data sets that provide evidence of current freight movements, either in terms of volume, route choice or journey time. These include classified 'loop' counts that provide quantification of volume at specific points in the network, Bluetooth monitoring that can imply journey time for goods vehicles discrete from cars over longer distances, and collated GPS data sets including TOMTOM and eRUC that provide journey time and route data. Whilst these data sets all provide components of the quantified 'freight' demand, individually they don't provide a full picture of the pattern of current movements, and as they are 'observed' data they don't provide the future assessment that is required.

However as all are long term sources of data there is a robustness that they provide that can inform an annualised long term assessment of freight demands, noting that in the case of several key freight categories, the movements vary through seasonal changes. These fluctuations are not just in agricultural exports, but also apply to construction related movements – so the use of data related to a single month would not represent the total freight picture.

7.4 Proposed Approach

The proposed way forward is to develop a base matrix of freight demand and of average journey times between areas of the Auckland network from the available observed data sets. This data will then be compared with the data in the ART model to provide an 'adjustment' matrix that will be used as a comparator for forecast changes. This technique is commonly used in transport modelling when seeking to develop a calibrated model with forecast demands being provided by a higher level strategic model. This differs in application here because the relative level of data pertaining to freight in the ART model is significantly lower than the observed data that we have available. As such, the approach is considered viable for the high level assessment and for comparing candidate schemes, but a greater degree of rigour is recommended to provide the evidence base for the assessment of individual schemes prior to implementation.

Specifically, it is suggested that the eRUC data be used as the platform for the assessment of the freight movements. This data set provides a sample of the freight movements on the network. The proportion of movements has increased over recent years, and analysis undertaken by others has suggested that the dataset does not contain any significant bias within freight movements. However, the proportions of HCVs that are recorded are still relatively low, and critically eRUC data in itself does not quantify that proportion. Where the eRUC data does provide valuable information is in its ability to provide long term (monthly and annual) data on route choice and journey time. We are therefore proposing to overlay the ART model zones onto the eRUC database and match the origin and destinations of all eRUC recorded journeys in Auckland. As well as the demand volume, the journey time and journey time variability can be extracted from the eRUC data set.

7.5 Scaling and Calibration

The ‘demand’ matrix will only be a minor proportion of freight movements. In order to develop a ‘full’ demand matrix we also propose to produce link counts from the eRUC data that match a sample of the classified loop counts across the Auckland network. These loop counts are considered to produce highly accurate (within 5%) rates and we would then use these observed rates to factor up the demand matrix. The specific methodology for this is to be defined once the data is supplied, but may consist of a uniform growth of the matrix using the average of the observed counts. Conversely, if there is a greater degree in the observed versus eRUC volumes along different key routes, then sector-based Furness and / or matrix estimation can be undertaken.

The Bluetooth data for available routes for several different time periods will be compared to the ART model and the eRUC data to provide models that link journey time to journey time variability for different network conditions.

It is also noted that eRUC vehicle classes do not immediately equate to those used by the Transport Agency’s Project Evaluation Manual (PEM). Assessment of complementary datasets would be required to better understand the composition of the eRUC data and how this might need to be factored for use in establishing a regional freight matrix.

7.6 Approach Summary

Combining all of these discrete data sets then produces the following methodology for the quantified assessment of the economic value of freight in different conditions:

1. Code base and forecast networks into the ART model
2. Output matrices of the travel time between OD pairs from ART
3. Create matrix of change in OD journey time between all the OD pairs in base and future ART models
4. Apply change matrix to observed (eRUC based) journey time.
5. Apply journey time variability model to calculate increase / reduction of reliability for OD pairs
6. Multiply inflated (eRUC and loop count based) demand matrix to quantify the total direct economic cost of freight travel (product of volume and efficiency).

There is the potential to apply a further level of sophistication to this model which would look at second order effects of changed freight efficiencies in relation to agglomeration, and third order benefits as a result of potential national and international competitiveness. However, whilst having significant economic value effects on the region, these are significant extrapolations from the data and so carry a high risk.

The above methodology relies on the use of the eRUC derived data. This data is owned by the NZTA and currently held by Beca.

We have considered the use of alternate data sources however an assessment showed that the eRUC data would provide the most robust and cost effective data source. Alternatives to matrix development could be used if the eRUC is not available in a timely manner or is not

considered cost effective. These alternatives include OD surveys and fully synthesised methods (from observed link counts) factored from employment land use.
It should be noted that, due to the tight delivery programme of ATAP, this work would need to extend beyond the completion of ATAP.

8.0 Conclusions & Recommendations

This investigation into freight in Auckland has confirmed the significance and importance of the region in the national freight task. Forecasts from the MoT expect the New Zealand freight industry to grow by 58 % by 2042 with a near doubling of existing flows experienced in Auckland. While rail and coastal shipping mode shares are expected to grow, in absolute terms road transport will continue to carry the vast majority of freight.

8.1 Road Freight Congestion

The belief that Auckland's congestion is having a negative impact on freight has been confirmed in recent meetings with the freight industry where evidence of decreasing service offerings over time, both in terms of frequency and geography, due to increasing congestion, was provided. As would be expected, areas of particular concern correlated to access to and from major production or distribution hubs.

Looking forward, freight carriers expect congestion issues to spread south. This is tied to the development and/or intensification of industrial land at Manukau / Wiri followed by Takanini and in due course Drury. They also noted the potential impact that development and intensification of proposed greenfield developments will have on freight generation and access.

Whilst there is uncertainty as to the impact of larger international ships visiting New Zealand and the subsequent role of rail as a shuttle to the inland ports and regions, road freight to and from PoAL is expected to continue to increase. A review of available data has confirmed that approximately 80% of freight originating from PoAL travels via the motorway network, validating to some extent the Regional Freight Network.

8.2 Assessing Freight Demand

To understand the cost to the economy of delay and congestion impacting the freight fleet now and in the future, both the cost of freight travel time and freight transport demand need to be understood. While we have values for the former, the latter item, namely an understanding of freight transport demand, is currently a significant gap.

Our assessment identifies an approach to assess freight transport demand that compares output from the ART model with a range of datasets including eRUC, Bluetooth and classified vehicle counts. This approach develops a base matrix of freight demand and of average journey times between areas of the Auckland network from the available observed data sets. This data would then be compared with the data in the ART model to provide an 'adjustment' matrix that could be used as a comparator for forecast changes.

8.3 Key Findings

The findings of this report are not particularly new. Comparison with the Auckland Regional Council (ARC) Freight Strategy (2006) and the Upper North Island Strategic Alliance's Critical Issues (2013) shows little advancement on a number of common issues. This is in part due to a lack of organisational capability and focus on the freight task.

Historically the Auckland Regional Transport Authority had a key focus on public transport, and local councils an emphasis on roads from an engineering perspective. As such there was and continues to be limited strategic planning relating to the freight task at the regional level.

Another key aspect that has previously held back understanding of the freight task has been the broad and diverse spectrum of the task and its participants which has made gathering of reliable and comprehensive data challenging. In recent years there have been significant advances in the industry's ability to gather data on freight traffic. While still not a perfect or entirely complete coverage of the freight sector, this step change provides a vital enabler for transport agencies to plan for freight. As such, investing in data capture, monitoring and ultimately development of multi-modal freight demand and distribution tools, such as models, to assist strategic planning should be considered.

8.4 Recommendations

The majority of the recommendations identified in this report require investment beyond ATAP. Actions for immediate consideration in ATAP are:

- From the Round 2 Package Evaluation – Consider how the inclusion or omission of the AWHC and other significant strategic freight network improvements impact freight congestion and distribution.
- While recognising that eRUC data only represents a proportion of freight traffic, use regional eRUC data to verify current assumptions of the Strategic Freight Network. One approach would be to assess which areas the package is affecting and compare these with freight congestion data e.g. AT's freight monitoring and eRUC heat maps. Unitary Plan zoning maps would assist in identifying current and future commercial areas.

Recommendations that should be considered beyond the current ATAP scope:

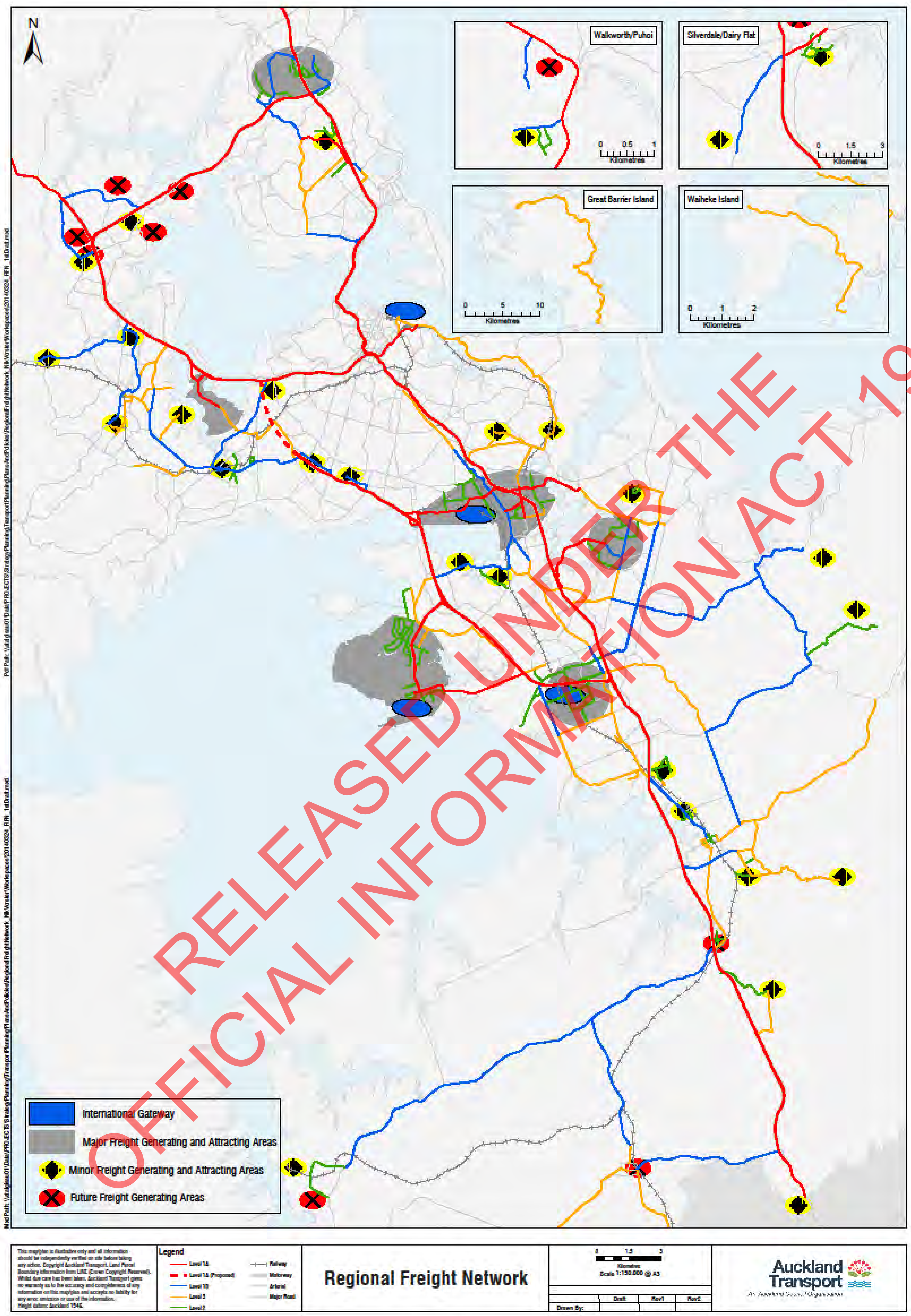
- Address knowledge and data deficiencies
  - Develop and apply an adjusted freight matrix to assess future freight demand and enable quantification of delay and congestion costs.
  - Establish a consolidated accessible freight dataset for the Auckland region.
  - Develop a multi-modal regional freight model(s) to assist in the management and planning of freight movement and distribution.
- Develop strategic freight planning capability
  - Engage further with PoAL, Port of Tauranga and KiwiRail to develop an enhanced understanding of capabilities, operations and future aspirations.
  - Develop organisational focus and capability in the freight sector to enable and enhance strategic planning of this significant transport sector.

Appendix A

As part of the review to identify locally available data and international studies on the topic, a number of papers have been reviewed as listed below:

- 2015 Urban Mobility Scorecard, The Texas A&M Transportation Institute (TTI), 2015
- Auckland Regional Freight Strategy, Auckland Regional Council (ARC), 2006.
- Beca Freight Studies 2015, Beca, 2015.
- Determining freight train delay costs on railroad lines in North America, A. Lovett, 2014.
- Economic Evaluation Manual, New Zealand Transport Agency (NZTA), 2014.
- Freight Information Gathering System, Ministry of Transport (MoT), 2016.
- Freight Story 2008, Federal Highway Administration (FHWA), 2008.
- Future Freight Scenarios study, Ministry of Transport (MoT), 2014b.
- Guide to Project Evaluation Part 4: Project Evaluation data, Austroads, 2012.
- Industry Insights- Transport, logistics and distribution, Westpac, 2015.
- Level of Service Metrics, Austroads, 2015.
- Monetizing truck freight and the cost of delay for major truck routes in Georgia by J. Gillett, 2011.
- National Freight Demand Study, Ministry of Transport (MoT), 2014a.
- NCHRP Synthesis 298 – Truck Trip Generation Data, Transportation Research Board, 2001.
- Road Freight Transport in Australia, IBISWorld, 2011.
- The impact of freight delay to economic productivity, Florida Department of Transport (FDOT),
- 2014.
- Traffic Counts, Abley Transportation Consultants, 2016.
- Upper North Island Freight Story, New Zealand Transport Agency (NZTA) 2013.
- Value of Freight Time Variability Reductions, Kruger, 2013.

Appendix B



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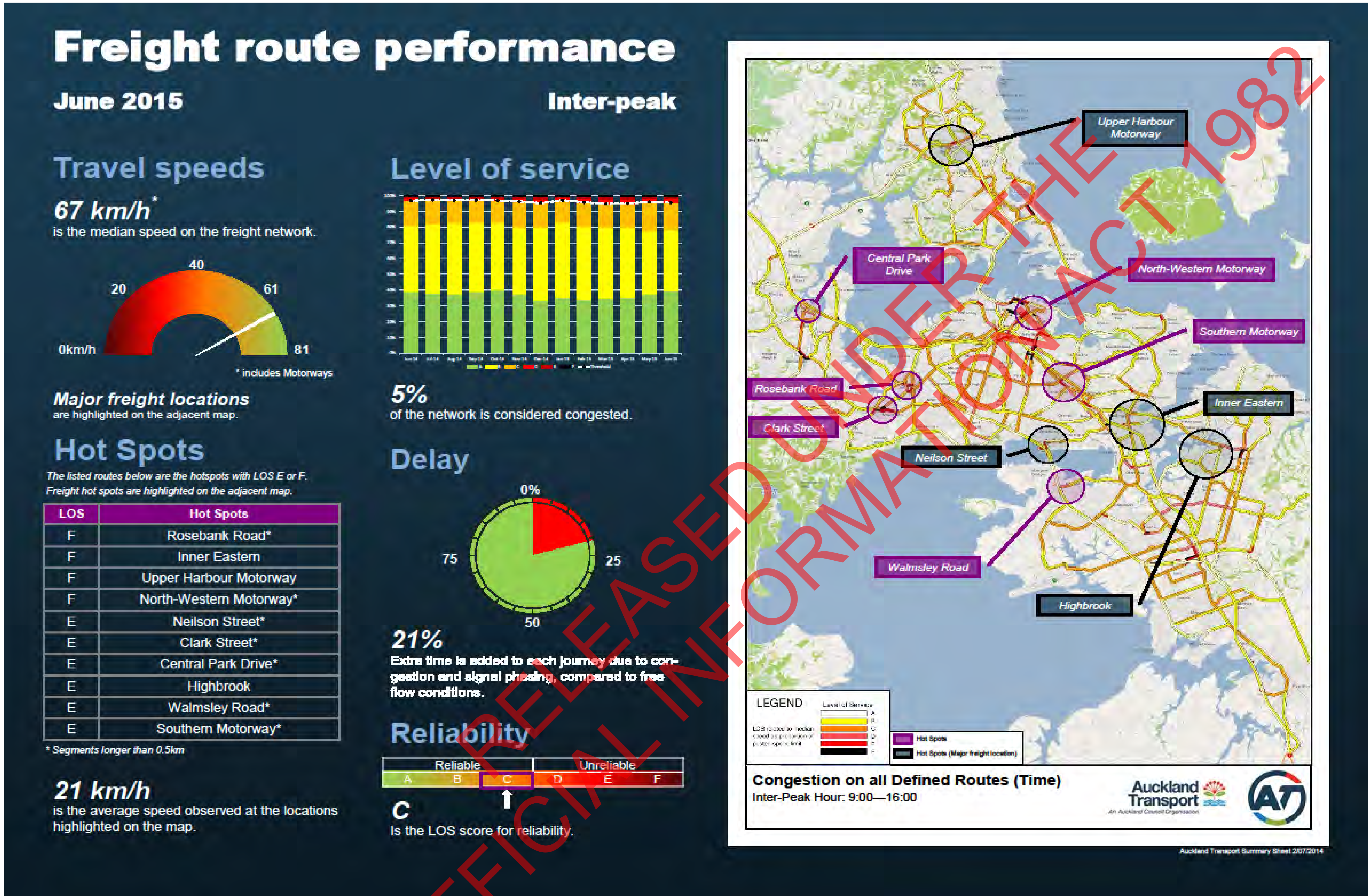
Appendix C



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Appendix D

REF #	NAME OF CORRIDOR	NAME OF CONSTRAINT	MONITORING REFERENCE ID (Freight flows model)	STRATEGIC LINK National Network i.e. State Highway classification / RLTS classification	KEY ISSUE with constraint in reducing the cost to do business	VOLUME Average Annual Daily Traffic (AADT) through constraint 2011 data	VOLUME % Heavy Vehicles within AADT through constraint	VALUE of product carried through constraint 2011 (2007$mil)	CORRIDOR LEVEL STRATEGIC RESPONSES What is the range of strategic interventions that could be considered? Includes short (0-5yrs), medium (6-10 yrs) and long –term (>10 yrs). Committed investments or current processes noted where known	BENEFITS POTENTIAL to be realised through a upper North Island collaborative approach	AREAS FOR UPPER NORTH ISLAND COLLABORATION To assist in resolving the constraint
Auckland – Road											
ARD1	Auckland North - South State Highway Corridor	**Auckland Harbour Crossing**	01N00424 01N10424 01N20424 (Centre span + 2 X clip ons)	SH1 National Strategic Route Classification	Congestion and travel time reliability. Need to manage growth in heavy vehicles in medium-term. Restrictions on use by HPMVs.	158,220 (2011)	5,850 (5.0%)	$75,458	**Short term:** • Alternative Western Ring Route (Waterview and SH16 committed) • SH1 Corridor Optimisation - signal optimisation, ramp metering, freight priority lanes • Removal of pinch points on the strategic road network to improve throughput • Auckland Harbour Bridge heavy freight vehicle management • Travel demand management programmes – public transport service improvements, increasing vehicle occupancy, parking management • Additional Harbour Crossing Route protection **Medium term:** • Complete removal of pinch points on the strategic road network • Auckland Harbour Bridge heavy freight vehicle management **Long term:** • Construction of additional Auckland harbour crossing • Travel demand management – road pricing	High	
ARD2	Auckland North - South State Highway Corridor	**General North - South route (SH1)** Ports of Auckland to SH2	01N00463	• SH1 National Strategic Route Classification. • Part of a HPMV Investment Route	Congestion and travel time reliability including HPMV structural constraints.	128,165 (2011 at Green Lane I/C)	7,180 (5.6%)	$70,874			
ARD3	Auckland Urban State Highway Links	**Airport Access (SH20A & SH20B)**	20A00003	SH20 National Strategic Route Classification.	Congestion and travel time reliability.	61,600 (2011, SH20A & SH20B)	3,600 (5.7%)	$14,436 (SH20A)	**Short term:** • Improved road access to the port - Grafton Gully investigation (underway) **Medium term:** • Upgrade of road access to the port **Long term:** • Upgrade SH20A to motorway standard (includes grade separation) • Upgrade SH20B to expressway • 6 lane SH20 from Mangere to Puhinui • Travel demand management – road pricing	High	
ARD4	Auckland Urban State Highway Links	**Port Access (SH16)**	01600001	SH16 National Strategic Route Classification Part of a HPMV Investment route	Congestion and travel time reliability.	42,790 (2011)	3,125 (7.3%)	$30,873			

Upper North Island Freight Story – Shared Evidence Base (April 2013) 15

Click on image to enlarge

Appendix E

Cost of freight $/hr breakdown (EEM)

Type	Value
Occupancy	1.2
Percentage of work trips by MCV/HCV (%)	
Work	90
Commute	5
Other	5
Update factor to convert from 2002 value to 2015	1.44
Human Capital Cost ($/hr 2002)	
Driver – Work	20.10
Commute	7.8
Other	6.9
Passenger – Work	20.10
Commute	5.85
Other	5.2
Freight cost ($/hr 2002)	
MCV	6.1
HCVI	17.1
HCVII	28.1
Percentage weighting of commercial vehicles (%):	
MCV	25
HCVI	25
HCVII	50

	Calculation	Total ($/hr)
Driver Value	(0.9 * 1 * 20.10) + (0.05 * 1 * 7.8) + (0.05 * 1 * 6.9)	18.83
Passenger Value	(0.9 * 0.2 * 20.10) + (0.05 * 0.2 * 5.85) + (0.05 * 0.2 * 5.2)	3.73
Freight Cost MCV HCVI HCVII	 0.25*6.1 0.25*17.1 0.50*28.1	 1.53 4.28 14.05
Total cost per hour ($/hr 2002)		42.42
Total cost per hour ($/hr 2015)	**42.4 * 1.44**	**61.10**

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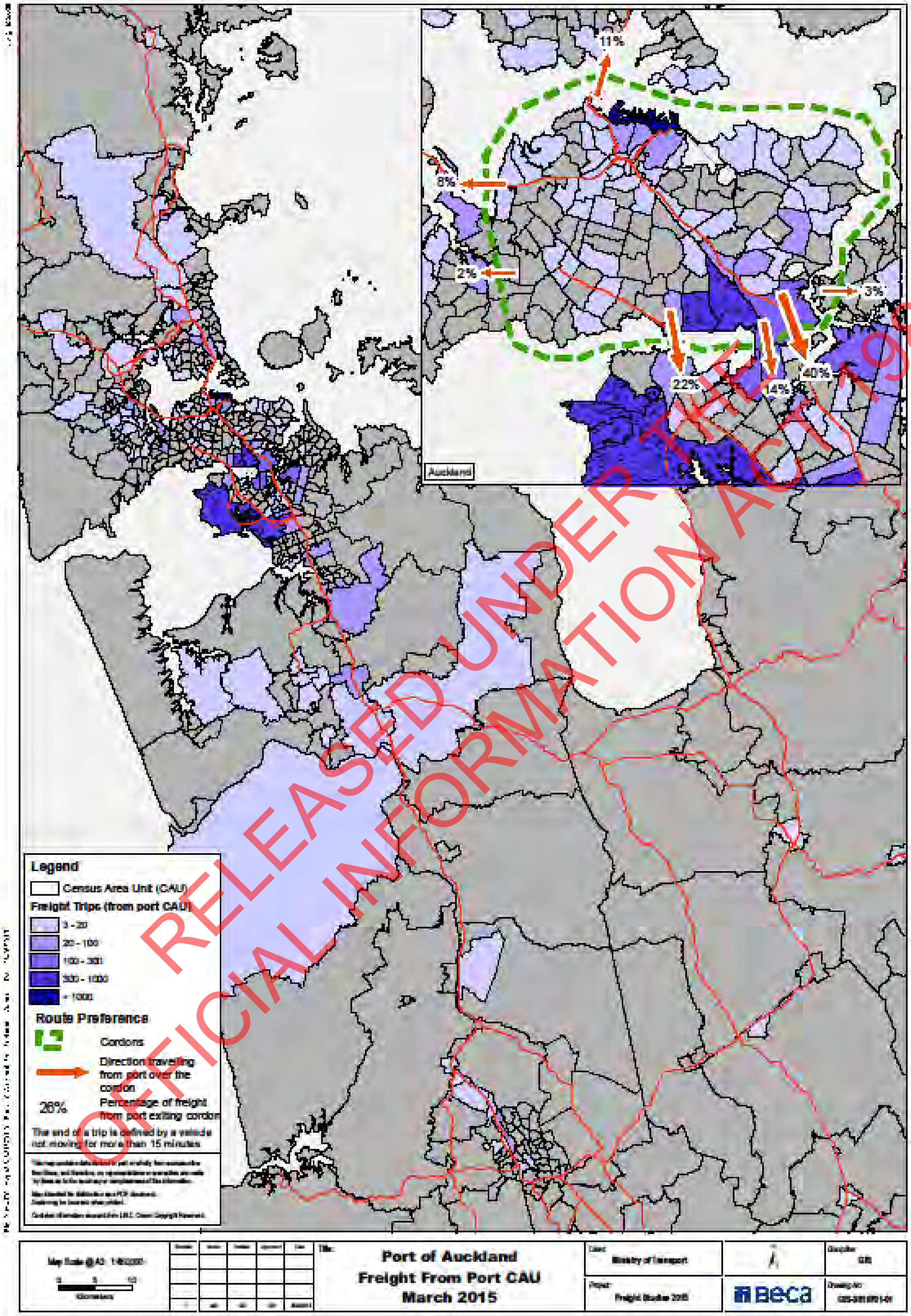
Appendix F



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Auckland Transport Alignment Project

Interim Report: Findings and Conclusions – May 2016

Ministry of Transport
Te Manatū Waka

The Treasury
Kaitohutohu Kaupapa Rawa

Auckland Council

Auckland Transport

State Services Commission
Te Komihana O Ngā Tari Kāwanatanga

NZ Transport Agency
Waka Kotahi

Document Structure

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  - Key learnings
  - Emerging strategic approach
  - Next steps
- 1. Background
  - Purpose and objectives
  - Auckland's transport challenge
  - Analysis informing this document
- 2. Key Learnings
  - Revenue and land use assumptions
  - Optimising existing networks
  - Testing alternative investments
  - New opportunities
- 3. Emerging Strategic Approach
  - Towards a strategic approach
  - Influence travel demand patterns
  - Make better use of existing networks
  - Provide new infrastructure and services
- 4. Next Steps
  - Steps to the final report
  - How should we prioritise future investments?
  - Feedback sought

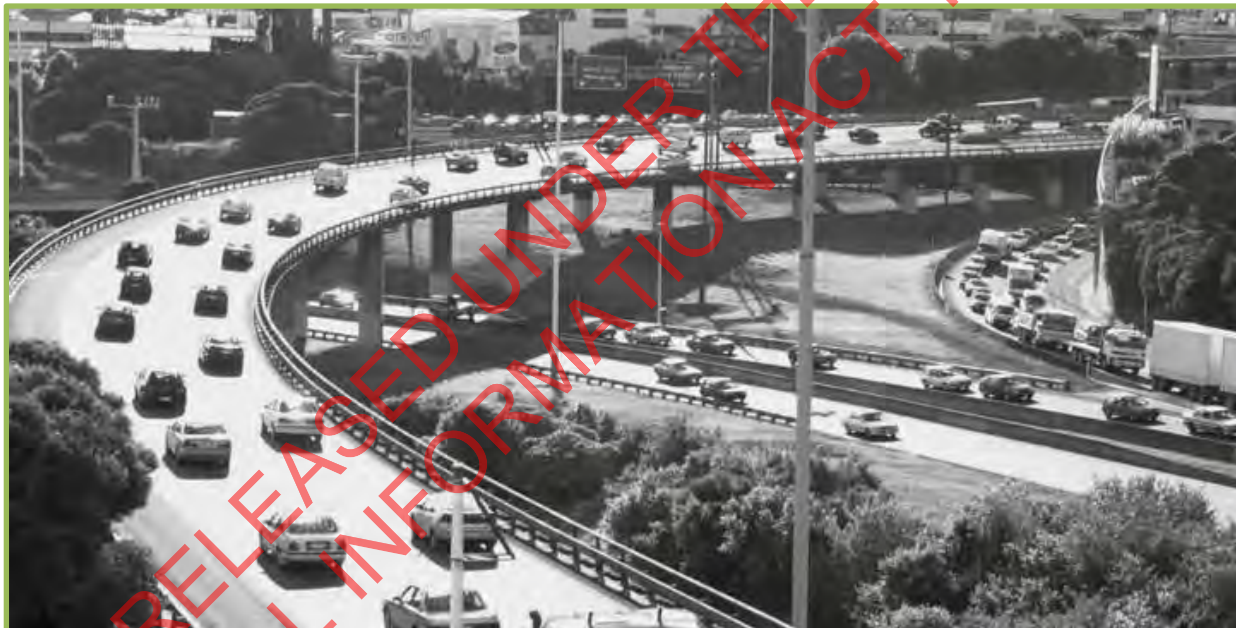
Executive Summary

Key learnings

Emerging strategic approach

Next steps

Executive Summary



Key Learnings

This report is the second ATAP deliverable. It presents interim findings and conclusions from the work undertaken to date and sets out the emerging strategic approach for review and feedback from the project parties.

Short-term funding plans are mostly committed

There is limited forecast discretionary funding available for investment in the short term, as much of the Decade 1 programme is already committed to significant investments including the City Rail Link, East West Connection, Puhoi-Warkworth, and the Accelerated Motorway Package.

Even with these investments in place, there is a projected decline in network performance by 2026. This problem will be exacerbated if, as recent trends suggest, growth is faster than the medium population projection assumed in ATAP.

We have developed two alternative scenarios to estimate future revenue available for transport in Auckland: one based on maintaining current per capita investment, and another maintaining the current share of Auckland's GDP invested in transport. These provide an indication of likely future affordability, but are above currently forecast funding levels.

Changing the investment mix will not achieve a step-change

The vast majority of Auckland's future transport network already exists today. To help accommodate growth, the productivity of this existing network needs to improve. This requires a combination of better network optimisation, continued improvements to asset management, and a greater focus on Intelligent Transport Systems (ITS).

It is possible to deliver better results by changing the mix of investments within existing funding constraints, but this will not deliver a major improvement in regional outcomes over and above the current plan (the Auckland Plan Transport Network, or APTN).

However there are differences in impact at the sub-regional level, and specific interventions can help improve accessibility in the west and south, which were identified as problem areas in the Foundation Report.

A greater focus on influencing demand patterns has benefits

New initiatives, including variable network pricing (directly charging for road use and varying charges by location and time of day), shared mobility and connected vehicle technology, would have a potentially significant positive impact on system performance.

Pricing has major potential to influence travel demand patterns and improve network productivity but would require substantial further investigation. A work programme, which could start this year, would be needed to address a broad range of implementation challenges.

A variety of specific transport challenges need to be addressed

Continued growth in public transport ridership will put pressure on key corridors into the central area. Efficiency improvements can address these challenges in the short term, but beyond that substantial further capacity increases will be required.

The existing Auckland Harbour Bridge has limits on its ability to cater for heavy traffic growth, but a new crossing has very high opportunity costs. Route protection for a new crossing needs to progress. However, a clearer understanding of cost and benefits, and better integration between road and public transport, is needed.

Enabling growth in newly developing areas requires significant transport investment. Early investment in route protection and land acquisition is critical, and an early start is needed on key connections in the north-west, the south and to support Special Housing Areas. In the existing urban area, the location of growth and intensification will affect the timing and priority of transport investments.

Towards a strategic approach: embracing new opportunities

- Historically, our approach to dealing with Auckland's transport issues has focused on investment in roading and public transport infrastructure and services, and optimising where possible to make better use of existing assets.

- Over time, this approach has become increasingly expensive and has struggled to keep pace with the demands that growth is placing on the system. Our analysis has shown that continuing on this path can deliver localised benefits, but will not provide the step change in transport system performance that Auckland needs.

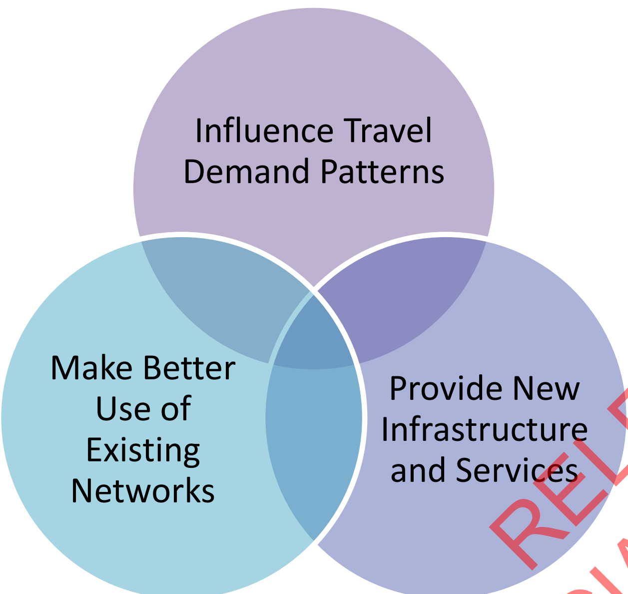
To achieve this, a change in approach is needed. Where should we focus our efforts?

Should we build more?	**Or should we address demand?**
One path is to focus on greater transport 'supply-side' provision by significantly accelerating the development of new infrastructure and services, to enable supply to get ahead of growth in demand. Although this option has not been specifically tested to date, our analysis suggests that this would be a very expensive approach, with diminishing returns over time. As growing cities around the world are finding, adding new infrastructure in existing urban areas requires increasingly expensive solutions. Only building our way out of the problem does not offer a compelling future.	An alternative path is to take advantage of new demand-side opportunities that have previously not been available. Rapid advances in transport and communications technology provide opportunities to influence the demand for private vehicle travel, through variable road pricing and the emergence of "mobility as a service" technologies. In addition, advances in intelligent transport system (ITS) and vehicle connectivity provide the opportunity for significant gains in network productivity. Our analysis has shown that, in combination, these initiatives have the potential to provide a step change in system performance.

- Auckland's continued growth means there is a need to continue work on optimising the current network, and adding new infrastructure and services. However, these actions will not on their own be sufficient. To make a real difference, we need to also take advantage of new demand-side opportunities, and ensure these are integrated with our investments and optimisation plans.

Emerging strategic approach

The emerging strategic approach involves an integrated combination of three types of intervention



Influence Travel Demand Patterns

- Ensure land-use decisions support an efficient transport network
- Maximise opportunities from new technologies to increase vehicle occupancy and throughput
- Progressively introduce a variable network pricing system to encourage more efficient travel patterns and reduce the long-term need for investment

Provide New Infrastructure and Services

- Tailor solutions to suit different circumstances
- Ensure transport enables and supports growth to address Auckland's housing challenge
- Strengthen strategic road, rail and public transport networks to ensure sufficient capacity, resilience and efficiency

Make Better Use of Existing Networks

- Better prioritise existing networks to more effectively deliver their required tasks
- Continue to improve efficiencies in maintaining, operating and renewing existing networks
- Accelerate the use of intelligent transport systems to provide real-time information and enable the benefits of emerging technologies

Recommended pathway

- The recommended approach requires a strong commitment to influencing travel demand patterns. This brings some implementation challenges, but the potential gains mean that a proactive approach is justified.
- In the short term this means prioritising resources towards making the transport system "technology ready", and laying the groundwork for variable network pricing, to enable a staged implementation.
- Because the benefits from these demand-side interventions may take some time to materialise, we need to ensure that progress is made on investments to improve our strategic networks and support Auckland's growth. Priority should be given to investments that will be required regardless of pricing or technology changes and those that enable and support Auckland's continued growth.

1st decade

- Better optimise use of the existing transport network
- Remove barriers to new technology and provide incentives to encourage uptake
- Pave the way for the staged implementation of variable network pricing
- Prioritise investments that facilitate early implementation of tools to influence demand
- Prioritise route protection, land acquisition and commence delivery of infrastructure in growth areas

2nd & 3rd decades

- Accelerate uptake and implementation of new tools
- Address public transport capacity constraints that may be exacerbated by pricing
- Continue base investment to enable and support growth

Implementing the recommended strategic approach will require the following issues to be addressed:

- How we accelerate a range of complementary interventions to influence future demand: including ride share services, connected vehicles, and pricing
- Whether to change level of investment in the first decade
- Where to focus early investment

Next steps will incorporate feedback with further analysis

Review and feedback on this report from parties (by mid-June) → Third round testing during June-July → Final ATAP report (August)

The next stage of the project will include further modelling and evaluation to supplement the work to date, and provide sufficient evidence to support the recommended approach, and demonstrate its costs and benefits.

A prioritisation framework consistent with the preferred strategic approach will be developed. In delivering value for money, recommended prioritisation criteria should include :

- Address most severe deficiencies against ATAP objectives
- Resilience to a range of different futures (pricing and technology)
- Unlock growth required for Auckland

Feedback on the following issues will be particularly useful to the project team:

- Is the emerging strategic approach supported?
- Do the parties support a move to embrace new technologies and demand management (variable pricing) as part of the preferred approach?
- Are there any differences in approach that should be considered?
- Are the recommended prioritisation criteria appropriate?
- Are there any additional issues that need to be addressed or options tested in the next phase of the project?

1. Background

1. Background
- Purpose and objectives
- Auckland's transport challenge
- Analysis informing this document

Purpose and objectives

ATAP Purpose and Objectives	Purpose of this Document
The focus of the project is to test whether better returns from transport investment can be achieved in the medium and long-term, particularly in relation to the following objectives: • To support economic growth and increased productivity by ensuring that access to employment/labour improves relative to current levels as Auckland's population grows • To improve congestion results, relative to predicted levels, in particular travel time and reliability, in the peak period and to ensure congestion does not become widespread during working hours • To improve public transport's mode share, relative to predicted results, where it will address congestion • To ensure any increases in the financial costs of using the transport system deliver net benefits to users of the system	• This is the second Auckland Transport Alignment Project (ATAP) deliverable and presents initial findings and conclusions from analysis undertaken to date • The document sets out an emerging strategic approach, based on these findings. It also identifies further work that is planned to inform the Final Report • Feedback from the parties on this report will be used to help shape the Final Report, which is due for completion in August 2016

Foundation Report

An overview of the context (including the impact of technology), problem definition, desired outcomes and measures

→

Preliminary findings & conclusions

(this document)

Initial advice reporting on the testing and evaluation of the broad intervention packages, seeking feedback to inform the next deliverable

→

Final Report

A final report detailing the best performing intervention packages, a preferred strategic approach and recommendations including necessary changes to achieve implementation

Auckland's transport challenge

The ATAP Foundation Report (released in February 2016) highlighted opportunites and challenges arising from Auckland's future growth.

Foundation Report Findings	Key Issues for ATAP
• While growth provides opportunities to capitalise on the benefits of a larger and more diverse labour force, driving productivity and prosperity gains, it also places pressure on transport networks leading to congestion, overcrowding and delays. • Some of most significant transport challenges appear to occur over the next 10 years, with projected congestion increasing to 2026 before flattening and eventually slightly decreasing. Growth in demand over this period means that, despite major investments either underway or committed, car accessibility and congestion results show a decline. • Auckland's fast growth since 2013, the base year for analysis, means that much of this early challenge may have already occurred. • Planned investments beyond the next decade appear to result in some improvements in network performance. • Of particular significance is how the opportunities and challenges from growth vary across different parts of Auckland. The Foundation Report indicated that under current plans there is a substantial and growing gap between areas in relation to their access to employment. Due to their distance from where projected employment growth occurs, the western and southern parts of Auckland appear to face the greatest future transport challenges.	The Foundation Report highlighted that subsequent stages of the project needed to focus on addressing the following key issues: ***Access to employment and labour*** • an overall decline in access to employment by car between 2013 and 2036, particularly in the west and south • a low level of improvement in public transport access for people in the south and west, for accessing jobs in the south, and the slowing of public transport access improvements beyond 2026 • the extent to which transport interventions alone can improve access to employment ***Congestion*** • increased levels of congestion between 2013 and 2036, particularly on the motorway network • key bottlenecks on the motorways and local road network which impact on overall accessibility and trip reliability ***Public transport mode share*** • investigation of options to increase public transport mode share, particularly attracting longer trips off the motorway network to reduce congestion • the low level of public transport mode share growth in South Auckland, particularly in the first decade.

Analysis informing this document

The findings described in this report come from a range of technical analysis and assessment

Package development, modelling and evaluation	Specialist workstreams	Project team engagement
• Two rounds of package development, transport modelling and evaluation assessed different mixes of transport interventions • A variety of road pricing options were tested, informing a refined option that was modelled in combination with a supporting set of infrastructure projects • 'What if' technology scenarios looking at connected vehicles and shared mobility were developed and tested	• Specialist reports have been prepared to provide information on the following key topics: • Arterial Roads • Emerging Transport Technologies • Rail Network Development • Freight • Revenue Assumptions	• Ongoing engagement with teams that are undertaking more detailed analysis into major projects, including: • Additional Waitemata Harbour Crossing • Transport for Future Urban Growth • Central Access • North Shore Rapid Transit • Airport Rapid Transit

This work will be fully documented in the Final Report and supporting Working Papers, which are currently in draft

2. Key Learnings

- **2. Key Learnings**
  - Revenue and land use assumptions
  - Optimising existing networks
  - Testing alternative investments
  - New opportunities

Revenue Assumptions

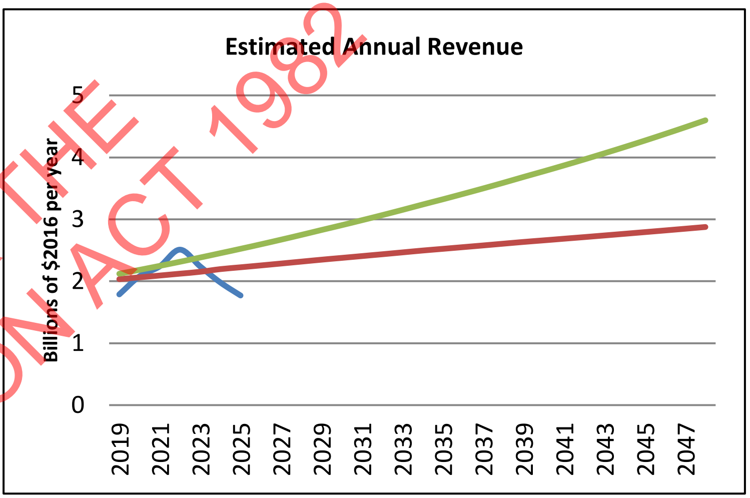
A key part of the project is to determine whether a funding gap exists.
This requires an estimate of likely future revenues.

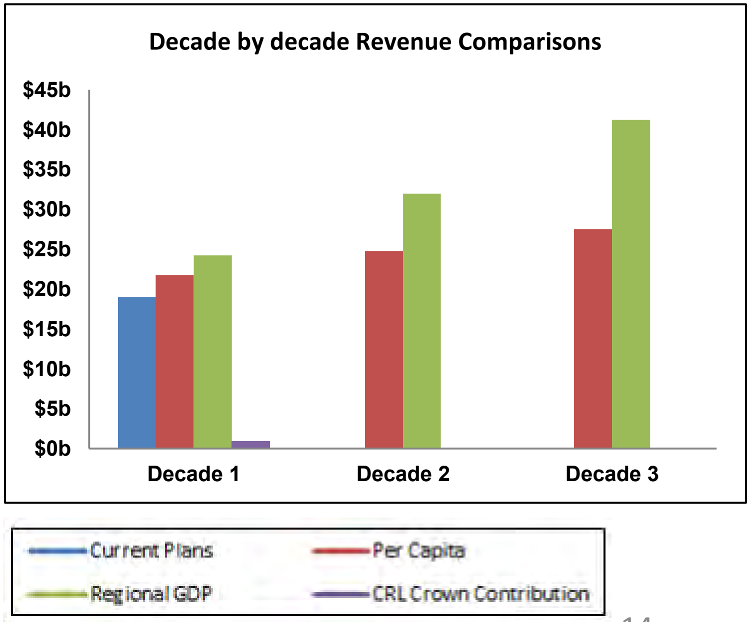
Recent & Planned Investment

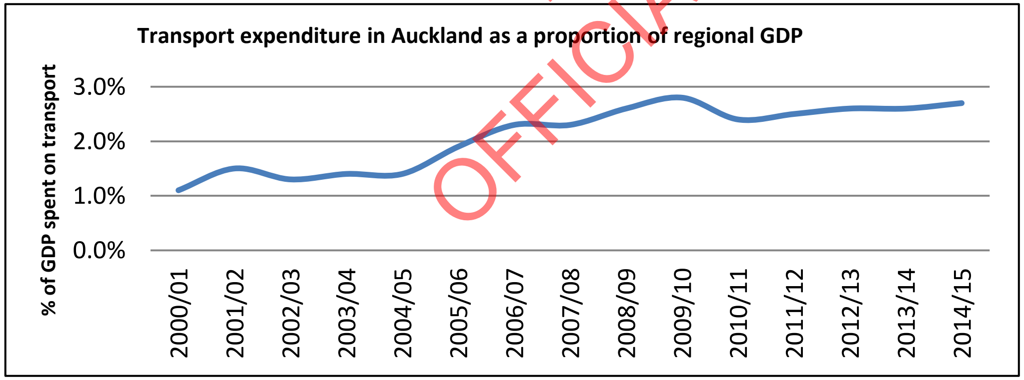
- There has been a five-fold increase in transport investment in Auckland over the past 15 years (in nominal terms).
- This rate of growth has outpaced both population and economic growth, meaning that the share of Auckland's economy being spent on transport has grown from around 1% to above 2.5% since 2000.
- Up to 2022, planned investment continues to grow quickly but subsequently sharply reduces once the City Rail Link is completed.
- Since current plans (Auckland's Regional Land Transport Plan and the National Land Transport Programme) were published in 2015, there have been some new investment commitments (e.g. East West Connections and pending Crown contribution to City Rail Link).

Future Revenue Assumptions

- Current financial plans only extend out 3-10 years so broad revenue assumptions are required beyond these timeframes.
- Two alternative scenarios were developed to estimate future revenue available for transport in Auckland: one based on maintaining current per capita spending, and another maintaining the current share of Auckland's GDP invested in transport. These provide an indication of likely future affordability, but are above currently forecast funding levels.
- Over the 30 year period, revenues would be approx. $74b under the Per Capita scenario and $97b under the Regional GDP scenario. Most of the difference occurs in the second and third decades
- Under both assumptions (and including an assumed Crown contribution to the City Rail Link) there would be a higher level of revenue than in current plans from 2024 onwards.







Land Use Assumptions

Where and when growth occurs has significant impacts on transport but is highly uncertain. Imbalances between the location of household and employment growth will increase pressure on the transport system.

Assumed Growth Pattern

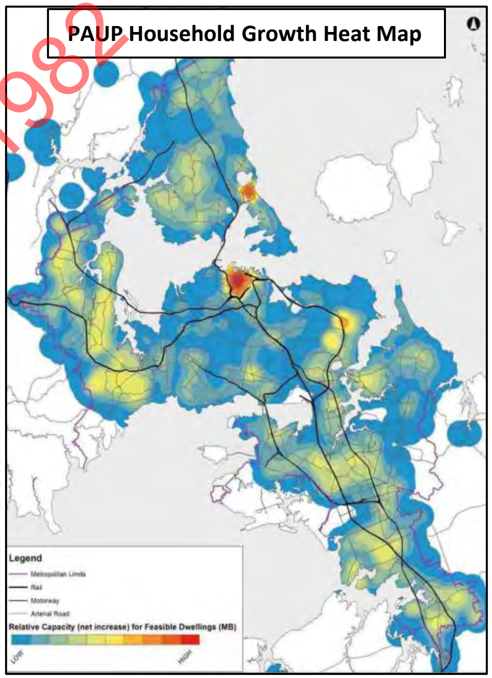
- The assumed pattern of household growth used for this project includes a substantial amount of growth throughout Auckland, including in inner parts of the urban area.
- The assumed pattern of employment growth (which has been peer reviewed) includes a very strong focus of growth in the Central Area and a limited number of other major centres such as the Airport and Westgate/Whenuapai.

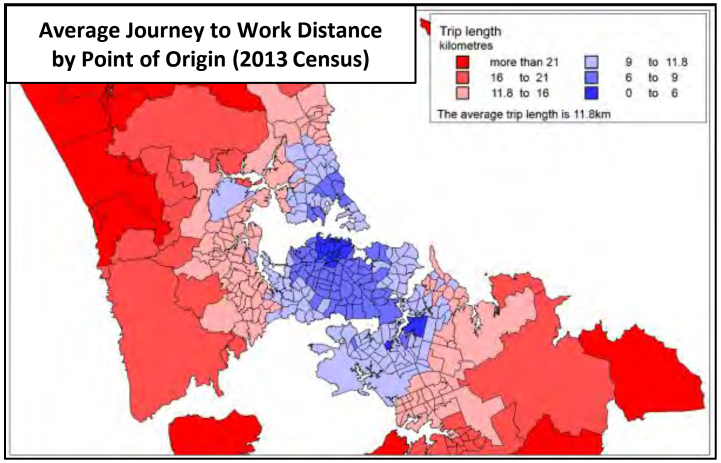
Growth Uncertainty

- Where are when growth occurs is subject to a wide variety of factors including the extent to which it is enabled by planning documents, infrastructure provision and market attractiveness. This leads to unavoidable uncertainty about future growth assumptions.
- There are some substantial differences between the growth assumptions used in this project and what is enabled by the Proposed Auckland Unitary Plan (PAUP). This is particularly true in the balance between inner urban and outer urban household growth with the PAUP providing feasible capacity for approximately 50,000 fewer dwellings on the Auckland isthmus than the growth assumptions used in this project.
- Where and when growth occurs affects the timing and priority of transport investments as well as the overall size of the transport challenge faced by Auckland. Depending on the outcome of the Unitary Plan, a greater balance of growth towards outer areas will need to be reflected in the prioritisation of investment.

Effect of Different Growth Patterns

- Average journey distances tend to increase, while the use of public transport, walking and cycling tends to decline, with distance from central Auckland.
- Therefore, the balance between where household and employment growth occurs has important transport implications. Projected trends of widespread household growth and concentrated employment growth contributes to Auckland's growing transport challenge, especially for the West and South which are most distant from where projected employment growth is greatest.
- Increasing household growth in inner areas, or employment growth in outer areas, can help address this imbalance.





Optimising Existing Networks

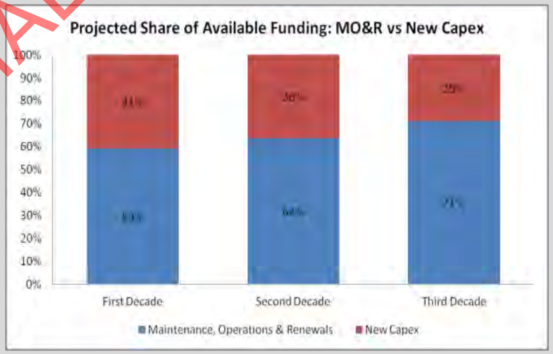
The vast majority of Auckland's future transport network already exists today.
To achieve ATAP objectives, it is critical to get more out of the existing network.
We have looked at opportunities to improve in three key areas:

Network Prioritisation

- Key challenge in providing for many competitive uses in the same corridors. Challenge is most acute on the arterial road network that have traffic, freight, public transport, walking & cycling, property access and place functions.
- No over-arching framework currently exists to guide trade-offs between competing uses for space on the arterial road network.
- To better optimise, greater specialisation of routes (e.g. general traffic, freight, public transport, place-making, cycling etc.) is required that balances network and place requirements.
- Major gains can be made in short-term by removing on-street parking, extending bus lane operating hours and improving pedestrian facilities in high volume areas. Often these changes can be difficult to implement, but they are very important and must be pursued.

Maintenance, Renewals and Operations

- Looking after current assets is crucial but is becoming more expensive as the asset base grows.
- Current projections suggest that the share of transport expenditure going to maintenance, operations and renewals will grow over time. Key drivers of this projected growth are public transport service costs, increased heavy vehicle traffic, and maintaining/renewing new and more complex assets. (e.g. tunnels).
- There appears to be scope for further improving efficiencies in this area through increased use of technology for monitoring assets and new ways of delivering public transport services (e.g. ridesharing or driverless vehicles)



Intelligent Transport Systems

- Intelligent network management encompasses a wide variety of distinct interventions designed to enable a comprehensive real-time understanding of network use, the ability to intervene to manage dynamically travel demand, and the associated data processing capability to perform these functions.
- Better network management can improve the utilisation of existing infrastructure - for example by re-routing traffic in response to congestion or incidents. It can also inform where to target maintenance and renewals expenditure and allow better planning of new infrastructure investment.
- Increasing investment in this area would enable more comprehensive real time information and analytics and better traffic management tools.
- Early investment is also necessary to capture the full benefits of emerging technologies, particularly vehicle-to-infrastructure communication.

Testing Alternative Investments

An important part of the work to date has been the testing of different intervention packages, to determine whether better results can be achieved by changing the mix of investment. Themed packages involving similar levels of investment were tested:

Auckland Plan Transport Network (APTN)

- The baseline package analysed in the ATAP Foundation Report. This mix of investments was developed to inform 2015 transport funding plans.

A mix of roading and public transport investments including Airport Rail, Additional Waitemata Harbour Crossing and substantial third decade motorway widening

Capacity constraints focus

- To test the impact of prioritising interventions that increase speed or capacity where levels of service are poor.

Significant motorway widening in the second and third decades and the Additional Waitemata Harbour Crossing. Also increases public transport services where demand is expected to exceed capacity.

Employment centres focus

- To test the impact of improved access to and between major employment centres.

A mix of public transport and roading investments focussed on improvements in travel times to the main employment growth centres (including the city centre, airport, & major town centres)

The next slides summarise the key findings from these package tests, and the extent to which different investments can address:

- Regional transport challenges: whether better results against ATAP objectives can be delivered at the region-wide level
- Access challenges in the South and West: whether better results can be achieved in areas where deficiencies have been identified

They also include a summary of findings from an assessment of key constraints and challenges that have been identified, including:

- Public transport capacity constraints
- Auckland Harbour Bridge constraints
- Auckland's housing challenge

Addressing Regional Transport Challenges

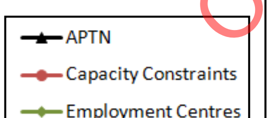
Modelling of different infrastructure programmes indicates broadly similar regional performance against key ATAP objectives, although some early gains can be made.

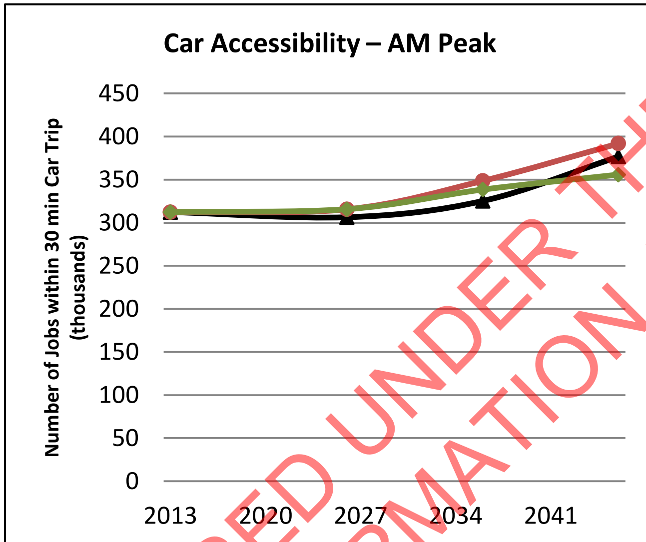
Model results show that it is possible to deliver some improvement in performance against the ATAP objectives, compared to APTN.

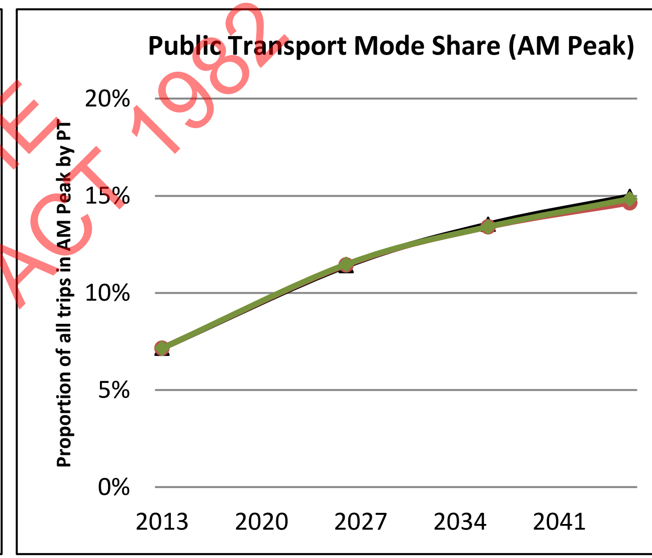
The most significant difference is for congestion levels on the strategic network (largely motorways) due to earlier and different levels of investment in motorway widening.

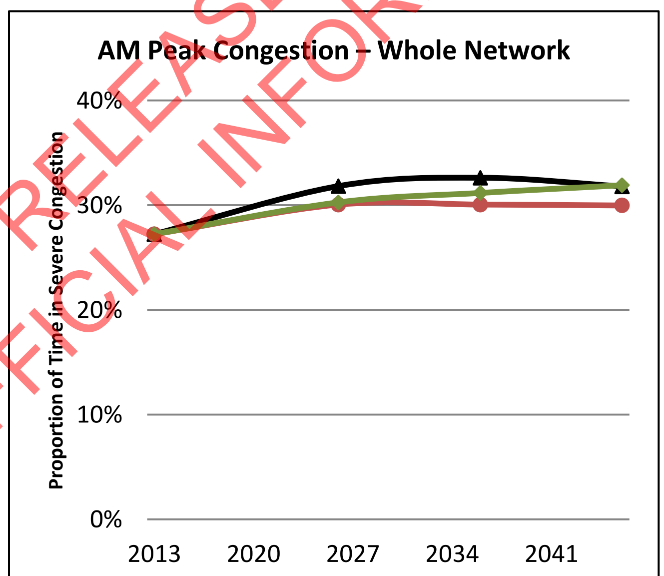
At the regional level, however, there is relatively little difference between the packages for key measures by the end of the third decade. This is because the infrastructure programmes tested only change a small part of the overall transport network

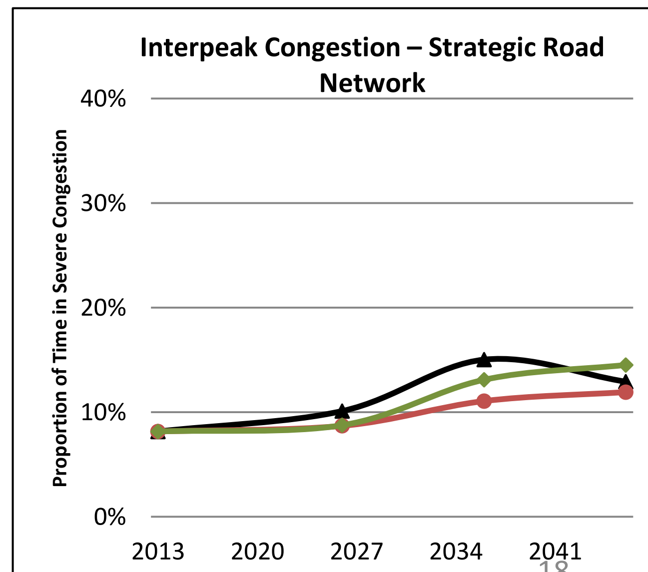
This suggests that changing the mix of investment within current expenditure levels will not achieve a ‘step-change’ in regionwide performance.











Addressing Access Challenges in the West and South

Specific interventions can help address identified deficiencies in the west and south

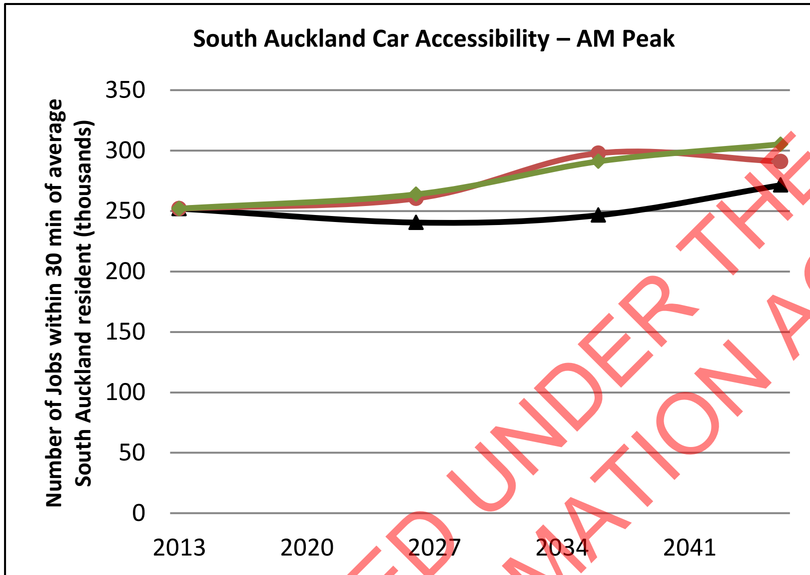
Access challenges in west and south Auckland

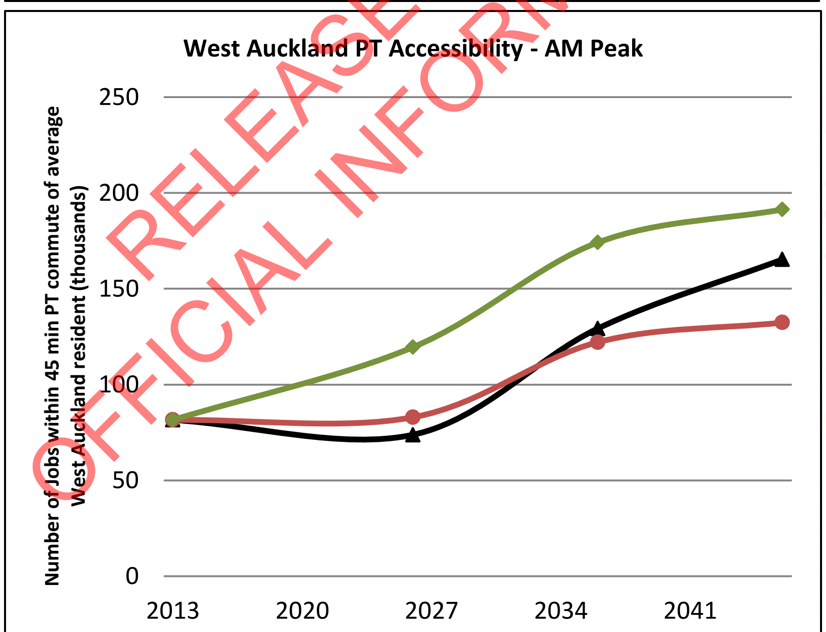
- The Foundation Report highlighted significant accessibility challenges in west and south Auckland.
- These findings were particularly concerning given substantial projected growth and higher levels of deprivation in these parts of Auckland.

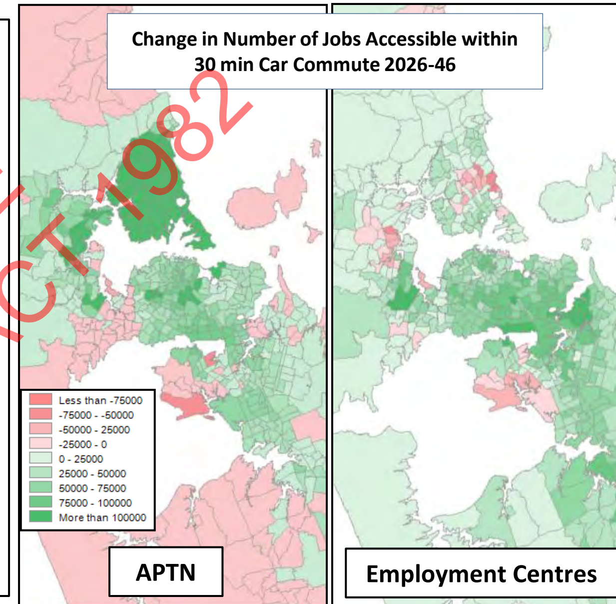
Different investment mixes do have sub-regional impacts

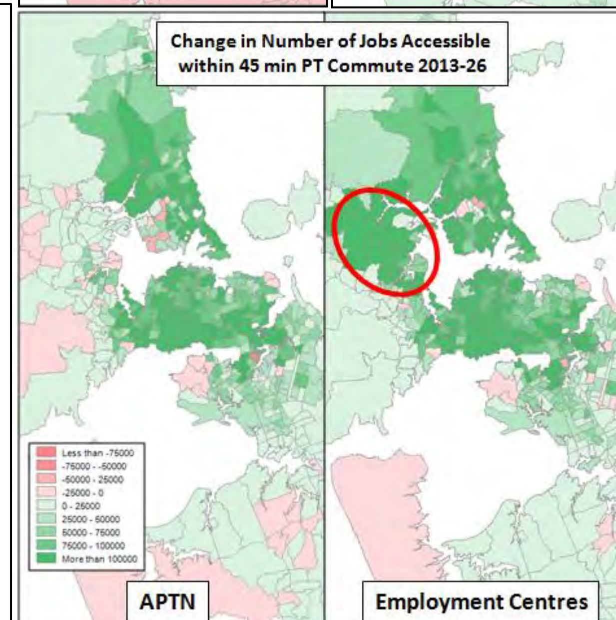
- Reconfigured motorway widening contributes to increasing 2046 South Auckland car accessibility by around 12% (34,000 more jobs within a 30 minute car commute)
- Advancing Northwest Busway contributes to increasing 2026 West Auckland public transport accessibility by around 60% (45,000 more jobs within a 45 min PT commute)

APTN
Capacity Constraints
Employment Centres









Addressing Public Transport Capacity Constraints

Continued growth in public transport ridership will put pressure on key bus corridors into the central area

Strong Projected Public Transport Growth

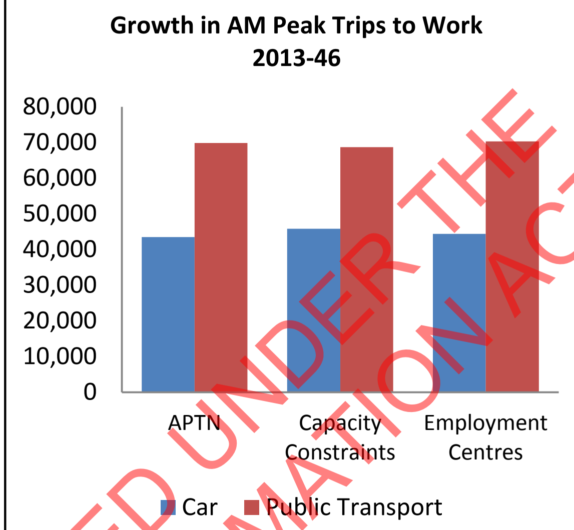
- Public transport ridership is expected to triple by 2046.
- Public transport expected to carry the majority of growth in AM peak trips to work over the next 30 years.

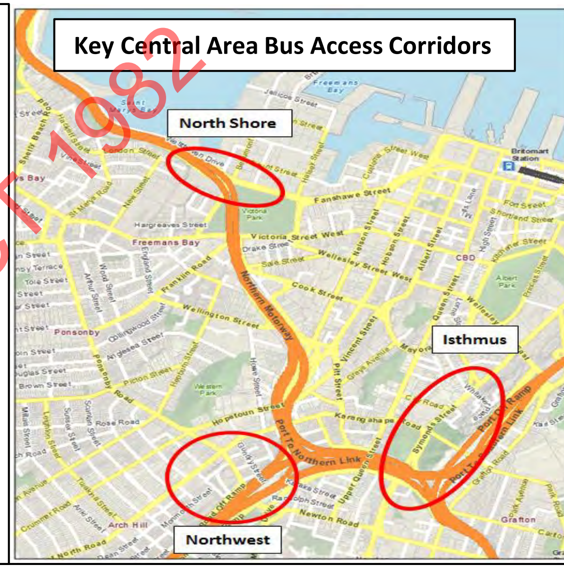
Concentration of Trips in Central Area

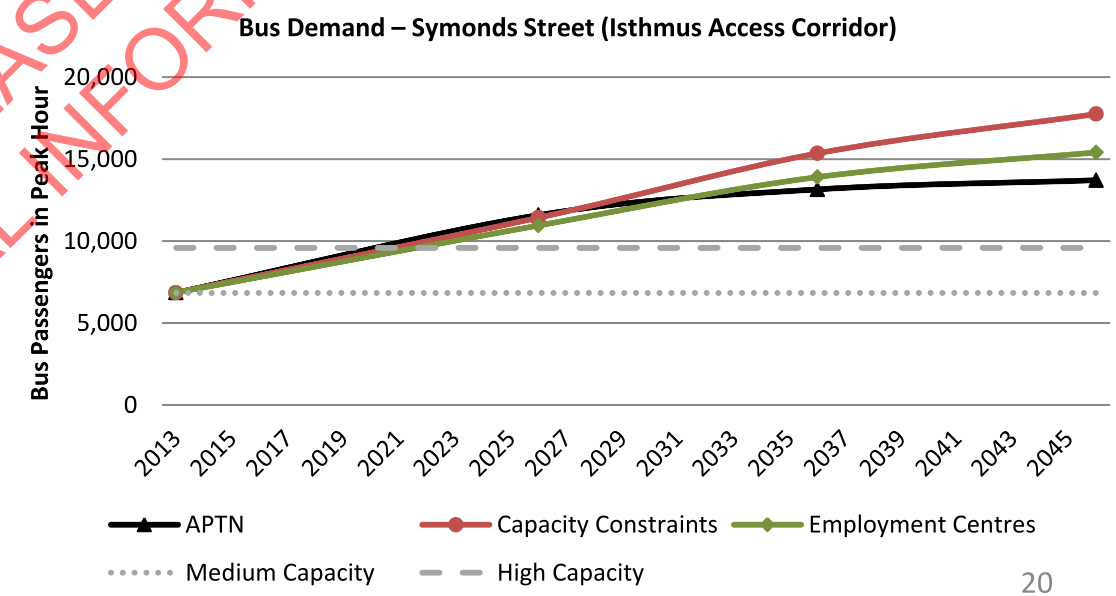
- The greatest concentration of PT trips is related to accessing Auckland's largest and fastest growing employment centre, the central area (city centre & fringe, Newmarket)
- Rail network serves the west, south and eastern parts of Auckland. However, access to central area from much of the isthmus, the North Shore and the northwest currently relies upon buses.

Bus Capacity Constraints

- There is substantial projected growth in bus passenger numbers accessing the central area from the isthmus, North Shore and the northwest.
- The number of buses required to meet this demand is channelled into a few key corridors and is reliant upon limited space within the city centre for passengers to board and alight.
- These constraints will have a widespread impact on the effectiveness of the bus system to meet demand, with widespread overcrowding projected on a variety of routes serving the isthmus, North Shore and the northwest. This will increase delays and decrease reliability.
- In the short term, efficiency improvements to the bus network (completing currently planned bus infrastructure improvements, rerouting services and fully utilising benefits of the City Rail Link project) will help to address these challenges.
- Beyond this, however, it appears that substantial further capacity increases are required to avoid severe overcrowding.







Addressing Auckland Harbour Bridge Constraints

The existing bridge has limits on its ability to cater for growth in heavy vehicles, but any new crossing will require very substantial investment

Preserving the Auckland Harbour Bridge's Lifespan

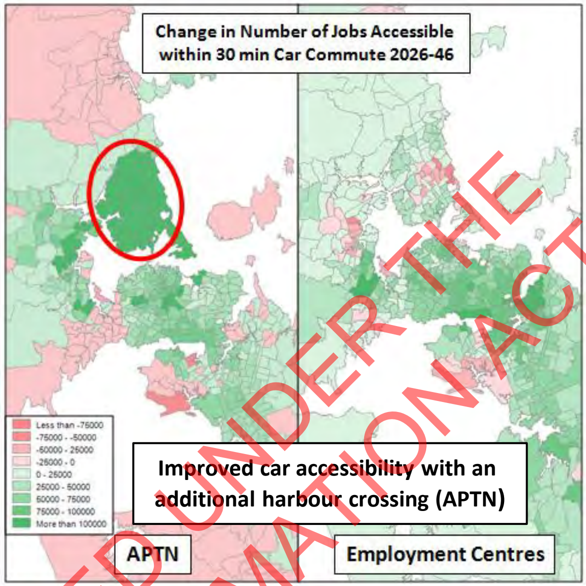
- The Auckland Harbour Bridge is one of the most important pieces of transport infrastructure in New Zealand, being both State Highway 1 and the main connection between the North Shore and the rest of Auckland. Preserving the bridge's lifespan is critical.
- Although strengthened in the past decade, the bridge has limitations in its ability to cater for growth in heavy vehicle traffic. Some level of heavy vehicle management will be necessary in the future to preserve its lifespan.
- Depending on the timing and nature of any restrictions on heavy vehicle traffic, there could be substantial economic costs for Auckland and New Zealand.

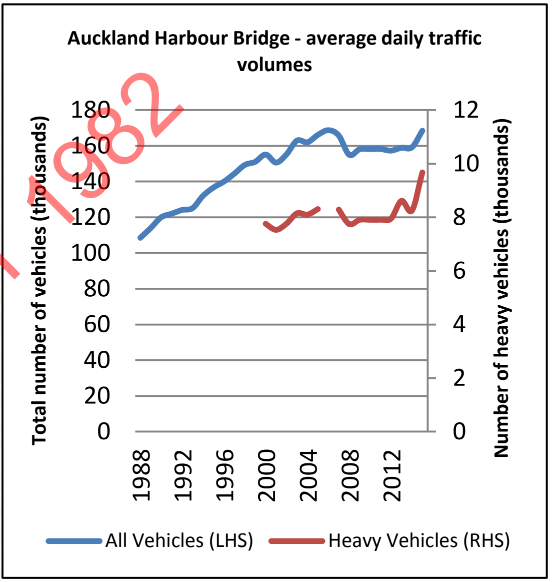
Improving access to and from the North Shore

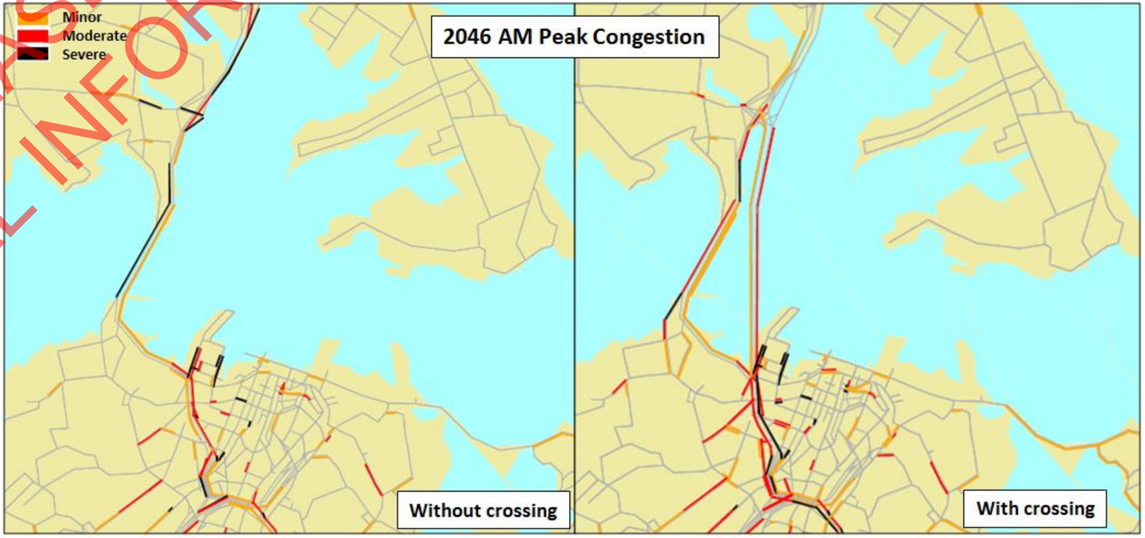
- The bridge and its approaches are a pinch-point on the transport network, particularly during the evening peak in both directions.
- An additional crossing significantly improves accessibility to/from the North Shore but does not appear to substantially improve congestion results.
- Projected growth in public transport demand appears likely to trigger the need for a new crossing within the next 30 years. There is potential for a shared road/PT crossing but the costs and benefits of different options require further analysis.

High cost of potential solutions

- Because any new crossing will be tunnelled, there is a significant opportunity cost arising from this investment. Fully understanding key drivers, alternatives, cost and benefits will be crucial before any investment decisions are made.
- It makes sense to protect the route for a new harbour crossing in a way that integrates potential future roading and public transport requirements.







Addressing Auckland's Housing Challenge

Enabling growth in newly developing areas will require significant transport investment.
Early investment in route protection, land acquisition and investments to support Special Housing Areas is critical

Transport enables growth

- Enabling and supporting a faster rate of housing development in Auckland is a critical element of improving housing affordability.
- Transport investment is a key enabler of growth, particularly in greenfield areas where transport shapes growth patterns and investment is required before growth can occur.

Substantial and ongoing investment to support greenfield growth

- Over 11,000 hectares of "Future Urban" land is identified in the Proposed Auckland Unitary Plan. New transport (and other) infrastructure is required to make this land ready for development.
- Travel demands generated by growth in these areas will also place pressure on existing networks, particularly as more peripheral areas tend to have longer average trip lengths and a lower use of public transport, walking and cycling.
- There are also substantial ongoing operational costs arising from this growth.

Early Focus

- Substantial early investment in route protection and land acquisition for future transport infrastructure will be required to minimise future costs and protect alignments.
- Early investment is also required to support Special Housing Areas, address current deficiencies and enable a faster rate of development, particularly in the northwest and parts of the south.

Urban redevelopment

- Major new infrastructure to enable greenfield growth will take a number of years to be constructed.
- Ensuring planning rules enable growth in locations with existing transport capacity and good access will have significant transport benefits and reduce investment requirements.

Location of Greenfield Growth Areas in Proposed Auckland Unitary Plan

Potential future transport improvements to serve south Auckland growth

New opportunities: Variable Network Pricing

2. Key Learnings

ATAP has explored the potential to use variable road network pricing as a demand management tool to achieve better network performance against ATAP objectives.

- The goal of demand management pricing is to achieve better performance by pricing users to face a greater proportion of the true costs of their travel, including impacts on other users. Over time this can reduce the extent of investment required in the transport system.
- Road pricing can improve transport network performance by changing travel patterns through shifting the mode, route or time of travel in a way that improves the efficiency of the transport system.
- Developing technologies enable more sophisticated pricing systems to be examined than was envisaged by earlier work – including whole of network dynamic pricing schemes.
- Early analysis looked at different options (CBD cordon, motorway access charge & whole of network system). Whole of network system had biggest impact and was merged with the motorway access charge (by applying slightly higher rates on the motorway network) in subsequent analysis.

Hypothetical network-wide pricing system

- Modelling was undertaken to investigate the impact of a hypothetical network-wide pricing system, with varying charges (between 3c and 40c per kilometre) depending on time of day, location and type of network travel occurs within (see table).
- Highest prices targeted to areas with most congestion and where travel alternatives are most available (e.g. the "inner urban" Auckland isthmus).
- Pricing tested with accompanying infrastructure investments focused on providing sufficient public transport capacity was available where possible to meet changing travel patterns. Reported as the "Managing Demand" package

		Peak	Inter-Peak	Off-Peak (night)
Inner Urban	Motorways	Highest Increase	Medium/High Increase	Decrease
	Other Roads	Medium/High Increase	Medium Increase	Decrease
Outer Urban	Motorways	Medium/High Increase	Medium Increase	Decrease
	Other Roads	Medium Increase	Smallest Increase	Decrease
Rural	All Roads	Decrease	Decrease	Decrease

New opportunities: Variable Network Pricing

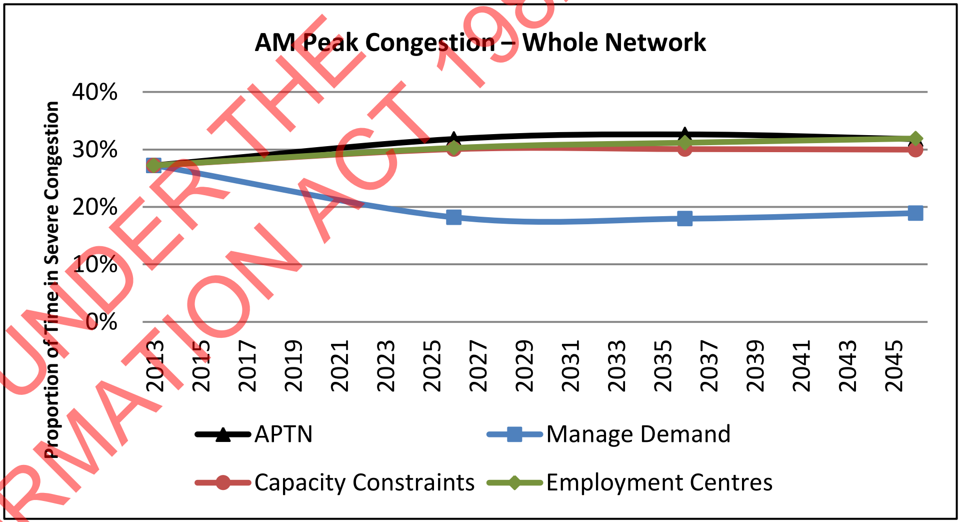
Model results show encouraging impacts on ATAP performance objectives, but further work is needed to assess user impacts

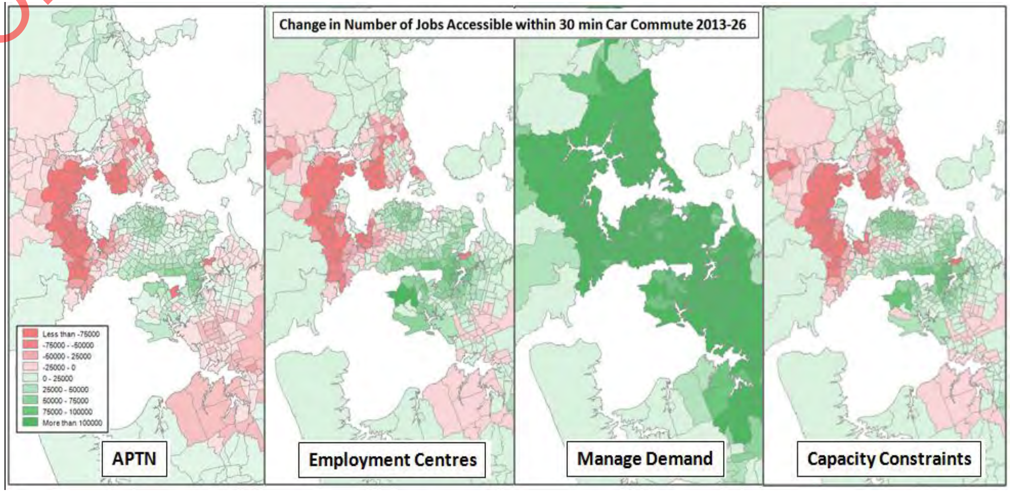
Encouraging impacts on ATAP performance objectives…

- Pricing has a substantial regional impact on congestion, leading to a significant reduction from current levels and well below the other packages tested.
- Pricing also leads to major accessibility improvements (in terms of how many jobs can be reached within certain commute times) due to reduced congestion.
- A substantial growth in public transport mode share was also evident with the introduction of pricing.
- As its impacts are far greater than different mixes of investment, pricing can help to avoid or defer significant infrastructure investment
- Pricing is adaptable, can be phased in over time, and changed to meet changing circumstances or demands. Unlike infrastructure investment, it is also reversible if it fails to meet its objectives.

…but further analysis is required to properly understand net user impacts and overall value for money

- Price levels tested so far indicate a net financial cost to users, based on the analytical tools available. Further refinement of pricing levels is underway to inform the final report.
- The improved congestion performance is a result of some trips being "priced off" the network. Overall value for money assessments need to consider wider benefits to society but also the potential for deferred/reduced transport expenditure that could be very substantial.





New opportunities: Transport Technologies

Emerging transport technologies have the potential to enable much more efficient use of existing transport infrastructure and to achieve better transport outcomes. The timing and impact of new technologies, which will be driven by private sector innovation, remains uncertain, but appear likely to have profound effects within the next 30 years.

Two different scenarios tested:

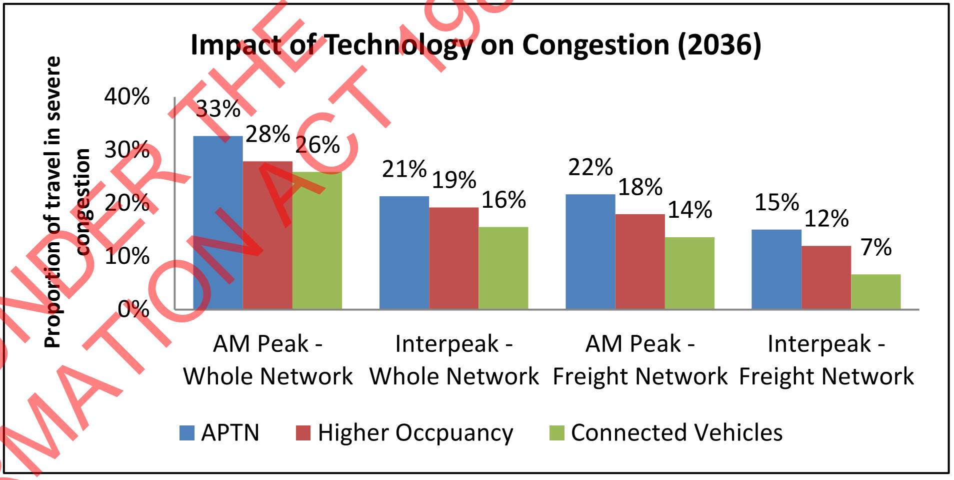
- "What-if" technology scenarios testing the impact of aggressive increases in vehicle occupancy (from more ridesharing enabled by ongoing IT advances) and connected vehicle uptake from current and future improvements in vehicle technology.
- All options were tested with a low-level investment programme to understand the impact of technology alone.

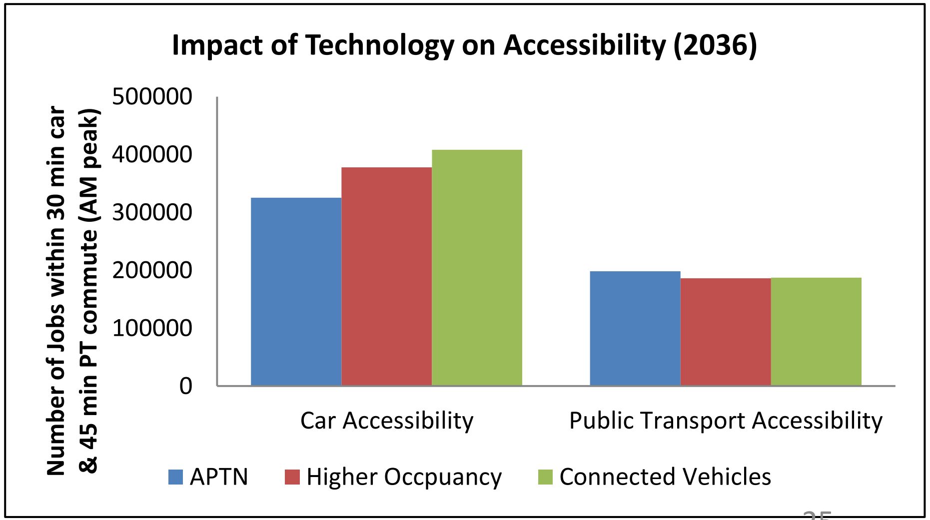
Initial results are encouraging…

- Increased vehicle occupancy delivers positive car accessibility and congestion outcomes.
- Improved vehicle connectivity delivers very positive outcomes – and is potentially easier to implement as it relies on technology rather than human behaviour change.
- The effect of these changes are cumulative, so both shared mobility and connected vehicles appear worth pursuing.
- Timing is important: the scenarios were developed for 2036: need to determine whether this is plausible, and what might occur in the meantime.

… but probably reflect a "best case", and some caution is needed…

- Scenarios assume a reasonably aggressive uptake of shared mobility and connected vehicles: further work needed to identify a level of uptake which is both sufficiently ambitious and plausible.
- Uptake of shared mobility will rely on behavioural change as well as technology – this has proven to be very challenging in the past.
- The results show a strong switch from PT to shared cars: however, this needs further analysis as it may simply reflect the way it is modelled.
- No attempt was made to estimate the impact of new technology on the overall demand for travel.





3. Emerging strategic approach

- **3. Emerging Strategic Approach**
  - Towards a strategic approach
  - Influence travel demand patterns
  - Make better use of existing networks
  - Provide new infrastructure and services

Towards a strategic approach: embracing new opportunities

- Historically, our approach to dealing with Auckland's transport issues has focussed on investment in roading and public transport infrastructure and services, and optimising where possible to make better use of existing assets.
- Over time, this approach has become increasingly expensive and has struggled to keep pace with the demands that growth is placing on the system. Our analysis has shown that continuing on this path can deliver localised benefits, but will not provide the step change in transport system performance that Auckland needs.

To achieve this, a change in approach is needed. What are our options?

Should we build more?

One path is to focus on greater transport 'supply-side' provision by significantly accelerating the development of new infrastructure and services, to enable supply to get ahead of growth in demand.

Although this option has not been specifically tested to date, our analysis suggests that this would be a very expensive approach, with diminishing returns over time. As growing cities around the world are finding, adding new infrastructure in existing urban areas requires increasingly expensive solutions. Only building our way out of the problem does not offer a compelling future.

Or should we address demand?

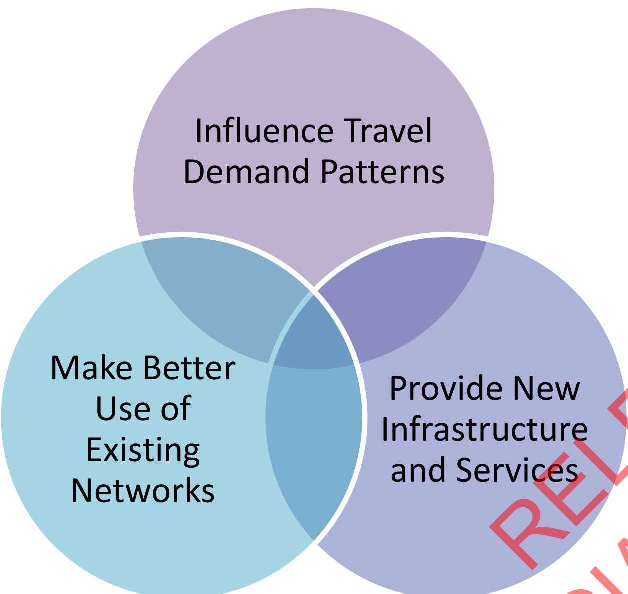
An alternative path is to take advantage of new demand-side opportunities that have previously not been available. Rapid advances in transport and communications technology provide opportunities to influence the demand for private vehicle travel, through variable road pricing and the emergence of "mobility as a service" technologies. In addition, advances intelligent transport system (ITS) and vehicle connectivity provide the opportunity for significant gains in network productivity.

Our analysis has shown that, in combination, these initiatives have the potential to provide a step change in system performance.

- Auckland's continued growth means there is a need to continue work on optimising the current network, and adding new infrastructure and services. However, these actions will not on their own be sufficient. To make a real difference, we need to also take advantage of new demand-side opportunities, which will offer Auckland-wide benefits, and ensure these are integrated with our investments and optimisation plans.

Emerging strategic approach

The emerging strategic approach involves an integrated combination of three types of intervention



Influence Travel Demand Patterns

- Ensure land-use decisions support an efficient transport network
- Maximise opportunities from new technologies to increase vehicle occupancy and throughput
- Progressively introduce a variable network pricing system to encourage more efficient travel patterns and reduce the long-term need for investment

Provide New Infrastructure and Services

- Tailor solutions to suit different circumstances
- Ensure transport enables and supports growth to address Auckland's housing challenge
- Strengthen strategic road, rail and public transport networks to ensure sufficient capacity, resilience and efficiency

Make Better Use of Existing Networks

- Better prioritise existing networks to more effectively deliver their required tasks
- Continue to improve efficiencies in maintaining, operating and renewing existing networks
- Accelerate the use of intelligent transport systems to provide real-time information and enable the benefits of emerging technologies

Recommended pathway

- The recommended approach requires a strong commitment to influencing travel demand patterns. This brings some implementation challenges, but the potential gains mean that a proactive approach is justified.
- In the short term this means prioritising resources towards making the transport system "technology ready", and laying the groundwork for variable network pricing, to enable a staged implementation.
- Because the benefits from these demand-side interventions may take some time to materialise, we need to ensure that progress is made on investments to improve our strategic networks and support Auckland's growth. Priority should be given to investments that will be required regardless of pricing or technology changes and investment that enable and support Auckland's continued growth

1st decade

- Better optimise use of the existing transport network
- Remove barriers to new technology and provide incentives to encourage uptake
- Pave the way for the staged implementation of variable network pricing
- Prioritise investments that facilitate early implementation of tools to influence demand
- Prioritise route protection, land acquisition and commence delivery of infrastructure in growth areas

2nd & 3rd decades

- Accelerate uptake and implementation of new tools
- Address public transport capacity constraints that may be exacerbated by pricing
- Continue base investment to enable and support growth

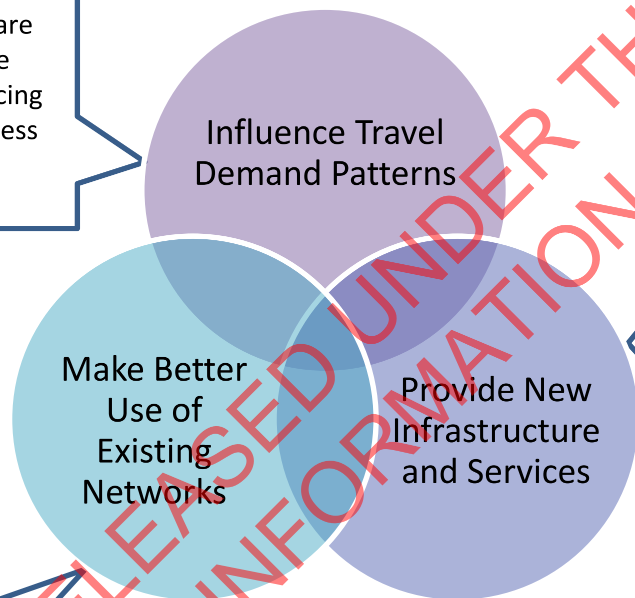
Implementing the recommended strategic approach will require the following issues to be addressed:

- How we accelerate a range of complementary interventions to influence future demand: including ride share services, connected vehicles, and pricing
- Whether to change level of investment in the first decade
- Where to focus early investment

Key elements of the emerging strategic approach

The following slides provide detail on the key elements of the emerging strategic approach

To take advantage of the significant potential benefits, early actions are needed to pave the way for the adoption of variable network pricing and new technology; and to address implementation issues and uncertainties



Transport investments need to support Auckland's growth. New urban growth areas in the north, north-west and south will need early investment in transport infrastructure before growth can occur.

Targeted investments are required to strengthen the ability of strategic networks to deal with the impacts of growth in travel demand, and to ensure that the strategic road, rail and public transport networks have sufficient capacity and resilience to operate effectively.

Improving the productivity of the existing transport system can be very cost-effective and potentially delay the need for more expensive investments in new infrastructure. In some key parts of the network (e.g. arterials) this will require difficult trade-offs

Influence travel demand patterns

- There is potential for significant benefits from a shift to variable network pricing, and mobility as a service technologies, which can influence travel behaviour, especially for single occupant vehicles. The benefits from these tools appear to be much stronger than traditional supply-side interventions.
- To maximise the opportunities that pricing and technology present, we need to take early actions to facilitate their adoption; and to address the issues and uncertainties that have been identified. Actions in the first decade will have a big influence on our ability to capture the potential benefits of technology in later decades.

Implementation Path - Pricing

- Progress further work to understand how and when a network-wide pricing system could be introduced in Auckland through a staged implementation pathway (including how national implications of such a system would be addressed).
- Undertake work to identify social and economic impacts, and how these should be mitigated
- Examine merits of an interim pricing scheme as a step towards implementation of a network-wide approach. Partial schemes may achieve some level of performance improvement but also may generate unintended outcomes (e.g. discouraging growth in some areas, shifting traffic flows) that need to be fully considered.
- Identify how variable network pricing might be phased in over time, in a manner that is compatible with any future development of the national charging system. The most likely implementation path for pricing would be a ‘phasing in’ approach, potentially over a fairly long time period. This could include some vehicle-type s (e.g. heavy vehicles) being phased in first. Other ways of phasing in pricing could be to shift to a GPS-based system but initially charge at current levels, with prices moving to variable rates over time
- Identify any necessary investments that may be required ahead of implementing a pricing scheme to deal with shifts in travel behaviour.
- Refine analytical tools to better understand the detailed effects of pricing. Current tools used to assess impacts of pricing have significant limitations.

Implementation Path - Technology

- In the short term, adopt a proactive approach to making the transport system “technology-ready”, by:
  - making maximum use of current ITS technologies, e.g. better synchronising traffic lights
  - investing in ITS improvements that will enable benefits of connected vehicle to be realised at an early stage
  - ensuring that regulatory settings don’t act as a barrier to technology uptake, and enable the private sector to respond and innovate;
  - providing incentives to increase vehicle occupancy. (e.g. road pricing)
  - ensuring that technology helps facilitate a move to variable network pricing
  - gaining a better understanding of behavioural aspects related to ridesharing, and identifying actions that are most likely to increase uptake
- Not able to conclude at this stage which infrastructure investments should be delayed or discarded due to technology changes. It would be risky to do this in the short term, given levels of uncertainty and high growth.

Further work required for final report: Better understand the next steps for enabling the use of these tools

Make better use of existing networks

- Investments in new major transport infrastructure can be expensive and disruptive. Therefore, improving the productivity of existing transport networks can be very cost-effective and potentially delay the need for more expensive investments in new infrastructure.
- There appears to be significant potential to increase road network productivity in Auckland, particularly the arterial network. This requires:
  - a stronger focus on network-level strategic planning of arterial roads to provide an effective basis for prioritisation, and addressing the trade-offs between competing activities on the network
  - taking advantage of new ITS technologies to assist with network optimisation
  - a stronger commitment to addressing incompatible activities, such as removal of parking on arterial roads
- The recommended strategic approach identifies opportunities to significantly increase future road productivity through technology improvements, particularly connected vehicles. ITS investments that enable these opportunities to be realised earlier should be prioritised.
- There are also opportunities to improve the productivity of the public transport system. For example, improvements to bus operations on high volume corridors can help to delay the need for large-scale investments in new mass-transit infrastructure.
- International evidence suggests improved asset management processes can also deliver significant benefits, improving efficiencies and informing the optimal timing of intervention. In the long-term this could lead to substantial savings in maintenance and renewals.

Further work required for final report: providing direction about how the existing network can be further optimised.

Provide new infrastructure and services:

Ensure that transport enables and supports growth

- New urban growth areas in the north, north-west and south will need investment in transport infrastructure before significant growth can occur.
- Without investment, a lack of transport infrastructure will constrain development in these areas. Early growth areas in the north-west and south require new internal and external connections within the next decade to enable their development.
- An early investment focus on route protection and land acquisition is required to ensure investment is able to proceed when required and in a cost-effective way. Route protection helps avoid incompatible development and reduces the cost of land purchase for key projects.
- Early investment will also be needed to support Special Housing Areas, address current deficiencies and enable a faster rate of development, particularly in the north-west and parts of the south.

- Transport investment within the existing urban area can also unlock growth by providing improved accessibility and making redevelopment more market attractive. Projects like AMETI, which improves access and connections in east Auckland, are important catalysts for growth, especially in the town centres they serve. Similarly, ensuring that planning documents enable growth in areas with good accessibility and spare capacity is an important way to minimise future investment requirements.
- The extent to which a transport investment enables growth should be an important consideration in its prioritisation for funding.

Further work required for final report: understand which potential investments enable the greatest level of growth, particularly in the next decade.

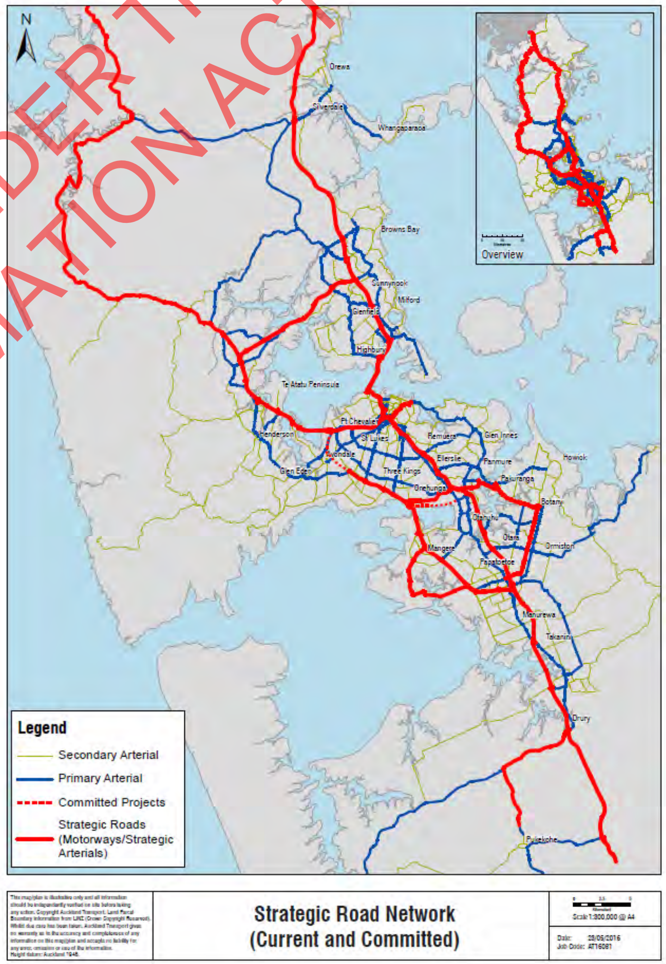
Provide new infrastructure and services:
Targeted investment to strengthen strategic networks

- The strategic road, public transport and rail networks carry a significant proportion of the daily transport task in Auckland.
- They are essential economic arteries, enabling access between different parts of the region, and connections to other parts of the country.
- As Auckland grows, demand pressures on these strategic routes will increase. Maintaining strong and resilient strategic networks that can cope with these increased demands is essential.

- Although there are some opportunities to add new corridors to these networks, this is often expensive and disruptive, especially in existing urban areas.
- This means that a targeted investment approach will be required to deal with the impacts of growth, and to ensure that the core parts of the network have sufficient capacity to operate effectively. The different investment drivers and emphases across each network are described in the following slides.

- A key focus for the next phase of the project is determining the relative priorities for improvements to the strategic networks and the extent to which some of them could be brought forward to deliver benefits at an earlier stage.

Strategic Road Network | Strategic Public Transport Network | Rail Network



Investments to strengthen the strategic road network

Context

- In the existing urban area there are very few opportunities to add new strategic road corridors beyond projects already underway (e.g. Waterview Connection) or committed (e.g. East-West Connections).
- Corridors protected many decades ago have now been largely utilised. Therefore, additional major new roading corridors will either have significant social/environmental/property impacts or will need to be expensively tunnelled, which makes achieving value for money challenging.
- Preliminary analysis suggests major new corridors in existing urban areas (e.g. a new Eastern highway corridor combined with an eastern harbour crossing) would be unlikely to deliver sufficient access improvements or congestion relief to the existing strategic network to offer value for money.

Broad Approach to Strategic Road Network

- Focus on improving existing strategic corridors, widening where needed, with some new connections e.g. East –West Connections, greenfield sites.
- In the long term, there is potential for greater productivity of the strategic network through ITS and vehicle technology improvements which will enable greater throughput.
- Variable network pricing will also enable improved management of the strategic road network to prioritise high value trips.
- In the short to medium term, growth in demand appears likely to drive the need for further improvements to the strategic road network.
- The drivers for these improvements will differ across Auckland, as outlined below:

Central Isthmus	North	West	South
• Inner parts of the motorway network are particularly constrained. In these areas, investment beyond highly targeted choke point treatments appears to deliver limited gains compared to the cost. • Improvements to SH20 (Southwestern Motorway) should focus on optimising available capacity in the Waterview Connection, the Mangere Bridge and the proposed East West Connections. • Ensure port connections are consistent with future port operations.	• Northern Motorway: future enhancements will be strongly tied to timing of Additional Waitemata Harbour Crossing (AWHC) and greenfield growth in the longer term, leading to demand growth north of Albany. • AWHC: protect route for a new crossing, but further analysis of drivers and timing, and better integration with public transport options is needed before investment decisions are made.	• SH16 (Northwestern Motorway): growth in the northwest will place this corridor under increasing strain: improvements should focus on optimising corridor, alongside proposed busway. • SH18 (Upper Harbour Motorway) upgrades are strongly related to enabling projected growth and providing access between the west and the North Shore.	• Southern motorway: once current improvements complete, shift focus to improving airport access from the east and optimising capacity between Manukau and the isthmus. • Upgrades to SH22 (connecting Pukekohe and Drury) and southern part of the southern motorway will be strongly driven by when growth occurs in the southern greenfield area • Investments in AMETI and the Mill Road corridor (the main arterial roading connection for new growth areas in the south) should seek to optimise the southern strategic roading network, improve freight reliability and enhance resilience.

Investments to strengthen the strategic public transport network

Context

- Public transport demand is projected to increase strongly under all future options, partly in response to investments that are already committed (e.g. City Rail Link).
- As Auckland grows, the strategic public transport network (current and future rapid transit and mass transit corridors) will need to carry an increasing proportion of this demand to provide fast, high-capacity attractive services that are reliable and free from road congestion.

Two Key Investment Drivers

- Future investment in public transport is expected to be focussed in two key areas: responding to capacity constraints on the current system; and expanding the strategic network to provide an alternative to car travel, especially in growth areas.

Respond to Capacity Constraints	Expand the strategic public transport network to improve overall network efficiency
• Demand projections for public transport have highlighted an emerging need for a step-change in capacity along some key corridors in the future. The timing and sequencing of this needs to be addressed as a system-wide wide strategic issue. • The future volume of buses needed to meet projected demand will create capacity constraints at key 'pinch-points' entering the city centre. Unless addressed, bus speeds and service levels will reduce, and overcrowding will limit the ability for public transport to meet its required share of the transport task in a critical part of the network. • Short term efficiency improvements to existing bus operations will address some of these problems, as will the City Rail Link. At some stage, however, substantial further capacity increases will be required. • The most pressing challenge is to relieve corridors serving the isthmus; followed by those serving the North Shore. • The specific investment response and proposed timing and are the subject to further analysis and will need to be considered alongside other regional priorities. At this stage it appears that an investment that enables many more people to be carried on substantially fewer vehicles will be needed.	• Public transport has an important role to play in enhancing the efficiency of the transport network by enabling greater person-throughput on main corridors. • This role is particularly important in serving new growth areas, which are likely to have longer average trip lengths and place considerable pressure on the transport network. Growth areas to the North and South can be connected to the rapid transit system through extensions to the Northern Busway and rail electrification from Papakura to Pukekohe. • There is no existing rapid transit connection to the new development areas in the North-west, where growth is expected to take place at an early stage. The most cost-effective rapid transit connection is the proposed Northwestern busway. The analysis shows that this would significantly improve accessibility to the West. • A future rapid transit connection would improve accessibility and provide a congestion-free alternative for travel to the Airport, where employment and visitor travel demands are growing rapidly. At this stage, the focus should be on route protection. Heavy rail is not favoured because it is more substantially more expensive and disruptive and would require a significant up-front investment to secure a suitable route within the airport precinct. • Further busway connections between Botany, Flat Bush, Manukau and the Airport should be timed to align with growth and addressing congestion levels along these corridors

Further work required for final report: when should these investments proceed, and how should they be prioritised?

4. Next steps

4. Next Steps

- Steps to the final report
- How should we prioritise future investments?
- Feedback sought

Steps to the final report

Review and feedback on this report from parties (by mid-June) → Third round testing during June-July → Final ATAP report (August)

Current Evidence Gaps

The next stage of the project will include:

- Further modelling and evaluation to supplement the work to date, and provide sufficient evidence to support the recommended approach, and demonstrate its costs and benefits
- Development and application of a prioritisation framework consistent with the preferred strategic approach

Evidence gaps:

- The extent to which a refined programme could improve outcomes (with no additional funding)
- Whether additional or advanced funding is value for money (we have not tested a higher level of investment)
- Whether we can ensure net benefits to users from introducing pricing
- The combined impact of pricing and technology
- Priority/triggers for the big investments
- Value for money and contribution to the wider economy
- The impact of a faster than projected rate of population growth

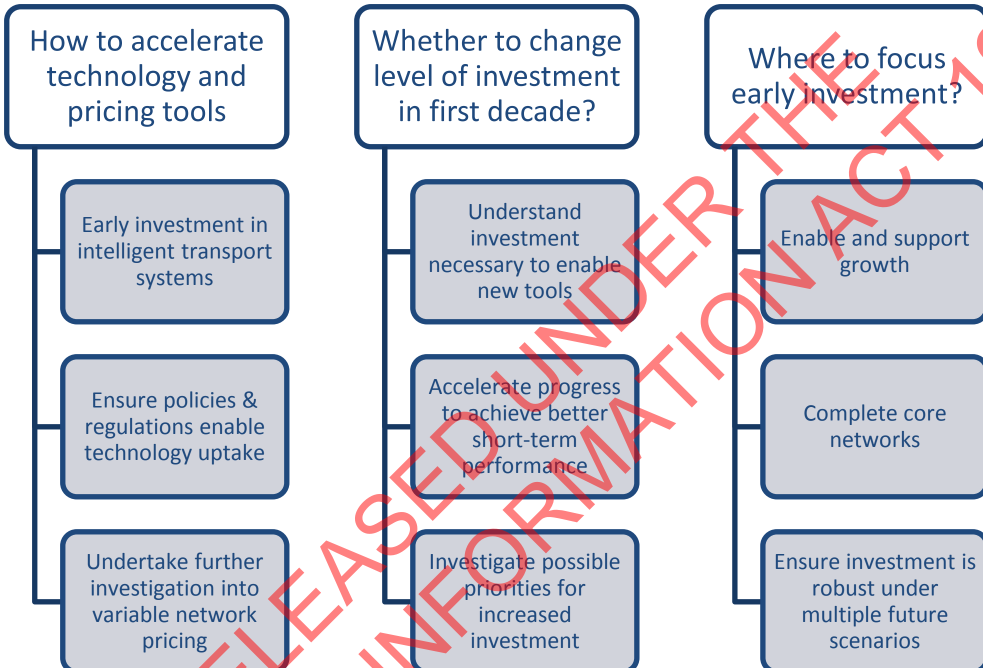
Final ATAP Report

The final ATAP report will recommend an aligned strategic approach for the development of Auckland's transport system that delivers the best possible outcomes for Auckland and New Zealand.

To meet the ATAP Terms of Reference, this will:

- Include an assessment of whether better returns from transport investment can be achieved
- Include preferred indicative package(s), for the long-term development of Auckland's land transport system
- Indicate the costs, benefits and other implications of implementing the aligned strategic approach and its main alternatives
- Include recommendations on how to implement the aligned strategic approach (including consideration of further work and any changes to statutory documents)

Issues to address in developing and implementing the recommended approach



- The final deliverable will identify the steps needed to ensure the next round of statutory documents relating to transport planning and funding in Auckland (including the Government Policy Statement, Regional Land Transport Plan, National Land Transport Programme, and Auckland Plan) are aligned with the strategic approach
- It will highlight the need to invest in improved modelling tools to enable the more detailed investigations needed to give effect to the preferred strategic approach (e.g. models that enable the impacts of pricing and technology to be better understood)
- The final deliverable will also identify where the current planning and funding system may need to change to give effect to the preferred strategic approach. The details of resolving these issues will need to occur beyond ATAP.

Proposed approach to Round 3 testing and what it will tell us

Recommended Approach	Alternative Investment Approaches	Scenario testing
• Show what our recommended approach will achieve & how it meets project objectives • Show the impacts of variable network pricing , timing and phasing implications • Show what investments in the current approach are/are not needed if pricing is introduced • Identify any specific investments needed to enable pricing (especially in first decade)	• Show how far you can get without a stronger focus on managing demand • Show what outcomes can be achieved from additional funding in the first decade • Better understand value for money from different levels of transport investment	• Test a higher rate of population growth to show requirements if recent growth levels continue

How should we prioritise future investments?

As part of the strategic approach there will be a need to prioritise key investments:

- Existing committed expenditure means there is high competition for available funds, particularly in the short-medium term
- Clear prioritisation can enable us to decide which investments should be in each decade.

A prioritisation framework will be developed and refined as part of the next stage of ATAP.

In delivering value for money, recommended prioritisation criteria should include :

- Address most severe deficiencies against ATAP objectives
- Resilience to a range of different futures (pricing and technology)
- Unlock growth required for Auckland

Feedback sought

To enable project timeframes to be met, feedback on this report from the parties is needed by mid-June.

Feedback on the following issues will be particularly useful to the project team:

- Is the emerging strategic approach supported?
- Do the parties support a move to embrace new technologies and demand management (variable pricing) as part of the preferred approach?
- Are there any differences in approach that should be considered?
- Are the recommended prioritisation criteria appropriate?
- Are there any additional issues that need to be addressed or options tested in the next phase of the project?

Auckland Transport Alignment Project

Maintenance, Operations and Renewals Report

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Preface

This is one of a series of research reports that were prepared as inputs to the Auckland Transport Alignment Project (ATAP), as illustrated below. It is one of a number of sources of information that have been considered as part of the project, and which have collectively contributed to the development of the recommended strategic approach. The content of this report may not be fully reflected in the recommended strategic approach, and does not necessarily reflect the views of the individuals involved in ATAP, or the organisations they represent. The material contained in this report should not be construed in any way as policy adopted by any of the ATAP parties. The full set of ATAP reports is available at www.transport.govt.nz/atap.

1. Executive summary

This report provides details of the estimated 30-year renewal, operations and maintenance investment profile commencing 1 July 2018. It is a “snapshot” as of August 2016, acknowledging that asset condition and the cost of doing work change over time, and that assets models are being further developed.

The scope covers both New Zealand Transport Agency (NZTA) and Auckland Transport (AT) investment. It excludes investment required by KiwiRail.

The analysis has been framed around the new capital investment programme ide3ntified in the Regional Land Transport Plan, the Long Term Plan 2015 – 2018 and the ATAP recommended strategic approach. The report identifies the base costs plus the consequential costs arising from capital development. The assumptions used to estimate these costs have not been subject to external peer review.

The 30 year totals are detailed in Table 1 and a breakdown between base and consequential costs in Table 2.

Table 1 - NZTA & AT 30-year Summary ($m)

$m uninflated		Decade 1 2018/19-2027/28	Decade 2 2028/29-2037/38	Decade 3 2038/39-2047/48	30 year Total
Renewals	Auckland Transport	3,084	4,065	4,132	11,281
	NZTA	348	427	501	1,276
	Subtotal	3,433	4,492	4,633	12,557
Operations & Maintenance	Auckland Transport	10,270	16,178	20,671	47,119
	NZTA	1,038	1,474	1,747	4,259
	Subtotal	11,308	17,652	22,418	51,378
Cost Total		**14,740**	**22,144**	**27,051**	**63,935**
Revenue	Auckland Transport	-4,070.4	-6,413.1	-7,985.6	-18,469.1
Net total		**10,669.9**	**15,730.8**	**19,065.3**	**45,466.0**

Table 2 - NZTA & AT 30-year Base and Consequential Costs ($m)

$m uninflated		Decade 1 2018/19 – 2027/28	Decade 2 2028/29 – 2037/38	Decade 3 2038/39 – 2047/48	30 year total
Base (current)	Auckland Transport	11,245	13,941	16,164	41,351
	NZTA	1,093	1,207	1,313	3,613
	Sub-total	12,338	15,149	17,477	44,964
Consequential	Auckland Transport	2,109	6,301	8,639	17,049
	NZTA	293	694	935	1,922
	Sub-total	2,402	6,995	9,574	18,971
Cost Total		**14,740**	**22,144**	**27,051**	**63,935**
Revenue	Auckland Transport	-4,070.4	-6,413.1	-7,985.6	-18,469.1
Net total		**10,669.9**	**15,730.8**	**19,065.3**	**45,466.0**

2. Background

The purpose of the Auckland Transport Alignment Project (ATAP) Maintenance, Operations and Renewals Work Stream was to collaboratively develop and test a 30-year projection of the costs necessary to operate, maintain and renew[1] the regional roading and transport network (excluding KiwiRail assets).

It has considered inputs from both Auckland Transport (AT) and New Zealand Transport Agency (NZTA).

The work stream has four principal inputs:

1. The Auckland Transport Renewals Optimisation Model
2. NZTA Highways and Network Operations group 30-year Maintenance and Operations (M&O) forecast
3. The Auckland Transport Consequential Opex Model
4. Auckland Transport's Public Transport Operations 30-year forecast.

Financial analysis has been undertaken to determine estimated maintenance, operations and renewals budgets over a 30-year horizon from July 2018. They are overlaid by a number of assumptions, each of which will impact upon the analysis undertaken. The budgets presented are the recommendations from the respective asset management teams, and have not been externally peer-reviewed.

Auckland Transport financial accounting distinguishes between capital (capex) and operational (opex) expenditure. Renewals are capex, whilst maintenance and operations are opex. The NLTP activity classes treat renewals as maintenance.

The 30-year projections for Auckland Transport's local roads and NZTA's state highways are presented separately.

The time available to prepare this analysis has been constrained. Accordingly, the analysis will be further refined over the coming months. This analysis is, in essence, a 'snapshot' as of August 2016. Since the One Network Road Classification (ONRC) framework, models and other forecasts such as Light Rail Transit (Mass Transit) are continuing to develop, the numbers presented will be subject to change over time.

The analysis will also be impacted by an on-going programme of condition assessments which will influence the required budgets presented.

All financial analysis undertaken and budgets presented in this paper are uninflated (2015/2016 base line).

[1] Renew' means replacing the asset at the end of its service life, but excluding any improvement in capacity

3. Narrative

The relationship between capital investment, maintenance, operations and renewals is relatively simple. The more physical infrastructure that there is in use the more it will cost to renew, operate and maintain for the same level of service.

However, there are options. As more infrastructure is built it is possible to:

1. Increase maintenance, operations and renewals budget to reflect increased costs
2. Reduce the level of service provided
3. Do nothing, increasing the level of risk of unplanned failure.

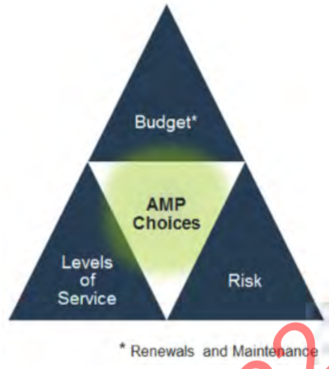


Figure 1 - Asset Management Options

There is of course a fourth option; that is reduce the quantum of new infrastructure that requires maintenance, operations and renewal through a reduction in the capital new build programme. This may not be palatable or practical in a growing city like Auckland.

The greatest single influence on maintenance, operations and renewal costs is the impact of the current and planned capital programme expanding and improving the network, along with the associated increase in public transport services.

The relationship between new capital investment, maintenance, operations and renewals has to be managed to derive the greatest benefit from the transport investment.

For physical assets, the social and economic benefits of transport infrastructure are dependent upon its ability to provide a safe, reliable and fit-for purpose level of service over the long term. Good infrastructure asset management practice ensures that sufficient investment is available for the maintenance of the existing network so that it can continue to deliver those benefits and outcomes. This approach ensures protection of the existing asset investment and the sustainability of the network in the long term.

As an example, the links between asset condition, level of service, cost and risk are shown in Table 3 for road pavements. This shows that as asset condition deteriorates with time and use, customer level of service declines, risk increases and the cost to bring the asset back to a fit for purpose condition increases.

Table 3 - Links between level of service, cost and risk for road pavements

Condition	Level of Service	Cost	Risk
Very Good, **Good** or **Moderate** condition	Customer expectations met 	Needs routine maintenance only. Cost: maintenance **$10,000 per km** per year	Low risk
Poor condition	Defects noticeable but won't change customer behaviour 	Extent of surface problems means spot fixes are no longer adequate. Water may be entering the road construction layers. HCV loadings will accelerate failure. Cost: pavement resurface **$100,000 per km**	Low risk
Very Poor condition	Poor customer experience 	Wheel ruts and edge breaks indicate that road construction layers are damaged. Road is less comfortable and safe for drivers and (especially) cyclists and motorcyclists. HCV loadings will cause rapid failure requiring urgent attention. Cost: road rehabilitation **$1,000,000 per km**	On a fast and/or busy road, there could be a significant safety risk

Table 3 also highlights the linkage between renewal and maintenance expenditure. Reducing expenditure in one increases investment pressure in the other. For example, reducing renewal investment will increase the need to undertake reactive maintenance beyond economic service life and conversely, reducing maintenance will accelerate asset deterioration resulting in increased renewal needs and the potential development of an unmanageable backlog.

The analysis undertaken in this paper considers a number of cost drivers which will impact maintenance, operations and renewal costs over the 30 year period:

- Customer level of service targets
- Growth in the size and complexity of network operations and infrastructure
- Growth in freight to build, service and supply a growing city
- Efficiency and effectiveness gains in operations and maintenance
- Infrastructure condition and contingent risk of service failure

The analysis undertaken excludes any increased compliance costs arising from the adoption of the Unitary Plan, and any required mitigation arising from climate change and sea level rise.

The analysis has been based on the level of new capital investment and work programme identified in the Regional Land Transport Plan and Long Term Plan 2015 – 2018. It also includes early estimates for Mass Transit but it should be noted that there is a higher level of uncertainty around Mass Transit analysis due to the early stage in the project development.

4. NZTA State Highway Maintenance, Operations and Renewals

NZTA manages and operates the State highway network across Auckland. This comprises:

- 1198 lane km of roads
- 304 Bridges
- 12970 Minor drainage assets
- 2657 ITS Assets
- 13262 Signs
- 7341 Street lights
- 3 Tunnels

The replacement value of the assets is $10.488 billion; this figure includes land but not corporate assets and intangibles (e.g. software).

The current State highway operation and maintenance costs for the Auckland Region are approximately $103 million per annum.

The size and complexity of the Auckland network infrastructure and operations is forecast to grow significantly over the next 30 years as capital projects extend and improve the network, and as operational management of the network expands as the city grows.

From the projects identified, the analysis recognised the future maintenance cost impact of 25 major new projects. While other improvement projects would incur additional maintenance costs, NZTA has assumed that these costs will be absorbed by gains in efficiency in maintaining the entire network.

Some of the major projects that are expected to have a material effect on the Maintenance, Operations and Renewals budget include:

- East West Connection
- Southern Corridor
- Northern Corridor
- Additional Harbour Crossing
- SH20 Kirkbride
- Waterview
- SH16 Upgrade
- Puhoi to Warkworth
- North Western Busway
- Pukekohe Expressway

A growing network increases the quantity of asset that must be maintained and renewed, hence the costs of maintenance and asset renewal are also increased. The forecast increase in network necessitates not only the increased cost of maintaining the physical asset, but also increases the scale of the traffic management and operations task. The network increases in length by 15 – 25% or an additional 209 lane km as a result of planned improvement projects. At this stage, the exact scope around the projects and the full increase these projects have on the network (apart from assessing maintenance costs through a percentage of the capital cost vs current $ per lane/km), are uncertain.

New complex infrastructure such as the Waterview tunnels requires conventional maintenance to maintain road pavements and similar conventional infrastructure. Additional operations and maintenance is required to operate and maintain safety equipment and for operational readiness to provide safe travel for customers. The impact is to increase operating and maintenance costs by about 113% at the end of the 30 years.

The increased costs of operating and maintaining each new significant project when it becomes operational has been recognised, and increased renewal costs when infrastructure subsequently deteriorates and requires renewal discounting individual project maintenance estimates to recognize economies of scale in the Auckland area. The impact is an increase in operational and maintenance costs of 19%; the breakdown of this includes 88% of Maintenance and Operations and 12% Renewals over the 30-year period. Some roads will also be elevated over time within the ONRC framework, which will require increased inputs. The costs are summarised in Table 4.

Furthermore, some of the long-life structural motorway pavements constructed in the 1960's and 1970's are likely to be reaching the end of their economic service lives within the 30 year horizon. It is often difficult to predict precisely when a pavement asset will need renewing, and decisions will continue to be made on the basis of asset condition monitoring.

It is estimated that the growth in the size and complexity of the State highway network will require additional operations, maintenance and renewal works to maintain service levels on the new infrastructure costing $116 million per annum or 113%; 86% of this is Maintenance and Operations and 14% Renewals. This is detailed in Attachment 3 and illustrated in Figure 2.

Table 4 - NZTA 30 Year Summary

$m uninflated	Decade 1 2018/19–2027/28	Decade 2 2028/29–2037/38	Decade 3 2038/39–2047/48	Estimated 30 Year Total
Renewals - base	319	341	350	1,010
Renewals - projects	30	86	151	267
Operations and Maintenance - base	716	733	752	2,201
Operations and Maintenance - projects	263	608	784	1,655
Other	58	133	211	402
Total	**1,386**	**1,901**	**2,248**	**5,535**

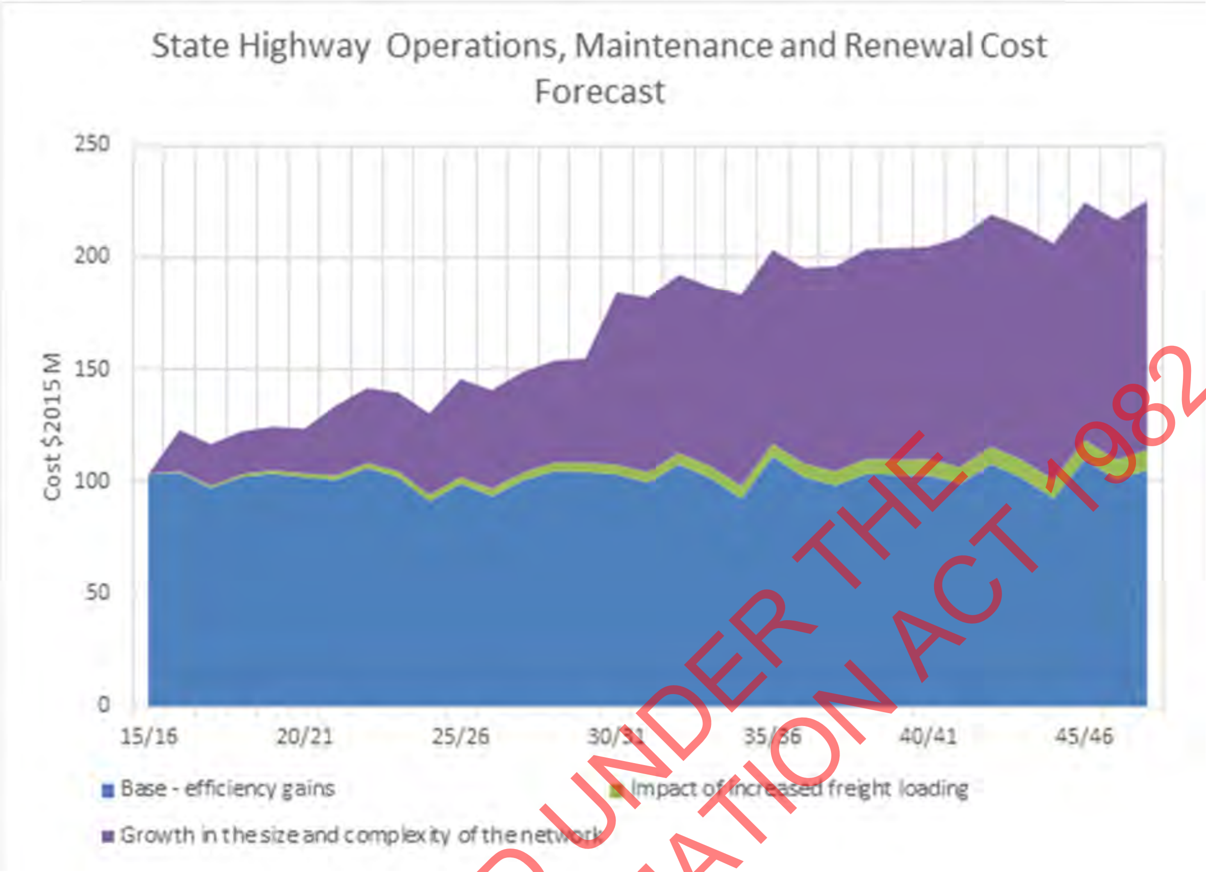


Figure 2 - NZTA 30 Year Summary

5. Auckland Transport

Auckland Transport manages and operates the local road network and public transport infrastructure across Auckland. This comprises:

- 7,302 km of roads
- 6,959 km of footpaths
- 321km of cycleways
- 1,020 bridges and major culverts
- 41 active rail stations, associated stabling and depot
- 57 electric trains (EMUs)
- 10 Diesel Multiple Units
- 6 Busway stations
- 2,342 bus shelters
- 21 ferry wharves

The replacement value of the assets is $13.4 billion excluding land, corporate assets and intangibles (e.g. software).

Auckland Transport currently spends $702.5 million annually (2015/2016) on maintenance, operations and renewals:

- Renewals - $198 million
- Maintenance - $110 million
- Operations (Asset-based) - $69.4 million
- Operations (Services) - $325.1 million

Asset based operations are defined as activities that directly consume resources to operate an asset such as energy, chemicals and materials. Examples of asset based operations include cleaning, electricity, fuel and weed control.

Service based operations are defined as activities associated with the provision of public transport and management of facilities and assets that do not directly consume resources against an asset e.g. security staff, corporate support, transport service contracts, events and incident management etc.

5.1. Growth

The growth in renewable and maintainable assets is based on asset class growth figures used within the 2015 AMP and LTP as well as more recent 30 year assessments for growth in road pavement and their directly associated assets. The network averages of the 30-year annual growth factors used within this report are:

- Road network 0.79% per year
- Public Transport network 0.56% per year

These growth percentage numbers exclude the City Rail Link (CRL) and Mass Transit. Those major capital projects are however allowed for in consequential renewals and opex costs.

Growth in non-asset opex such as public transport services from 2019 - 2025 are based on the Annual Plan. Subsequent years 2026 - 2048 are increased by 2% for the base case per year in line with LTP passenger targets. Figure 3 shows the total passenger targets based on the APT model.

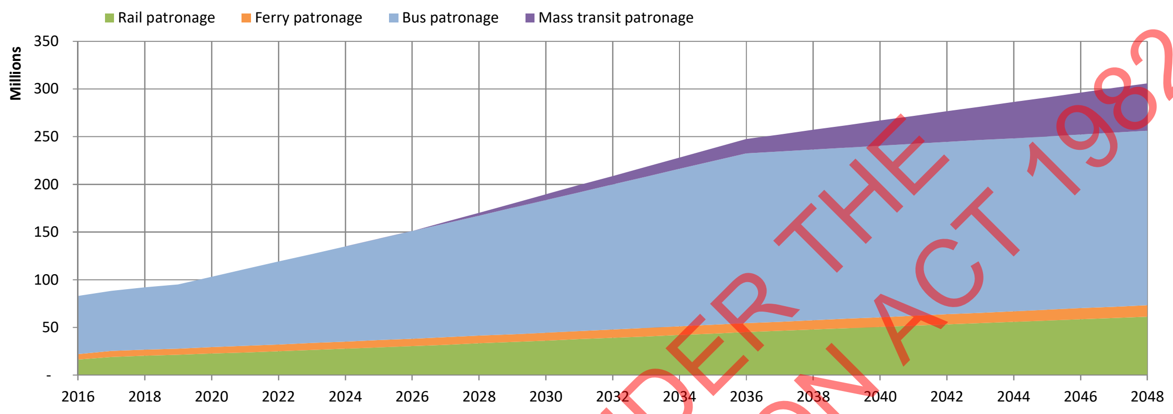


Figure 3 - Public transport patronage growth

5.2. Renewals and maintenance summary

The estimated 30-year renewal, asset-based operations and maintenance investment is summarised in Table 5. This investment allows for growth using the above figures on the existing network and includes the CRL and Mass Transit projects[2].

The renewals and maintenance investment also incorporates changes in levels of service and management of risk to reflect the One Network Road Classification (ONRC).

Table 5 - AT 30-year summary

$m uninflated	Decade 1 (2018/19 – 2027/28)	Decade 2 (2028/29 – 2037/38)	Decade 3 (2038/39 – 2047/48)	30 Year Total
Renewals	3,084	4,065	4,132	11,281
Maintenance	1,705	2,239	3,117	7,061
Operations (Asset Based)	749	1,205	1,690	3,645
Total	**5,539**	**7,509**	**8,939**	**21,986**

[2] See Attachment 2 for the assumptions that have been used in estimating costs associated with these investments. Note that assumptions on the scope and timing of mass transit investment may differ from that suggested in the ATAP Indicative Package.

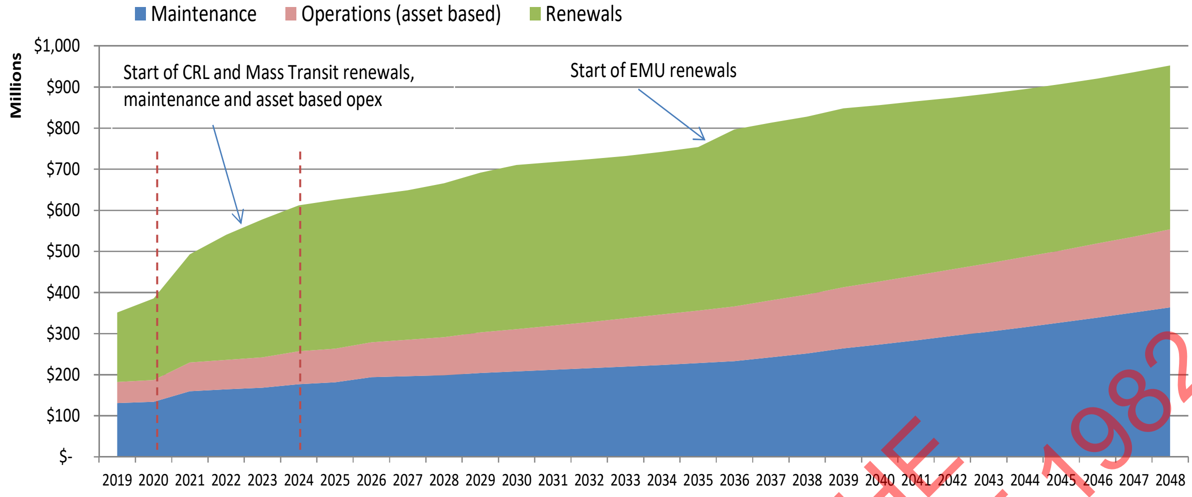


Figure 4 – 30-year asset-based maintenance operations and renewals expenditure

Figure 4 shows the AT 30-year asset-based maintenance, operations and renewals expenditure. The step up from 2021-2024 reflects the beginning of CRL and Mass Transit costs and in 2036 committed renewals of $30 million/year for rail EMU rolling stock begins.

A detailed breakdown of this summary is included in Attachment 4.

The existing asset base is currently maintained to a reasonable standard. Last year's Auditor General's report noted the quality of data and planning behind Auckland's transport asset management. This provides assurance that the numbers used in the report are materially accurate.

5.3. Renewals

Total estimated renewals investment is made up of renewals required for existing assets plus those that arise from future new assets. The analysis therefore provides for growth arising from AT capital projects and assets vested to AT from developers and council. Figure 5 shows the 30 year renewals investment profile, including CRL and Mass Transit, rising from $169 million in 2019 to $399 million in 2048.

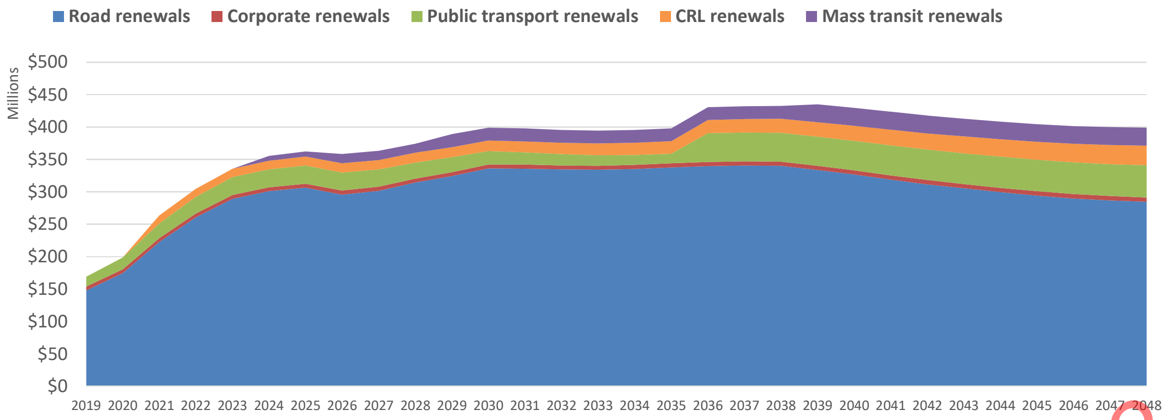


Figure 5 - Renewals 30-year expenditure by network

Figure 6 details the same information but presented to show renewals expenditure related to existing assets (base renewals) and consequential renewals that will be required to replace new assets (including the CRL and mass transit). These consequential renewals will increase in cost from $0 in 2019 to $79 million per annum by 2048.

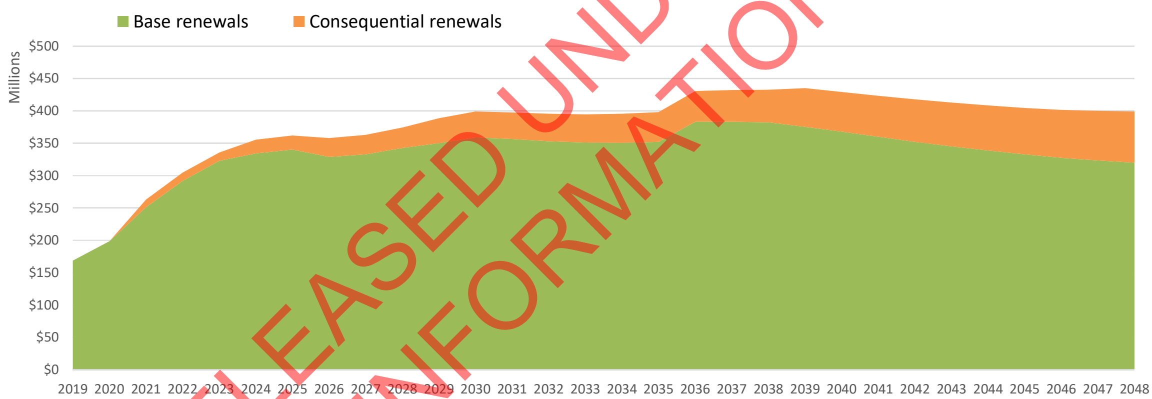


Figure 6 - AT 30 Year renewals expenditure by type and growth

5.3.1. Miscellaneous renewals

Included within the renewals figures are those that are not analysed but are currently committed by AT. These include the following annual costs:

- Rolling stock (electric motor units) $30 million beginning 2036
- Rolling Stock (diesel motor units) $0.5 million
- Storm water $1.4 million
- Corporate renewals $6 million
- Other $14.4 million

Corporate renewals include for AT internal time and professional services charged against renewals projects, resource consents and other renewals planning requirements such as One Network Road classification (ONRC) and the Forward Works Plan.

Miscellaneous renewals grow from $16.6 million in 2019 to $60 million in 2048 including $30million/year for EMUs beginning in 2036.

5.3.2. Cost efficient renewals

Infrastructure management requires ongoing renewals investment to maintain levels of service. The most cost-efficient renewals investment minimises whole of life cost across the network portfolio for the required level of service. This requires that the network be brought into its most cost-efficient state over the long term.

Figure 7 shows the 30-year profile of renewals cost vs. condition and backlog. This is the recommended renewals investment. Condition is displayed as five grades from very good (dark green) through to very poor (red).

This investment profile shows significant increases in the first decade as existing backlog is reduced and levels of service are normalised across the region. Thereafter, despite significant network growth, the second and third decades show stable renewals need as the network settles into a more cost-efficient condition state where levels of service and backlog have largely been addressed.

The estimated renewals investment provides for normalising levels of service across the region through renewals interventions that manage levels of service, risk and ONRC requirements across the network. The cost-efficient analysis excludes CRL, Mass Transit, miscellaneous renewals and the impact of inflation.

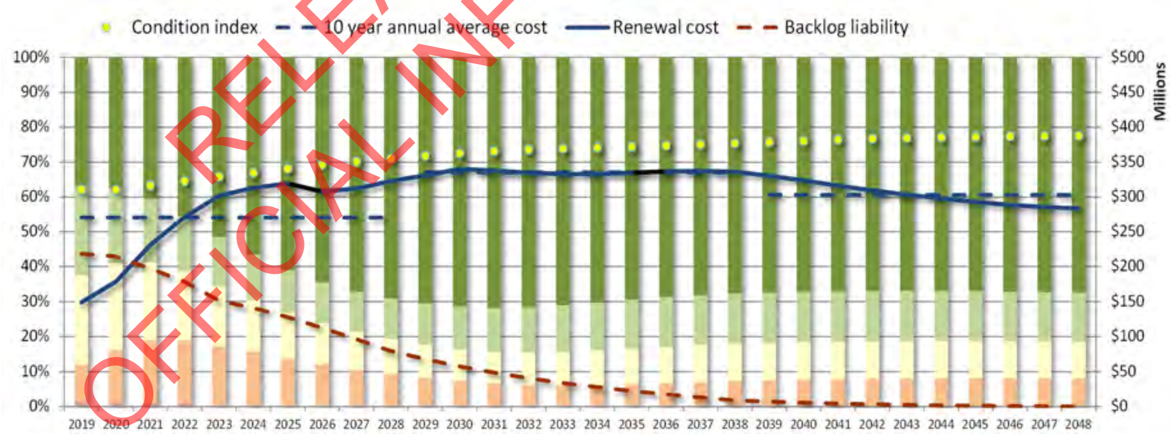


Figure 7 - AT cost-efficient investment vs. condition

The longer-term analysis shows increasing renewals cost resulting from increasing inventory, network complexity and usage including increased heavy commercial vehicle loadings.

The cost-efficient investment profile is proposed as it addresses levels of service and risk and leads to a more cost-effective management of the network in the long-term.

5.3.3. Base case

As a comparison, a base case analysis has been undertaken. The base case investment assumes renewals occur just before asset failure. As such it does not address long-term cost-efficiency nor stakeholder requirements for levels of service, risk management and ONRC. Figure 8 shows that the renewals base case first decade costs are less than the efficient investment profile in Figure 7, but there is little between them by 2037.

The base case investment results in a significant increase in very poor condition assets, especially in the first decade. This has ongoing negative consequences of increased risk, reduced customer satisfaction and increased pressure on maintenance budgets.

The base case analysis excludes miscellaneous, CRL and Mass Transit renewals.

Figure 8 - Renewals base case investment

Figure 9 shows the base case investment vs the efficient investment (both modelled) within the context of the total ATAP renewals forecast which includes miscellaneous, corporate, CRL and Mass Transit renewals.

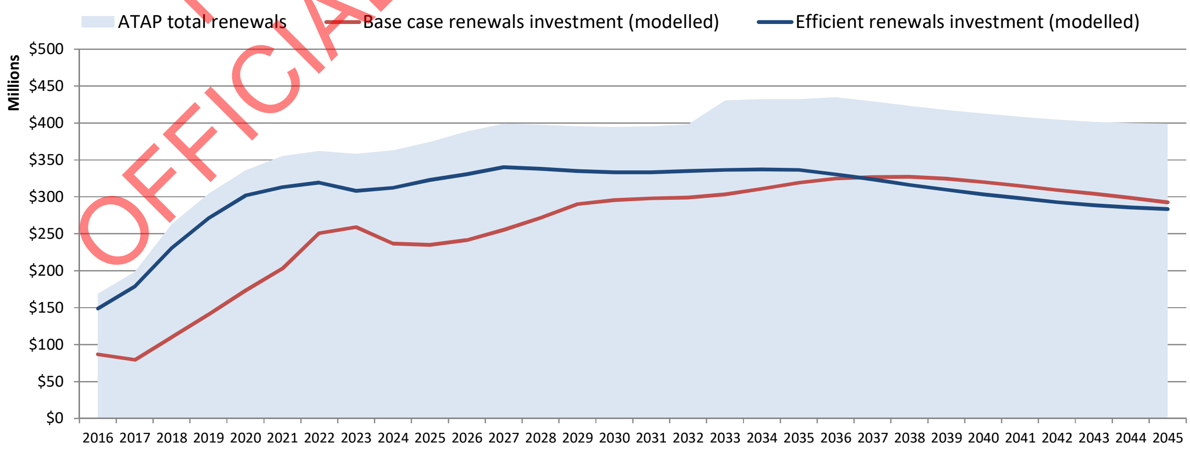


Figure 9 – Renewals base case vs. cost-efficient investment

5.3.4. Efficiency gains

The implementation of the ‘One Network Road Classification’ (ONRC) based on road function and ‘fit for purpose’ customer levels of service and incorporation of ‘Road Efficiency Group’ (REG) principles in the 2018-21 NLTP and beyond will result in on-going efficiency gains in maintaining and renewing the physical asset.

The analysis has incorporated these expected efficiency gains, as follows:

- 12.4% ($354 million) in decade 1
- 4.7% ($160 million) in decade 2
- 0.3% ($10 million) in decade 3

This shows that the current opportunity for ONRC and REG efficiency gains is high but reduces over time as the network approaches its long-term steady-state and appropriate service levels. Overall ONRC efficiency gains over the 30 years of the plan are 5.7% or $524 million.

The 2017 AMP update identifies a reducing per capita cost of renewals and maintenance and a reducing per trip cost for public transport services through to 2025.

Further efficiency gains have not been assessed at this stage as they cannot be supported by analysis.

5.4. Opex expenditure

Figure 10 shows a summary of the 30-year opex expenditure. The most significant cost is operational services which rise from $573 million in 2019 to $1,696 million in 2048, mainly driven by significant increases in patronage and service levels. Maintenance and asset based operations together rise from $183 million in 2019 to $554 million in 2048.

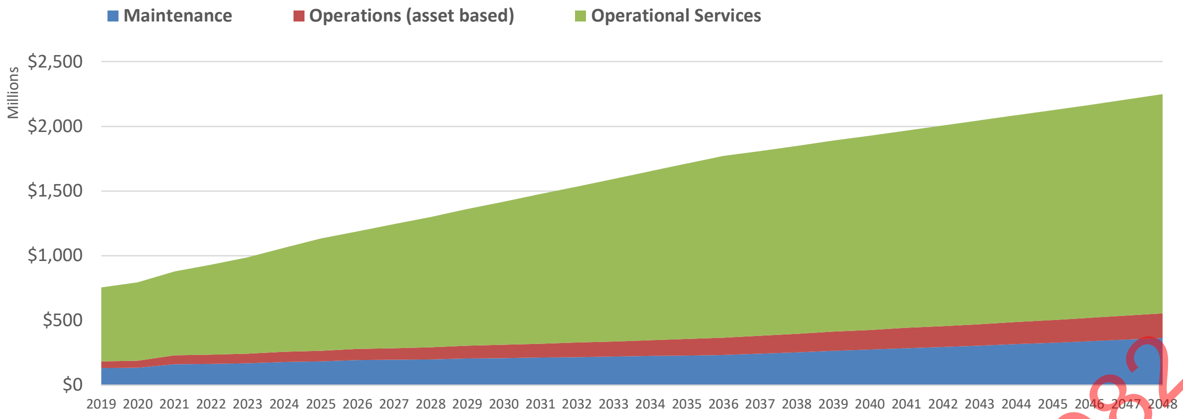


Figure 10 - Opex 30-year expenditure

5.4.1. Consequential opex

Over the 30-year period (2019 to 2048) the increase in operations and maintenance costs directly related to assets are:

- Maintenance - $131 million (2019) to $364 million (2048)
- Operations (asset-based) - $52 million (2019) to $190 million (2048)

These increases, shown in Table 6, are largely the result of the significant consequential opex requirements of:

- New assets developed by AT including CRL and Mass Transit
- Vested assets i.e. transport assets transferred to AT ownership and management from developers and council.

Consequential estimates for operations and maintenance are based on current analysis of historical costs, new capital projects and vested assets. This analysis is subject to further refinement.

Table 6 - AT 30 Year Consequential Opex

$m uninflated	Decade 1 2018/19 – 2027/28	Decade 2 2028/29 – 2037/38	Decade 3 2038/39 – 2047/48	30 Year Total
Maintenance	429	593	770	1,793
Operations (Asset Based)	241	562	807	1,610
Total	**670**	**1,155**	**1,577**	**3,403**

AT's modelling of consequential opex is not yet mature and ATAP decisions will have a significant impact on this. More work is needed before investment decisions are made. Financial modelling is relatively sensitive to the assumptions used in the model and these should be further tested.

5.4.2. Maintenance and asset-based operations

AT maintenance and asset-based operations are shown in Figure 11. This includes maintenance and opex costs for CRL of $38 million in 2021 rising to $95 million by 2048 and for Mass Transit of $8.6 million in 2024 rising to $20 million by 2048.

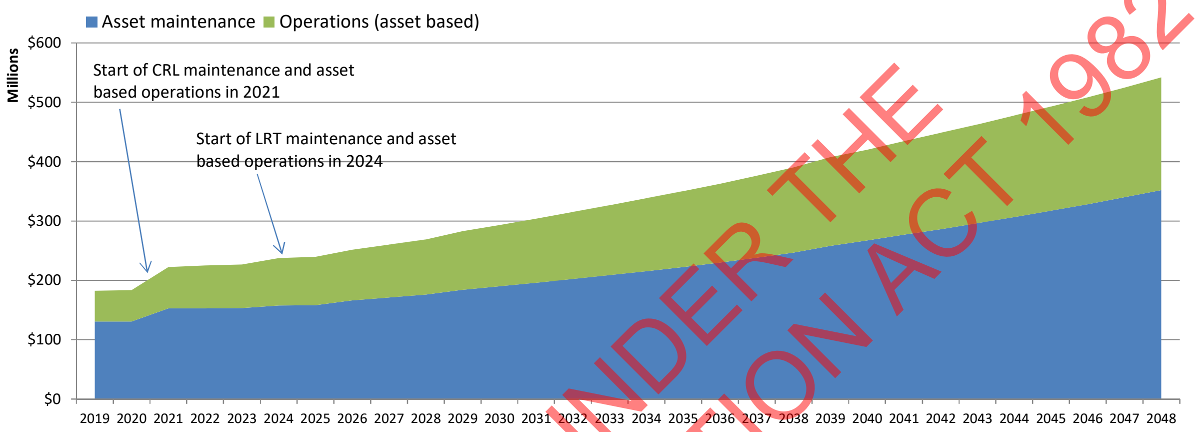


Figure 11 - AT maintenance and asset-based operations

5.4.3. Operational services and revenue

Operations (services) are those activities associated with the management of facilities and assets that do not directly consume resources against an asset e.g. security, corporate support, transport service contracts, line charges, events and incident management etc. These include the major public transport service contracts for bus, rail and ferry. Against these there are revenue streams from user and contract service charges. These include:

- Public transport farebox revenue (including public transport contract revenue for rail and PTOM revenue for bus and ferry services)
- Supergold (for seniors) and concessionary fares (child, school and disability)
- Operator access fees, and wharf berthage and freight levies received from ferry operators
- Commercial rentals for leasing public transport facilities
- Adshell, bus stations and advertising revenue received from private companies for advertising in public transport facilities
- Special events revenue

Operational services are approximately half the annual expenditure incorporated in this paper. In the past two years the fare box recovery rate has been increased from 46% to 50% and this rate is assumed for the period of the plan. The Public Transport Operating Model

(PTOM) is anticipated to deliver savings which will be reinvested in service improvement to grow public transport patronage and tackle traffic congestion.

Table 7 shows the 30-year summary of operational services and revenue.

Table 7 - Operations (services) Costs and Revenues

$m uninflated	Decade 1 (2018/19 – 027/28)	Decade 2 (2028/29 –2037/38)	Decade 3 (2038/39 – 2047/48)	30 Year Total
Operations services (base)	6,550	8,031	9,491	24,072
Consequential operational services	1,266	4,703	6,373	12,342
Revenue generated against services	-3,942	-6,254	-7,804	-18,000
Total	**3,874**	**6,480**	**8,060**	**18,413**

Figure 12 shows the 30-year expenditure and revenue for operational services. Net operating expenditure (the difference between services opex and revenue) increases from $278 million in 2019 to $860 million by 2048. This is driven mainly by the significant increase in projected public transport patronage.

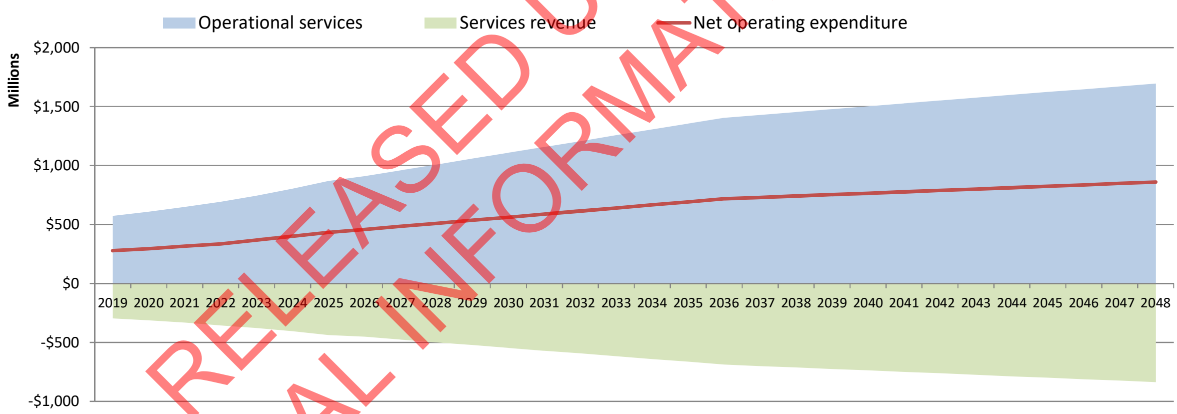


Figure 12 Operational services vs services revenue

6. Conclusions and recommendations

The total recommended expenditure over the 30-year period 2018/2019 to 2047/2048 is summarised in Tables 8 and Table 9. This is the minimum level of funding for renewals, operations and maintenance that should be included in the 30 year ATAP budgets.

Table 8 - NZTA & AT 30 Year Summary

$m uninflated		Decade 1 2018/19–2027/28	Decade 2 (2028/29–2037/38	Decade 3 2038/39–2047/48	30 Year Total
AT	Renewals	3,084	4,065	4,132	11,281
	Maintenance	1,705	2,239	3,117	7,061
	Operations (asset-based)	749	1,205	1,690	3,645
	Operational services	7,816	12,734	15,864	36,414
	Cost total	**13,354**	**20,243**	**24,803**	**58,400**
	AT revenue	-4,070	-6,413	-7,986	-18,469
	Net total	**9,284**	**13,830**	**16,817**	**39,931**
NZTA	Renewals	348	427	501	1,276
	Operations & Maintenance	979	1,341	1,536	3,856
	Other	58	133	211	402
	Cost Total	**1,386**	**1,901**	**2,248**	**5,535**
Net total		**10,670**	**15,731**	**19,065**	**45,466**

Table 9 – Renewals, operations and maintenance 30 Year Summary

$m uninflated		Decade 1 2018/19-2027/28	Decade 2 2028/29-2037/38	Decade 3 2038/39-2047/48	30 year Total
Renewals	Auckland Transport	3,084	4,065	4,132	11,281
	NZTA	348	427	501	1,276
	Subtotal	3,433	4,492	4,633	12,557
Operations & Maintenance	Auckland Transport	10,270	16,178	20,671	47,119
	NZTA	1,038	1,474	1,747	4,259
	Subtotal	11,308	17,652	22,418	51,378
Cost Total		**14,740**	**22,144**	**27,051**	**63,935**
Revenue	Auckland Transport	-4,070.4	-6,413.1	-7,985.6	-18,469.1
Net total		**10,669.9**	**15,730.8**	**19,065.3**	**45,466.0**

Attachment 1 – NZTA assumptions and limitations

NZTA modelling includes a number of assumptions.

1. No change in service levels and costs in the base case. Potential changes to level of service outside the core areas of safety, access and journey times have been reviewed. Potential savings in areas such as amenity are immaterial as the vast bulk of expenditure is directed to maintaining core service levels
2. Freight volumes are forecast to grow as the Auckland economy grows. Increased freight volumes cause increasingly rapid deterioration of road pavements causing service lives of road surfaces and pavements to reduce and costs increase as more frequent works are implemented using increasingly robust treatments. It is estimated that the impact of increased freight will require additional expenditure of $9 million pa or 8% over 30 years to maintain service levels
3. The same proportion of infrastructure that is in good or bad condition today will be maintained over 30 years and that consequently the risk of rapid deterioration leading to service failure is unchanged over the 30-year period.
4. Sustained reductions in cost due to efficiency and effectiveness improvements of 0.25% pa have a 30-year impact of reducing costs by 7.5%
5. The above savings are assumed to be small currently due to NZTA already implementing the REG principles and the M&O review since 2012. The majority of the savings of the M&O were realised in 2015 on the Auckland North Maintenance Tender and also with the Auckland Motorway and Harbour Bridge being an Alliance there has been substantial savings in 2015 that are shown in the base figures.
6. Retendering operations and maintenance contracts has no impact on unit costs, but contributes to efficiency and effectiveness gains.
7. There is no dramatic change in fleet or traffic causing significantly different maintenance or operational requirements to those used currently
8. Transfers in responsibility for State highways to or from Auckland Transport are cost neutral, uncertain in extent or timing. NZTA costs include the cost of any State highway that may be transferred to local roads and AT costs include no costs for these roads.

Attachment 2 – Auckland Transport assumptions and limitations

The analysis to determine recommended budgets is framed around a number of assumptions and limitations. These are listed below.

Overall assumptions and limitations

- The timing of roading revocations from NZTA to AT has not been considered. Accordingly, the appropriate budgets have been accounted for within the NZTA portfolio.
- Noting the relationship between renewal investment and maintenance costs, the renewal analysis has assumed that the recommended funding for maintenance activities will be adopted.
- Income, including that generated through fare box recovery has been included.
- As for the previous 2015 – 2018 Long Term Plan analysis, replacement of technology assets for AT HOP, JTOC/ATOC and Parking Enforcement are deemed to be new capital and have not been included in the renewal totals:
- AT HOP and Metro Customer Experience operational services expenditure is included
- It is not possible to get a complete alignment between the ATAP and LTP opex forecasts. This is due mainly to ongoing changes and improvements in financial reporting as well as additional detail coming through on projects such as CRL and Mass Transit.
- Condition data dating from January 2016 has been used to undertake the renewal analysis.
- Freight is currently allowed for as a percentage of the network as a whole. Its impact is reflected in carriageway deterioration but is subject to further analysis.
- Assumptions and limitations for road network consequential operations and maintenance are:
    - 2016 LTP opex budget is used as a base for the calculation of consequential opex for 2019-2048.
    - Asset classes used are those budgeted against in the LTP.
    - Cumulative growth factors used are 0.5% in the 1st decade, 0.7% in the 2nd decade and 1.0% in the 3rd decade for the road asset classes.
    - Asset based operational costs appear to be on the low side, especially the cleaning and vegetation costs. This is due to the lack of visibility of the vested assets.
    - A comprehensive vested assets programme will influence the opex requirements, mainly the asset based operations costs.
- No direct allowance has been made for potential increases in general access axle weights. Since the relationship between axle weight and the rate of pavement wear is considered to be exponential, any significant increase would impact heavily on maintenance costs and reduce asset life. Currently, there are proposals to allow slightly increased limits for single decked urban buses to operate under permit, and a slight increase for eight axle truck combinations. However, these changes legitimise long standing areas of non-compliance so will not have a significant financial impact.

ATAP PT Opex Model (APT) – assumptions

- The Public Transport (PT) Opex model generates two scenarios:
    - Base case
    - Additional consequential opex based on the preferred ATAP scenario
- The time period for the analysis is for three decades from 2018-48.
- The first decade of the base case scenario is calculated based on AT's 2016/17 Annual Plan Version (SAP V102). This version is very similar to the published 2015 10-year LTP (for the period from 2018-25). For the second and third decades, costs are based on a combination of actual historic costs and expected future contract costs, with a new PT system reflecting changes in the bus network.
- The base case scenario 2026 – 2048 assumes annual growth of 2% based on 2025 expenditure and PT services revenue, and 1% for asset based revenue (e.g. rail station advertising).
- Patronage/boarding numbers are used to calculate the unit cost of PT services:
    - Unit cost for PT services = PT contract cost per boarding
    - Unit of revenue for PT services = Fare box revenue per boarding
- PT contract cost, fare box revenue and patronage numbers are obtained from AT's 2016/17 Annual Plan Version (SAP V102).
- In the long run (three decades) patronage is a reasonable proxy measure to estimate the services cost. Future increases in service cost and revenue are therefore assumed to move in line with forecast patronage growth.
- Service kilometres (Service km) are used to calculate Rail track access and rolling stock maintenance.
    - Unit cost for track access charges = Total track access charges / Service km
    - Unit cost for rolling stock maintenance = Total rolling stock maintenance cost / Service km
- Total track access charges, total rolling stock maintenance cost and service km are obtained from AT's 2016/17 Annual Plan Version (SAP V102)
- In the long run, Service km is a reasonable measure to estimate the maintenance cost. Accordingly, maintenance costs are projected to increase in line with service km.
- Annual asset based consequential opex for Bus Stations is calculated based on the following table:

Size/Quality	Cost
High	1,000,000
Medium	500,000
Low	300,000
Park & Ride - L	500,000
Park & Ride - M	350,000
Interchange - L	400,000
Interchange - M	250,000

- Asset based consequential opex for Rail Stations is calculated based on the following table:

Size/Quality	Cost
High	5,000,000
Medium	450,000
Low	200,000
Park & Ride - L	500,000
Park & Ride - M	350,000
Interchange - L	400,000
Interchange - M	250,000

- PT boarding and Service km are derived from the APT model. An annualisation factor of 250 is used to calculate annual PT boardings, and 322 to calculate annual service km. The results are shown in the tables below.

Annual PT boarding estimates (based on APT model outputs with annualisation factor 250): millions

Mode	2026	2036	2046
Bus	145.4	229.5	234.8
Ferry	6.0	7.3	7.6
Light rail		19.2	56.4
Heavy rail	39.0	57.9	75.5

Annual PT service km estimates (based on APT model outputs with annualisation factor 322): millions

Mode	2026	2036	2046
Bus	57.9	75.2	69.2
Ferry	1.7	1.7	1.7
Light rail		1.1	4.2
Heavy rail	6.5	4.9	6.3

- Asset based bus maintenance expenditure (e.g. Bus station repairs and maintenance) is estimated at 20% of the operations expenditure (e.g. Bus station electricity, security etc.).
- Similarly, asset based bus operations revenue (e.g. bus stations advertising) is estimated at 10% of the operations expenditure.
- The above assumptions are based on AT's 2016/17 Annual Plan Version (SAP V102) forecasts.
- Only the base case scenario is provided for Ferry opex. This is because there are no material investments in Ferry facilities in the ATAP 30-year period.
- Mass Transit service cost and revenue are calculated based on the unit cost of bus service expenditure and revenue. It is assumed that Mass Transit will potentially replace bus services. ATAP Working Group Meeting held on 20 July 2016 agreed with this assumption.
- No inflation is used in any of the calculations. Fare box recovery does not exceed 50%. These are both assumptions that were agreed on by the ATAP Working Group.

Road maintenance assumptions and limitations

- Assumed the maintenance costs for the current assets remains constant.
- Where current fair value data differs from information in AMP, the AMP numbers have been used.
- Cycleways consequential maintenance is assumed to be $250k per annum, calculated using $10/m costs for all the known projects currently in the pipeline. There is uncertainty

around the actual maintenance costs requirements for all cycleways and this will be investigated. This expenditure is currently not included in the analysis.

Road operations (asset-based) assumptions and limitations

- There is no visibility of the costs related to new town centres.
- Level crossing maintenance is 100% NZTA funded, hence excluded.

Road capex new works assumptions and limitations

- The new capital projects list within the current financial version of the LTP was used to determine the number of assets created each year.
- The year of completion for each capex project was calculated based on the last year of funding.
- The numbers of assets being created was calculated using the asset costs for new assets from the LTP capex programme, 2014 valuation numbers and the inventory numbers from the AMP.

CRL assumptions and limitations

CRL numbers are from the CRL Operating Costs Projection Supplementary Report, Revision: 1.0; 31 July 2015. With the agreement of CRL management, this ATAP report uses the depreciation figures from this report as a proxy for CRL renewals.

Key assumptions within this report are:

- It is assumed that the CRL stations will be at Aotea, Karangahape and Mt Eden.
- The model applies an escalation percentage each year using data supplied by AT. This enables cost to be derived for a nominal CRL start-up year of 2021. The base year in all cases is 2014, even though some of the new information used in this supplementary report has been sourced in 2015.
- CRL rail and station infrastructure maintenance includes costs to maintain the infrastructure and facilities. It excludes infrastructure renewals and excludes non infrastructure related opex (such as utility costs, station staffing for customer service, security).
- It has not yet been decided which organisation(s) will manage and maintain the CRL infrastructure. This may have a bearing on infrastructure maintenance opex and could be further reviewed.

Major categories of opex cost are:

- Rail and station infrastructure maintenance
- EMU maintenance
- Station operations
- Train operations
- Control centre operations
- Depreciation

Mass transit assumptions and limitations

- Mass transit estimates based on the assumption that LRT operations commence approx. 2024. Note that this may differ from the timing suggested in the ATAP Indicative Package.
- Mass Transit numbers provided are for programme business case, not for financial analysis.
- Mass Transit R&M total numbers include for bus R&M annual cost savings of $13.3m.
- Mass Transit renewals are based on an annualised assessment of need rather than programmed interventions.
- Network infrastructure renewals is set at 37% of total maintenance over 30 years, annualised.
- There is a higher level of uncertainty around the Mass Transit analysis due to the early stage in project development. A proper method of estimating costs needs to be developed for this project so that costs can be properly assessed.

Attachment 3 – NZTA 30-year detail report

ATAP report 29
August 2016 Attachm

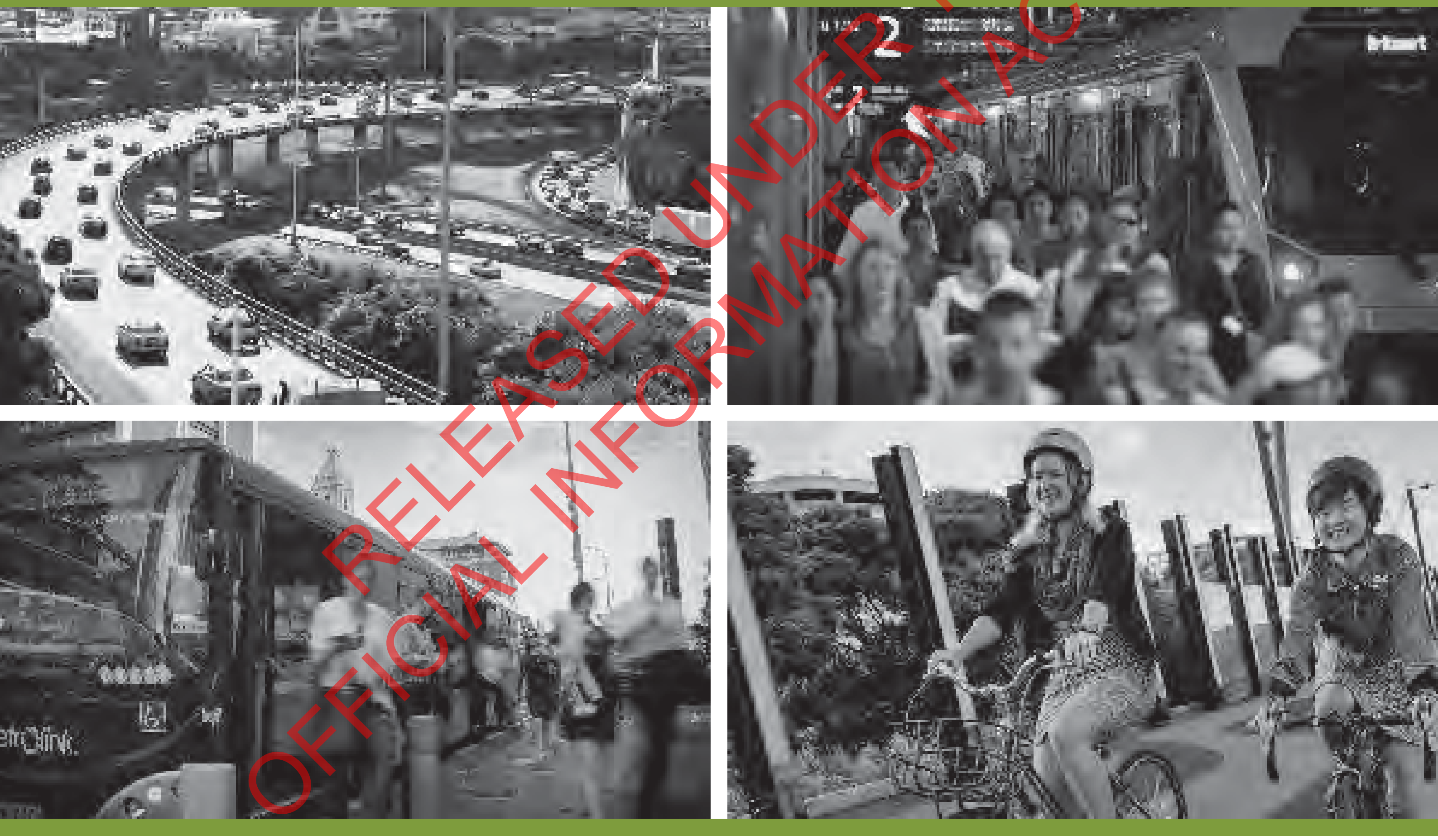
Attachment 4 – AT 30 year detail report

ATAP report 7
September 2016 Atta

Auckland Transport Alignment Project

Recommended Strategic Approach

September 2016



Ministry of Transport
Te Manatū Waka

The Treasury

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Auckland Transport

State Services Commission
Te Komihana O Ngā Tari Kāwanatanga

NZ Transport Agency
Waka Kotahi

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Foreword

We are all familiar with the pressures that Auckland's population growth puts on the city's transport system. This growth is expected to continue in the foreseeable future, with Auckland expected to grow by around 700,000 people - or more than half of New Zealand's total expected population growth - over the next 30 years.

It is essential that the Government and Auckland Council are on the same page when it comes to how we can best plan for and meet the growing transport demand that flows directly from population growth. This is why we decided to set up the Auckland Transport Alignment Project (ATAP).

The completion of ATAP means we have a common understanding of how and where Auckland is likely to grow, what the transport priorities are and when they need to be addressed.

ATAP has recommended we focus on getting more throughput on the existing network because this is where most growth in travel demand will happen. It has also concluded we need to better target what we invest in. ATAP has identified the following priorities for additional funding over the next decade:

- New and upgraded roads to unlock land for housing in the northwest, the south and the north
- The first phase of the Northwestern Busway from Westgate to Te Atatu to provide for growth, increased access into the city centre and help tackle congestion on the Northwestern Motorway
- Motorway improvements to address congestion and provide for ongoing growth in the northwest, south and southwest
- Upgraded access to Auckland Airport from the east to address congestion and improve journey reliability of bus services and safety for cyclists
- Ongoing investment to improve Auckland's rail network for both passengers and freight, including more electric trains and extending electrification to Pukekohe.

ATAP has also found that Auckland needs to capitalise on the very real opportunities emerging transport technologies present - both in terms of the network itself and how it is used - for meeting the city's transport needs.

Lastly, ATAP has concluded that to achieve a step-change in the performance of Auckland's transport system we need to begin laying the groundwork to move towards smarter pricing.

I look forward to working with the Mayor of Auckland and Auckland Council on how we can best implement this ambitious strategic approach, and address the funding implications.

Hon Simon Bridges,
Minister of Transport

When Auckland's eight local authorities amalgamated in 2010, much was expected of the new, unified Auckland. One expectation was that Auckland would engage in more fruitful collaborations with Government. The Auckland Transport Alignment Project delivers on that expectation.

Since the new Auckland was formed, employment has grown by 190 thousand people, or 30 percent. We need a transport system that gets these people from where they live, to where they work, with as little time lost to congestion as possible. That is why the Government and Auckland Council agreed - improving access to employment was a primary objective.

ATAP also aims to improve public transport use. We are already seeing an unprecedented increase. Public transport is growing faster than any other major transport mode, up by 36 percent over the last six years. The stand-out is rail, where we have doubled patronage.

Auckland's growth throws us many challenges. The biggest constraint is not lack of people wanting to use our roads, trains, buses, ferries and cycleways. It is our ability to prioritise and fund additional capacity.

ATAP is a major step forward. Through ATAP, we have agreed Auckland's transport priorities and a 30 year investment prioritisation programme. Now we need a sustainable funding track. Auckland will pay its way, but that should not mean an increasing share of costs to be carried by ratepayers. We need a fairer, more efficient funding system. That is why I welcome the focus on road pricing.

Road pricing offers a mechanism that can manage demand and fill the funding gap, while delivering the optimal programme. Our next challenge is to design a system that gets this balance right and is acceptable to Aucklanders.

Auckland is more than ready for that conversation. We have spent five years preparing for it and building a broad consensus. We have a programme, now let's fund it and give growing successful Auckland the transport system it needs to be the world's most liveable city.

Len Brown,
Mayor of Auckland


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ONEHUNGA/N 0824
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Executive Summary

i. As joint transport funders with a shared interest in a successful Auckland, the Government and Auckland Council have worked together to identify an aligned strategic approach for the development of Auckland's transport system. This report presents joint officials' recommended strategic approach. It builds on work reported in two previous documents: the *Foundation Report* (February 2016) and the *Interim Report* (June 2016).

ii. A sharp recent increase in Auckland's population is placing significant pressure on our transport networks, and this will be compounded by substantial projected population growth over the next 30 years. While a very significant programme of infrastructure investment is under way and committed, we will need to do things differently to effectively address this challenge.

iii. We identified four critical transport challenges that need to be the focus of our efforts over the next decade:

- Enabling a faster rate of housing growth, particularly in new greenfield growth areas
- Addressing projected declines in access to jobs for people living in large parts of the west, and some parts of the south
- Addressing increasing congestion on the motorway and arterial road network, particularly at inter-peak times
- Increasing public transport mode share on congested corridors.

iv. We considered a range of options for addressing Auckland's transport challenges to see how we could get better returns than from current plans.

v. Changing the mix of investment would deliver improvements in some areas, but it cannot deliver a step-change in performance across the region, and would struggle to keep pace with projected demand growth.

vi. We also looked at options to substantially increase or bring forward new infrastructure investment, or to shift to a greater focus on influencing demand. We concluded that neither of these approaches alone is sufficient to address Auckland's transport challenges.

vii. Instead, we need to better balance transport demand with the capacity of our infrastructure and services. This requires a fundamental shift to a greater focus on influencing travel demand through smarter transport pricing, and accelerating the uptake and implementation of new technologies, alongside substantial ongoing transport investment, and getting more out of our existing networks.

viii. Our recommended strategic approach therefore contains three integrated elements, as illustrated in *Figure 1*.

ix. Implementing this approach will provide much better returns than current plans, delivering better access to employment, reduced congestion, and increased public transport mode share. This does, however, rely on the three elements being progressed in an integrated manner. In particular, the main benefits will not be realised until we shift to smarter transport pricing.

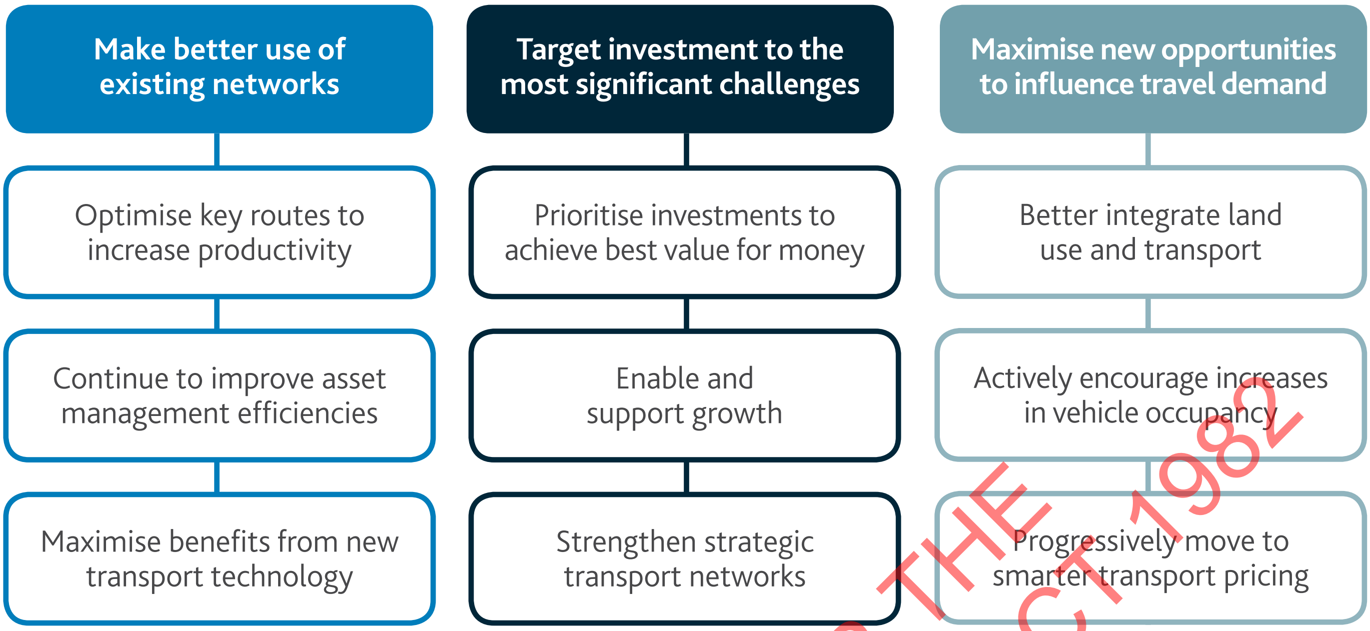


Figure 1.

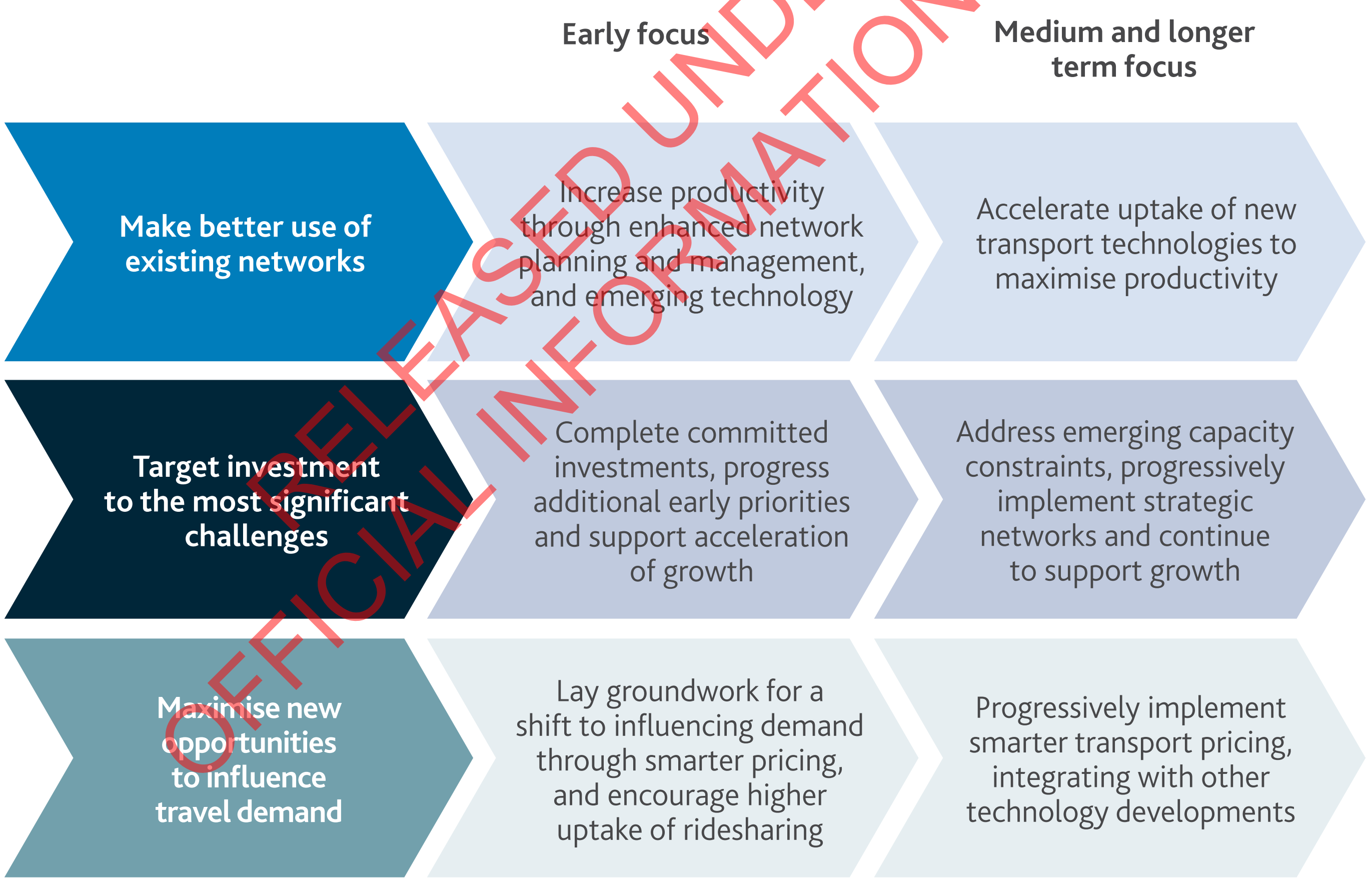


Figure 2.

x. The recommended strategic approach will need to be progressively delivered through infrastructure investment, policies and services over the next 30 years. To give an indication of how the approach could be applied, we developed an indicative package of the types of interventions likely to be needed, as well as the overall scale and sequencing of investment. Our broad approach is shown in *Figure 2*.

xi. The indicative package is not an investment programme, as individual projects need to go through statutory processes to proceed. However, it provides an illustration of the type and quantum of investment that is likely to be required to implement the strategic approach.

xii. We have placed greater emphasis on the first 10 years because many of our current assumptions about the location of housing and employment growth and the timing and impacts of technological change become less accurate after this period. The estimated expenditure in the first decade, from 2018-2028, is around $24 billion. Over the 30-year period, estimated expenditure totals $83 billion, nearly half of which represents capital expenditure, with the remainder a combination of asset renewals, maintenance and operational costs.

xiii. The expenditure identified for the first decade exceeds the funding expected to be available from current funding plans by around $4 billion. Auckland Council and the Government will need to consider options to address this gap, ahead of the next round of statutory funding decisions in 2018.

xiv. The indicative package outlines interventions for the three decades from 2018. This does not mean that we can wait until 2018. A number of actions can be taken now to set us along the path towards our recommended strategic approach. The sooner we start, the sooner we can expect the benefits.

Recommendations

We recommend the Government and Auckland Council adopt the recommended strategic approach, which contains the following key components:

a. Make better use of existing networks

b. Target investment to the most significant challenges

c. Maximise opportunities to influence travel demand.

To implement the strategic approach, we also recommend:

a. Government, Auckland Council, Auckland Transport and the NZ Transport Agency incorporate the strategic approach into their statutory strategic documents

b. Government and Auckland Council work together to consider options and agree on an approach to address the funding gap by mid-2017, to inform statutory funding documents

c. Early establishment of a dedicated project to progress smarter transport pricing, with a view to implementation within the next 10 years

d. Review of investment processes to ensure they align with the strategic approach

e. Government and Auckland Council consider whether statutory changes are required to support ongoing joint strategic transport planning

f. Complete work on identified priority actions as soon as possible.

The Auckland Transport Alignment Project

1. As joint transport funders with a shared interest in a successful Auckland, the Government and Auckland Council agreed in August 2015 to work together on the Auckland Transport Alignment Project, to identify an aligned strategic approach for the development of Auckland's transport system that delivers the best possible outcomes for Auckland and New Zealand.
2. This report has been jointly prepared by officials from the six agencies involved in the project[1], and presents our recommended strategic approach. It includes an indicative package of measures, covering the broad timing and scale of interventions, and estimates of costs and benefits, together with the nature, scale and timing of the funding gap for the recommended strategic approach. It also sets out recommended implementation actions.
3. This report marks the completion of the Auckland Transport Alignment Project, and builds on the work reported in two previous documents: the *Foundation Report* (February 2016) and the Interim Report (June 2016). A companion document, *Auckland Transport Alignment Project: Supporting Information* presents the background information to support this report.
4. In a number of areas, including safety and active modes (walking and cycling), the views of central and local government are already well aligned on the priorities and likely level of future funding. We have therefore taken as given, the initiatives that are already underway in these areas, including the *Safer Journeys Action Plan*, the *Auckland Road Safety Plan*, and the *Urban Cycleways Programme*.
5. While the focus of this report is on the transport system within Auckland, it is important that this is considered within its broader inter-regional context, particularly the linkages between Auckland and the Upper North Island. We note and support the initiatives that are currently underway to strengthen the strategic connections to Northland, Waikato and the Bay of Plenty, including the Auckland to Northland corridor initiatives ('Connecting Northland') and the Waikato Expressway.

Project Objectives

The focus of the Auckland Transport Alignment Project is to test whether better returns from transport investment can be achieved in the medium and long-term, particularly in relation to the following objectives:

i. To support economic growth and increased productivity by ensuring **access to employment/labour improves** relative to current levels as Auckland's population grows

ii. To **improve congestion results**, relative to predicted levels, in particular, travel time and reliability in the peak period and to ensure congestion does not become widespread during working hours

iii. To **improve public transport's mode share**, relative to predicted results, where it will address congestion

iv. To ensure any increases in the financial costs of using the transport system **deliver net benefits to users** of the system

[1] Ministry of Transport, Auckland Council, NZ Transport Agency, Auckland Transport, The Treasury, and the State Services Commission.

Auckland's Transport Challenges

6. Auckland is growing quickly: the city's population is projected to increase by 45% to 2.2 million over the next 30 years, accompanied by a 40% increase in jobs to over 850,000. Continued strong growth in visitor numbers is also expected. This growth places pressure on transport networks, reducing performance and increasing congestion. Left unaddressed or without alternatives for travel, congestion will reduce the opportunities that Auckland's growth can provide.

7. The most significant projected transport challenges over the next decade are:
   - Enabling a faster rate of housing growth, particularly in Special Housing Areas and greenfield areas live-zoned[2] in the Auckland Unitary Plan.
   - Addressing projected declines in access to jobs for people living in large parts of the west, and some parts of the south.
   - Addressing increasing congestion on the motorway and arterial road network during peak periods, and increasingly at other times of the day, which adversely affects the efficient movement of freight and services.
   - Increasing public transport mode share, particularly along high volume, congested corridors.

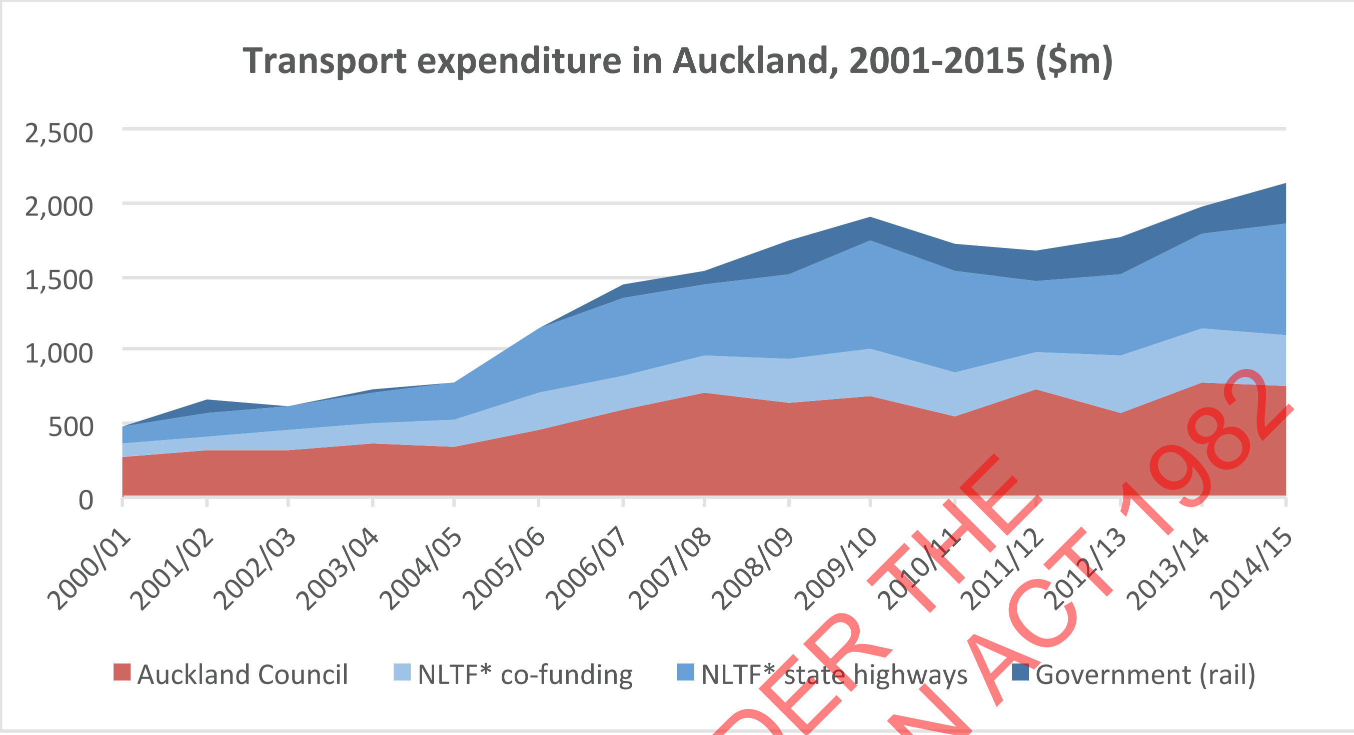
8. In addition to these focus areas, there is a need to continue to make improvements to road safety and active modes (walking and cycling).

9. Transport is Auckland Council's largest and central Government's fourth largest investment area. A combination of catching up on past under-investment and accommodating Auckland's growth has resulted in transport expenditure in Auckland increasing from $500m per year in 2000 to $2.1 billion in 2015[3] , as illustrated in the following graph.

10. Overall, the challenge for Auckland's transport system is to support the city's growth in a way that is affordable and provides value for money, while also delivering benefits to Auckland and New Zealand as a whole.

[2] "Live-zoning" means a residential or business zone where development can occur, rather than a future urban zone where structure planning is required.

[3] Includes all public expenditure on land transport, including capital and operations, but excludes debt servicing.



*NLTF denotes funding from National Land Transport Fund.

Strategic Choices

11. In common with most cities in the world, the response to growing travel demand in Auckland has been to increase road capacity and to provide public transport, walking and cycling infrastructure and services. Relatively little attention has been paid to influencing that demand.

12. This has involved a substantial increase in investment over the past 15 years, which has delivered significant benefits through the expansion of Auckland's motorway network, the modernisation of the rail network and the construction of the Northern Busway. This approach is continuing through a programme of committed and agreed investments in projects such as the Waterview Connection, the City Rail Link, the Auckland-Manukau Eastern Transport Initiative (AMETI), the Puhoi-Warkworth extension of the Northern Motorway, the Accelerated Motorway Package and the East-West Link.

13. While these investments will make a positive difference, our analysis shows that Auckland's fast rate of growth and challenging physical geography mean congestion and access to employment are unlikely to improve in the next decade from recent levels[4]. In particular, access challenges are expected to become most significant in the west and some parts of the south due to lengthening travel times and a relative lack of local employment.

14. We examined options for changing the mix of what we invest in (spending the same amount as current plans but on different priorities) to consider whether this could achieve better returns. This would generate improvements in some areas, but not a step-change in performance across the region, and will struggle to keep pace with projected demand growth.

15. To achieve that step-change in performance we need a different approach. We looked at two future pathways:

Mainly focus on building more transport infrastructure	A greater focus on influencing transport demand
This pathway substantially increases or brings forward our investment in transport infrastructure to respond to demand, and to support growth.	This pathway shifts to a greater focus on influencing transport demand through taking advantage of new transport technologies, making full use of network capacity, and using a smarter transport pricing system.

16. Our analysis has shown we cannot rely solely on either approach.

17. Simply increasing investment to build our way out of the problem is unlikely to be cost-effective in the long run and will struggle to deliver significant access and congestion improvements. In part, this is because providing new transport infrastructure in existing urban areas is increasingly expensive due to costly land acquisition or tunnelling. It can also have significant amenity impacts.

[4] Our base year for analysis is 2013. Since 2013 Auckland has experienced rapid population growth and increased congestion, with average peak time travel speeds on the State highway network declining by 9% (from 61 to 56 km/h).

18. Conversely, Auckland's substantial projected growth, current challenges and uncertainties about the timing and effects of new technologies mean we cannot solely rely on influencing travel demand either.

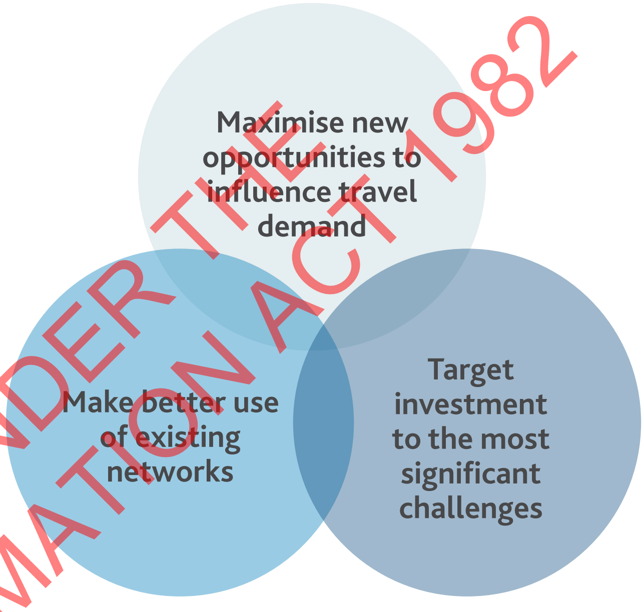
19. Instead, we need to better balance transport demand with the capacity of our infrastructure and services. This requires a fundamental shift to a greater focus on influencing travel demand through smarter transport pricing and accelerating the uptake and implementation of new technologies, alongside substantial ongoing transport investment, and getting more out of our existing networks.

Recommended Strategic Approach

20. To address Auckland's transport challenges and get better returns from the transport system, we need to better balance transport demand with the capacity of our infrastructure and services. Over time, this means influencing travel demand patterns through smarter transport pricing and accelerating the uptake and implementation of new technologies.

21. Our recommended strategic approach contains three integrated elements, each with three key components, as outlined below.

22. Our analysis shows that implementing this approach will provide better returns than current plans, and deliver positive results against the key objectives of access to employment, congestion, and public transport mode share. This does, however, rely on the three elements being progressed in an integrated manner. In particular, the main benefits will not be realised until we shift to smarter transport pricing.



Make better use of existing networks	Target investment to the most significant challenges	Maximise new opportunities to influence travel demand
Optimise key routes to increase productivity	Prioritise investments to achieve best value for money	Better integrate land use and transport
Continue to improve asset management efficiencies	Enable and support growth	Actively encourage increases in vehicle occupancy
Maximise benefits from new transport technology	Strengthen strategic transport networks	Progressively move to smarter transport pricing

Make better use of existing networks

23. The vast majority of Auckland's future transport footprint already exists today. Most growth in travel demand will need to be accommodated on the existing networks, meaning we need to be much smarter about how we use them.

24. Developing transport technology provides exciting new opportunities to get more out of our existing networks by increasing vehicle throughput and occupancy levels. Maximising these benefits will require optimising key routes to increase their productivity.

Optimise key routes to increase productivity

25. Parts of Auckland's existing transport network have crucial national, city-wide and local functions to enable the efficient movement of people, goods and services.

26. Much of Auckland's motorway network carries significantly higher traffic volumes than anywhere else in New Zealand, and parts of the arterial network carry traffic volumes greater than most State highways elsewhere in New Zealand. For these roads significant through-movement is of primary importance.

27. Many arterial roads also have a variety of other, potentially competing uses, including providing access to local centres. Many Aucklanders live along these roads, which are the focus of substantial future growth.

28. We need a stronger focus on network-level strategic planning to identify and manage these routes. This includes clear criteria to help balance different user requirements, and to address conflicts between through-movement and amenity. While there has been substantial progress in identifying these key routes and developing a framework to help resolve competing issues, this work needs to be completed with urgency.

29. Once the framework has been finalised, some difficult decisions will need to be made to enable increased productivity, such as removing on-street parking, upgrading intersections, extending bus lane operating hours, or introducing freight priority measures. There will also need to be an increase in accompanying investment to enable these changes.

Continue to improve asset management efficiencies

30. Over half of Auckland's future transport investment will need to be on maintaining, operating and renewing existing and future assets. This has implications for the amount of funding available for investment in new transport infrastructure.

31. A relatively large proportion of local roads maintenance and renewals expenditure is not currently co-funded from the National Land Transport Fund. Agreement is needed on appropriate levels of service and required funding for asset management. While progress has been made through the "One Network Roads Classification" process, it is important that this agreement is reached as soon as possible.

32. Our analysis has also highlighted the need for ongoing improvements in asset management efficiencies, including greater use of technology to remotely monitor assets to help inform the optimal timing for intervention. We consider there are opportunities for further efficiency improvements in this area, with the potential for substantial overall savings.

Maximise benefits from new transport technology

33. We are on the cusp of a paradigm shift in transport technology. Emerging transport and related technology has the potential to significantly improve the performance of Auckland's transport network over the next 30 years. The outcome could be much more efficient use of existing transport infrastructure, vehicles and services and better value for money from future infrastructure and service investments. However, it is unclear when we will be able to implement new technologies in Auckland and what their real-world impacts will be.

34. In the short-term, increasing our use of intelligent network management presents significant opportunities to get more out of our transport networks through additional throughput. Focus areas include more comprehensive real-time understanding of network use, better data processing capability to support network management decisions and more effective travel demand management tools (e.g. adaptive traffic signals, dynamic lanes and traveller information provision). Specific funding provision for these types of activities in the next round of statutory funding plans would help to highlight their importance.

35. In the medium to longer-term, connected and autonomous vehicles, combined with ride-sharing, have the potential to help increase vehicle throughput (particularly on motorways), reduce traffic accidents, and improve travel time reliability. This could present opportunities to defer or avoid future investment in additional road capacity. These benefits will take some time to materialise, especially if there are institutional, regulatory or infrastructure barriers to their adoption. A coordinated work programme is needed to identify and remove unnecessary barriers and facilitate the uptake of connected and autonomous vehicles.

Target investment to the most significant challenges

36. To ensure the best possible returns from transport investment, we need to focus on addressing Auckland's most significant challenges in providing safe and efficient access to employment, addressing road and public transport congestion and supporting growth. We have identified strategic priorities for investment over the next 30 years, and where efforts should be focused in the short-term (early priorities, 2018-28).

Prioritise investments to achieve best value for money

37. Our framework for identifying early priorities is set out below. It provides a basis for assessing the extent to which different investment options will effectively target the most significant first decade challenges (as outlined in paragraph 7), and the extent to which an investment is likely to deliver value for money. The key assessment measures are the impact on throughput of people, goods and services, travel speeds, and enabling growth.

		Potential to deliver value for money in first decade		
		High	**Medium**	**Low**
Extent to which the investment targets the most significant first decade challanges	**High**	Highest priority to be progressed in the first decade	Secondary priority to be progressed in the first decade	Unlikely to be first decade priority
	Medium	Secondary priority to be progressed in the first decade	Unlikely to be first decade priority	Not a first decade priority
	Low	Unlikely to be first decade priority	Not a first decade priority	Not a first decade priority

38. Achieving best value for money requires identifying the right solution in the right part of the network at the right time. This means that investments should recognise the strengths of each part of the network:

- Public transport: access to concentrated activity centres (e.g. the city centre, major employment areas) where there is little or no capacity to take additional vehicle traffic.
- Roads: access for people, goods and services to wide transport catchments with diverse trip origins and destinations.
- Rail: providing a dual function of high capacity public transport backbone and strategic freight connections, especially to/from the Ports of Auckland and Tauranga.
- Walking and cycling: serving higher intensity areas, short-to-medium length trips and extending the reach of strategic public transport corridors.

39. As we move towards a greater focus on influencing patterns of demand, investment will also be required to assist the take-up of new technologies that improve vehicle throughput and occupancy rates, and to support the implementation of smarter transport pricing. It will also be important to ensure that investments will continue to stack up in a future with much greater use of transport technology.

Enable and support growth

40. New urban growth areas in the north, west and south will need substantial investment in transport infrastructure before significant development can occur. Some of this investment is required to 'open up' land for development, alongside larger scale improvements needed to better connect these areas to the rest of Auckland.

41. Transport investment within the existing urban area is also necessary to unlock growth, by improving access and making redevelopment more market attractive.

42. We have identified a number of potential transport investments to support and enable growth. Early investment is needed in areas 'live-zoned' by the Auckland Unitary Plan and through Special Housing Area processes, and to protect routes and secure land for longer-term networks.

New future urban land
New "live zoned" urban areas

Strengthen strategic transport networks

43. Auckland's strategic road, rail and public transport networks are the most critical elements of the city's transport system. It is essential to maintain and develop strong, safe and resilient strategic networks that can cope with increased demand.

44. Although there are some opportunities to add new corridors, options are limited in existing urban areas. A targeted investment approach is required to address the impacts of growth and to ensure that these core parts of the network have sufficient capacity to operate effectively.

45. Our recommended approach to the development of the strategic road and public transport networks is summarised in the following table, although further work is required to determine which parts of the primary arterial road network should have strategic functions. The maps that follow illustrate our agreed view on how these networks will need to develop over the next 30 years.

	Strategic Road Network	Strategic Public Transport Network
Description	• Backbone of the road network, providing for a wide variety of travel and the highest traffic volumes. • Core links between major parts of Auckland and the rest of NZ, carries heaviest freight volumes and provides access to Port and Airport. • Through-movement of people and goods is primary consideration and access is limited or controlled.	• Backbone of the public transport network, providing for high volumes of travel to major employment centres, especially into the central area. • Frequent, high capacity services operating along corridors separated from private vehicles and unaffected by road congestion. • Passenger rail network shares corridor with freight.

Approach	• Primarily focus on improving the efficiency of existing corridors by better balancing demand and capacity.
	• Provide new corridors in greenfield areas to support growth and improve connections to existing urban areas.
	• Focus additional capacity primarily on outer parts of the network, along the Western Ring Route and improving Port and Airport access.
	• Maximise benefits from new technology to increase vehicle throughput and occupancy levels.
		• Two key drivers for prioritising development of the strategic public transport network:
		  ∘ Addressing emerging capacity constraints as demand increases
		  ∘ Expanding the network to improve overall corridor efficiency and throughput.
		• Mode choice for strategic network improvements should be driven by capacity requirements to meet forecast demand, integration with the wider network and achieving value for money.


Proposed Future Strategic Road Network
WARKWORTH
Puhoi - Warkworth
Kahikatea Flat Rd
Hibiscus Coast Hwy
Penlink
Dairy Flat Hwy
ALBANY
Albany Hwy
East Coast Rd
TAKAPUNA
Coatesville-Riverhead Hwy
Upper Harbour Mwy
Glenfield Rd
Northern Mwy
Lake Rd
KUMEU
Auckland Harbour Bridge
Additional Waitemata Harbour Crossing
CBD
PORT
Tamaki Dr
MASSEY NORTH
NEWMARKET
Apirana Ave/ Te Horeta Rd
North-Western Mwy
Remuera Rd
Taupaki Ext.
Don Buck Rd
Lincoln Rd
Dominion Rd
Southern Mwy
Pakuranga Hwy
Balmoral Rd
Te Atatu Rd
HENDERSON
Mt Albert Rd
Manukau Rd
Ti Rakau Dr
BOTANY
SYLVIA PARK
Great North Rd
New North Rd
Highbrook Dr
Te Irirangi Dr
East West Link
Ormiston Rd
NEW LYNN
South Western Mwy
East Tamaki Dr
Great South Rd
Massey Rd
SH20A
Cavendish Rd
MANUKAU
AUCKLAND AIRPORT
SH20B
Roscommon Rd
Popes Rd
Mill Rd
Beach Rd
PAPAKURA
Southern Mwy
PUKEKOHE
Metropolitan Centre
Strategic Network (Tier 1)
Future Strategic Network
Primary Arterial Road
Future Primary Arterial Road
Major Upgrade or re-alignment envisaged

Proposed Future Strategic Public Transport Network
Orewa
Albany
Constellation
Takapuna
Akoranga
Kumeu / Huapai
Devonport
Britomart
Wynyard
Aotea
Karangahape
Massey North
Newmarket
Lincoln Rd
Panmure
Botany
Ellerslie
Penrose
Sylvia Park
Swanson
Mt Roskill
Otahuhu
Henderson
New Lynn
Onehunga
Manukau
Puhinui
Auckland Airport
Papakura
Pukekohe
Metropolitan Centre
Major Interchange
Existing Strategic Public Transport (heavy rail)
Future Strategic Public Transport (heavy rail)
Existing Strategic Public Transport
Future Strategic Public Transport
Frequent Ferry

Maximise new opportunities to influence travel demand

46. A stronger focus on improving the balance between transport demand and the capacity of our infrastructure and services is critical to achieve a step-change in the performance of our transport system.

47. Stronger land-use and transport integration is required to reduce the need for longer trips during peak times. Auckland's rapid growth makes this challenging, but also presents opportunities to better match housing and employment locations to transport capacity and send more consistent signals to the market about the timing and location of development.

48. New and emerging technologies also provide opportunities to influence travel demand in ways that have not previously been possible. In particular, this includes moving over time to a smarter transport pricing system, which varies charges according to time and location. There are a number of challenges that will need to be addressed to take advantage of these opportunities, but the sooner we are able to start, the earlier we can expect to see the benefits.

Better integrate land use and transport

49. Land use lies at the heart of travel demand patterns. The location of Auckland's households, employment, education facilities, port, airport, factories, distribution centres, hospitals, shops and recreation opportunities determines trip origins and destinations. Imbalances between the location of household and employment growth will increase pressure on the transport system.

50. Integrating land use and transport is necessary to:
    - Fully realise the economic benefits from population and employment growth
    - Ensure the transport network can continue to operate effectively as Auckland grows
    - Ensure value for money and good utilisation of new infrastructure and services

51. We can improve transport network efficiency through land use decisions. These decisions should aim to:
    - Encourage housing growth in areas with better access to employment and more transport options, such as around the strategic public transport network and on the isthmus.
    - Encourage employment growth where transport connections and options are strongest and where additional jobs would reduce reliance on long commutes across major transport bottlenecks, such as in the west and south.
    - Enable the consolidation of freight movements, minimise amenity impacts and ensure efficient connections to the strategic network

52. The Auckland Unitary Plan, adopted in August 2016, provides the legal planning framework for enabling growth, including future changes in land use. The Unitary Plan provides sufficient development capacity to meet Auckland's growth requirements for the next 30 years, enabling around 65% of future growth to be accommodated within the existing urban area, with greater intensification in and around centres, transport nodes and corridors. It also provides significant capacity for employment growth, particularly in major centres.

53. The balance of growth that the Unitary Plan enables between existing and future parts of Auckland matches the land-use assumptions that we have used in the project reasonably well. The main difference relates to the potential acceleration of some greenfield development in the north, but we have reflected this difference in our indicative early investment priorities.

54. Realising the Unitary Plan's capacity in a way that supports our desired land use and transport outcomes is an ongoing task that requires:

- A more flexible and responsive approach to the planning, funding and staging of infrastructure and services to better integrate with the location and timing of development. (This includes supporting the market attractiveness of residential development and successful centres through early investment in enabling infrastructure).
- Making sure that transport funding processes take account of the broader social and economic benefits of enabling growth.

Actively encourage increases in vehicle occupancy

55. Increasing private vehicle occupancy rates through ridesharing, carpooling and other emerging shared mobility opportunities such as shared taxis and taxi buses can help improve the transport system's performance.

56. Past efforts to increase private vehicle occupancy levels have had limited success. However, emerging technologies, particularly based around smartphone applications, provide new opportunities to overcome these challenges, by instantly connecting users with similar travel demands. When combined with the introduction of autonomous vehicles, shared mobility has the potential to fundamentally reshape the way transport is provided and consumed.

57. The private sector has led most recent advances in this area, and we would expect this to continue in future. However, public sector agencies will need to continue to encourage these initiatives by better understanding and reducing barriers, ensuring regulation enables innovation in this area, promoting pilot schemes, ensuring open access to data, and exploring opportunities to allocate road space to encourage ridesharing where it will result in greater overall throughput.

Progressively move to smarter transport pricing

58. The use of our roads is not free. The current system of charging for motor vehicle use (through petrol taxes, road user charges and vehicle registration fees) is based on the cost of providing and maintaining roads, but does not reflect differences in the true cost of travel for the individual user by time, location and mode. This "flat-rate" approach under-prices some trips, resulting in congestion, while over-pricing others. A progressive move to a pricing system that reflects the actual costs of each trip has the potential to result in much more efficient use of our existing road network, and provide better information on where investment in new capacity is required.

59. Developing technologies enable more sophisticated pricing systems than currently exist. This includes whole of network dynamic systems (the focus of our analysis) that can vary the price of travel by time and location. A system that applies across Auckland's entire road network offers the greatest potential to influence demand in a way that delivers step-change improvements in accessibility, congestion and public transport mode share. Applying charges across the whole network also reduces the likelihood of unintended consequences resulting from diverting traffic, as prices can be fine-tuned across the network to support desired outcomes.

60. A shift to smarter transport pricing would increase the cost of travel for some and reduce it for others, depending on the time and location of travel. In further work to develop smarter pricing, it will be important to fully understand where travel cost increases occur so that equity impacts can be assessed. This will require consideration of the affordability of travel, the impact of pricing on access to jobs, education and services, and any necessary mitigation, particularly for lower income residents who face long commutes.

61. Our focus has been on smarter pricing as a means of influencing demand, rather than as a revenue-raising tool. Full implementation of such a system will take some time due to its complexities, the developing nature of its supporting technology, and the need to gain community awareness and support. However, as smarter pricing is key to delivering a step-change in Auckland's transport performance, we should start laying the groundwork now, with a view to implementation within the next decade.

Delivering the Strategic Approach

62. The strategic approach will need to be progressively delivered through infrastructure investment, policies and services over the next 30 years. To give an indication of how the approach could be applied, we have developed an indicative package of the types of interventions likely to be required, as well as the overall scale and sequencing of investment.

63. We have focused on identifying early priorities, which roughly correspond to the 10 years from 2018 onwards when new transport and Auckland Council funding plans need to be in place; and medium to longer term priorities, which would be delivered beyond the first decade. The broad approach of the package, showing earlier and medium/later interventions is outlined below:

	Early focus	Medium and longer term focus
Make better use of existing networks	Increase productivity through enhanced network planning and management, and emerging technology	Accelerate uptake of new transport technologies to maximise productivity
Target investment to the most significant challenges	Complete committed investments, progress additional early priorities and support acceleration of growth	Address emerging capacity constraints, progressively implement strategic networks and continue to support growth
Maximise new opportunities to influence travel demand	Lay groundwork for a shift to influencing demand through smarter pricing, and encourage higher uptake of ridesharing	Progressively implement smarter transport pricing, integrating with other technology developments

Key focus areas

64. The indicative package includes a significant amount of investment in maintaining and operating the existing transport system, and in continuing to make improvements in safety and active modes through ongoing investments in these areas. In addition to these investments, we have identified six key areas where major interventions will be required to deliver the strategic approach. These are:
    - Supporting greenfield growth.
    - Addressing motorway capacity constraints.
    - Strengthening central area access.
    - Improving Airport access.
    - Enabling rail passenger and freight growth.
    - Shifting to a greater focus on influencing travel demand.
65. The following sections briefly outline the key drivers and potential timing of these major interventions. Early priorities (for the first decade) and medium to longer term priorities (beyond the first decade) are highlighted.

Supporting greenfield growth

66. Investment is needed to open up land for development and to address the impact of increased travel demands to and from new urban areas.
67. The Unitary Plan identifies over 12,000 hectares of "future urban" zoned land, as well as a number of locations where land currently used for rural activities has been "live zoned" to enable urbanisation in the near future. In total, the Unitary Plan enables around 150,000 dwellings of feasible capacity outside the existing urban area.

Early priorities	Medium and longer term priorities

• Early investment to enable growth in areas that have been 'live zoned' in the Unitary Plan, as well as in Special Housing Areas.
• Route protection, land purchase and early works to ensure future opportunities are not built out and to minimise land costs.
• Progress the Northwestern Busway to increase access to and from the northwest greenfield area and increase throughput along the congested Northwestern Motorway corridor.
	• Progressive implementation of future transport networks in greenfield areas, depending on the timing and rate of development.
	  ◦ Some investments may be needed 'up front' to unlock growth capacity, help shape land use and support the establishment of successful town centres.
	  ◦ Other investments can be provided later, once growth has occurred, in response to capacity constraints.
	• Ongoing monitoring of the impacts of greenfield growth on travel patterns and refinement of when interventions are required.

Addressing motorway capacity constraints

68. Parts of Auckland's motorway network experience substantial congestion, both at peak times and increasingly throughout the day. Completion of the Western Ring Route, through the Waterview Connection and other committed motorway upgrades, will ease pressure on State Highway 1 and improve network resilience by providing an alternative north-south route. However, projected growth in travel means the motorway network will remain under significant pressure.

69. The inner part of Auckland's motorway network has the highest traffic volumes in the country, but is physically constrained – particularly along State Highway 1 between Takapuna and Mt Wellington where the motorway pushes up against high intensity and high value development, coastlines and other major infrastructure (such as railway lines). Limited capacity additions on this part of the network can provide some local benefits, but appear to shift bottlenecks and congestion points, rather than address them. Conversely, increasing capacity along entire corridors involves significant land acquisition, extremely high costs and potentially major amenity impacts.

70. A major new eastern strategic corridor would provide significant access and congestion benefits, but its extremely high costs suggest this will not be cost-effective in the next 30 years. However, given Auckland's ongoing growth it is prudent to retain existing route protection.

71. The Auckland Harbour Bridge forms a critical part of the motorway network as the main connection between the North Shore, the city centre and locations further south. Growth in freight, private vehicle and public transport use of the bridge will create a number of future challenges, particularly as providing an additional harbour crossing will involve very high costs. It is important to continue the work currently underway to protect the route for a new harbour crossing in a way that integrates potential future road and public transport requirements.

Early priorities	Medium and longer term priorities
• Ensure maximum network-wide benefits from completion of the Western Ring Route by providing for capacity upgrades at each end to address bottlenecks, optimising its performance and ensuring it integrates with the East-West Link. • Public transport investments, including the City Rail Link, extending the Northern Busway and accelerating the Northwestern Busway, to assist in taking pressure off the motorway network at peak times, especially for trips heading to the city centre. • Upgrades to outer parts of the motorway network, particularly to the northwest and the south, to enable and support growth.	• Ongoing targeted widening in outer parts of the network to enable and support growth. • Support developing vehicle technologies, increasing vehicle occupancy rates and smarter transport pricing to enable existing motorways to be used far more efficiently. • Progress cross-harbour improvements in a way that provides enduring benefits along the broader north-south corridor, integrates with public transport, and provides value for money. • Maintain existing route protection for an additional north-south corridor which may be needed beyond the 30-year timeframe.

Strengthening central area access

72. The city centre and its surrounds (including Newmarket) is New Zealand's largest employment hub and is projected to grow strongly over the next 30 years to reach nearly a quarter of a million jobs. This growth, expected to be largely driven by highly productive service-sector jobs, will be accompanied by a substantial projected increase in tertiary student numbers and continued household growth.

73. Access to this area is physically constrained, and there is competition for limited street-space between vehicles, pedestrians, cyclists and public amenity. This means it is imperative over time to move more people in fewer vehicles. This requires a continued modal shift towards public transport, walking and cycling.

74. Although bus efficiency improvements can help cope with increased demand in the short term, there are limits to the extent to which such improvements can continue to provide sufficient capacity. A mass transit solution will be required in the medium term. Key criteria for determining the best long-term solution should be the ability to meet projected demand in a way that integrates with the broader strategic network, provides for and stimulates ongoing growth along these corridors and in the city centre, and delivers value for money.

75. The Port of Auckland is located on the edge of the central area and is a significant freight origin and destination including for high-value imports that travel by both road and rail to and from other parts of Auckland and New Zealand. Consistent with the conclusions from Auckland Council's recent Port Future Study, we have assumed the Port will remain in its current location within the 30-year period of this project. In the meantime, strong growth in freight demand which is competing with general traffic congestion, needs to be addressed. Connections between the Port and the strategic road network could be improved, and growth in demand for rail passenger and freight services will progressively impact on the efficient operation of the Port.

Early priorities	Medium and longer term priorities
• City Rail Link and associated further rail improvements will cater for a substantial proportion of increased trip demand into the central area over the next decade and beyond. • Bus efficiency improvements on city centre corridors serving the north, northwest and central isthmus will provide additional capacity to address growth demands over the next decade. • Port access improvements focused on improved efficiency between the Port and the motorway network. • Improvements to the core rail network to enable passenger and freight to operate reliably together.	• Invest in additional mass transit capacity to relieve demand pressures on bus corridors serving the isthmus; followed by those serving the North Shore. • Improvements to Port access from the motorway network.

Improving Airport access

76. The Airport area is nationally significant. It is New Zealand's primary international gateway, the country's third largest port by value of goods and a major and growing employment centre. Substantial employment growth in the broader Airport area, combined with growing passenger and freight flows, is projected to result in an increase in daily trips to and from the area from 63,000 currently to around 140,000 over the next 30 years.

77. Providing for this growth in travel demand is challenging due to the Airport's location in the southwest corner of Auckland's urban area, the limited number of access points, the dispersed nature of trip origins and destinations within the broader Airport area, and the long average length of inbound and outbound trips.

78. Substantial access improvements are currently underway to extend the motorway from the north to the Airport's edge and future-proof the route for a higher capacity public transport mode. This is expected to ease congestion on the northern access corridor for some time. Capacity improvements are also required on the eastern access route, to address congestion and improve access from the east and south. These initiatives need to be supplemented with ongoing improvements in public transport services.

79. Over time, space constraints within the Airport area and capacity challenges on the broader road network make it increasingly difficult to serve the Airport area's transport demands through road and bus service improvements alone. This will require investment in mass transit, and route protection to enable this needs to be an early priority.

Early priorities	Medium and longer term priorities
• Complete access improvements from the north to extend the motorway to the Airport's edge. • Increase capacity of the strategic road network from the east (including provision for public transport), which will also improve access from the south. • Increase bus services and frequencies (especially for employees in the area), and extend bus lanes to improve reliability. • Protect the routes for future mass transit corridors linking the Airport with the north and the east.	• Implement mass transit following consideration of: ∘ Required capacity to meet demand generated by Airport passenger and employee growth ∘ Integration with the strategic public transport network (especially isthmus mass transit to the north) ∘ Timing of major improvements to the Airport's internal road network.

Enabling rail passenger and freight growth

80. Auckland's rail network, combined with the Northern Busway, forms the core of the city's strategic public transport network. Investment over the past 15 years has resulted in impressive growth in passenger numbers, with rail accounting for a growing proportion of public transport trips. The network also plays a key role in the movement of freight, particularly to and from the Ports of Auckland and Tauranga. Continued strong growth in passenger trips and freight carried by rail is forecast over the next 30 years.

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

Early priorities	Medium and longer term priorities

• The City Rail Link will provide benefits for rail passengers through significant reductions in travel times, particularly from the west, improved access to the city centre and increased capacity by removing the current Britomart bottleneck.
• Other key short term improvements likely to be required include:
  ◦ Additional infrastructure including a third track to address key capacity constraints and enable passenger and freight services to operate reliably
  ◦ Additional trains to cater for growing passenger numbers
  ◦ Removal of some road/rail level crossings to better manage safety risks and address road congestion
  ◦ Extension of electrification to Pukekohe to serve growth in the south.
	• Depending on demand, longer term improvements are likely to include:
	  ◦ Providing a fourth track between Wiri and Westfield
	  ◦ Further extension of triple-tracking to Papakura and potentially Pukekohe
	  ◦ Potential extension of the fourth main to Papakura
	  ◦ Further tranches of additional trains and a second depot
	  ◦ Ongoing level crossing removal programme.

Shift to a greater focus on influencing travel demand

82. Shifting to a greater focus on influencing travel demand should commence with early work to develop a pathway for moving to smarter pricing. This includes developing a basis for assessing the potential impacts on different users of the transport system, including affordability and equity considerations, and how access to jobs, education and services could best be met under such a system.

83. Work will also be needed to address the implications for the current national system of charging for transport use, the case for legislative change to enable charging for use of existing roads, the technology options, and ultimately the development of a work programme for implementation.

Early priorities	Medium and longer term priorities
• More detailed assessment of the benefits and impacts of smarter pricing, particularly net user effects, affordability, equity and any necessary mitigation. • Develop an implementation pathway that includes consideration of technology, national implications, legislative requirements, staging and trials; and progress priority actions. • Investment in intelligent transport systems to enable increased productivity, and smarter pricing. • Increased use of non-pricing demand management measures, such as high-occupancy lanes.	• Full implementation of smarter transport pricing. • Increased capacity of the public transport system where necessary to accommodate shifts in demand as a result of smarter pricing.

Indicative investment package

84. The indicative package illustrates how the strategic approach could be implemented over time. It is not an 'investment programme', as neither the Government nor Auckland Council are able to commit to funding over 30 years and all transport investments need to go through business case approval and statutory processes to proceed. We have placed greater emphasis on the first 10 years (2018 to 2028) because of considerable uncertainty about the rate and location of housing and employment growth, and the timing and impacts of technological change beyond this period.

85. Committed infrastructure investments form a key part of the indicative package in the first decade. The largest committed investments are listed below, with estimated expenditure incurred during the first decade, 2018-2028[5]:

- City Rail Link ($2 billion).
- Puhoi to Warkworth extension of the Northern Motorway ($500 million).
- East-West Link ($1,500 million).
- Accelerated motorway package ($500 million), which includes:
  - Northern corridor improvements and Northern Busway extension
  - Southern Motorway improvements.
  - Airport access (northern) improvements.
- Mill Road northern section (partly committed, $290 million).
- Panmure-Botany Busway and roading improvements (AMETI) (partly committed, $700 million).

86. We used the prioritisation framework in paragraph 37 to assess potential new investments beyond these current commitments (including the uncommitted elements of Mill Road and AMETI). This included an assessment of the extent to which they address the most significant early transport challenges, and may provide value for money in the next decade. The indicative sequencing of major new investments is outlined in the following map and table.

87. The large scale of most of these investments means that they have long lead times (seven years or more for planning, design, procurement and construction). This highlights the need to commence work on these projects at an early stage. To reflect this, we have allocated 10% of the capital cost of projects listed as medium priorities for the first decade.

88. In addition to these major investments, the indicative package also includes a significant amount of expenditure on safety programmes, walking and cycling, and minor road and public transport improvements. It also includes provision for maintaining and operating the transport system and asset renewals, and an allowance for additional expenditure as a consequence of growth in the asset base and user demand.

[5] Does not include costs incurred up to 2018. Puhoi to Warkworth reflects estimated Public-Private Partnership costs during 2018-28.

Indicative priorities for major new investments		
Early priorities (completion in decade 1)	**Medium term priorities (completion in decade 2)**	**Longer term priorities (completion in decade 3)**
• Northwestern Busway (Westgate to Te Atatu section). • Address bottlenecks on Western Ring Route (SH20 Dominion Rd to Queenstown Rd) and Southern Motorway (Papakura to Drury). • New or upgraded arterial roads to enable greenfield growth in priority areas. • Protect routes and acquire land for greenfield networks. • Complete SH16 to SH18 connection. • Early Rail Development Plan priorities (see paragraph 81). • Upgraded eastern Airport access (SH20B). • Investments to enable smarter pricing. • Increased investment in Intelligent Network Management. • Progress advance works on medium-term priorities.	• Continued investment to enable greenfield growth. • New strategic roads to Kumeu and Pukekohe. • Implementation of mass transit on isthmus and then to the Airport. • Bus improvements Airport – Manukau – Botany. • Improved access to Port/ Grafton Gully. • Northwestern Busway extensions. • Improve connection between East-West link and East Tamaki. • Penlink. • Medium-term Rail Development Plan priorities.	• Continued investment to enable greenfield growth. • Southern Motorway improvements south tof Manukau. • Southwest Motorway (SH20) improvements and improved northern Airport access. • Northern Motorway widening. • Waitematā Harbour crossing improvements, including mass transit upgrade of Northern Busway. • Longer term Rail Development Plan priorities.

ATAP Indicative Package: Major Interventions, all decades

Expected outcomes

89. The indicative package is projected to deliver substantially better outcomes against the key project objectives of access to employment, congestion and public transport mode share, when compared to the current plan[6]. In combination, this will make a positive contribution to regional and national economic growth and productivity. The graphs below outline the projected performance of both the indicative package and the current plan, using strategic transport modelling outputs for 2013, 2026, 2036 and 2046.

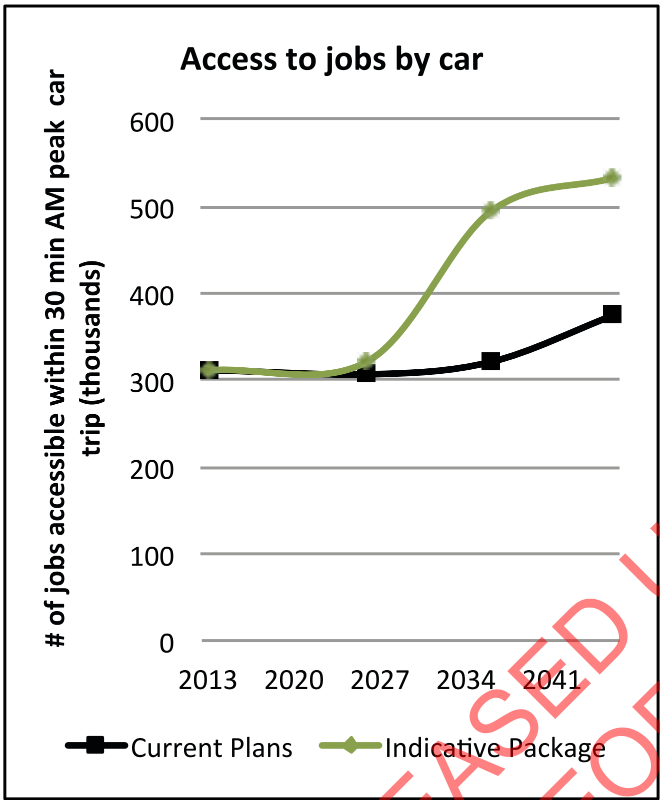
90. The use of a 2013 base year means that the model results need to be treated with some caution. Monitoring shows a significant recent increase in traffic volumes, and a decrease in average peak motorway speeds of 9% between 2013 and 2016. This suggests that the congestion and accessibility results in 2016 will already be significantly worse than indicated in the graphs below.

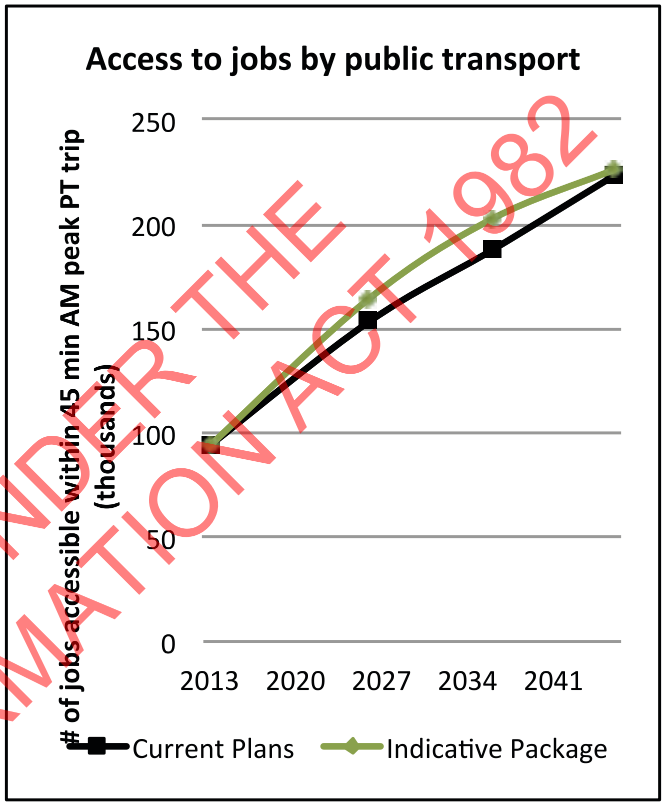
91. Our analysis shows that implementing this approach will provide better returns than the current plan. The most significant gains are increases to accessibility by car and reductions in peak congestion levels. It is important to emphasise that the 'step-change' in performance against these objectives is largely driven by the introduction of smarter transport pricing, which is assumed to be fully implemented in the second decade[7].

[6] For the "current plan", we used the 30-year investment proposals that were developed for the 2015-25 Auckland Regional Land Transport Plan and Long-term Plan. This is referred to as the "Auckland Plan Transport Network", or APTN.

[7] For modelling purposes, we tested prices ranging from 2.25 cents to 30 cents per kilometre, depending on time period, location and road type. We assumed that these charges would replace existing fuel taxes and road user charges for light vehicles (approximately 6 cents per kilometre).

92. **Access to employment[8]:** The average number of jobs accessible within 30 minutes by car in the morning peak increases sharply between 2026 and 2036, reflecting the less congested network as a result of smarter pricing. Public transport accessibility improves under both the current plan and the indicative package, so that the number of jobs accessible within 45 minutes doubles by 2036. This reflects the stronger focus on the strategic public transport network under both the current plan and, more particularly, the indicative package.

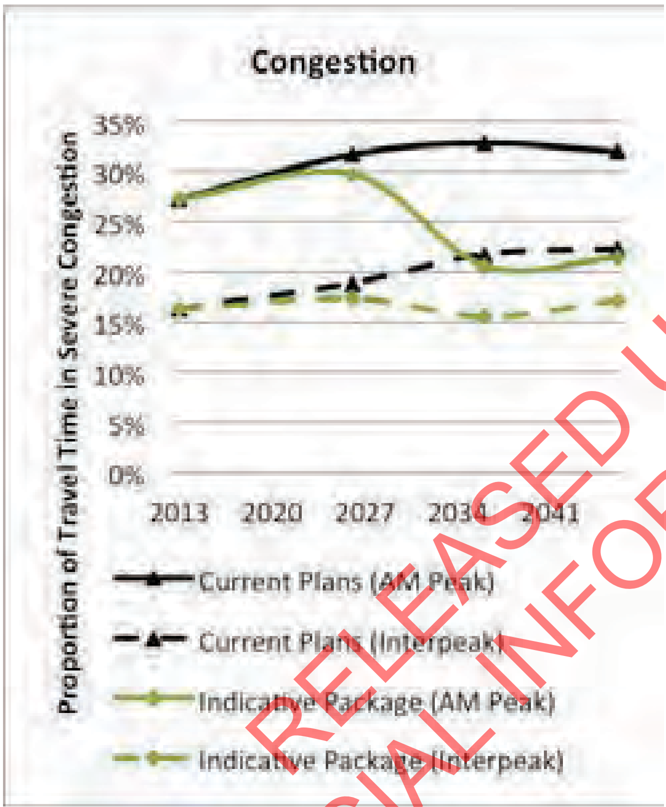


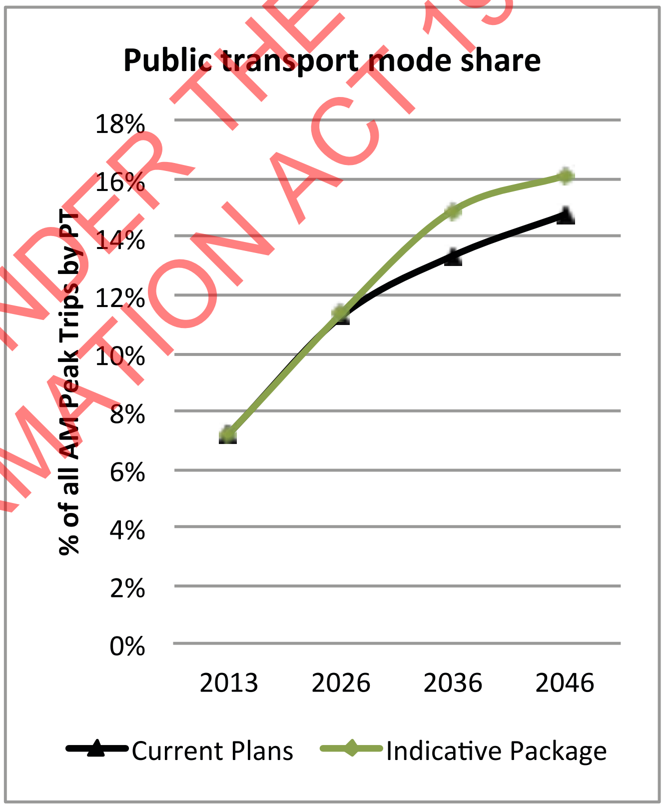


[8] Accessibility is measured as travel time rather than travel costs and therefore for this purpose does not assess the additional financial costs users face from pricing. A 30-minute car trip roughly corresponds to average journey to work time in Auckland. A 45-minute public transport trip includes walk and wait times.

93. **Congestion:** The proportion of travel time spent in severe congestion during the morning peak period is projected to increase from 27% in 2013 under the current plan to 32% by 2026. The indicative package performs slightly better than the current plan over this period (30%), but congestion remains higher than 2013 levels until the introduction of smarter pricing, assumed to be in the second decade. By 2036, the time spent in peak congestion falls to 21%, which is significantly better than 2013. Inter-peak congestion also shows improvement.

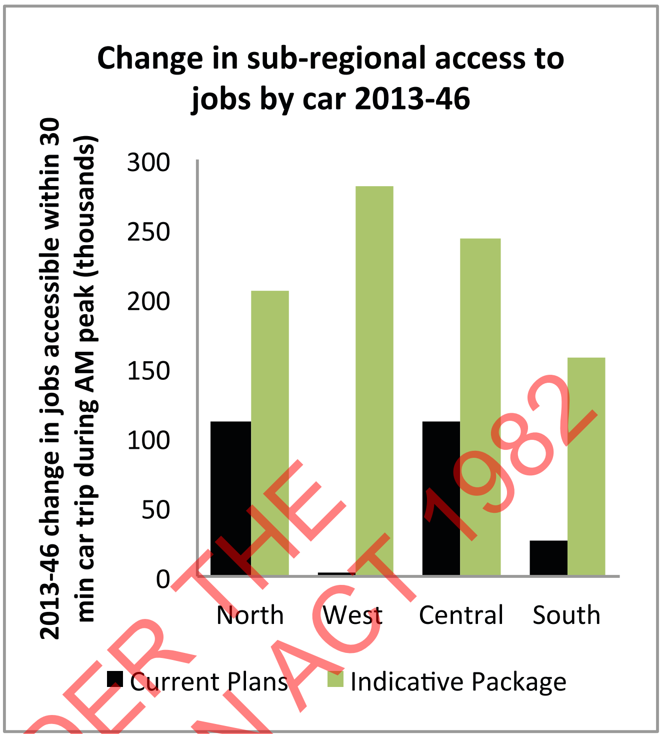
94. **Public transport mode share:** Both the current plan and the indicative package project a strong increase in public transport mode share, from 7% in 2013 to 11% by 2026. This equates to a doubling in total annual public transport tripsover that period, to around 146 million by 2026. Further improvements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





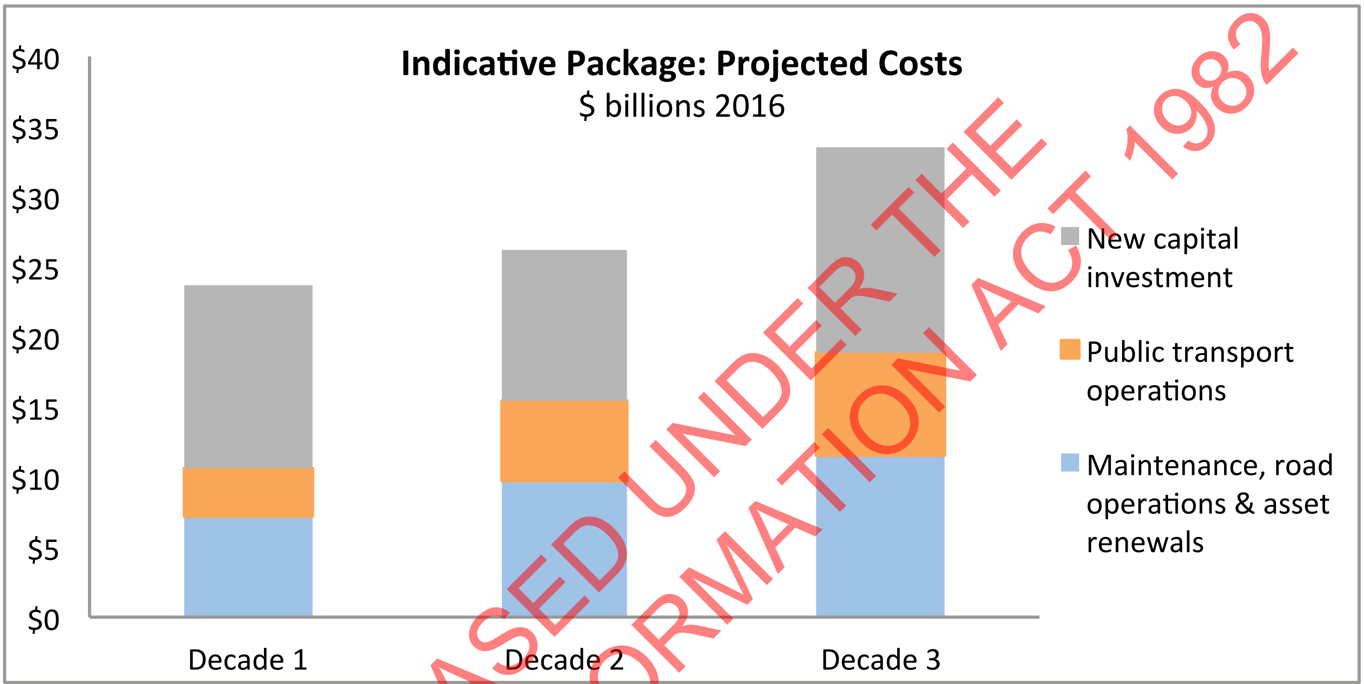
95. The indicative package also addresses some of the key sub-regional challenges facing Auckland.

96. Under the current plan, access to employment from West Auckland by a 30-minute car trip is projected to barely change over the next 30 years, despite Auckland's employment growth. However, under the indicative package the west achieves the greatest improvement in employment access, with around 280,000 more jobs being accessible compared to the current plan in 2046. In the south, the indicative package provides access to around 130,000 more jobs within a 30-minute peak trip by car than the current plan.



Cost estimates

97. The estimated expenditure to implement the indicative package in the first decade (2018 to 2028) is $23.7 billion (at 2016 prices). This includes $7.2 billion on maintenance, road operations and asset renewals, $3.4 billion on public transport operations (net of fare revenue), and $13.0 billion on new capital investment. The graph below summarises the cost estimates for these three components of the indicative package over the next three decades. A total of $84 billion of investment would be required over the 30-year period, of which $38.6 billion, or 46%, represents new capital expenditure.



98. The cost estimates show significant projected growth in expenditure on maintenance, operations and asset renewals. This reflects:

- the increased demands of a rapidly growing asset base
- a strong increase in projected expenditure on local road renewals in the first decade, targeted at achieving a consistent and appropriate level of service across the network[9]
- increased public transport operating costs as a result of additional services and projected growth in passenger volumes.

99. Given the strategic nature of the project, there has been limited opportunity to fully scrutinise these cost estimates, and they should be therefore treated with some caution. In some cases, there will be opportunities to make savings, but conversely, some investments may cost more than has been estimated.

[9] Subject to review and agreement on appropriate levels of service and required funding.

Value for money

100. The project's terms of reference require consideration of the costs and benefits of alternative combinations of interventions and whether better returns can be achieved from transport investment than current plans. Value for money is normally assessed through cost benefit analysis, which measures society's willingness to pay for the various benefits that arise from an investment.

101. Before funding is committed all transport investments require a rigorous investment process to demonstrate value for money, based on robust value for money estimates as part of individual business cases.

102. We used Auckland's existing regional transport models to understand the differences in performance against our key objectives, reported above. Our analysis has shown that the recommended strategic approach will deliver better region-wide outcomes than current plans. Furthermore, our analysis showed that the indicative package would deliver significantly better results than a larger investment package that did not include smarter pricing. This suggests that the inclusion of smarter pricing is key to achieving value for money.

103. The existing modelling tools have limitations in providing detailed information on all the economic benefits that would be expected from a mix of large and complex interventions, such as those tested as part of the indicative package. For this reason, we have not relied on a package-wide benefit cost assessment based on modelling outputs.

104. Instead, we have focused on ensuring that the identified 'early priorities' are likely to provide value for money if they are implemented over the next decade. A number of these priorities have existing value for money assessments, which indicate they deliver benefits that exceed their costs.

105. Beyond these early priorities, it becomes more challenging to assess value for money, as uncertainties relating to project costs and the impacts of smarter pricing and new technologies become increasingly significant. Our most substantial uncertainty relates to large, longer-term infrastructure investments. The timing and scope of these investments should be monitored over time, particularly with regard to whether they provide value for money as we shift to a greater focus on influencing demand.

106. These caveats emphasise the need to consider the package and the implied funding gap as 'indicative'.

Funding Implications

107. A key task for the project is to provide advice on "the nature, scale and timing of any funding gap for the recommended strategic approach and its alternatives".

108. Funding for transport in Auckland comes from a variety of sources, most collected by either the Government or Auckland Council. These include fuel excise duty, road user charges, motor vehicle licensing, rates, taxes, public transport fares, parking charges, development contributions, and tolling. Under current funding policies, different types of projects have different funding sources. These are broadly outlined below:

- State highways are fully funded by the Government through the National Land Transport Fund (NLTF)
- rail network infrastructure (tracks, signals, electrification etc.) is fully funded by the Government from general taxation (except the City Rail Link, which is subject to separate negotiations)
- local roads, public transport operations (net of fares) and public transport infrastructure are jointly funded by Auckland Council and the Government, through the NLTF
- some local roads and public transport infrastructure is solely funded by Auckland Council, either because it is not eligible for NLTF funding (e.g. street cleaning or footpath renewals) or is not prioritised for co-funding from the NLTF.

109. The current funding plans (Auckland Transport's 2015-25 Regional Land Transport Plan informed by Auckland's Council's 2015-25 Long-term Plan and the NZ Transport Agency's 2015-18 National Land Transport Programme provided us with a seven-year funding estimate for 2018 to 2025. We extrapolated this out to 2028 to provide an estimate of funding from Auckland Council and the NLTF for the first decade (2018-2028).

110. The estimate of total funding available also needs to include rail network funding. Our estimate is based on the expectation that the Government will fund half the City Rail Link, and that it will also continue to fund the network infrastructure component of future rail development in Auckland, subject to business cases. The indicative package includes an estimated cost of $470 million for rail network infrastructure in the first decade, which we assume is able to be funded by the Government and is therefore not included in funding gap calculations.

111. Based on these assumptions, we estimate that the total transport funding available to Auckland is likely to be around $19.8 billion in the first decade.

112. The difference between the $23.7 billion estimated cost of the indicative package and the funding available from current plans indicates a first decade funding gap in the order of $4 billion. The actual size of the gap, and the shares that can be attributed to the Council and the NLTF will vary depending on the assumptions made, especially in relation to:

- The total size of the investment programme, including the amount spent on maintenance, operations and asset renewals.
- Whether the share of investment between Auckland Council and the NLTF follows recent trends, or changes over time.

113. Further work will be needed to understand the implications of these different assumptions on the quantum of additional funding that will be needed from the Council and the NLTF, and to determine the options that are available for the Council and the Government to address the funding gap.

114. We have not calculated a funding gap beyond the first decade, due to greater uncertainty about the timing of longer-term interventions and the lack of any current funding plans against which to compare the package.

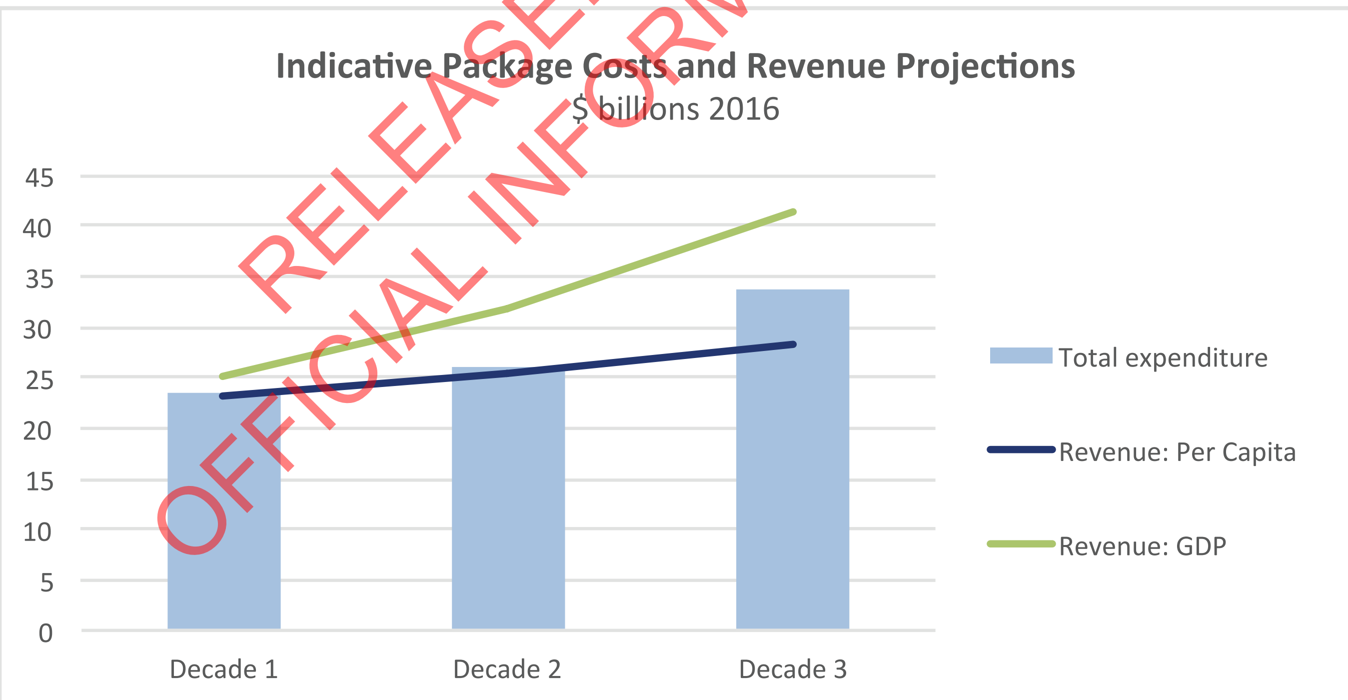
115. However, we developed two scenarios to understand the potential funding that could be available in the longer term to help understand the potential affordability of the indicative package.

116. Taking 2012-2015 expenditure levels as a baseline, our scenarios were:

- A "Per Capita" scenario, where future transport expenditure increases in line with Auckland's population (i.e. the amount invested per Aucklander remains the same, but the total continues to increase in line with Auckland's population growth).
- A "GDP" scenario, where future transport expenditure increases in line with Auckland's economic growth (i.e. transport investment as a proportion of the Auckland region's Gross Domestic Product, or GDP, is maintained over time by increasing investment in line with economic growth)

117. Under the "Per Capita" scenario approximately $75 billion would be available for transport investment over the next 30 years compared with approximately $96 billion under the "GDP" scenario. However, in the first decade the difference between the two scenarios is only approximately $2 billion.

118. The graph below compares total expenditure estimates for the indicative package across the three decades with the revenue available under the "Per Capita" and "GDP" scenarios. In each decade, total expenditure would be higher than the "Per Capita" revenue, but less than the share of "GDP" revenue.



Recommendations

119. Putting the strategic approach into practice will require a number of key decisions in the next few months.

We recommend that the Government and Auckland Council:

- **Adopt the recommended strategic approach, which contains the following key components:**
  - **a. Make better use of existing networks**
  - **b. Target investment to the most significant challenges**
  - **c. Maximise opportunities to influence travel demand**
- **Implement the recommended strategic approach by:**
  - **a. Reflecting the strategic approach in statutory documents**
  - **b. Considering options for addressing the funding gap**
  - **c. Laying the groundwork for smarter transport pricing**
  - **d. Ensuring supportive investment processes**
  - **e. Taking steps to maintain ongoing alignment**
  - **f. Completing work on priority actions as soon as possible**

120. Reflecting the strategic approach in statutory strategic documents (the next Government Policy Statement for land transport and the forthcoming refresh of the Auckland Plan) will ensure future policy and investment decisions are aligned with this approach. These documents give guidance to statutory funding and planning documents prepared by Auckland Transport, Auckland Council and the NZ Transport Agency.[10]

We recommend the Government, Auckland Council, Auckland Transport and the NZ Transport Agency incorporate the strategic approach into their statutory strategic documents.

121. Our estimates suggest an indicative funding gap of around $4 billion in the first decade. To implement the strategic approach, this gap needs to be bridged. A number of options are available.

122. Additional funding could be provided, by either increasing funding available for transport from current funding sources or through introducing new funding tools. The merits of these options need to be jointly considered in a timely manner, so that clarity is provided to the 2018 funding plans.

123. Both the Council and Government will need to consider what this means for their current funding arrangements, and to identify future options for joint consideration.

We recommend the Government and Auckland Council work together to consider options and agree on an approach to address the funding gap by mid-2017, to inform statutory funding documents.

[10] Auckland Transport's Regional Land Transport Plan and Regional Public Transport Plan, NZ Transport Agency's National Land Transport Programme and Auckland Council's Long-term Plan.

124. Progressively shifting to smarter transport pricing is crucial to achieve a step-change in the performance of Auckland's transport system. We believe that preparatory work on smarter pricing should be progressed with urgency, to develop an ambitious but feasible programme for implementation. The first key step along this pathway is to establish a dedicated smarter pricing project that leads to:

- more detailed assessment of the benefits and impacts of smarter pricing, particularly net user effects, equity and any necessary mitigation
- development of an implementation pathway that includes consideration of national implications, legislative requirements, technology, staging and trials.

We recommend the early establishment of a dedicated project to progress smarter transport pricing with a view to implementation within the next 10 years.

125. Transport investment processes need to ensure the best performing interventions are prioritised for funding, regardless of type. Funding arrangements would benefit from greater consistency, particularly across the strategic networks. This includes moving to consistent and integrated decision-making for rail.

We recommend investment processes are reviewed to ensure they align with the strategic approach.

126. Achieving an aligned strategic approach through this project has demonstrated the value of establishing an agreed set of objectives, measures, problem definitions and assumptions. A continuation of this collaborative approach is recommended as ongoing review will be important as land use and population growth projections are adjusted.

127. The requirement for six-yearly reviews of the Auckland Plan provides a possible opportunity to incorporate a review of the strategic approach. The Government and Auckland Council should further consider how we review the strategic approach over time, including whether statutory changes are required.

We recommend the Government and Auckland Council consider whether statutory changes are required to support ongoing joint strategic transport planning.

128. We have identified a number of high priority actions that should progress over the next 12 months to support the strategic approach. These are set out in the following schedule.

We recommend that the identified priority actions be completed as soon as possible.

Action	Responsibility
• Agree the location of key routes where through-movement should be prioritised, as well as a target for improved productivity on these routes. • Complete and implement a framework for managing competing uses on these routes, through traffic management actions and investment priorities.	Auckland Transport and NZ Transport Agency (with Auckland Council).
• Agree appropriate asset management levels of service, associated funding requirements and provide improved visibility of the trade-offs from different levels of asset management investment.	Auckland Transport and NZ Transport Agency.
• Develop a shared work programme to facilitate the uptake of new transport technologies, including intelligent network management, connected and autonomous vehicles, and shared mobility; with a focus on enabling regulation, supporting infrastructure and trials.	Ministry of Transport, NZ Transport Agency and Auckland Transport.
• Consider how government transport funding processes should reflect the benefits of enabling growth.	Ministry of Transport and NZ Transport Agency (with Auckland Council and Auckland Transport).
• Complete business cases for each of the high priority interventions identified in this report, to enable early decisions on funding, timing and route protection to proceed as soon as possible.	Auckland Transport and NZ Transport Agency.

Find out more:
transport.govt.nz/atap
aucklandcouncil.govt.nz/atap

Auckland Transport Alignment Project

Revenue and Expenditure Report

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Preface

This is one of a series of research reports that were prepared as inputs to the Auckland Transport Alignment Project (ATAP). It is one of a number of sources of information that have been considered as part of the project, and which have collectively contributed to the development of the recommended strategic approach. The content of this report may not be fully reflected in the recommended strategic approach, and does not necessarily reflect the views of the individuals involved in ATAP, or the organisations they represent. The material contained in this report should not be construed in any way as policy adopted by any of the ATAP parties. The full set of ATAP reports is available at www.transport.govt.nz/atap.

1. Introduction

This Auckland Transport Alignment Project (ATAP) is a joint investigation to test whether better returns from transport investment in Auckland can be achieved over the next 30 years.

The Government and Auckland Council want to identify an aligned strategic approach for the development of Auckland's transport system that delivers the best possible outcomes for users of the transport system and delivers the best value for money.

The revenue and expenditure workstream has been tasked with estimating the overall level of expenditure associated with the different investment packages developed by ATAP, together with estimates of future revenues. This information has been used to identify the nature, scope and timing of any funding gap between current revenue plans and the expenditure envisaged in the Indicative Package, as outlined in the *Auckland Transport Alignment Project: Recommended Strategic Approach.*

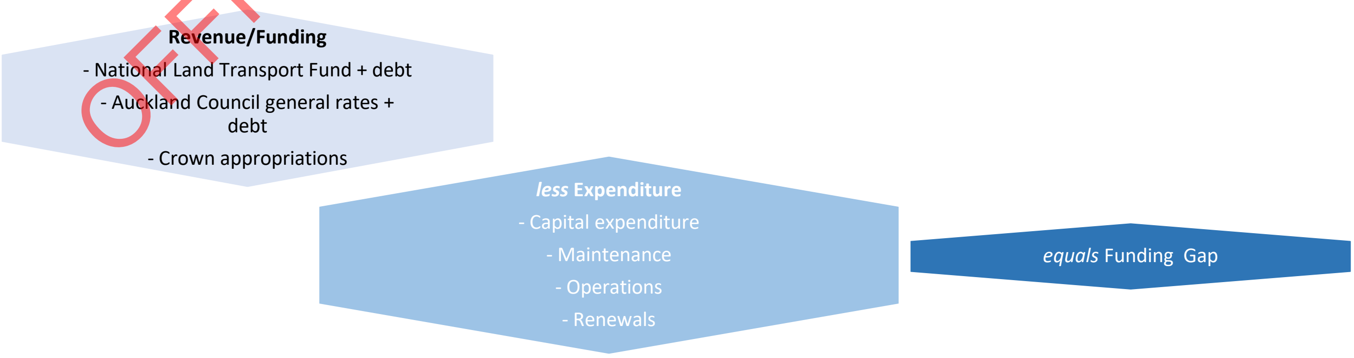
2. Approach

An expenditure and revenue model was developed to forecast Auckland's overall transport financial performance for the 30-year period 2019-2048. The model, which has been externally peer reviewed, comprises interconnected spread sheets of estimated revenue, capital and operating expenditure, which have been used to identify the ATAP funding gap.

As illustrated below in Figure 1, the size of any funding gap is a function of the projected transport funding (also referred to as 'revenue'), and the expenditure required to deliver the package of projects and on-going costs proposed under the Indicative Package, as outlined in the ATAP *Recommended Strategic Approach.*

The model allows the impact of different revenue and expenditure assumptions to be tested. It has also been used to identify the allocation of the funding gap between the parties under different co-funding assumptions.

Figure 1: Schema of the expenditure and revenue model



Unless otherwise stated, all revenues and costs are in 2016 dollars.

For the purposes of ATAP, costs associated with interest on the Council's debt, and an allocation of debt repayments has been excluded for the following reasons:

- They relate to Council expenditure in previous periods;
- The allocation of debt to transport is arbitrary. Debt arises from a shortfall of revenue over expenditure from all Council activities, and there is no objective way of saying which activity gave rise to the shortfall.
- The purpose of debt funding is to defer the impact of the expenditure on ratepayers. In present value terms the cost of debt plus deferred rates is equal to the cost of charging to cost to current rates. In economic terms the cost of debt is therefore nil.
- The interest and debt repayment cost is a cost of deferring rates, not of incurring expenditure on transport projects.

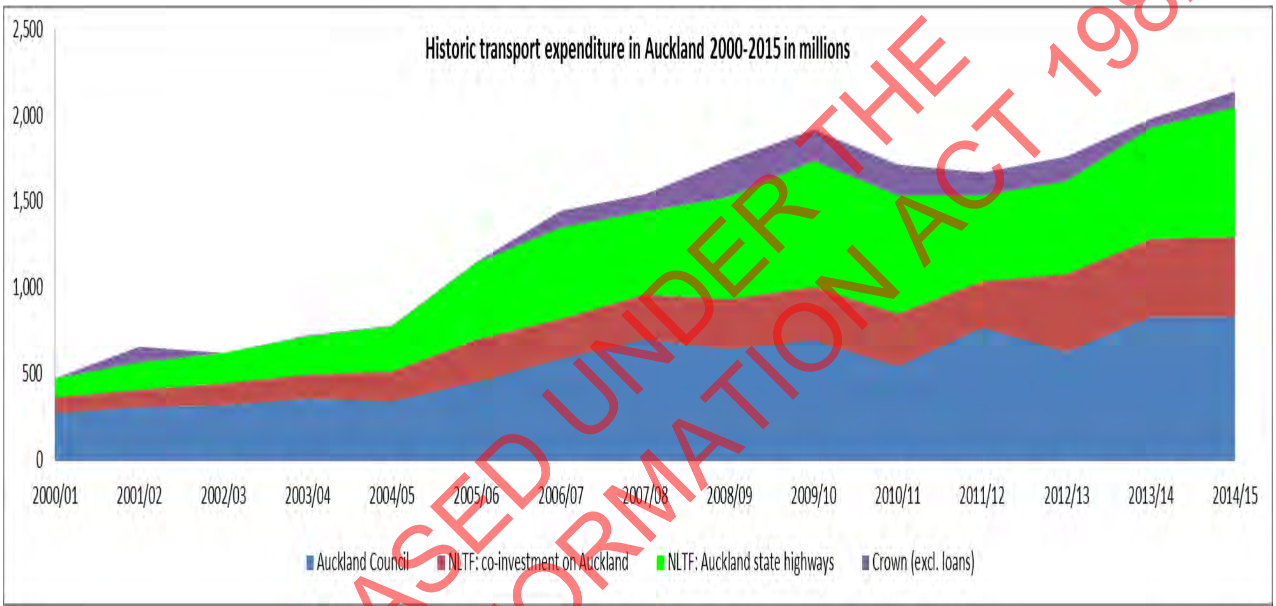
The details and assumptions underlying the individual components of the expenditure and revenue model are discussed in more detail in the following sections.

3. Expenditure

3.1. Historic transport expenditure 2001-2015

Figure 2 below highlights the growth in transport related expenditure in Auckland from 2001-2015 in nominal dollars (see Table 1 for details). This historic growth has been as a result of addressing under-investment in transport as well as to accommodate Auckland's population growth. Recent expenditure on transport in Auckland has totalled around $2 billion per annum.

Figure 2: Historic spend on transport activities in Auckland 2001-2015 (actual dollars)



Source: Ministry of Transport

Table 1: Historic spend on transport activities in Auckland 2001-2015 actual dollars ($m)

$millions	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
Auckland Council	275	309	322	358	343	455	590	702	647	698	547	771	630	834	834
NLTF: co-investment on Auckland	91	101	127	141	173	247	232	260	288	309	305	269	451	451	462
NLTF: Auckland state highways	111	158	176	222	262	445	528	481	594	731	686	498	539	644	753
Crown (excl. loans)	0	91	0	5	5	4	98	100	215	179	179	132	143	53	91
	477	660	624	726	783	1,151	1,448	1,544	1,744	1,918	1,716	1,670	1,763	1,983	2,140

3.2. Expenditure model

ATAP has involved an assessment of a number of intervention packages, made up of different combinations of investment. An expenditure model was developed to provide cost estimates for each of these packages across the three decades covered by ATAP (from 2018/19 to 2047/48), based on cost information from a variety of sources. Some of the cost

estimates used for this purpose were refined as the project progressed, especially where the scope of interventions changed. This means that cost comparisons between packages developed at different stages of ATAP need to be treated with caution.
Costs were estimated for the following main expenditure categories:

- Capital-improvement expenditure (not including asset renewals)
- Asset renewals
- Maintenance and operations (excluding public transport operations)
- Public transport operating costs

Capital expenditure

The expenditure model used estimates of capital cost of projects derived from the following sources:

- Business cases for committed and agreed projects.
- Project teams estimated high level costs for new projects
- The Transport for Future Urban Growth (TFUG) business case informed the estimates for the ATAP transport for urban growth costs
- AECOM provided consultant support in estimating new project costs
- Rail development plan costs have been provided from the AT Strategic business case estimates

It should be noted that:

- Costs for Auckland Transport capital projects have been externally reviewed by AECOM and have provided 'midpoint' likelihood estimates.
- Costs for State highway projects are based on 50 percentile high level costs provided by NZTA. These costs have been reviewed by the appropriate senior Auckland Highways Networks Operations manager.

Because capital projects have a long lead time, it will be necessary for some expenditure to be incurred in the first decade for projects that will not be completed and in service until the second decade. To account of this, an allocation of 10% of the capital cost of projects slated for completion in decade 2 was allocated to decade 1. Similarly, 10% of the cost of projects expected to be completed in decade 3 was allocated to decade 2.

Maintenance, Operations and Renewals

Estimates of future expenditure on maintenance, operations and asset renewals have been prepared by the ATAP Maintenance, Operations and Renewals workstream and documented in the *ATAP Renewals, Operations and Maintenance* report. The workstream collaboratively developed a 30-year projection of the costs necessary to operate, maintain and renew the current and planned future road and transport networks, excluding Kiwi Rail assets.

The level of expenditure on maintenance, operations and renewals is influenced by the scale of the existing network and service levels; and also by the level of investment in new assets and services to deal with growth. This means that the level of expenditure will differ between intervention packages, especially where those package involve a significantly different mix of new investments (with different future maintenance and renewal profiles); or a significant difference in the level of public transport activity (resulting in different level of public transport operating spend on services).

For this reason, public transport operating costs were estimated using a separate cost model which took account of estimates of passenger numbers, farebox revenues and service kilometres for each package, based on patronage outputs from the Auckland Public Transport (APT) model.

The estimates of renewals, operations, maintenance and net public transport costs can be regarded as a conservative estimate of an upper range of costs. The potential for productivity gains through shifting to a 'fit for purpose' regime and improved standards setting, as required by GPS 2015, was treated as out of scope for ATAP purposes.

3.3. Cost estimates for early packages

The expenditure model was used to estimate the total 30-year costs for the packages tested as part of the early stages of ATAP. A detailed description of these initial packages is contained in the *Auckland Transport Alignment Project Supporting Information* report.

These early packages included:

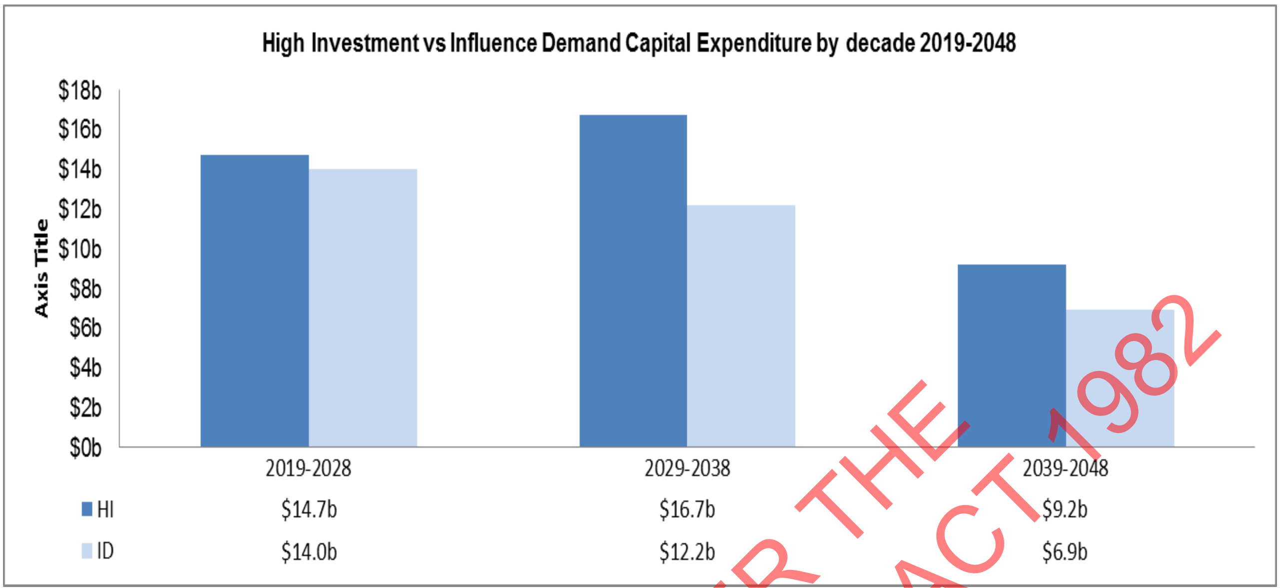
- The Auckland Plan Transport Network (APTN) which was used to represent "current plans" and evaluated as part of the Foundation Report. This included an estimate for NZTA projects. The escalated capital expenditure for the APTN in 2016 dollars is estimated at $27.8 billion over the 30-year period.

- Round 2 packages, referred to as Employment Centres, Capacity Constraints, and Smarter Pricing. These packages were each designed to have a similar level of total capital expenditure as the APTN at approximately $29.5billion.

- Round 3 packages tested different levels of capital investment and demand management interventions. Two packages were developed, with different investment profiles:
    - Higher investment (HI) $40.7 billion capital expenditure
    - Influence demand (ID) $33.2 billion capital expenditure

Figure 3 shows the difference in total capital expenditure for these two packages over the three decades.

Figure 3: Capital cost estimates for Round 3 packages: Higher Investment (HI) and Influence Demand (ID) in 2016 dollars ($b)



3.4. Indicative Package Cost Estimates

The final ATAP report includes an Indicative Package, which identifies the type of transport investments likely to be needed to deliver ATAP's preferred strategic approach. The Indicative Package includes a significant amount of investment in maintaining and operating the existing transport system, and in continuing to make improvements in safety and active modes through on-going investments in these areas.

The expenditure model provides a 30-year cost estimate of the Indicative Package, as summarised below.

Capital expenditure

A total capital expenditure of $38.6 billion is projected over the 30-year period, as shown in Figure 4 and Table 2. The first decade estimate of $13 billion is made up of a number of large projects that are either committed or agreed, together with projects that were prioritised for completion in the first decade. As noted above, an allowance of 10% of the cost of projects due to be completed in decade 2 was also included in decade 1.

Figure 4: Indicative Package 30-year capital expenditure costs in 2016 dollars ($b)

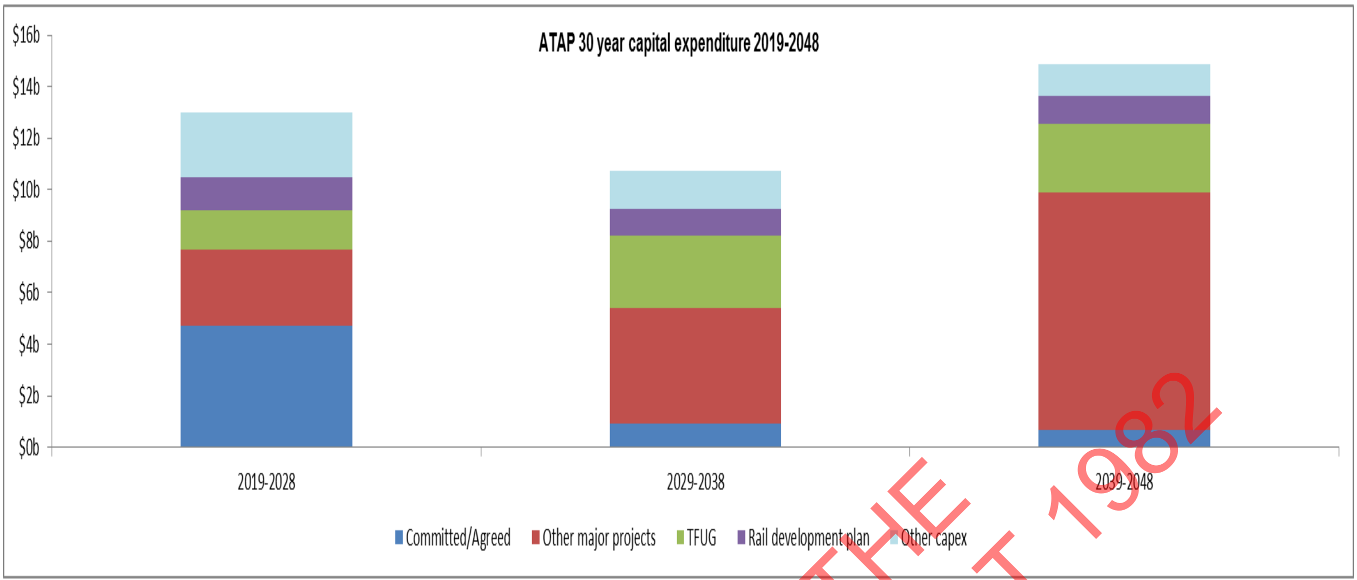


Table 2: Indicative Package capital expenditure costs in 2016 dollars ($b)

	2019-2028	2029-2038	2039-2048	Total Capital Expenditure (30 years)
Committed/Agreed	4.7	0.9	0.7	**6.3**
Other major projects[1]	3.0	4.5	9.3	**16.7**
TFUG	1.5	2.8	2.6	**7.0**
Rail development plan[2]	1.3	1.0	1.1	**3.4**
Other capex	2.5	1.5	1.3	**5.3**
Total	**$13.0b**	**$10.7b**	**$14.9b**	**$38.6b**

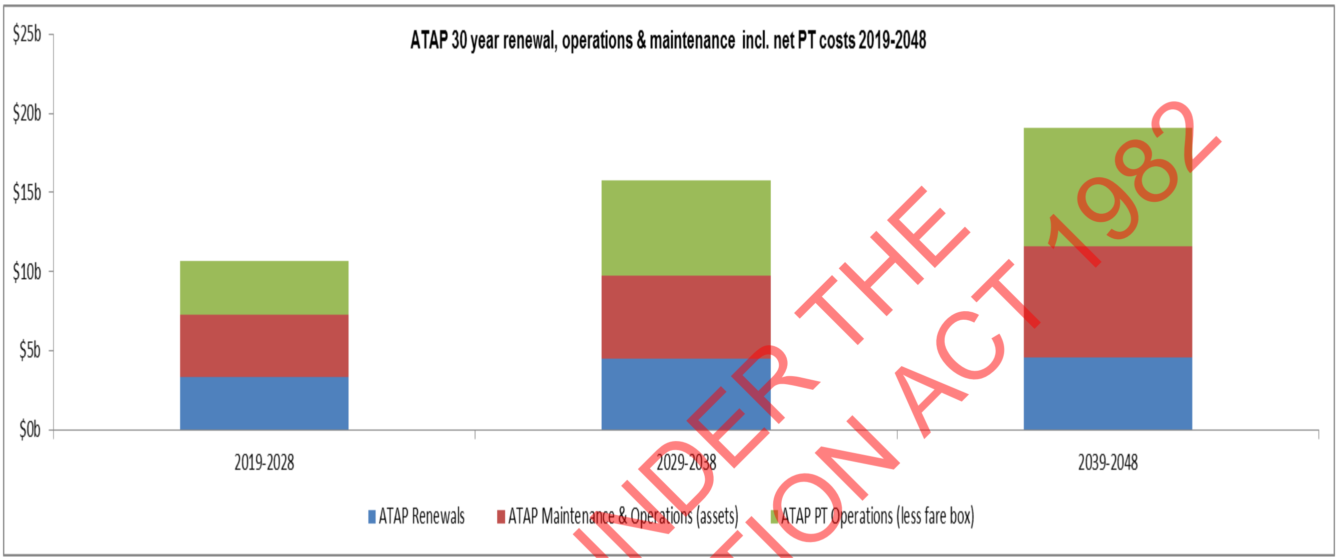
[1] Other major projects are new projects estimated to cost over $150m to implement.

[2] Part of the rail development plan ($600m) is included as part of TFUG costs in the TFUG business case. In ATAP these are shown in the rail development plan.

Maintenance, operations and renewals

Estimated future expenditure on renewals, operations, maintenance and public transport operating costs for the Indicative Package are presented in Figure 5 below.

Figure 5: Indicative Package: renewals, operations, maintenance and net public transport operating costs in 2016 dollars ($b)



Total expenditure

Table 3 summarises the total projected 30-year expenditure for the Indicative Package.

Table 3: Total Indicative Package costs in 2016 dollars ($b)

	2019-2028	2029-2038	2039-2048	**Total ATAP Expenditure**
ATAP Indicative Package Capital Expenditure	13.0	10.7	14.9	**38.6**
ATAP Renewals	3.4	4.5	4.6	**12.5**
ATAP Maintenance & Operations (assets)	3.9	5.3	7.0	**16.1**
ATAP PT Operations (less fare box)	3.4	5.9	7.5	**16.8**
Total	$23.7b	$26.4b	$33.9b	**$84.0b**

4. Revenue

Transport in Auckland is currently funded from a number of revenue sources (see Figure 2 above). These include:

- Auckland Council, which funds Auckland Transport (AT) to deliver local roads, including active modes, and public transport. This is funded from general rates, dividends, and development contributions. The Council also receives revenues from public transport fares and parking. The Council currently finances much of its capital investment through a combination of external and Crown debt. The financing costs are also met from the revenue sources noted above. Some of this investment qualifies for national grant assistance from the NLTF (co-funding), as discussed below.

- The National Land Transport Fund (NLTF) administered by the NZTA, consisting of the revenue from petrol excise duty, road user charges and motor vehicle registration. These funds are used to support delivery of State highways and road safety (100% funded), and qualifying local roads, public transport, and active modes (co-funded). See Appendix 1 for further explanation of co-funding rates.

- The Crown supplements the NLTF funding by means of appropriations to specific investments, such as electrification of Auckland rail lines and the accelerated State highway package (an interest free loan).

4.1. Recent funding levels

Auckland Council funding

Table 4 shows the amount of transport funding from the Auckland Council over the past four years. A calculation of per capita funding (in 2016 dollars) is also shown. All amounts are exclusive of financing costs to ensure that the focus is on actual cash flows spent on transport activity.

The local component of transport funding was estimated using the published audited accounts for AT, excluding the NLTF co-funding component, plus a further estimate for development contributions.

The published numbers used were for the 4 years 2012-2015 as 2012 was the first full complete year of reporting for AT. The development contributions have been provided by Auckland Council.

Table 4: Auckland Council funding for transport in Auckland, 2012-2015 ($m)

	FY2012	FY2013	FY2014	FY2015
Net operating expenditure	313	255	271	271
Net capital expenditure	496	455	528	566
Total	809	710	799	837
Inflator	1.04	1.03	1.02	1.00
Population (millions)	1.48	1.49	1.52	1.55
Est. per cap local spend on transport	569	488	532	540
Est. per capita development contribution				21
Average per capita spend by AC over 2012-2015 plus development contribution				***$553***

National Land Transport Fund (NLTF) funding

Table 5 shows the amount of NLTF funding for transport in the Auckland region over the past four years. A calculation of per capita funding (in 2016 dollars) is also shown.

The information in the table is based on reported transport cash flows from NZTA's Transport Information System which captures all local and national costs. For this exercise only local Auckland costs have been included.

Table 5: NLTF funding for transport in Auckland, 2012-2015 ($m)

	FY2012	FY2013	FY2014	FY2015
Auckland HNO expenditure	491	665	769	783
Local co-funding from the NLTF	238	387	373	360
Total NLTF	729	1,053	1,142	1,143
Inflator	1.04	1.03	1.02	1.00
Population (millions)	1.48	1.49	1.52	1.55
Est. per capita local spend on transport	512	724	761	738
Average per capita spend from the NLTF over 2012-2015:				***$684***

4.2. Funding available from current plans

In order to determine the size, nature and timing of any future funding gap, it was necessary to estimate the amount of funding that is likely to be available for transport in Auckland. For the first decade (2018/19 to 2027/28) we used information from existing funding plans to estimate likely revenues, as outlined below.

Auckland Council

We used Auckland Council's LTP 2015-2025 to identify planned funding for transport for the first 7 years, and this was extrapolated to provide a 10-year estimate.

National Land Transport Fund (NLTF)

The April 2016 Budgeted Economic Fiscal Update from the Ministry of Transport (MOT) provides the latest estimated available funding from the NLTF over the next 10 years. The Treasury have advised MOT that this forecast should exclude the annual CPI increase. Previously NLTF forecasts included an annual CPI increase, as stated in the guidance from the Government Policy Statement.

It is assumed for decade 1 that the amount of NLTF funding for transport in Auckland would be in line with the historic allocation.

Crown appropriations

We have assumed that the Government and Auckland Council will share the costs of the City Rail Link (CRL) on a 50/50 basis. In 2016 dollars the government contribution to the CRL is estimated to be approximately $1.2b in decade 1 – as advised by AT.

The Auckland Rail Development Plan is expected cost $3.4b over 30 years. It is expected that the Crown will continue to fund rail network infrastructure projects as it has in the recent past. The Crown appropriation for this activity is estimated to be $1.6b over 30 years and $0.5b in decade 1.

Figure 6 and Table 6 show the resulting estimate of funding for decade 1. A total of $19.7 billion is estimated to be available over the 10-year period.

Figure 6: Decade 1 funding estimate: "current plans" in 2016 dollars ($b)

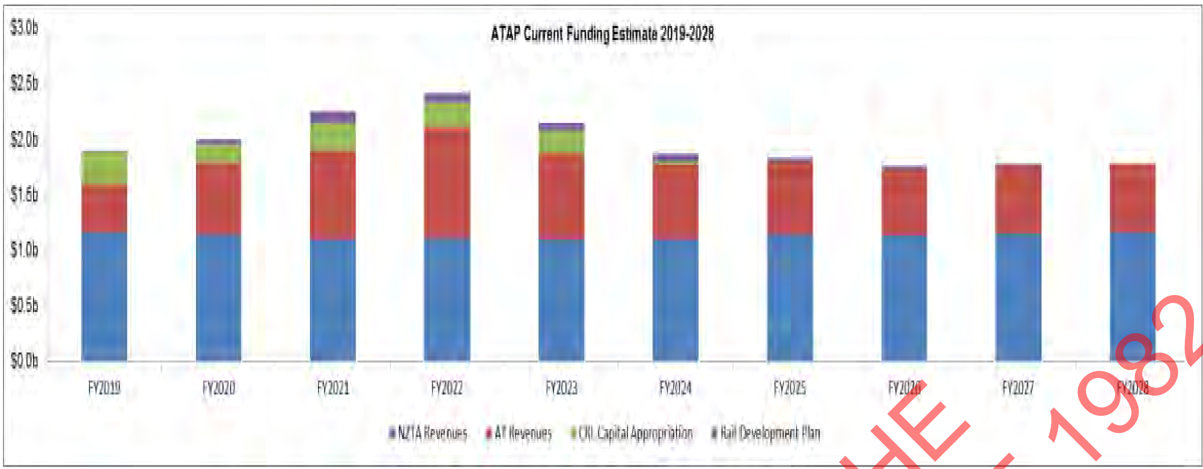


Table 6: Decade 1 funding estimate: "current plans" in 2016 dollars ($b)

	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028	**FY19-28**
NZTA Revenues	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	**11.3**
AT Revenues	0.4	0.6	0.8	1.0	0.8	0.7	0.7	0.6	0.6	0.6	**6.8**
CRL Capital Appropriation	0.3	0.2	0.3	0.2	0.2	0.0	0.0	0.0	0.0	0.0	**1.2**
Rail Development Plan	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	**0.5**
Total	$1.9b	$2.0b	$2.3b	$2.4b	$2.2b	$1.9b	$1.8b	$1.8b	$1.8b	$1.8b	**$19.7b**

4.3. Alternative future revenue scenarios

The estimates of decade 1 funding based on current plans suggest a lower level of annual funding in later years than has occurred recently. To understand the impacts of different revenue assumptions, the revenue model was used to develop two alternative revenue scenarios, to determine the level of funding that might be considered affordable into the future. Both scenarios were based on the recent levels of funding from Auckland Council and the NLTF, as outlined above.

The two revenue scenarios are:

- *Per capita scenario*: the recent per capita level of funding for transport in Auckland from both the Auckland Council and NLTF remains constant over time, meaning that the total level of funding increases in line with population growth. ATAP has used the Statistics New Zealand medium population growth forecast, under which Auckland is predicted to grow by 700 000 people over the next 30 years.[3]

[3] http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/SubnationalPopulationProjections_HOTP2013base.aspx

- *Regional GDP scenario:* this scenario assumes that the current share of Auckland's GDP that is invested in transport will be maintained, so that the total funding increases in line with growth in the regional economy. This approach is consistent with long-term historical trends across local government in New Zealand. The Treasury projects 1.5% p.a. real growth in per capita GDP for New Zealand as a whole, so this figure combined with the Department of Statistic's medium population growth projections for Auckland was used to calculate projected revenue[4].

Figure 7 illustrates the estimates of future revenue generated by each of the two scenarios. The per capita scenario generates $74 billion over the 30 years, while the GDP scenario generates $96 billion over the same period. Estimated revenues within each of three ATAP modelling decades are shown in Table 7.

First decade revenues under both scenarios are higher than the projections based on current plans.

Figure 7: Projected annual revenues: per capita and GDP scenarios

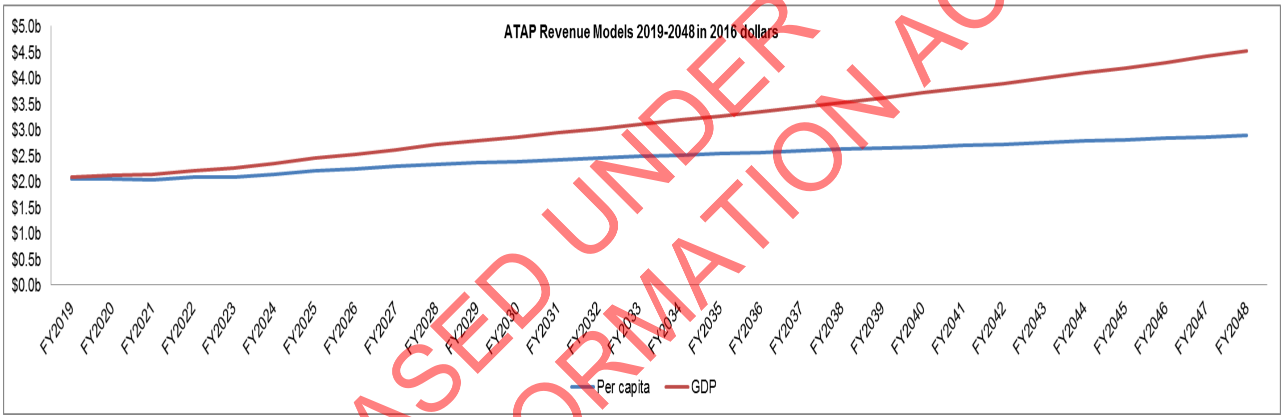


Table 7: Per capita and GDP revenue scenarios by decade 2019-2048 by organisation

Per capita scenario	**2019-2028**	**2029-2038**	**2039-2048**	**Total**
NZTA	11.6	13.6	15.1	**40.4**
AC	9.9	11.3	12.5	**33.7**
Crown (CRL)	1.2	0.0	0.0	**1.2**
Akl Rail Development Plan	0.5	0.4	0.7	**1.6**
Total	$23.2b	$25.3b	$28.4b	**$76.9b**
GDP scenario				
NZTA	12.7	17.3	22.3	**52.2**
AC	10.8	14.2	18.3	**43.3**
Crown (CRL)	1.2	0.0	0.0	**1.2**
Akl Rail Development Plan	0.5	0.4	0.7	**1.6**
Total	$25.1b	$31.9b	$41.3b	**$98.3b**

[4] The population projection can be found here: http://www.treasury.govt.nz/government/fiscalstrategy/model, and the GDP projection can be found here: http://www.treasury.govt.nz/government/assets/nzsf/contributionratemodel (second tab).

5. Funding gap

5.1. Funding gap estimates

Figure 8 below compares the 30-year expenditure estimates for Indicative Package with the revenue estimates for the per capita and GDP scenarios. The projected revenue from existing funding plans is also shown for the first decade.

The graph shows that estimated expenditure lies within the range of the two future revenue scenarios for each of the three decades. This suggests that the Indicative Package is likely to be affordable, provided funding available for transport in Auckland continues at close to its current share of the regional economy.

However, the difference between estimated expenditure and revenue from current funding plans indicates a $4 billion funding gap for the Indicative Package in the first decade.

Figure 8: Indicative Package: expenditure and revenue projections 2019-2048 ($b)

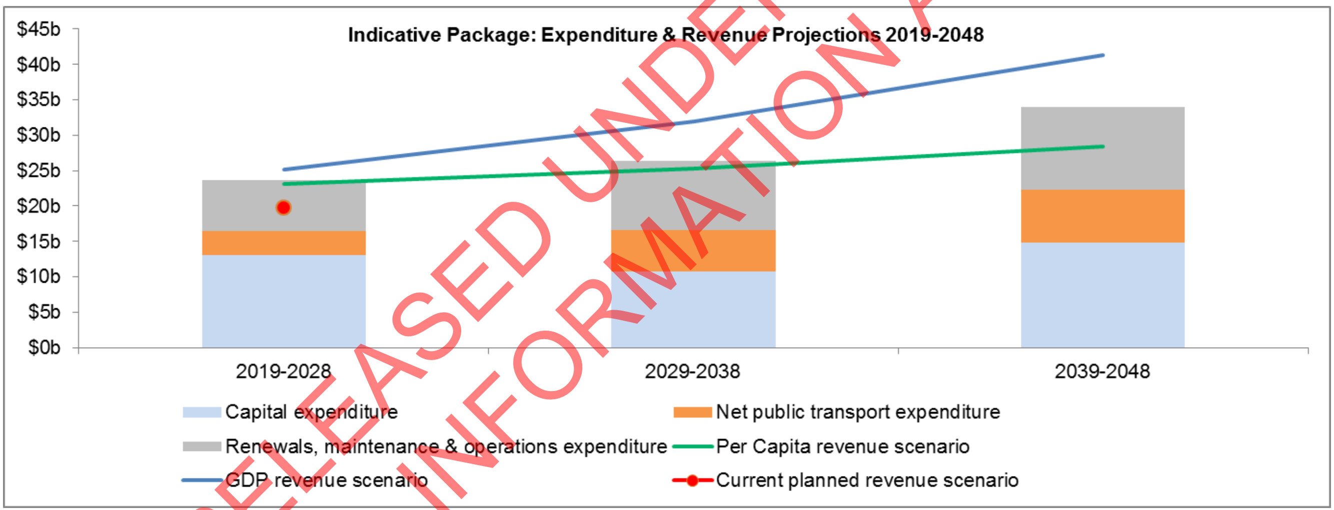


Table 8: Indicative Package: expenditure and revenue projections 2019-2048 in 2016 dollars ($b)

Costs	**2019-2028**	**2029-2038**	**2039-2048**	**Total**
Capital expenditure	13.0	10.7	14.9	**38.6**
Net public transport expenditure	3.4	5.9	7.5	**16.8**
Renewals, maintenance & operations expenditure	7.3	9.8	11.6	**28.7**
Total costs	$23.7b	$26.4b	$33.9b	**$84.0b**
Revenue scenarios				
Per Capita revenue scenario	23.2	25.3	28.4	**$76.9b**
GDP revenue scenario	25.1	31.9	41.3	**$98.3b**
Current planned revenue scenario	19.7			

5.2. Council and NLTF shares of funding gap

We have used the revenue and expenditure model to allocate the $4 billion first decade funding gap between the Auckland Council and the NLTF[5] based on current policies. Their respective shares are influenced the mix of investments and assumptions on the level of co-funding for local transport activities from the NLTF.

State highway activities are 100% funded from the NLTF, while the cost of local land transport activities (for example local roads, public transport) is shared between local government and the NLTF.

The percentage of local land transport funding eligible to be received from the NLTF is called the Funding Assistance Rate (FAR). The normal FAR for Auckland Transport and Auckland Council for the National Land Transport Programme (NLTP) 2015-2018 is 51%.

However not all local transport activities are funded at 51% from the national fund for the following reasons:

- Some transport activities and capital expenditure are not eligible for co-funding from the national fund. The scope of the NLTF is determined by a combination of the Government Policy Statement's approach to use of road taxes, and the NZTAs assessment of which investments will deliver the best possible returns.

- When the NLTP is adopted, each activity class is allocated a funding budget. Available funds are allocated to the investments that deliver the best possible returns to society. Depending on the national prioritisation, funding may not be available for all eligible transport activities. Demand for funds tends to exceed supply, so some projects miss-out on grant funding in any given year. Councils may still choose to proceed with the activity without NLTF contribution.

To understand the implications of FAR on the funding gap, we have used the expenditure and revenue model to estimate shares of the first decade funding gap under two different FAR scenarios:

- A current/historic scenario – based on individual FAR for each transport expenditure type based on recent co-funding percentages, as set out in the table below.
- A full co-investment scenario – assuming all eligible local transport is funded at the rate of 51 percent.

[5] Our assumptions in relation to Crown funding for rail network infrastructure are that the Crown will meet the costs, so none of the funding gap has been allocated to the Crown

Table 9 shows the FAR assumptions for the two scenarios, for each type of expenditure.

Table 9: FAR rates for two co-funding scenarios

Transport spend type	Scenario 1 – Current FAR over eligible activities	Scenario 2 – Full co-investment of 51% FAR over eligible activities
Capital expenditure	40%	51%
Renewals	32%	51%
Maintenance + operations (assets)	45%	51%
PT Ops	51%	51%

Table 10 presents the allocation of costs in the final indicative package under the FAR scenarios above.

Table 10: Indicative ATAP Package under co-funding scenarios ($b, 2016 dollars)

	Current FAR over eligible activities				Full co-investment FAR over ligible activities			
Final Indicative ATAP package	2019-2028	2029-2038	2039-2048	**2019-2048**	2019-2028	2029-2038	2039-2048	**2019-2048**
AC	10.84	12.91	14.84	**38.58**	9.63	11.44	13.15	**34.22**
NZTA subsidy to AC	5.53	7.41	8.91	**21.85**	6.74	8.88	10.60	**26.22**
NZTA highway allocation	5.66	5.72	9.48	**20.86**	5.66	5.72	9.48	**20.86**
CRL Crown appropriation	1.17	0.00	0.00	**1.17**	1.17	0.00	0.00	**1.17**
Auckland rail development plan	0.47	0.40	0.70	**1.57**	0.47	0.40	0.70	**1.57**
Total	23.66	26.44	33.94	**84.04**	23.66	26.44	33.94	**84.04**

Decade 1 (2019-2028) funding gap by organisation

The resulting allocation of the funding gap between the Council and the NLTF under the two FAR scenarios is shown in Table 11 below. Under Scenario 1, based on current average FARs, all of the $4 billion funding gap would be attributable to the Council. Under Scenario 2, however, the Council's share of the funding gap would be $2.8 billion, or 70%.

Table 11: FY2019-FY2028 funding gap by organisation by FAR scenario

	Scenario 1 FY19-FY28	Scenario 2 FY19-FY28	Variance
NLTF	0.1	(1.1)	1.2
AC	(4.0)	(2.8)	(1.2)
Crown (CRL)	0.0	0.0	0.0
Rail development plan	0.0	0.0	0.0
Total $billions	**($3.9)**	**($3.9)**	**0.0**

Both scenarios are based on "current funding arrangements" for different types of projects and existing FARs, which could be changed in the future.

Appendix 1: Revenue Model Assumptions

Category	Source	Assumptions
Current funding forecast	Ministry of Transport Budgeted Updated Fiscal Update (BEFU), April 2016	• Auckland receives an allocation of the of the National Land Transport Fund in line with the Statistics NZ forecast population in decade 1. • BEFU does not include a CPI adjustment and is in in 2016 dollars.
	Auckland Council's Regional Long Term Plan (RLTP) funding for transport	• Funding from general rates & external borrowings in decade 1 per the RLTP. • Excludes interest payments for previous debt incurred for transport related activity.
	Crown appropriations	• Assumes that Crown will fund 50% of the total CRL cost from 2019 onwards
Per Capita revenue estimate	Assumed modelled revenue scenarios based on historical organisational transport spend in the Auckland region growing in line with forecast population growth.	• Annual transport funding will increase in line with Auckland's population growth in 2016 dollars. • The basis for the per capita spend on transport is the 2012-2015 historical averages for transport spend by Auckland HNO and Auckland Transport. • Auckland HNO costs are based on data obtained from NZTA's Transport Information Online database. • AC/AT numbers are derived from AT's published audited annual reports net of any interest payments. • Population increases are in line with Statistics NZ medium forecast for Auckland over the next 30 years.
GDP revenue estimate	Assumed modelled revenue scenario based on historical transport spend in the Auckland region growing in line with region growing in line with forecast population growth.& GDP rate of 1.5% pa.	• The annual spend on transport in Auckland increases in line with assumed increased level of wealth in the region. • Increase of real GDP of 1.5% pa - based on difference between historical regional GDP less 30 year Treasury inflation forecast of 2%.

Appendix 2: Expenditure Model Assumptions

Category	Source	Assumptions
ATAP Indicative Package Capital Expenditure	Auckland Highway Network Operations (HNO)/NZ Transport Agency	• Auckland HNO projects and maintenance, operations and renewals are 100% funded from the National Land Transport Fund. • Project capital costs are percentile 50 (P50) estimates. • Costs have been agreed at the individual approved organisational level.
	Auckland Transport Strategy Division	• Projects are funded at the assumed historic FAR of 40% or the reported FAR of 51% • Historically not all AT projects have been co-funded under the constraint of the NLTP activity classes or available funding. • Some projects are historically not co-invested in.
City Rail Link	Auckland Transport Strategy Division	• Estimated total cost $1.9b 2019-2028. • Crown grant covers $1.2b/50% of the build cost from 2019 onwards. • AT funds $740m of the estimated cost at 100%. • No co-funding from NZTA for CRL.
Auckland Rail Development Plan	Auckland Transport Strategy Division	• Costs are for above ground and below ground rail improvements - $3.4b in total over 30 years. • AC/AT fund above ground capital of $1.8b and this amount is co-funded with NZTA • Assumed that Kiwi Rail through the Crown will fund the remaining $1.4b
Joint Projects	Auckland Transport Strategy Division	• ATAP Evaluation work stream haven't identified what the cost to each AO is at this stage. • Costs shared 50/50 between AC/AT and NZTA (HNO) • AC/AT costs are not co-funded

Appendix 3: Maintenance, Operations and Renewals Assumptions

Category	Source	Assumptions
Auckland Transport Renewals	ATAP R, O & M work stream	• AT transport renewals optimisation model. • Existing asset renewals plus consequential renewals from new assets being built. • Co-funded at 32% and 51% respectively for eligible renewals for the respective scenarios.
Auckland Transport Maintenance & Operations (assets)	ATAP R, O & M work stream	• Costs remain constant for existing assets. • Consequential assets costs based on past 3 years average costs. • Co-funded at 32% and 51% respectively for eligible maintenance & operations for the respective scenarios.
Auckland Transport Operations (services)	AT Finance – based on JMAC modelled APT Transport Model	• Co-funded at 51% respectively for eligible renewals for the respective scenarios. • PT fare-box recovery has been estimated from APT modelled boarding scenarios.

Auckland Transport Alignment Project

Supporting information

Ministry of Transport
TE MANATŪ WAKA

THE TREASURY
Kaitohutohu Kaupapa Rawa

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Auckland Transport

STATE SERVICES COMMISSION
Te Komihana O Ngā Tari Kāwanatanga

NZ TRANSPORT AGENCY
WAKA KOTAHI

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Introduction

1. Background

As joint transport funders with a shared interest in a successful Auckland, the Government and Auckland Council have agreed on the need to improve alignment on a long-term strategic approach to transport in Auckland.

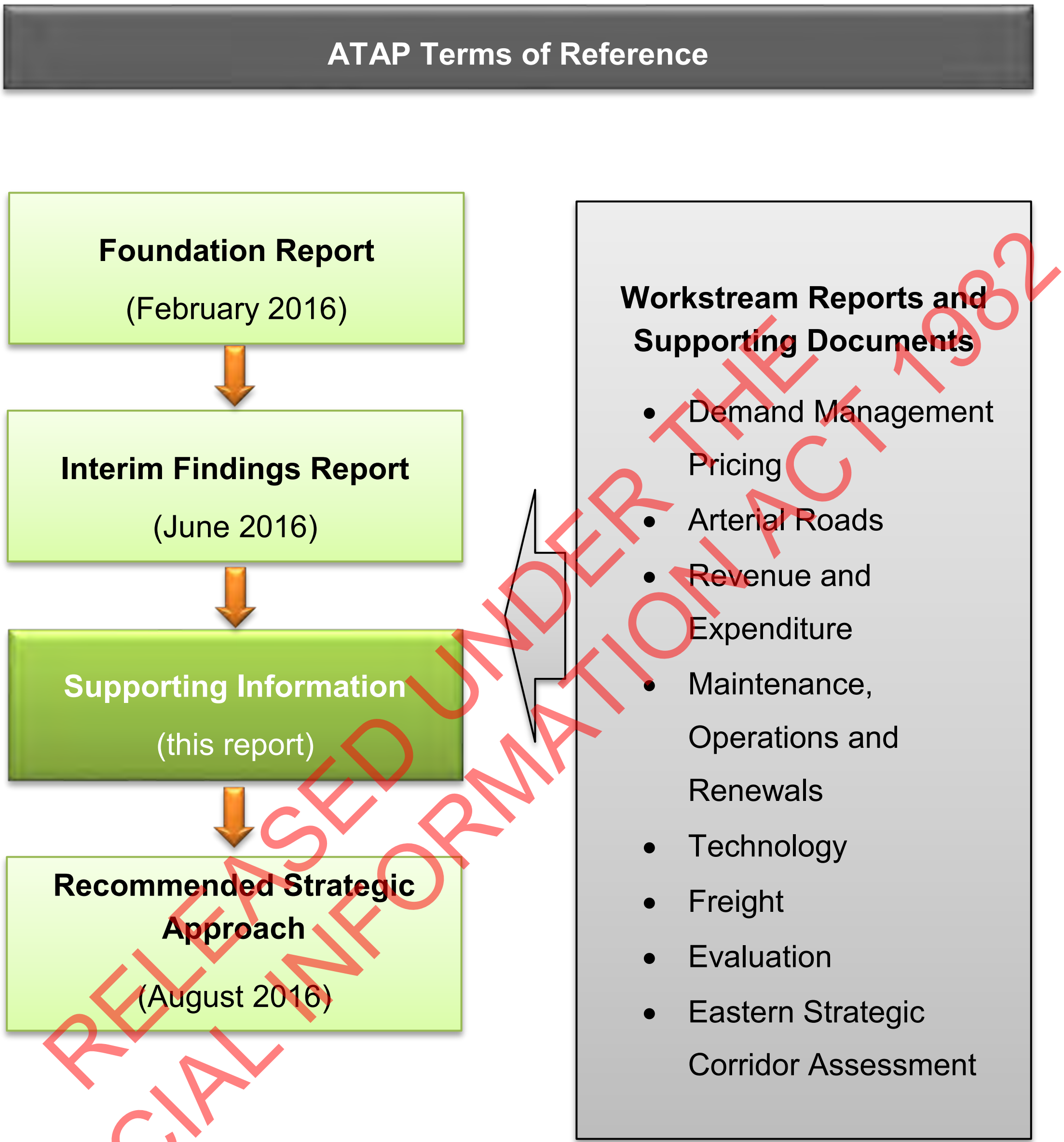
The focus of the Auckland Transport Alignment Project (ATAP) is to test whether better returns from transport investment can be achieved in the medium and long-term, particularly in relation to the following objectives:

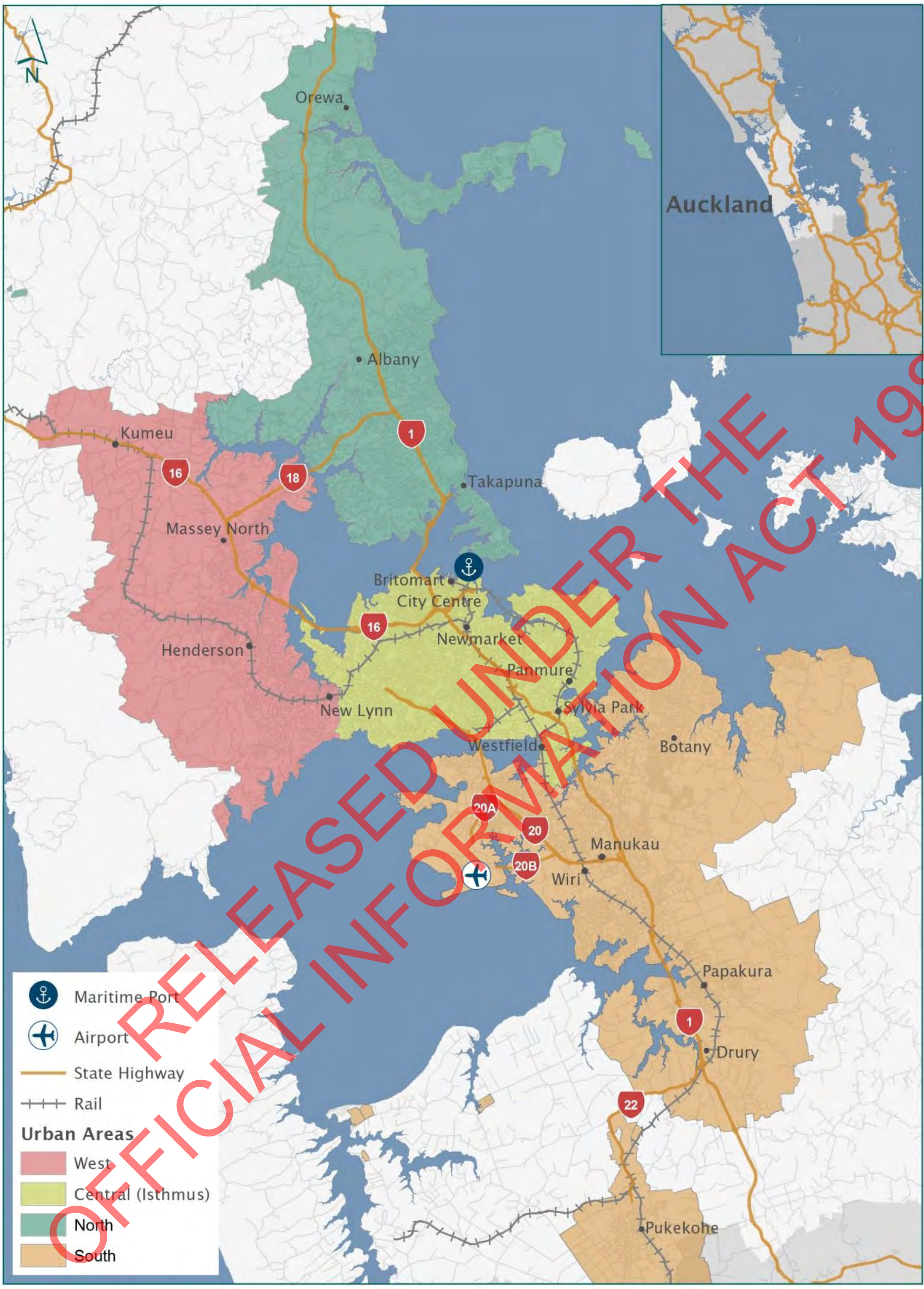
i. To support economic growth and increased productivity by ensuring **access to employment/labour improves** relative to current levels as Auckland's population grows
ii. To **improve congestion results**, relative to predicted levels, in particular travel time and reliability, in the peak period and to ensure congestion does not become widespread during working hours
iii. To **improve public transport's mode share**, relative to predicted results, where it will address congestion
iv. To ensure any increases in the financial costs of using the transport system **deliver net benefits to users** of the system.

This report supports the *Auckland Transport Alignment Project: Recommended Strategic Approach,* together forming the completion of the Project. It builds on the work reported in two previous documents: the *Foundation Report* (February 2016) and the *Interim Report* (June 2016),

This report outlines the approach and methodology adopted for the project, and provides details of the analysis that has been undertaken to support the conclusions in the *Recommended Strategic Approach.* This work has also been informed by research reports from a number of specialist workstreams. The relationship between the key ATAP documents is illustrated below.

Key ATAP documents





Auckland Region

2. Methodology

The analysis to support the project has been undertaken in three main phases:

This report outlines key findings from each phase, drawing on a range of workstreams and technical analysis, including strategic transport modelling, cost and revenue estimates, input from specialist project teams and engagement with key stakeholders.

2.1. Project objectives and KPIs

An evaluation framework was developed to test how the current 30-year transport plan[1] and different packages perform against the project objectives, an overall requirement to achieve value for money, and other key outcomes.

For each project objective, measures and key performance indicators (KPIs) were developed to enable evaluation. These are listed below.

Objective	Measure	Headline KPI
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30-minute trip in the AM peak • Jobs accessible by public transport within a 45-minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30-minute trip in the inter-peak
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to maximum throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak
	Impact on freight and goods (commercial traffic) congestion	• Proportion of business and freight travel time spent in severe congestion (in the AM peak and inter-peak
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, PM peak and inter-peak.

[1] The Auckland Plan Transport Network (APTN) was assessed to represent 'current plans', as required by the project Terms of Reference. The APTN was developed by Auckland Transport, the NZ Transport Agency and Auckland Council to inform 2015 funding plans. The term APTN is used throughout this report to refer to the current 30-year transport plan.

Objective	Measure	Headline KPI
Increase public transport mode share	Public transport mode share	• Proportion of vehicular trips in the AM peak made by public transport
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 10km in the AM peak made by public transport
	Increase vehicle occupancy	• Average vehicle occupancy
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost
Ensure value for money	Value for money	• Package benefits and costs

In addition to the project objectives, a number of other key outcomes were included in the evaluation framework, as outlined below.

Other Key Outcomes	Measure	Headline Key Performance Indicator
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy.
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled
	Emissions	• Greenhouse gas emissions
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog
Social inclusion and equity	Impacts on geographical areas	• Access to employment in high deprivation areas • Distribution of impacts (costs and benefits) by area
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption on vulnerable parts of the network

Measuring accessibility

This project has focused on measuring 'accessibility'" by reporting on the potential number of jobs that can be reached within a certain travel time (30 minutes by car and 45 minutes by public transport, which includes allowance for walk and wait times).

These measures enable comparisons between different options, and align with commonly reported international measures. The use of 'number of jobs' is considered a reasonable proxy for accessing other opportunities (e.g. shopping, education, healthcare, recreation) as these activities tend to cluster in similar locations.

However, the use of travel time to measure accessibility does not reflect the financial cost of travel to the individual, which can also impact on accessibility, especially for options where the user faces additional costs, such as road pricing.

Future consideration of options may need to take this broader measure of accessibility into account. This issue is also relevant to measurement of the objective that increased financial costs deliver net user benefits.

2.2. *Analytical tools*

Two main strategic transport models were used for much of the project's technical analysis.

- The Auckland Regional Transport Model (ART3) provides regional outputs on private vehicle use and public transport trips. It also provides an indication of the likely changes to vehicle volumes and speeds on each major road and public transport route in the city.
- The Auckland Public Transport Model (APT3) provides more detailed information on public transport use resulting from infrastructure and service changes.

Each strategic modelling tool has strengths and weaknesses. Both tools, particularly ART3, are strongest at a 'high' regional level - rather than for providing detailed information at a 'street by street' level. Furthermore, utilising the APT3 model is necessary to simulate the impacts of public transport capacity constraints, as the capacity of buses, trains and ferries is not constrained in the ART3 model.

Limitations of the transport modelling tools are outlined in more detail in the 'Risks and Uncertainties' section at the end of this report and were taken into consideration throughout the project. Strategic transport modelling was supplemented with other information to inform decision-making.

The table below shows the transport modelling tests undertaken at different stages of the project. In addition, various 'baselines' were used in each phase to help gain an understanding of the impact of the interventions tested.

Project Phase	Stage	Packages Tested	Pricing tests	Other tests
Understanding the Challenge		• Auckland Plan Transport Network (APTN)		
Option Testing	Initial Testing (Round 1)	• Individual project testing (particularly new ideas)	• CBD cordon • Motorway charge • Peak/off-peak network charge	
	Package Development (Round 2)	• 'Capacity Constraints' package • 'Employment Centres' package • 'Smarter Pricing' package	• "Smarter pricing" package tested a full network charge varying by time, location and route	• Scenario tests: effect of connected vehicles, and effect of higher vehicle occupancy • Test of new strategic corridor (eastern corridor)
	Refined Packages (Round 3)	• 'Higher Investment' package • 'Influence Demand' package	• Different pricing levels	• Scenario tests: effect of higher population growth rate
Refinement & Prioritisation	Final Indicative Package	• 'Indicative Package'		

Model results were produced for 2026, 2036 and 2046. The results for these years are indicative of the conditions that are expected to prevail towards the end of each of the three decades under review in this project (2018-28, 2028-38, and 2038-48).

Throughout the project we have used a base year of 2013 for our analysis, because the transport models are calibrated against Census information and travel patterns from this base year. It is important to note that since 2013 there has been a marked increase in travel demand, resulting in slower travel speeds and higher congestion in Auckland. This recent decline in performance needs to be taken into account when reviewing changes in performance between 2013 and 2026.

Phase 1 - Understanding the Challenge

The first phase of the Project focused on understanding Auckland's current and future transport challenges in detail through assessing the Auckland Plan Transport Network (APTN).

The *Foundation Report* released in February 2016 provides an overview of the key transport challenges facing Auckland over the next 30 years. Analysis of the APTN against key indicators showed mixed results. The following sections build on this work, and highlight the key points and conclusions.

3. Increasing Demand for Travel

In the last three years Auckland has grown by approximately 120,000 people. This growth has resulted in a marked increase in travel demand.

- Total vehicle travel has increased by around 10%, from 12.2 billion km in 2012 to 13.4 billion in 2015. 2015's increase equates to around 78 million additional car driver trips. This increase in vehicular travel has ended a period of slow growth since the mid-2000s, although vehicle travel per capita is still below 2007 levels.
- Annual public transport boardings have increased by around 20%, from 69.1 million in 2013 to 82.9 million in the year to July 2016.

On the motorway network, this growth has contributed to average peak time travel speeds declining by around 9% because of growing congestion. In some parts of Auckland, such as the southern section of the Southern Motorway and parts of the Northwestern Motorway, increases in congestion have been particularly significant. Bus services have also faced significant overcrowding, especially on isthmus routes serving the city centre.

3.1. Growth assumptions

The scale, timing, nature and location of future travel demand will be largely be driven by where and when population and employment growth occurs. We have used Statistics New Zealand's medium population growth scenario for the majority of our analysis, although a high growth population scenario has also been used as a sensitivity test, as recent growth has been tracking well ahead of the medium projection.

The spatial distribution of this growth into new households and jobs will be determined by many thousands of individual decisions over time. However, our best estimate of where and when growth may happen has been developed by Auckland Council's in-house research unit, based on population and employment growth assumptions. This projection is known as

'Scenario I9'. It reflects the Auckland Plan's development strategy and matches fairly well with where growth has been enabled by the Auckland Unitary Plan adopted in August 2016. The main difference relates to the timing of some greenfield development areas (particularly in the north), which has been addressed throughout the project.

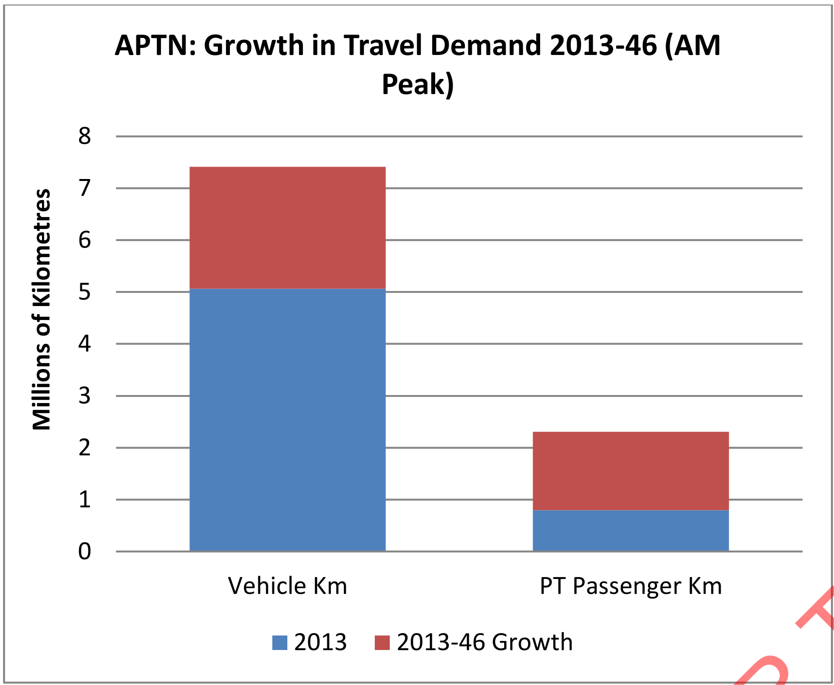
In Scenario I9, future population growth is expected to be accommodated throughout the Auckland urban area and major future urban growth areas. Projected employment growth, driven by an on-going shift to service-sector employment, is relatively concentrated in a few locations, with over a third of employment growth projected to occur within 5km of the city centre. The patterns of travel demand generated by this projected land-use place significant pressure on the transport network through longer trip lengths, especially to the city centre and other major centres.

Source: Scenario I9 growth assumptions

3.2. Projected travel demand growth

Under the APTN, growth in travel demand is projected to occur across all travel purposes: commuting to employment or education, shopping, business and freight trips and trips for other purposes (visiting friends and relatives, undertaking errands, etc.). During the morning peak, when the transport system is under the greatest pressure, the greatest projected increase in travel demand is for trips to employment, followed by trips for other purposes.

By 2046 there are expected to be around 270,000 more morning peak vehicular trips (car and public transport) than in 2013 under the APTN. This growth is projected to be split broadly evenly between car and public transport across all trip types under current plans. However, there are considerable differences in mode split by trip purpose. The majority of growth in morning peak journeys to employment, education and shopping is projected to be by public transport while most growth in business/freight and other trips purposes is projected to be by car.



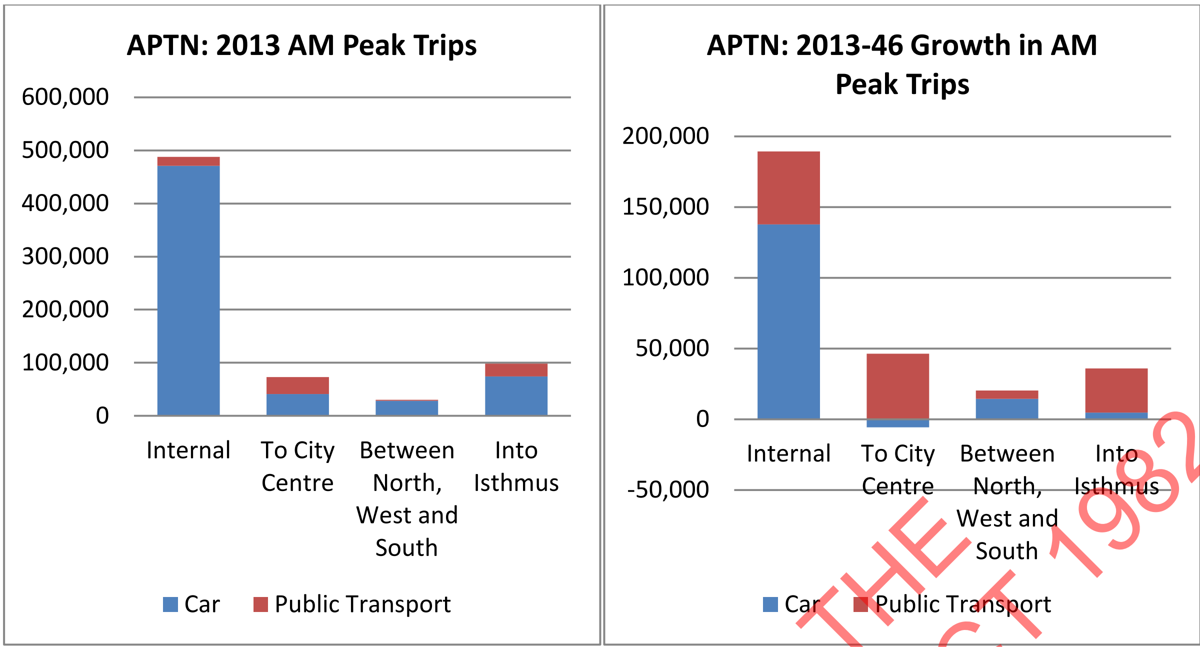
Source: APTN ART3 model outputs

Growth in travel demand contributes to substantial increases in the number of trips by private and commercial vehicles and public transport over the next 30 years.

- Vehicle travel during the morning peak is projected to grow by 2.3 million kilometres from 2013 to 2046, a 46% increase
- Morning peak public transport passenger kilometres are projected to grow by 1.3 million kilometres over the same time period, an increase of 190% on 2013 levels.
- Heavy vehicle trip numbers in the morning peak are projected to grow by 65%, from 26,000 in 2013 to 43,000 by 2046.

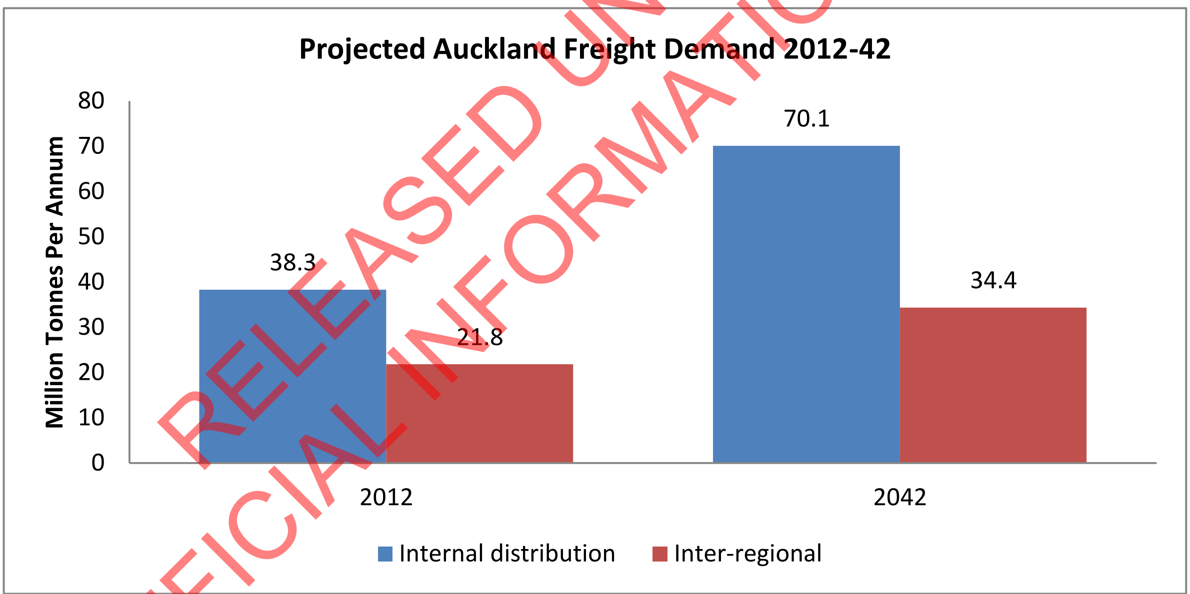
Auckland's geography creates particular challenges in serving trips between different parts of the region, as there are only a limited number of connections able to be used (e.g. the Auckland Harbour Bridge, crossings of the Tamaki River, etc.). Trips accessing the city centre also face particular challenges, due to the limited number of access points and very high, competing demands for limited street space.

The majority of trips are 'internal' to their sub-region – for example a trip from one part of the North Shore to another. Private vehicles are projected to continue to serve the majority of these trips into the future. However, as shown below, the role of public transport is much more significant for trips into the central isthmus and into the city centre. Almost all growth in these 'inbound' trips is projected to be through public transport under the APTN.



Source: APTN ART3 model outputs

Commercial and freight travel is projected to increase by78% over the next 30 years, driven by growth in Auckland's economy.



Source: Ministry of Transport freight demand study (2012)

International/inter-regional freight is generally larger scale (i.e. containers) than domestic freight and can be carried by road, rail and coastal shipping. However, the vast majority of commercial travel within Auckland is for internal distribution and service trips, with over 70% of freight kilometres travelled within Auckland being light commercial vehicles such as couriers and local deliveries[2].

[2] Ministry of Transport Fleet Profile 2012

4. Regional and Sub-Regional Challenges

As outlined in the project's *Foundation Report,* a combination of Auckland's constrained natural geography, population growth and forecast land-use patterns makes providing an effective and efficient transport network challenging into the future. Under the APTN, road and public transport networks come under increasing pressure over time, leading to increased congestion, more frequent overcrowding, and reduced reliability. Many of the issues currently experienced during morning and evening peak periods are projected to spread to other times of the day.

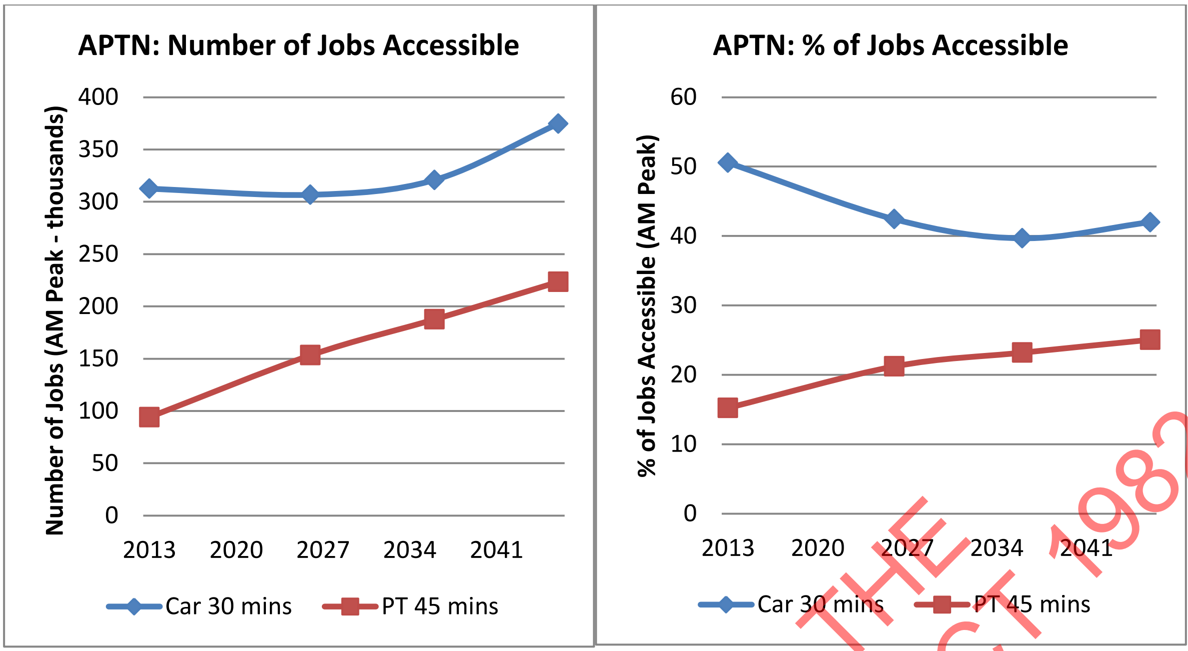
Overall transport network performance is best measured through the extent to which it enables people to access opportunities. If Auckland is to benefit from future growth, then the opportunities each resident can reach in a given travel time need to be increased or at least held constant. This is challenging to achieve in a growing city.

The APTN was assessed against the evaluation framework outlined in the *Foundation Report.* This helped inform where efforts should be focused to improve performance against the project objectives and other important outcomes. A summary of this analysis, at regional and sub-regional levels, is outlined in this section.

4.1. Region-wide performance of APTN

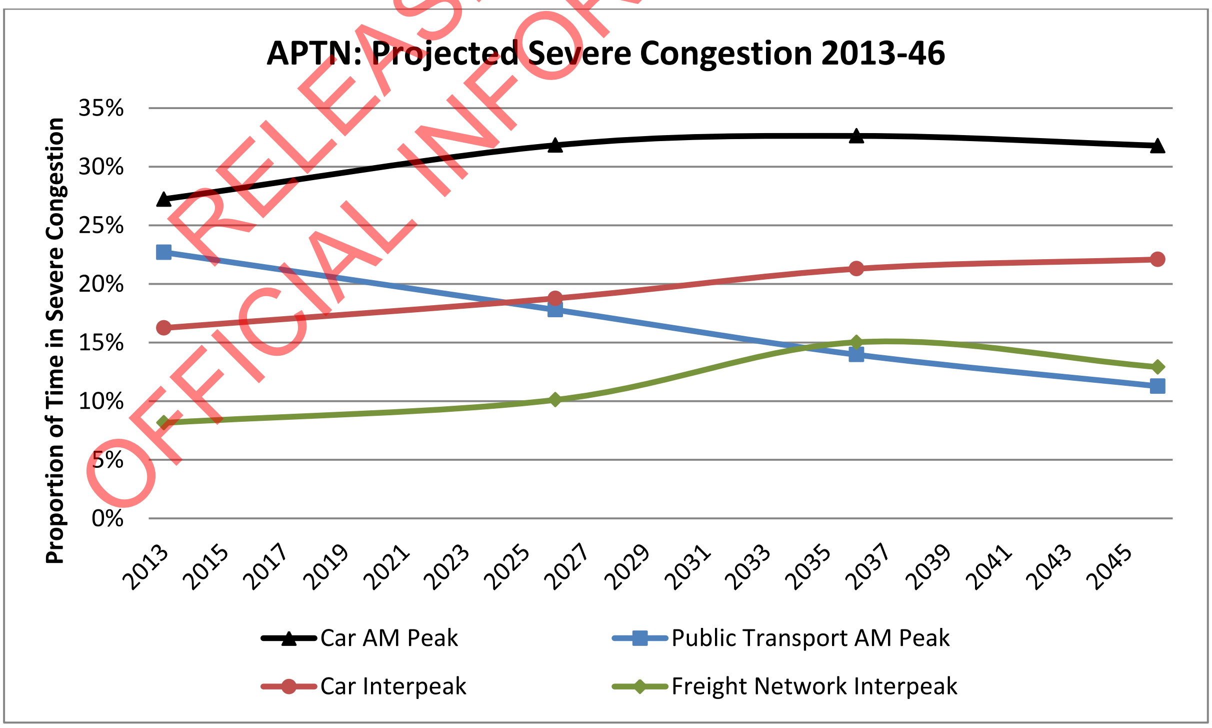
At a regional level, the APTN delivers mixed results: addressing some of the challenges posed by Auckland's projected growth but struggling with others. Overall employment access is projected to grow over time, but access to employment by car only increases after 2030 through delivery of a substantial motorway widening programme. Furthermore, increasing congestion over the next 20 years means that access to employment by car does not keep up with total projected employment growth. This results in the proportion of Auckland jobs within a 30-minute peak time car commute declining until the mid-2030s.

Access to employment by public transport is projected to perform much better, with a substantial increase in the number and proportion of jobs able to be reached within a 45-minute trip.



Source: APTN ART3 model outputs

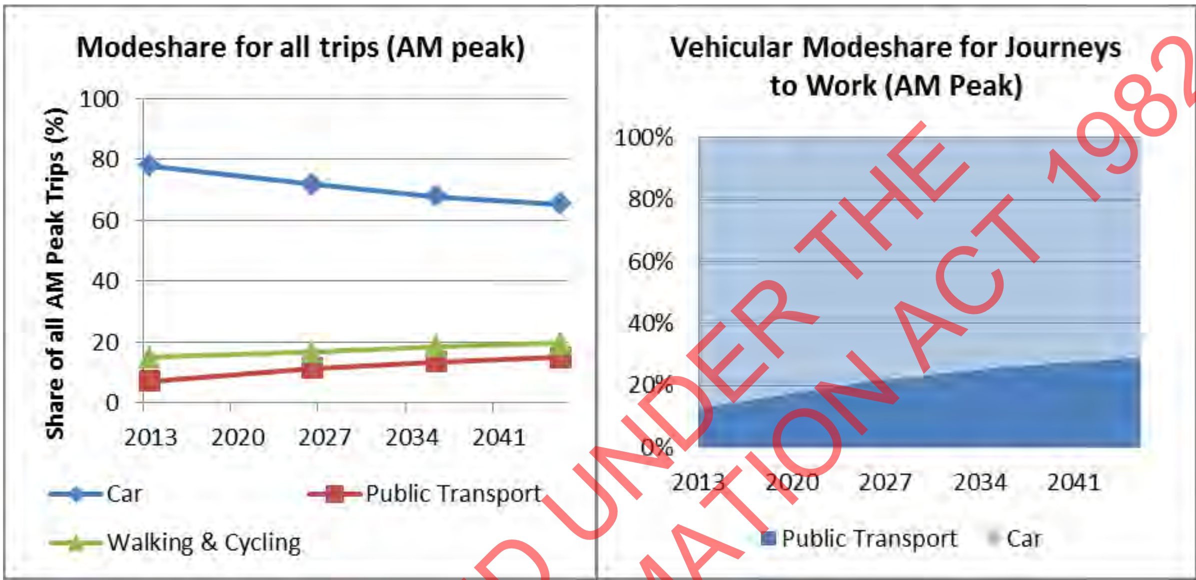
As illustrated below, congestion is projected to increase and spread under the APTN, as capacity is exceeded by growing demand. This crowding increasingly extends into the inter-peak, affecting travel throughout the business day, with particular impacts on high value commercial trips. Conditions are projected to improve in the longer term as investments increase capacity, but not sufficiently to get back to 2013 levels.



Source: APTN ART3 model outputs

Morning peak public transport services are projected to be less affected by road congestion over time, as a greater proportion of trips are taken on dedicated rights of way. However, a growing proportion of bus services would be severely overcrowded, particularly on approaches to the city centre from the isthmus and North Shore.

Public transport mode share in the morning peak is projected to grow over time, more than doubling from 7% in 2013 to 15% by 2046. For vehicular trips (i.e. excluding walking and cycling) to employment at peak times, public transport mode share grows from 13% in 2013 to 29% by 2046.

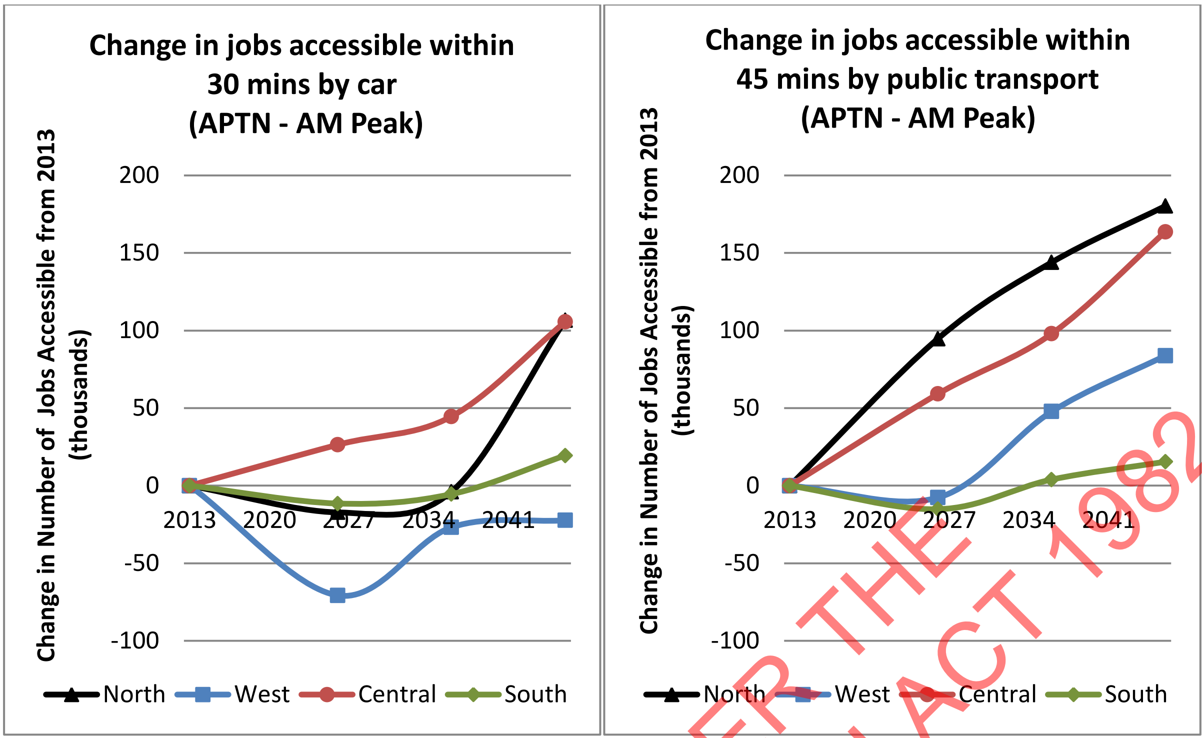


Source: APTN ART3 model outputs

4.2. Sub-regional performance of APTN

Access to employment projections discussed in the previous sections vary significantly across different parts of Auckland:

- In central isthmus areas, current plans enable substantial growth in accessibility by both car and public transport as job numbers in the central area increase.
- In the north, accessibility gains are limited to public transport users until the 2030s when substantial additional road capacity is provided.
- In the west and south, access to employment from the west and the south by both car and public transport is projected to decline, or grow more slowly than in other parts of the city.



Source: APTN ART3 model outputs

With over one million people projected to live in west and south Auckland by 2046, these projections are cause for concern. Furthermore, west and south Auckland include many of Auckland's substantial future growth areas and most deprived communities. A major focus for subsequent phases of the project was exploring options for addressing projected access challenges in the west and south.

5. Specific Focus Areas

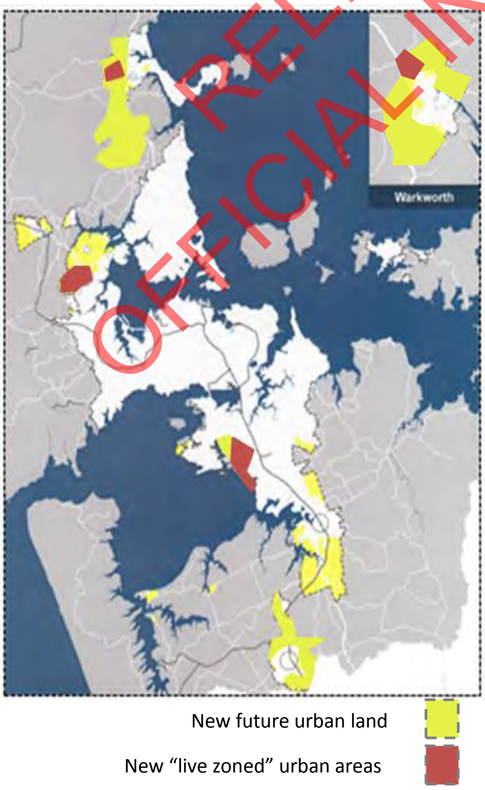
Alongside the broad regional and sub-regional transport challenges Auckland is projected to face over the next 30 years, there are a number of specific major challenges, focus areas and opportunities that need to be addressed. These include:

- Auckland's housing growth
- Central area access
- Airport area access
- Growing motorway network demand
- Growing cross-harbour demand
- Growing freight and service demand
- Rail passenger and freight growth
- Arterial road network demands
- New transport technologies.

This section briefly discusses the nature of each of these focus areas, and how they are expected to evolve over time.

5.1. Auckland's housing growth

Auckland is expected to grow by around 700,000 people in the next 30 years. Transport has a critical role to play in enabling and supporting this growth, particularly through providing new infrastructure that opens up land for urbanisation. Within existing urban areas, transport investment can also support growth by improving the commercial feasibility of redevelopment and the market attractiveness of areas by increasing accessibility and improving transport choices.



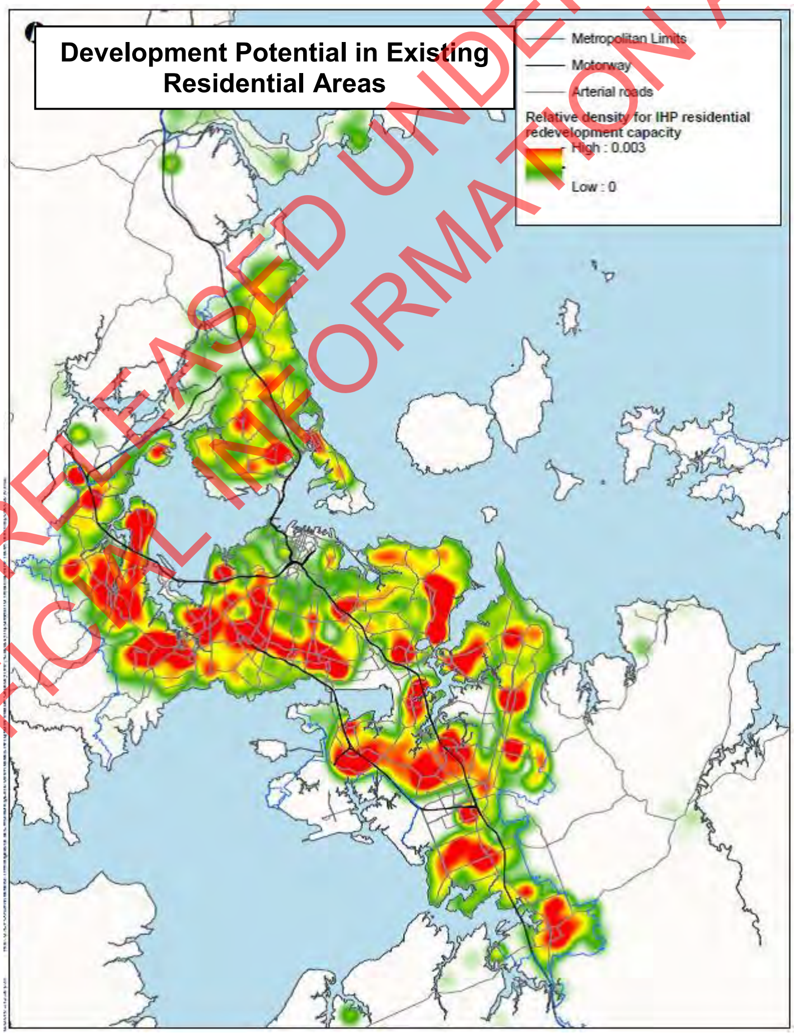
Over 12,000 hectares of 'Future Urban' land has been identified in the Auckland Unitary Plan, providing capacity for around 150,000 new houses and large areas of new business land. Substantial and ongoing investment will be required to realise this capacity, including new arterial roads to make land ready for development and larger upgrades to improve connections with existing urban areas. Travel demands generated by growth in these areas will also place pressure on existing networks, especially major road and public transport corridors that extend to the north, west and south.

Early investment needs to focus on accelerating housing development in areas 'live-zoned' by the Unitary Plan, as well as Special Housing Areas. There is also a need for substantial early investment in route protection and land acquisition for future transport infrastructure, to minimise future costs and protect corridors.

Supporting redevelopment of existing urban areas is also an important task, as around 65% of Auckland's future growth is expected to occur through redevelopment to higher densities. Transport investment in these areas can help unlock growth by improving accessibility and making redevelopment more market attractive. For example:

- Public transport investments can enable 'transit-oriented developments' around key stops and stations, encouraging higher intensity developments that make more efficient use of available land.
- Road investments can redirect through-traffic away from town centres, encouraging more vibrant, successful centres.
- Walking and cycling investments in centres and higher intensity areas can boost land values and encourage higher development intensities.

A 'heat map' of where future redevelopment of residential areas is projected to be concentrated under the Unitary Plan (based on current market feasibility) is shown below.



Source: Unitary Plan Independent Hearings Panel Report:
http://www.aucklandcity.govt.nz/council/documents/unitaryplan/ihpoverviewofrecommendationsann1.pdf

Supporting this growth, as well as ensuring that Auckland's transport networks can continue to operate effectively as growth occurs in these areas, is a fundamental requirement of future transport investment.

5.2. Central area access

The central part of Auckland (city centre, its surrounds and Newmarket) is New Zealand's largest employment hub. The area is projected to grow strongly to reach nearly a quarter of a million jobs by 2046. This jobs growth will be accompanied by a substantial projected increase in tertiary student and visitor numbers and a continuation of the household growth that has occurred over the past 20 years.

Accommodating such significant growth in trip-making to the central area will be challenging. High competition for limited street-space between vehicles, pedestrians, cyclists and public space in the city centre creates a need to move more people in progressively less space over time. This will need to be achieved through a substantial modal shift towards public transport, walking and cycling.

Over the next 30 years, around 60,000 more public transport trips (from 35,000 to 93,000) into the central area during the morning peak will need to be provided for. Outside the peak, private vehicle access to the central area is still expected to play an important role – especially for deliveries and business trips – but most growth in trip making is still anticipated to be via public transport.

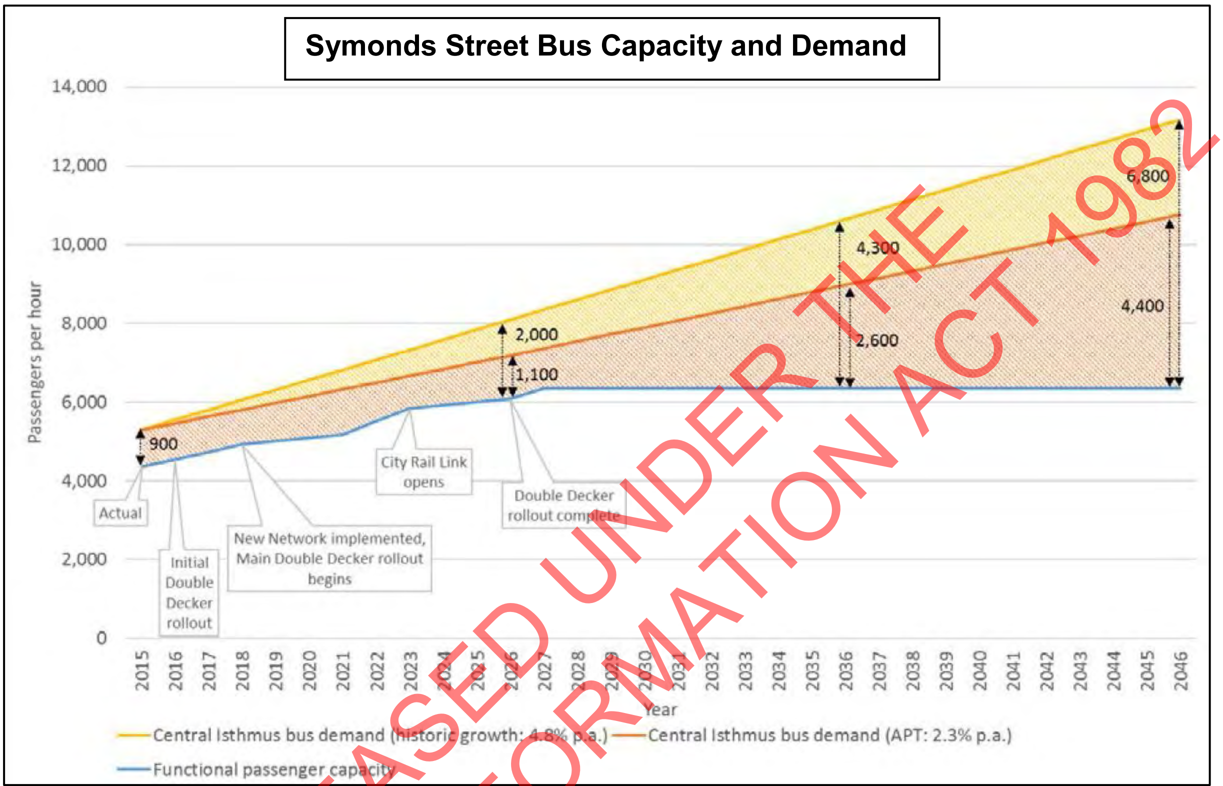
Recent investment in the rail network, coupled with the City Rail Link and associated further rail network improvements, will cater for a substantial proportion of future growth. Public transport trips into the central area from the south, southeast, west and parts of the isthmus will be increasingly made via rail, as bus networks are reconfigured to feed into the rail network as a more integrated system. Ferry services also have an important role in city centre access from some locations.

However, three key parts of Auckland (the North Shore, the northwest and the central and southern isthmus) are not served by rail or buses that feed into the rail network. Trips from these parts of Auckland into the central area will continue to rely on the bus network under current plans. As bus demand grows, substantial ongoing additional services will need to be provided. Over time, a variety of constraints, including use of corridor space, limited turnaround facilities, frequent intersections and bus stop capacity limits, will create major challenges in catering for growth in bus services to meet demand.

Efficiency improvements to the bus network will enable an increase in the effective capacity of key bus corridors over the next decade. These improvements include:

- Fully utilising the benefits of City Rail Link to turn more routes into rail-feeder buses
- Moving to double-decker buses along major corridors into the city centre
- New and upgraded bus interchange and terminus facilities in the downtown, Wynyard Quarter and universities areas
- Upgraded bus priority along Fanshawe and Wellesley streets
- Re-routing of bus services away from key bottlenecks.

The diagram below shows the relationship between bus capacity and demand on the Symonds Street corridor which serves the southern and central isthmus. Capacity increases enabled by the improvements outlined above are projected to be broadly matched by modelled demand growth, meaning that current capacity constraints do not substantially grow until after the middle of the next decade. However, ongoing projected demand growth means bus efficiency improvements alone will increasingly struggle to deliver the capacity that is required in the central isthmus.



Source: Central Access Plan, Project Team

Over time, similar issues will be faced on Fanshawe Street, which serves the North Shore. Towards the end of the third decade, capacity challenges may also start to be faced along Karangahape Road, the key access point for buses serving the northwest.

Without capacity improvements and use of alternative corridors, there is likely to be a reduction in public transport mode share and potentially an increase in congestion faced by those attempting to access the central area. Overall accessibility to the city centre would also be reduced.

Long-term solutions to these capacity constraints potentially involve substantial investments with major network-wide implications. A network-wide approach to their planning, timing and funding is important to inform investment decisions.

5.3. Airport area access

The Airport area is nationally significant as New Zealand’s main international gateway, Auckland’s air gateway to the rest of the country, a major and growing employment area and a significant freight hub. Growth in travel demand to and from the Airport area is projected to place significant pressure on existing networks, which if left unaddressed will have significant economic implications.

Auckland International Airport has the highest number of passengers per year in New Zealand, with 17 million passenger movements currently (up from 14 million in 2013). The Airport projects this growth to continue, to 40 million passenger movements by 2044[3]. Auckland Airport also handles about 15% of foreign trade by value and on this basis is New Zealand's third largest port behind the Auckland seaport and Port of Tauranga[4].

The Airport area is also a growing employment area: both within the Airport's landholdings and in adjacent industrial and business park areas. Job numbers in the broader Airport area are projected to grow substantially over the next 30 years to become one of the largest job centres in Auckland. Combined with growing passenger and freight flows, this employment growth is projected to drive an increase in forecast daily trips to and from the Airport area from 63,000 currently to around 140,000 by 2044[5].

Providing for this growth in travel demand is challenging due to the Airport's location in the southwest corner of Auckland's urban area, with access limited to two primary corridors. The very specialised nature of the Airport also means that people come from all over Auckland to work at the Airport business area and travel though the Airport. This is expected to lead to an increase in congestion on Airport area access points from the north along the State Highway 20A corridor, and east along the State Highway 20B corridor.

Improvements are currently being made to State Highway 20A that will improve access from the north and extend the motorway to the Airport's edge. State Highway 20B from the east, which also provides access to the Airport from the south, has seen a rapid increase in congestion in recent years and is where efforts need to be focused next.

Over time, space and capacity constraints within the Airport area mean that road capacity and bus service improvements alone are unlikely to be sufficient to meet the area's transport requirements. A mass transit improvement will ultimately be necessary to support the area's employment growth and take pressure off the road network.

5.4. Growing motorway network demand

Motorways cater for around one-third of total vehicle travel in Auckland. Much of the network carries higher volumes of vehicles, including freight, than transport networks anywhere else in New Zealand.

Ensuring the motorway network can function effectively is of critical importance to Auckland and New Zealand's economy, as well as to the daily lives of the many hundreds of thousands of people who use it.

Ongoing growth across Auckland will place significant pressure on the motorway network. Addressing these constraints will be challenging as most corridors previously protected for

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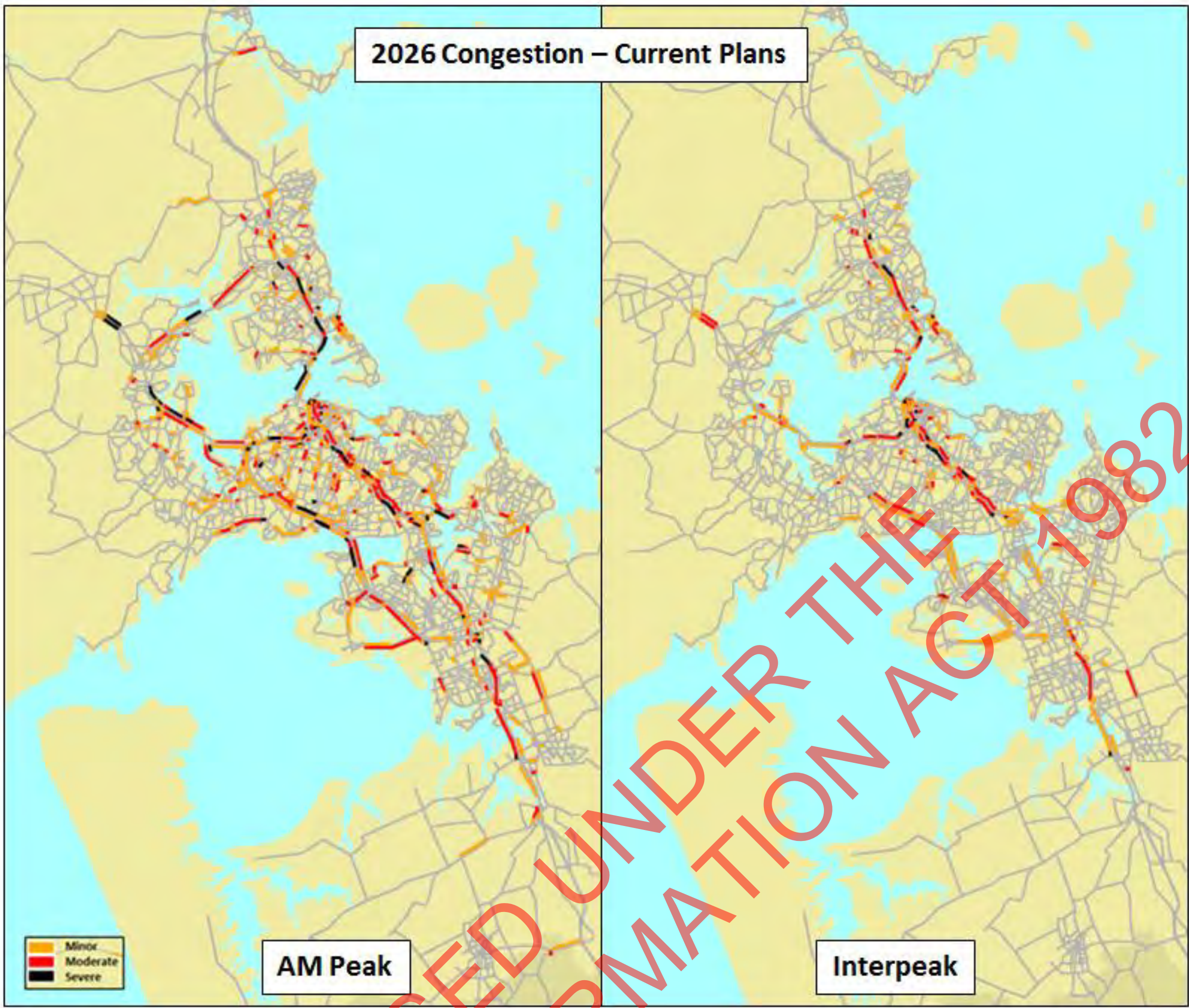
3 Auckland Airport Master Plan http://www.aucklandairport.co.nz/downloads/aial-masterplan.pdf
4 King, M & Paling, R (2016) *New Zealand International Air Freight*, prepared for Ministry of Transport
5 Auckland Airport Master Plan, p29

network expansion have now been utilised and in parts of the current network adding capacity appears infeasible or prohibitively expensive.

Parts of the motorway network have different characteristics and constraints:

- Inner parts of the network carry the highest traffic volumes but face physical constraints to further widening, particularly along State Highway 1 between Takapuna and Mt Wellington where the motorway pushes right up against high intensity development, coastlines and other major infrastructure (such as railway lines). Within the inner motorway network, limited capacity additions can provide some local benefits but appear to shift rather than address congestion. Conversely, major widening is likely to involve significant land acquisition, extremely high costs and potentially major amenity impacts.
- Outer parts of the network are generally less physically constrained, making the provision for additional capacity more feasible and cost-effective. Motorway improvements north of Albany, west of Waterview, south of Manukau, along the Western Ring Route and connections to the Airport and Port appears to generate more substantial accessibility and congestion benefits than in inner areas. The outer motorway network also has a key role to play in providing critical links to new greenfield housing areas.

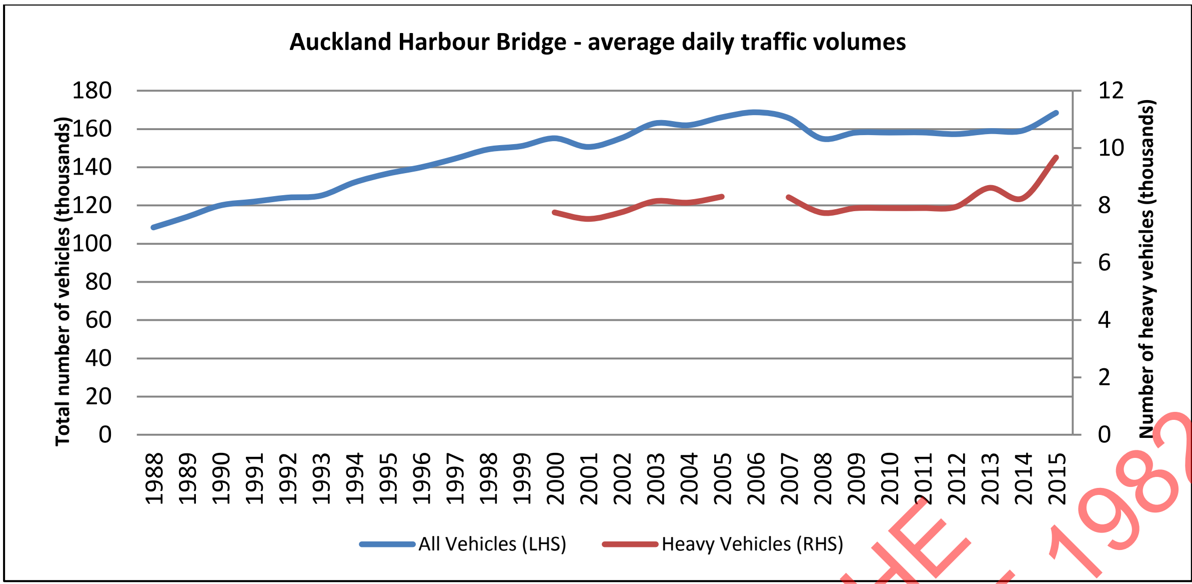
Under the APTN, a substantial proportion of future congestion is projected to occur on the motorway network, particularly on its innermost core where providing additional capacity is most challenging. This is illustrated by the congestion plots below.



Source: APTN ART3 model outputs

5.5. Growing cross-harbour demand

The existing harbour bridge carries around 170,000 vehicles per day, including 7,500 heavy vehicles. The bridge also carries around 4 million bus passengers annually. After a lull between 2006 and 2014, the bridge is again experiencing increases in daily vehicular transport demand, as illustrated below.



Source: NZTA

Increasing traffic flows across the harbour present two challenges:

- Providing sufficient cross-harbour capacity to provide for the movement of people, goods and services
- Protecting the continued functionality of the Auckland Harbour Bridge's structure, ensuring a resilient transport network for Auckland.

Existing capacity constraints are mainly on approaches to the bridge in the peak direction (especially from the north), although the variable lane operation frequently results in severe counter-peak congestion. These delays also affect public transport services, as there is no dedicated public transport corridor over the harbour. Over time, the bridge itself is projected to become increasingly congested.

Although the bridge has been strengthened in the past decade, it has limited ability to cater for ongoing growth in heavy vehicle traffic. Consequently, some level of heavy vehicle management will be needed in the future. Initial work indicates that the economic impacts of this heavy vehicle management on its own are likely to be relatively minor compared to the construction cost of a new crossing.

Due to environmental and resource consent issues, previous work has indicated that any new crossing of the Waitemata Harbour would be tunnelled and therefore involve significant costs.

Overall the timing of harbour crossing improvements would appear to be driven by a combination of factors, including:

- Cross-harbour public transport and road capacity in this corridor to provide sufficient accessibility to/from the North Shore
- Improving the overall network resilience of the transport system
- The need to limit and manage heavy traffic on the existing bridge.

5.6. *Growing freight and services demand*

Auckland's freight and service task is forecast to grow faster than commuter and education related travel as the economy grows. The city's road and rail networks are of critical importance to business traffic, including light and heavy freight. Congestion on the road network and increasingly frequent passenger rail services are projected to affect the distribution of goods and services throughout the business day.

The two most severe projected future freight and service challenges are:

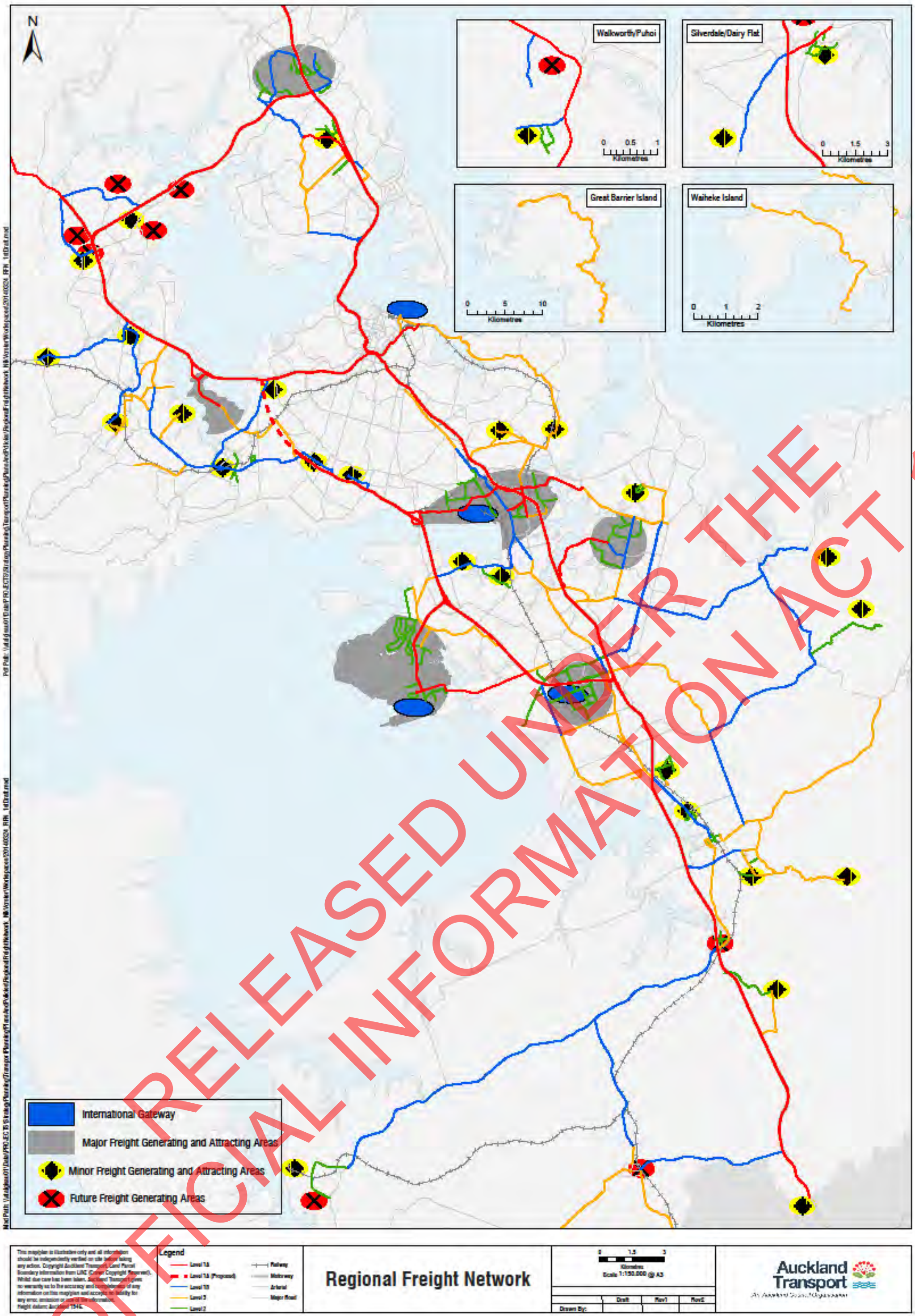
- *Network delays and travel time variability*: increasing congestion during the business day is forcing freight operators to increase the size of their fleets or reduce the frequency of services and needing to allow for worst case delivery/travel times.
- *Access to key freight hubs:* constraints in these locations affect large freight volumes. Locations of particular concern include road and rail access to the Port of Auckland access to Airport area, and connectivity between East Tamaki and logistics centres to the west.

The Port of Auckland is the country's largest import container port by volume and value. Approximately $26.4 billion of trade passes through Ports of Auckland each year, roughly 31% of New Zealand's total trade. Over 900,000 containers are moved to and from the port every year, along with bulk imports and exports. Auckland Council's recently completed Future Port Study has concluded that the port will need to be in use at its current location for the time horizon of this project.

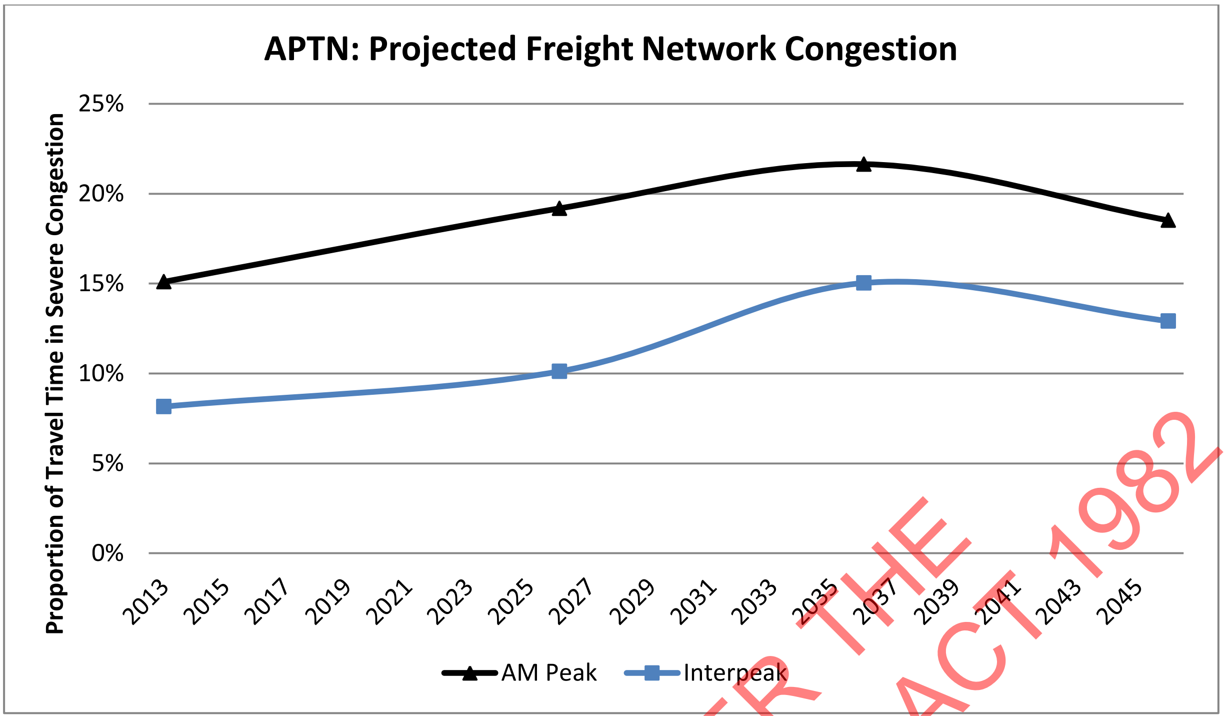
The Metro Port terminal in Penrose, operated by the Port of Tauranga, is also an important international gateway for exports and imports. Around 170,000 containers annually move to and from the terminal by road within Auckland, with rail moving freight to Metro Port to and from the Port of Tauranga. Currently trains carrying up to 100 containers run five to six times a day to and from this part of Auckland.

Auckland Airport is also a key freight hub, as New Zealand's third largest port by value.

The 'Regional Freight Network' is shown in the map below, alongside the location of freight generating areas and international gateways.



Under the APTN, congestion on the key freight routes is projected to grow and spread south over time. Conditions improve for traffic on the motorway network after 2036 due to capacity improvements, but do not return to 2013 levels. Inter-peak congestion projections follow a similar trend, but generally increase faster than at peaks, suggesting 'peak spreading' will occur over time.



Source: APTN ART3 model outputs

There is limited and incomplete available detailed information on the movement of freight in Auckland at a 'street by street' level. This makes specific recommendations challenging, but at a high level to address Auckland's freight challenge, we consider the following outcomes are important:

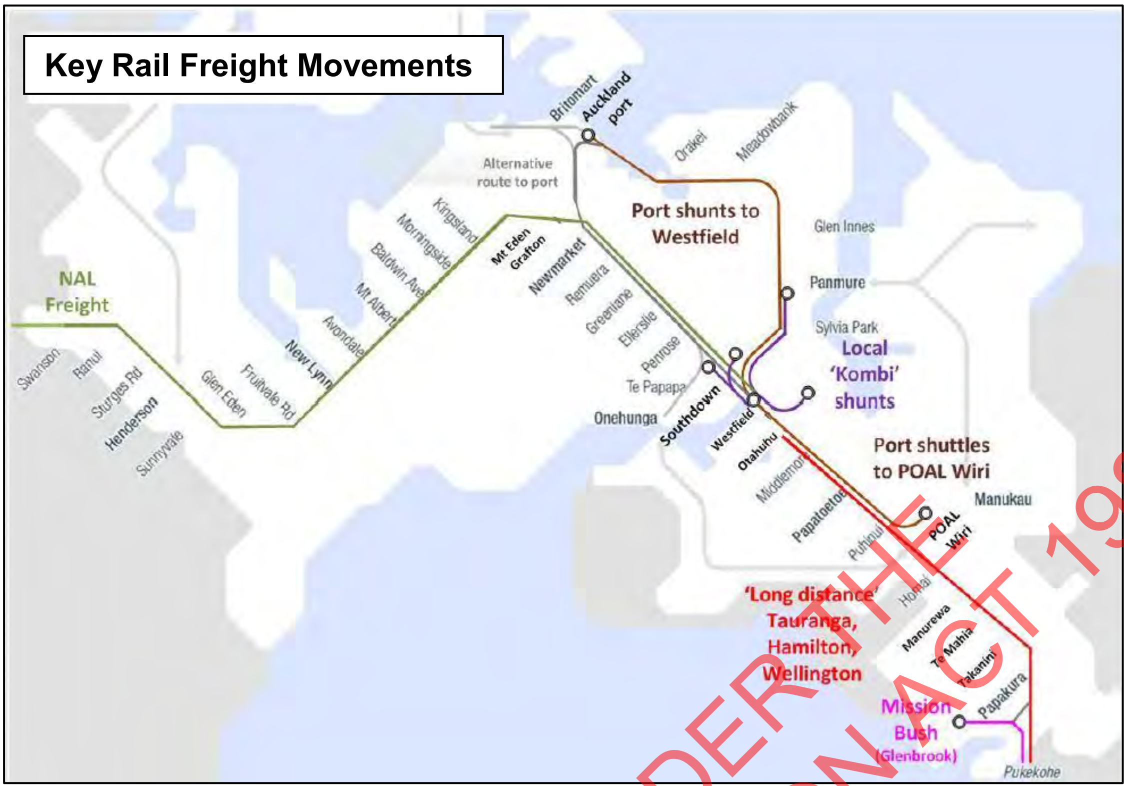
- Limiting the growth in congestion on the freight network, particularly during inter-peak periods
- Improving the efficiency of connections to major freight hubs, especially the ports and the Airport
- Ensuring that the rail network is able to provide for growing passenger and freight volumes (discussed further below).

5.7. Rail passenger and freight growth

Auckland's rail network has two key functions:

- It forms a core part of the public transport network, providing high capacity services to parts of the isthmus, the west, and the south. Annual passenger trips are forecast to increase from around 17 million trips currently to over 60 million in the next 30 years.
- Rail freight connects Auckland to other cities and ports, providing an alternative to road freight. Port shuttles to rail hubs also help take pressure off road networks within Auckland. Growth in freight services is projected to continue over the next 30 years.

Key current rail freight movements are shown in the map below. These highlight the pressure being placed on the rail network between Wiri and Southdown, where different freight services need to be provided alongside regular passenger services on the Southern and Eastern Lines.



Catering for growing demand in both passenger and freight services will require ongoing improvements in infrastructure. Without this, the rail network will be unable to reliably meet freight and passenger demand, which will ultimately limit the extent to which it can perform either of its key functions.

5.8. Arterial road network demands

Auckland's arterial road network is distinct from the motorway network and local/collector streets. This network has a number of crucial and contradictory functions:

- Many roads carry high traffic and freight volumes, often higher than major state highways outside Auckland. For these roads, through-movement is of primary importance.
- A number of high demand bus corridors utilise arterial roads, particularly on the isthmus
- A large number of Aucklanders live on or very near arterial roads, and they are the focus of substantial future population growth
- Arterial roads pass through a number of metropolitan, town and local centres, forming a key part of the city's public space
- Increasingly arterial roads are being utilised for cycle infrastructure improvements.

Prioritising this wide variety of competing uses is challenging, especially where movement and place functions come into conflict, requiring unavoidable but challenging trade-offs.

As Auckland grows, these trade-offs will become increasingly challenging. With most growth occurring in existing urban areas and limited potential for major new corridors, our current transport network – including arterial roads – will need to move greater volumes of people, goods and services. Poor performance of this network will lengthen journey times, reduce accessibility and ultimately undermine the extent to which Aucklanders benefits from this future growth.

Conversely, population and employment growth in centres and along transport corridors – as enabled by the Unitary Plan – will increase the number of people living, working and visiting locations along arterial roads. High traffic volumes could adversely affect amenity values, safety for those walking or cycling, the economic success of centres and overall quality of life along these routes.

A number of existing documents provide guidance for the management, operation and development of arterial roads. However, stronger direction is necessary to ensure that trade-offs consider network-wide impacts and that key movement routes are managed in a way that improves their throughput and efficiency.

5.9. New transport technologies

Emerging transport technology is developing rapidly. Intelligent Transport Systems (ITS) as well as emerging vehicle and communication technologies have the potential to radically alter the way that transport is delivered in the future, with significant impacts on demand and supply. Such changes have the potential to improve network productivity, as well as deliver significant improvements in congestion, safety and environmental outcomes.

The three main components of current and emerging transport technology, and their potential benefits, are outlined in the table below.

	Intelligent Network Management	Shared Mobility	Emerging Vehicle Technology
Components	• Real-time understanding of network use • Dynamically manage travel demand	• Ride-sharing, car-sharing, bike-sharing, motorbike-sharing through supporting applications	• Connected vehicles enable communication between vehicles and infrastructure • Automated vehicles enable self-driving features, ranging from partial to full automation
Potential benefits	• Greater network productivity • More accurate targeting of maintenance and renewals and better planning of new infrastructure	• Higher vehicle occupancy rates leading to greater network productivity • Increasing public transport catchment areas through better first leg/last leg • Reduced cost of transportation through lower vehicle ownership rates	• Connected and/or autonomous vehicles can increase lane throughput, reduce accidents and improve reliability • Accessibility improvements for those unable to drive • Reduced chauffeuring trips

Our work on transport technology was informed by a workstream that provided research about the potential timing and effects of developing technologies. Key findings in each area are:

- *Intelligent network management:* Further investment in this area could lead to material accessibility and congestion improvements by enabling more comprehensive real time information and analytics, better traffic management tools (such as smarter traffic signals) and preparation for the roll-out and management of new vehicle technologies through vehicle-to-infrastructure communication. Additional investment is likely to deliver good value for money, by enabling more efficient use of existing infrastructure.

- *Shared mobility:* New technology (e.g. instant matching of trip demands) enables many previous barriers to ride-sharing or carpooling to be overcome. Increasing vehicle occupancy rates could provide significant congestion relief and environmental benefits by lowering total vehicle travel. Most advances in this area are likely to be private sector led, but will require public sector co-ordination to bring together providers, developers, customers, trials, data, research, public transport planning and funding.

- *Developing vehicle technologies:* Connected vehicles enable communication between vehicles, roadside infrastructure or the 'cloud'. There is a growing industry and academic consensus that fully autonomously-driven vehicles will eventually replace the conventional vehicle fleet. Key players such as Google, Tesla, Ford and Volvo also consider that privately-owned vehicles are likely to be replaced by industry-owned vehicles and in the future mobility will be provided as a service. These firms are developing new business models and investing billions of dollars aimed at achieving this change. Uptake of new vehicle technologies is expected to grow slowly at first, but accelerate throughout the next 30 years. This could enable significant productivity gains, especially on the motorway network.

Overall, we expect developing transport technologies will have profound impacts on Auckland's transport requirements over the next 30 years, particularly through enabling much more efficient use of existing transport infrastructure. It is likely that these new technologies will work together, potentially in unforeseen ways, to provide new options that will help Auckland achieve its transport objectives.

However, the timing and more detailed effects of new transport technologies are highly uncertain and the tools for assessing these impacts in detail are still under development. In particular, the effect of developing technology on travel demand patterns is highly uncertain (e.g. it could result in additional trips for current non-drivers such as the very old and very young which could be positive for access but not congestion). This uncertainty led us to progress a 'what if' approach in our technical analysis and to focus on the potential effects of higher vehicle occupancies and the uptake of connected vehicles.

Phase 2 - Option Testing

In this phase of the project, we progressively refined intervention packages in three main stages of analysis.

- **Initial Testing (Round 1)** examined a wide range of interventions to compare performance against the project objectives.
- **Package Analysis (Round 2)** took the best performing interventions and tested the effect of changing the mix of investment and the potential of new technology and smarter transport pricing.
- **Package Refinement (Round 3)** compared increasing investment with a pricing focused approach.

6. Initial Testing (Round 1)

Initial analysis cast a wide net to look at different approaches to current plans to see whether it was possible to achieve better performance against the project objectives. A number of possible new interventions were identified that could be applied either in addition to, or in place of, interventions in the current plans.

6.1. Potential interventions

Potential new interventions to address key issues identified in the *Foundation Report* are outlined below.

Key Deficiencies to Address	Potential New Interventions
Worsening congestion and region-wide car accessibility until the mid-2030s	• Targeted further motorway widening • Eastern strategic roading corridor • Motorway and network pricing schemes
Slowing of region-wide improvement in public transport access after 2026	• Isthmus mass transit • North Shore rapid transit • Busway expansion/extension schemes
Substantial decline in car accessibility for the west and south between 2013 and 2036	• Various motorway and local road widening projects • Karaka-Weymouth connection

Key Deficiencies to Address	Potential New Interventions
Little improvement in public transport access for west and south until after 2026	• Northwest busway extension • Express train services and targeted station closures to reduce travel times
Key bottlenecks on motorway and local road network affecting access and reliability.	• Targeted further motorway widening • Improved access to Auckland Airport • Improvements to Port access • Enhanced East Tamaki connections
Limited increases in overall public transport mode share, especially to address congestion on the motorway network	• Rapid transit (bus, light-rail and heavy rail) improvements • City centre, motorway and network pricing schemes • Public transport fare adjustments

The following interventions were not carried forward for further analysis because they did not provide sufficient improvements against the project objectives:

- Some motorway and local road widening projects
- Karaka-Weymouth connection
- Rail station closures (aimed at faster overall journey times)
- Public transport fare adjustments.

The State highway 1 Warkworth to Wellsford project was not considered for inclusion in later stages of the project. This project is primarily focused on improving an inter-regional route (better connecting Auckland and Northland to provide safer and more reliable journeys) rather than the project objectives. It was therefore concluded that the project should be considered as part of the NZ Transport Agency's national programme rather than as part of further package development.

6.2. Smarter pricing: initial analysis

In this initial phase, three approaches to varying the cost of private motor vehicle travel (we have called these interventions 'smarter road pricing' in the project) were tested[6] to understand their potential to improve performance against the project objectives:

- A city centre cordon scheme (a peak-time only charge for vehicles entering the city centre)
- A motorway network charge (a flat-rate charge for vehicles entering the motorway network, with a higher charge at peak times)
- A whole of network charge (a per kilometre charge across all parts of the road network, with a higher rate at peak times).

The options were assessed to understand their potential impact on the project's access, congestion and public transport mode share objectives. We also attempted to assess the

[6] For detailed analysis, see *ATAP Demand Management Pricing Report. Peak prices tested in this round were: CBD Cordon $10 inbound; Motorway Charge $5 per trip; Whole of Network Charge 44 cents per kilometre.*

options against the project's net benefits to users objective, but the limitations of our analytical tools meant a robust assessment against this objective was not possible. We did not assess any option from a revenue raising perspective as this was outside the scope of the project's Terms of Reference.

Initial testing and evaluation indicated has all three approaches have the potential to improve congestion and increase public transport mode share, when compared to the unpriced APTN. Of the three schemes, the comprehensive network charge with its region-wide impact has by far the greatest impact on improving access (as measured by travel time), reducing congestion and increasing public transport mode share.

However, as the initial option tested was a simplistic fixed-rate charge per kilometre for all trips across the network, analysis indicated poor net benefits to users. This was particularly the case for trips made in outer areas where there was little benefit from reduced congestion but a very high cost due to much longer average trip lengths and few realistic alternatives available to driving.

The city centre cordon charge had the smallest regional impact because of its narrow focus on the city centre, but it was effective at achieving modal shift to public transport and a corresponding reduction in car trips to the city centre. The main potential use of a city centre cordon charge could be as a transition to a broader scheme, but its relatively minor regional impacts mean that other schemes were the focus of further analysis.

The motorway charge scheme improved regional congestion, particularly on the motorway network. However, the use of a 'flat-rate' and charging for the motorway network only, resulted in large scale diversion of motorway traffic onto local roads, with resulting congestion. A distance-based motorway charge was considered more likely to be successful in improving access and congestion so a higher per kilometre charge on the motorway network was incorporated into the network-wide system for the next phase of more detailed analysis.

6.3. Technology scenario testing

As previously discussed, the potential future impacts of developing transport technologies are profound, but highly uncertain. We developed two 'what if' scenarios to test the effects of:

- Increasing vehicle occupancy rates
- The uptake of connected vehicles.

To understand the impact of technology changes in isolation from other interventions, the impact of connected vehicles and ridesharing were analysed using a common baseline of interventions.

Increases in car occupancy were analysed through directly modifying assumed occupancy rates in the strategic modelling tools. Vehicle occupancy rates convert car person trips into car vehicle trips by purpose. The modelling tools are not able to simulate trip diversion to 'pick up' passengers or reflect any changes in trip generation rates that may occur through greater use of ride-sharing. This means the analysis is likely to over-estimate the impact of increased occupancy on reducing demand levels for travel by other means (e.g. drive-alone or use of public transport).

The uptake of ride-sharing is expected to vary by trip purpose. Due to their recurrent and regular nature, coupled with low existing occupancy levels, the greatest increase in occupancy rates is expected to be in trips to and from work.

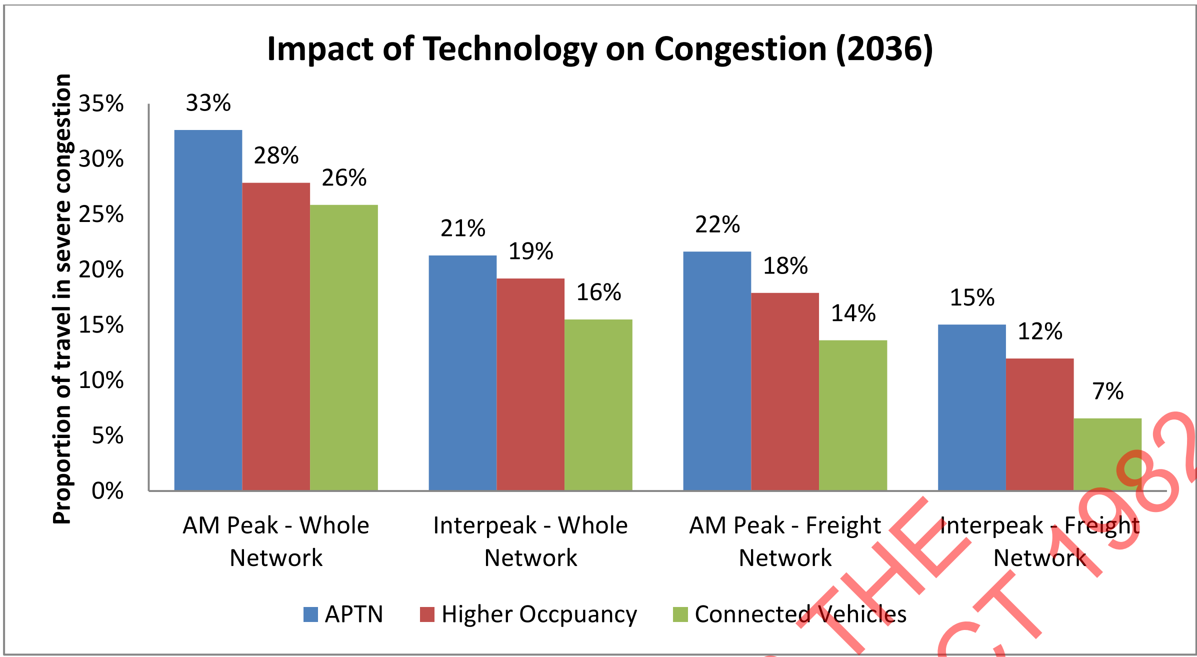
Two scenarios were developed, based around a 50% and a 100% increase in occupancy rates for work-related trips. Changes in occupancy for other trip types were adjusted accordingly, as shown in the table below.

Trip Purposes	Car occupancy rate increase
Work Related	50%-100%
Education Related	10% - 20%
Shopping Related	10% - 20%
Other Purposes	10% - 20%
Employer's Business	5% - 10%

The potential impacts of increasing connected vehicle use were tested in the strategic transport modelling tools by increasing road-lane capacity and reducing the extent of lost time per phase at signalised intersections (i.e. interventions which increase network productivity through improved vehicle throughput). Advancements in ITS will also improve the operation of signalised intersections. A 75% uptake of connected vehicles by 2036 was assumed for the purpose of this test.

The modelling showed a reduction in public transport trips. In reality, greater use of ride-sharing is more likely to replace public transport service in lower density areas than in higher capacity routes where public transport is more likely to offer a time advantage over cars.

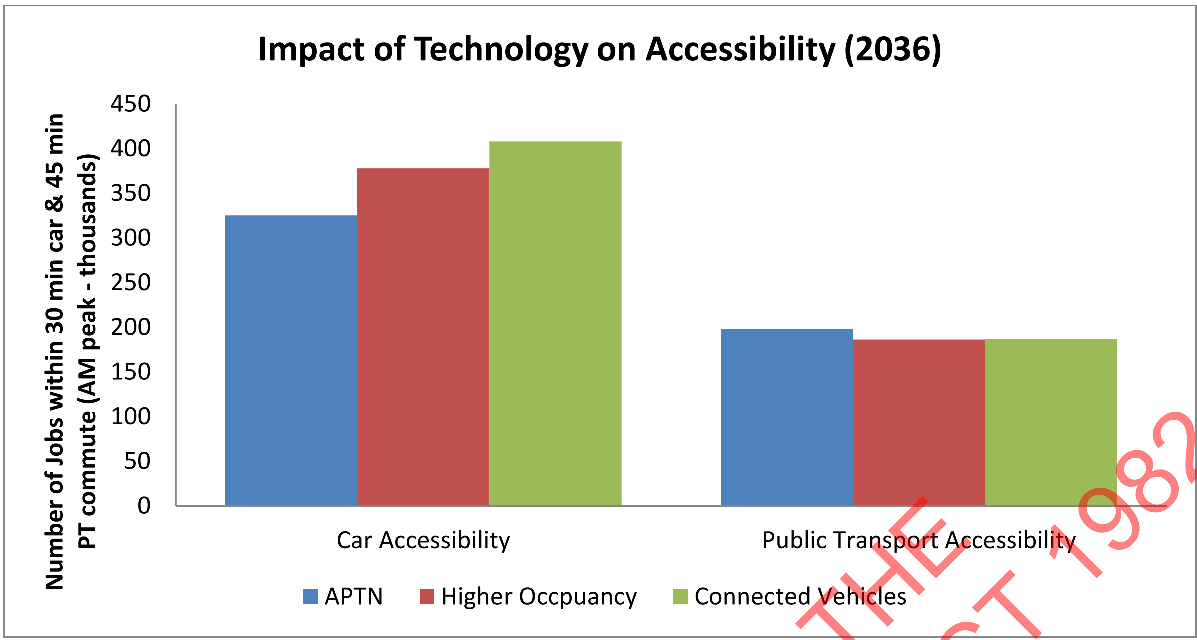
The main areas where connected vehicles and higher occupancy rates improve performance against the project objectives are in relation to congestion and car accessibility.



Source: ART3 model outputs, technology scenario tests

Connected vehicles appear likely to have a larger effect on reducing congestion than increases in vehicle occupancy, although our analysis also showed that these impacts were independent and therefore cumulative if increased occupancy rates and connected vehicles occur simultaneously, as can be expected. Congestion reduction from connected vehicles was most significant on the motorway network, because this is where vehicle connectivity is projected to result in the greatest throughput increase due to fewer intersections and less interaction with pedestrians, cyclists and other vehicles.

Potential technology-related congestion improvements translate directly into equivalent accessibility gains. The modelling indicates the accessibility gains could be greater than what could be achieved through infrastructure investments alone. This is likely to reflect the region-wide assumptions of technology improvements to Auckland's private motor vehicle fleet, road network and uptake of ride-sharing.



Source: ART3 model outputs, technology scenario tests

In contrast, public transport accessibility slightly reduced under the two technology scenarios when compared to the APTN. This indicates that neither of the technology improvements tested is likely to significantly improve public transport journey times.

As was the case for road pricing, it is important to recognise that with the technology scenario, the strategic modelling tools were being used for very different tasks than what they had been designed for. This was particularly the case for increased vehicle occupancy rates.

Given the level of uncertainty around the nature, scale and timing of technological innovation we decided not to build major technology assumptions into the later phases of technical modelling analysis. Some general conclusions were possible though:

- The benefits of developing vehicle technologies are likely to be substantial, and strongest on the motorway network.
- Increasing vehicle occupancy rates can help reduce congestion and improve car accessibility. Impacts on public transport are more complex, but seem more likely to affect demand in lower density areas more than along core strategic corridors.
- Ride-sharing also has the potential to complement road pricing by offering practical alternatives for commuters where public transport is unlikely to be a realistic option under any of the packages we have analysed.

6.4. Eastern strategic corridor

Our analysis of APTN highlighted congestion on the inner motorway network that was very difficult to address, due to physical constraints that make substantial widening extremely challenging. As an alternative approach to addressing this challenge, we tested the potential of a new north-south strategic road corridor to the east of State highway 1. This analysis was undertaken by the project's Independent Advisors[7], and was focused on understanding potential costs and benefits.

Two options were tested:

- An expressway standard route that combined an eastern harbour crossing and a new road corridor from the city centre to East Tamaki.
- A motorway standard route along the same corridor.

Both options were assumed to require extensive tunnelling, resulting in very high costs of around $11 billion. Analysis of the two options suggested that a full motorway version would generate regional access and congestion benefits, but neither option significantly reduced congestion on State Highway 1. Furthermore, the project's extremely high costs meant that it was considered unlikely to provide value for money within the next 30 years and was therefore not carried forward into later stages of options testing. However, as Auckland may need an additional north-south corridor beyond the next 30 years, it was concluded that route protection for this route should be retained where it currently exists.

[7] AECOM: *Eastern Strategic Corridor: Preliminary Assessment*

7. Package Analysis (Round 2)

Information from initial testing was used to develop full packages of interventions that could be compared against each other and current plans to assess their performance against the project's objectives. This work informed our *Interim Findings* report that was released in June 2016.

In this stage, we focused on testing:

- Changing the mix of investment
- Smarter transport pricing.

7.1. Changing the mix of investment

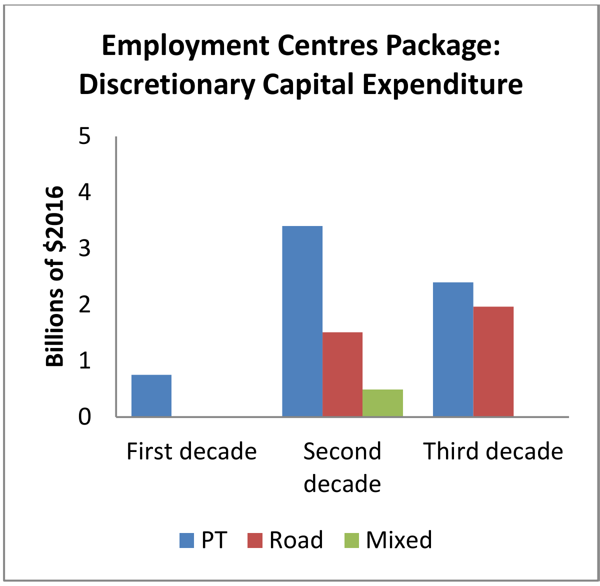
The core task of the project is to test whether better returns can be achieved from transport investment. Therefore, we looked at whether investing the same amount as current plans but on different priorities could deliver better results against our objectives.

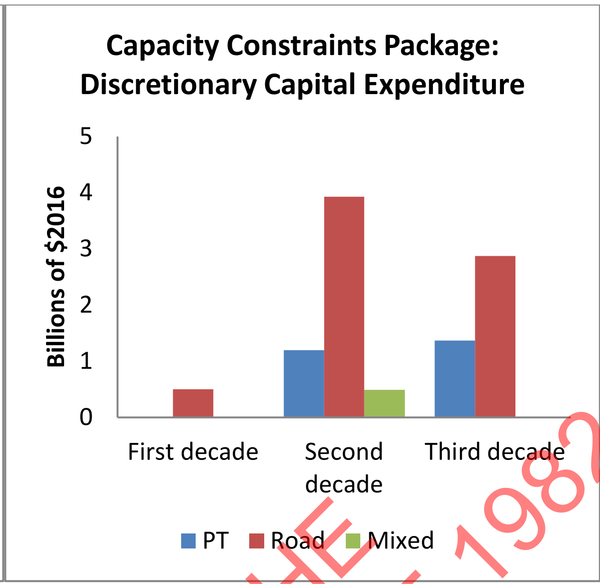
The packages were evaluated to understand their strengths and weaknesses, to inform our interim findings and further package refinement.

Each package included common assumptions on the levels of maintenance, operations and asset renewals, and a 'common baseline' of capital expenditure (existing commitments and projects whose benefits were unable to be assessed using the strategic regional modelling tools used in this project). Once these items were accounted for, around $9 billion of 'discretionary funding' was available over the 30-year period for allocation to different investment priorities. The level of existing commitments meant that limited discretionary funding was available in the first decade.

Two intervention packages were developed using broadly similar decade-by-decade funding levels to the current plans. The core focus and broad allocation of discretionary investment across major modes of each package is outlined below.

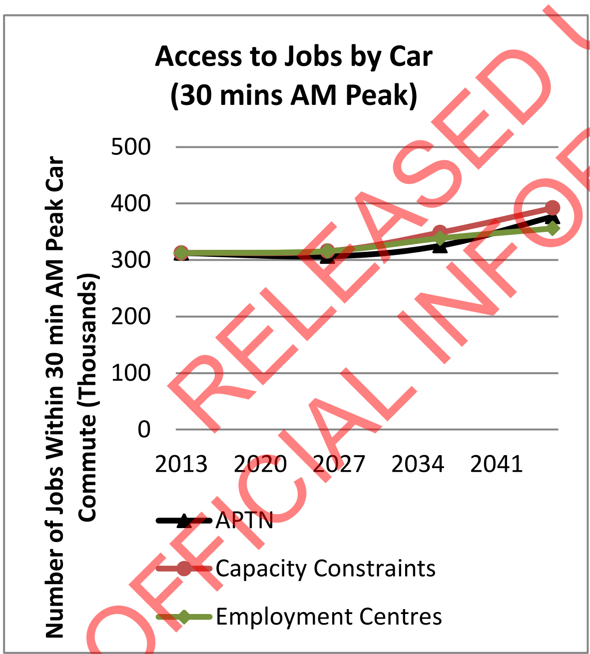
Focus on Access to Employment Centres	Focus on Addressing Capacity Constraints
Because Auckland's employment growth is expected to be in main employment centres, this approach strongly focussed on improving access to locations with large numbers of jobs and where significant jobs growth is projected.	Because growing transport demand across Auckland will place pressure on the transport network in a variety of different locations, this approach strongly focussed on addressing the most severe constraints to increase speed and capacity.

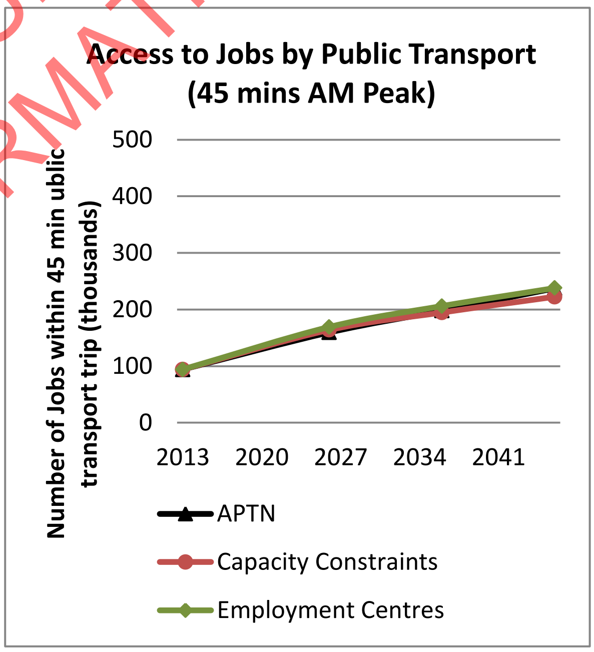




Source: ATAP Revenue & Expenditure workstream estimates, ATAP round 2

The packages performed broadly similarly to the APTN at a region-wide scale, particularly by 2046. However, there were congestion improvements in earlier years from bringing forward some road projects and overall both packages achieved moderate improvements (but not a step-change).



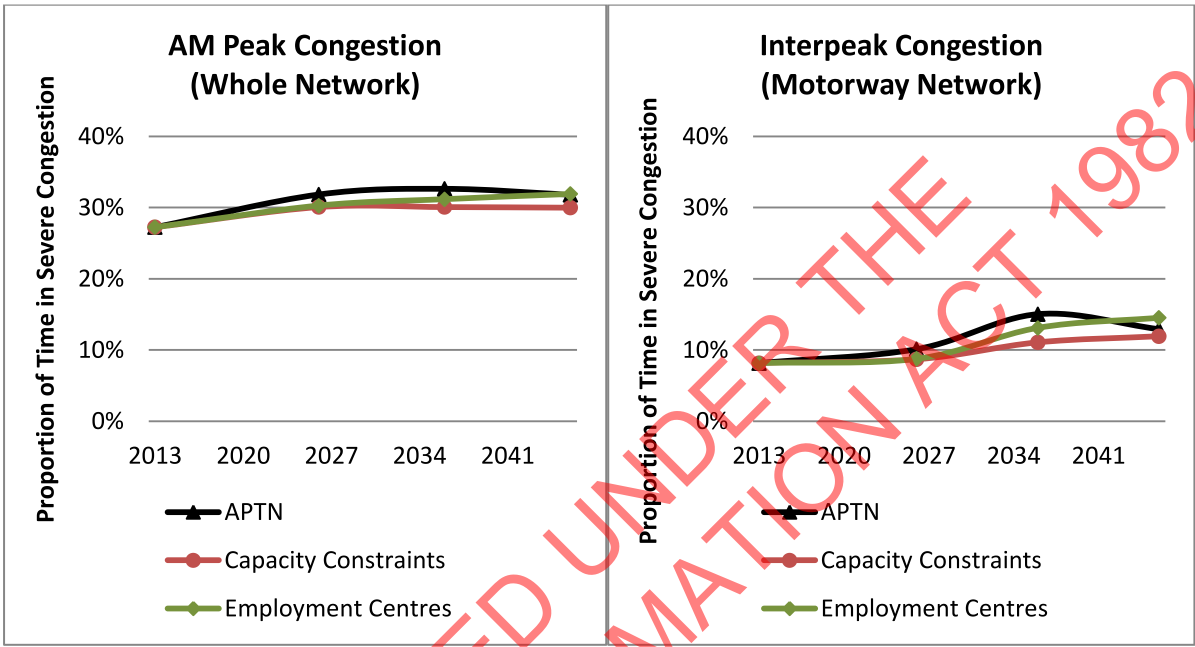


Source: ART3 model outputs, ATAP round 2

Differences in car and public transport accessibility between the packages follow similar trends to the APTN, and do not result in fundamental improvements. However, there were some notable findings:

- The ‘Capacity Constraints’ package provided access to around 350,000 jobs within a 30-minute car trip in 2036, around 28,000 (7%) more than APTN, although this difference subsequently declined to 17,000 (4%) by 2046.
- The 'Employment Centres' package provided access to around 16,000 (6%) more jobs within a 45-minute public transport trip in 2026 than the APTN. This increase appeared to be concentrated in the northwest due to acceleration of a Northwestern Busway.

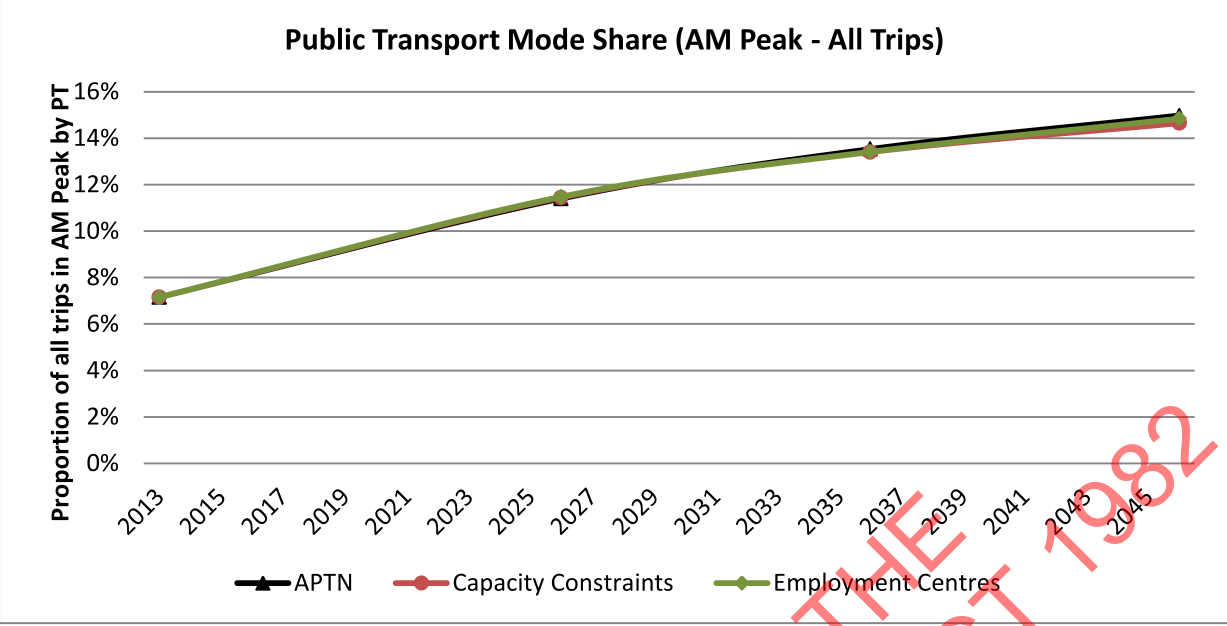
Congestion modelling of the different packages is outlined in the graphs below.



Source: ART3 model outputs, ATAP round 2

Similar to accessibility results, the differences compared to APTN were moderate, although the ‘Capacity Constraints’ package resulted in a significant reduction in 2036 inter-peak motorway network congestion (11% of average travel time spent in severe congestion, compared to 15% for the APTN). At peak times, all projections were within 2-3 percentage points of each other and the APTN.

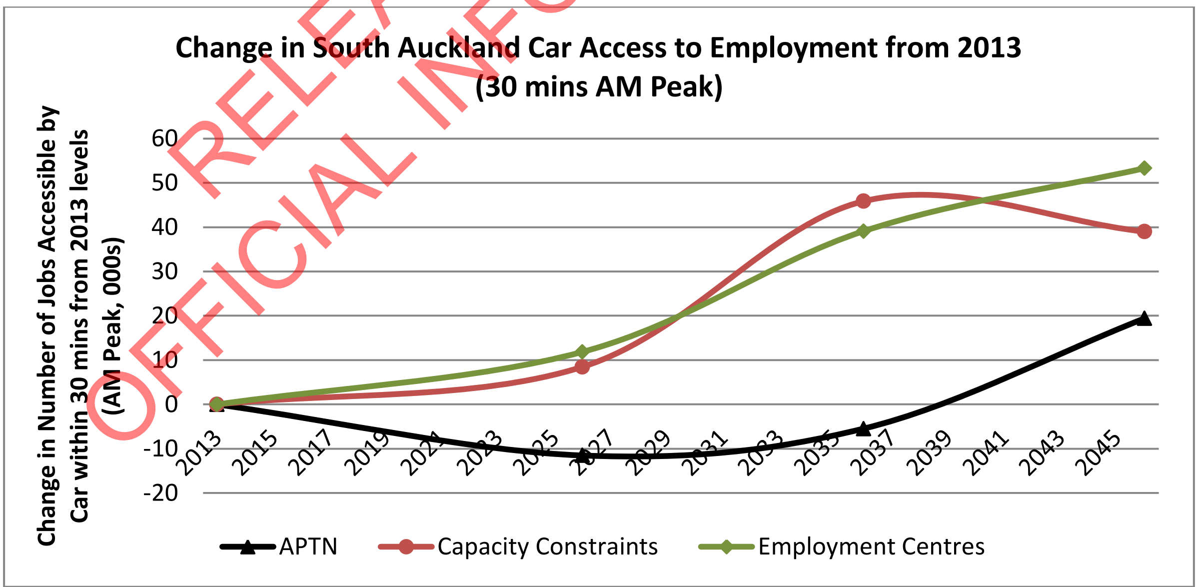
Public transport mode share results are similar for all three packages, with differences of less than one percentage point for the proportion of all trips during the morning peak being taken by public transport.



Source: ART3 model outputs, ATAP round 2

While changing the mix of investment does not achieve a 'step-change' in regional performance, impacts at a sub-regional level are significant. In particular, improvements for the west and south appear possible through changes to the mix and timing of investment. This is important because these were the areas where access challenges were found to be most significant in the first phase of the project.

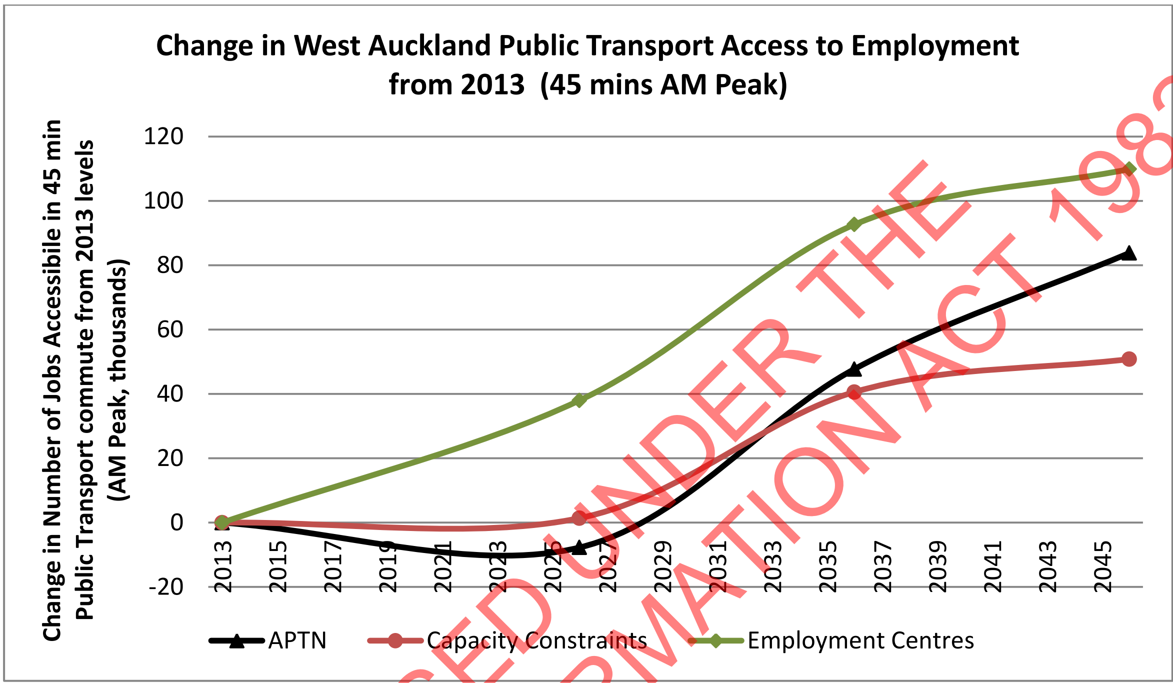
In the south, whereas under APTN access to employment by car declined and only increased strongly after 2036, both the 'Capacity Constraints' and 'Employment Centres' packages show better performance can be achieved.



Source: ART3 model outputs, ATAP round 2

Both packages increase the number of jobs able to be reached within a 30-minute car commute from the south by around 20% in 2036 compared to the APTN.

In the west, the greatest variation found between the packages is for public transport accessibility. Here, the 'Employment Centres' package provided substantially higher public transport accessibility than the other packages, particularly in 2026 and 2036. Advancing the full Northwestern Busway from Kumeu to the city centre in this package is the main contributor to this improvement.



Source: ART3 model outputs, ATAP round 2

Overall, analysis of changing the mix of investments – with a similar overall level of investment – highlights the potential to achieve minor to moderate improvements in region wide performance against the project objectives, but not a step-change. Sub-regional changes in performance suggested there was merit in continuing to optimise the timing and priority of investments. In particular, the analysis undertaken of different investment mixes suggests it would be possible to substantially improve employment accessibility in the south and west.

7.2. Smarter transport pricing

As noted, the initial phase of the project found a whole of network pricing system had the greatest high-level potential for improving accessibility, congestion and public transport mode share.

Our analytical tools are not calibrated to assess the detail of a potential pricing system because of the following:

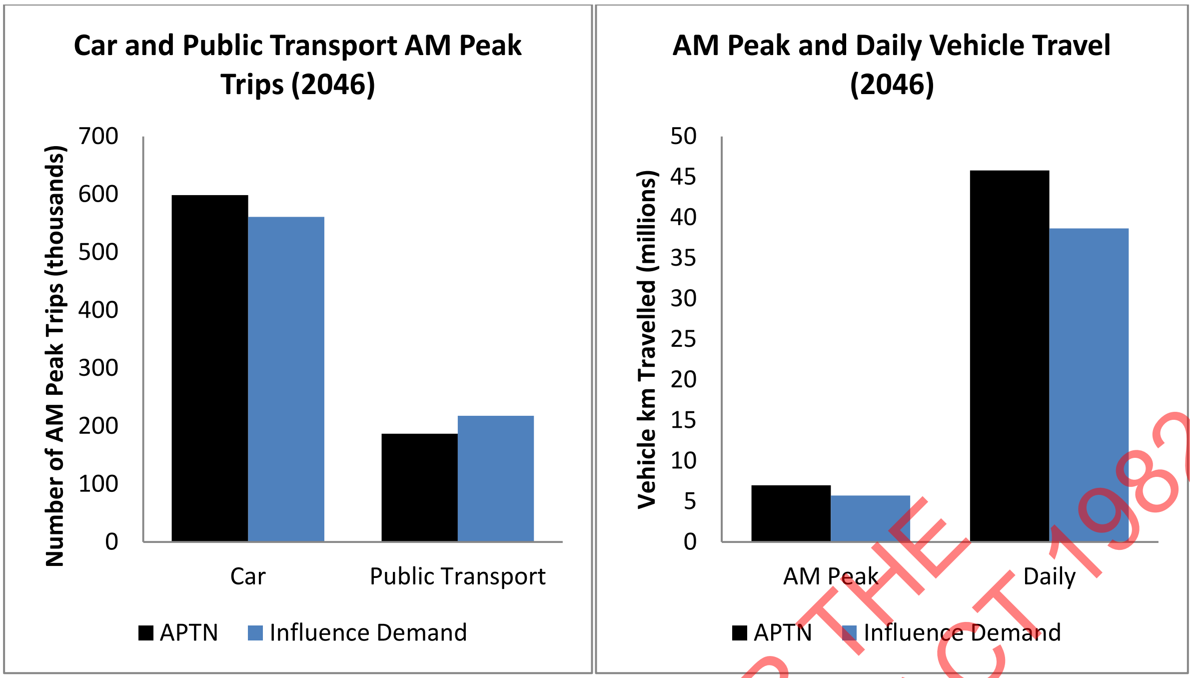
- They use fixed-trip matrices so are unable to show the extent to which the introduction of pricing may result in trip suppression (trips no longer being made).
- They are also not able to consider different values of time or vary prices at a more micro-level so provide a very simplistic representation of what the impacts of a scheme might be.

Therefore, the pricing structure we developed for the second phase of the analysis should be considered very much 'hypothetical'. The structure used is summarised in the table below, with prices varying from 3c/km to 40c/km. We assumed that these prices would replace existing fuel excise and road user charges, which average approximately 6c/km.

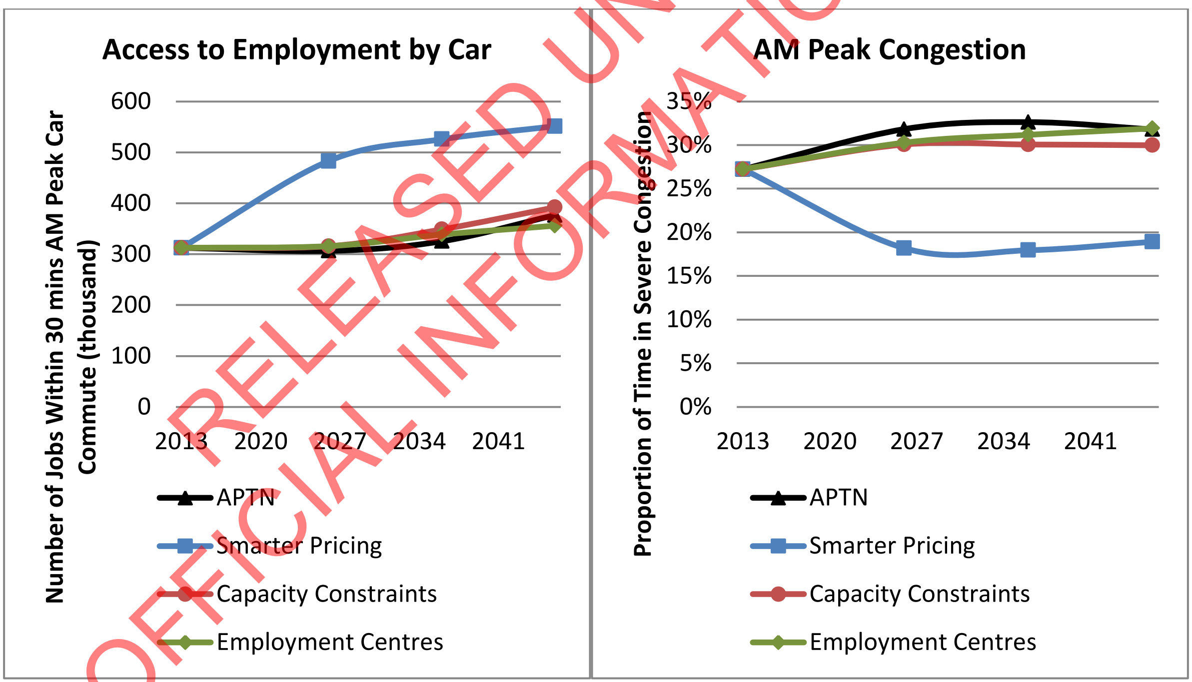
Round 2 hypothetical price levels used for testing (c/km)				
Area	**Network**	**Peak**	**Inter-Peak**	**Off-Peak**
Inner Urban (isthmus)	Motorways	40	30	3
	Other Roads	30	20	3
Outer Urban	Motorways	30	20	3
	Other Roads	20	10	3
Rural	All Roads	3	3	3

Highest prices were targeted to the most congested locations and where travel alternatives were most likely to be available. In outer areas, prices were reduced from the levels used in the earlier round of testing. The pricing system was tested with complementary infrastructure investment focused on providing improved public transport options and capacity to meet changing travel patterns.

The main effects on travel patterns appear to be a slight reduction in trip length made by private vehicles and a mode shift from private vehicle to public transport. There were approximately 39,000 (6%) fewer private vehicle trips and around 16% less vehicle travel at peak times in 2046 compared to current plans. These changes have a profound effect on the transport network's performance.



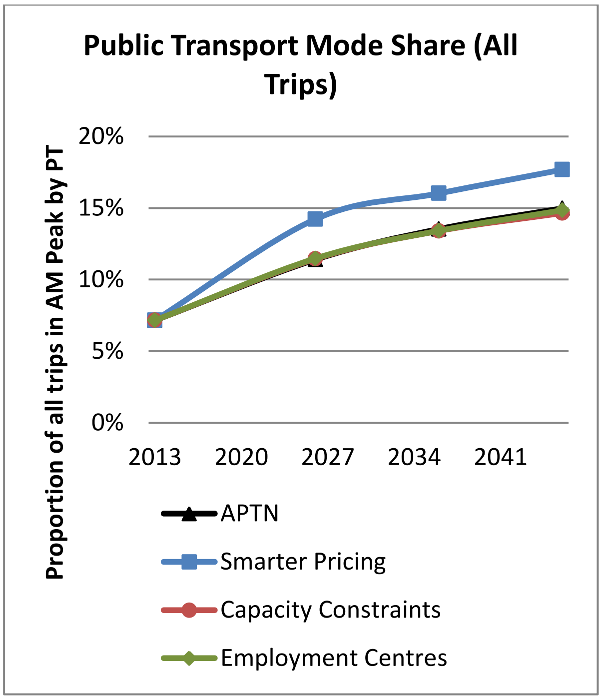
Source: ART3 model outputs, ATAP round 2

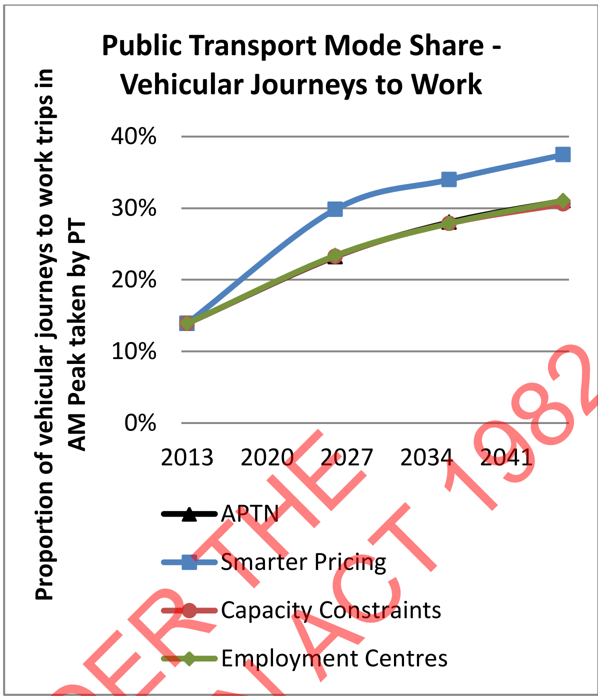


Source: ART3 model outputs, ATAP round 2

Access to employment by car and morning peak congestion results improve substantially. . However, the extent to which this gain in 'potential access' through faster travel speed would be offset by the increased cost of travel needs to be assessed further using more sophisticated modelling tools and a much refined pricing structure. Our initial analysis suggested that it would make sense to test lower prices as the added cost of travel appeared to outweigh travel time savings for many trips.

The graphs below show the projected increase in public transport mode share.

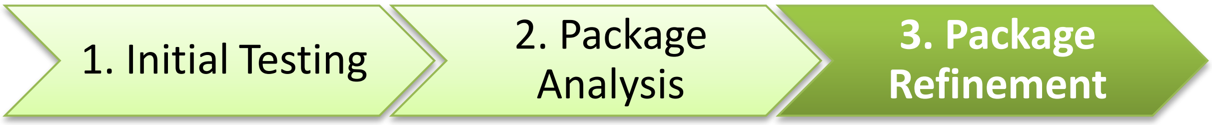




Source: ART3 model outputs, ATAP round 2

Overall, our analysis of smarter transport pricing showed it offers the potential to achieve a step-change in transport network performance and should therefore form a core part of the strategic approach. However, setting prices at the right levels is extremely challenging as performance improvement, travel time savings and increased travel costs need to be carefully balanced. While some further work was undertaken to assess different pricing levels, much more sophisticated analytical tools will be required to undertake this work before implementation can occur.

8. Package Refinement (Round 3)



Following the publication of the *Interim Report* in June 2016, the final phase of the work focused on developing an Indicative Package to support the recommended strategic approach.

Because we had also only tested changing the mix of investment, but not increasing the overall level of transport investment, further refinement of the intervention packages was necessary – particularly to understand the extent to which increasing investment could deliver a similar step-change as the emerging tools of technology and pricing. Refinements of the smarter transport pricing system were also undertaken to test the extent to which network performance gains would still be achieved with lower prices..

8.1. Refined package development

The packages were:

- "Higher Investment": a higher level of infrastructure investment (particularly in the first 10-20 years)
- "Influence demand": refined pricing levels and accompanying investment

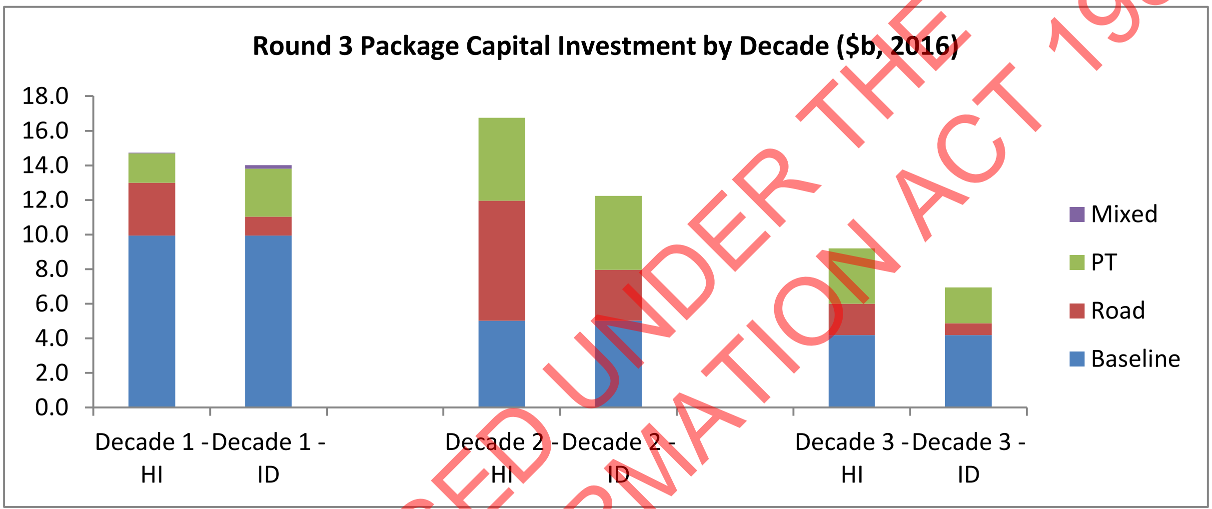
A summary of the two packages is outlined below:

Higher Investment	Influence Demand
• Delivers the strategic public transport network (see section 8.2 below) • Includes a substantial programme to improve the strategic roading network (see section 8.2 below), including accelerating to first decade a number of new investments targeted to the most severe capacity issues. • Involves expenditure of approximately $21.6 billion for new capital improvements above the common baseline used in this round of analysis (see description below).	• Includes a shift to smarter transport pricing, progressively introduced between 2026 and 2036. • Accelerates delivery of the strategic public transport network to coincide with implementation of pricing • Involves expenditure of approximately $14.0 billion for new capital improvements above the common baseline used in this round of analysis (see description below).

The common baseline for both packages was generally similar to that used for the previous packages, but was refined and narrowed in greenfield growth areas to only include investments that were directly required to enable growth (i.e. local road networks). The common baseline has a capital cost of approximately $19 billion for new improvements over the 30-year period. Key components of the common baseline still included committed projects (e.g. City Rail Link, East-West link, Puhoi-Warkworth etc.), the Rail Development

Programme[8] (because it cannot be effectively modelled using existing tools), the walking and cycling programme (because its scale is broadly agreed) and a variety of other minor investments either unable to be evaluated using available tools or would be expected to occur over the next 30 years (e.g. safety programmes, walking and cycling improvements, and minor road and public transport improvements).

The capital investment for the two packages across the three decades is illustrated below. For the Higher Investment (HI) package, investment in the third decade is lower than decades 1 and 2 because investments have been brought forward; and for the Influence Demand (ID) package, the lower investment in the third decade also reflects an expectation that less infrastructure will be required.



Source: ATAP Revenue & Expenditure workstream estimates, ATAP round 3

In developing the Influence Demand package, different pricing levels were tested to better understand the relationship between the cost of travel and changed travel patterns. As a result of this analysis, price levels were reduced by 25% from what was tested in the previous stage. The charges modelled were therefore:

Influence Demand package: hypothetical price levels (c/km)				
Area	**Network**	**Peak**	**Inter-Peak**	**Off-Peak**
Inner Urban (isthmus)	Motorways	30	22.5	2.25
	Other Roads	22.5	15	2.25
Outer Urban	Motorways	22.5	15	2.25
	Other Roads	15	7.5	2.25
Rural	All Roads	2.25	2.25	2.25

[8] For details of the Rail Development Programme, see section 9

8.2. Strategic road and public transport networks

Part of the development of the refined packages involved a focus on investment on the major road and public transport corridors. The *Interim Report* highlighted the importance of strengthening these networks to ensure their continued safe and efficient operation. The networks are described in the following table, and the maps that follow illustrate how the networks can be expected to develop in future, subject to the investment approach that is chosen. Note that further work is required to determine parts of the primary arterial network that should have strategic functions.

Strategic Road Network	Strategic Public Transport Network
• Backbone of the road network, providing for a wide variety of travel and the highest traffic volumes. • Core links between major parts of Auckland and the rest of NZ, carries heaviest freight volumes and provides access to Port and Airport. • Through-movement of people and goods is primary consideration and access is limited or controlled.	• Backbone of the public transport network, providing for high volumes of travel to major employment centres, especially into the central area. • Frequent, high capacity services operating along corridors separated from private vehicles and unaffected by road congestion. • Passenger rail network shares corridor with freight


Proposed Future Strategic Road Network
WARKWORTH
Puhoi - Warkworth
Kahikatea Flat Rd
Hibiscus Coast Hwy
Penlink
Dairy Flat Hwy
ALBANY
Albany Hwy
East Coast Rd
TAKAPUNA
Coatesville-Riverhead Hwy
Upper Harbour Mwy
Glenfield Rd
Northern Mwy
Lake Rd
KUMEU
Auckland Harbour Bridge
Additional Waitemata Harbour Crossing
CBD
PORT
Tamaki Dr
MASSEY NORTH
NEWMARKET
Taupaki Ext
Don Buck Rd
Lincoln Rd
North-Western Mwy
Dominion Rd
Remuera Rd
Apirana Ave/ Te Horeta Rd
Southern Mwy
Balmoral Rd
Pakuranga Hwy
HENDERSON
Te Atatu Rd
Great North Rd
New North Rd
Mt Albert Rd
Manukau Rd
Ti Rakau Dr
BOTANY
SYLVIA PARK
Highbrook Dr
Te Irirangi Dr
East Tamaki Dr
East West Link
Ormiston Rd
NEW LYNN
South Western Mwy
Great South Rd
Massey Rd
SH20A
AUCKLAND AIRPORT
SH20B
MANUKAU
Cavendish Rd
Roscommon Rd
Popes Rd
Beach Rd
Mill Rd
PAPAKURA
Southern Mwy
PUKEKOHE
Metropolitan Centre
Strategic Network (Tier 1)
Future Strategic Network
Primary Arterial Road
Future Primary Arterial Road
Major Upgrade or re-alignment envisaged


Proposed Future Strategic Public Transport Network
Orewa
Albany
Constellation
Takapuna
Akoranga
Kumeu / Huapai
Devonport
Britomart
Wynyard
Aotea
Karangahape
Massey North
Newmarket
Lincoln Rd
Panmure
Botany
Ellerslie
Penrose
Sylvia Park
Swanson
Mt Roskill
Henderson
New Lynn
Otahuhu
Onehunga
Manukau
Puhinui
Auckland Airport
Papakura
Pukekohe
Metropolitan Centre
Major Interchange
Existing Strategic Public Transport (heavy rail)
Future Strategic Public Transport (heavy rail)
Existing Strategic Public Transport
Future Strategic Public Transport
Frequent Ferry

The table below compares the major strategic network upgrades for the Higher Investment and Influence Demand packages (common baseline projects are not included).

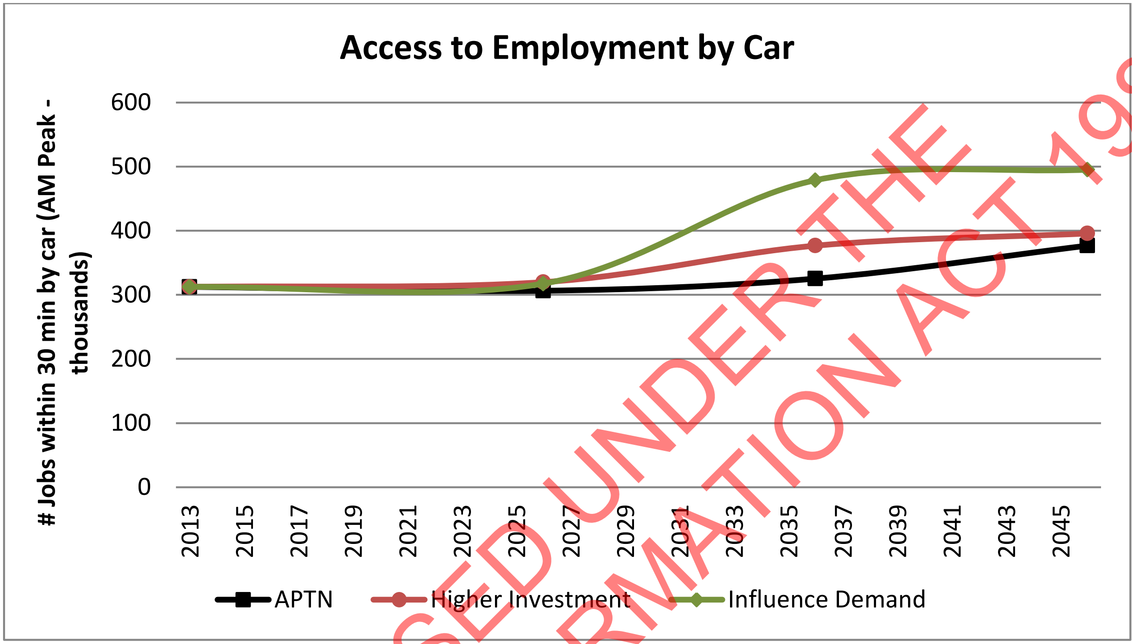
Network	Intervention	Higher Investment by decade			Influence Demand by decade		
		1st	2nd	3rd	1st	2nd	3rd
Strategic Road Network	Additional Waitemata Harbour Crossing (road)		2nd				
	Port access (Grafton Gully-The Strand)	1st				2nd	
	SH1 Princes to Manukau	1st				2nd	
	SH1 Hill Rd to Papakura		2nd				3rd
	SH16 Westgate to Te Atatu		2nd				
	SH20 Onehunga to Manukau		2nd				
	Northern SH1 widening			3rd			
	SH20A – 6 laning			3rd			
	Kumeu Bypass (TFUG)	1st				2nd	
	Pukekohe Expressway (TFUG)	1st				2nd	
	Penlink (TFUG)		2nd				
Strategic Public Transport network	Dominion Road to City Mass Transit		2nd		1st		
	Airport Mass Transit			3rd		2nd	
	City to Takapuna Mass Transit (with PT tunnel)		2nd			2nd	
	Takapuna to Orewa Mass Transit			3rd			3rd
	Sandringham Rd Mass Transit			3rd			3rd
	NW Busway Westgate-Pt Chevalier	1st			1st		
	NW Busway Pt Chev-City & Westgate-Kumeu		2nd			2nd	
	Pakuranga-Botany Busway			3rd			3rd

8.3. Refined Package Analysis

The two packages were compared against each other and the APTN.

Access to employment

Modelling outputs indicate that additional investment before 2026 appears to have a very limited effect on accessibility by car. After 2026, once smarter pricing has been introduced, the Influence Demand package provides substantially higher car accessibility, despite containing around $8 billion less investment than Higher Investment.

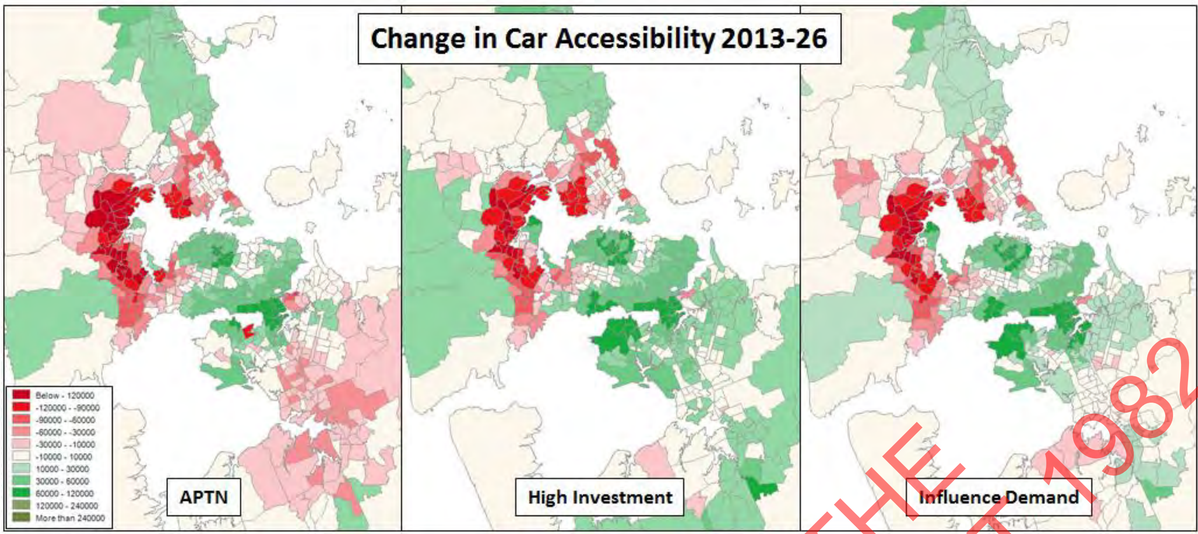


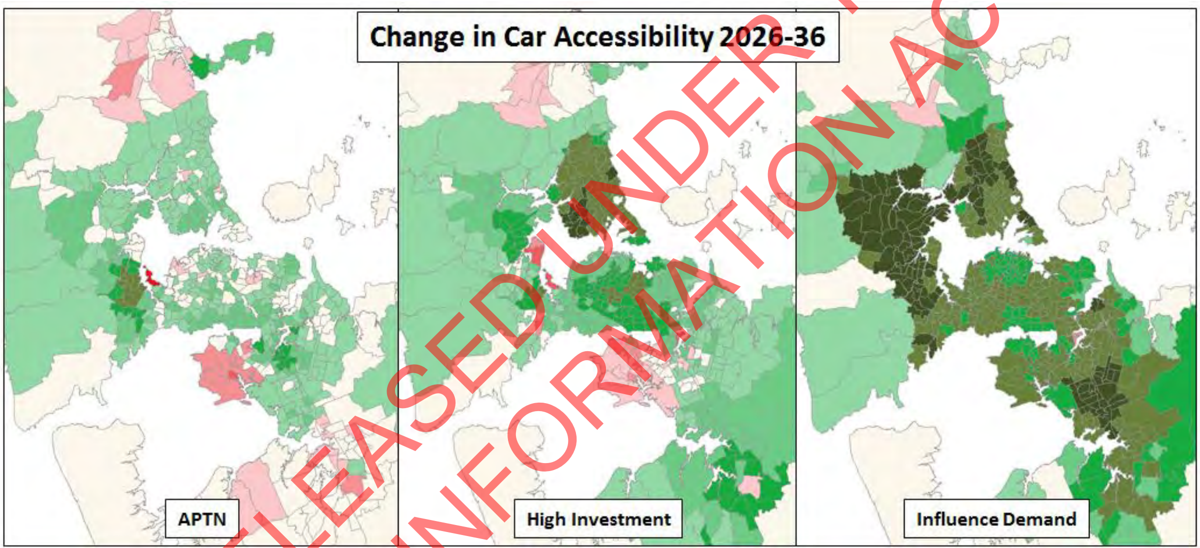
Source: ART3 model outputs, ATAP round 3

The *Foundation Report* highlighted access challenges in the west and the south as a key focus for further work on the project.

The maps below illustrate increases (green) or decreases (red) in the number of jobs accessible by car within a 30-minute AM peak trip between 2013 and 2026, and subsequently between 2026 and 2046.

In the first decade, while both packages address issues in the south, car access remains a major challenge for the west and parts of the North Shore. In the case of the west, this is despite the Higher Investment package including widening of the Northwestern Motorway and the Influence Demand package including the Northwestern Busway.





Source: ART3 model outputs, ATAP round 3

Between 2026 and 2036, car accessibility improves for most of Auckland under both the APTN and Higher Investment packages, and improves very strongly for nearly all of Auckland under the Influence Demand package as smarter pricing is implemented. There are some noteworthy findings to highlight:

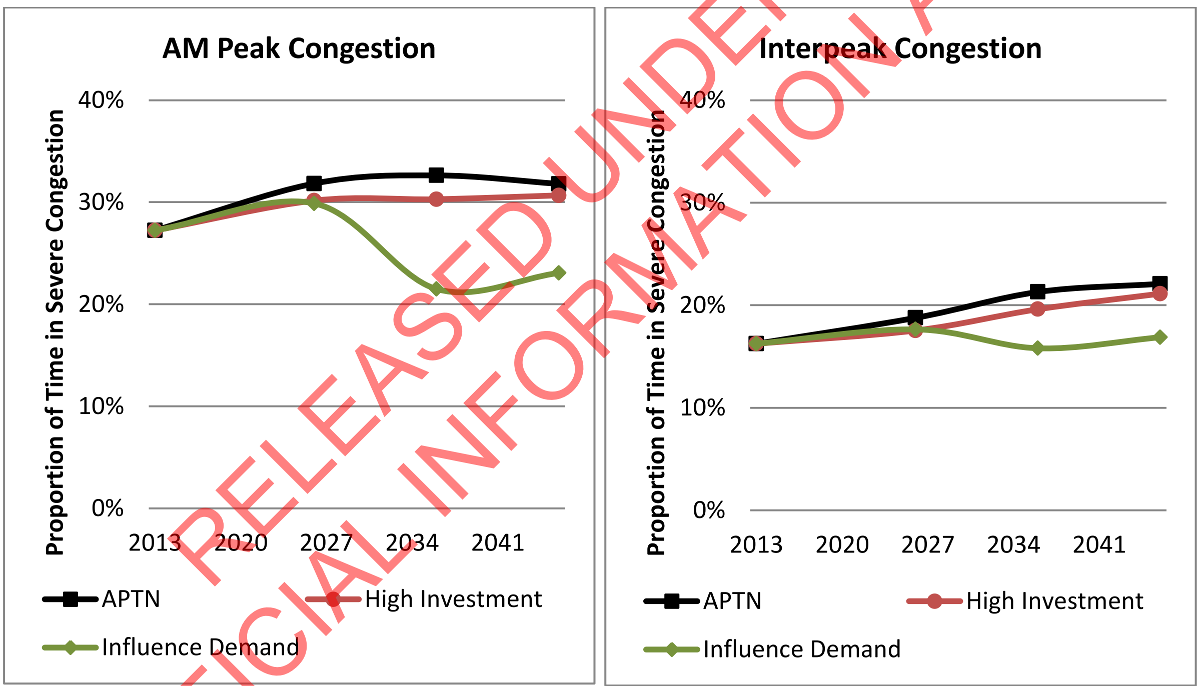
- Under the APTN and Higher Investment packages people living near the airport area have limited access to employment as the motorways serving this area are congested in both directions at peak times, increasing travel times by car and public transport to jobs outside the airport area.
- Inclusion of the Additional Waitemata Harbour Crossing project into the second decade of the Higher Investment package creates a significant increase in car accessibility for the North Shore. However, this increase is not as high as seen under the Influence Demand package, which has smarter pricing in place but no additional crossing.

- The northwest and parts of the south appear to experience the greatest accessibility gains from the implementation of smarter pricing. This may be because pricing is particularly effective at reducing congestion along the routes serving these areas, bringing them back within a 30-minute travel time of the substantial employment opportunities in the central area. However, these travel time savings would need to be balanced against the increased direct travel costs from pricing to fully understand access impacts.

Congestion

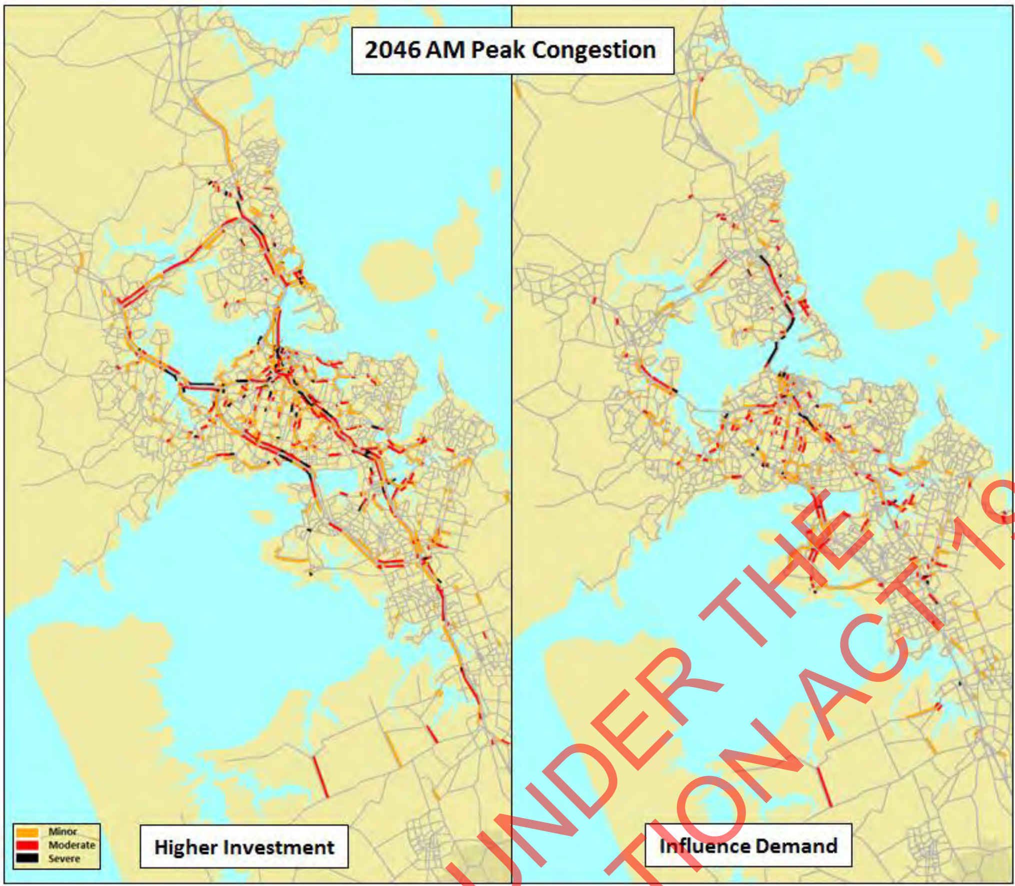
Analysis of projected congestion levels mirrors the car accessibility outputs discussed above. While the Higher Investment package performs slightly better than the APTN (particularly in 2026 and 2036 as a result of earlier investment in additional highway capacity), it is only the progressive introduction of smarter transport pricing in the Influence Demand package that delivers a step-change impact on congestion levels.

Most of this change results from a combination of reduced trip lengths and a shift to public transport in response to the increased cost of car travel.



Source: ART3 model outputs, ATAP round 3

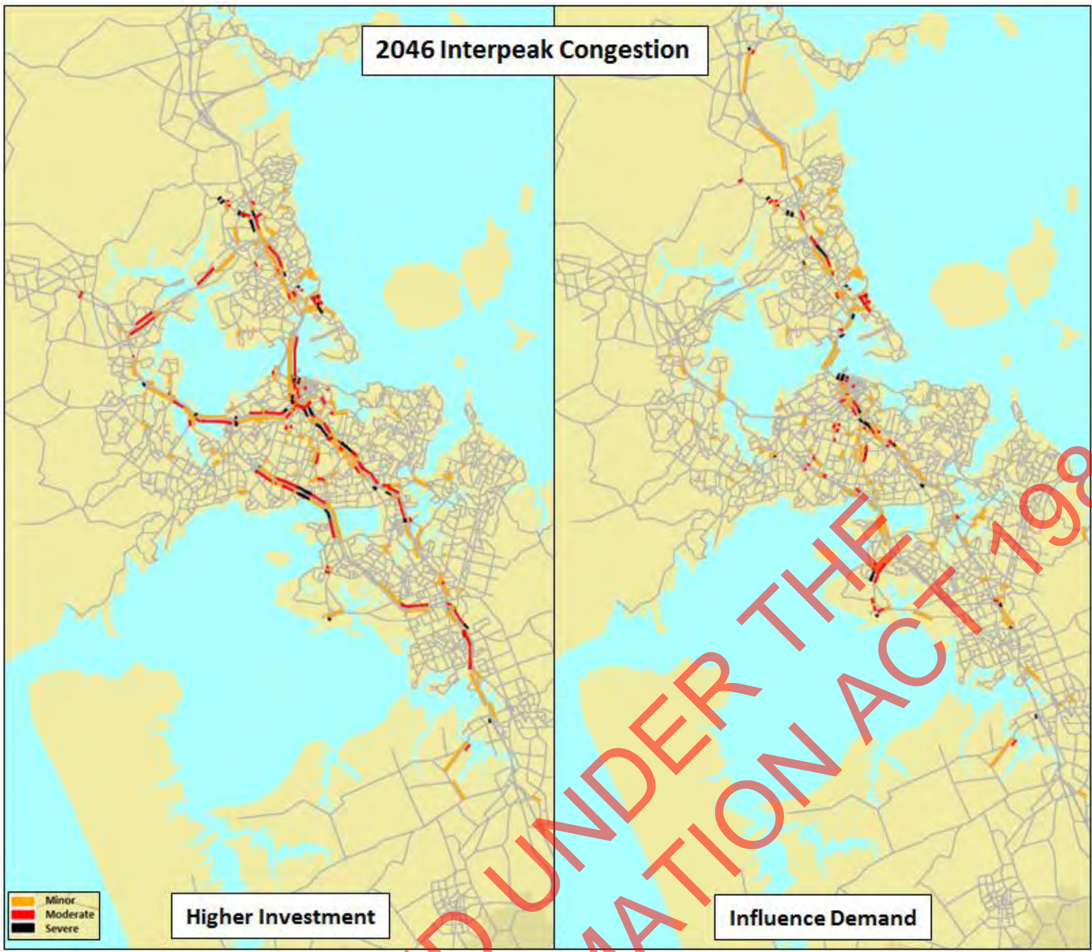
The lower level of congestion for the Influence Demand package is reflected in the more detailed congestion plots for 2046 below.



Source: ART3 model outputs, ATAP round 3

These plots also indicate congestion in the Influence Demand package, especially on the Northern Motorway, including the harbour crossing, and inner parts of the Southern Motorway. Addressing these areas of congestion informed development of the final package, as well as the need to continue to refine the details of the pricing system over time, as changes to the pricing structure could also address these issues.

Inter-peak congestion plots for the two packages also indicate a much lower level of congestion under Influence Demand.



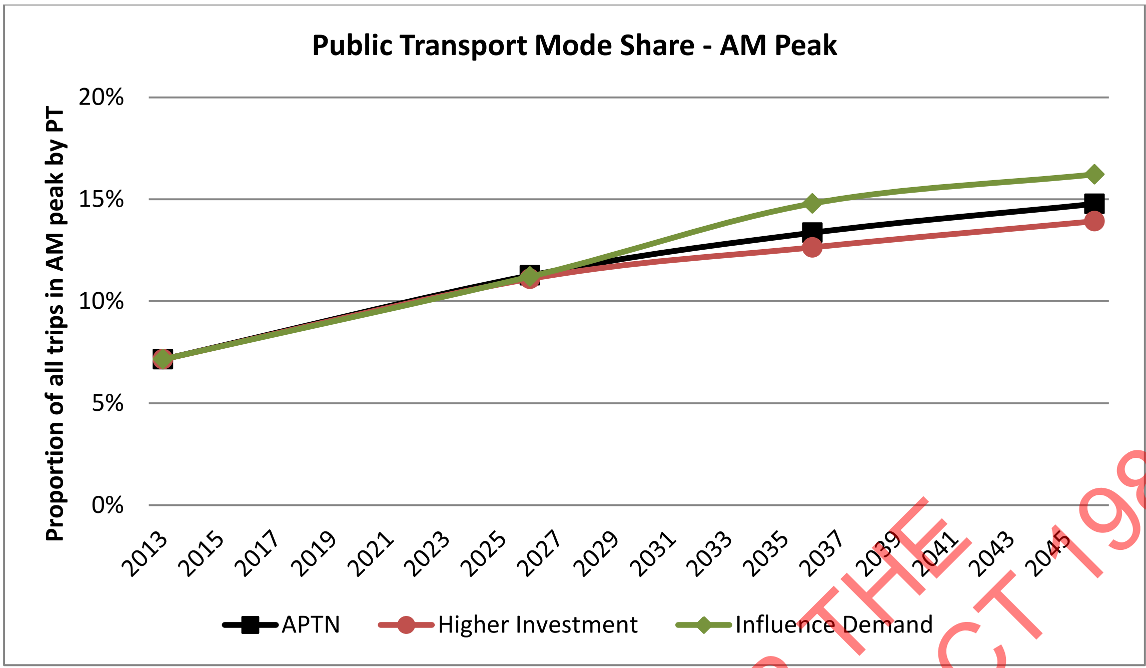
Source: ART3 model outputs, ATAP round 3

While some patches of congestion remain in the Influence Demand package, most of the inner motorway network is operating below moderate or severe congestion levels in 2046.

Public transport mode share

By 2046, the Influence Demand package is expected to result in a public transport mode share of 16% in the morning peak, compared with 15% for the APTN and 14% for the Higher Investment Package. This suggests that the introduction of pricing results in a higher level of public transport use.

Higher Investment has a lower public transport mode share than APTN, even though it includes a number of additional public transport investments. This suggests that its acceleration of roading projects results in a lower level of public transport use.



Source: ART3 model outputs, ATAP round 3

Overall, the more significant modal shift to public transport that occurs in Influence Demand throughout large parts of Auckland appears to make an important contribution to the much lower levels of congestion in this package. In common with other objectives, it is the implementation of smarter pricing that plays a crucial role in achieving these outcomes.

Net benefits to users

While our analysis suggests moving to smarter transport pricing would deliver very material gains in travel times and a shift to public transport, it would impose additional financial costs on many road users. We modelling outputs to analyse the balance between travel time savings and increased financial costs. This analysis suggested that the prices charged would exceed the value of the time gained for the average road user.

These findings should be treated with caution, however. The analysis was a necessarily coarse approximation of how pricing might be applied, which means that some uncongested roads were subject to the same charge as congested routes. Furthermore, our analytical tools were not able to consider the likelihood that some users would place a much higher value on travel time savings than others. Further work, using much more detailed analytical tools, is required to identify efficient pricing levels which effectively address these issues.

We expect this more detailed development and analysis will go a long way towards ensuring overall net user benefits from the introduction of pricing. Prices could be adjusted to lower levels and a finer-grain (e.g. on uncongested counter-peak motorways) and better information about the impacts on users with different values of time could be taken into account.

It will be important to understand where travel cost increases occur under a particular pricing structure so that equity impacts (including the affordability of travel to different groups, and the impact of pricing on access to jobs, education and services) can be assessed and any necessary mitigation can be developed.

8.4. Refined package conclusions

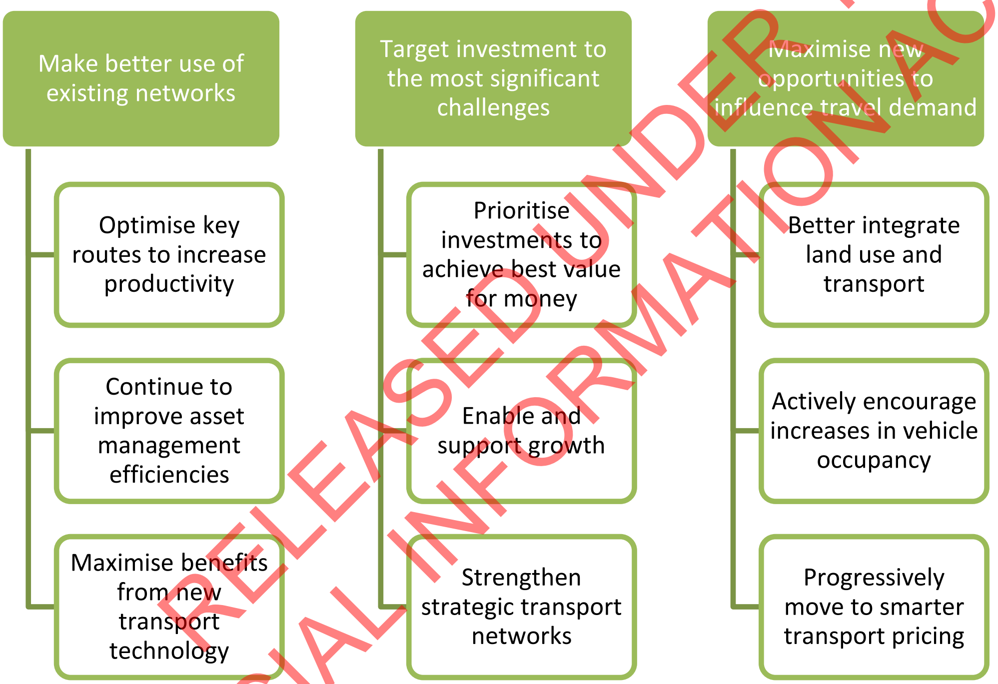
Key findings from analysing the Higher Investment and Influence Demand packages that informed development of the final package were:

- Additional investment in the first decade did not appear to improve performance against the project objectives at a regional level, but some of these extra investments did have some important sub-regional effects. Therefore, development of the final package should adopt a more targeted approach to identifying early priorities which both align with the project objectives and appear likely to deliver value for money (refer to next section).
- The introduction of smarter pricing in the Influence Demand package has the most significant impacts on the project objectives, but unclear net benefits to users that would require more detailed analysis.
- Because of its significantly better performance against the project objectives, Influence Demand should form the base of the final package.

Phase 3 – Indicative Package

9. Indicative Package Development

The three stages of option testing informed development of the strategic approach outlined in the *Recommended Strategic Approach*. This is an integrated approach that aims to balance transport demand with the capacity of our infrastructure and services. It requires a fundamental shift to a greater focus on influencing travel demand through smarter transport pricing and accelerating the uptake and implementation of new technologies, alongside substantial ongoing transport investment, and getting more out of existing networks.



To give an indication of how the approach could be applied required development of an Indicative Package of interventions likely to be required. This also enabled estimates of the overall scale and sequencing of investment.

The final Indicative Package was based on the "Influence Demand" package assessed in the previous phase, with the main focus of additional work being on identifying early priority interventions to be progressed over the next decade.

The Indicative Package includes the following key components:

Component	Discussion
Maintenance, Operations and Renewals	Future investment requirements for these activities were assessed by the Maintenance, Operations and Renewals workstream. This work considered future asset service levels and took account of the need for additional expenditure as a consequence of growth in the asset base and user demand. The work also included estimates of public transport operating costs (net of farebox revenues), which were derived from modelled ridership projections for the Indicative Package. These costs have been incorporated in the Indicative Package but have not been subject to further scrutiny.
Committed Capital Projects	Projects where there is already a funding commitment or agreement between the parties to progress (e.g. the City Rail Link, East-West Link, Puhoi to Warkworth extension of the Northern Motorway, completion of the accelerated motorway package) were included in the Indicative Package.
Baseline Investments	Continued expenditure on safety programmes, walking and cycling, and minor road and public transport improvements were assumed for inclusion either due to existing alignment or because the analytical tools used in the project would be unable to capture the benefits of these investments.
Rail Development Programme	Joint work by Auckland Transport and KiwiRail in recent years has identified a programme of upgrades to provide for growing passenger and freight demand, based around three main components: • Upgrading the rail network's infrastructure, including additional third and fourth tracks on parts of the North Island Main Trunk Line between Westfield and Pukekohe, will be necessary to provide for growth in demand for passenger and freight services. • Increased rail passenger demands will drive the need to purchase additional trains. Three tranches of 21 new trains are projected to be required over the next 30 years to cater for forecast demand growth. • Grade separation of level crossings will become an increasingly acute requirement, as increasing train frequencies and traffic volumes lead to long delays for road users and safety issues. These investments have not been subject to additional scrutiny as part of the project, but were included in the Indicative Package as they are consistent with the strategic approach.
Major New Investments	These investments were prioritised and sequenced through developing and applying a prioritisation framework, as detailed below. The emphasis on the first decade reflects the greater level of uncertainty about the rate and location of future growth, and the timing and impacts of technological change beyond this period.

10. Prioritisation Framework

Our framework for identifying early priorities considered two broad factors:

- The extent to which investment targets the most significant first decade challenges
- The potential to deliver value for money in the first decade

Evidence collected through package development and evaluation, as well as information shared through engagement with individual infrastructure project teams, was used to prioritise investments.

The resulting priorities and timings identified by the framework should be considered a projection of what would occur if the strategic approach is implemented, and should relevant business cases demonstrate value for money similar to the potential we have identified.

10.1. Key assumptions

Four key assumptions were made:

- Investment would be targeted on addressing the key challenges:
  - Enabling a faster rate of housing growth, particularly in new greenfield growth areas
  - Addressing projected declines in access to jobs for people living in large parts of the west, and some parts of the south
  - Addressing growing congestion on the motorway and arterial road network, particularly at inter-peak times
  - Increasing public transport mode share on congested corridors
- The focus would be on evidence relating to the first decade
- Only major investments (generally above $200m) which are not currently committed would be prioritised
- Only investments that had comparable sources of evidence would be prioritised, with other factors considered in formulating the implementation plan for the wider strategic approach.

By focusing on investments over $200m, we could consider investments that have a measurable impact in the analysis tools available, at a sub-regional level. Additionally, by prioritising investments of this scale, it was possible to address a majority of the prioritisation problem by looking at a relatively small number of investments. This approach does mean that many investments have not been prioritised (i.e. the Indicative Package does not list specific investments with less scale although they were included in modelling and overall cost calculations).

Finally, some major new investments were not considered in the prioritisation. These included investments necessary to realise the strategic approach, such as those necessary for smarter pricing or intelligent network management, as there is currently insufficient information on their costs and timing.

10.2. Methodology

The prioritisation methodology resulted in each investment being rated as high, medium or low against two criteria:

- Extent to which investment targets the most significant first decade challenges
- Potential to deliver value for money in the first decade

The extent to which an investment targets the challenges was rated using the multi-criteria analysis outlined below.

Alignment with Objectives						
Objective	**First decade focus**	**Targets most significant first decade challenges**				
Employment accessibility	Improve accessibility, particularly from west and south	✓✓✓ Addresses AM peak accessibility from the west	✓✓ Addresses AM peak accessibility from the south, or to the city centre, Airport or Westgate/ Whenuapai	✓ Addresses AM peak accessibility in other areas	- Does not improve accessibility	
Congestion	Address severe congestion on the strategic road network, particularly in the inter-peak period	✓✓✓ Impacts areas with: - AM peak V/C ratios > 1.0- Inter-peak V/C ratios > 0.9	✓✓ Impacts areas with: - AM peak V/C ratios > 0.9- Inter-peak V/C ratios > 0.8	✓ Impacts areas with: - AM peak V/C ratios > 0.8	- Impacts areas with AM peak or inter-peak V/C ratios < 0.8	
PT Mode Share	Increase peak person throughput on high volume corridors with targeted PT investment	✓✓✓ Increases PT capacity on corridors with 2-hour AM peak volumes > 10,000 people	✓✓ Increases PT capacity on corridors with 2-hour AM peak volumes > 5,000 people.	✓ Increases PT capacity on corridors with 2-hour AM peak volumes > 2,000 people.	- Does not increase PT capacity.	X Detracts from an objective
Enables Growth	Enable housing growth; particularly SHAs and greenfield growth in the northwest and south	✓✓✓ Direct requirement for new housing in priority greenfield areas (SHAs, northwest and south).	✓✓ Enables and supports growth in priority greenfield areas (SHAs, northwest and south).	✓ Enables and supports growth or intensification enabled by the unitary plan	- Does not support identified growth areas	

To enable a consistent comparison of potential value for money, we developed a framework that enabled measurement of the main value for money components, alongside the intervention's estimated cost.

Potential Value for Money	
Measure of Potential Benefits	**Indicator**
Amount of housing enabled	Expected growth in number of households by 2028
AM peak throughput	Modelled change in AM peak person throughput at end of first decade as a result of the project (public transport and road)
Corridor AM peak travel speed	Modelled change in AM peak road speed at end of first decade as a result of the project
Corridor inter-peak speeds	Modelled change in inter-peak road speed at end of first decade as a result of the project

Investments were ranked by the total of their ratings, with the highest scoring third being rated as 'high', the middle third rated as 'medium' and the lowest third rated as 'low'.

The objective relating to *net user benefits* was not relevant to the prioritisation framework. This is because the prioritisation framework did not consider any additional costs which might result for users from funding the investments and the investments considered were infrastructure related and therefore did not include pricing scenarios.

The evidence for all these factors was considered to establish relative potential value for money in the first decade. In some instances this included significant additional evidence on specific projects that had been provided through the course of the project (e.g. the Additional Waitemata Harbour Crossing and the Isthmus Mass Transit). The findings relating to these areas can be found in relevant sections in this report and the *Recommended Strategic Approach*.

10.3. Priorities

The following table presents the result of the prioritisation.

		Potential to deliver value for money in first decade		
		High	**Medium**	**Low**
Extent to which investment targets most significant first decade challenges	**High**	• *New or upgraded arterial roads to enable greenfield growth in priority areas* • *Northwestern Busway*	• *AMETI Pakuranga-Botany*[9] • Isthmus mass transit • SH16 added road capacity	• Upper harbour rapid transit • Airport mass transit • Mass transit upgrade of Northern Busway
	Medium	• *SH20 Dominion Rd to Queenstown Rd* • *Southern Motorway (Papakura to Drury)* • *SH16 to SH18 connection* • New strategic road to Kumeu	• Southern motorway interchange upgrades at Green Lane and Ellerslie • Mill Road (southern section) • Penlink	• Northern motorway widening (south of Albany) • Waitemata Harbour Crossing improvements • Southwest Motorway (SH20) improvements • Southern Motorway improvements south of Manukau
	Low		• New arterial road to Pukekohe • Improved access to Port/Grafton Gully	• Improved northern airport access • Northern motorway widening (north of Albany)

Investments closer to the top left hand corner of the table are considered higher priorities for completion in the first decade, as they both target more significant challenges and also offer

[9] AMETI was prioritised to confirm timing of remaining phases

better potential value for money. This information was used to formulate the Indicative Package.

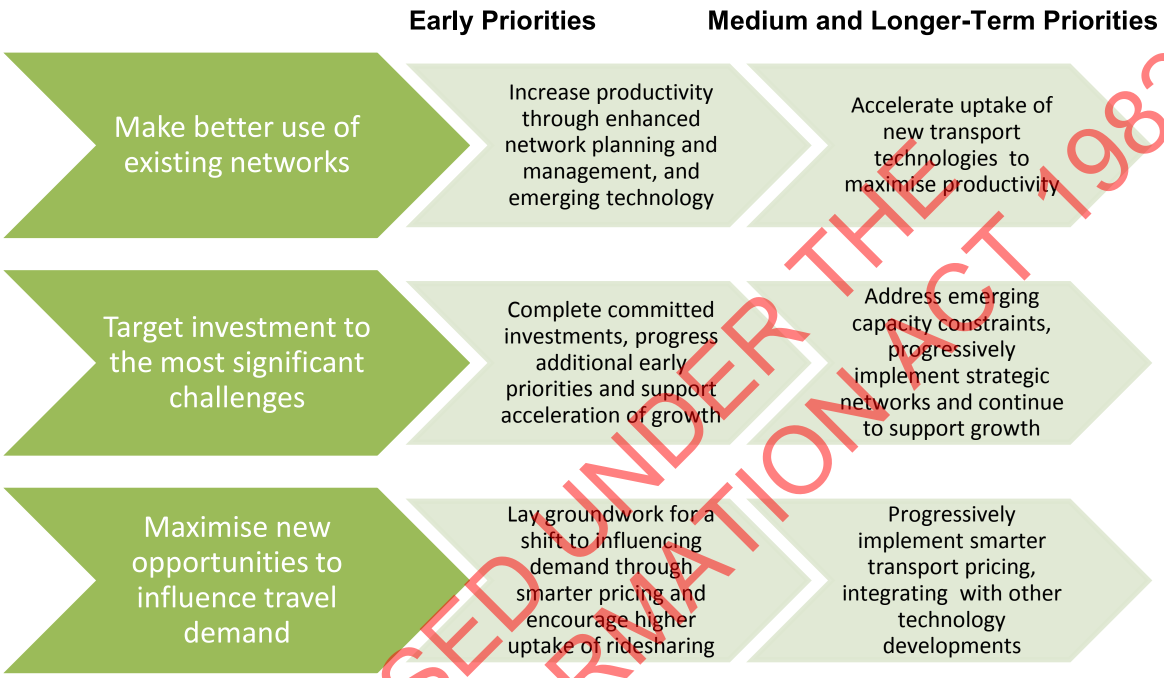
Early priorities, targeted for completion in the first decade are shown in italics. We have included all of the projects with High/High or High/Medium ratings in the first decade, except for:

- New strategic road to Kumeu: information provided by the project team suggested this is a lower priority relative to some other projects in the northwest greenfield area.
- Isthmus mass transit: More detailed analysis provided by the project team suggests that bus improvements could avoid capacity constraints from deteriorating further until around the start of the second decade.
- Added road capacity on SH16 between Te Atatu and Westgate: this was prioritised as part of a future sequencing of the Northwestern Busway (to be confirmed by the appropriate business case).

11. Final Indicative Package

11.1. Overview of Indicative package

As outlined in the *Recommended Strategic Approach*, the final Indicative Package illustrates how the strategic approach could be implemented over time. Therefore, it includes elements from all three key parts of the strategic approach:



The impact of some key elements in the strategic approach is difficult to assess using our available evaluation tools. In particular, we have not assessed the impact of changing technology that could enable increased vehicle throughput and occupancy rates. As discussed in previous sections, we have also assessed a fairly crude version of smarter transport pricing. Including the impacts of technology or a more refined version of pricing is likely to improve performance of the Indicative Package against the project objectives.

While investment to enable smarter pricing is included as a first decade priority, we have assumed implementation in the second decade, meaning that its impact is only assessed by strategic modelling of 2036 and 2046. The price levels used for testing the Indicative Package are the same as those used in Round 3, as shown in section 8.1 above.

11.2. Timing of major investments

The majority of investments likely to occur in the first decade are already committed or partly committed. This includes the City Rail Link, the Accelerated Motorway Package, the Puhoi to Warkworth extension of the Northern Motorway and the East West Link. The indicative priority of investment additional to current commitments is outlined in the table below, and illustrated in the map that follows.

Indicative priorities for major new investments		
Early Priorities (completion in decade 1)	**Medium Term Priorities (completion in decade 2)**	**Longer Term Priorities (completion in decade 3)**
• Northwestern Busway (Westgate to Te Atatu section) • Address bottlenecks on Western Ring Route (SH20 Dominion Rd to Queenstown Rd) and Southern Motorway (Papakura to Drury) • New or upgraded arterial roads to enable greenfield growth in priority areas • Protect routes and acquire land for greenfield networks • Complete SH16 to SH18 connection • Early Rail Development Programme priorities (see paragraph 81) • Upgraded eastern airport access (SH20B) • Investments to enable smarter pricing • Increased investment in Intelligent Network Management • Progress advance works on medium-term priorities	• Continued investment to enable greenfield growth • New strategic roads to Kumeu and Pukekohe • Implementation of mass transit on isthmus and then to the Airport • Bus improvements Airport – Manukau – Botany • Improved access to Port/Grafton Gully • Northwestern Busway extensions • Improve connection between East-West link and East Tamaki • Penlink • Medium-term Rail Development Programme priorities	• Continued investment to enable greenfield growth • Southern Motorway improvements south of Manukau • Southwest motorway (SH20) improvements and improved northern airport access • Northern motorway widening • Waitemata harbour crossing improvements, including mass transit upgrade of Northern Busway • Longer term Rail Development Programme priorities

In allocating major projects to decades, we have used the prioritisation process described in section 10 above, together with a broad spreading of investment across the three decades. This has affected the indicative timing for two major expenditure items (Additional Waitemata Harbour Crossing and Isthmus/Airport mass transit), as discussed below.

Additional Waitemata Harbour Crossing

An additional Waitemata Harbour crossing is estimated to cost around $4 billion and needs to be considered against other investment priorities. Based on the scale of the investment, other Auckland priorities, and the long-term nature of benefits from an additional crossing, we concluded this project – alongside a mass transit upgrade of the Northern Busway – is likely to be required in the long-term (2038-2048).

Our analysis has shown that in the short and medium term, access to and from the North Shore is not as constrained as for other parts of Auckland (particularly the west and south). While an additional crossing could significantly improve access to/from the North Shore, it does not appear to improve congestion on either side of the crossing.

Forecast growth in freight demand indicates that without a new crossing, some restrictions for heavy vehicles using the Auckland Harbour Bridge may be needed by around 2030 to ensure the longevity of the Harbour Bridge. However, economic analysis showed that the costs of any restrictions are likely to have a minimal impact compared with the costs of a new crossing. Heavy vehicles will continue to be monitored and managed to keep motorists and freight moving across the Auckland Harbour Bridge.

We concluded that the overall the timing of an additional crossing is likely to be driven by a combination of factors, including providing sufficient cross-harbour capacity for private vehicles and public transport, improving the resilience of the transport network, and the need to manage heavy vehicle traffic on the existing bridge.

Mass transit

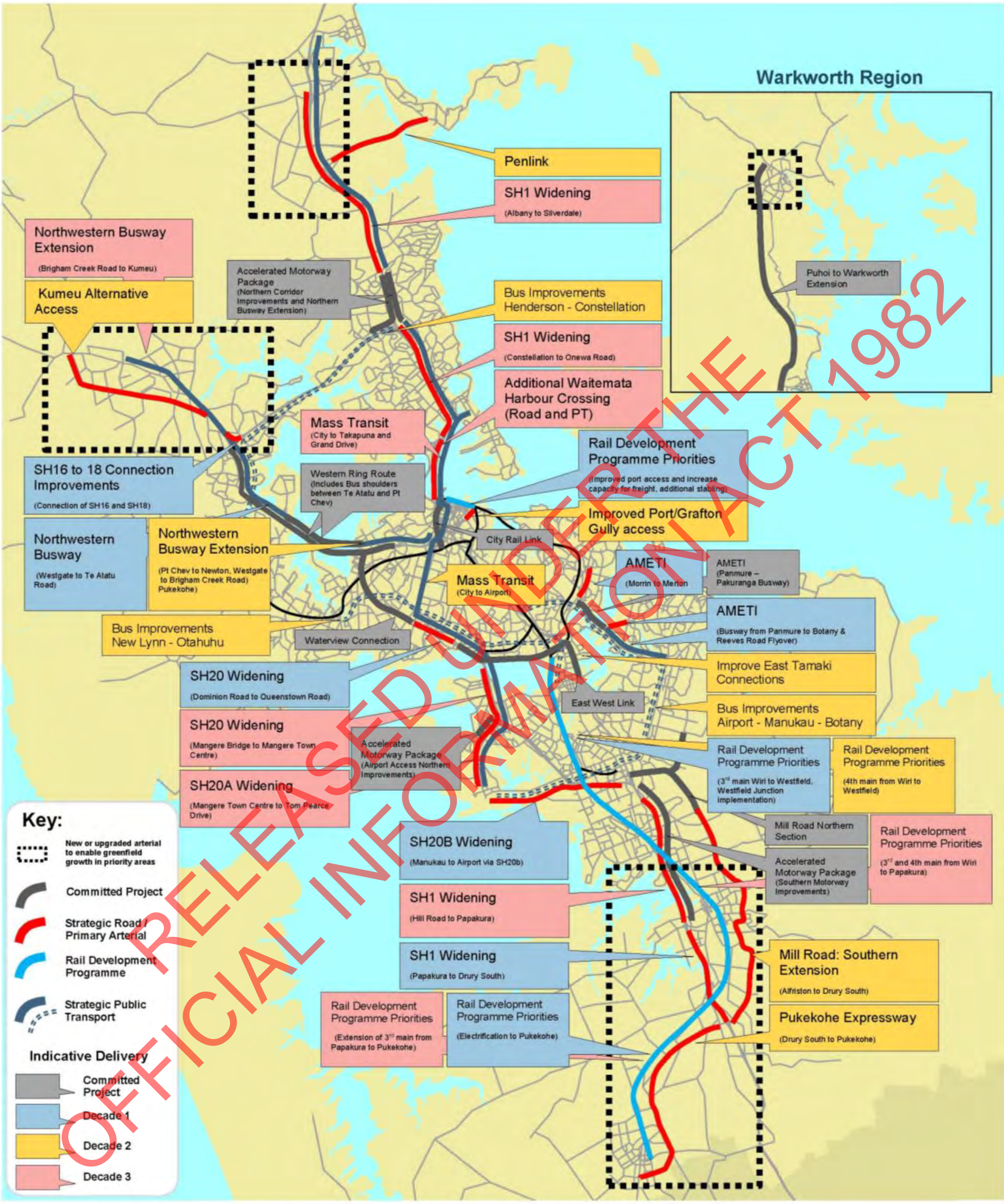
Mass transit proposals respond to growth in public transport, particularly in central Auckland where there are limited opportunities to deliver large scale efficiency improvements or increase capacity in the existing bus system.

Mass transit improvements (possibly light rail) to serve the central isthmus would cost around $1.2 billion for a line from the city centre to Mt Roskill. We considered the challenges addressed by investing in mass transit and the expected costs and benefits.

Based on current forecasts, we concluded that the constraints in central Auckland can be managed through bus efficiency improvements for the next 10 years. Efficiency improvements over the next decade include continuing the roll out of double decker buses, changes to bus stops, and improving the routes taken into the central city.

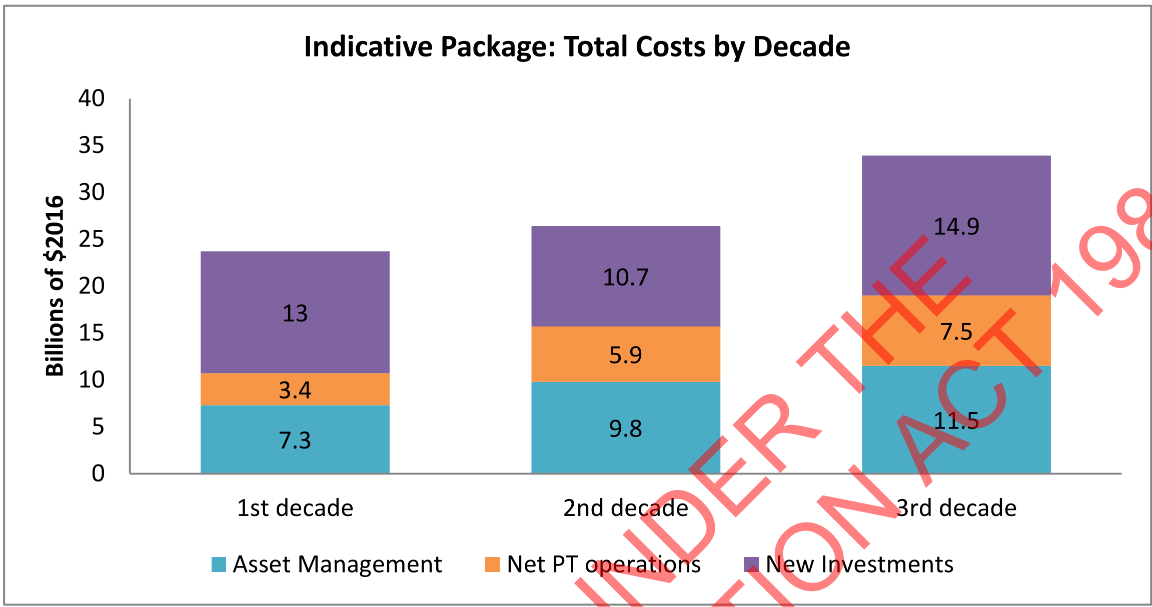
On that basis, we concluded that a higher capacity mode, possibly light rail, is likely to be required on the central isthmus in the medium-term (2028-2038), and subsequently extended to Auckland Airport.

Indicative Package: major investments by decade



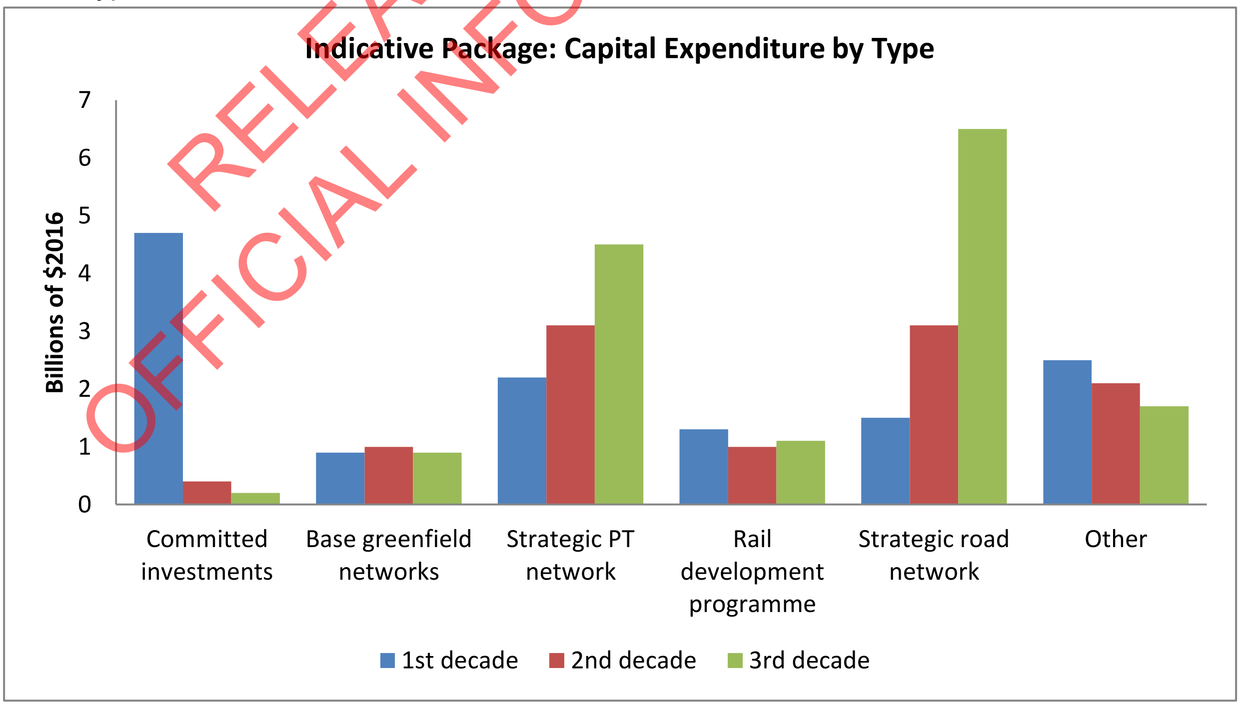
11.3. Cost estimates for Indicative Package

The total estimated 30-year cost of the Indicative Package is $84 billion (in 2016 dollars). The following graph provides a breakdown of costs by decade and across major investment types (asset maintenance, operations and asset renewals, net public transport operations and new investments):



Source: ATAP Revenue & Expenditure workstream estimates, ATAP round 4

Of the total package, $38.6 billion (in 2016 dollars) is capital expenditure (excluding renewals). The following graph provides a breakdown of those costs by decade and by broad type.



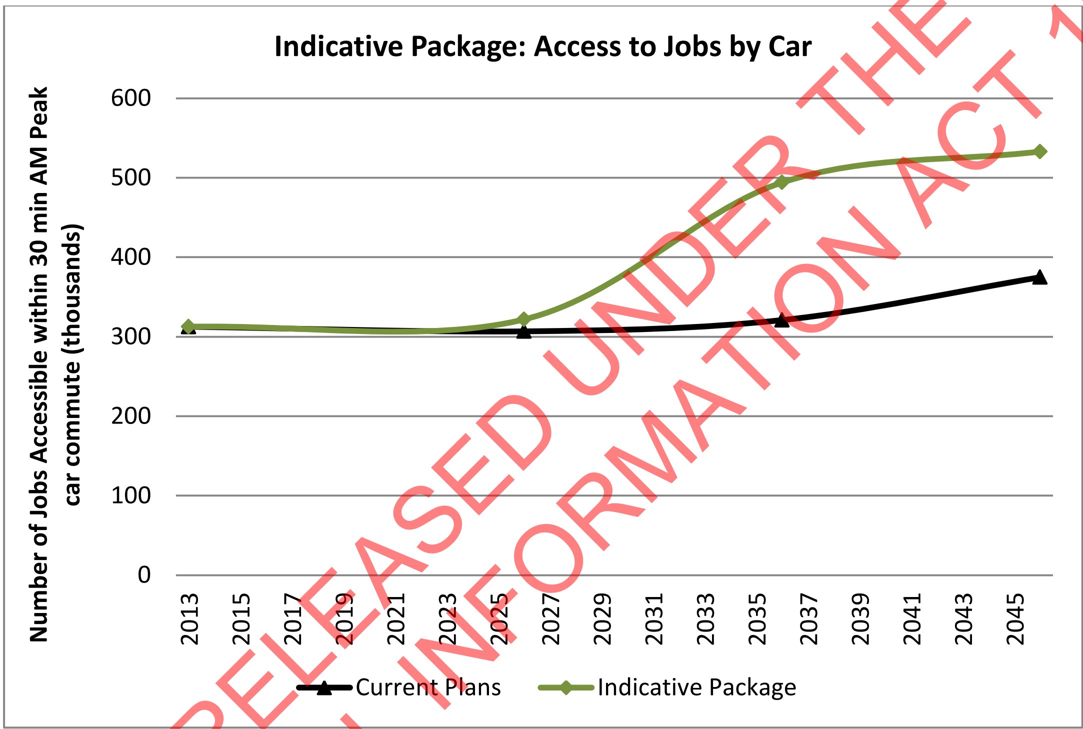
Source: ATAP Revenue & Expenditure workstream estimates, ATAP round 4

12. Indicative Package Evaluation

Evaluation of the Indicative Package was primarily focused on understanding the extent to which it could provide better returns from transport investment than the APTN against the project objectives. Note that the graphs in this section refer to the APTN as "current plans".

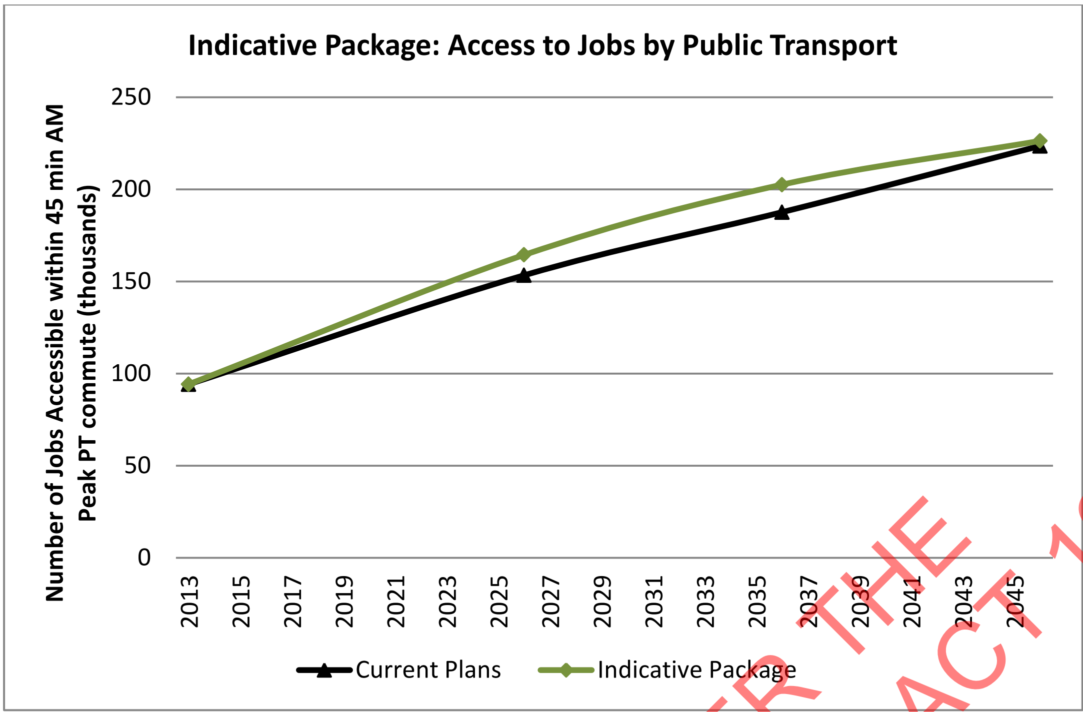
12.1. Access to employment

Access to employment by car under the Indicative Package shows a significant improvement in the second decade in response to the implementation of smarter pricing. Additional third decade investment in the Indicative Package provides further increases in car accessibility. Overall, the Indicative Package provides access to around 160,000 more jobs within a 30-minute morning peak car trip in 2046 than the APTN.



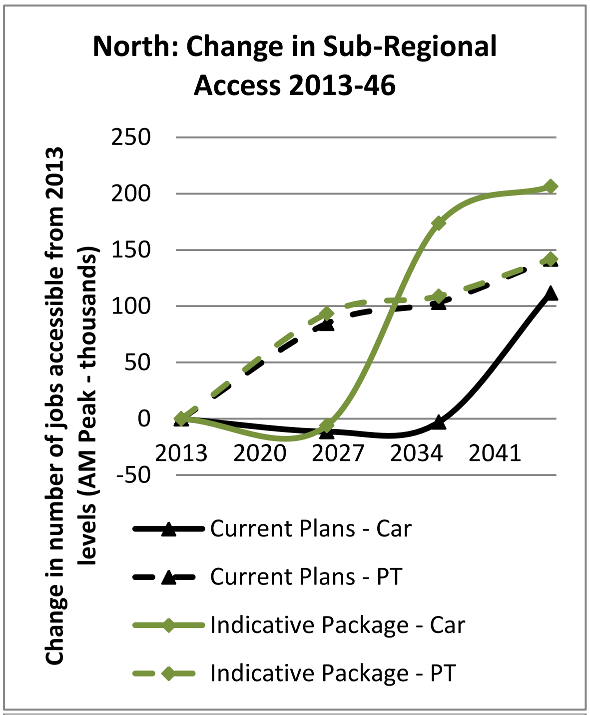
Source: ART3 model outputs, ATAP round 4

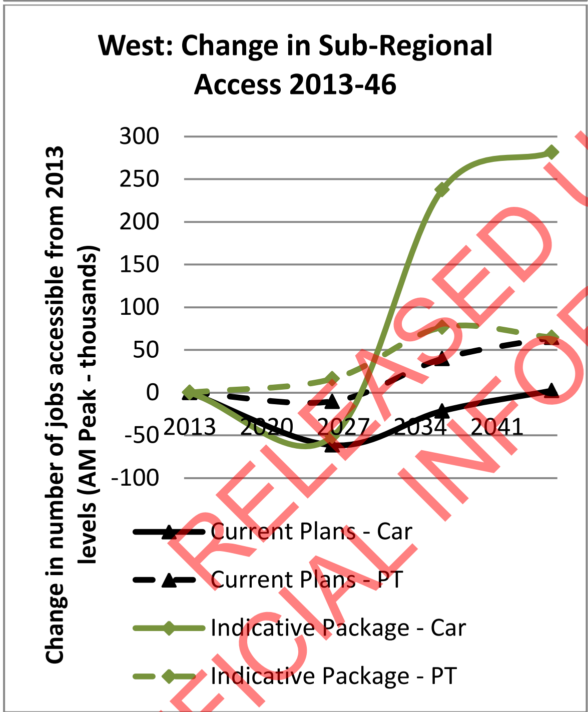
Public transport accessibility outputs are similar to the APTN. However, they do indicate the Indicative Package would provide slightly better public transport access than current plans and significant growth from current levels.



Source: ART3 model outputs, ATAP round 4

Sub-regional car accessibility was highlighted as a major challenge in Phase One of the project, particularly for the west and south. The graphs below show sub-regional results.





North:

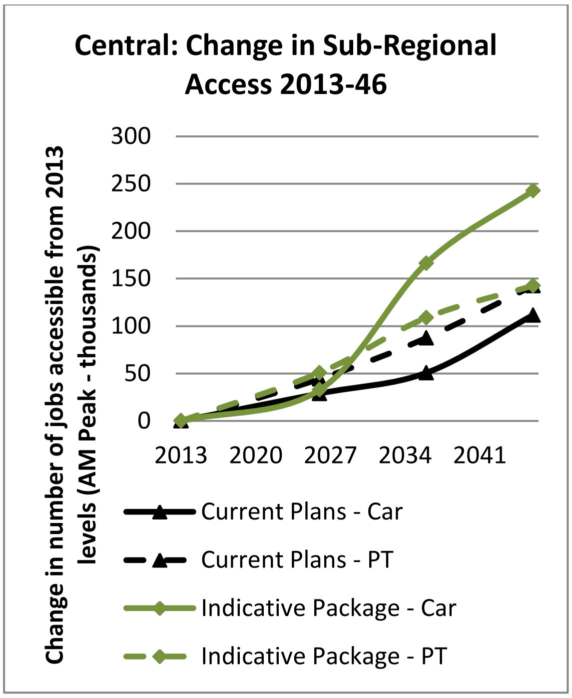
Car accessibility for both packages does not improve in the first decade. Subsequently, the introduction of smarter pricing significantly improves car access, which is continued to a minor extent in the third decade by construction of a new harbour crossing.

Public transport access increases at a similar level for both packages throughout the next 30 years, with increases in the third decade driven by a major upgrade to a higher capacity mass transit option from the North Shore to the city centre.

West:

Car accessibility is projected to get worse in the first decade for both packages, and only just fully recovers by 2046 under current plans. In the Indicative Package, the introduction of smarter pricing is very effective - bringing almost an additional 250,000 jobs within reach of a 30-minute car commute.

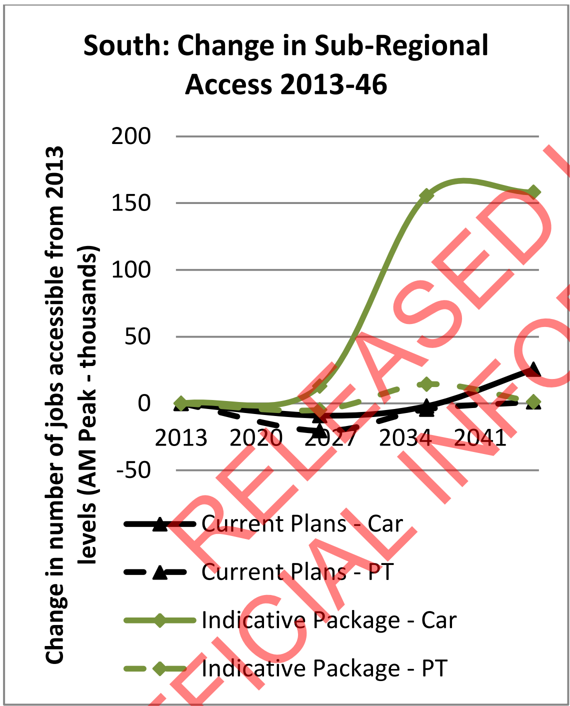
The Indicative Package provides noticeably higher public transport access in the first and second decades.



Central:

Both car and public transport accessibility steadily increase throughout the 30-year period in current plans, reflecting the large growth in employment projected in central Auckland.

The Indicative Package provides a much greater increase in car accessibility in the second and third decades.



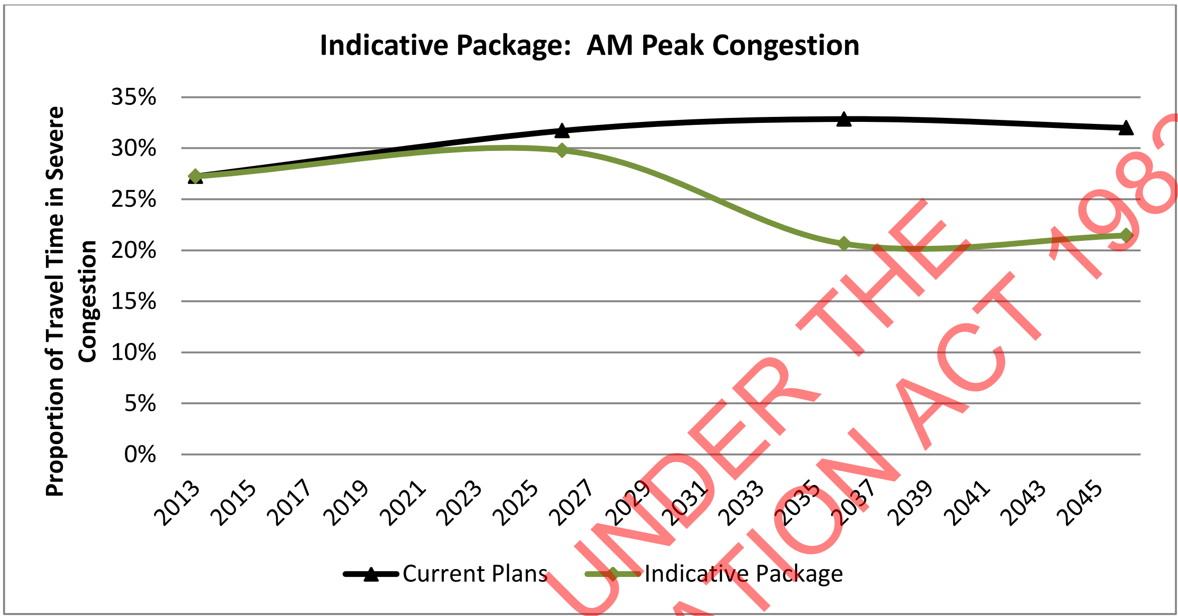
South:

Current plans would result in poorer access over the first decade and minimal accessibility improvements over the next 30 years for either car or public transport.

Under the Indicative Package there is a marked improvement in car accessibility in the second decade, driven by the implementation of pricing. However, public transport access in the south remains low under the Indicative Package, barely increasing at all over time.

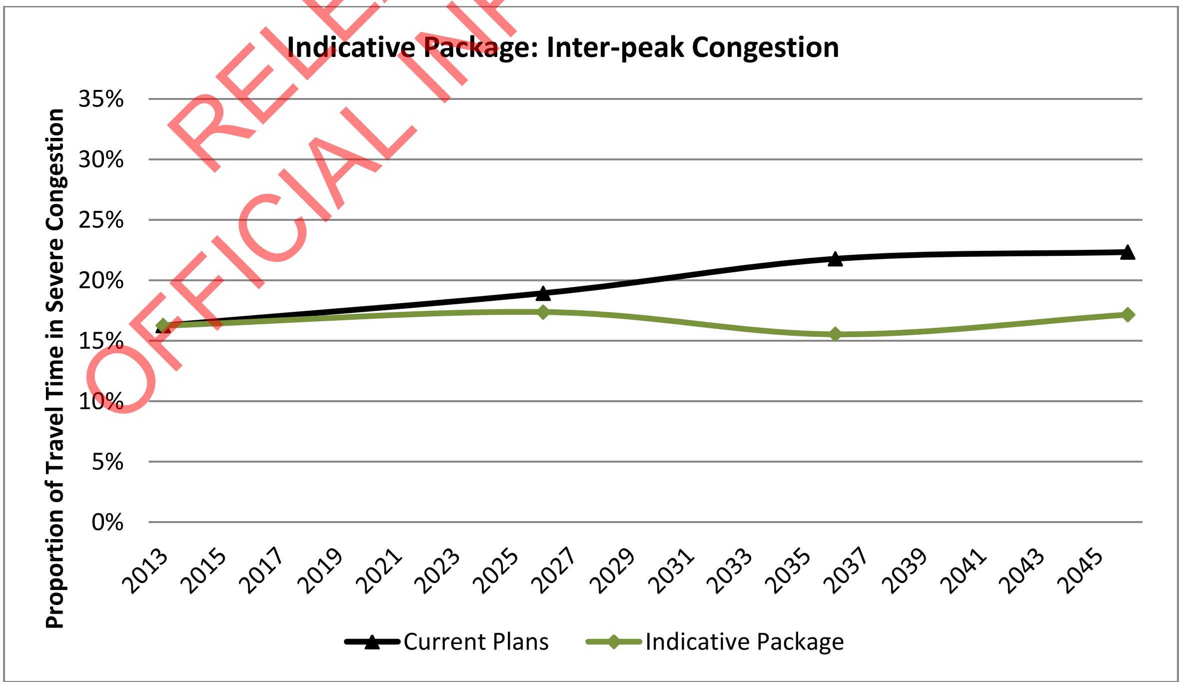
12.2. Congestion

The Indicative Package addresses congestion to a greater extent than the APTN. The proportion of travel time in severe congestion during the morning peak, across the whole transport network, is projected to decline from 27% to 21% over the next 30 years. As previously noted, this result is mainly achieved through progressively implementing smarter pricing rather than increasing the level of investment in infrastructure.



Source: ART3 model outputs, ATAP round 3 and 4

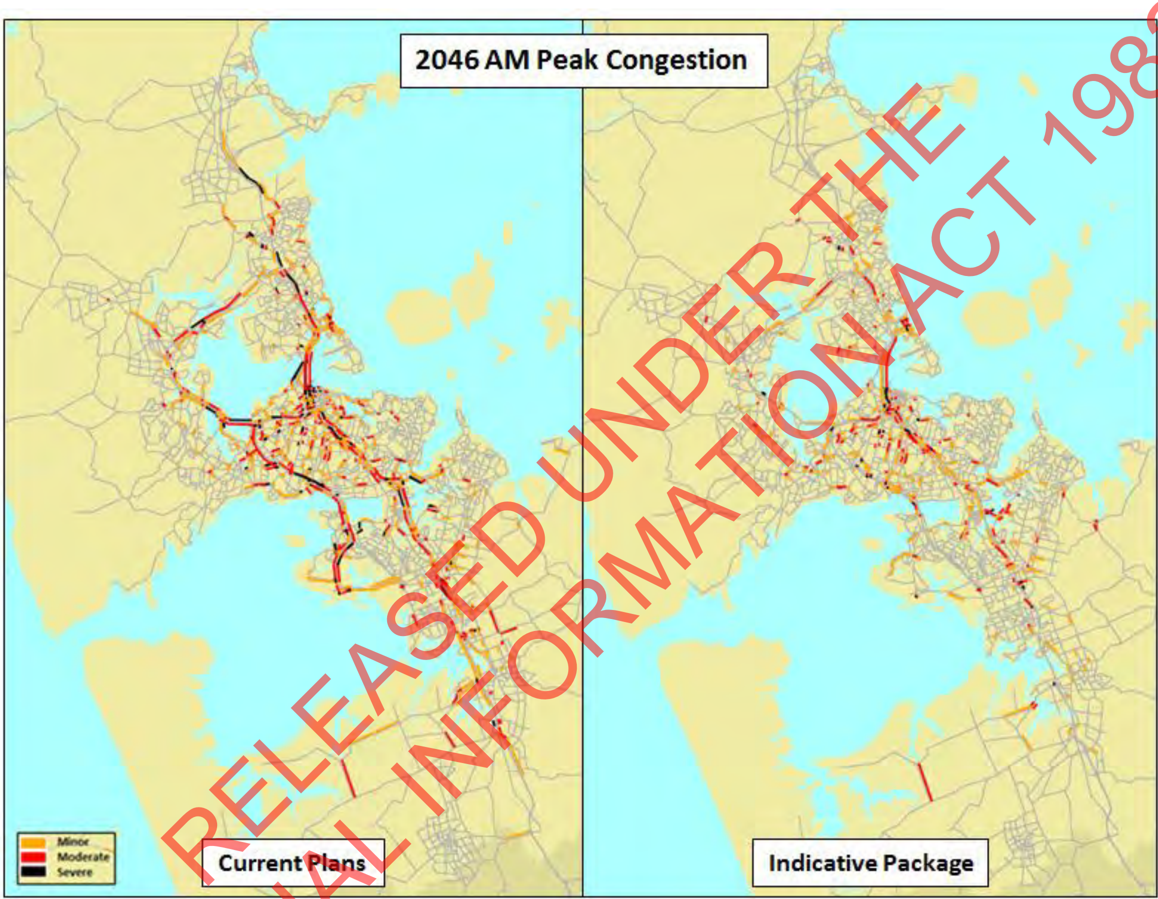
Projected inter-peak congestion shows similar trends, with the introduction of smarter pricing holding congestion at around 2013 levels over the next 30 years, despite population and employment growth.

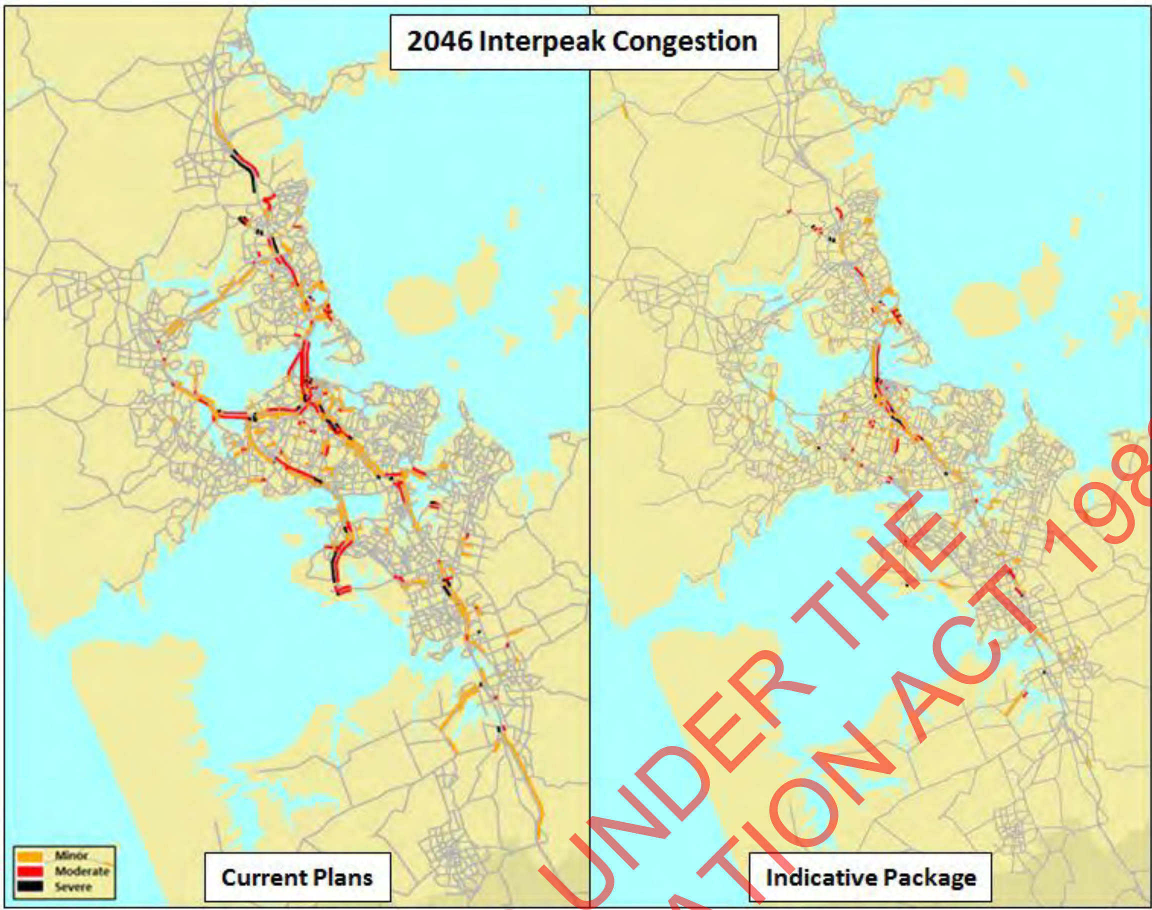


Source: ART3 model outputs, ATAP round 3 and 4

The much lower levels of congestion in the Indicative Package, compared to the APTN, are illustrated in more detail in the following volume/capacity plots. While some patches of congestion remain, most of the network is operating below moderate or severe congestion levels in 2046.

In contrast, under the APTN much of the transport network, particularly the motorway network, is projected to experience moderate or severe congestion during peak periods (and increasingly during the inter-peak). With the Indicative Package severe congestion is reduced to isolated pockets. Further refinement of investment may enable these areas of congestion to be addressed over time.

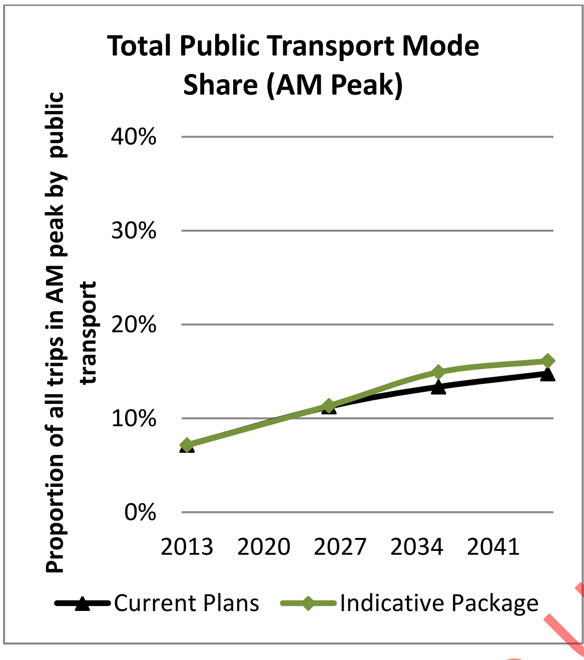


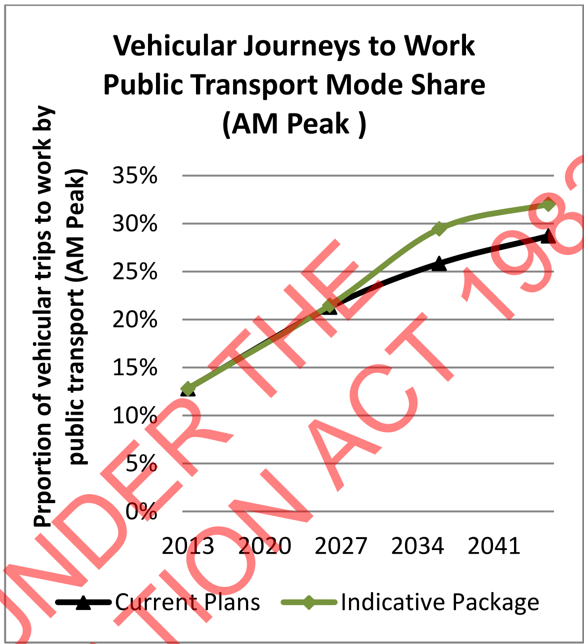


Source: ART3 model outputs, APTN analysis and Round 4

12.3. Public transport mode share

The Indicative Package increases public transport mode share for all trips in the morning peak from what is projected to occur under current plans. By 2046, around 16% of all trips are projected to be made via public transport under this package compared with 15% under the APTN.





Approximately a third of vehicular journeys to work (trips to employment either by public transport or private vehicle) in the morning peak are projected to be taken by public transport by 2046 under the Indicative Package compared with 29% under the APTN. Combined with population growth, this growth in public transport mode share is projected to increase annual boardings from 83 million (in the year to July 2016) to around 265 million over the next 30 years.

12.4. Value for money

The project's Terms of Reference require consideration of the costs and benefits of alternative combinations of interventions and whether better returns can be achieved from transport investment than current plans. Value for money is normally assessed through cost benefit analysis, which compares the level of benefits against the size of an investment.

We used outputs from Auckland's regional transport models to estimate the total quantum of benefits from the Indicative Package (relative to a base investment).

In undertaking this value for money assessment, large differences between the cost benefit calculations at a 'package-wide' level and at a 'project' level became clear. In particular, more refined project level analysis appeared to capture project benefits to a much greater degree than the package wide analysis. Limitations of the strategic modelling tools[10] were considered to be the likely cause of this difference and therefore we did not rely on package-wide cost benefit assessment based on modelling outputs.

Instead, we focused on assessing the Indicative Package's value for money in the following ways:

- Ensuring identified 'early priorities' are likely to provide value for money if they are implemented over the next decade. Our prioritisation framework assessed the likely relative costs and benefits of major investments.
- A number of identified early priorities have existing value for money assessments indicating they deliver benefits that exceed their costs.
- Analysis against our evaluation framework showed the Indicative Package will deliver better region-wide outcomes than current plans and significantly better results than a higher investment package that did not include smarter pricing. This finding suggests that the inclusion of smarter pricing is key to achieving value for money.

Beyond these early priorities it becomes more challenging to assess value for money, as uncertainties relating to project costs, the location and quantum of growth, and the impacts of smarter pricing and new technologies become increasingly significant. Our most substantial uncertainty relates to large, longer-term infrastructure investments. The timing and scope of these investments should be monitored over time, particularly with regard to whether they provide value for money as we shift to a greater focus on influencing demand.

12.5. Full evaluation results

The following table presents the results of our evaluation of the Indicative Package against the evaluation criteria established in the *Foundation Report*. The results relate to the 2046 year, unless otherwise specified.

[10] Discussed further in the Evaluation Working Paper.

Objective	Measure	Headline KPI	Indicative Package	APTN	Comment in relation to Indicative Package
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30-minute trip in the AM peak [313,000 (51% of available jobs) were accessible in 2013] • Jobs accessible by public transport within a 45-minute trip in AM peak [94,100 (15% of available jobs) were accessible in 2013] • Proportion of jobs accessible to other jobs by car within a 30-minute trip in the inter-peak [466,529 jobs (75% of available jobs) were accessible in 2013]	533,000 i.e. 60% of available jobs 226,000 i.e. 25% of available jobs 656,000 i.e. 74% of available jobs	386,000 i.e.43% of available jobs 215,000 i.e. 24% of available jobs 590,000 i.e. 66%	The Indicative Package significantly increases car accessibility (measured only in relation to travel time, not financial cost) in the morning peak (7-9 am) in 2046, with a moderate increase in accessibility by public transport. Car accessibility (measured only in relation to travel time, not financial cost) during the day is at similar levels in 2046 as in 2013.
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak	4 hours 8 minutes per person per annum 21.4% AM 17.2% inter-peak	13 hours 33 minutes per person per annum 31.9% AM 21.9% inter-peak	Forecast congestion on the road network is significantly better throughout the day, compared to the APTN.
	Impact on freight and goods (commercial traffic) congestion	• Proportion of business and freight travel time spent in severe congestion (in the AM peak and inter-peak)	10.1% AM 8.0% inter-peak	18.6% AM 12.9% inter-peak	Forecast congestion on the freight network is significantly better throughout the day, compared to the APTN.
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, inter-peak and PM peak.	9% AM 7% inter-peak 11% PM	19% AM 13% inter-peak 23% PM	Forecast reliability of travel times for motor vehicle trips is expected to be significantly better throughout the day, compared to APTN.

Objective	Measure	Headline KPI	Indicative Package	APTN	Comment in relation to Indicative Package
Increase public transport mode share	Public transport mode share	• Proportion of vehicular trips in the AM peak made by public transport	20.1%	18.0%	Forecast public transport mode share is slightly higher than APTN.
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 9 km in the AM peak made by public transport	37.4%	31.7%	It is forecast that a higher proportion of longer commute trips would be by public transport in the Indicative Package than APTN.
	Increase vehicle occupancy	• Average vehicle occupancy	-	-	It wasn't possible to model changes in vehicle occupancy. The input assumptions of 1.36 people per vehicle in am peak and 1.25 in inter-peak remained constant for all packages and all model years. The Indicative Package includes programmes to increase vehicle occupancy.
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	-	Not applicable	Financial costs (see pricing schedule) replace current road user charges and fuel excise duties. Savings in travel time and VOC vary by trip. This analysis requires better model/tools to provide robust quantification of benefits.
Ensure value for money	Value for money	• Package benefits and costs	-	-	Package benefits include the contributions to objectives as measured in this table. The total cost of the 30 year programme is estimated as $84 billion (in 2016 dollars).

In addition to the project objectives, a number of other key outcomes have been evaluated through the evaluation framework below.

Other Key Outcomes	Measure	Headline Key Performance Indicator	Indicative Package	APTN	Comment in relation to Indicative Package
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Does not meet timeframes of FULSS.	Approximately half of major greenfield network projects are programmed to be in place in accordance with timeframes of the FULSS.
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled	-	-	Model forecasts can't identify number of deaths and serious injuries.
	Emissions	• Greenhouse gas emissions	7.4 million kg of CO_2 per day	8.1 million kg of CO_2 per day	Model forecasts 9% fewer emissions in Indicative Package than APTN. This is mostly due to fewer trips and shorter distance of trips.
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog	The Indicative Package programme is expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears any renewals backlog.	Similar to Indicative Package	The maintenance and renewals programme aims to achieve service levels that reflect the ONRC and AT's goal of attaining a network 'steady state' and achieve consistent levels of service across legacy networks.
Social inclusion and equity	Impacts on geographical areas	• Access employment in high deprivation areas • Distribution of impacts (costs and benefits) by area	Compared to the APTN, accessibility improves for high deprivation areas, but access by motor vehicle is subject to pricing.	The Deficiency Analysis identified significantly lower levels of access in the south and west.	The Indicative Package has prioritised investment in the first decade to improve access from the south and the west. The evaluation working paper contains graphs showing the geographic impacts of the Indicative Package.

Other Key Outcomes	Measure	Headline Key Performance Indicator	Indicative Package	APTN	Comment in relation to Indicative Package
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network	-	-	The Indicative Package network has a similar level of network resilience to the APTN. Resilience is improved in the Indicative Package in the following ways: Firstly, pricing of the road network reduces vehicle kilometres travelled on the road network by about 10% which could result in less diversion and impact in the event of disruption to the road network. Secondly, there is greater capacity in the public transport network. This enables public transport to take additional people in the case of disruption. Optimisation of technology provides choice and information during a disruption. There are a similar number of additional crossings in the IP compared to the APTN.

13. Risks and Uncertainties

As with any exercise that involves future forecasting – in this case, up to 30 years – it is important to recognise the risks and uncertainties that are inherent in our conclusions. The most significant of these are summarised below.

Subject area	What we assumed	Future risks and uncertainties
Indicative Package	The Indicative Package is not an investment programme, but is intended to provide an illustration of the type and level of interventions that would be required to implement the strategic approach	There is a risk that the Indicative Package will be interpreted as a definitive investment programme, with a level of specificity (especially beyond the first decade) that is not supported by the strategic-level analysis undertaken for the project. Ongoing refinement of proposed investments will be needed at each 3-yearly budget cycle, and specific investments will be subject to business cases.
Population growth	Population growth over 3 decades based on Statistics NZ medium growth projections	Recent population growth rates have exceeded the medium projections. A continuation of high growth rates could bring forward the need for some of the interventions outlined in this report.
Land use	Future location of households and employment based on an interpretation of the Auckland Plan urban growth and future urban land supply strategy	The Council's decisions on the Unitary Plan are broadly consistent with the land use assumed for ATAP. However, the exact timing and location of growth will be determined by market decisions which may vary from what has been assumed, especially in new growth areas. Faster growth in these areas could hasten the need for investment in supporting infrastructure
Technology	Our analysis has generally not made any assumptions on the rate and impact of technology changes, but some scenario testing was undertaken to test the impacts of higher vehicle occupancies and connected vehicle technology.	Our analysis has highlighted the significant potential for new technologies to have a positive impact on the future performance of Auckland's transport system, but the nature of these changes and the speed of uptake remain highly uncertain, as is the potential behavioural and demand response. In general, however, our conservative assumptions mean that an accelerated uptake of new technologies should result in better outcomes than we have reported here.
Pricing impacts	Given the limits of our analytical tools, our testing was based on a relatively simple network-wide pricing system, with behavioural responses based on average value of travel time savings.	As noted in the report, there are a number of risks and uncertainties associated with a shift to smarter transport pricing that will require further more detailed analysis. These include the technical feasibility of a network-wide pricing approach, how users will respond to the new charges, and the social and economic consequences of those responses.
Future Revenue	Local and national revenue potentially available for transport in Auckland has been estimated based on recent historical levels of funding allocated to transport expenditure in Auckland.	A key risk of this estimation is that the National Land Transport Fund (NLTF) is not allocated on a regional basis. The 2015 Government Policy Statement cannot direct funding to any particular project but does direct how much funding may be available by activity class. The use of population as a proxy for an Auckland allocation of the NLTF is the best approximation for revenue for the purposes of this project.

Expenditure	All transport infrastructure and service costs have been considered from a whole of life perspective based on the best available cost information at the time of the analysis. Individual intervention costs have been aggregated for the indicative 30-year package. The purpose of this was to provide an estimated order of cost for the purposes of estimating the overall funding requirements.	There is a risk that the estimated expenditure at an intervention level, particularly in the later decades, may change through subsequent investigations (both in quantum and timing). These reasons include changed scope through business case development, and better information about benefits and risks. It is expected that to a lesser extent, this could affect the nature of the overall expenditure. The technological uncertainties highlighted in this report mean that the nature of some projects/services will change depending on the nature and timing of advances in transport technologies. This will also affect expenditure.

As the emphasis shifts towards implementation of the strategic approach, it is important that steps are taken to better understand these issues, and where necessary to adjust our actions accordingly. This suggests the following steps:

- Establish a monitoring and review programme to identify the extent to which the actual outcomes continue to reflect our assumptions, and whether further analysis and review of the conclusions is required
- Invest in updated and more sophisticated analytical tools, with a particular focus on models that enable better testing of behavioural responses to pricing and technology changes, and more robust assessment of benefits and costs.
- Ensure that business cases for major investments include an assessment of different future scenarios.

Find out more:
transport.govt.nz/atap
aucklandcouncil.govt.nz/atap

Auckland Transport Alignment Project

Technology Report

Role of emerging technologies

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Preface

This is one of a series of research reports that were prepared as inputs to the Auckland Transport Alignment Project (ATAP). It is one of a number of sources of information that have been considered as part of the project, and which have collectively contributed to the development of the recommended strategic approach. The content of this report may not be fully reflected in the recommended strategic approach, and does not necessarily reflect the views of the individuals involved in ATAP, or the organisations they represent. The material contained in this report should not be construed in any way as policy adopted by any of the ATAP parties. The full set of ATAP reports is available at www.transport.govt.nz/atap.

1. Executive summary

The purpose of the technology workstream of the Auckland Transport Alignment Project (ATAP) is to understand the potential impacts of three specific areas of transport technology on Auckland's transport system and their implications for transport over the next 30 years. The three areas of transport technology are:

- Intelligent network management;
- Emerging vehicle technology
- Shared mobility.

These technologies were selected because they are expected to have the greatest potential impact on the performance of Auckland's transport system.

This report was prepared by officials from the Ministry of Transport, the New Zealand Transport Agency, Auckland Council and Auckland Transport. Analysis was peer reviewed by AECOM experts in the United States and New Zealand.

Intelligent Network Management

Intelligent network management encompasses a wide variety of distinct interventions designed to enable a comprehensive real-time understanding of network use, the ability to intervene to dynamically manage travel demand, and the associated data processing capability to perform these functions. Examples include: provision of sensors on the network to monitor traffic movements; adaptive traffic signals; dynamic lanes or information provision to manage demand; and staff capable of using advanced analytical tools to manage the transport network in real-time.

Benefits of intelligent network management include: improved optimisation of existing transport infrastructure (for example by managing traffic flows in response to congestion or incidents); better targeting of maintenance and renewals expenditure; and better planning of new infrastructure investment.

The current state of network management in Auckland is comparatively mature but there is still significant opportunity for improvement. Over the next ten years, the New Zealand Transport Agency and Auckland Transport have tentatively forecast investment of around $350 million in intelligent network management. Initial analysis indicates that additional investment of around $200 million would provide good value for money, enabling Auckland to take better advantage of the latest advances in transport technology and prepare the network for the roll-out and management of connected and automated vehicles (see below).

Emerging Vehicle Technology

Connected automated vehicles (CAVs) is a term used to describe vehicles that are both 'connected' and 'automated' – two distinct areas of vehicle technology. Connected vehicles enable communication between vehicles, infrastructure and other connected devices. Automated vehicles are equipped with technology which enables self-driving features, ranging from partial automation (like single-lane motorway autopilot, closely monitored by the driver), through to fully autonomous vehicles (which require no driver monitoring). Connected and automated vehicles have the potential to significantly improve network performance by increasing lane capacity (through shorter following distances and mitigation of start-stop shockwaves), improving safety (by removing human error, the cause of around 80% of traffic accidents), and improving travel time reliability.

However, the extent of these impacts will depend on what proportion of the fleet are CAVs, and the degree to which efficiency benefits are offset by induced demand. For example, fully autonomous vehicles may stimulate demand by making travel easier for certain groups (e.g. the elderly, people with disabilities or children) or they may encourage more travel as time spent in the vehicle can be used for other purposes. In addition, fully autonomous vehicles could add to congestion through re-positioning trips to pick up new users or park.

While it is difficult to estimate the uptake and impacts of CAVs in Auckland given a high degree of uncertainty, we anticipate that it could be at least 10 years before they start to make a significant difference to network performance. When they do arrive in significant numbers, their impact on increasing lane capacity will be much more prominently felt on the motorway network than on local roads (due to the effect of intersections and more complicated vehicle movements on local roads).

Based on synthesising findings from a comprehensive literature review and taking into account Auckland's particular characteristics, we have made the following estimates for the uptake of CAVs and their corresponding impact on lane throughput. The broad ranges reflect uncertainty regarding the speed at which the technology will become commercially attractive and the extent of any potential central or local government interventions to accelerate uptake.

	2026	2036	2046
CAVs (proportion of fleet)	6 - 11%	22 - 52%	60 - 90%
Increase in motorway throughput[1]	+0.7 – 1.3%	+3.8 – 16.3%	+21.3 – 65.3%
Increase in local road throughput	+0.2 – 0.4%	+1.3 – 5.4%	+7.1 – 21.8%

Shared Mobility

Shared mobility is the shared use of transport modes other than public transport. Examples include car sharing, ride sharing and bicycle sharing, often facilitated by websites or smart phone apps.

Potential benefits of shared mobility include: reducing congestion by increasing vehicle occupancy at peak times; extending public transport catchment areas through better first and last leg connections; and providing greater access and choice to users of the transport system.

In the long run, shared mobility may extend to the widespread use of shared fleets of CAVs if they present a more cost-effective travel option than private vehicle ownership for the public.

[1] Measured as vehicle/lane/hour.

The elimination of most labour costs with driverless vehicles may result in shared CAVs providing a compelling alternative to private vehicle ownership and some public transport services.

Shared mobility is also key to uptake of ‘mobility as a service’ – the concept that urban travel can be consumed as a service, rather than provided through personally owned modes of transportation. Mobility as a service could work by combining public transport and shared mobility options through a single system (for example a smart phone app), which recommends, manages and pays for the trip.

More work is needed to further investigate the behavioural drivers behind decisions to share transport and what both central and local government could do to facilitate a widespread shift.

Combined impact of technologies

In the long-term, shared fleets of CAVs supported by intelligent network management have the potential to dramatically improve travel time, accessibility and congestion outcomes for Auckland. The impact on traditional public transport is unclear with the potential that patronage could increase or decrease, depending on the extent to which shared CAVs compete against or complement services. Investment in these emerging transport technologies is likely to deliver good value for money for central and local government given the scale of potential benefits and their relatively low cost to implement in comparison to traditional infrastructure.

Further work is required to better understand the potential implications of emerging technology on demand for transport infrastructure. However the need for additional motorway capacity and the provision of lower-demand public transport services appear particularly sensitive to changes in vehicle technology and shared mobility.

Recommendations

- Further investigate the case for increased investment in intelligent network management of around $200 million over the next 10 years (in addition to what is already tentatively forecast by the New Zealand Transport Agency and Auckland Transport over this period).
- Undertake detailed research into the drivers of shared mobility and what central and local government could do to facilitate a widespread shift; including the provision of enabling and flexible regulation, development of an open data policy, and conducting shared mobility trials.
- Further investigate how to best prepare for and potentially accelerate the uptake of connected and automated vehicles.
- Ensure transport agencies involved in Auckland build staff capability in intelligent transport systems and work collaboratively to deliver outcomes.
- Ensure that potential changes in transport technology are taken into account when planning future infrastructure to reduce the chance of stranded investment.

2. Purpose and approach to analysis

2.1. Purpose and scope

The purpose of the technology workstream of the Auckland Transport Alignment Project (ATAP) is to understand the potential impacts of three specific areas of transport technology on Auckland's transport system over the next 30 years. The three areas of transport technology are:

- Intelligent network management;
- Emerging vehicle technology
- Shared mobility.

These technologies were selected because they are assumed to have the greatest potential impact on the performance of Auckland's transport system.

Road pricing is dealt with elsewhere in ATAP, while initiatives to encourage the uptake of electric vehicles and provision of supporting infrastructure is national in scope, with work taking place outside of ATAP.[2]

2.2. Approach to analysis

Preface

Cities around the world are grappling with how to make best use of existing transport technology and plan for the introduction of emerging technology that could significantly alter the nature of urban transport.

The degree to which existing technology is utilised to enable better network management varies considerably city by city, but there is broad international agreement that further investment can yield significant benefits and is value for money.

What is less certain is the timing and impact of emerging technologies, particularly connected and automated vehicles (CAVs) and changes in behaviour towards shared mobility. Very few cities have attempted to forecast the impacts of these technologies on their urban transport systems, yet many acknowledge the potential for a paradigm shift in performance. In response to this uncertainty, a number of jurisdictions are prioritising enabling regulation and trials of CAVs.

Approach

Given the high degree of uncertainty inherent in assessing the potential uptake and impact of transport technology over a 30-year horizon, the work adopted a scenarios-based approach to the analysis, informed by a comprehensive literature review. Projected impacts

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[2] In May 2016, the Government announced its Electric Vehicles Programme, which aims to increase the uptake of electric vehicles in New Zealand. More information can be found on the Ministry of Transport's website at: http://www.transport.govt.nz/ourwork/climatechange/electric-vehicles/

were tested using the Auckland Regional Transport (ART) Model to better understand how these technologies could impact on Auckland's transport system.

Given time and modelling constraints, two scenarios were developed for the rate of technological development, utilisation and associated behaviour change over the next 30 years. One scenario reflects relatively conservative estimates for the uptake of new technology, while the other assumes uptake increases faster than expected, strongly supported by a concerted effort across central and local government.

Analysis was peer reviewed by AECOM experts in the United States and New Zealand. Drafts were shared with AUSTROADS and Dr Marcus Enoch (Senior Lecturer in Transport Studies at Loughborough University, England).

3. Intelligent network management

3.1. What is it?

Intelligent network management encompasses a wide variety of distinct interventions designed to enable a comprehensive real-time understanding of network use, the ability to intervene to dynamically manage travel demand, and the associated data processing capability to perform these functions. Examples include: provision of sensors on the network to monitor traffic movements; adaptive traffic signals; dynamic lanes or information provision to manage demand; and trained professionals using advanced analytical tools to manage the transport network in real-time.

Benefits of intelligent network management include: improved optimisation of transport infrastructure (for example by managing traffic flows in response to congestion or incidents); better targeting of maintenance and renewals expenditure; and better planning of new infrastructure investment.

3.2. Current state in Auckland

The current state of transport network management in Auckland is comparatively mature, but there is still significant room for improvement. Notable features of the system include: a relatively small sensor network, two transport network operations centres, the use of an adaptive traffic light control system (planned to be significantly upgraded soon), motorway ramp signalling, traveller information systems (variable messaging signs and websites), and an electronic card-based integrated ticketing system for public transport. Toll charging is carried out on one motorway section (the Northern Gateway). Real-time data analysis and dynamic management of the network are in their infancy.

3.3. Emerging technology and trends

Data collection and analysis

Data collection, analysis and distribution is at the heart of intelligent network management. Without a clear picture of network use, better investment decisions and real-time management of travel demand is not possible.

Closed circuit television cameras and various types of sensors are commonly used to gather information about network use, however their coverage is limited (typically only to key corridors). Extending the reach of sensors across more of the network enables a more comprehensive view of network performance and provides the data necessary for better travel demand management and investment decisions. Sensors however have significant capital and operating cost implications, and a cheaper alternative in third-party data is rapidly gaining prominence.

Data sourced from third parties is likely to play an increasingly important role in intelligent network management. Smart phones, wearable devices and connected vehicles provide a platform for data collection and distribution that does not directly rely on the provision of road-side sensors. Benefits of data sourced from third parties include; reduced cost to central and local government, faster technological upgrade and greater network coverage (assuming relative ubiquity of traveller connectivity). However, commercial sensitivity issues can limit the level of detail and therefore usefulness of third-party data for investment and network management decisions. Targeted investment in developing a more comprehensive sensor network, while actively exploring and leveraging third-party data, may therefore be the most prudent course of action going forward.

Data collected from various sources is most useful if it is available in a form that stakeholders in both the public and private sectors can easily use. Common data standards, aligned to emerging international standards, which take into account accuracy, reliability and privacy requirements, will be necessary to enable this.

Various types of software can be used to interpret and analyse transport data to help inform decision-making. There are three broad types of analytical tools; 'descriptive' (what is happening), 'predictive' (what will happen) and 'prescriptive' (what should the response be). Software to enable descriptive analytics is commonly used in network management today, whereas the more advanced predictive and prescriptive tools have yet to be widely employed (due to data and cost constraints). Once implemented, predictive and prescriptive analytics should enable a faster and more effective response to congestion and incident management.

In addition to data collection and analytical tools, a skilled workforce capable of managing a smart transport network will be needed. All transport agencies involved in Auckland will need to ensure adequate capability.

Dynamic management of the network

Understanding what is happening on the network in real-time is only half of the equation. The other half is the ability to dynamically manage travel demand. Provision of traveller information through radio, variable messaging signs, smart phones, and in the future connected vehicles, is one key way to enable transport users to make better route or mode choices in response to congestion or incidents. Other means involve dynamic physical infrastructure to manage traffic flows such as: adaptive traffic signals, motorway on-ramp signals, dynamic lane and speed control, and enforcement technology.

Preparation for the roll-out of CAVs

In addition to investment to better manage today's transport network, central and local government agencies will need to look ahead for what will be required to support the roll-out of CAVs. Upgrading road marking, connected traffic signals, augmented satellite positioning and/or digital maps (for fully autonomous vehicle navigation) and a radio spectrum for connected vehicles (for vehicle to vehicle communication), will all likely be necessary.

Balancing risks of implementation

It is important not to lose sight of the risks of implementation as new technologies are investigated. Technology changes rapidly and care must be taken to avoid being locked in to particular applications or providers. Waiting for a commercial off-the-shelf solution and being a fast follower can reduce the risk of wasted time and money. On the other hand, deploying new technology early gives network operators the chance to test more creative solutions and form collaborative relationships with suppliers.

The key will be harnessing the benefits of new technology as soon as possible while minimising early implementation risk.

3.4. Key findings

Over the next decade, the New Zealand Transport Agency and Auckland Transport have tentatively forecast around $350 million for investment in intelligent network management. This includes investment in the following broad areas.

Investment	Description	Cost (millions)
Dynamic management of the network	Traveller information provision and tools required to manage traffic movements in real-time such as; adaptive traffic lights, ramp signals, variable message signs, dynamic lane and speed control and incident management systems.	$285
Data collection	Systems to collect, transfer, store and manage data on network use.	$37
Transport Operations Centres	Staffing and other operational costs.	$22
Data analysis	Real-time analysis of performance of the network including limited applications of 'predictive analytics' (what will happen) and 'prescriptive analytics' (what should the response be).	$10

Initial analysis indicates that further investment of around $200 million in intelligent network management over the next decade (2016-2026) is likely to deliver good value for money. Additional investment would also better prepare Auckland to take full advantage of emerging technology, including CAVs, in subsequent decades.

The following interventions and indicative costs are recommended as a basis for a higher investment package (noting substantial further work post-ATAP will be required to develop detailed business cases).

Investment	Description	Cost (millions)
Data analysis	Additional investment would provide comprehensive real-time analysis of system wide performance, enabling more advanced applications of 'predictive analytics' (what will happen) and 'prescriptive analytics' (what should the response be). This investment could also support communication and data transfer with vehicles.	$86
Data collection	Additional investment in information gathering devices (and supporting communication network) to cover more of the transport system.	$38
	Development of an open-source data platform (including both public sector and third party data) to enable a more accurate view of system performance and encourage private sector development of effective transport apps.	$35
Dynamic management of the network	Additional investment in dynamic network management tools to enable rollout on parts of the network not covered by new capital projects.	$8
	Further investment in more comprehensive traveller information provision and tailored services for the freight sector.	$4
Transport Operations Centre	Expansion of the operations centre to manage a larger and more complex intelligent network, and enable better cross-agency response to incidents.	$10

Estimating what intelligent network management investment will be needed for the second and third decades is challenging given a high degree of uncertainty. However, some investment in the following areas is likely to be needed; provision of new forms of sensors, continued development of data integration (including data from third parties which is likely to be more prominent) and infrastructure / initiatives to support the widespread use and management of CAVs.

4. Emerging vehicle technology

4.1. What is it?

Connected vehicles enable communication between vehicles, infrastructure and other connected devices. Automated vehicles are equipped with technology which enables self-driving features, ranging from partial automation (like single-lane motorway autopilot, closely monitored by the driver) through to fully autonomous vehicles (which require no driver monitoring). Connected automated vehicles (CAVs) is a term used to describe vehicles that are both connected and automated.

Emerging vehicle technology has the potential to significantly improve network performance by increasing lane capacity (through shorter following distances and mitigation of start-stop shockwaves), improving safety (by removing human error, the cause of around 80 percent of traffic accidents), and improving travel time reliability. However, the extent of these impacts will depend on what proportion of the fleet adopt new technologies, the provision of supporting infrastructure and regulation, and the extent to which efficiency benefits are offset by induced demand (for example from increased trips by the elderly, children or disabled).

4.2. Current state in Auckland

Auckland has the youngest light passenger vehicle fleet in New Zealand (12.5 years compared to the national average of 14.3). However, this is still relatively old by OECD standards. The makeup of Auckland's fleet points to both the likely delay between introduction to the market of new vehicle technologies and their comprehensive adoption. New vehicles tend to be purchased by companies while individuals typically buy older second-hand vehicles from Japan. Currently very few vehicles have advanced driver assistance systems.

4.3. Emerging technology and trends

Automated vehicles

Vehicle automation is commonly classified into different levels, based on the degree to which human involvement is necessary in driving functions. The Society of Automotive Engineers (SAE) has developed one such classification system, which is widely recognised internationally and is used for this report.

SAE classification system

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability (*Driving Modes*)
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	System	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	System	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	All driving modes

Advanced driver assistance systems (ADAS) which are currently on the market foreshadow the more advanced automated technology currently under development. ADAS systems include the following:[3]

Feature	Introduced	Automation level	Description
Adaptive Cruise Control	2006	1	Automates vehicle speed to keep a set following distance from preceding vehicle using sensors (no communication with other vehicles or infrastructure).
Parallel-park assist	2006	2	Uses cameras and ultrasound to guide the vehicle into a parking space.
Automatic emergency braking[4]	2008	1	Activates itself when the vehicle risks collision with another object.
Lane-keeping technology	2014	1	Warns the driver when the vehicle risks drifting out of its lane and in some versions prevents the vehicle from doing so.

More advanced automated features will to come to market over the next decade, with timing depending on the validation of technology by manufacturers and regulation in various jurisdictions (particularly large key markets). Based on likely readiness of technology and manufacturer announcements, the following timeframes for commercial introduction of automated features are estimated:[5]

[3] *Revolution in the driver's seat, the road to autonomous vehicles.* The Boston Consulting Group. April 2015.
[4] The Government's Safer Journeys Action Plan 2016-2020 has an action to undertake initial investigation by December 2017 on the value of mandating automatic emergency braking for all vehicles except motorcycles.
[5] *Revolution in the driver's seat, the road to autonomous vehicles.* The Boston Consulting Group. April 2015.

Feature	Expected introduction	Automation level	Description
Single-lane highway autopilot	2015/16	2	Enables a vehicle to drive itself in a single lane on a highway.
Traffic jam autopilot	2017	2	Takes control of vehicle functions in low-speed stop-and-go traffic conditions.
Automated valet parking	2017	3	Enables the vehicle to park and retrieve itself when summoned (however, the vehicle cannot independently find a vacant parking space).
Highway autopilot with lane changing	2018	3	Enables the vehicle to drive itself on highways, including changing lanes.
Urban autopilot	2022	4	Allows the vehicle to drive itself in virtually all urban environments at low speed.
Full automation	2025	5	Enables the vehicle to drive itself in almost any environment without driver intervention or constant monitoring (limitations of operation in severe weather conditions are yet to be determined).

Connected vehicles

In addition to automated features, a number of connected features are likely to be introduced commercially over the next decade.

These features will enable vehicles to:

- communicate with other vehicles;
- communicate with roadside infrastructure; and
- communicate with transport control centres for real-time data exchange.

These capabilities will facilitate traveller information and navigation, safety alerts and warnings, improved maintenance diagnostics, infotainment, software updates, and potentially provide a platform for road pricing in the future.

Most importantly, connected vehicles (particularly when coupled with vehicle automation) have the potential to significantly improve the efficiency of urban roading networks. This is achieved through vehicle-to-vehicle communication features like Cooperative Adaptive Cruise Control (which enables shorter following distances and mitigation of start-stop shockwaves) and dynamic management of traffic flows.

Retrofitting connected and automated features

While increasing numbers of new vehicles will be equipped with connected automated features, a significant after-market industry is also likely to emerge in the decades ahead to enable older vehicles to be upgraded to various levels of connection and automation. One such application which may hold some promise in the medium term is 'here I am' communication units. These relatively inexpensive, after-market units (estimated at around US $100-200) could be installed in older vehicles to enable some of the capacity benefits of higher level connected vehicles to be realised in advance of fleet turnover (as well as potentially providing a platform for road pricing).[6]

4.4. Key findings

Uptake

Projections for uptake of emerging vehicle technologies vary widely. For example, some studies predict as high as 75 percent fleet penetration of fully autonomous vehicles by 2040 (Institute of Electrical and Electronics Engineers) while others only predict 50 percent penetration by 2055 (Todd Litman, Victoria Transport Policy Institute).

Making projections is difficult given the diverse nature of challenges to the widespread uptake of emerging vehicle technologies, chief among which include issues around; safety, liability, reliability, cyber security, privacy, cost, licensing, the need for digital mapping and other supporting infrastructure, public acceptance and consumer demand, and potentially incompatible communication standards for vehicles sourced from Europe, Japan and the United States. In addition, the extent and nature of potential central and local government interventions to accelerate uptake will have a significant impact.

As emerging vehicle technology will be a key component in the development of Auckland's transport system over the next 30 years, it is necessary to estimate a plausible rate of uptake to inform decision making. To this end, a comprehensive literature review has been undertaken to provide the best possible foundation for forecasts. Estimates were developed by combining analysis on: when vehicle technology is likely to be introduced to the market globally; the additional cost of automated features; willingness to pay surveys; historical trends for uptake of similar vehicle technology; Australian uptake estimates; and Auckland-specific fleet turnover characteristics.

The table below shows the proportion of the vehicle fleet estimated to be automated (according to level) and connected, with broad ranges reflecting uncertainty about the speed of technological development/commercialisation and the degree to which central or local government interventions could accelerate uptake. Note that the table shows that as higher levels of automation enter the vehicle fleet, the proportion of vehicles equipped only with lower levels of automation declines as older technology is updated.

[6] *Impacts of Cooperative Adaptive Cruise Control on Freeway Traffic Flow.* Shladover, S. California PATH Program, University of California, Berkeley. January 2012.

Technology	2026	2036	2046
Vehicle automation			
Level 0 – No Automation	59 - 79%	15 - 38%	5 - 15%
Level 1 – Driver Assistance	15- 30%	33 - 40%	5 - 25%
Level 2/3 – Partial/Conditional Automation[7]	5 - 8%	10 - 20%	10 - 35%
Level 4 – High Automation	1 - 2%	7 - 17%	N/A[8]
Level 5 – Full Automation	<1 - 1%	5 -15%	25 - 80%
Vehicle communication (connected)			
Cooperative Adaptive Cruise Control[9]	6 - 11%	22 - 52%	60 - 90%

Road capacity

To estimate road capacity (or throughput) effects for motorways, the above fleet uptake estimates were matched with results from micro-simulation modelling studies which assess the impact of CAVs as fleet penetration increases. One such study (Shladover, 2012) is used as the basis for road capacity projections in this report because it attempts to incorporate the interaction between humans and technology to provide a more realistic estimate of capacity effects (time-gap settings were selected by members of the general public).

The potential impact of CAVs on local road throughput is less well understood, with literature indicating it to be around one third of motorway throughput impacts due to more complicated vehicle movements (e.g. more lane-changing and intersections).[10]
Shladover's modelling results below show how motorway throughput (measured as vehicles/lane/hour) increases as the proportion of vehicles in the fleet equipped with Adaptive Cruise Control (non-communicating vehicles) and Cooperative Adaptive Cruise Control (communicating vehicles) changes. Remaining vehicles are assumed to be manually driven.[11]

Percentage of ACC Vehicles	Percentage of CACC Vehicles: 10%	20%	30%	40%	50%	60%	70%	80%	90%
10%	2065	2090	2170	2265	2389	2458	2662	2963	3389
20%	2065	2110	2179	2265	2378	2456	2671	2977	0
30%	2077	2127	2179	2269	2384	2487	2710	0	0
40%	2088	2128	2192	2273	2314	2522	0	0	0
50%	2095	2133	2188	2230	2365	0	0	0	0
60%	2101	2138	2136	2231	0	0	0	0	0
70%	2110	2084	2155	0	0	0	0	0	0
80%	2087	2101	0	0	0	0	0	0	0
90%	2068	0	0	0	0	0	0	0	0

[7] Given level 2 and level 3 automation is likely to come to market within a couple of years, we assume the same rate of uptake by 2026 and beyond.
[8] Due to software updates this feature is assumed to be no longer distinguishable from fully automated vehicles by 2046.
[9] We assume all vehicles with level 2 automation or above are equipped with the ability to perform cooperative adaptive cruise control.
[10] *Preparing a nation for autonomous vehicles.* Eno Centre for Transportation. October 2013.
[11] *Impacts of Cooperative Adaptive Cruise Control on Freeway Traffic Flow.* Shladover, S. California PATH Program, University of California, Berkeley. January 2012.

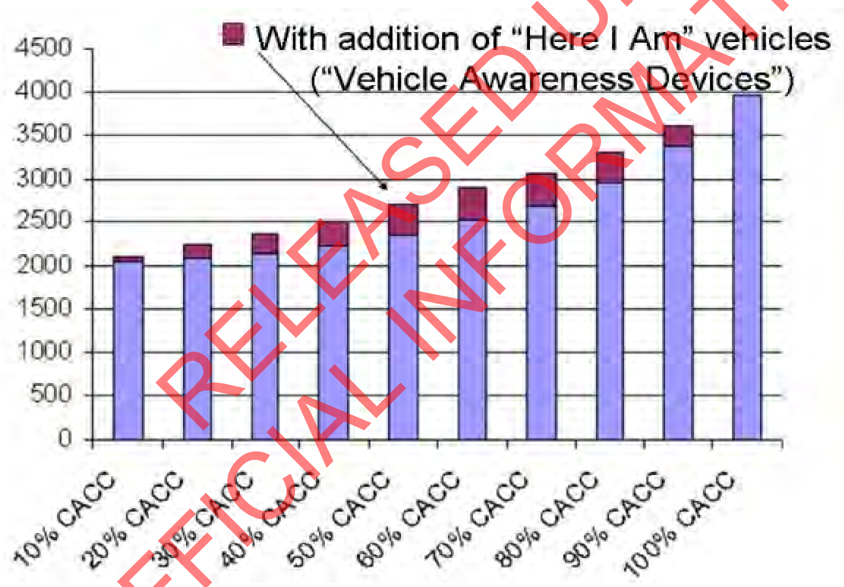
Note that Adaptive Cruise Control is not assumed to significantly improve throughput as driver preference indicates similar following distances to manual vehicles. This contrasts with Cooperative Adaptive Cruise Control where throughput increases dramatically once fleet penetration thresholds are met (around 50-60 percent of fleet). This is because the shorter following distances that Cooperative Adaptive Cruise Control allows over Adaptive Cruise Control are only possible when both the lead and following vehicle are communicating.

Given average throughput on Auckland's motorway network is assumed to be around 2050 vehicles/lane/hour, and using figures from Shladover 2012, we estimate the following road capacity increases on motorways and local roads.

Change in throughput	2026	2036	2046
Motorways	+0.7 - 1.3%	+3.8 - 16.3%	+21.3 - 65.3%
Local roads	+0.2 - 0.4%	+1.3 - 5.4%	+7.1 - 21.8%

It may also be possible to bring forward some of the throughput benefits of vehicle-to-vehicle communication ahead of fleet turnover by equipping non-communicating vehicles with after-market 'here I am' units. These units communicate with Cooperative Adaptive Cruise Control vehicles, enabling them to safely follow closely behind (thus allowing higher throughput at lower Cooperative Adaptive Cruise Control fleet penetration).

The graph below shows the estimated impact of 'here I am' units.



Induced demand

Induced demand from CAVs may well offset some of the capacity benefits outlined above. Additional demand may stem from fully autonomous vehicles making travel easier for certain groups (e.g. the elderly, people with disabilities or children), or it may encourage more travel as time spent in the vehicle can be used for other purposes. In addition, fully autonomous vehicles could add to congestion through re-positioning trips to pick up new users or park.

It is very difficult to estimate to what degree this technology will stimulate demand, however some predict at 50 percent fleet penetration, vehicle kilometres travelled could increase by between 5 and 20 percent. At 95 percent fleet penetration, vehicle kilometres travelled could increase by as much as 35 percent on parts of the network.[12]

Potential interventions to accelerate uptake

Both the central and local government have a number of potential interventions available if increasing uptake of CAVs is deemed desirable. Options include:

- Carrying out trials of CAVs to test impacts
- Investing in supporting infrastructure (e.g. fitting out road-side infrastructure with Direct Short Range Communications capability)
- Ensuring the network is digitally mapped
- Mandating 'here I am' communication units or new vehicle sales being at least level 3 automated
- Creating financial incentives to stimulate uptake (e.g. through tax breaks, subsidies, or free parking)
- Enabling CAVs to use express lanes
- Replacing some low capacity public transport services with fleets of shared CAVs, which likely would either be provided by the private sector under contract to local government, or in free competition.

[12] *Effects of next-generation vehicles on travel demand and highway capacity.* FP Think. Bierstedt. J, Gooze. A, Gray. C, Peterman. J, Raykin.L and Walters. J. January 2014

5. Shared mobility

5.1. What is it?

Shared mobility is the shared use of transport modes other than public transport. Examples include car sharing, ride sharing and bicycle sharing, often facilitated by websites or smart phone apps. In the long run, shared mobility may extend to the widespread use of shared fully autonomous vehicles.

Shared mobility is also key to uptake of 'mobility as a service' – the concept that urban travel can be consumed as a service, rather than provided through personally owned modes of transportation. Mobility as a service could work by combining public transport and shared mobility options through a single system (for example a smart phone app), which recommends, manages and pays for the trip.

5.2. Current state in Auckland

The current extent of shared mobility in Auckland is limited, evidenced by the average car occupancy being 1.45[13] in the morning peak. While ride-sharing and car-sharing schemes exist, they have had little traction to date. The same is true of car-pooling despite Auckland Transport operating a website and conducting promotional campaigns. Auckland has a few small-scale and independent bike-sharing schemes, and websites or apps to enable the public to compare travel options are relatively limited.

5.3. Emerging technology and trends

The 'internet of things'

The internet of things refers to everyday objects being equipped with network connectivity, enabling them to send and receive data. For transport, this means smart phones, private vehicles, public transport, bicycles and infrastructure.

Internet connectivity is important because it enables the location and status of transport networks and services to be monitored and, through smart phone apps or websites, trips to be organised in real-time for users. Ubiquity of connectivity is therefore necessary to enable easy and seamless access to shared mobility options as well as transfers with public transport (thus enabling mobility as a service).

Rise of the sharing economy

Many sectors have been disrupted by the rise of the sharing economy - or peer-to-peer renting of goods or services (e.g. finance and accommodation). Transport is not immune to this trend, with car-sharing and ride-sharing services projected to experience significant growth in some overseas markets.[14]

[13] Household travel survey data for Auckland (average of 2009-2014).

[14] What's Ahead for Car Sharing?: the new Mobility and its impact on vehicle sales, Boston Consulting Group, February 2016

Both the public and private sectors have sought to take advantage of an increasing propensity for transport users to share with varied results. One key lesson from trials of ride sharing services conducted overseas is the importance of achieving sufficient size to enable economies of scale and convenient levels of service for customers.[15]

Shared fully autonomous vehicles

The introduction of fully autonomous vehicles has the potential to facilitate a widespread shift to shared mobility. Fully autonomous vehicles shared between many users would likely significantly reduce the cost of travel as labour costs associated with taxis and public transport could be eliminated. As a result, these shared vehicles could provide a mode of transport which offers the door-to-door level of service of private vehicle travel, at a similar cost to traditional subsidised public transport. However, scale will likely be important to achieve an economically viable and attractive service.

Projections for uptake of shared mobility

While limited evidence exists to make projections for uptake of shared mobility in Auckland (in part due to the complex behavioural drivers behind sharing), Auckland Transport have tentatively estimated the following rates of uptake over the next 30 years.

	2026	2036	2046
Proportion of trips shared	<2 - 5%	5 - 10%	15 - 50%

5.4. Key findings

Potential benefits of shared mobility include:

- Fewer private vehicles on the road during peak travel times as a result of higher average vehicle occupancy, with consequential positive impacts on accessibility and congestion. Results from transport modelling support this, but also show a significant decline in public transport patronage. While mode shift away from public transport towards ride-sharing would be likely to occur in some circumstances, the effect may be much less pronounced in reality, with literature indicating that shared mobility could also support access to public transport spines.
- Increasing public transport catchments areas through better first and last leg connections as a result of greater access to car share, ride share and bicycle share options and mobility as a service apps facilitating transitions. The effect on patronage may be most pronounced for public transport trips on the periphery. Greater use of shared mobility to feed into rapid transit spines also has the potential to reduce the need for feeder public transport services, with resulting implications for public transport subsidies.
- Greater access to transport for those who do not own a private vehicle. Improved shared mobility options give the public more flexibility and choice in how and when to travel. If at sufficient scale and priced appropriately, shared mobility may also improve access to transport for lower income groups.

[15] *Why Helsinki's innovative on-demand bus service failed*. Citiscope. March 2016

In addition, widespread uptake of shared mobility may reduce the need for parking (thus allowing land to be re-purposed) and reduce transport related greenhouse gas emissions by decreasing average vehicle kilometres travelled.

However, any widespread shift to shared mobility involves significant changes to behaviour that, despite advances in technology, have not been observed to date. Comprehensive research will be needed to better understand current attitudes towards shared mobility in Auckland, what the key behavioural drivers for sharing are, and what central and local government could do to facilitate a widespread shift.

Based on actions taken in other jurisdictions, central and local government could investigate the following initiatives to help facilitate uptake:

- Provision of enabling and flexible regulation to support a range of shared mobility business models.
- Development of an open data platform, drawing on sources from across the public and private sectors and provided in a standardised, anonymous and user-friendly way. Doing so would provide the data necessary to aid private sector development of shared mobility business models and mobility as a service apps.
- Conducting trials of shared mobility services to determine what works, what doesn't, and why.
- Communication strategies promoting the service offerings of shared mobility and links with the public transport network.

In addition, land use and demographic patterns will affect what shared mobility services are likely to be available and sustainable in Auckland. Higher densities and restriction of parking availability in particular would likely be conducive to enabling shared mobility services to succeed.

6. Combined effects of technologies

While intelligent network management, emerging vehicle technologies and shared mobility could each individually improve transport outcomes in Auckland, when combined their effects are likely to be more pronounced.

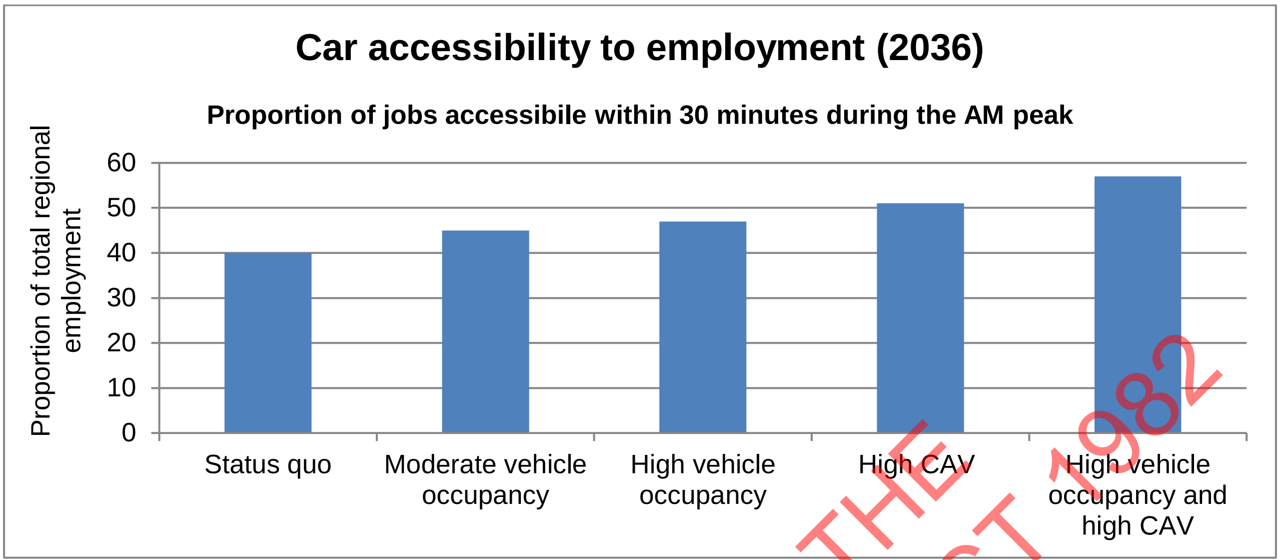
To assess the potential contribution of these technologies towards the core ATAP objectives, literature from a wide range of sources and results from the Auckland Regional Transport (ART) Model were used.

6.1. Modelling

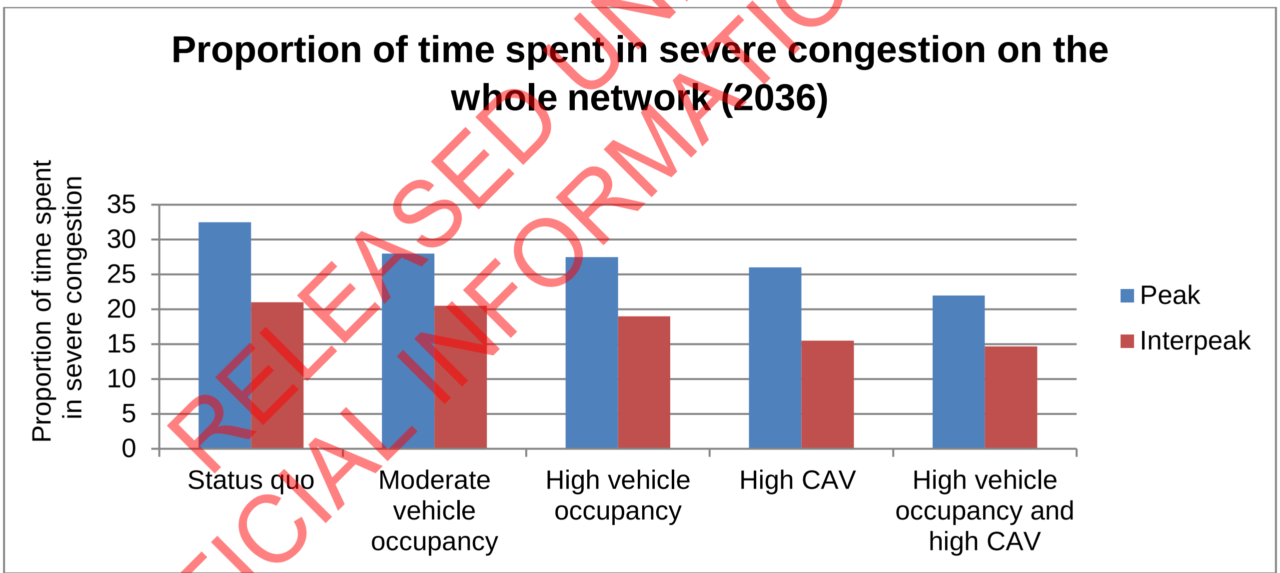
Four 'what if' modelling scenarios were tested for 2036 that reflect a reasonably aggressive increase in vehicle occupancy (to simulate shared mobility) and uptake of CAVs. The four scenarios were:

- Moderate vehicle occupancy – assumed a 50 percent increase in vehicle occupancy for commuter trips with a smaller increase for other trip types (like shopping or business trips), reflecting that rates of ride-sharing are likely to vary by trip purpose. Overall, average peak-time occupancy was assumed to increase from 1.36 to 1.61.
- High vehicle occupancy – assumed a 100 percent increase in vehicle occupancy for commuter trips with a smaller increase for other trip types. Overall, average peak-time occupancy was assumed to increase from 1.36 to 1.73.
- High CAV – assumed 75 percent of the fleet are CAVs, resulting in a 29 percent increase in lane capacity for motorways and a 10 percent increase on other roads. Capacity of signalised intersections was also assumed to increase by 15 percent as a result of supporting intelligent infrastructure.
- High vehicle occupancy and high CAV – assumed both a 100 percent increase in vehicle occupancy for commuter trips and 75 percent of the fleet being CAVs.

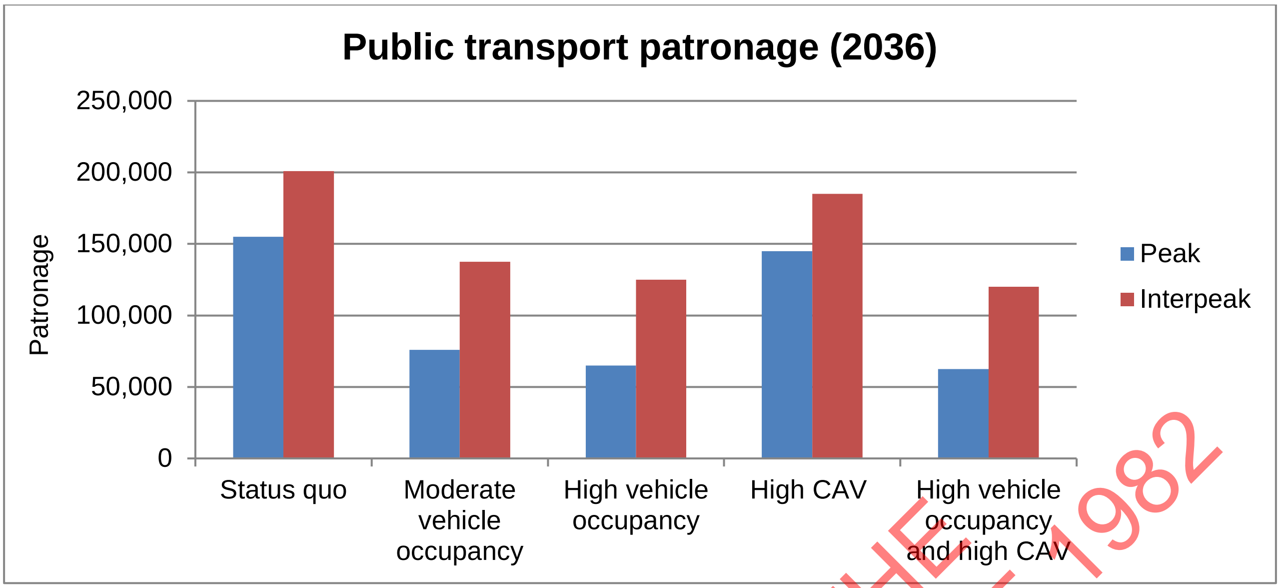
Results



All scenarios showed a considerable improvement in car accessibility to employment, particularly the high vehicle occupancy and CAV scenario, where the proportion of jobs accessible within 30 minutes increased by 45 percent in comparison to the status quo.



Time spent in congested conditions during the peak decreased under all scenarios, but particularly the high vehicle occupancy and CAV scenario, where it reduced by around 33 percent in comparison to the status quo. Interpeak congestion improved more as a result of CAVs than higher vehicle occupancy.



Under scenarios where vehicle occupancy increased, public transport patronage decreased by over 50 percent in the peak, with smaller but still significant declines in the interpeak. CAVs alone did not appear to have a significant impact on patronage.

6.2. Limitations of modelling

While useful for gaining a sense of the scale of potential impacts stemming from these changes in transport technology, the nature of the model used means a number of simplifying assumptions are necessary. These include: vehicle occupancy changes being uniform across the region whereas different locations and urban densities may be more or less conducive to ride sharing; user preferences regarding mode choice not being accurately reflected in the model (meaning that public transport patronage results should be treated with caution); and induced travel demand stemming from technology changes not being incorporated (meaning accessibility and congestion results probably reflect a 'best case'). To more realistically estimate the effect of shared mobility and CAVs on Auckland's network, the Ministry of Transport, with the support of Auckland Transport, have partnered with the International Transport Forum (the transport branch of the OECD), to investigate developing a purpose-built transport model.

6.3. Summary of impacts

In the medium-term, better intelligent network management could aid accessibility results by managing incidents and congestion more effectively through more comprehensive traveller information incentivising users to choose alternative routes, modes or times to travel. It may also support public transport patronage due to greater provision of real-time travel information for users and better prioritisation of bus services through emerging vehicle-to-infrastructure communication technology.

In the longer-term as uptake of CAVs increases, accessibility and congestion results could improve considerably because of higher lane capacity, particularly on motorways, and mitigation of start-stop shock waves. Shared mobility could further improve accessibility and congestion results as average vehicle occupancy increases and proportionally fewer private vehicles travel during peak periods.

If shared fully autonomous vehicles become widely adopted, the impact on public transport demand could also be material. Research indicates that the cost per passenger kilometre of fully autonomous vehicles could potentially be similar to that of traditional subsidised public transport and significantly cheaper than taxis, while offering a broadly equivalent level of service to private vehicle travel (in urban environments).

This suggests that shared fully autonomous vehicles may provide an attractive alternative to both private vehicle travel and some public transport services – particularly those that do not experience corridor constraints or very high demand (where traditional public transport is likely to remain relatively attractive). Alternatively, fully autonomous vehicles may increase catchment areas for public transport spines by making it easier to get from home to the station.

Further research and analysis is required to better understand the potential infrastructure implications of emerging transport technology. However, the need for additional motorway capacity and some public transport services appear particularly sensitive to changes in vehicle technology and shared mobility.

7. Conclusions

There is a growing international consensus that transport is on the cusp of disruptive change driven by new technology. However, the timing and detailed impacts of these technologies are very uncertain.

While investment in intelligent transport systems is already planned for Auckland over the next decade, preliminary analysis indicates that additional targeted investment would likely deliver good value for money and better prepare Auckland to take advantage of new technologies in subsequent decades.

Shared mobility, particularly if average peak-time vehicle occupancy increases significantly, has the potential to greatly improve accessibility and congestion results due to proportionally fewer vehicles on the road. More work will be needed to understand the behavioural drivers behind shared mobility and what both central and local government could do to facilitate a widespread shift.

Once uptake is sufficiently high (around 50-60 percent of the fleet) CAVs have the potential to significantly increase vehicle throughput on motorways by enabling shorter following distances and mitigation of start-stop shockwaves. While still material, their effect on local road capacity is expected to be much lower as a result of intersections and more complicated vehicle movements. Traffic accidents are also likely to decline as uptake of CAVs increases.

In the long run, shared fleets of CAVs supported by intelligent infrastructure have the potential to greatly improve the performance of Auckland's transport system and change the nature of public transport as we know it. However, the degree to which changes in technology may stimulate additional travel demand remains uncertain, with the possibility that efficiency benefits may be offset to some extent.

Given a high degree of uncertainty and the scale of potential impacts of these emerging transport technologies, a flexible approach to infrastructure planning and funding decisions is crucial, particularly for investments in the second and third decades of ATAP's 30-year horizon.

8. Recommendations

- Further investigate the case for increased investment in intelligent network management of around $200 million over the next 10 years (in addition to what is already tentatively earmarked by the New Zealand Transport Agency and Auckland Transport over this period).

- Undertake detailed research into the drivers of shared mobility and what central and local government could do to facilitate a widespread shift; including the provision of enabling and flexible regulation, development of an open data policy, and conducting shared mobility trials.

- Further investigate how to best prepare for and potentially accelerate the uptake of connected and automated vehicles.

- Ensure transport agencies involved in Auckland build staff capability in intelligent transport systems and work collaboratively to deliver outcomes.

- Ensure that potential changes in transport technology are taken into account when planning future infrastructure to reduce the chance of stranded investment.

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A step closer to Auckland transport alignment

Update on the Auckland Transport Alignment Project June 2016

Ministry of Transport
Te Manatū Waka

The Treasury

NZ Transport Agency
Waka Kotahi

Auckland Transport

State Services Commission
Te Komihana O Ngā Tari Kāwanatanga

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Update on the Auckland Transport Alignment Project

This update reports on progress in the Auckland Transport Alignment Project (ATAP) since the release of the Foundation Report in February 2016. It highlights some of the preliminary findings and conclusions from the analysis completed to date, and outlines issues the ATAP parties are considering in developing an aligned strategic approach.

The ATAP Foundation Report highlighted the opportunities and challenges arising from Auckland's growth. While growth provides opportunities to capitalise on the benefits of a larger and more diverse labour force, driving productivity and prosperity gains, it also places pressure on transport networks leading to congestion, overcrowding and delays.

The challenges vary across different parts of Auckland. The Foundation Report indicated that under current plans there will be a growing gap between areas in relation to their access to employment. Due to their distance from locations where major employment growth is expected, the western and southern parts of Auckland appear to face the greatest future transport challenges. Part of the more recent ATAP work has focused on options to address these problems.

We are a step closer to agreeing a strategic approach for Auckland's transport system

ATAP has delivered an interim report to the Minister of Finance, Hon Bill English, the Minister of Transport, Hon Simon Bridges, the Mayor of Auckland, Len Brown, and Auckland Councillor, Bill Cashmore, which sets out the preliminary findings and conclusions.

The Parties are considering this initial advice.

Feedback from the Parties and further analysis will inform the final ATAP report in August.

Foundation Report

An overview of the context (including the impact of technology), problem definition, desired outcomes and measures.

→

Interim Report: Findings and Conclusions

Initial advice reporting on the testing and evaluation of the broad intervention packages, seeking feedback to inform the next deliverable.

→

Final Report

A final report detailing the best performing intervention packages, a preferred strategic approach and recommendations including necessary changes to achieve implementation.

Towards a strategic approach

Historically, our approach to dealing with Auckland's transport issues has focused on investment in roading and public transport infrastructure and services, and optimising where possible to make better use of existing assets. Over time, this approach has become increasingly expensive and has struggled to keep pace with the demands that growth is placing on the system. Our analysis shows that continuing on this path can deliver localised benefits, but will not provide the step-change in system performance that Auckland needs.

To achieve this step-change, we will need to change our approach. Based on our preliminary findings, the emerging strategic approach recommends a strong commitment to influencing travel demand patterns including pricing, with complementary technology to help shift demand. In the short term this means making the transport system "technology ready," and laying the groundwork for variable network pricing, to enable a staged implementation.

Because the benefits from these demand-side interventions may take some time to materialise, we need to ensure that progress is made on investments to improve our strategic networks. Priority should be given to investments that will be required regardless of pricing or technology changes and those that enable and support Auckland's continued growth.

Key findings to date

A key focus of ATAP is to test whether better returns from transport investment can be achieved in the medium and long-term, particularly in relation to the following objectives:

- To support economic growth and increased productivity by ensuring access to employment/labour improves relative to current levels as Auckland's population grows.
- To improve congestion results, relative to predicted levels, in particular travel time and reliability in the peak period, and to ensure congestion does not become widespread during working hours.
- To improve public transport's mode share, relative to predicted results, where it will address congestion.
- To ensure any increases in the financial costs of using the transport system deliver net benefits to users of the system.

The ATAP team has drawn from a wide range of technical analysis and information gathering to inform its findings. This includes modelling a variety of road pricing options, "what if" technology scenarios, and different mixes of transport projects. ATAP has had ongoing engagement with teams working on major infrastructure projects, received reports from specialist workstreams and has considered input from stakeholders.

Based on the analysis undertaken so far, the following key findings have emerged:

- It is possible to deliver better results by changing the mix of investments within existing funding constraints, but this is not likely to deliver a major improvement in regional outcomes over and above the current plan (the Auckland Plan Transport Network, or APTN).
- However there are differences in impact at the sub-regional level, and specific interventions can help improve accessibility in the west and south, which were identified as problem areas in the Foundation Report. For example, the Northwestern Busway appears to make a substantial difference to public transport accessibility in the west while reconfigured motorway improvements appear to improve car accessibility in the south.
- New initiatives, including variable network pricing, shared mobility and connected vehicle technology, have potentially significant positive impacts on system performance and could defer or reduce investment in infrastructure.
- We need to do more work to understand the effect of pricing on other project objectives including access and net user benefits in more depth. A network pricing system would probably need to evolve by way of a series of steps over time.
- Technology advances provide new avenues to improve congestion and could have fundamental implications for transport investment. ATAP will consider how we can capitalise on the potential benefits of technology, including understanding behavioural elements.
- The existing and pending commitments to large projects in the next 10 years, including the City Rail Link, East West Connections, Puhoi-Warkworth, and the Accelerated Motorway Package, reduce the funding available for discretionary investment up until 2028.
- Even with these investments in place, there is a projected decline in network performance by 2026. This problem could be exacerbated if, as recent trends suggest, growth is faster than the medium projection assumed in ATAP.

- As demand increases, the productivity of the existing network needs to improve. This requires a combination of better network optimisation, and a focus on Intelligent Transport Systems (ITS) – such as providing real-time information to users about congestion levels on the network, and better intervening through dynamic traffic signals.
- Continued growth in public transport ridership will put pressure on key bus corridors into the central area. Efficiency improvements to the bus network (completing currently planned bus infrastructure improvements, rerouting services and fully utilising benefits of the City Rail Link project) will help to address these challenges. However, substantial further capacity increases will be required to avoid severe overcrowding in the future.
- The existing Auckland Harbour Bridge has limits on its ability to cater for heavy traffic growth, and increased private vehicle and public transport demand. A new crossing has very high opportunity costs meaning it is very important to understand key drivers, alternatives, costs and benefits before any investment decisions are made. Route protection for a new crossing needs to progress in a way that integrates further roading and public transport requirements.
- Enabling growth in newly developing areas requires early investment in route protection and land acquisition, and an early start is needed on key connections in the north-west and south, including investment to support Special Housing Area development.

Next stage of ATAP

Parties and further analysis will inform the final ATAP report in August.

This next stage of ATAP will ensure that the recommended aligned strategic approach is evidence-based, and demonstrate its costs and benefits. This further work will also involve the development of a prioritisation framework.

The final report will recommend an aligned strategic approach for the development of Auckland's transport system. It will also include recommendations on how to implement the aligned strategic approach, including consideration of further work and any changes to statutory documents.

We expect to publicly release the final report in September 2016.

Find out more:
transport.govt.nz/atap
aucklandcouncil.govt.nz/atap