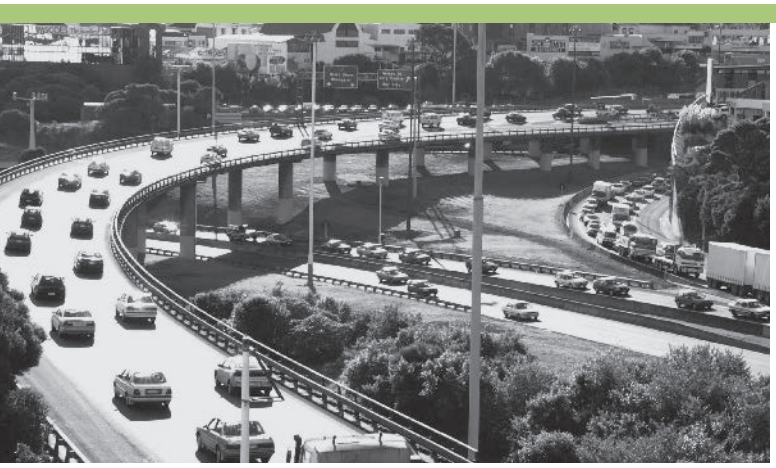
BCS979

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.

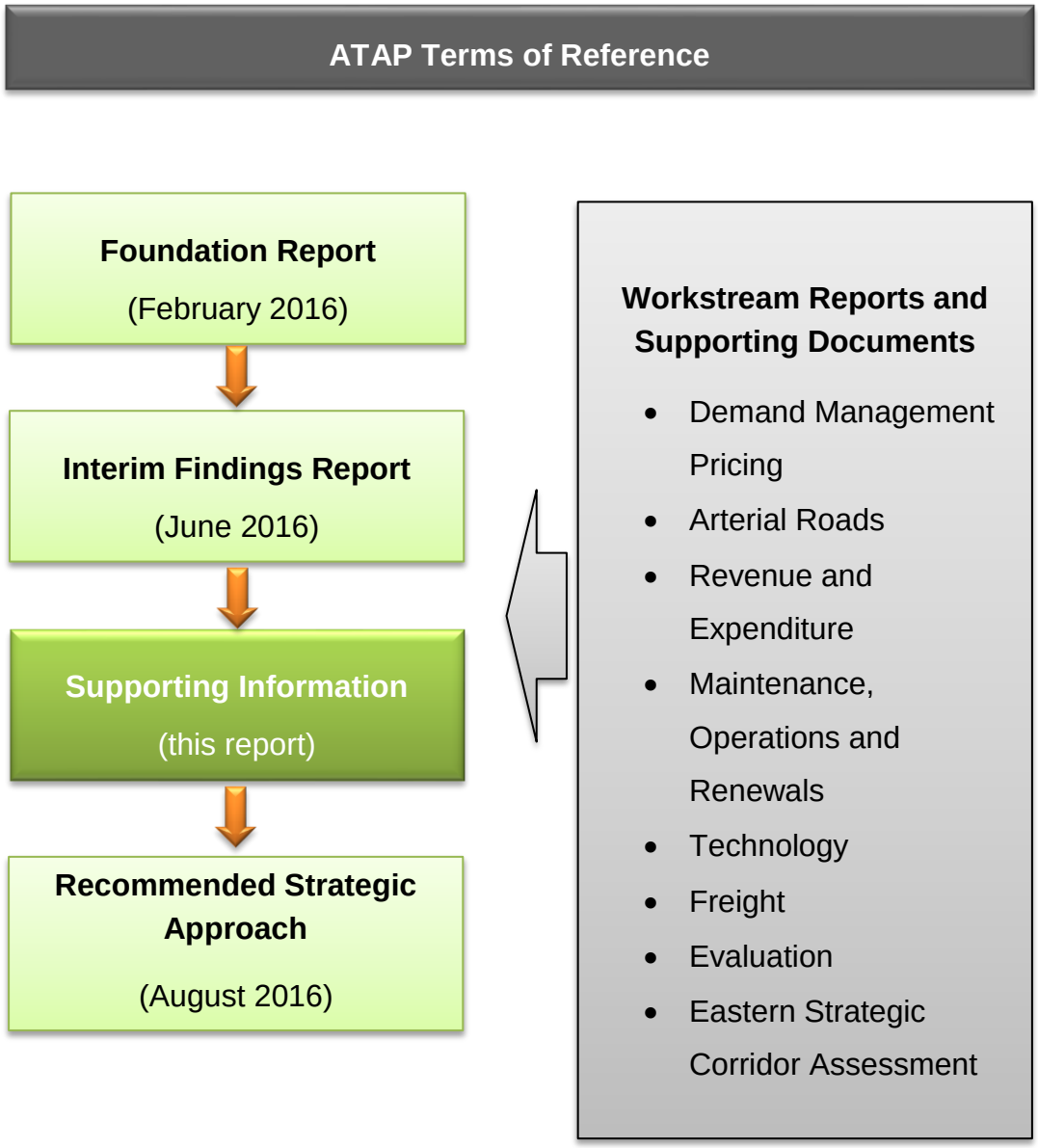
The focus of the Auckland Transport Alignment Project (ATAP) is to test whether better returns from transport investment can be achieved in the medium and long-term, particularly in relation to the following objectives:

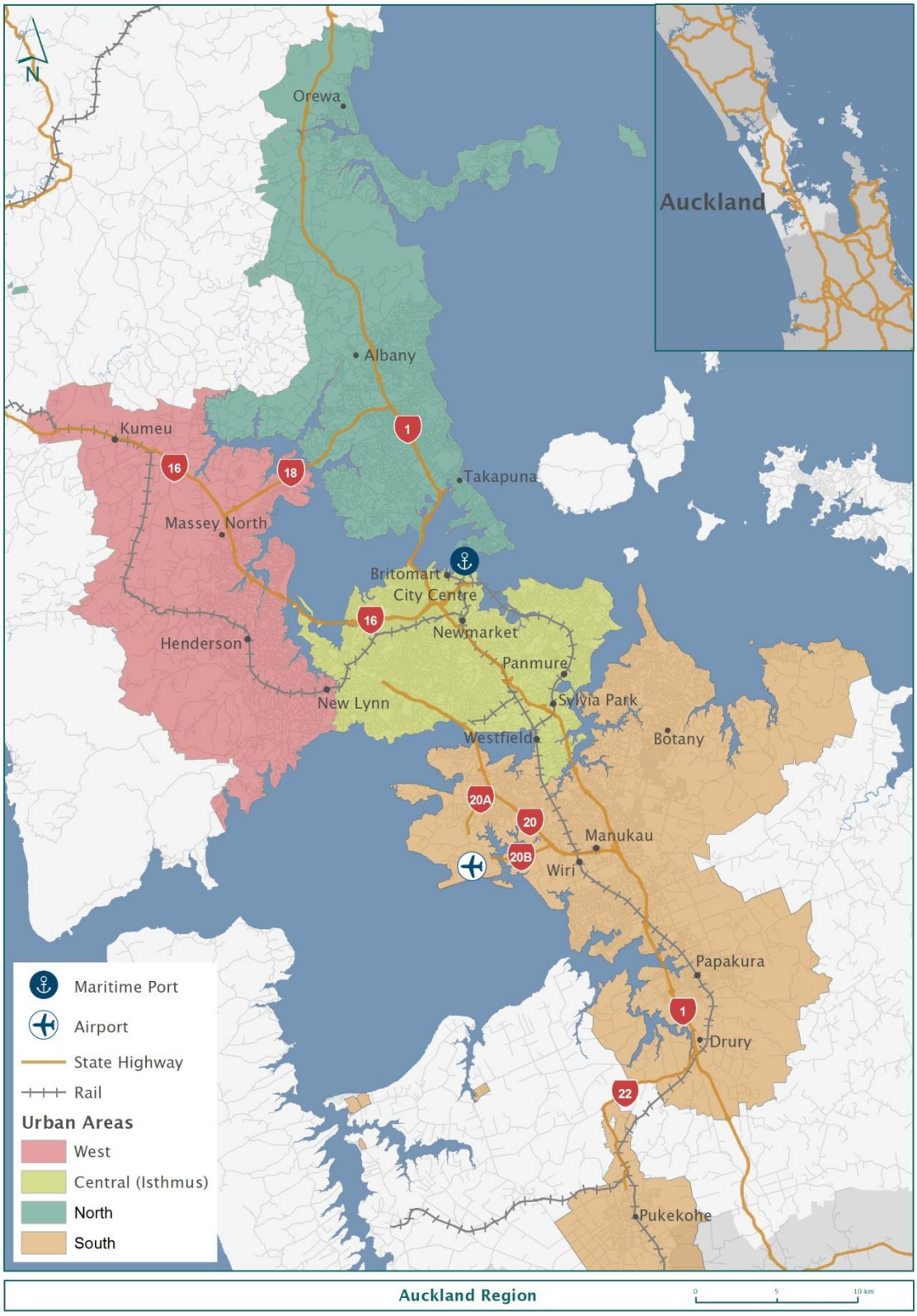
i. To support economic growth and increased productivity by ensuring **access to employment/labour improves** relative to current levels as Auckland's population grows
ii. To **improve congestion results**, relative to predicted levels, in particular travel time and reliability, in the peak period and 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.

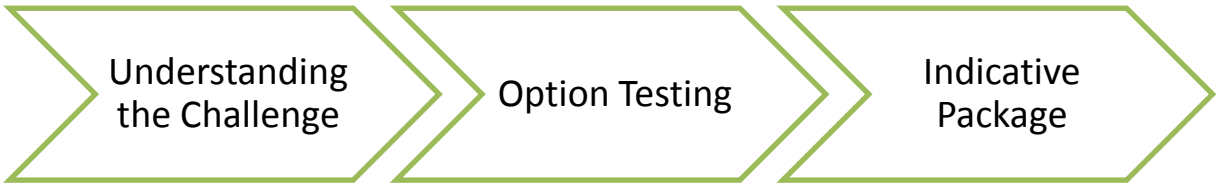
Key ATAP documents




N
Orewa
Albany
Kumeu
Takapuna
Massey North
Britomart
City Centre
Newmarket
Henderson
Panmure
New Lynn
Sylvia Park
Westfield
Botany
Manukau
Wiri
Papakura
Drury
Pukekohe
Auckland
1
16
18
20A
20
20B
22
Maritime Port
Airport
State Highway
Rail
Urban Areas
West
Central (Isthmus)
North
South
Auckland Region
0
5
10 km

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.

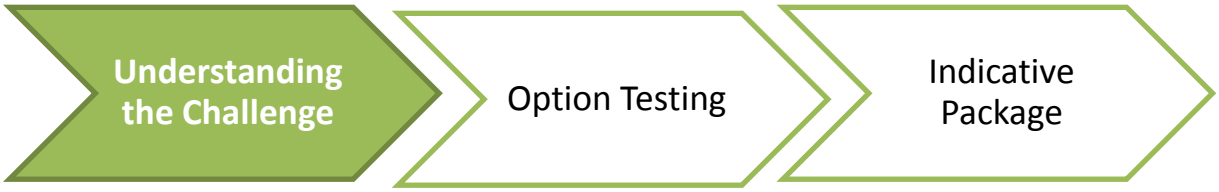
The table below shows the transport modelling tests undertaken at different stages of the project. In addition, various ’baselines’ were used in each phase to help gain an understanding of the impact of the interventions tested.

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.

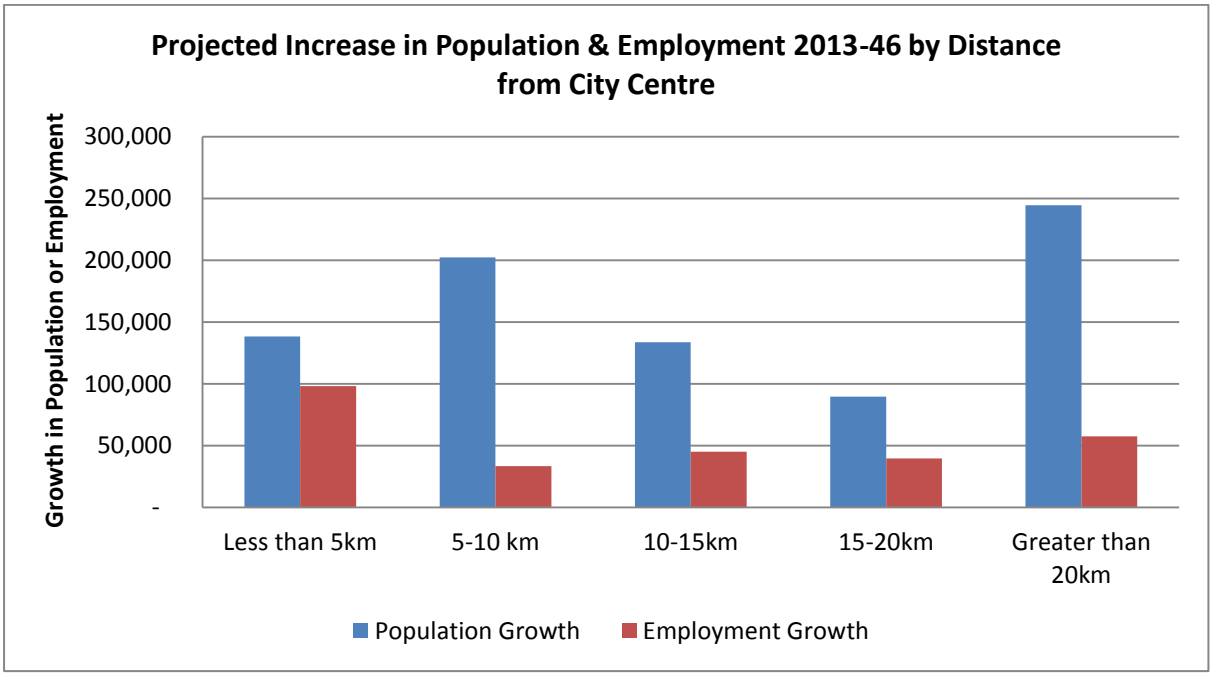
3.1. Growth assumptions

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.

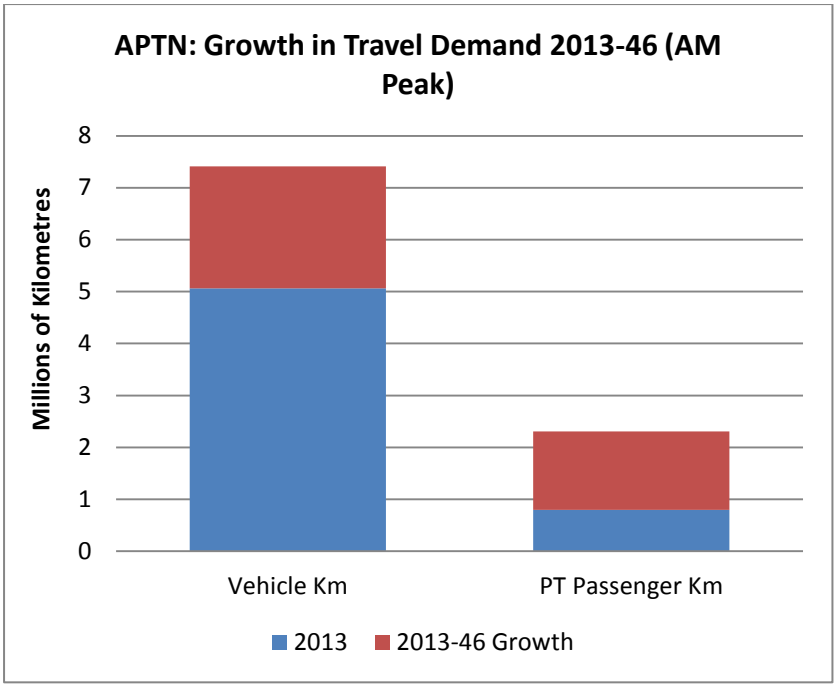


Source: Scenario I9 growth assumptions

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.



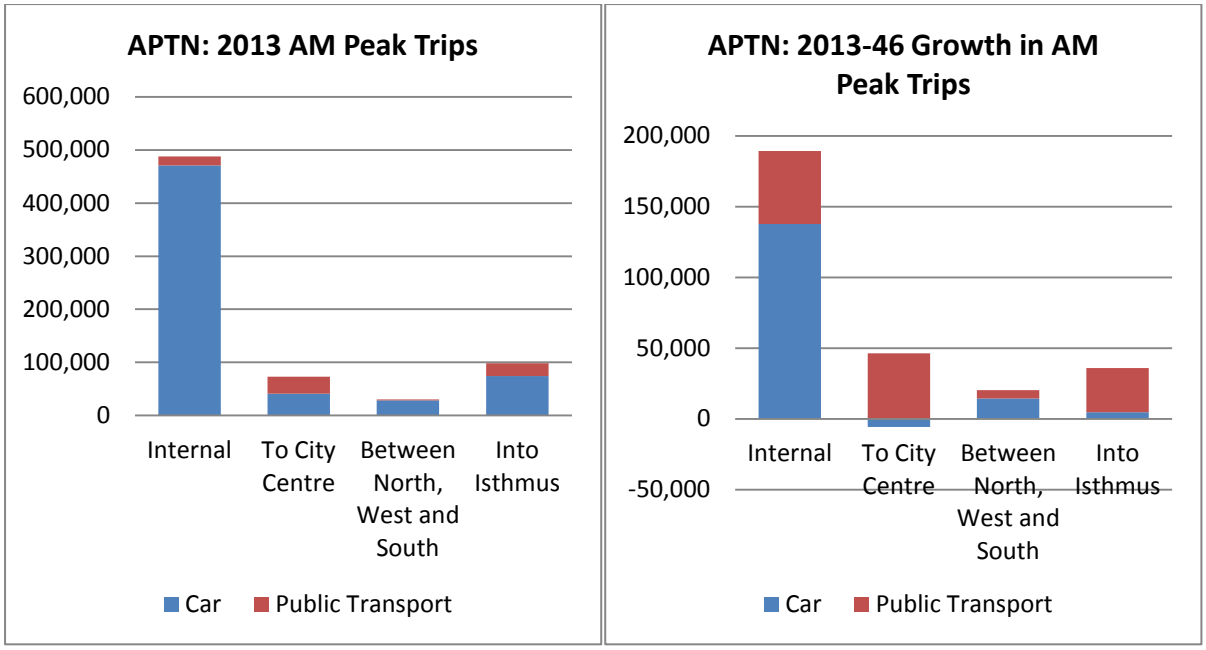
Source: APTN ART3 model outputs

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.

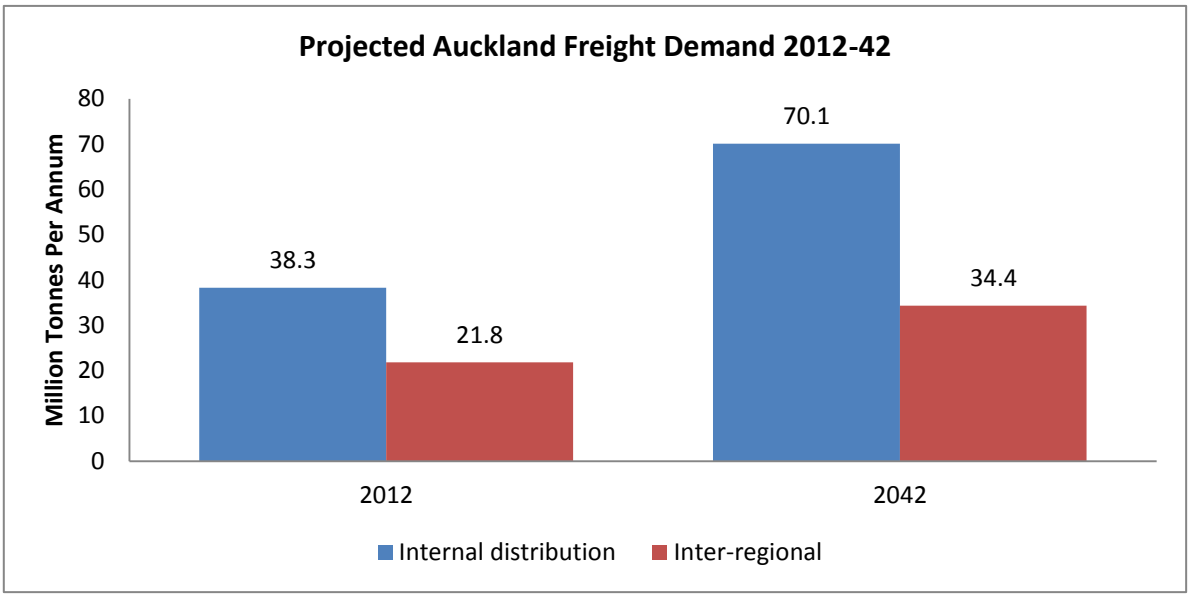
Auckland's geography creates particular challenges in serving trips between different parts of the region, as there are only a limited number of connections able to be used (e.g. the Auckland Harbour Bridge, crossings of the Tamaki River, etc.). Trips accessing the city centre also face particular challenges, 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.

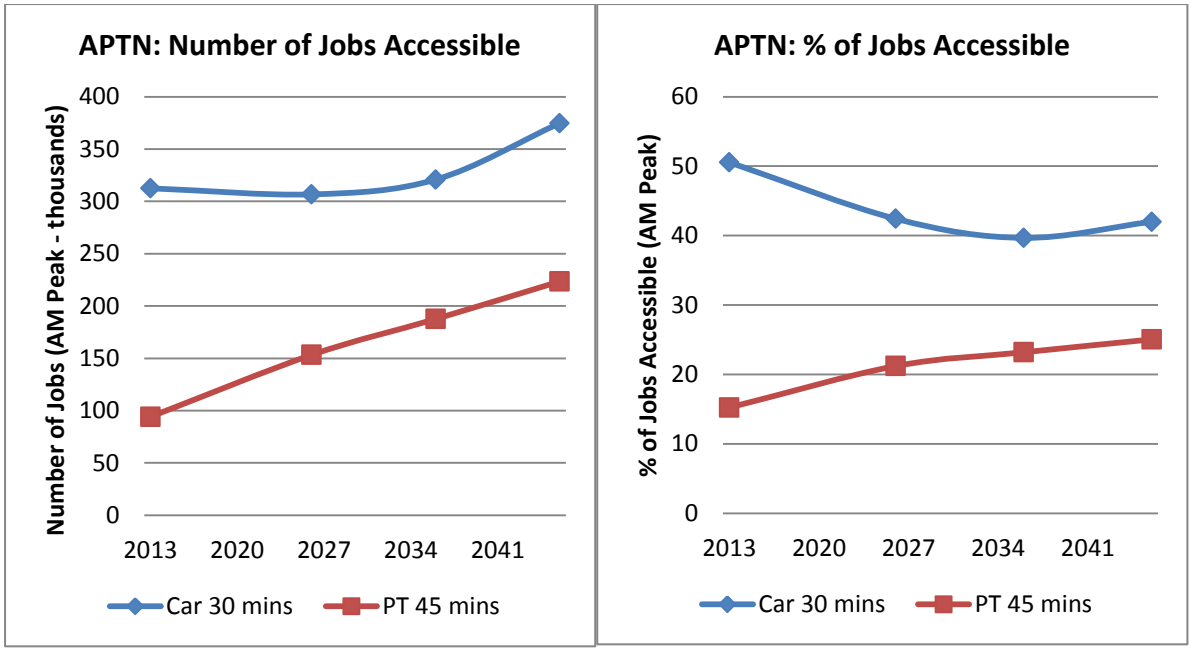
Overall transport network performance is best measured through the extent to which it enables people to access opportunities. If Auckland is to benefit from future growth, then the opportunities each resident can reach in a given travel time need to be increased or at least held constant. This is challenging 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

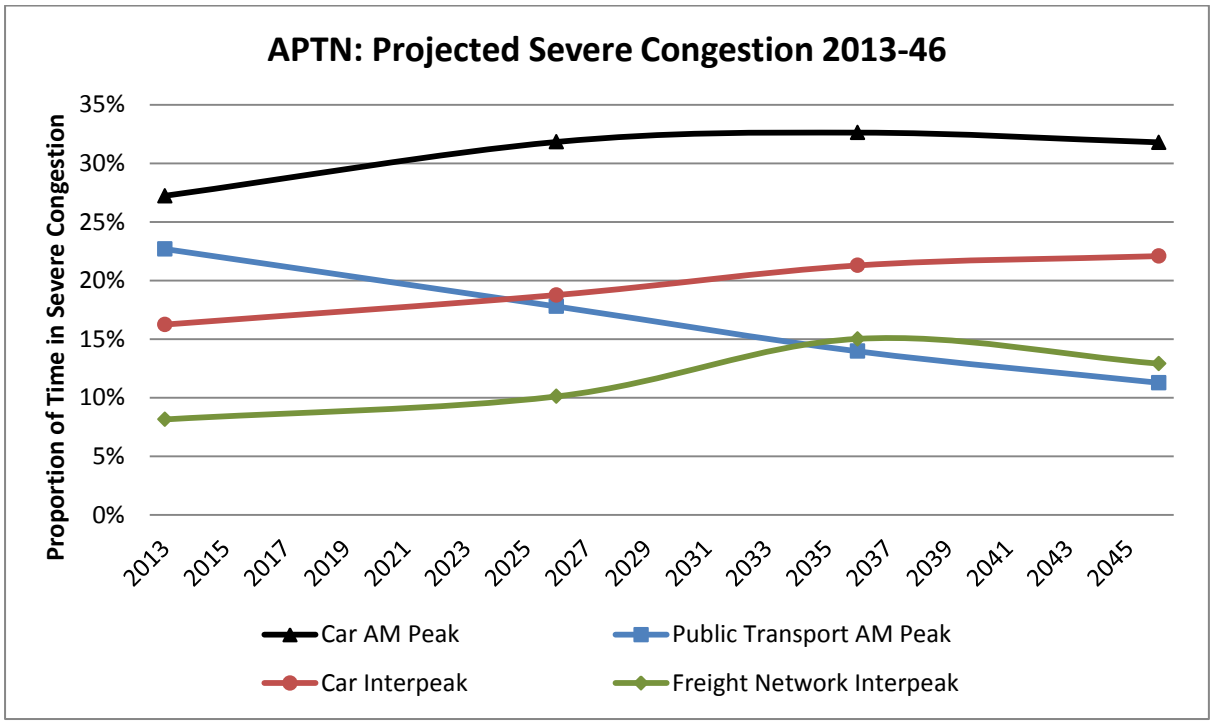
At a regional level, the APTN delivers mixed results: addressing some of the challenges posed by Auckland's projected growth but struggling with others. Overall employment access is projected to grow over time, but access to employment by car only increases after 2030 through delivery of a substantial 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

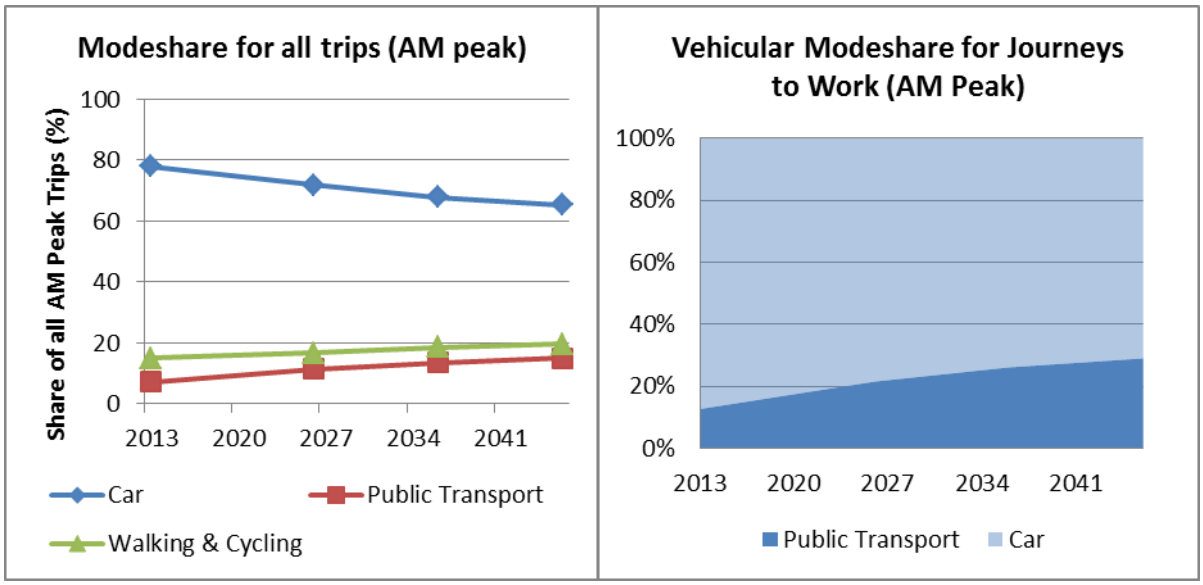
As illustrated below, congestion is projected to increase and spread under the APTN, as capacity is exceeded by growing demand. This crowding increasingly extends into the inter-peak, affecting travel throughout the business day, with particular impacts on high value commercial trips. Conditions are 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.

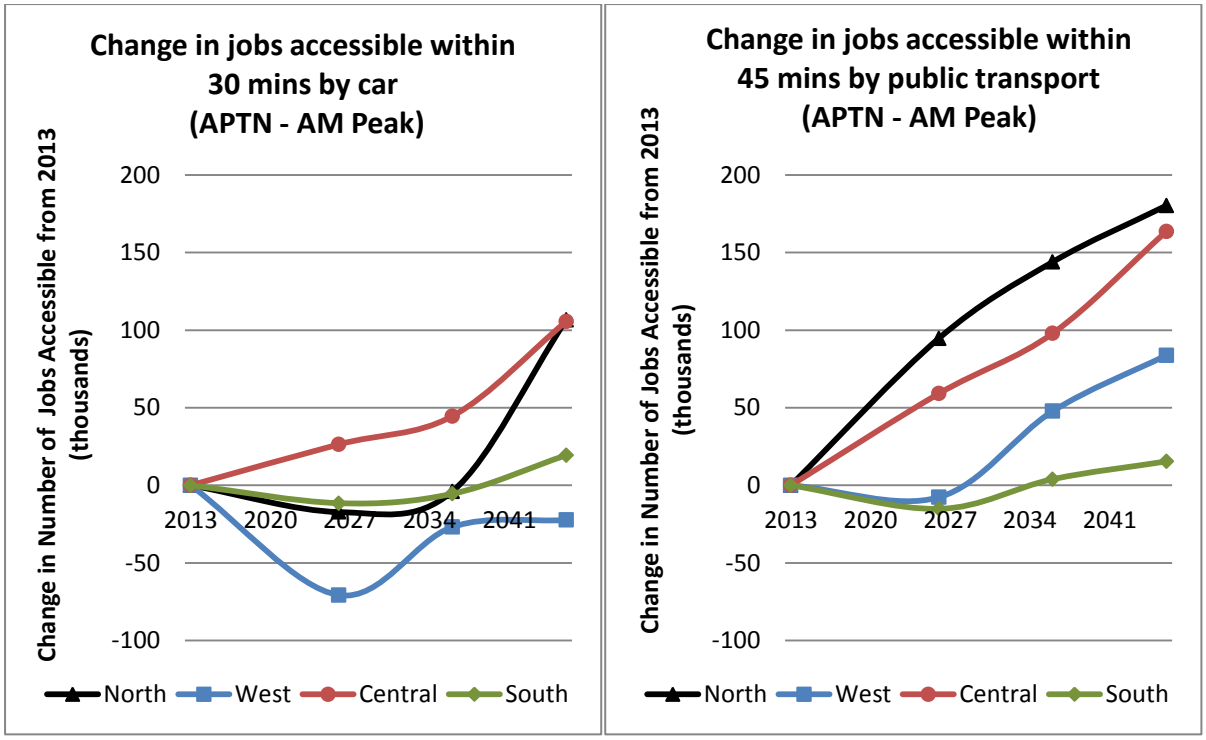


Source: APTN ART3 model outputs

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

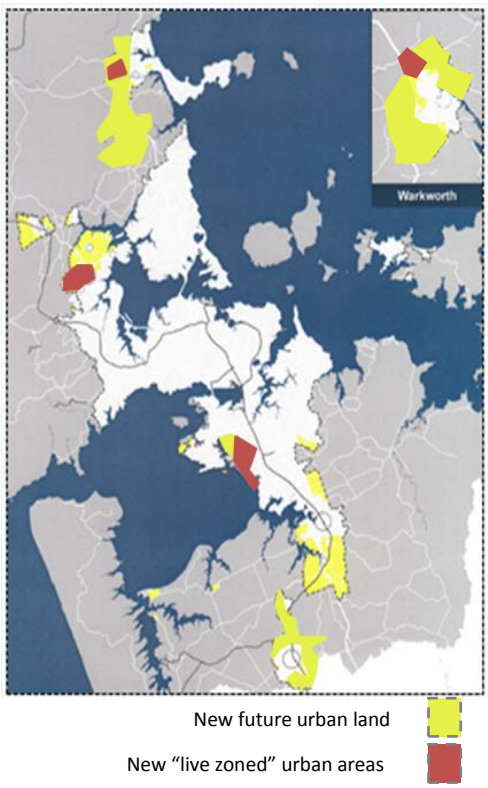
Alongside the broad regional and sub-regional transport challenges Auckland is projected to face over the next 30 years, there are a number of specific major challenges, focus areas and opportunities that need to be addressed. These include:

- 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.

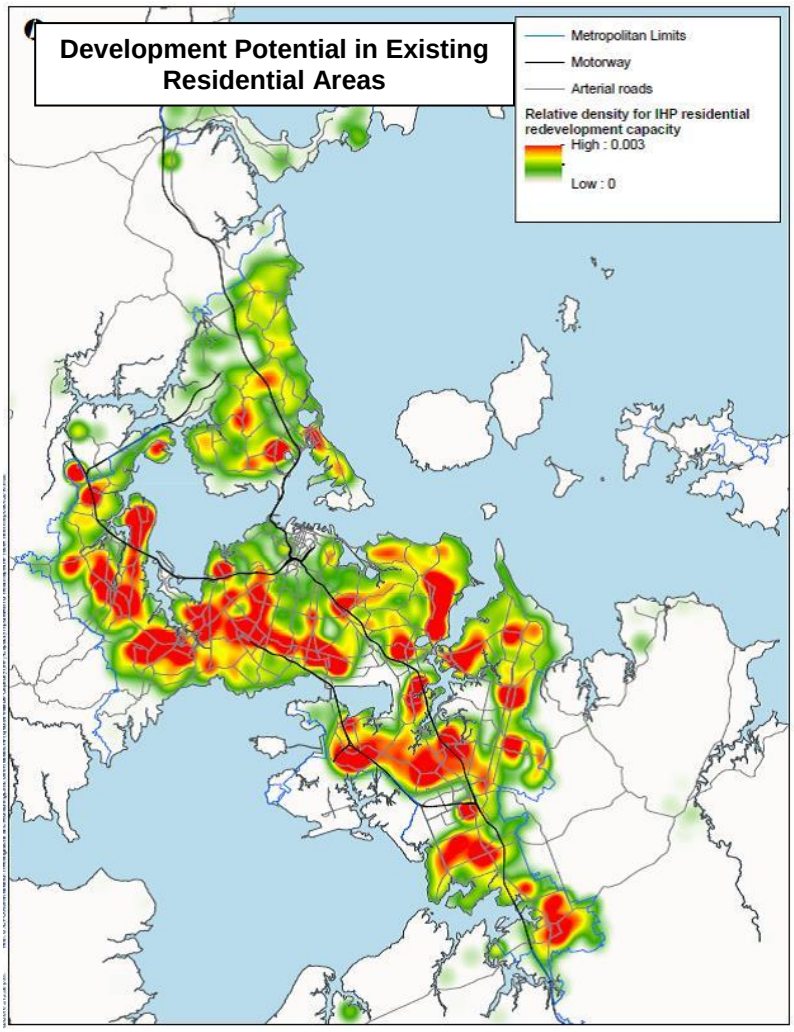
Early investment needs to focus on accelerating housing development in areas 'live-zoned' by the Unitary Plan, as well as Special Housing Areas. There is also a need for substantial early investment in route

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.

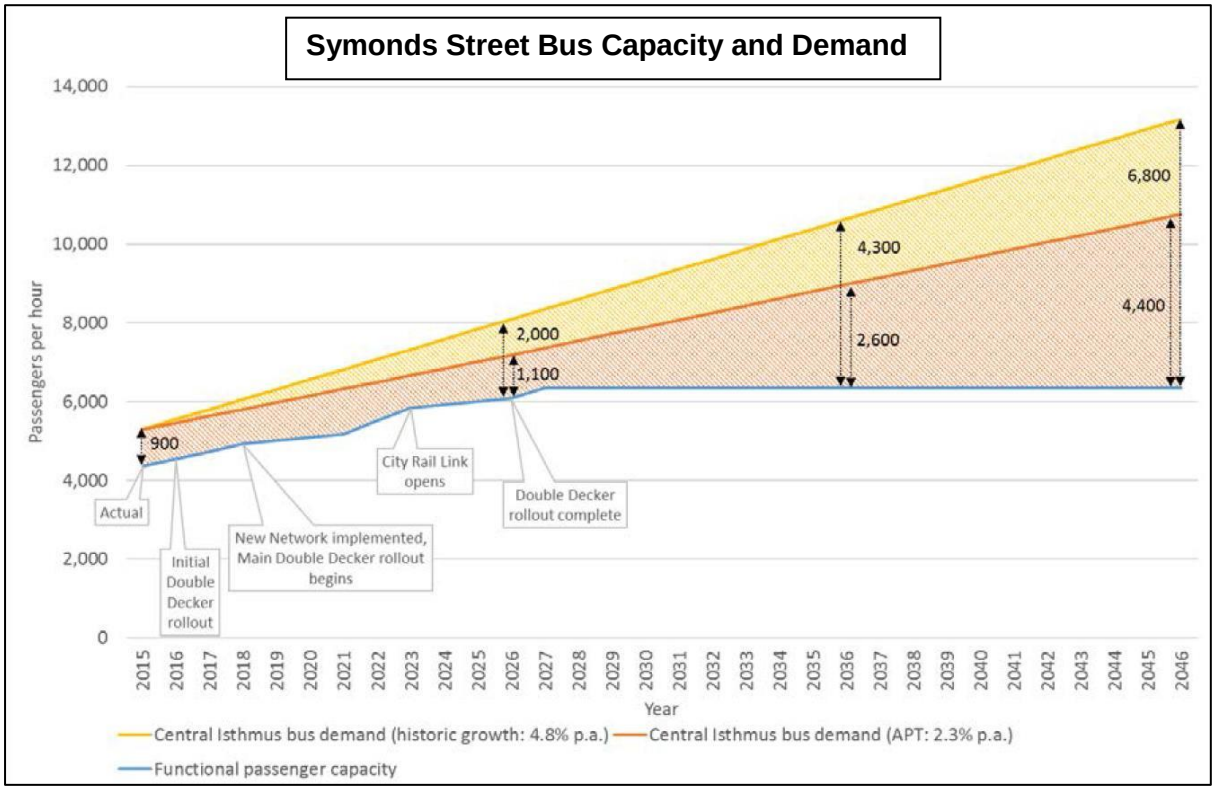
Recent investment in the rail network, coupled with the City Rail Link and associated further rail network improvements, will cater for a substantial proportion of future growth. Public transport trips into the central area from the south, southeast, west and parts of the isthmus will be increasingly 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

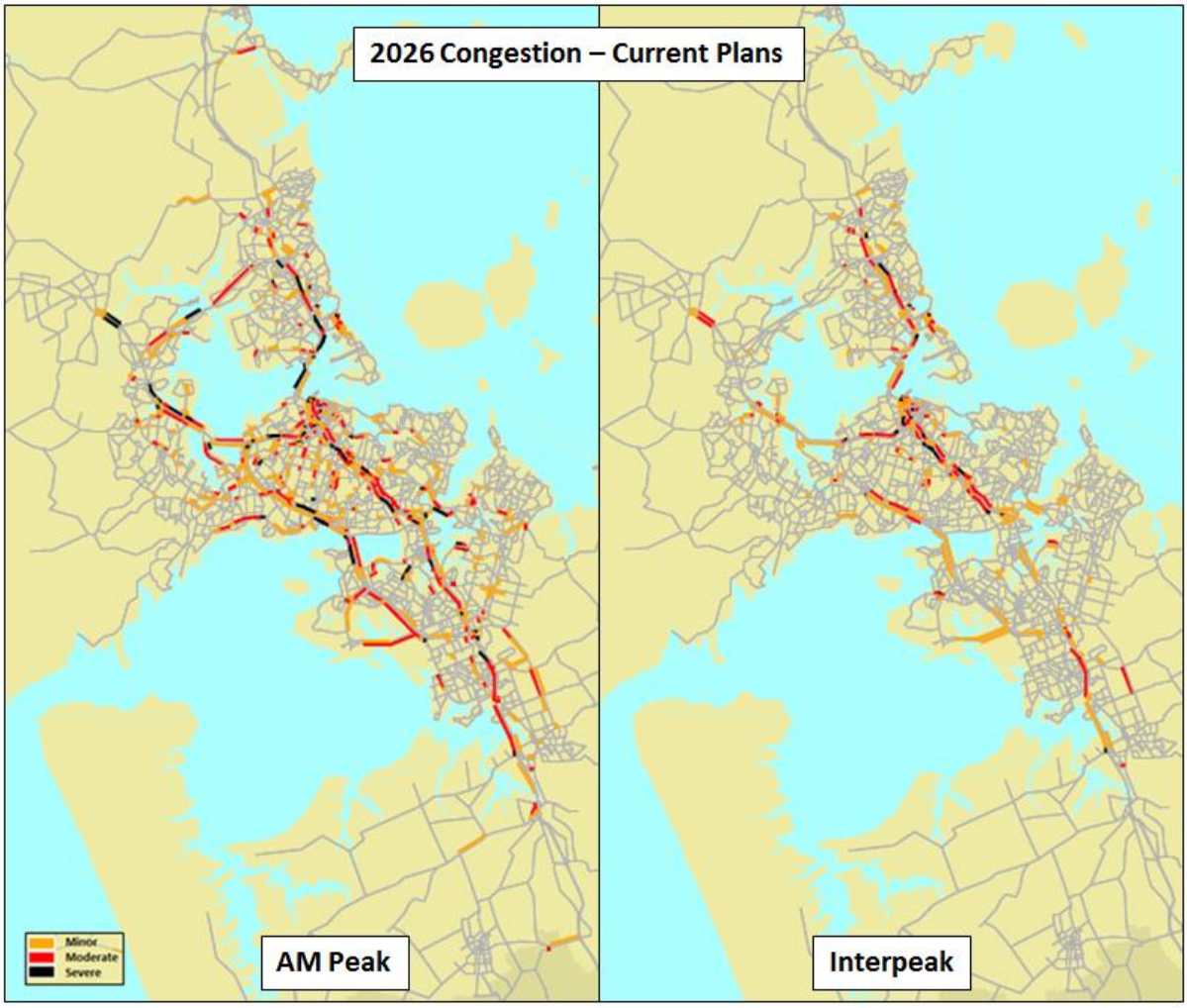
[3] Auckland Airport Master Plan http://www.aucklandairport.co.nz/downloads/aial-masterplan.pdf
[4] King, M & Paling, R (2016) *New Zealand International Air Freight*, prepared for Ministry of Transport
[5] Auckland Airport Master Plan, p29

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.

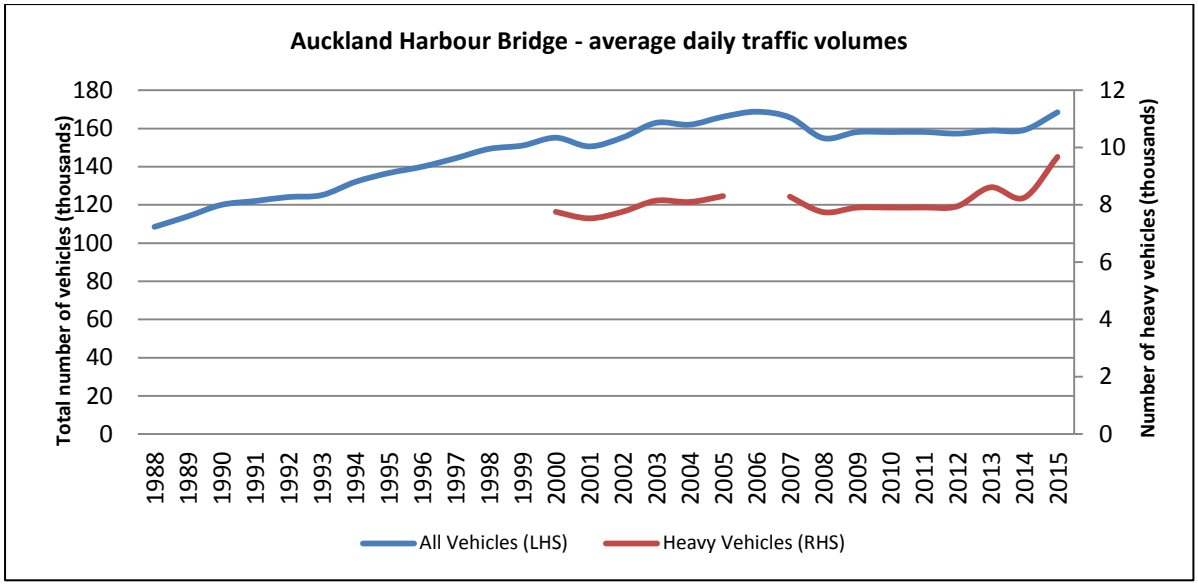
Under the APTN, a substantial proportion of future congestion is projected to occur on the motorway network, particularly on its innermost core where providing additional capacity is most challenging. This is illustrated by the congestion plots below.



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:

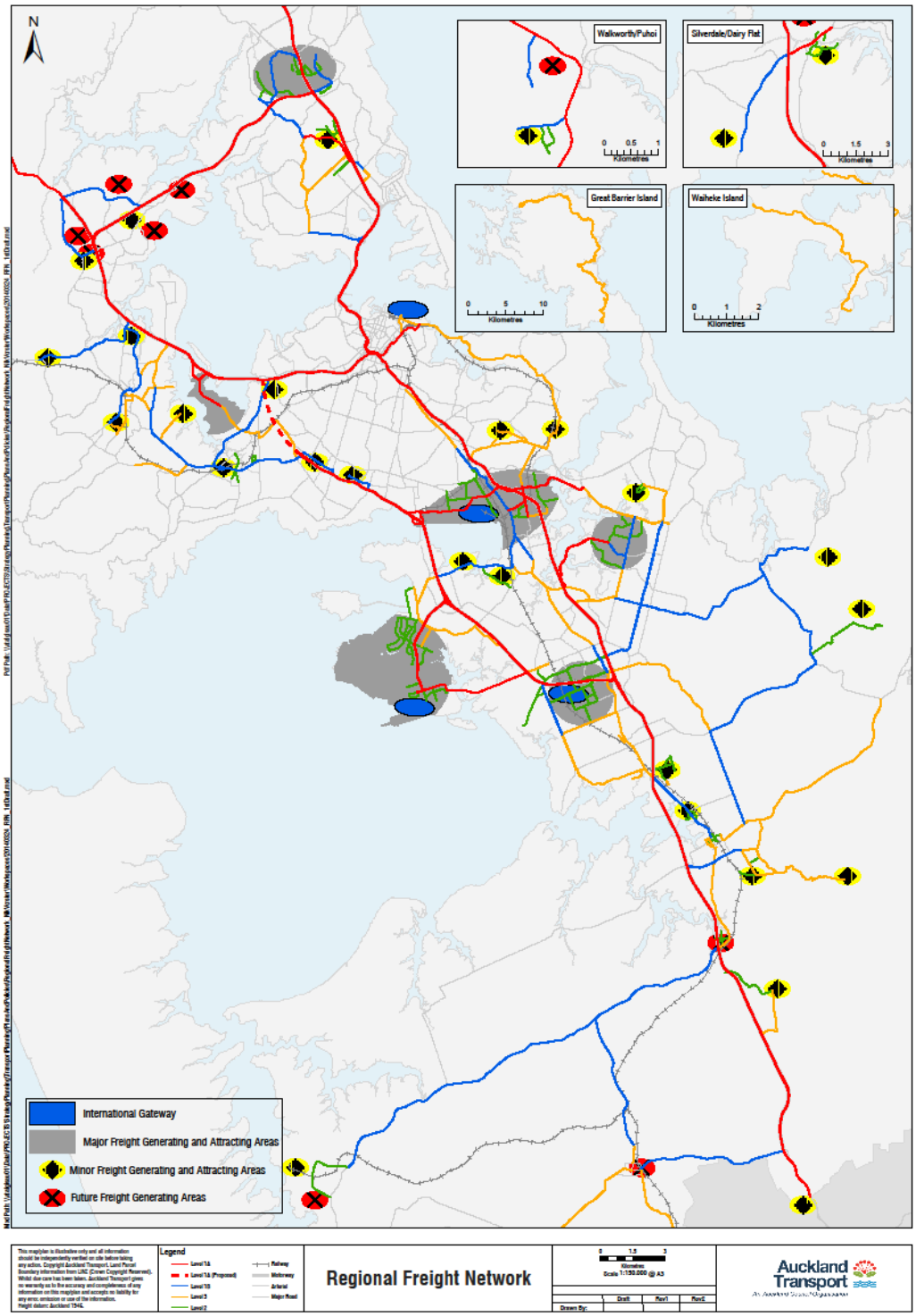
- *Network delays and travel time variability*: increasing congestion during the business day is forcing freight operators to increase the size of their fleets or reduce the frequency of services and needing to allow for worst case delivery/travel times.
- *Access to key freight hubs:* constraints in 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.

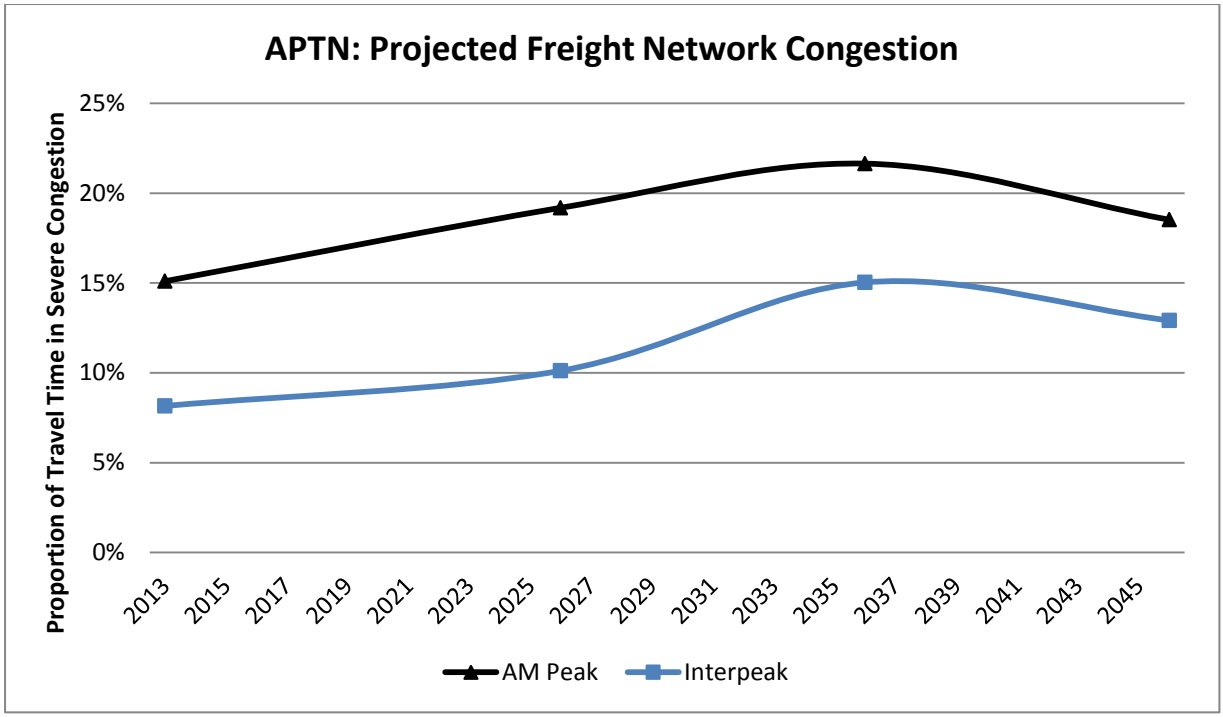
The Metro Port terminal in Penrose, operated by the Port of Tauranga, is also an important international gateway for exports and imports. Around 170,000 containers annually move to and from the terminal by road within Auckland, with rail moving freight to Metro Port to and from the Port of Tauranga. 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:

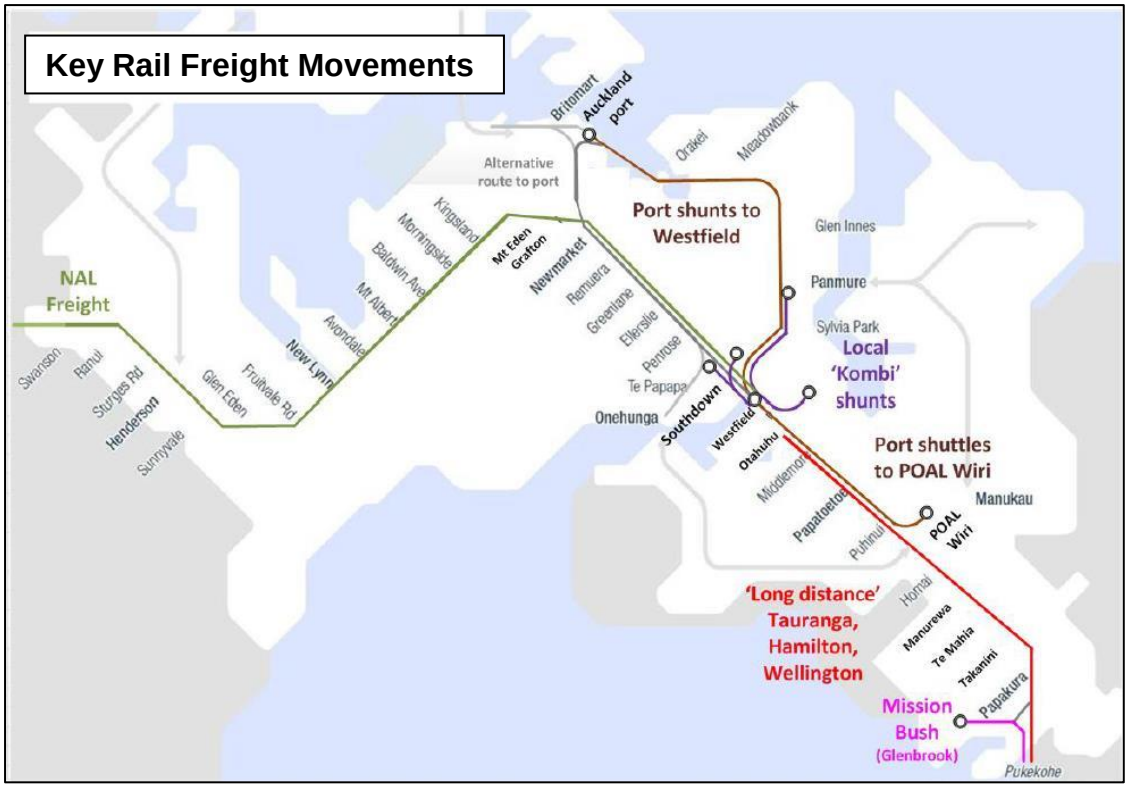
- Limiting the growth in congestion on the freight network, particularly during inter-peak periods
- Improving the efficiency of connections to major freight hubs, especially the ports and the Airport
- Ensuring that the rail network is able to provide for growing passenger and freight volumes (discussed 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.

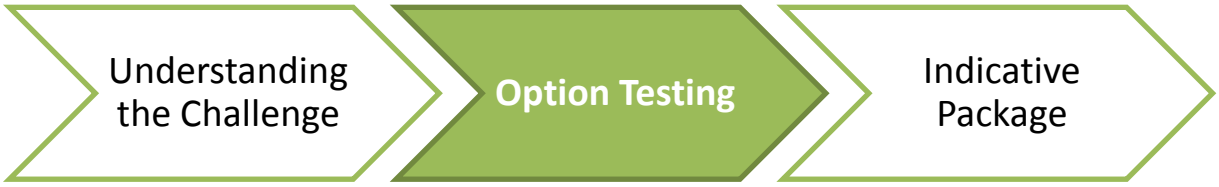
- *Shared mobility:* New technology (e.g. instant matching of trip demands) enables many previous barriers to ride-sharing or carpooling to be overcome. Increasing vehicle occupancy rates could provide significant congestion relief and environmental benefits by lowering total vehicle travel. Most advances 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.

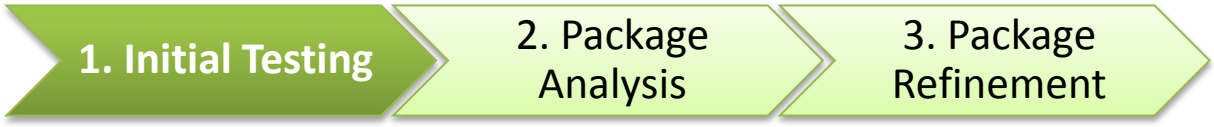
Phase 2 - Option Testing



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.

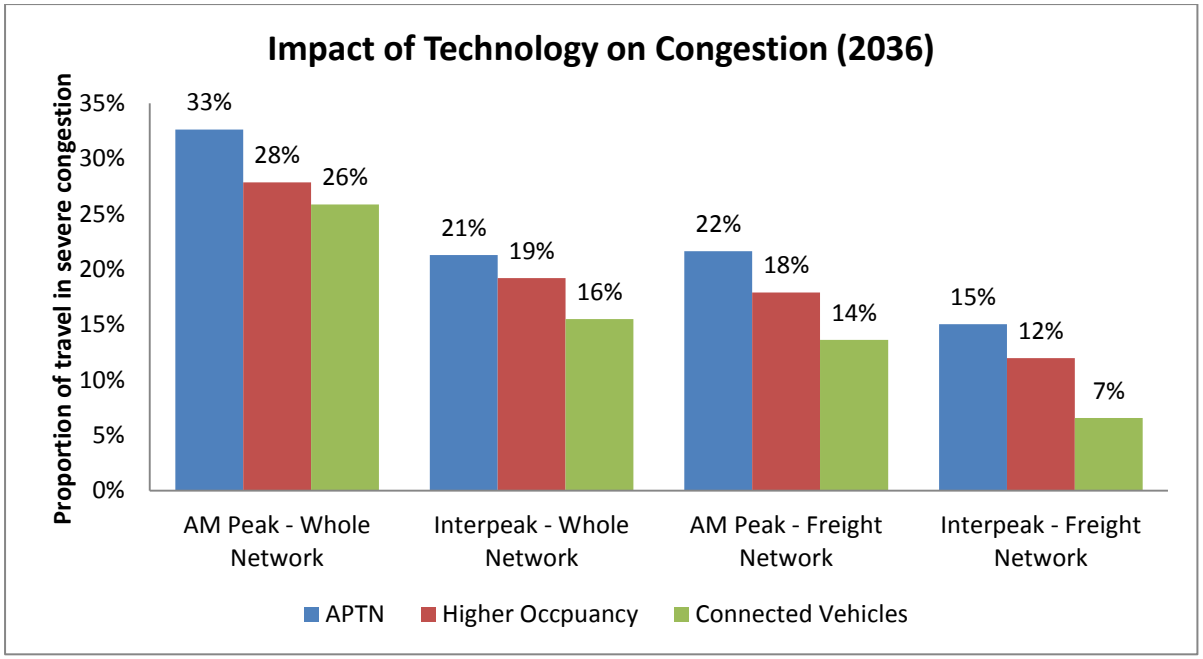
Two scenarios were developed, based around a 50% and a 100% increase in occupancy rates for work-related trips. Changes in occupancy for other trip types were adjusted accordingly, as shown in the table below.

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.

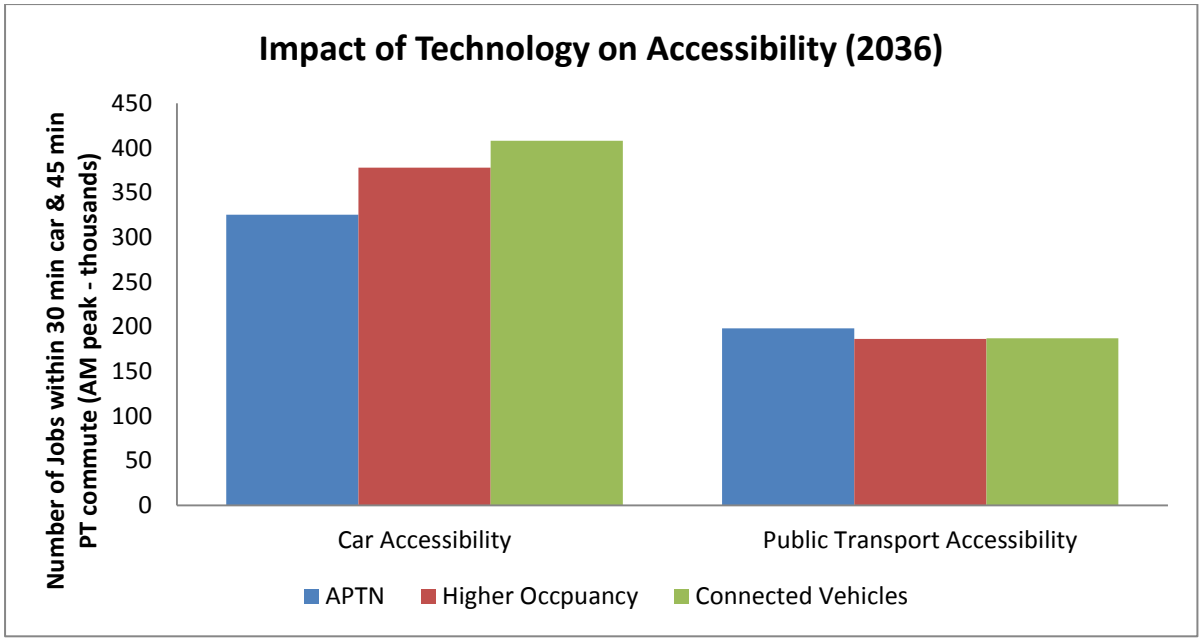
The main areas where connected vehicles and higher occupancy rates improve performance against the project objectives are in relation to congestion and car accessibility.



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

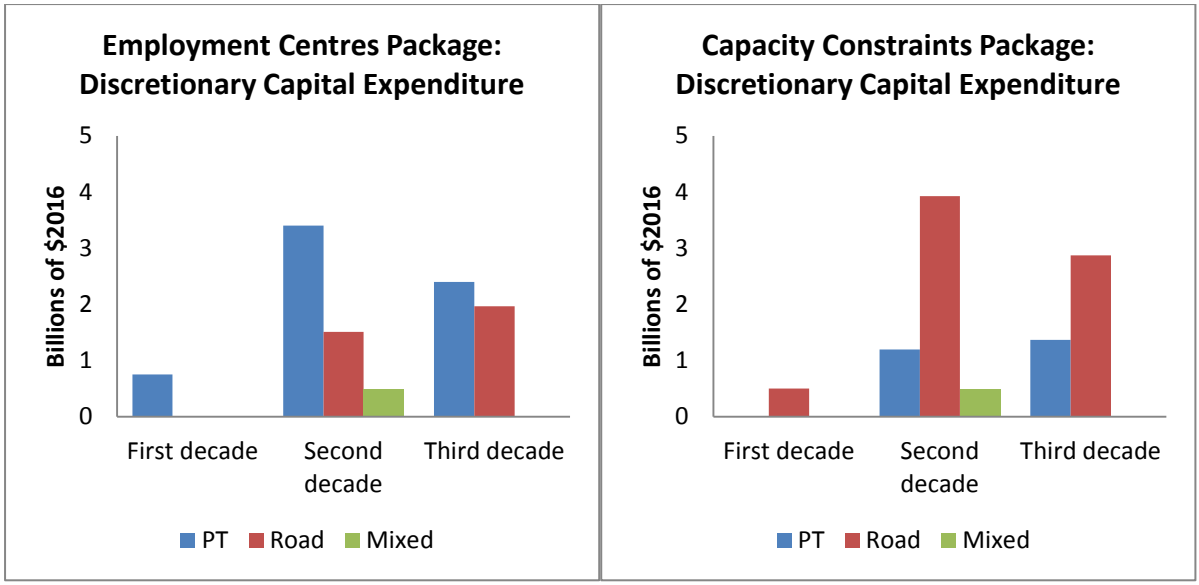
The core task of the project is to test whether better returns can be achieved from transport investment. Therefore, we looked at whether investing the same amount as current plans but on different priorities could deliver better results against our objectives.

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.

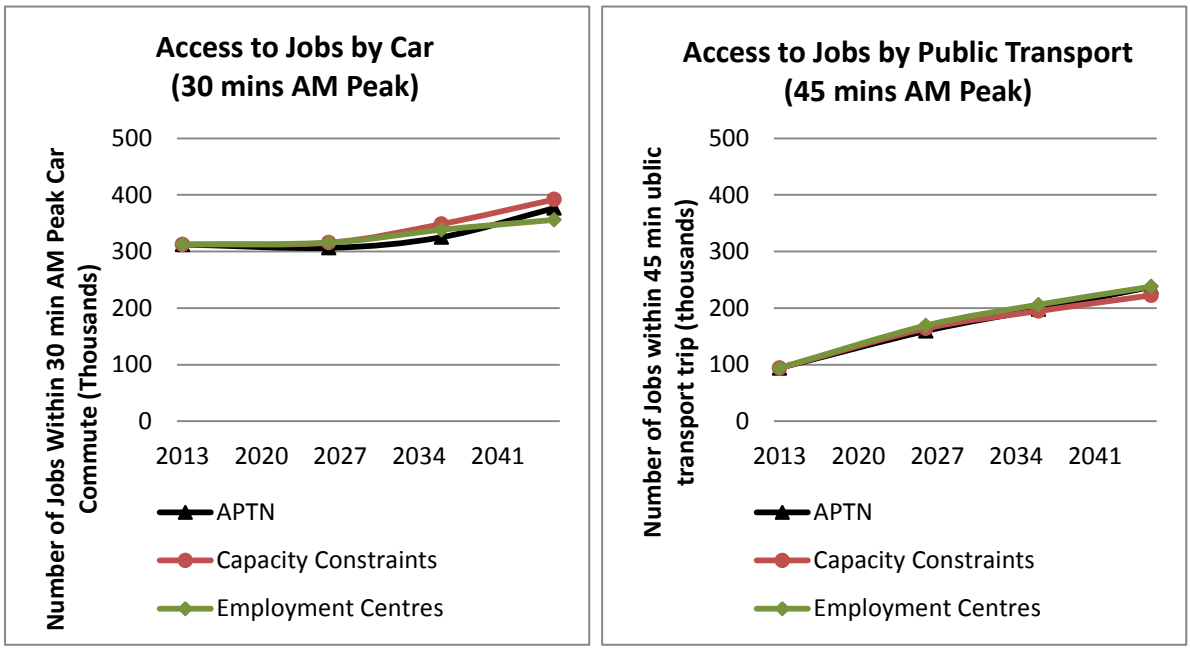
Two intervention packages were developed using broadly similar decade-by-decade funding levels to the current plans. The core focus and broad allocation of discretionary investment across major modes of each package is outlined below.

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).

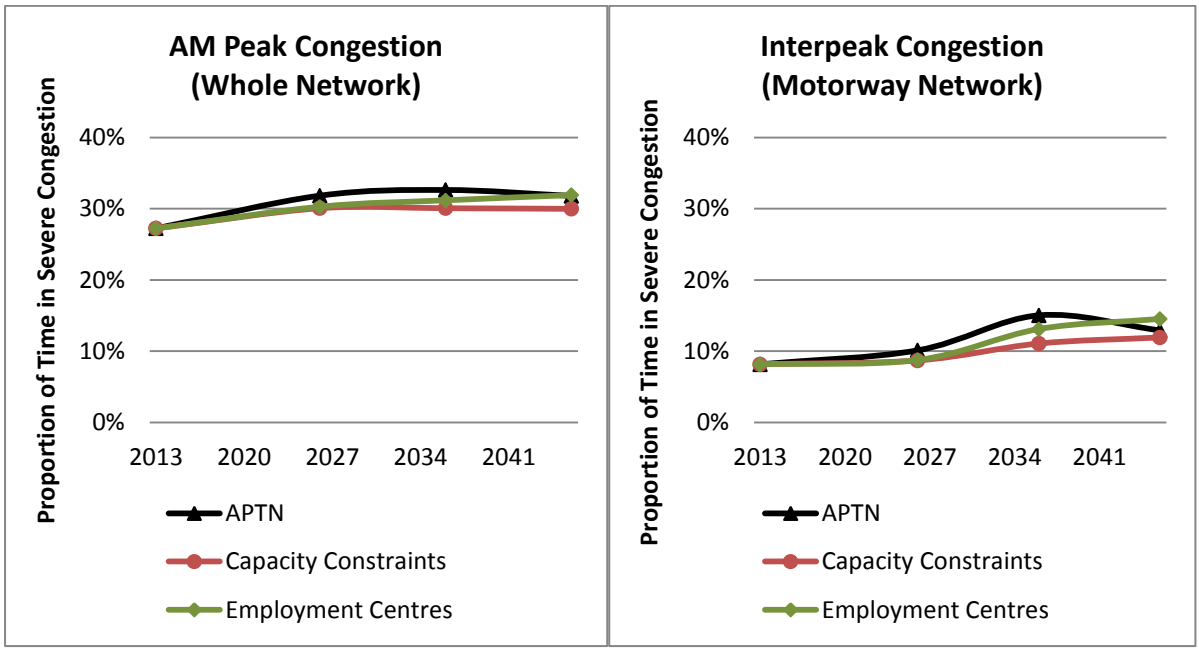


Source: ART3 model outputs, ATAP round 2

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.

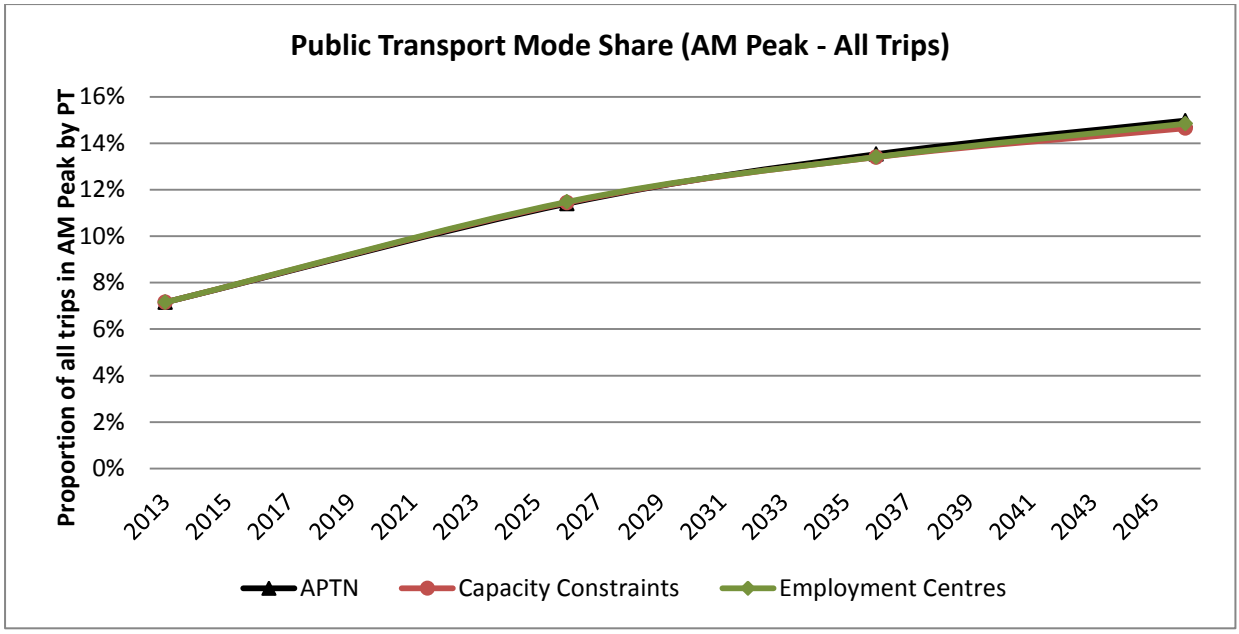
Congestion modelling of the different packages is outlined in the graphs below.



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.

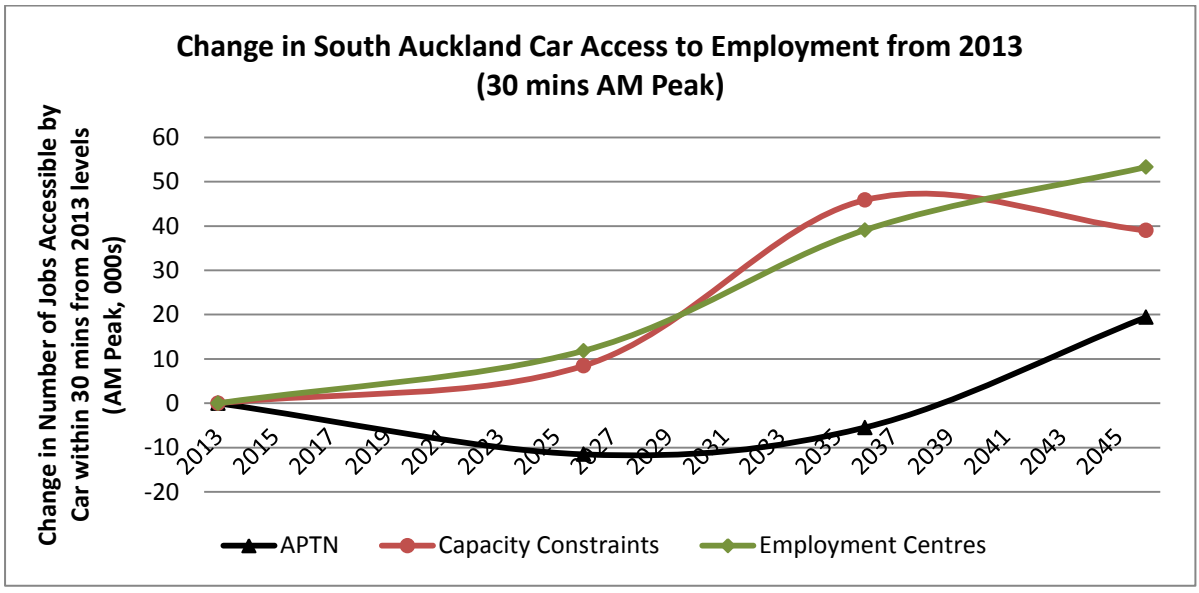
Public transport mode share results are similar for all three packages, with differences of less than one percentage point for the proportion of all trips during the morning peak being taken by public transport.



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.

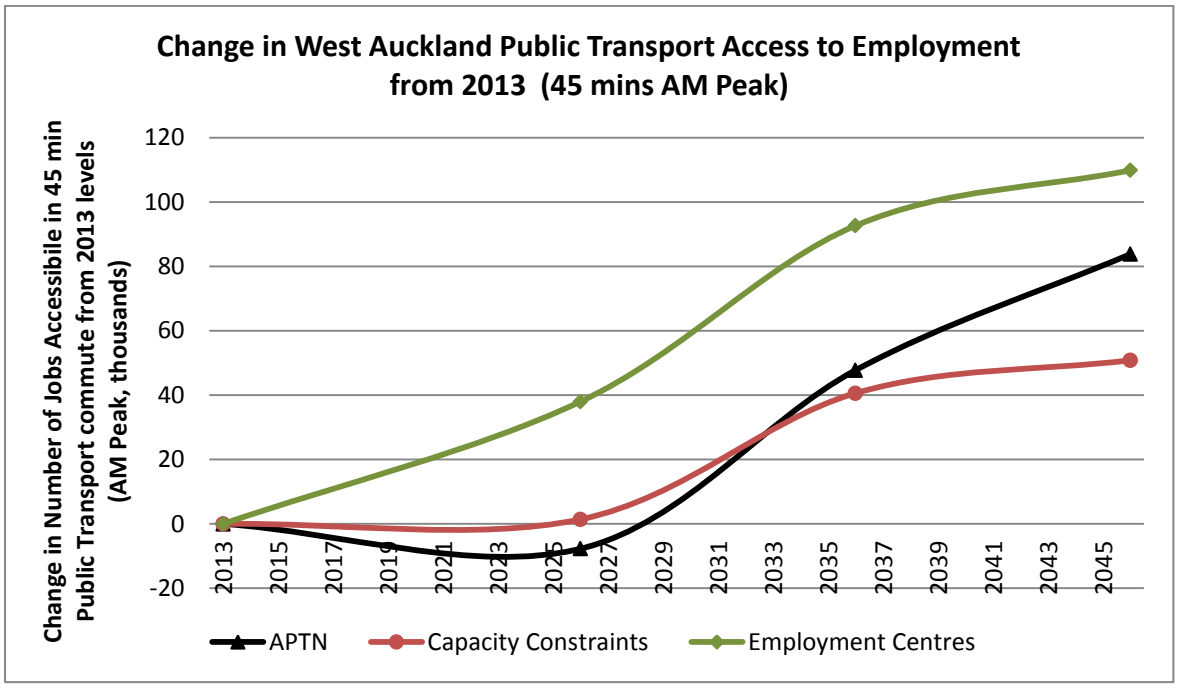
In the south, whereas under APTN access to employment by car declined and only increased strongly after 2036, both the 'Capacity Constraints' and 'Employment Centres' packages show better performance can be achieved.



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:

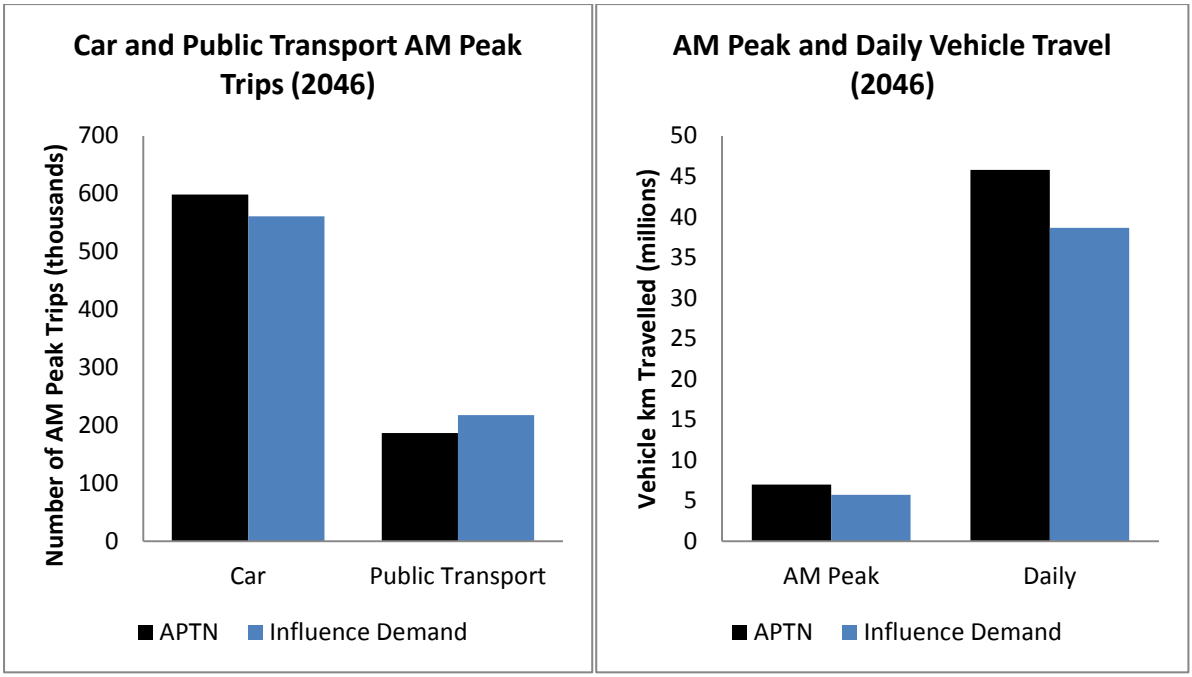
- They use fixed-trip matrices so are unable to show the extent to which the introduction of pricing may result in trip suppression (trips no longer being made).
- They are also not able to consider different values of time or vary prices at a more micro-level so provide a very simplistic representation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

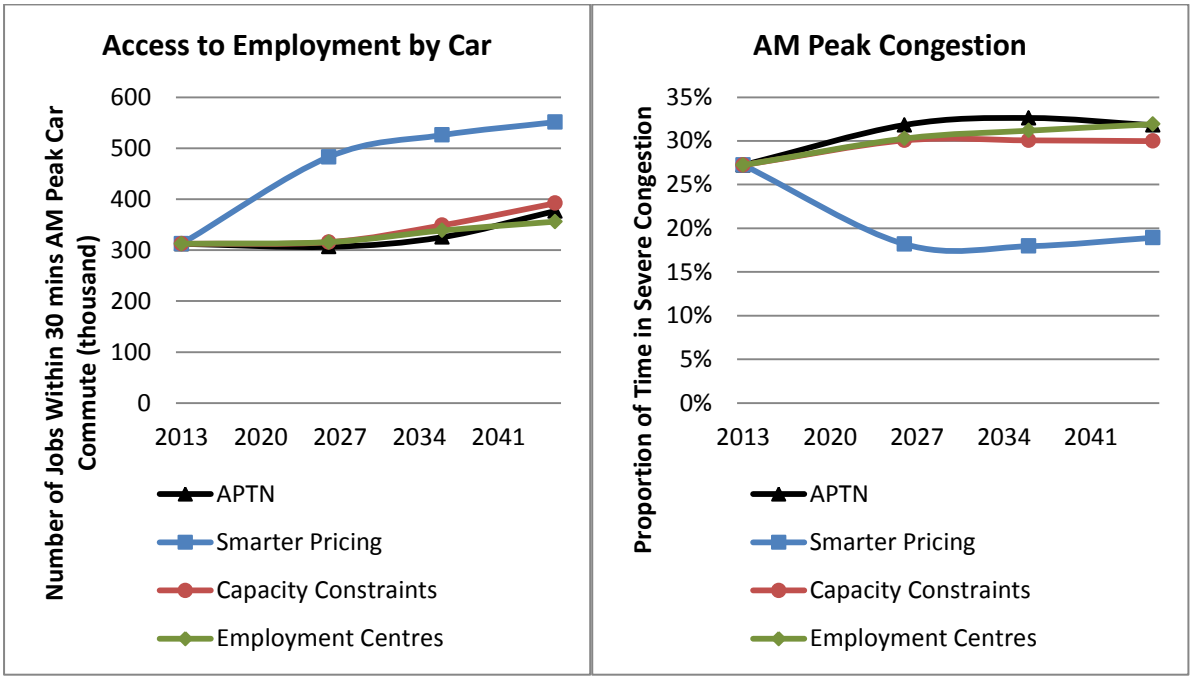
Round 2 hypothetical price levels used for testing (c/km)				
Area	**Network**	**Peak**	**Inter-Peak**	**Off-Peak**
Inner Urban (isthmus)	Motorways	40	30	3
	Other Roads	30	20	3
Outer Urban	Motorways	30	20	3
	Other Roads	20	10	3
Rural	All Roads	3	3	3

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.



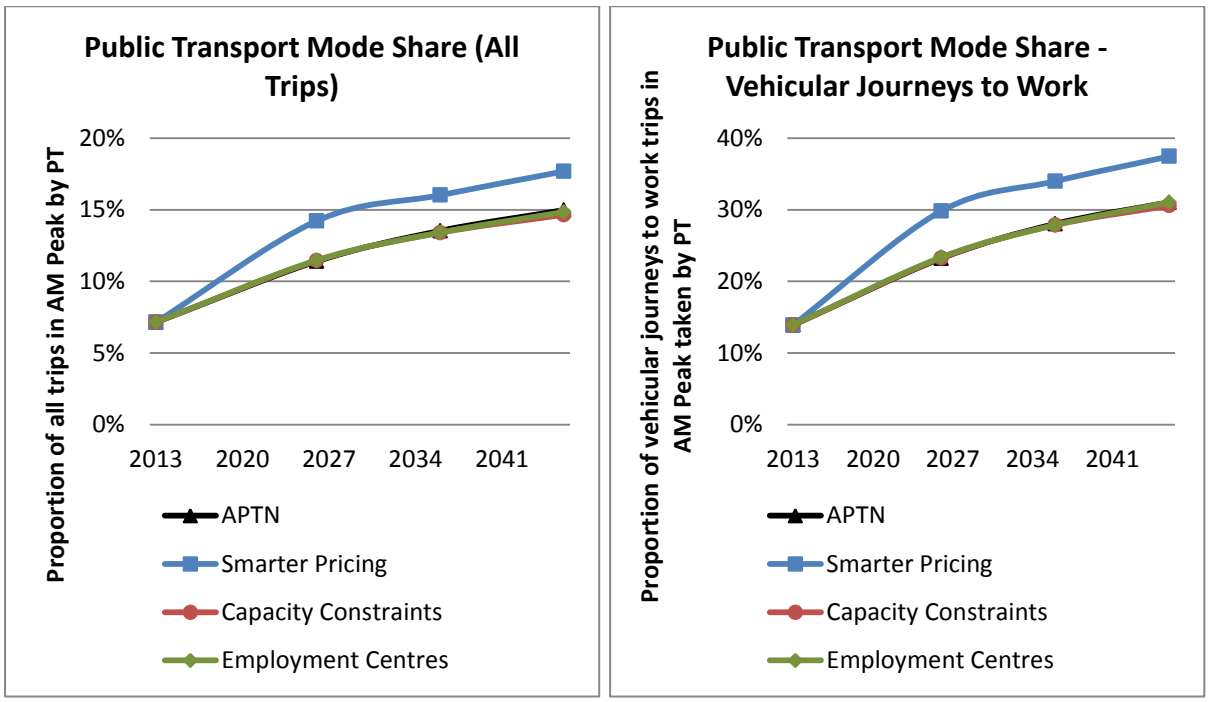
Source: ART3 model outputs, ATAP round 2



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.

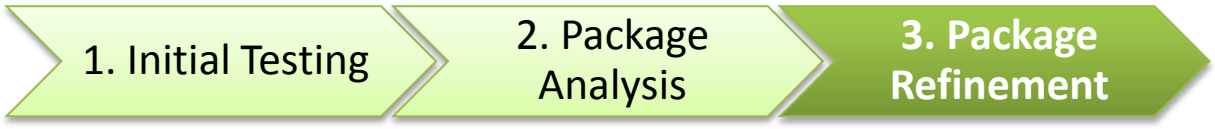
The graphs below show the projected increase in public transport mode share.



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

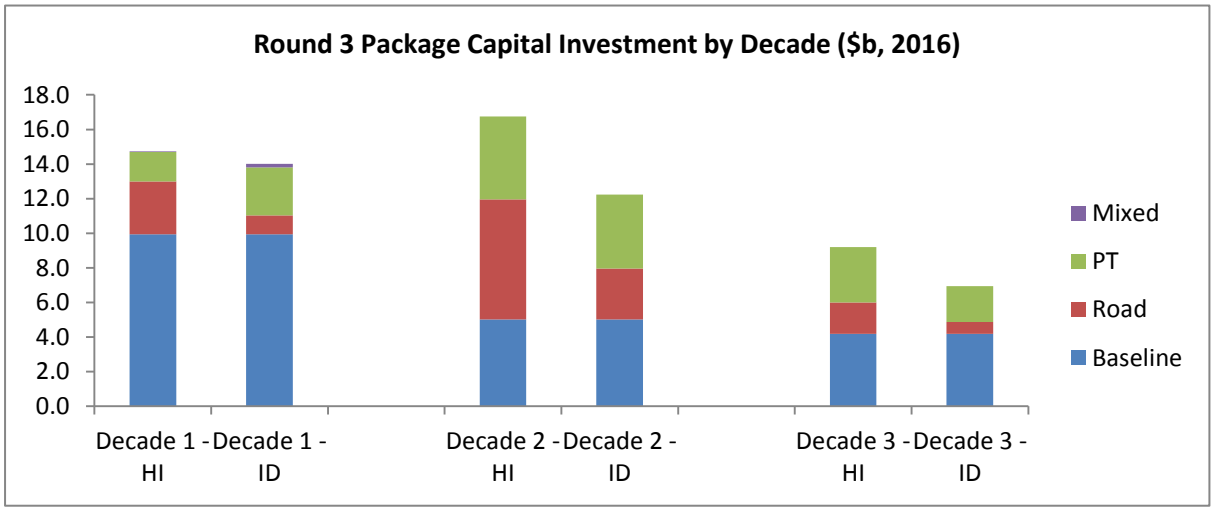
A summary of the two packages is outlined below:

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:

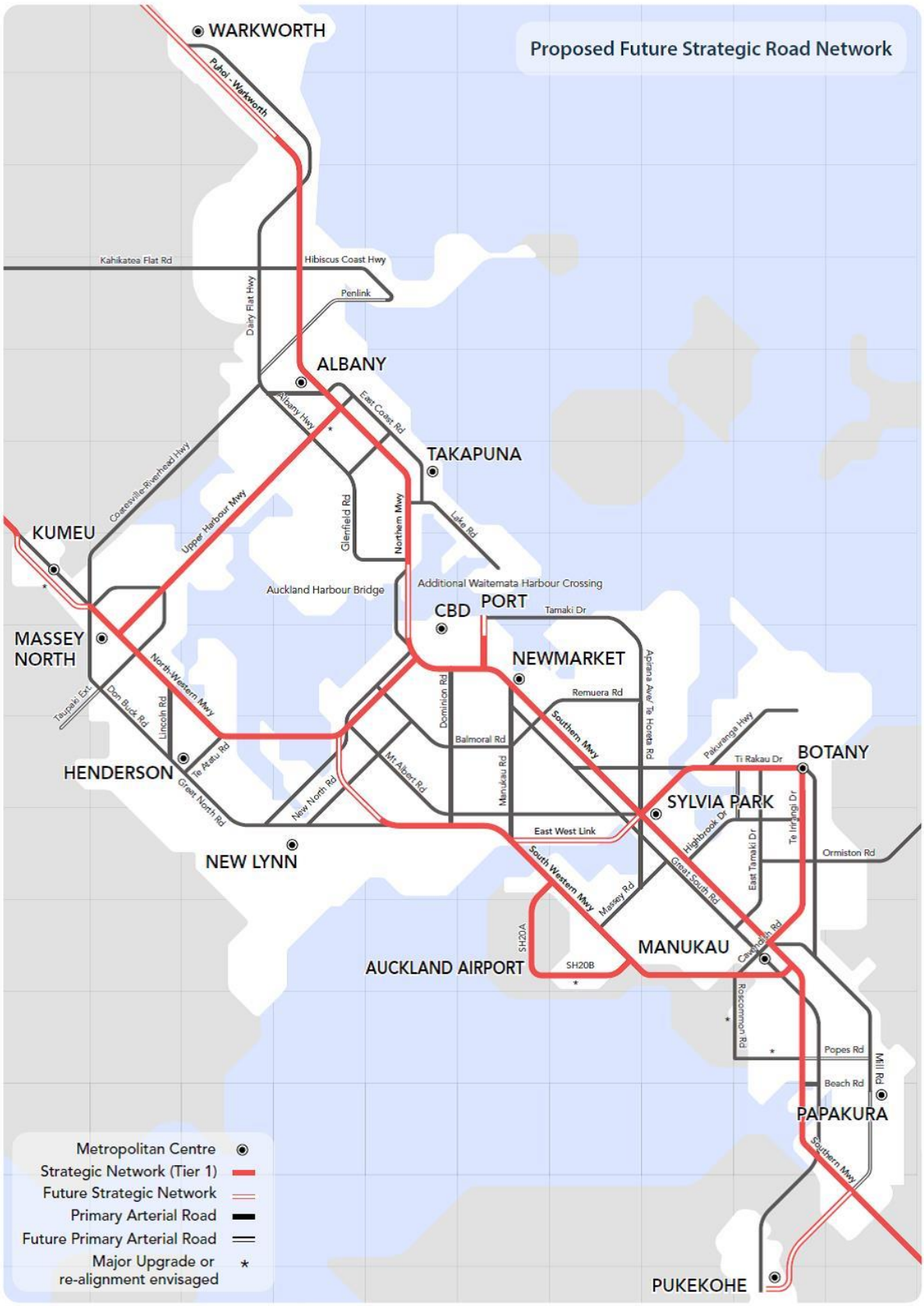
Influence Demand package: hypothetical price levels (c/km)				
Area	**Network**	**Peak**	**Inter-Peak**	**Off-Peak**
Inner Urban (isthmus)	Motorways	30	22.5	2.25
	Other Roads	22.5	15	2.25
Outer Urban	Motorways	22.5	15	2.25
	Other Roads	15	7.5	2.25
Rural	All Roads	2.25	2.25	2.25

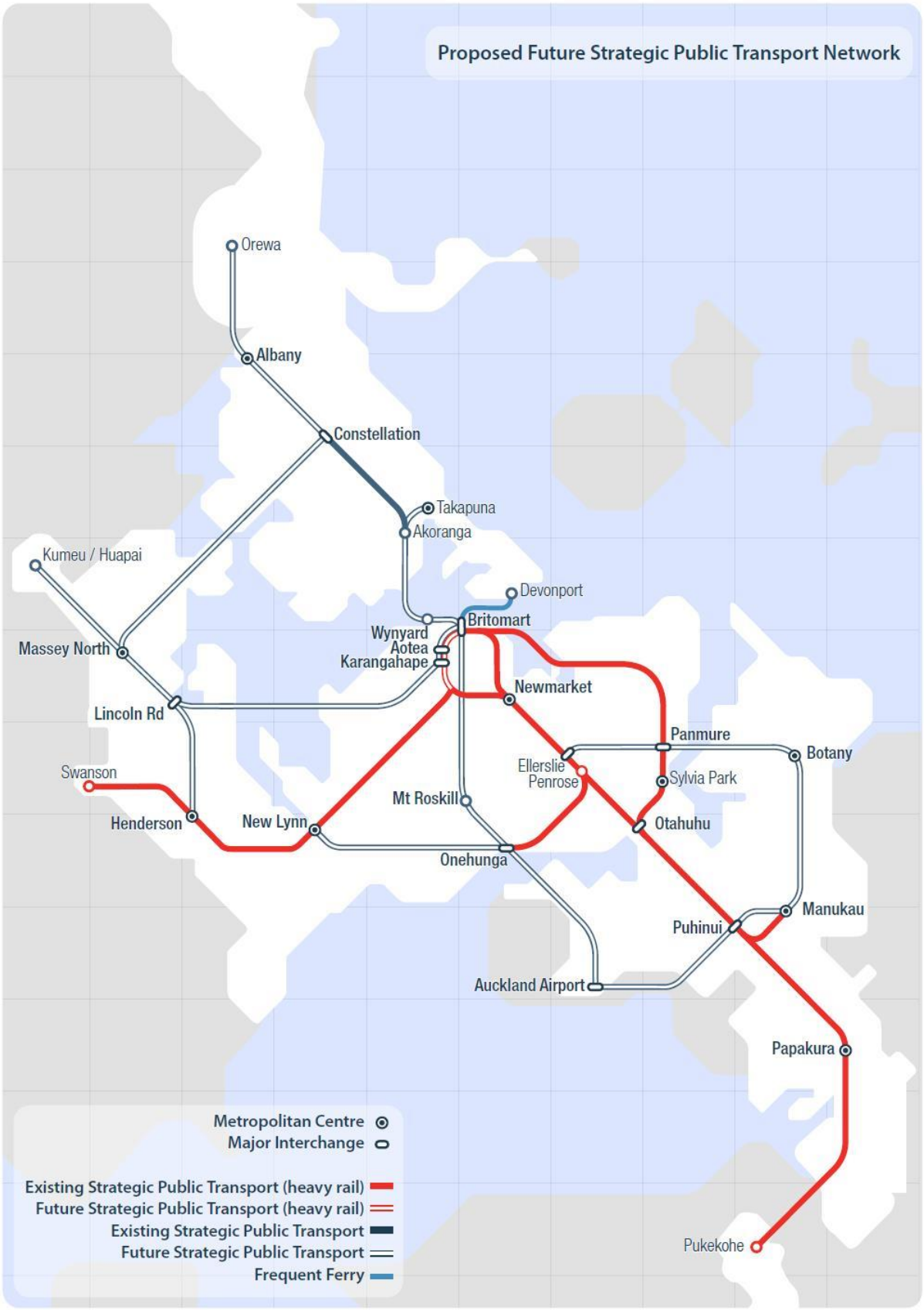
[8] For details of the Rail Development Programme, see section 9

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
North-Western Mwy
Taupaki Ext
Don Buck Rd
Lincoln Rd
Dominion Rd
Remuera Rd
Aprirana Ave/ Te Horeta Rd
Southern Mwy
Balmoral Rd
Pakuranga Hwy
Ti Rakau Dr
BOTANY
HENDERSON
Te Atatu Rd
Great North Rd
Mt Albert Rd
New North Rd
Manukau Rd
SYLVIA PARK
Highbrook Dr
Te Irirangi Dr
East West Link
Ormiston Rd
NEW LYNN
South Western Mwy
Massey Rd
East Tamaki Dr
Great South Rd
SH20A
MANUKAU
Cavendish Rd
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
Swanson
Ellerslie
Penrose
Sylvia Park
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).

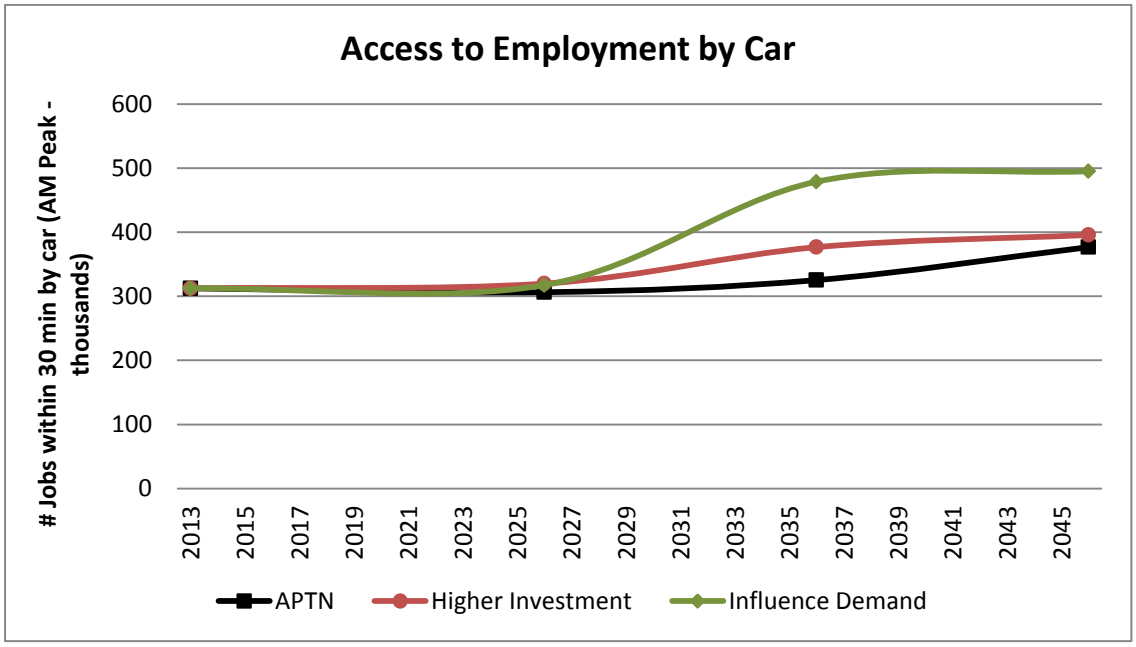
Network	Intervention	Higher Investment by decade			Influence Demand by decade		
		1st	2nd	3rd	1st	2nd	3rd
Strategic Road Network	Additional Waitemata Harbour Crossing (road)		2nd				
	Port access (Grafton Gully-The Strand)	1st				2nd	
	SH1 Princes to Manukau	1st				2nd	
	SH1 Hill Rd to Papakura		2nd				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.

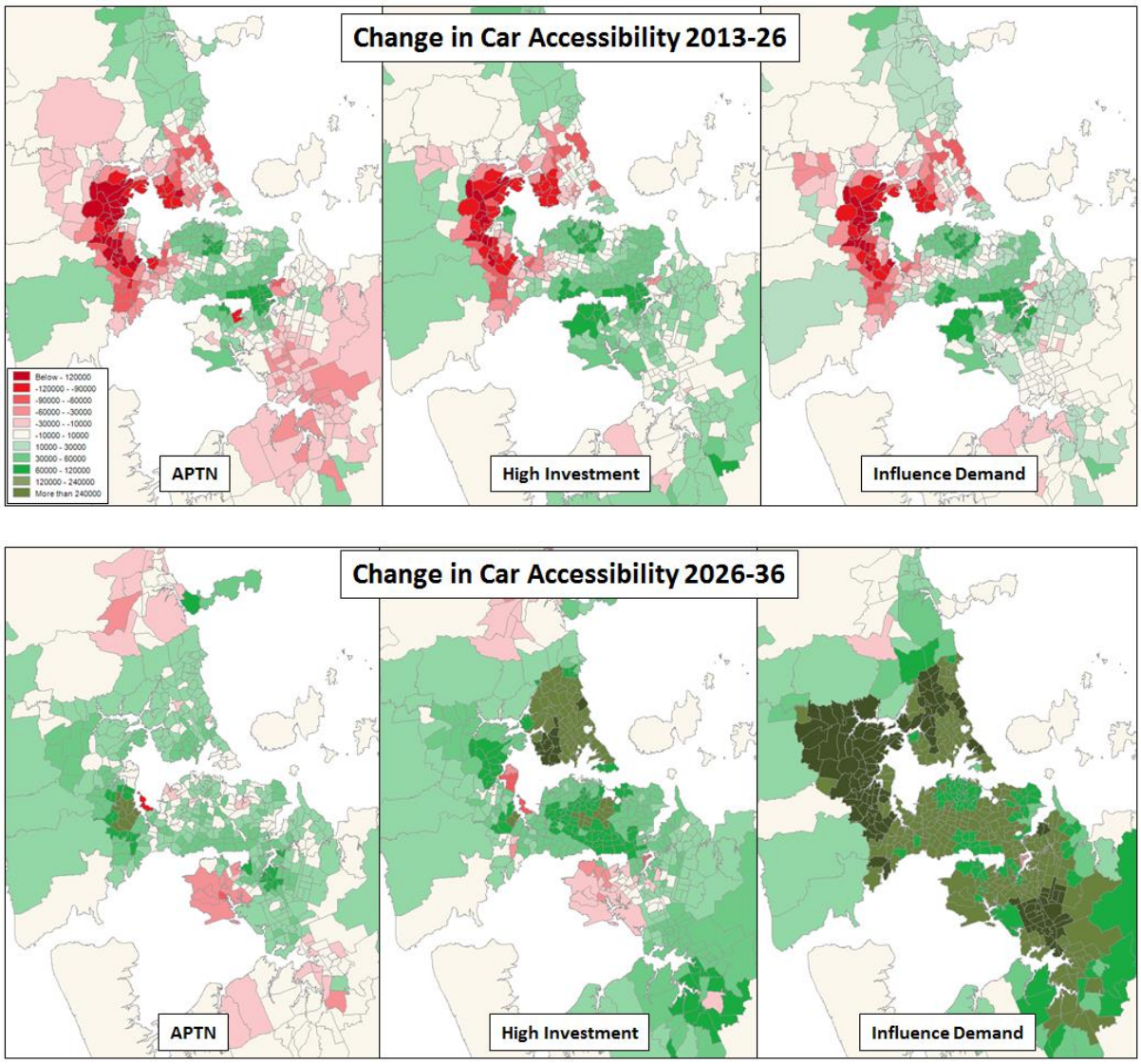


Source: ART3 model outputs, ATAP round 3

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:

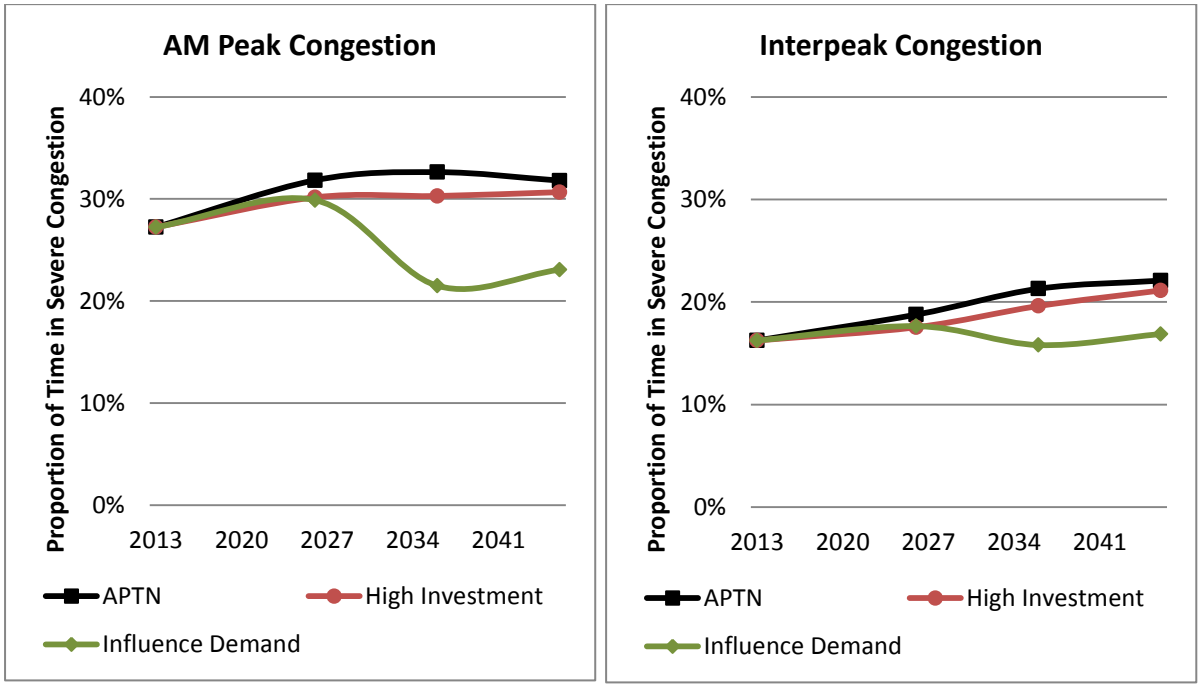
- Under the APTN and Higher Investment packages people living near the airport area have limited access to employment as the motorways serving this area are congested in both directions at peak times, increasing travel times by car and public transport to jobs outside the airport area.
- Inclusion of 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

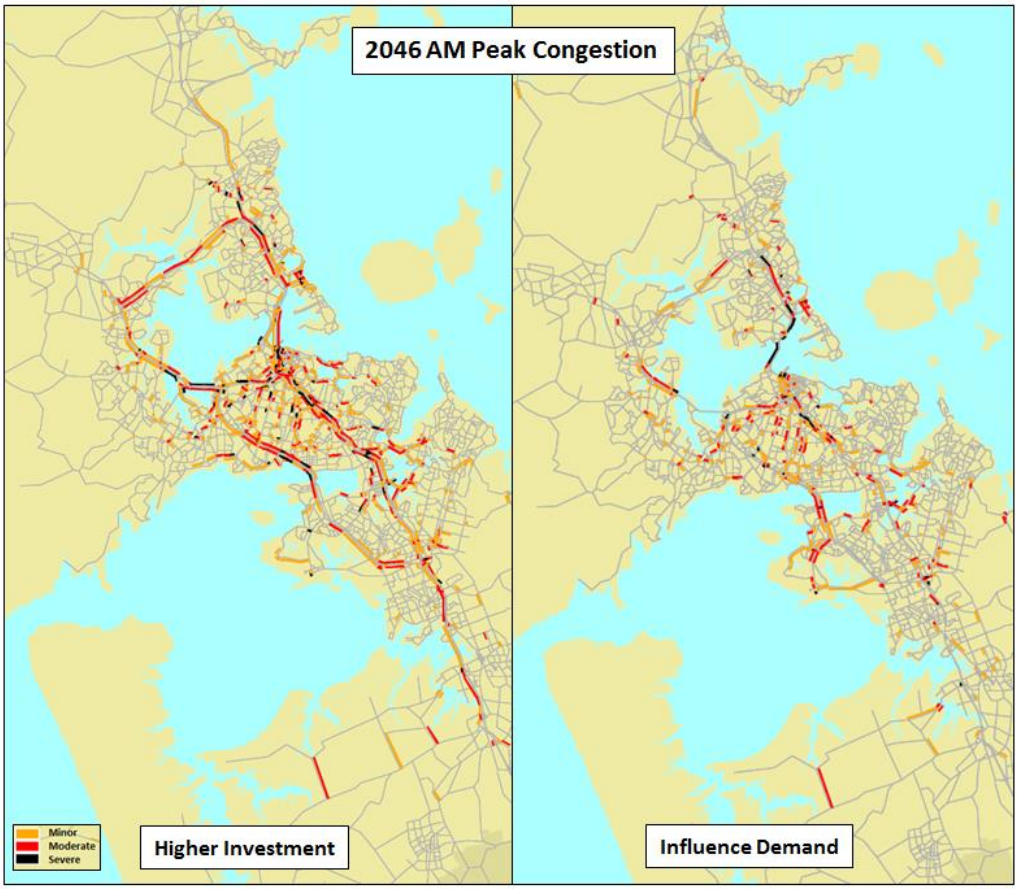
Analysis of projected congestion levels mirrors the car accessibility outputs discussed above. While the Higher Investment package performs slightly better than the APTN (particularly in 2026 and 2036 as a result of earlier investment in additional highway capacity), it is only the progressive introduction 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

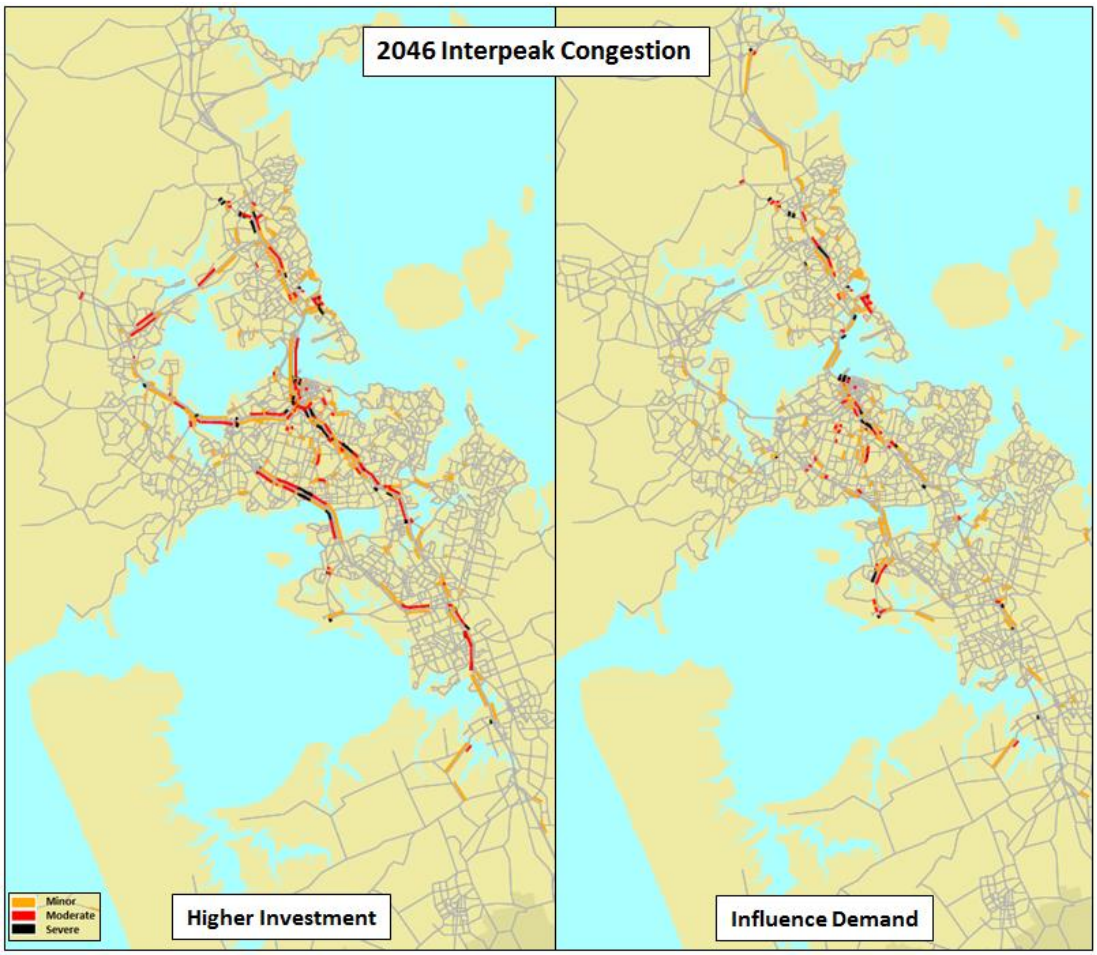
The lower level of congestion for the Influence Demand package is reflected in the more detailed congestion plots for 2046 below.



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.



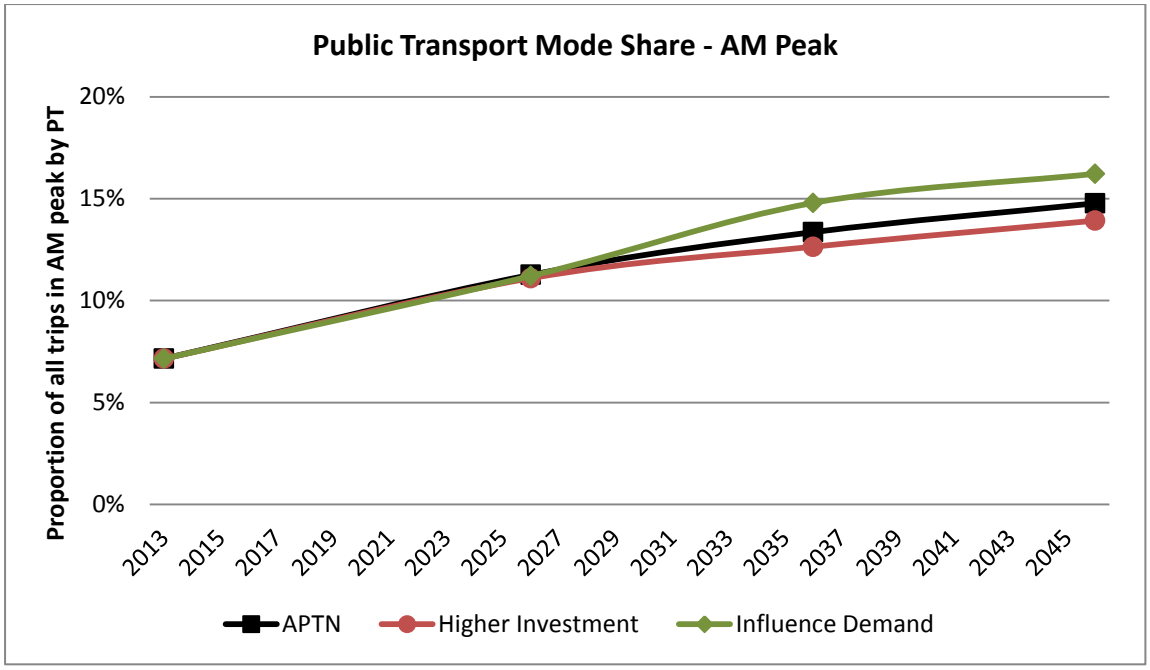
Source: ART3 model outputs, ATAP round 3

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.

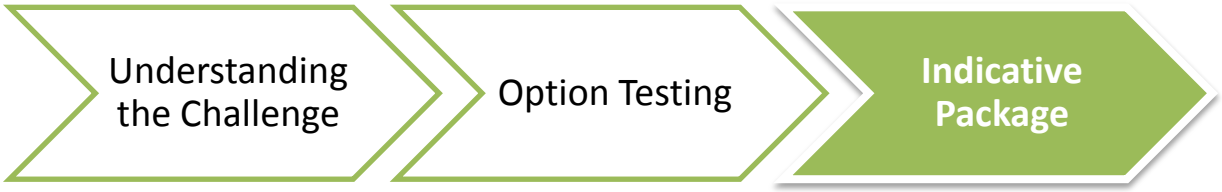
It will be important to understand where travel cost increases occur under a particular pricing structure so that equity impacts (including the affordability of travel to different groups, and the impact of pricing on access to jobs, education and services) can be assessed and any necessary mitigation 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:

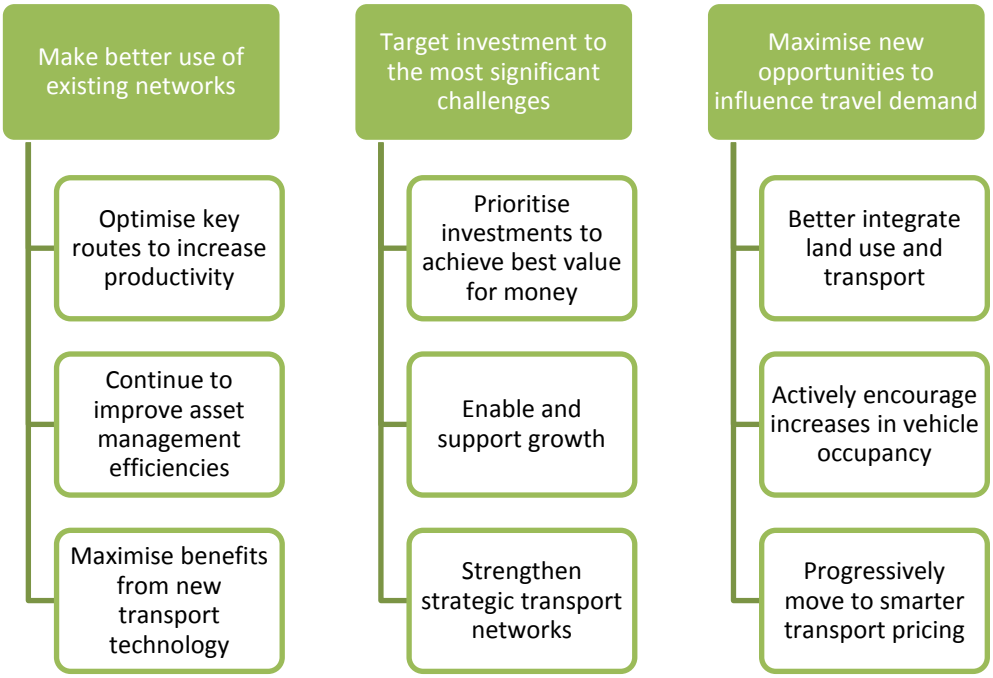
- Additional investment in the first decade did not appear to improve performance against the project objectives at a regional level, but some of these extra investments did have some important sub-regional effects. Therefore, development of the final package should adopt a more targeted approach to 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	X Detracts from an objective
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.	
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.

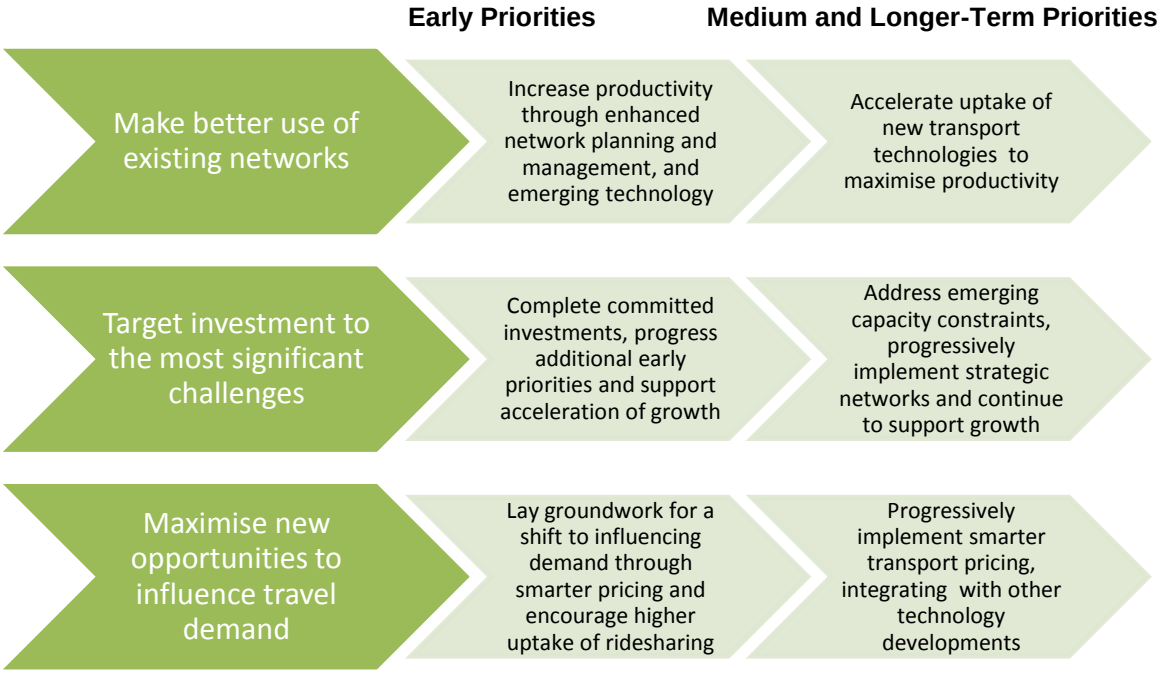
Early priorities, targeted for completion in the first decade are shown in italics. We have included all of the projects with High/High or High/Medium ratings in the first decade, except for:

- 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

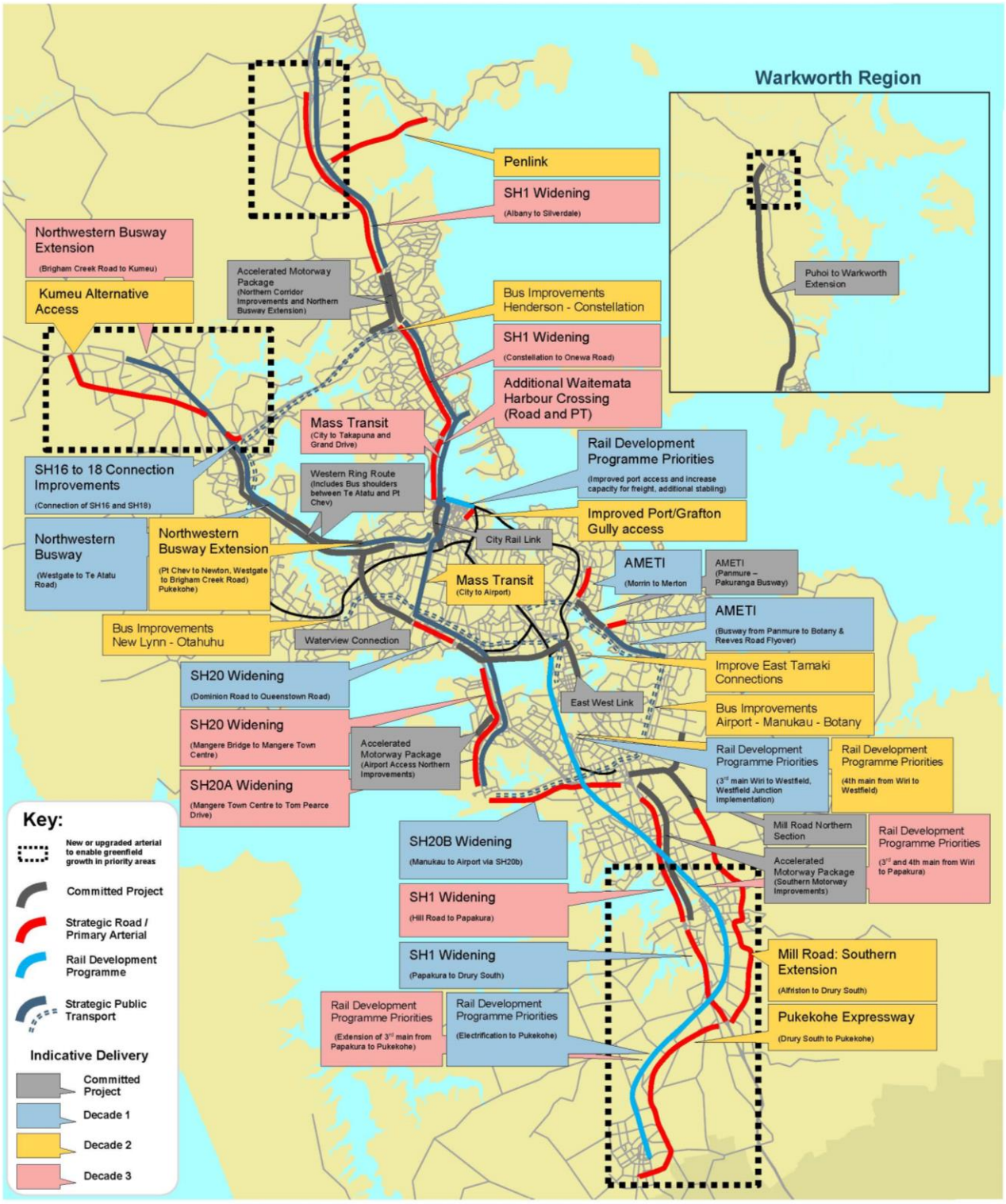
Mass transit proposals respond to growth in public transport, particularly in central Auckland where there are limited opportunities to deliver large scale efficiency improvements or increase capacity in the existing bus system.

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.

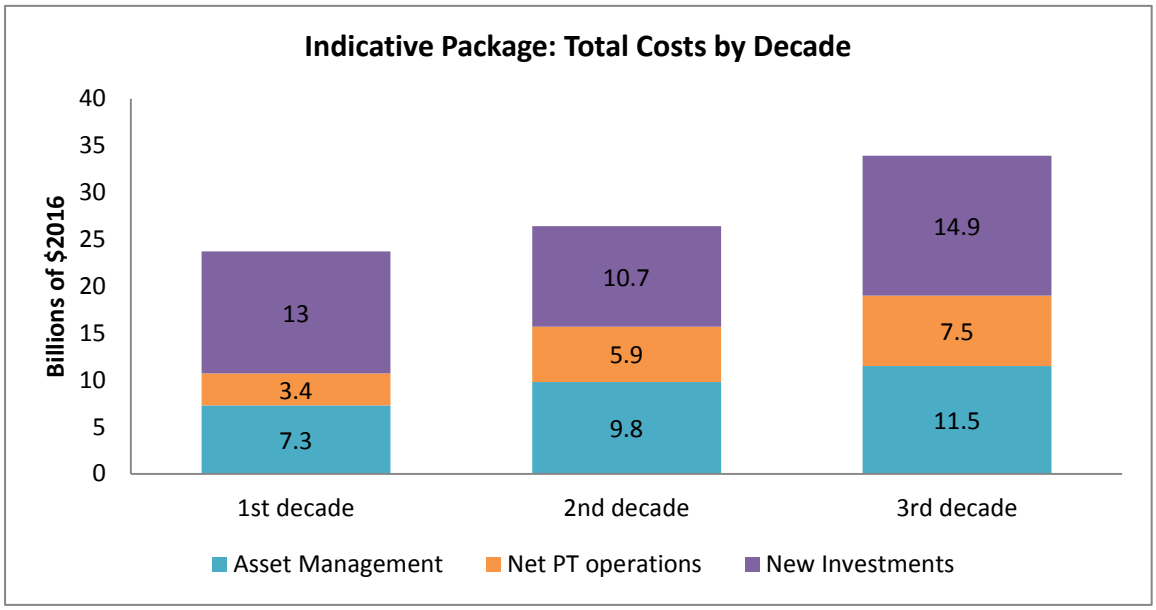
On that basis, we concluded that a higher capacity mode, possibly light rail, is likely to be required on the central isthmus in the medium-term (2028-2038), and subsequently extended to Auckland Airport.

Indicative Package: major investments by decade



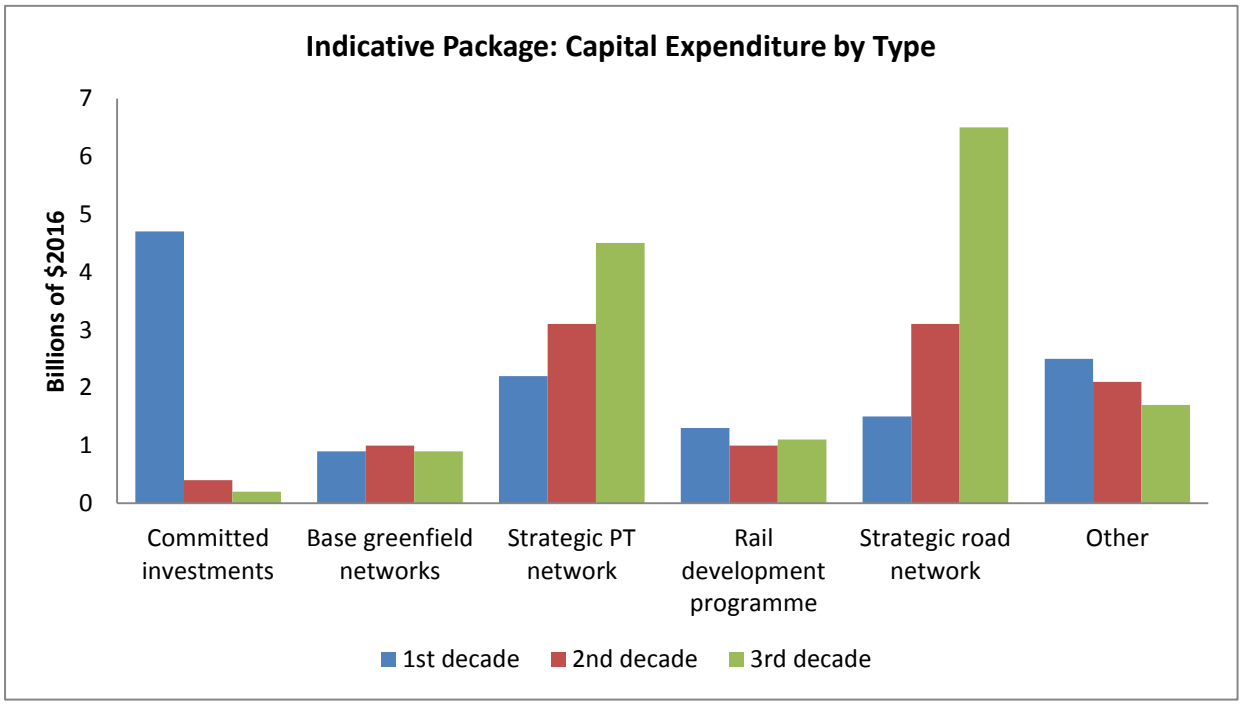
11.3. Cost estimates for Indicative Package

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.



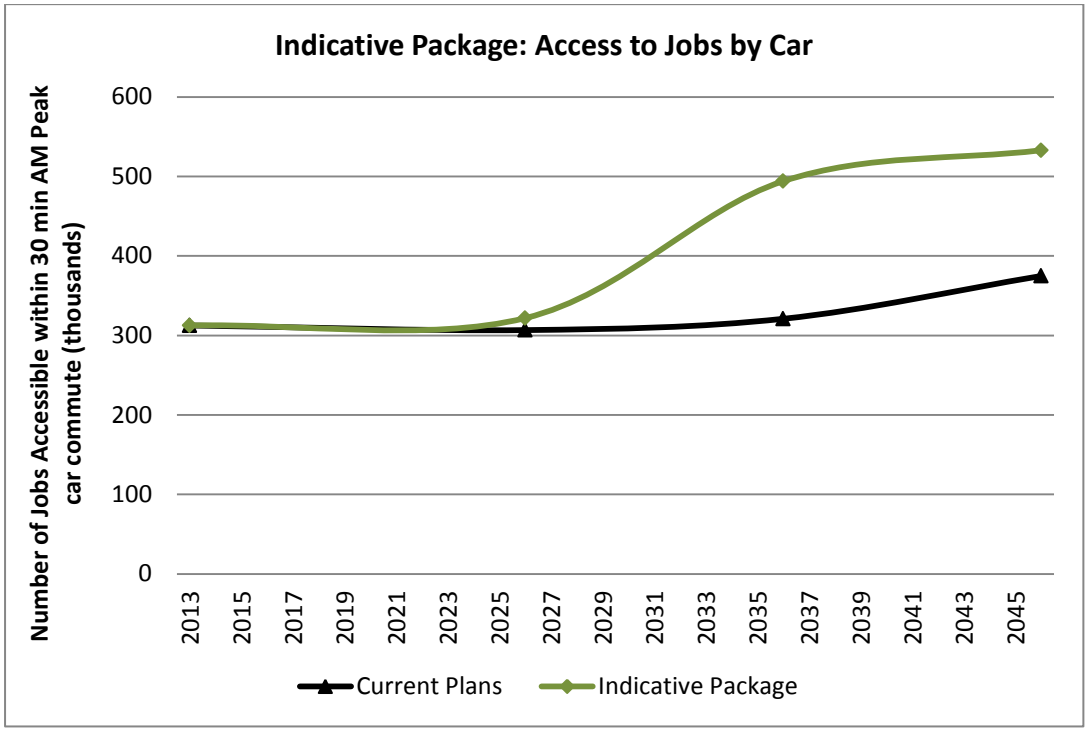
Source: ATAP Revenue & Expenditure workstream estimates, ATAP round 4

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".

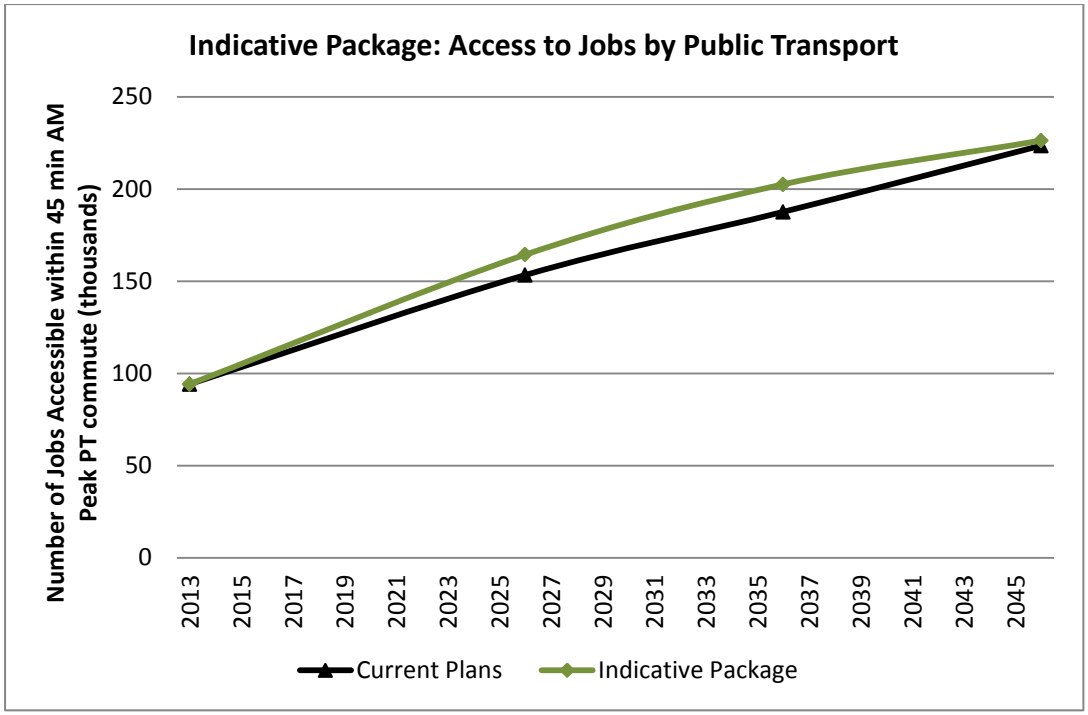
12.1. Access to employment

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.



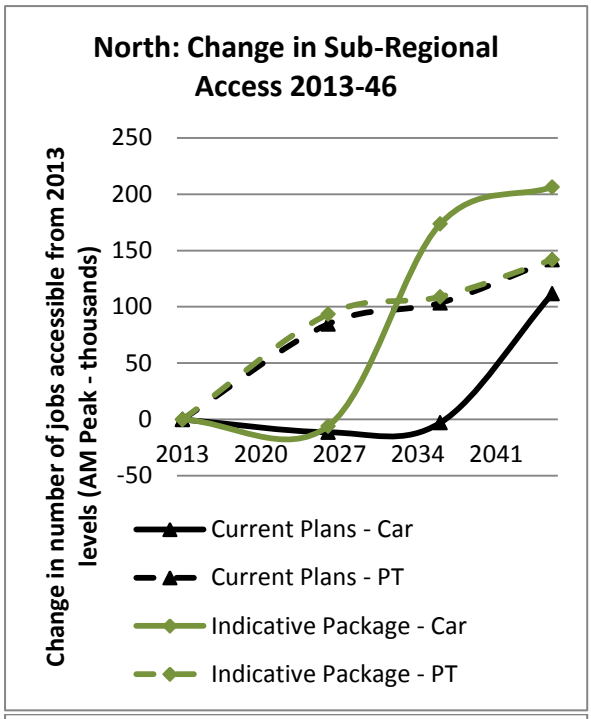
Source: ART3 model outputs, ATAP round 4

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

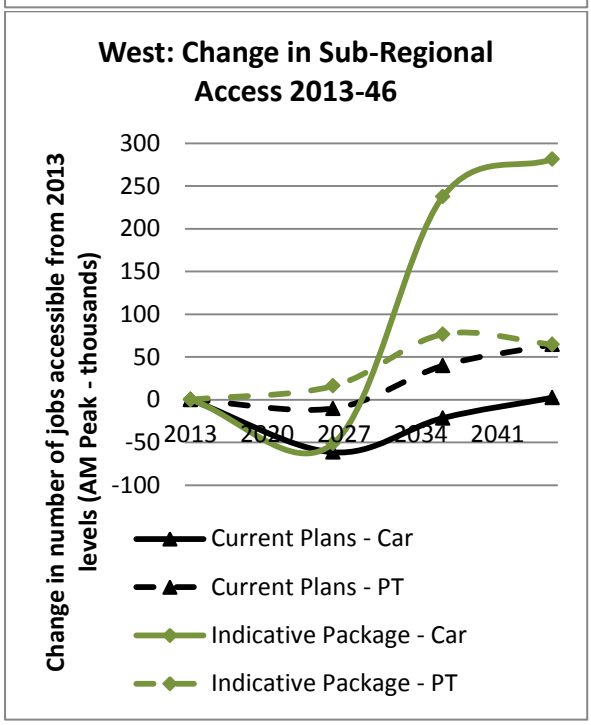
Sub-regional car accessibility was highlighted as a major challenge in Phase One of the project, particularly for the west and south. The graphs below show sub-regional results.



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.

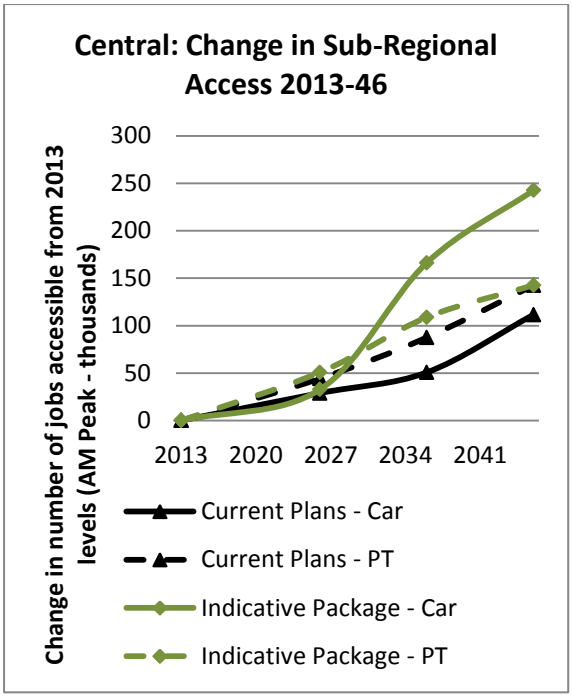
Public transport access increases at a similar level for both packages throughout the next 30 years, with increases in the third decade driven by a major upgrade to a higher capacity mass transit option from the North Shore to the city centre.



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.

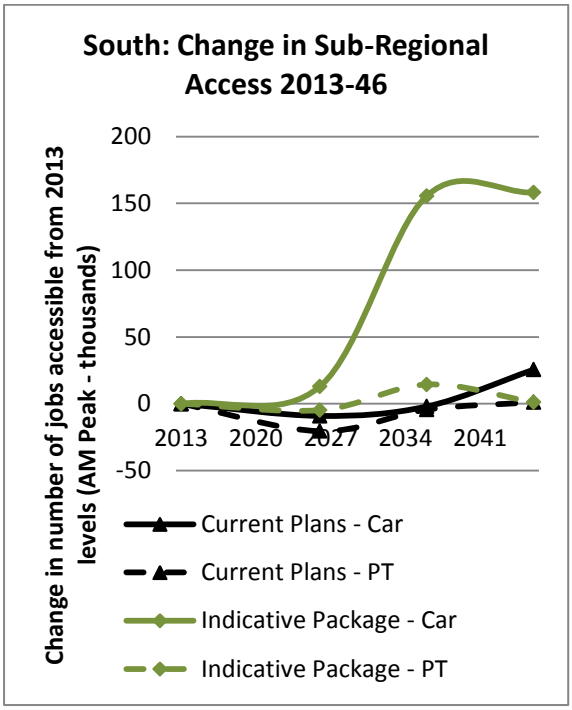
The Indicative Package provides noticeably higher public transport access in the first and second decades.



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.



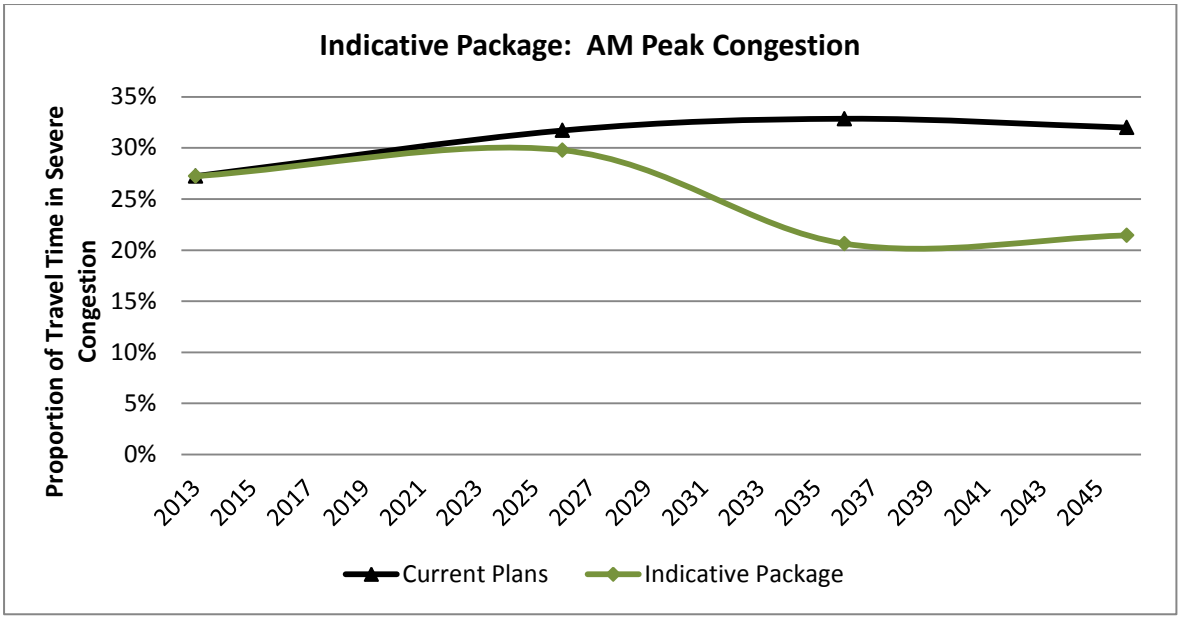
South:

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.

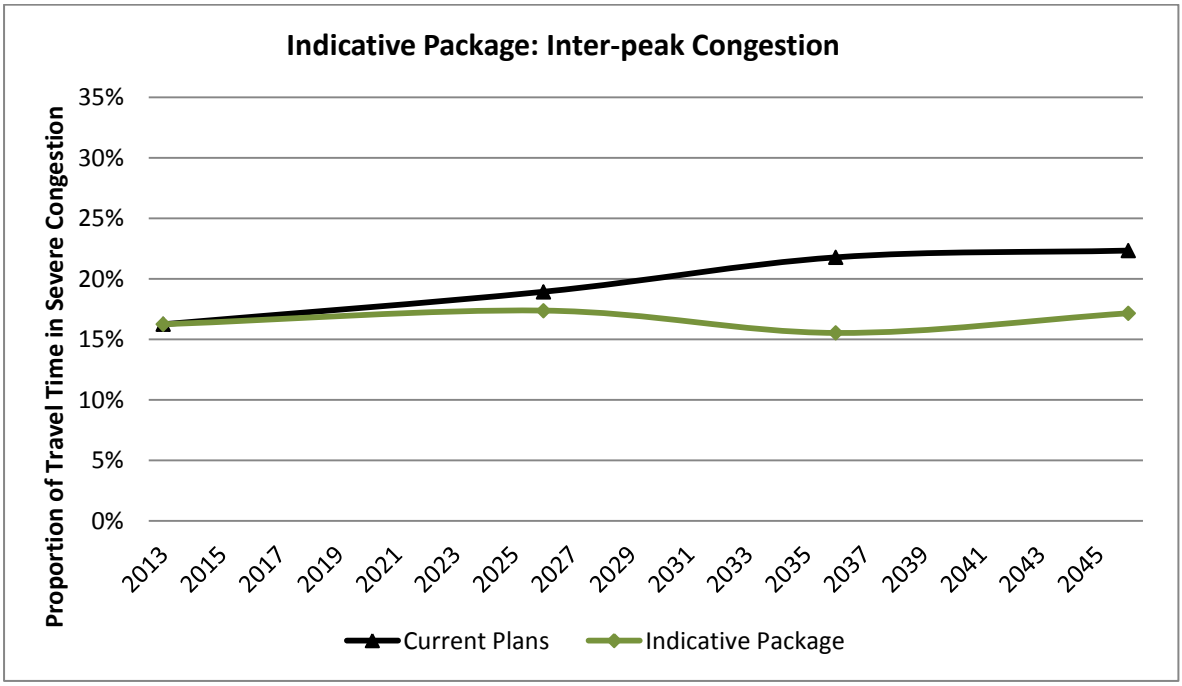
12.2. Congestion

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

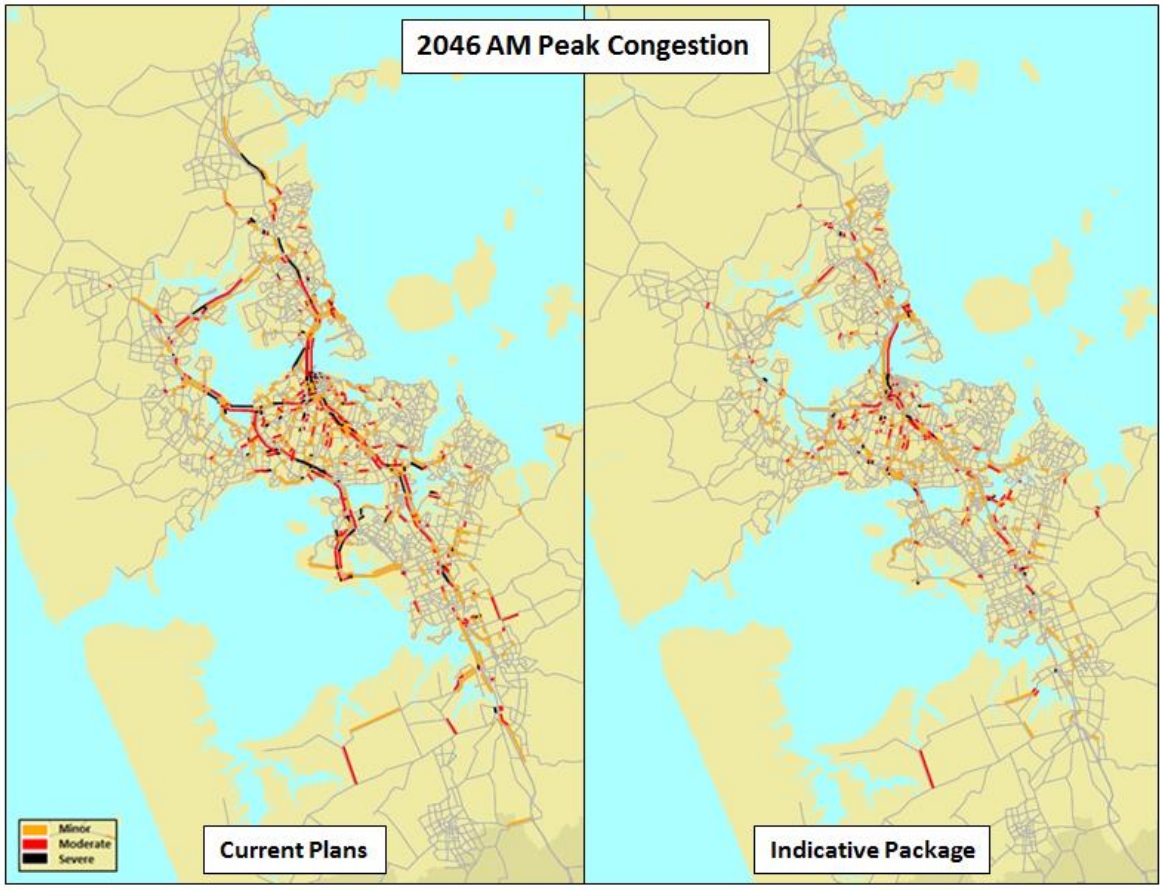
Projected inter-peak congestion shows similar trends, with the introduction of smarter pricing holding congestion at around 2013 levels over the next 30 years, despite population and employment growth.

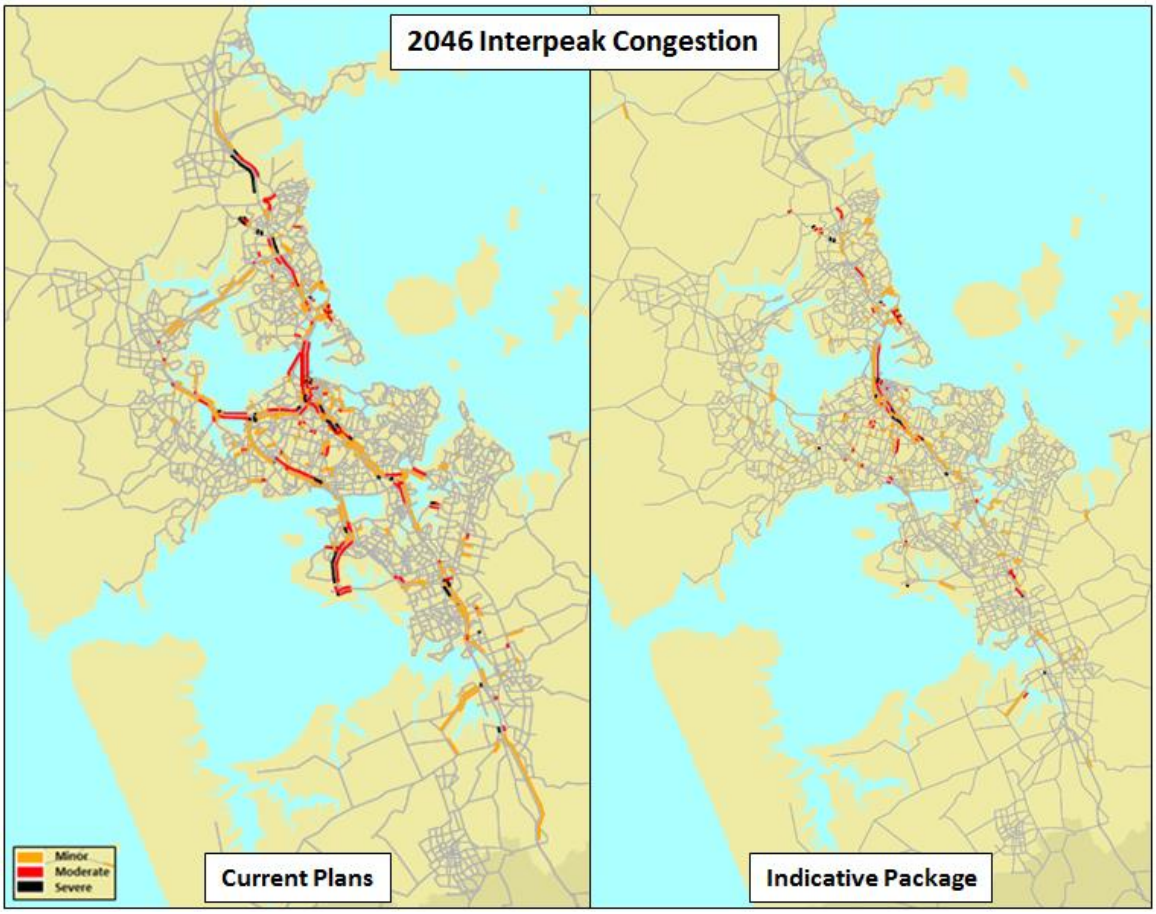


Source: ART3 model outputs, ATAP round 3 and 4

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.

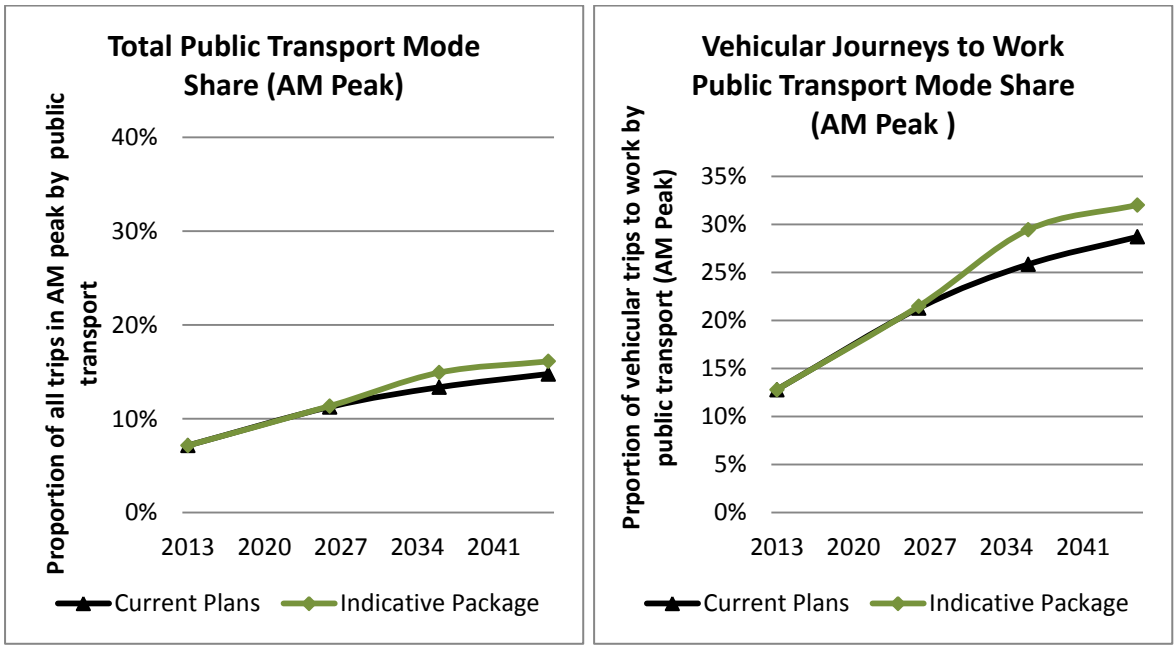




Source: ART3 model outputs, APTN analysis and Round 4

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.

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