Auckland Transport Alignment Project

Evaluation Report

Contents

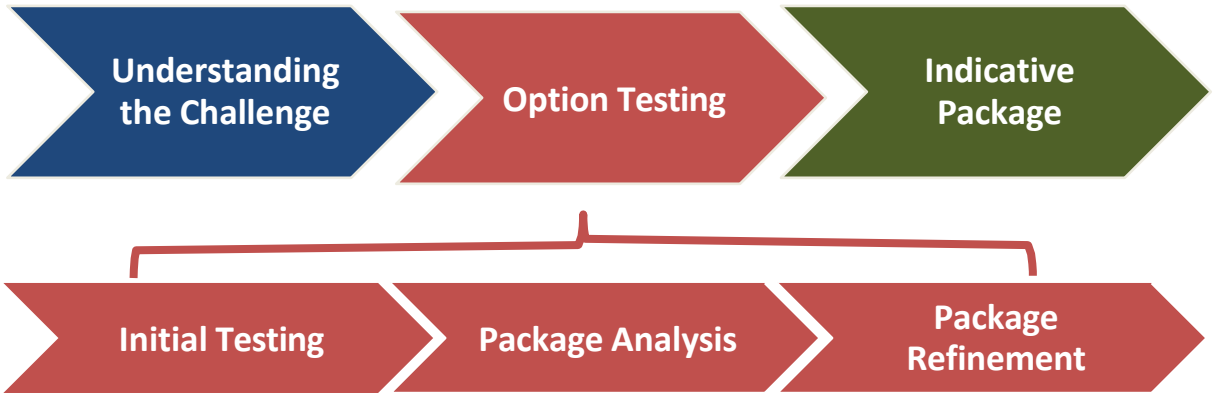
Preface

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

Introduction

i. Purpose of Report

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



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

ii. Project Objectives

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

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

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

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

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

iii. Project Deliverables

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

The Foundation Report

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

The Interim Findings Report

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

The Final Report

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

iv. Evaluation Framework

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

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

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

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

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

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

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

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

v. Evaluation Tools

Background

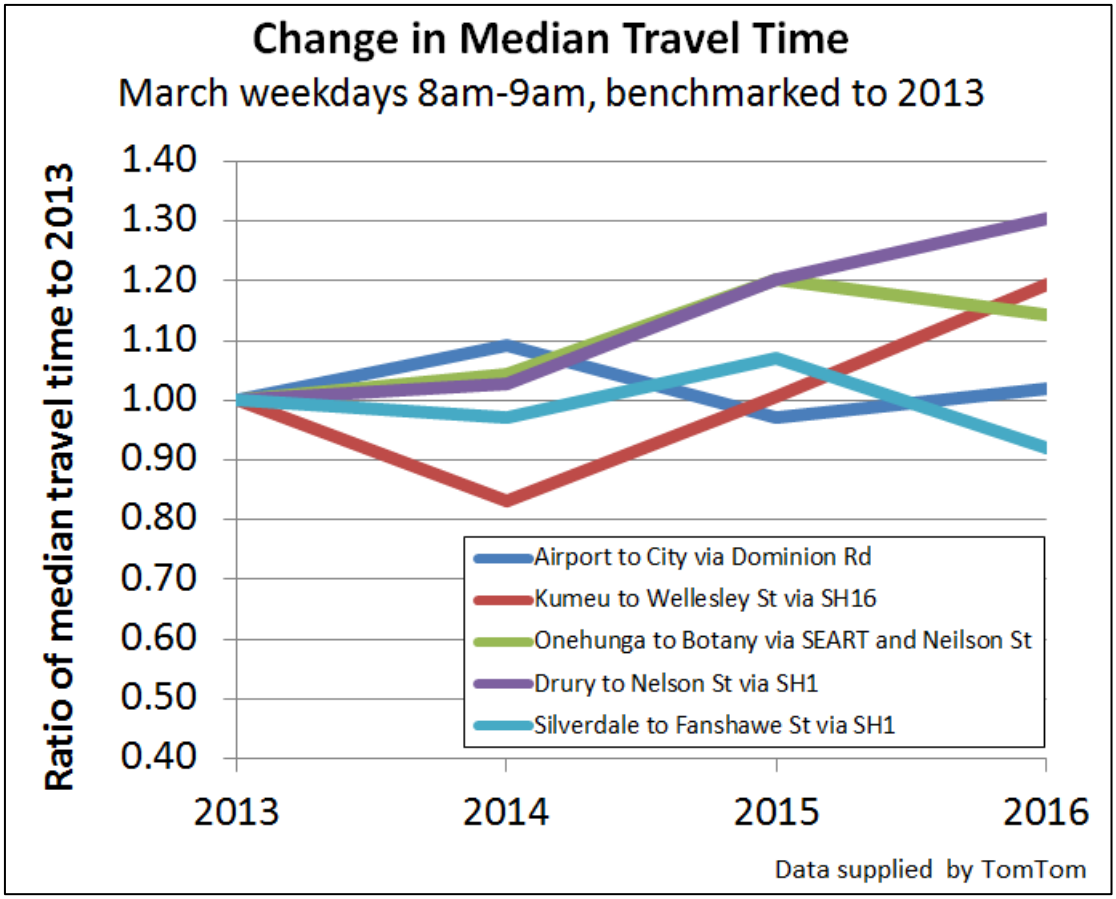
The Project uses the Auckland Regional Transport model (ART3) and Auckland Public Transport model (APT3) in its evaluation of projects and packages. Both models are regional scale demand models and have modelling strengths and limitations that need to be taken into consideration when selecting appropriate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

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

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

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

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



Model input assumptions

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

Application of the models to the evaluation

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

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

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

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

Common baseline used for modelling purposes

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

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

Suggestions for future detailed modelling evaluation

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

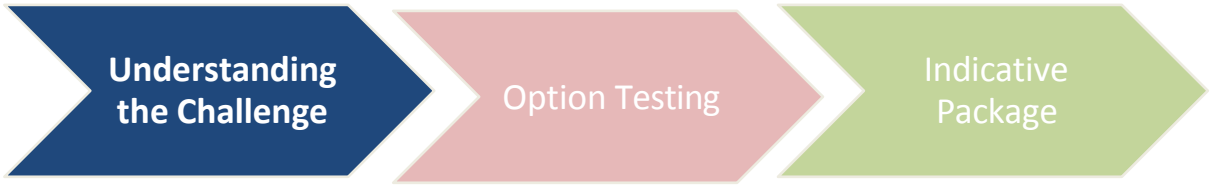
The following suggestions were raised during the project for future detailed modelling evaluation:

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

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

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

Phase 1 – Understanding the Challenge



1. The Auckland Plan Transport Network

1.1 Package Description

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

Background

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

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

Key Interventions by Time Period

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

Table 1.1: APTN key interventions by decade

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

1.2 Key Findings

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

Region-wide Transport Challenges

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

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

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

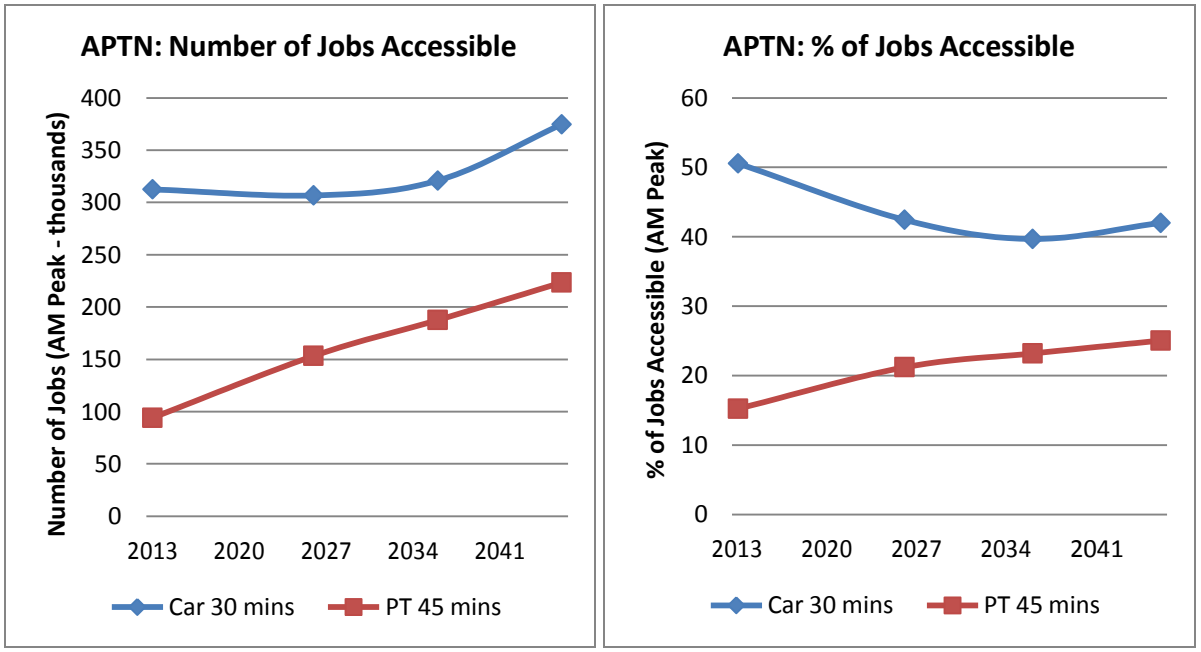


Figure 1.1: Accessibility to jobs for car and public transport in AM peak (APTN)

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

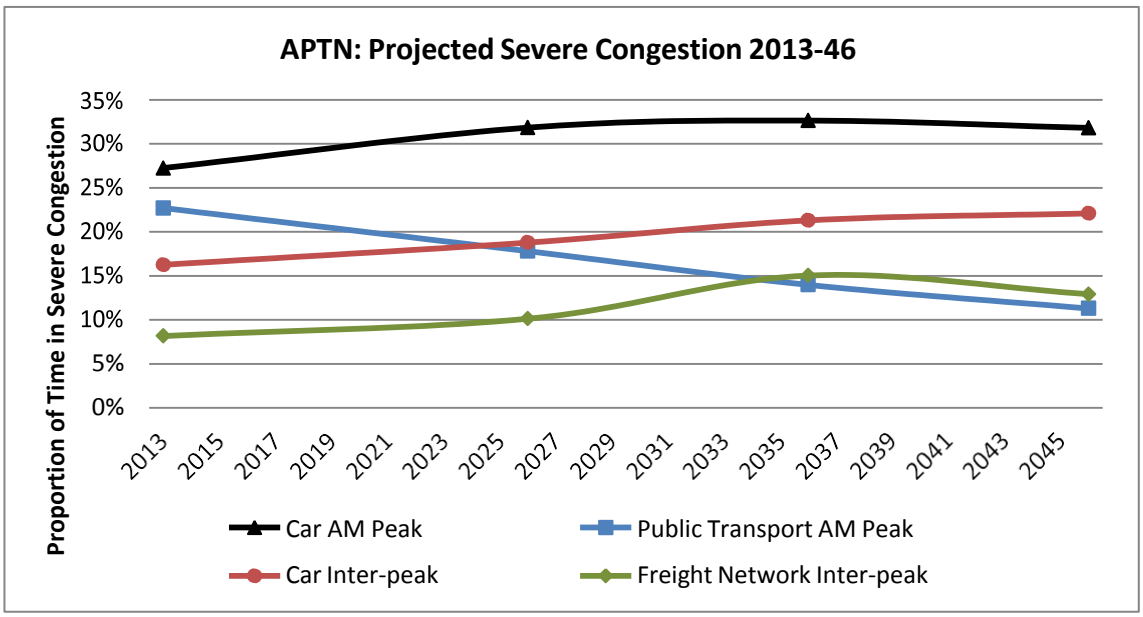


Figure 1.2: Projected severe congestion for car, public transport and freight (APTN)

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

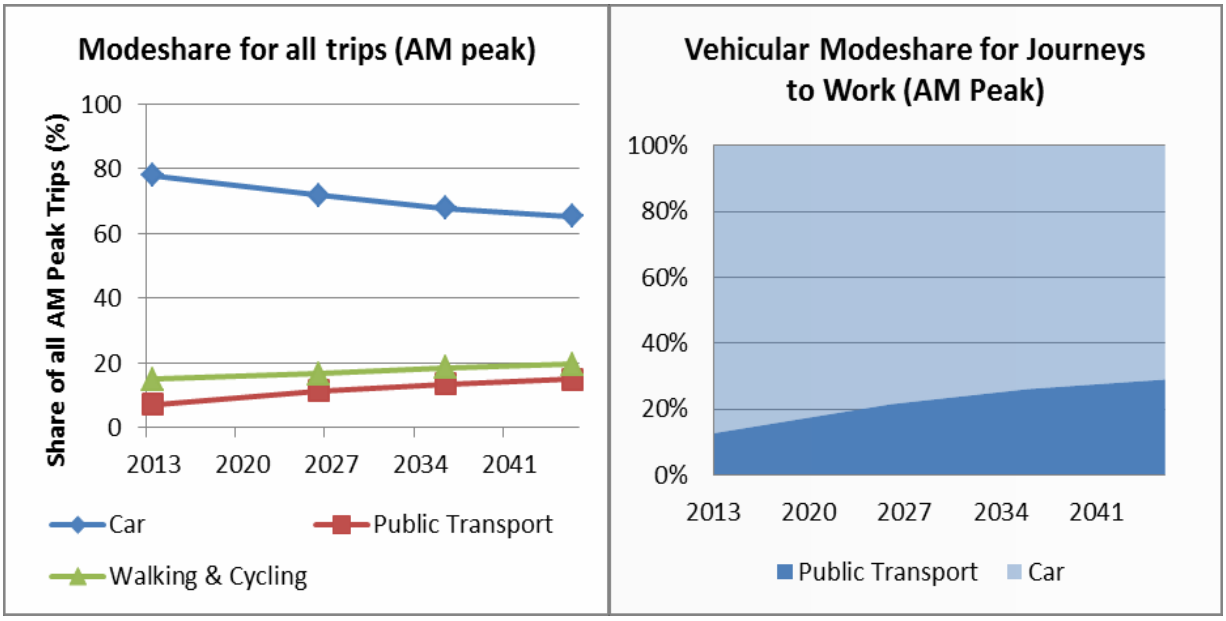


Figure 1.3: Projected mode share (APTN)

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

Access to Employment and Labour

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

Congestion

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

Public Transport Mode Share

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

Value for Money

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

Specific Transport Challenges

Accessibility in West and South Auckland

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

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

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

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

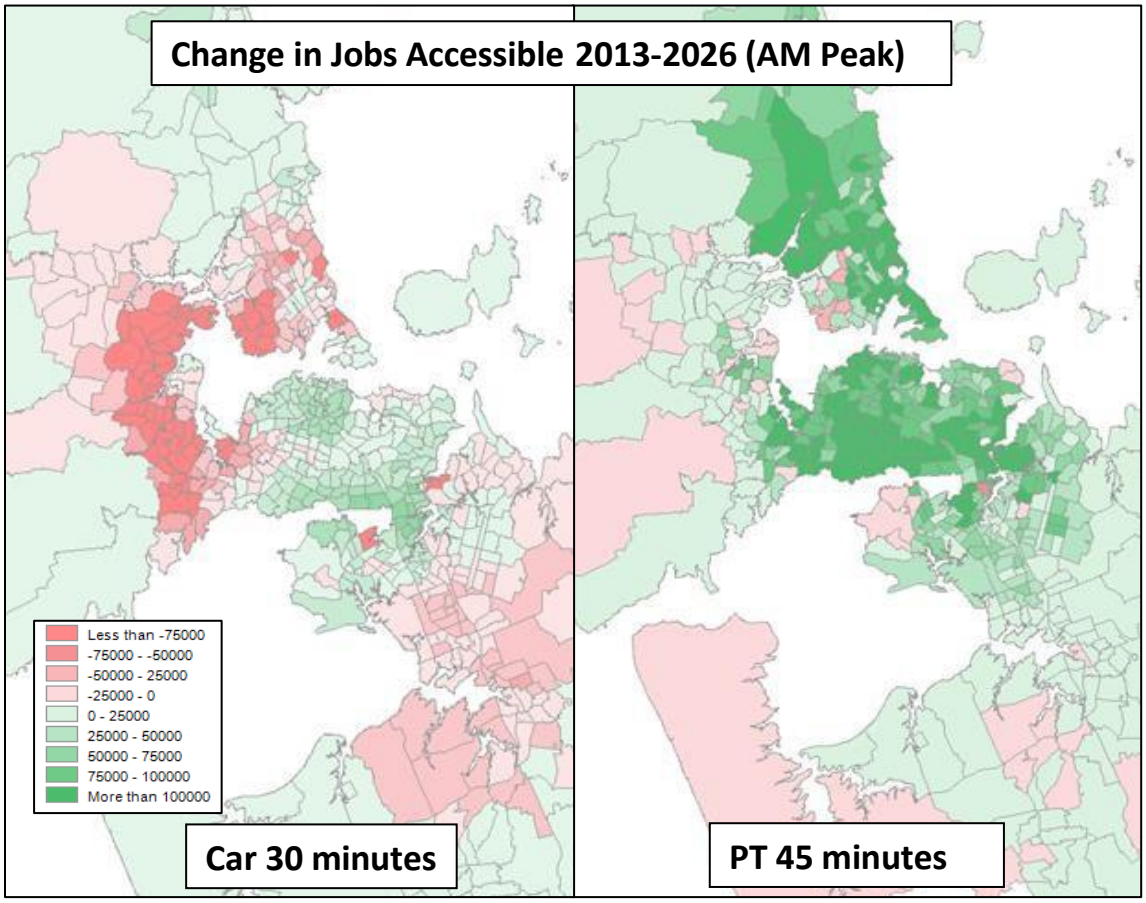


Figure 1.4: Change in accessibility to jobs 2013 vs 2026 (APTN)

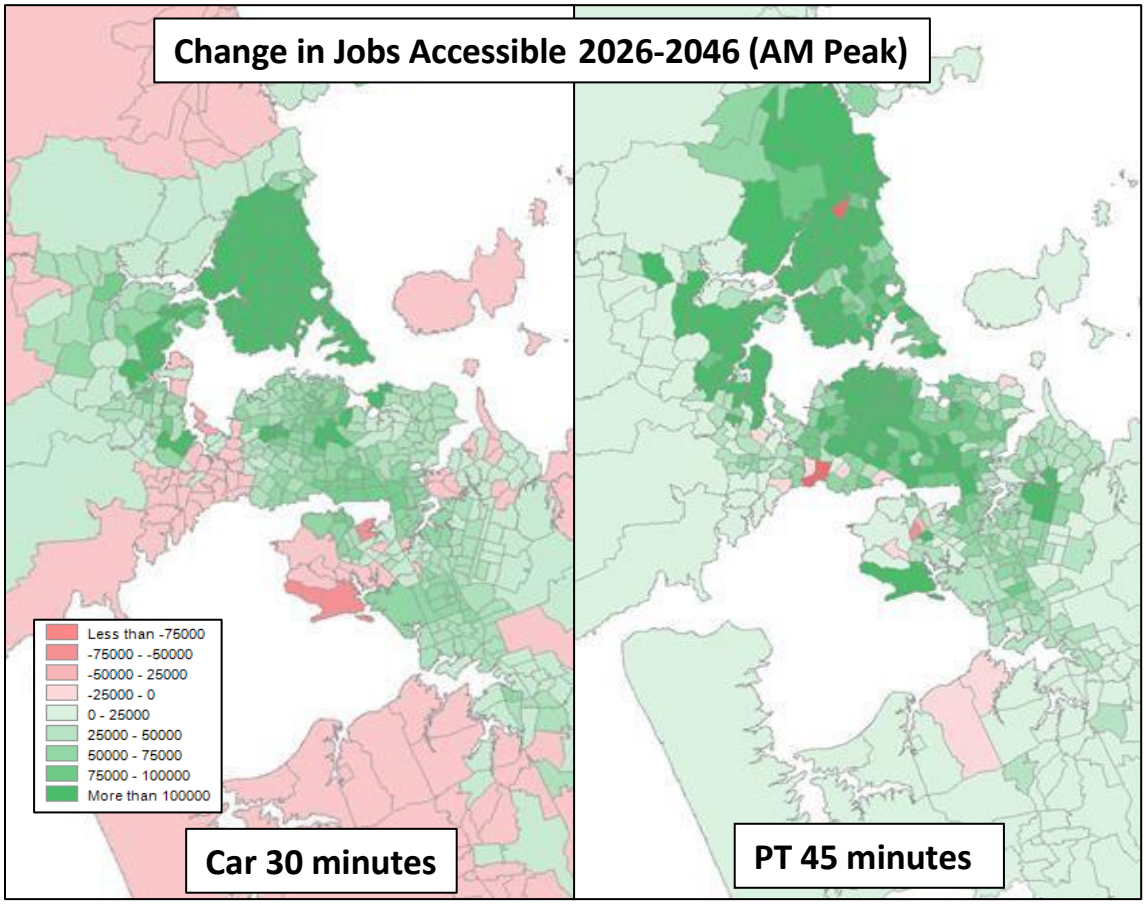


Figure 1.5: Change in accessibility to jobs 2026 vs 2046 (APTN)

1.3 Key Learnings

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

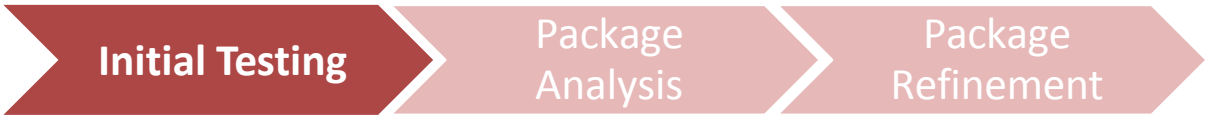
A modest increase in public transport mode share occurs broadly over the next 30 years, although improvements are unevenly spread, with a particularly low level of mode share growth occurring in the south. For large parts of the overall transport task, particularly in outer areas of Auckland, public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

Phase 2 – Option Testing

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

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

2. Initial Testing



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

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

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

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

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

2.1 Smarter Pricing: Initial Analysis

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

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

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

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

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

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

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

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

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

2.2 Emerging Transport Technologies

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

- Increasing vehicle occupancy rates
- The uptake of connected vehicles

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

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

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

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

Table 2.1: Changes to car occupancy rate

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

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

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

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

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

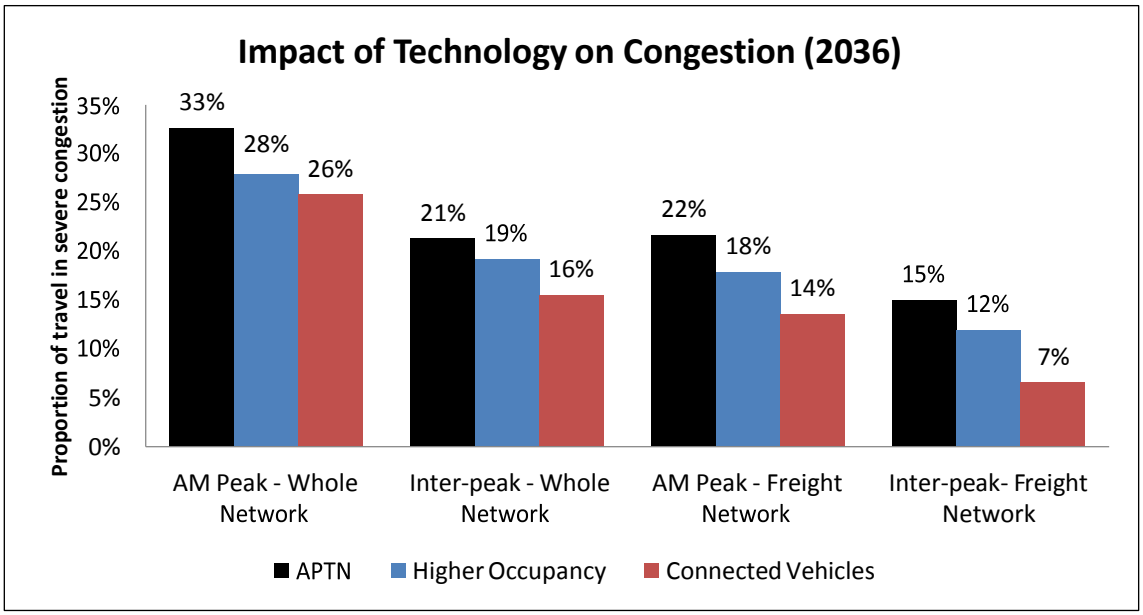


Figure 2.1: Impact of technology on congestion (2036)

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

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

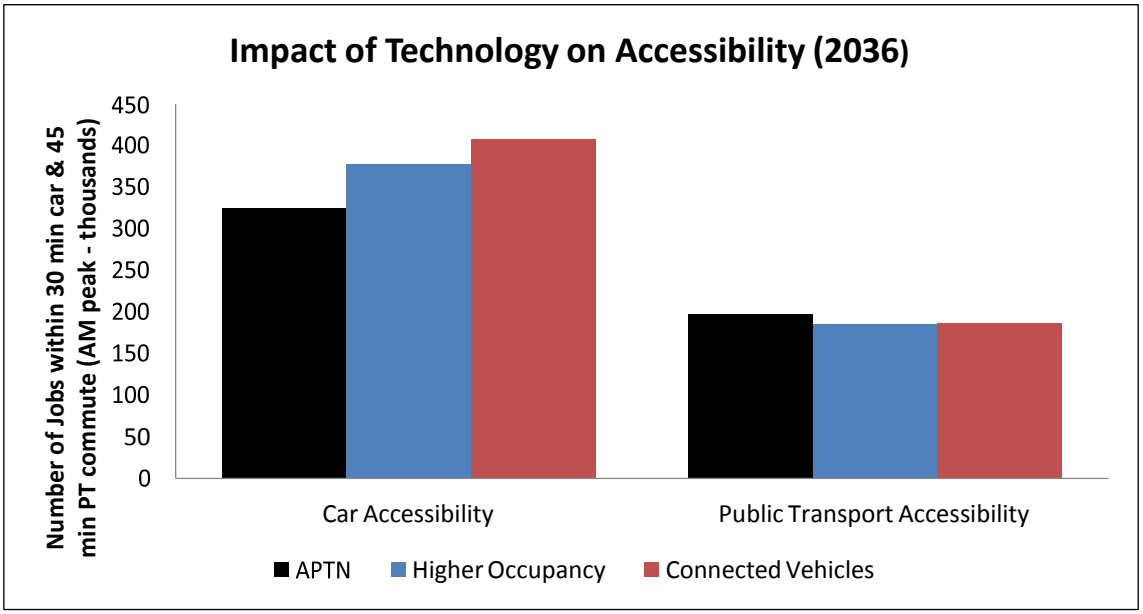


Figure 2.2: Impact of technology on accessibility (2036)

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

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

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

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

3. Package Analysis

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

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

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

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

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

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

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

3.1 Focus on Addressing Capacity Constraints

3.1.1 Package description

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

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

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

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

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

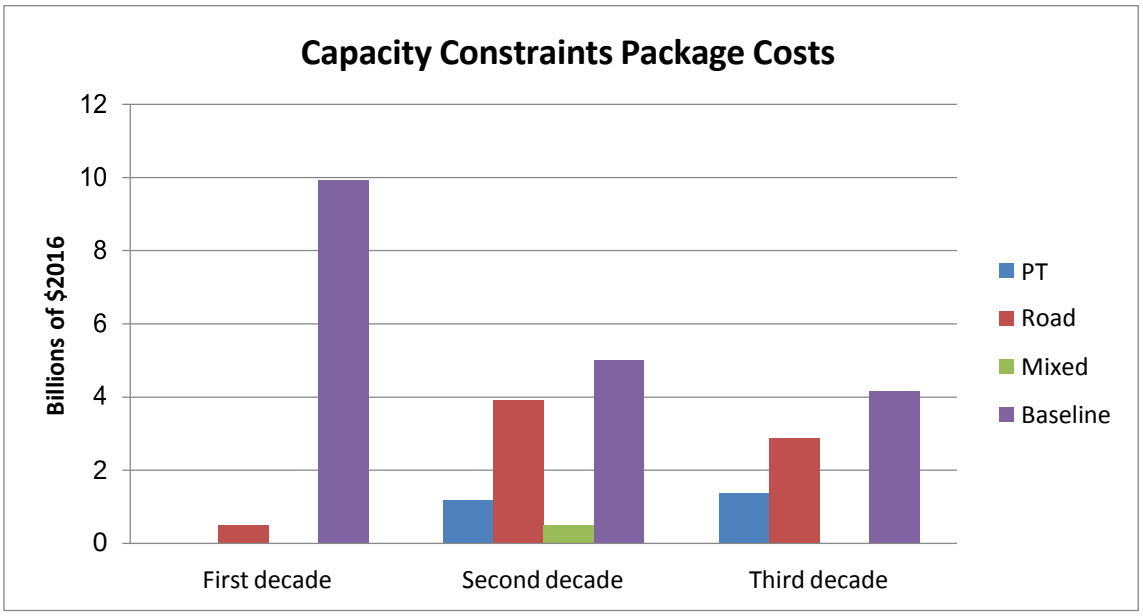


Figure 3.1: Estimated cost of new capital improvements (excluding renewals) of Capacity Constraints package (2018 – 2048)

Key interventions by time period

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

Table 3.1: Capacity Constraints key interventions by decade

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

3.1.2 Key Findings
Accessibility

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

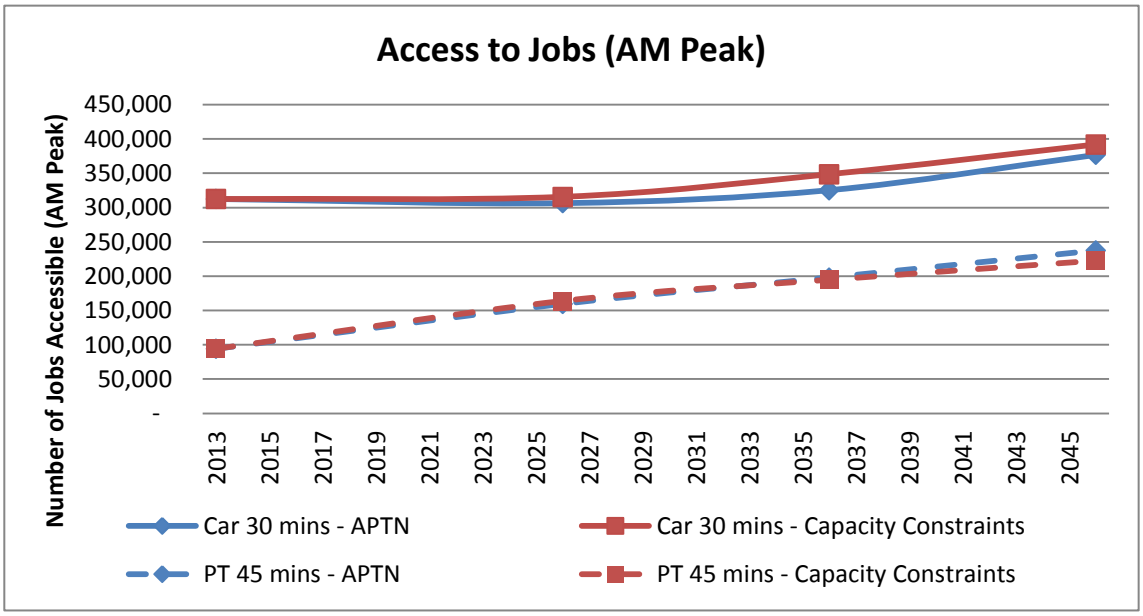


Figure 3.2: Access to jobs (Capacity Constraints and APTN)

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

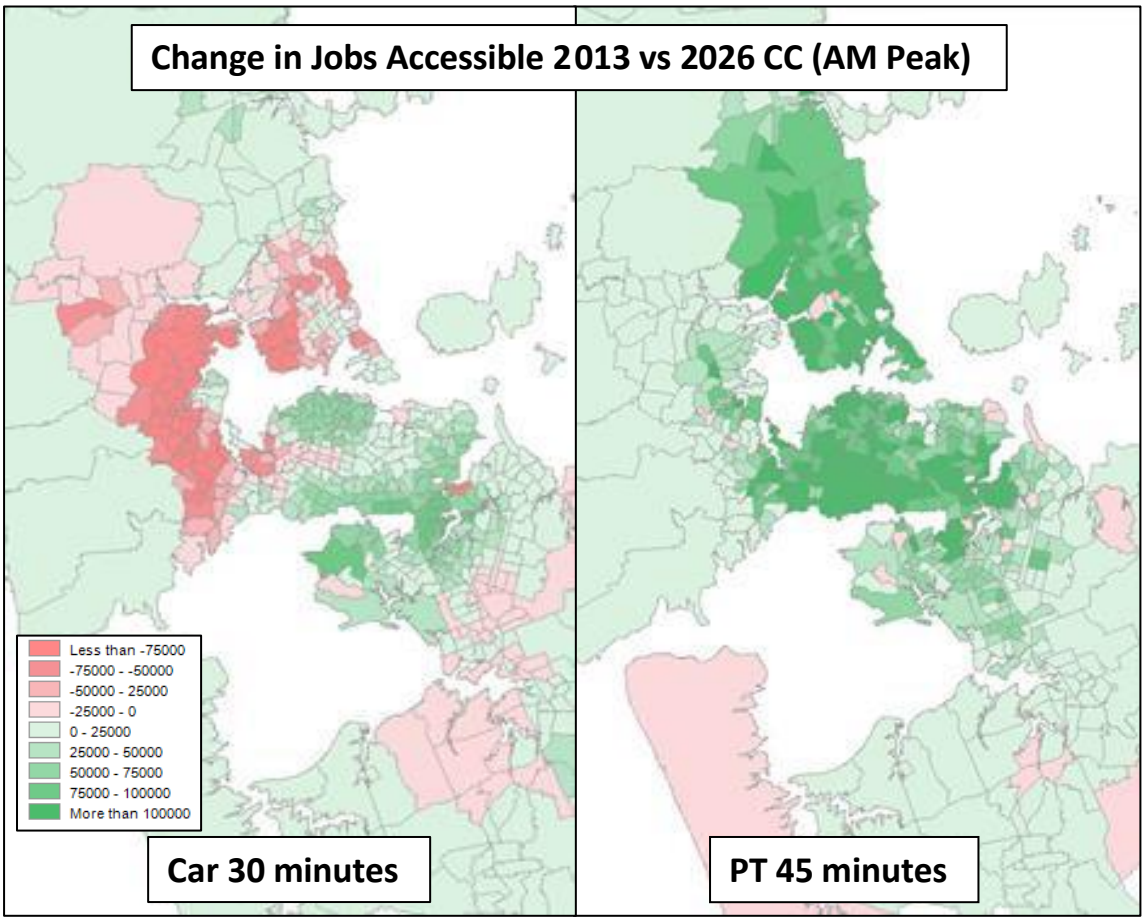


Figure 3.3: Change in accessibility to jobs 2013 vs 2026 (Capacity Constraints)

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

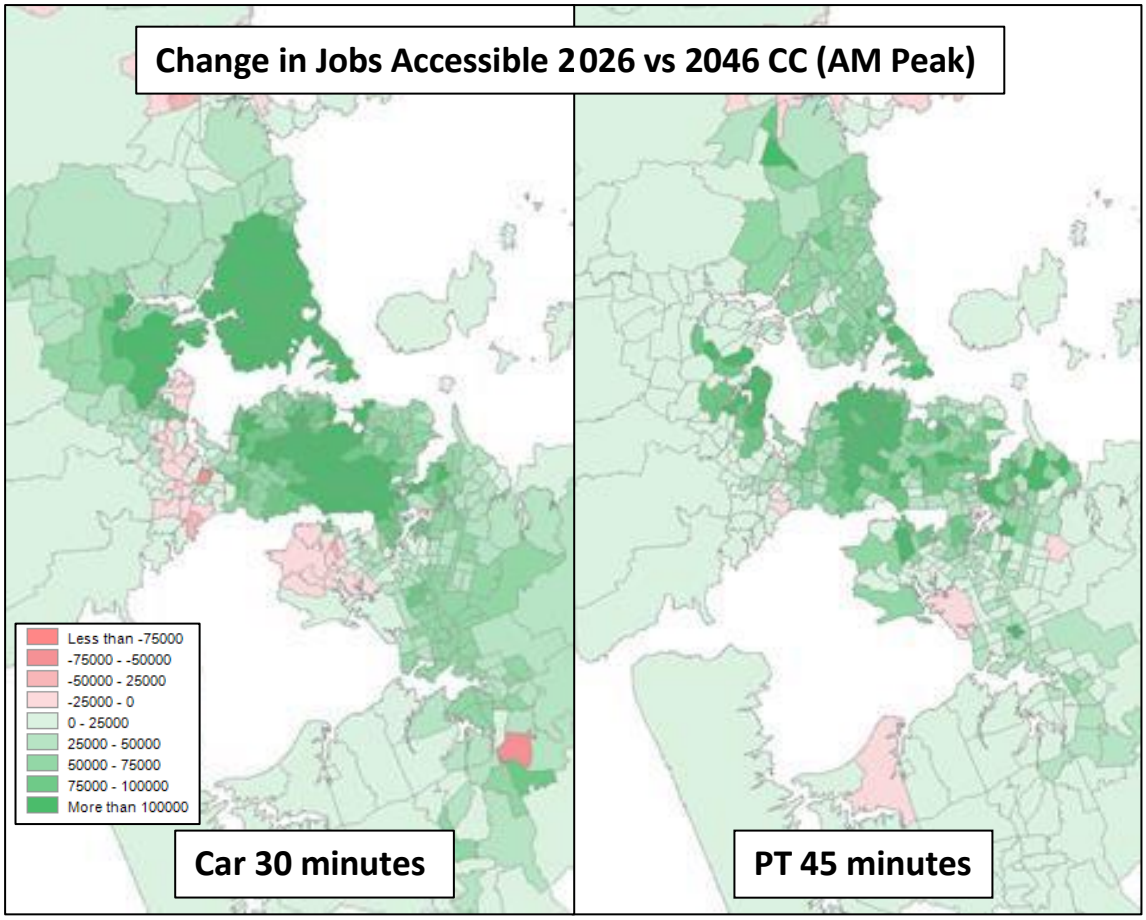


Figure 3.4: Change in accessibility to jobs 2026 vs 2046 (Capacity Constraints)

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

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

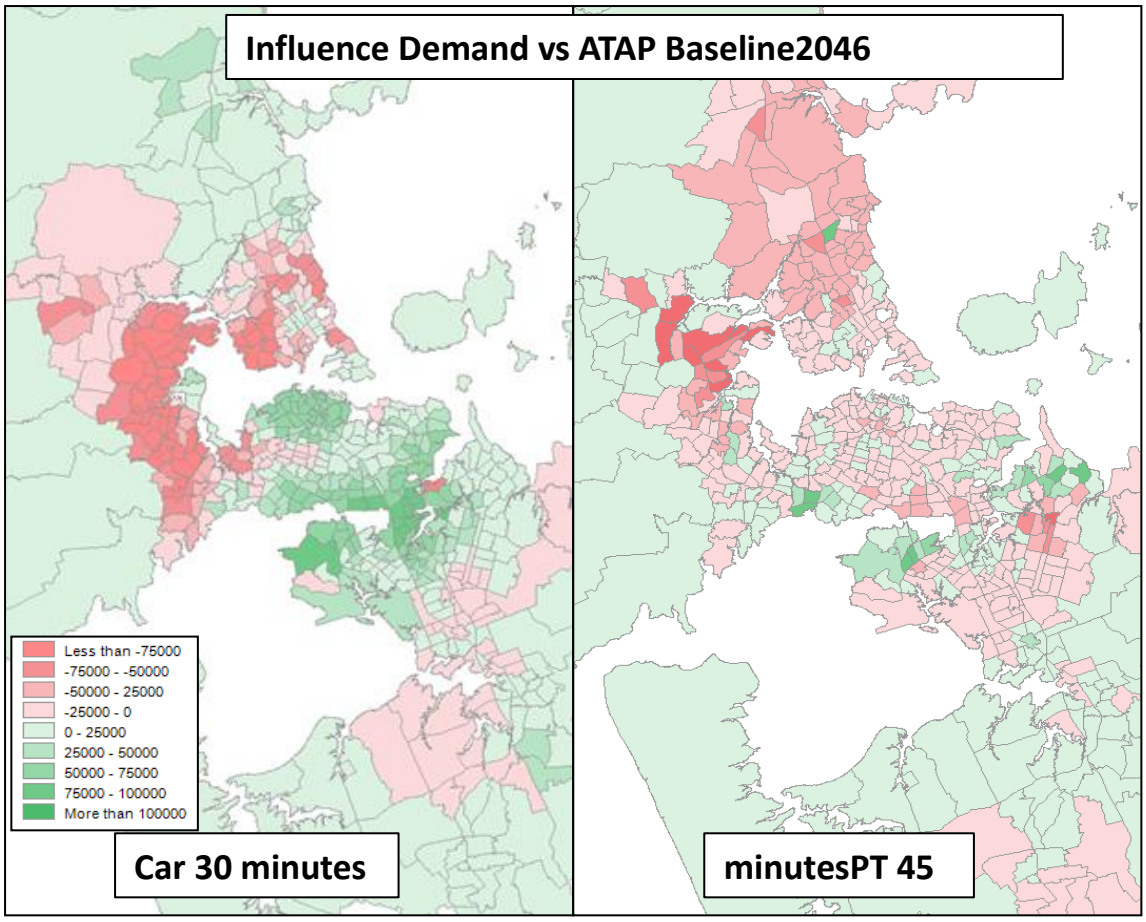


Figure 3.5: Accessibility to jobs (Capacity Constraints and APTN)

Congestion

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

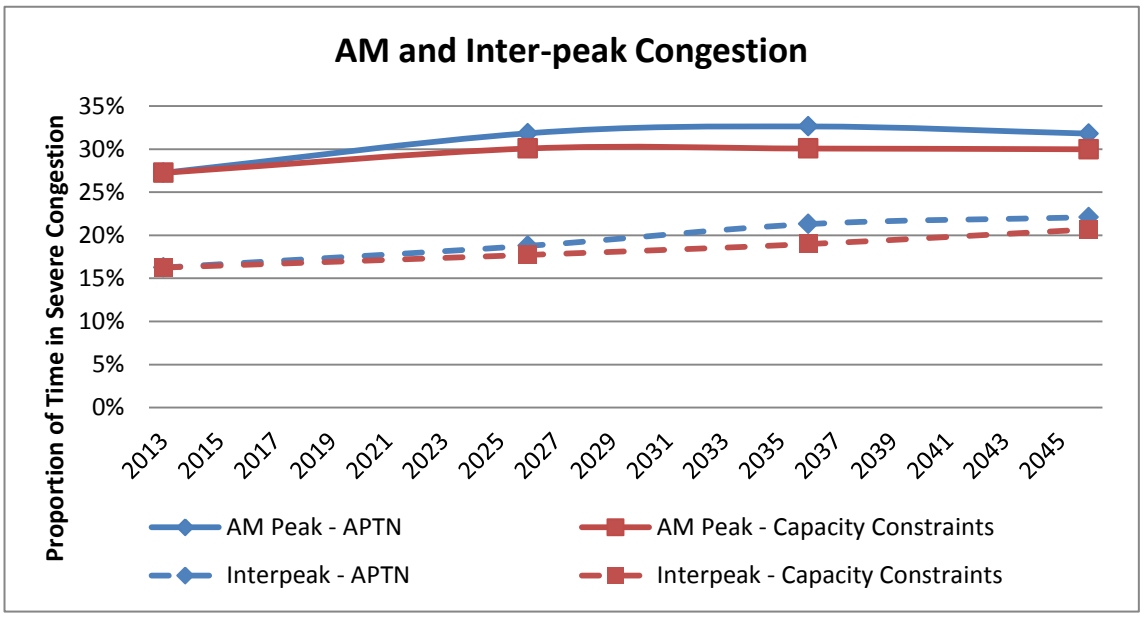


Figure 3.6: AM peak and inter-peak congestion (Capacity Constraints and APTN)

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

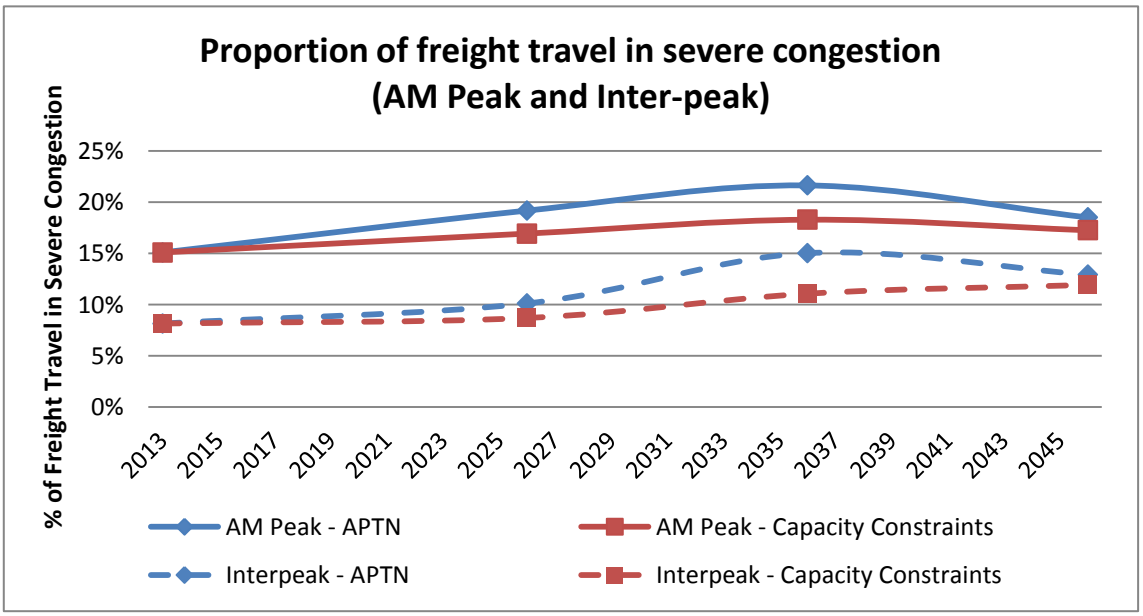


Figure 3.7: Proportion of freight travel in severe congestion (Capacity Constraints and APTN)

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

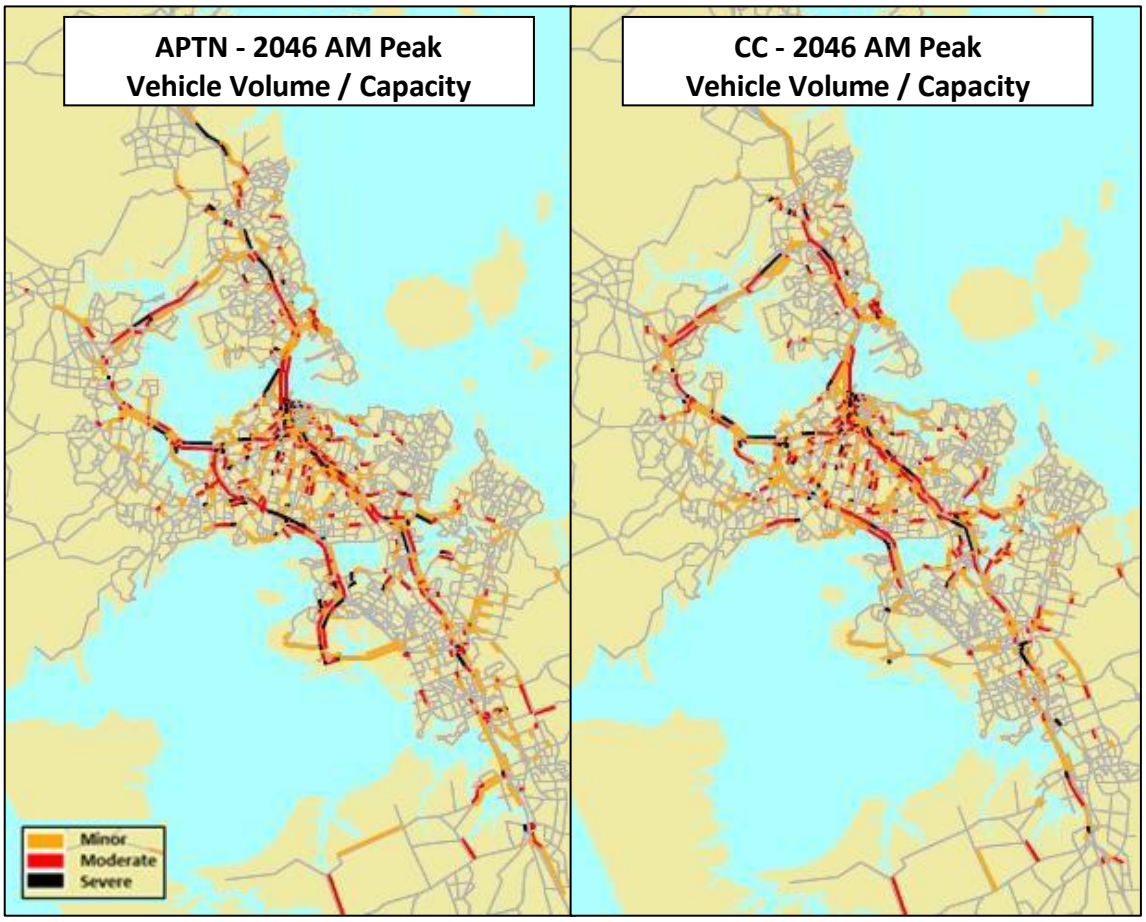


Figure 3.8: AM peak vehicle travel demand (Capacity Constraints and APTN)

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

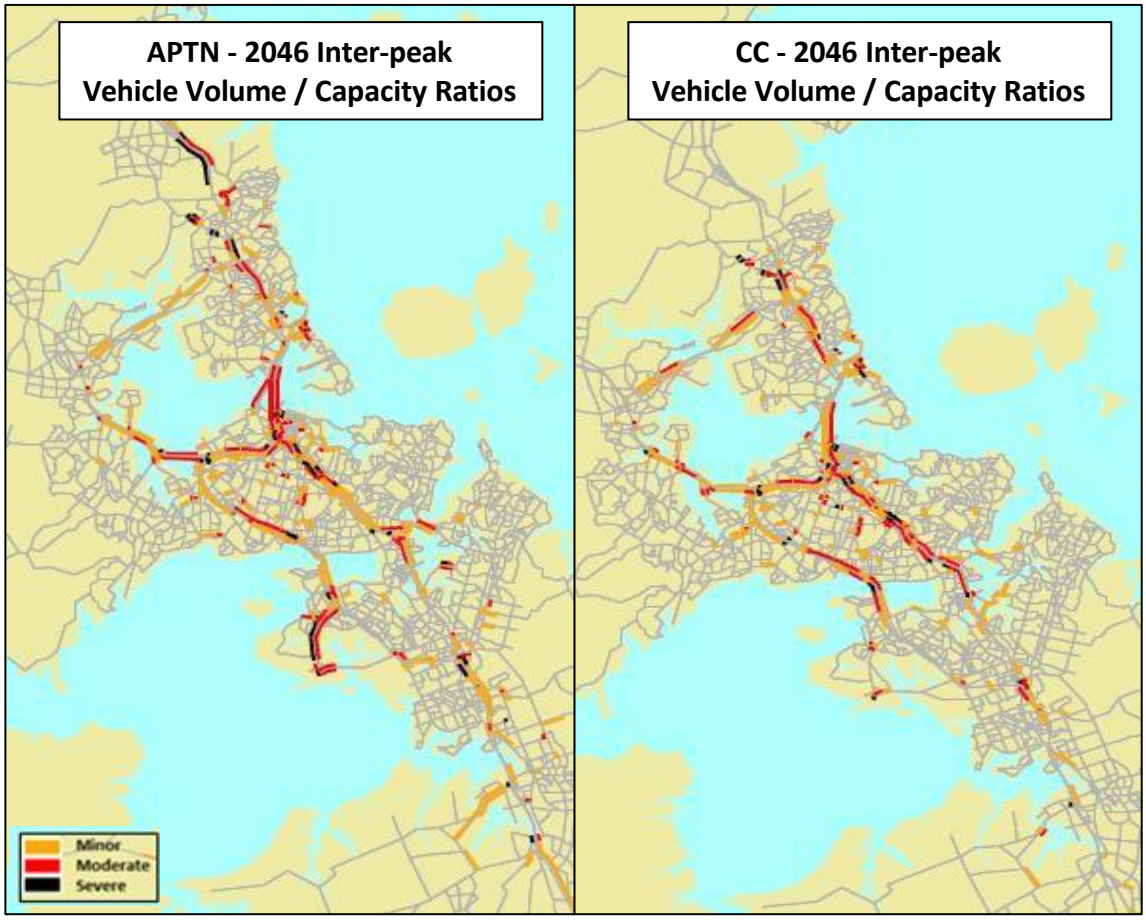


Figure 3.9: Inter-peak vehicle travel demand (Capacity Constraints and APTN)

Public Transport Mode Share

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

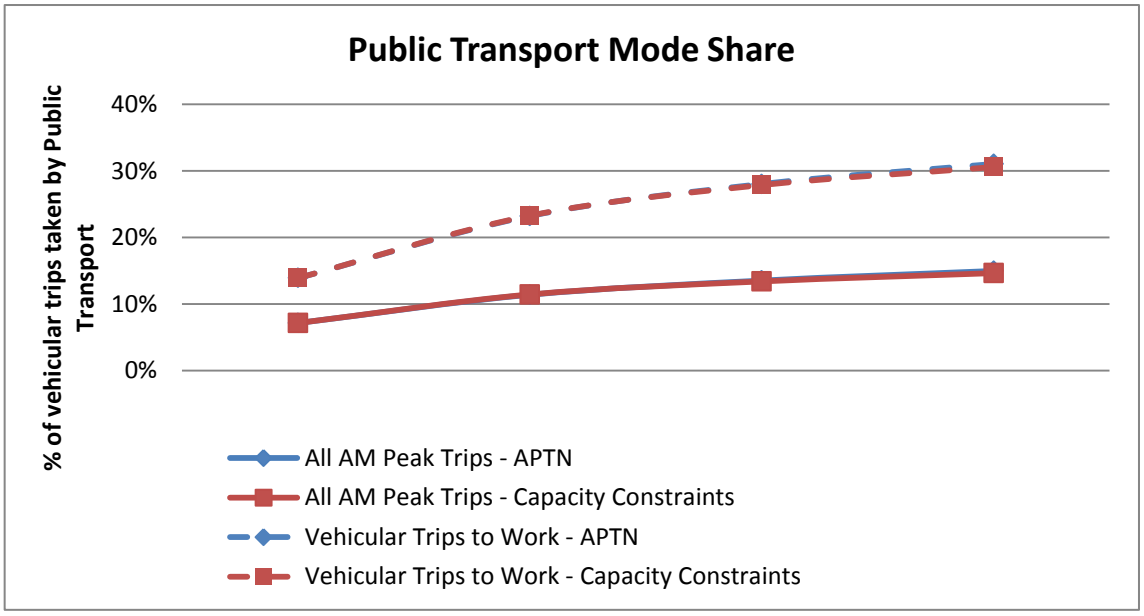


Figure 3.10: Public transport mode share (Capacity Constraints and APTN)

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

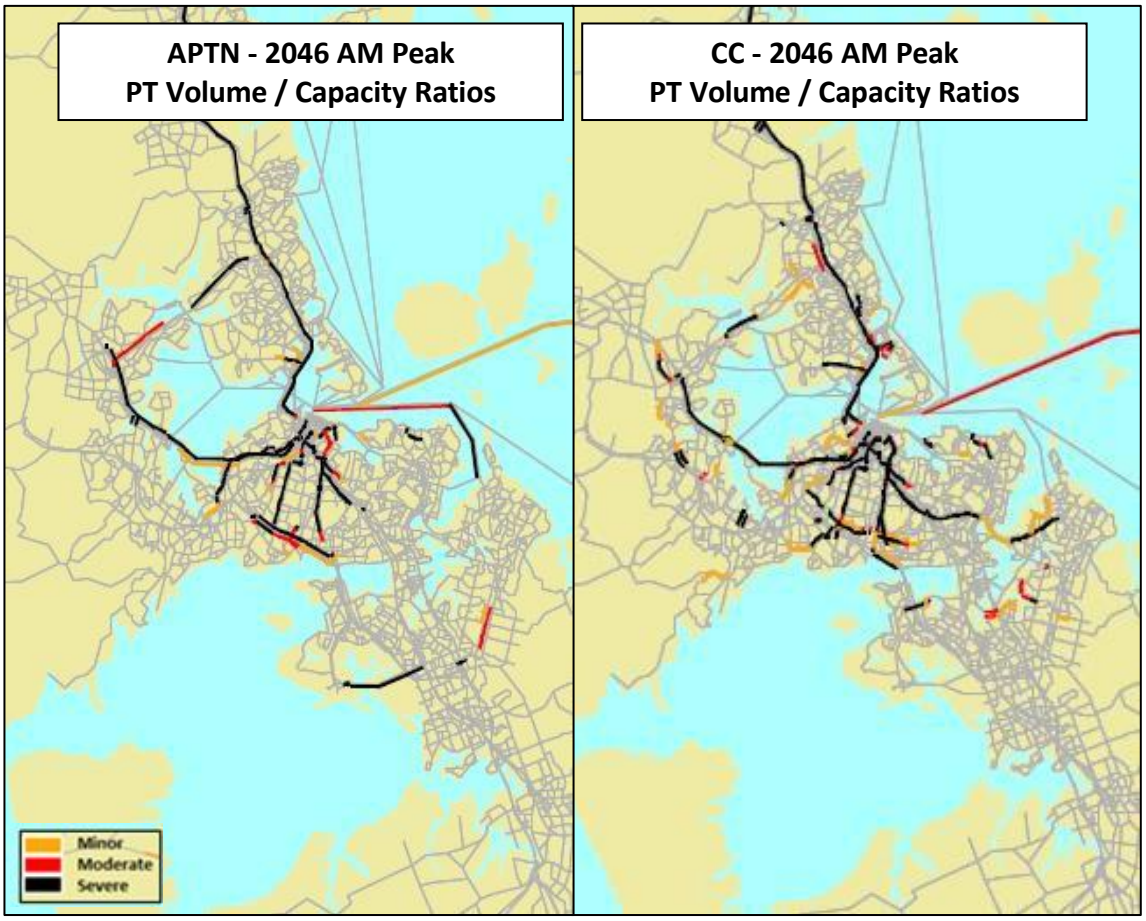


Figure 3.11: Public transport demand (Capacity Constraints and APTN)

Value for Money

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

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

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

3.1.3 Key Learnings

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

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

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

3.2 Focus on Employment Centres

3.2.1 Package Description

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

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

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

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

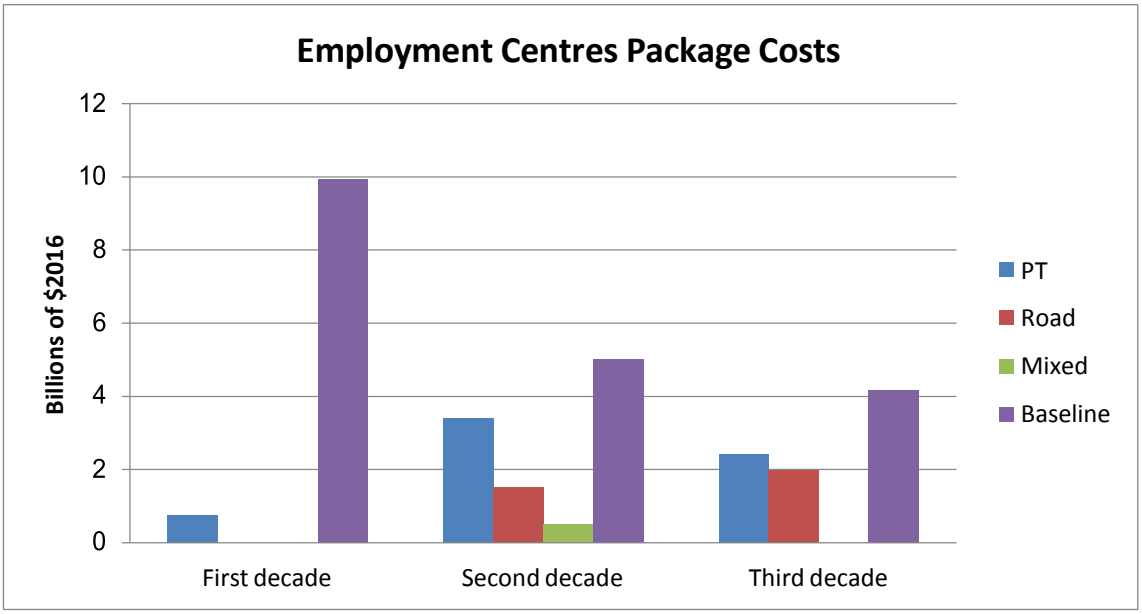


Figure 3.12: Estimated cost of new capital improvements (excluding renewals) of the Employment Centres package (2018 – 2048)

Key interventions by time period

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

Table 3.2: Employment Centres key interventions by decade

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

3.2.2 Key Findings
Accessibility

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

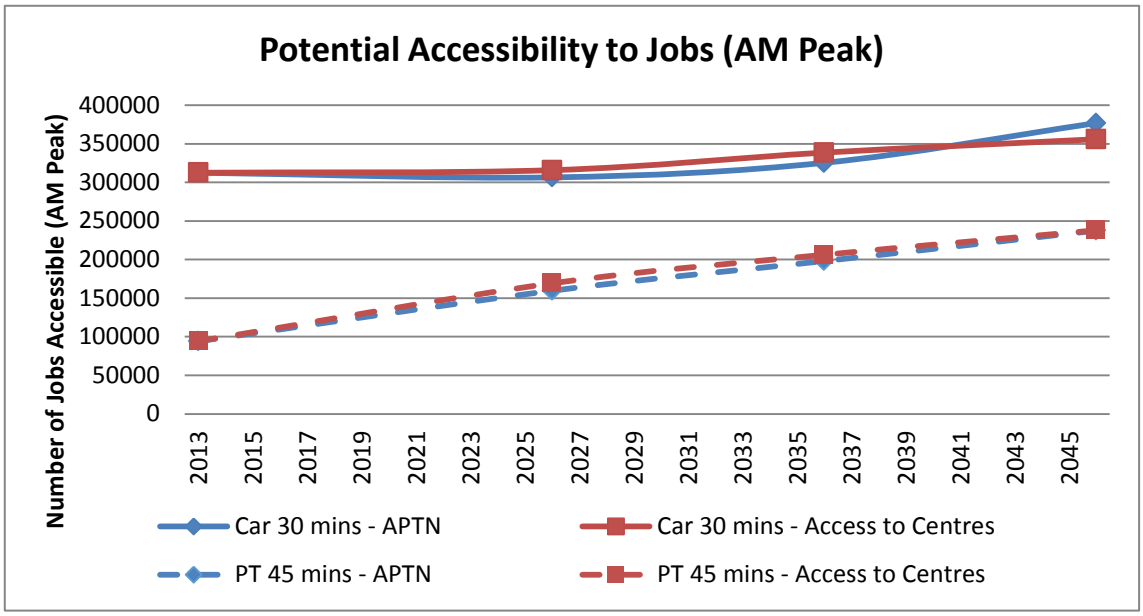


Figure 3.13: Potential accessibility to jobs (Employment Centres and APTN)

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

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

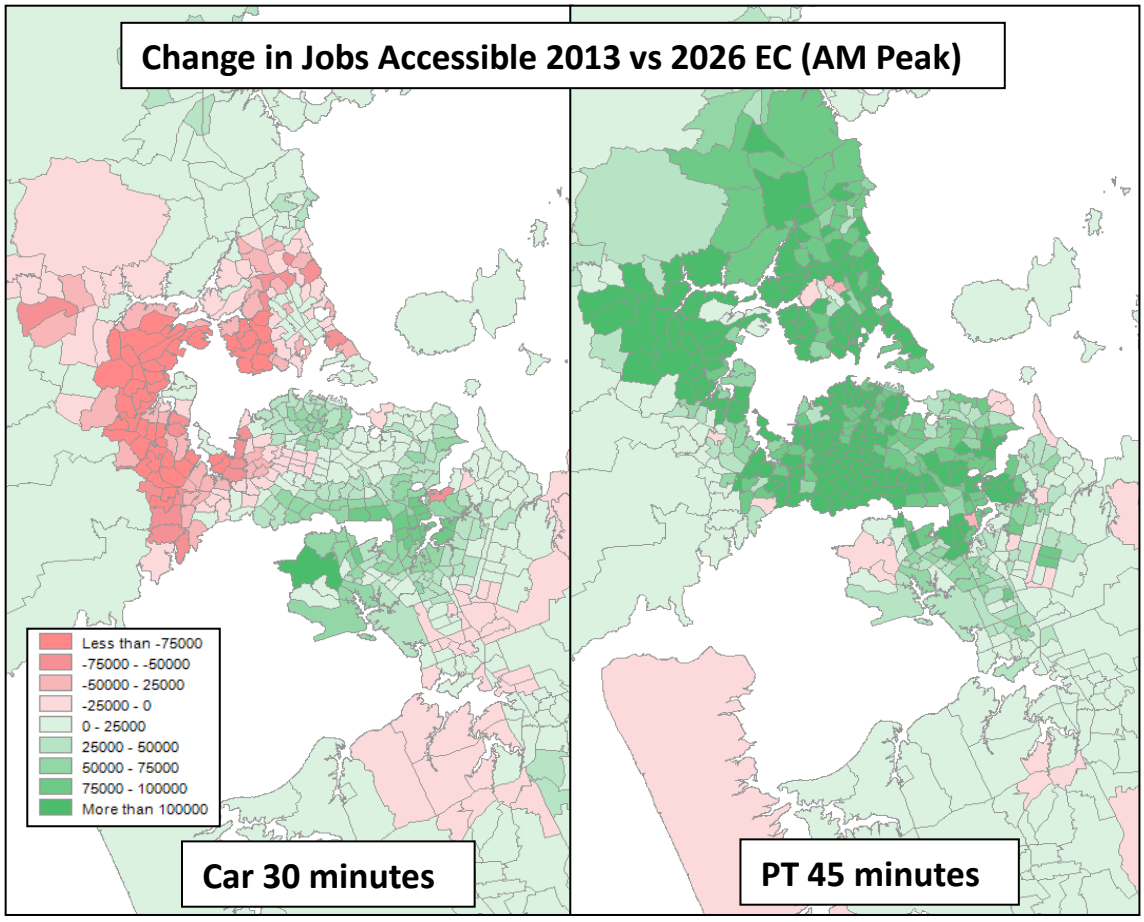


Figure 3.14: Change in accessibility to jobs 2013 vs 2026 (Employment Centres)

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

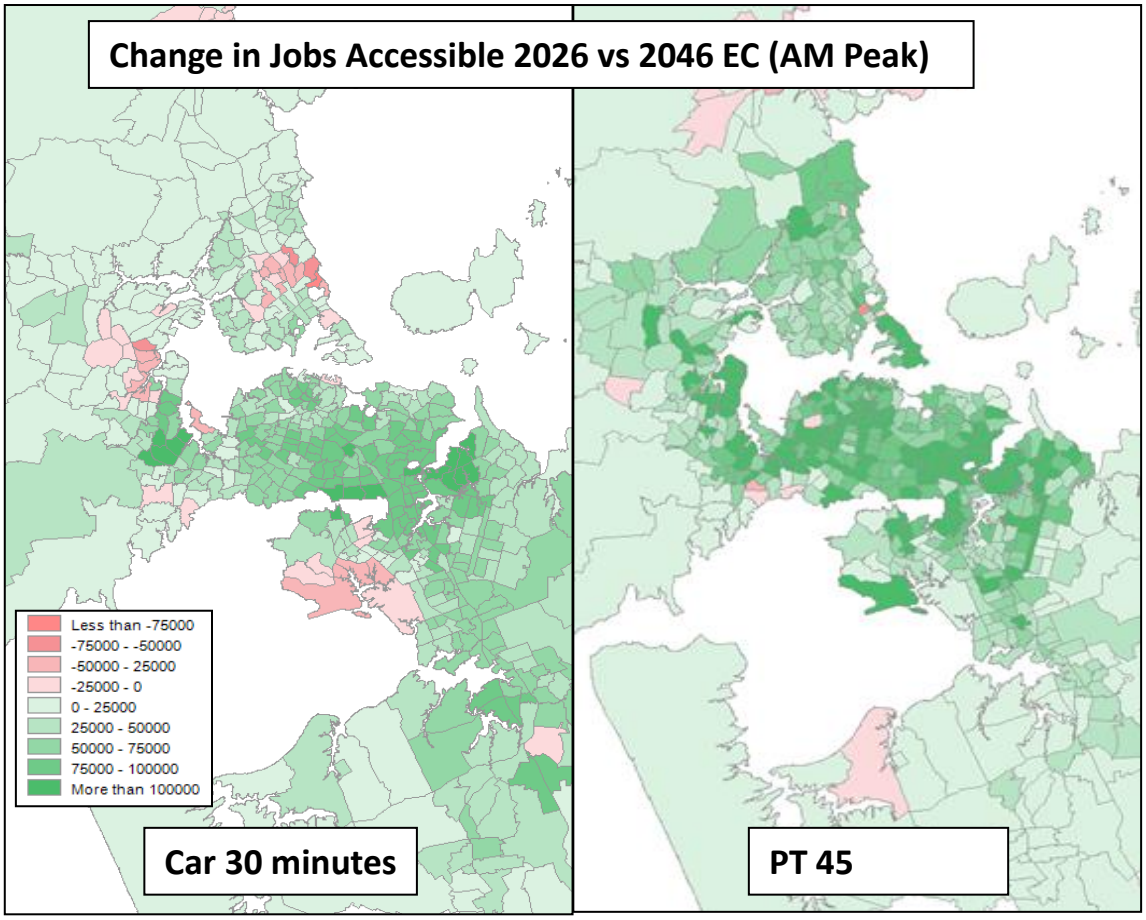


Figure 3.15: Change in accessibility to jobs 2026 vs 2046 (Employment Centres)

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

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

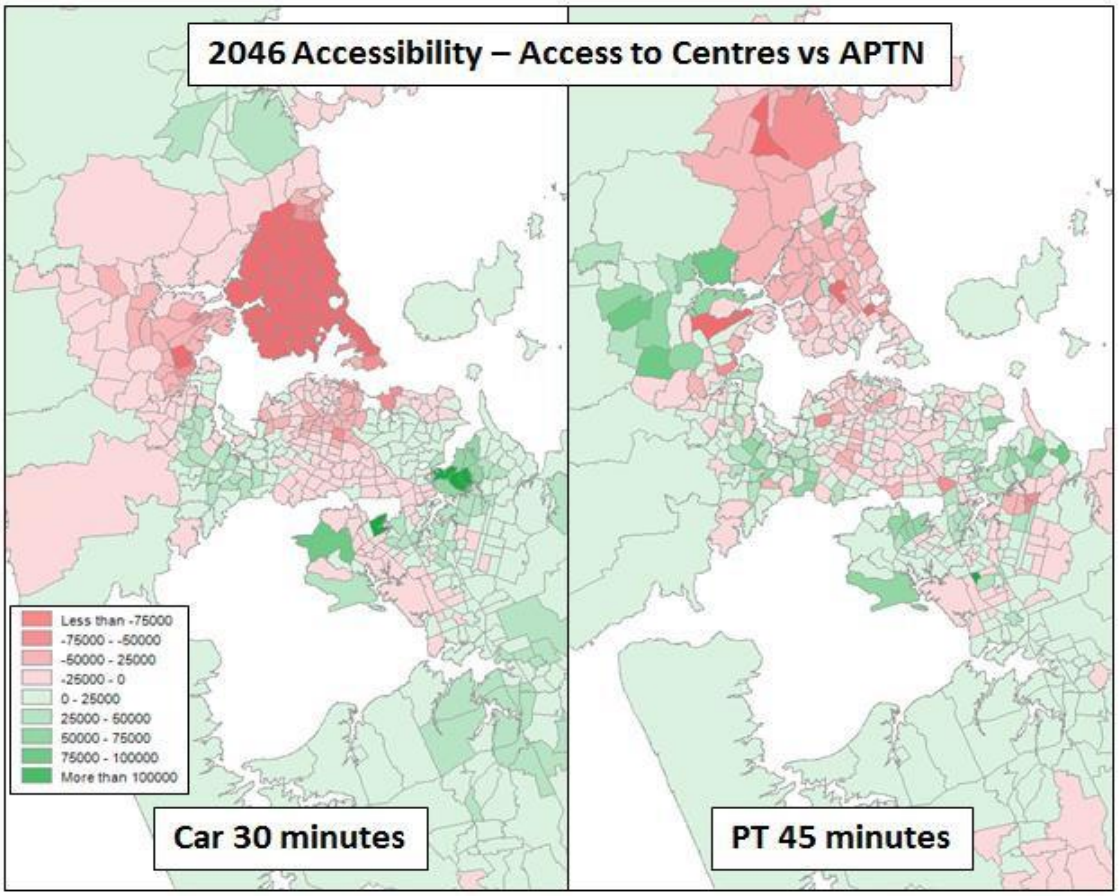


Figure 3.16: Access to jobs (Employment Centres and APTN)

Congestion

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

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

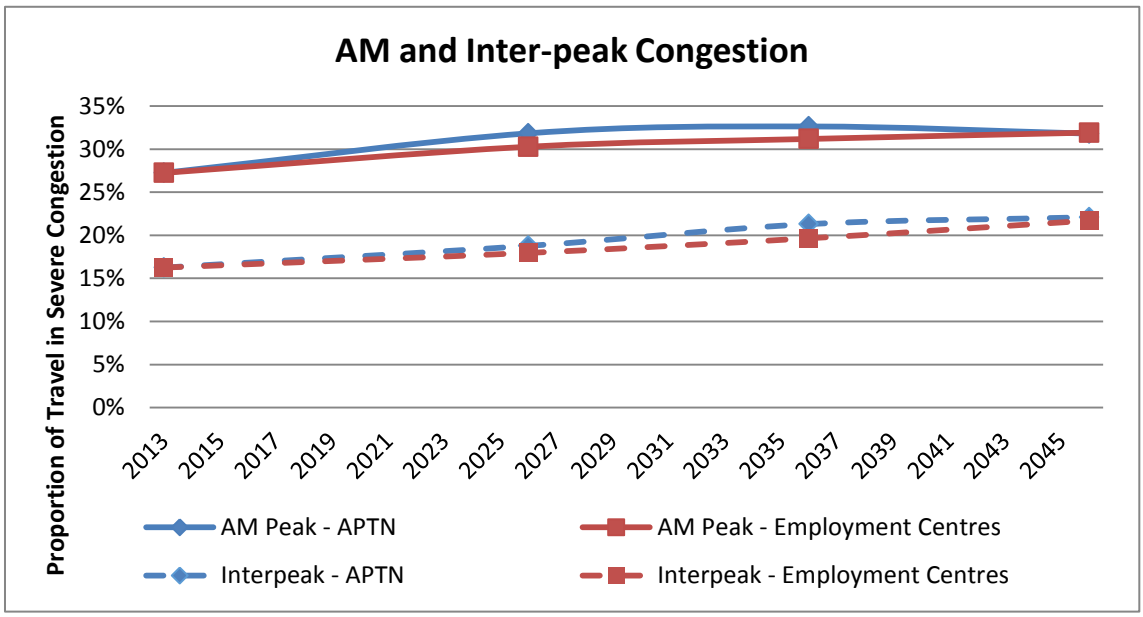


Figure 3.17: AM and inter-peak congestion (Employment Centres and APTN)

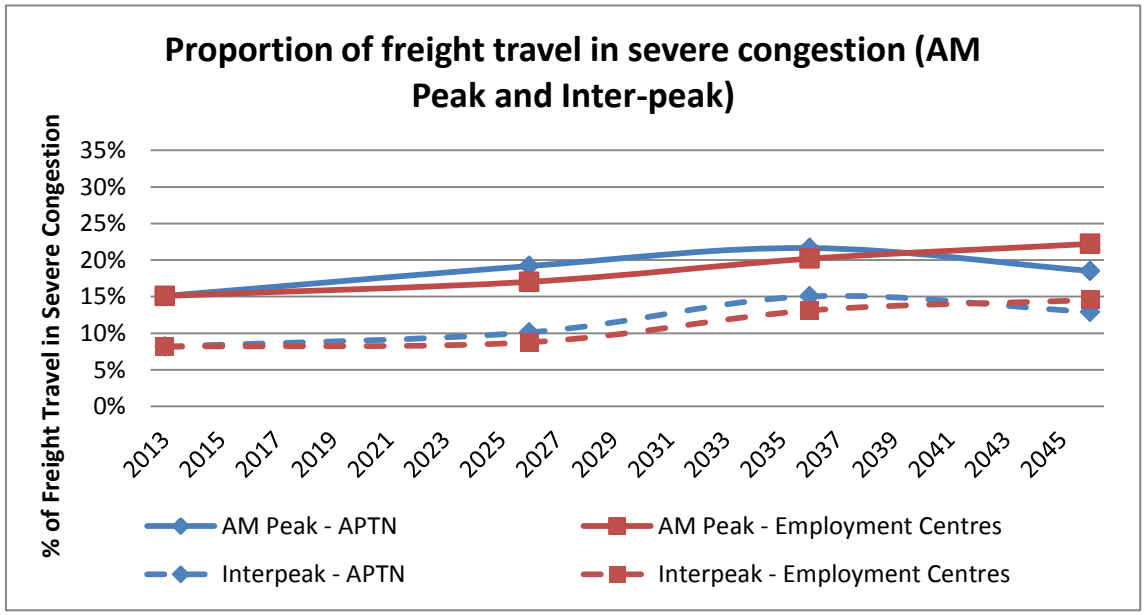


Figure 3.18: Proportion of freight travel in severe congestion (Employment Centres and APTN)

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

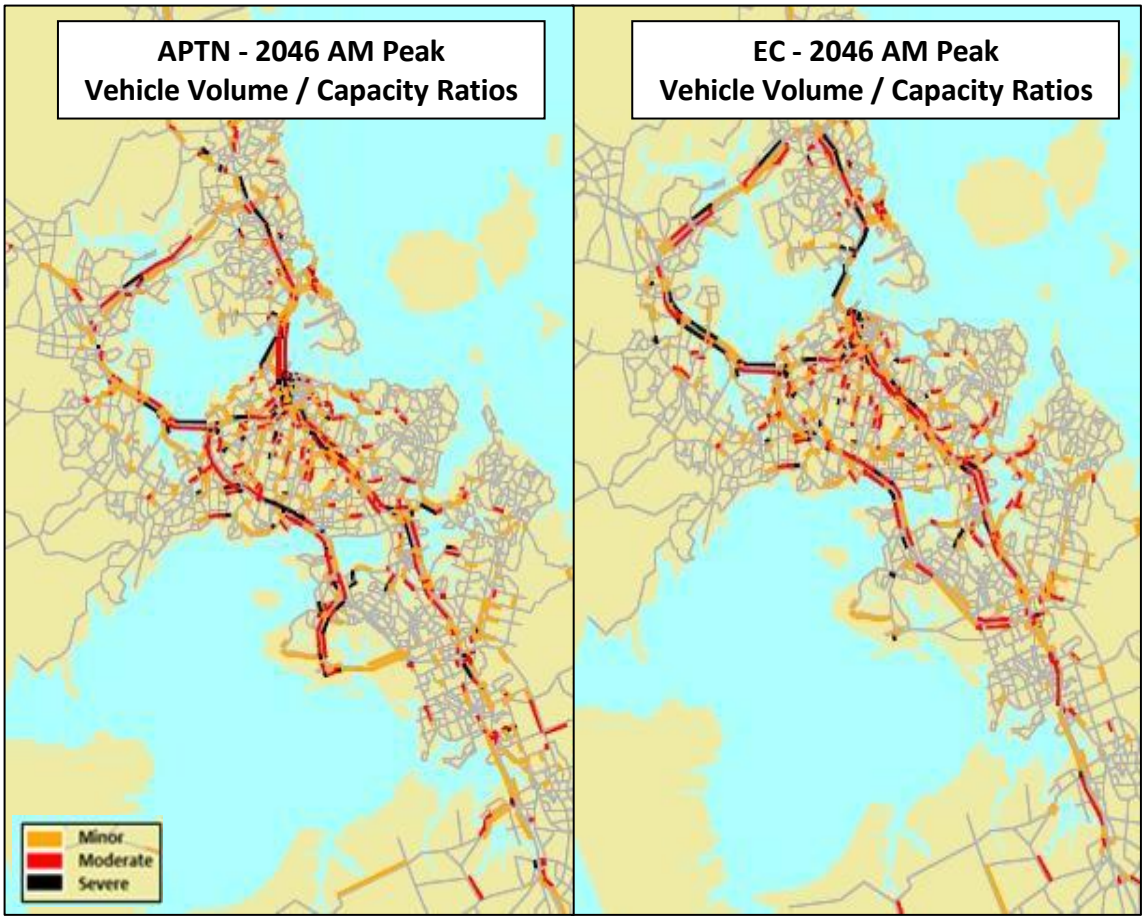


Figure 3.19: AM peak vehicle travel demand (Employment Centres and APTN)

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

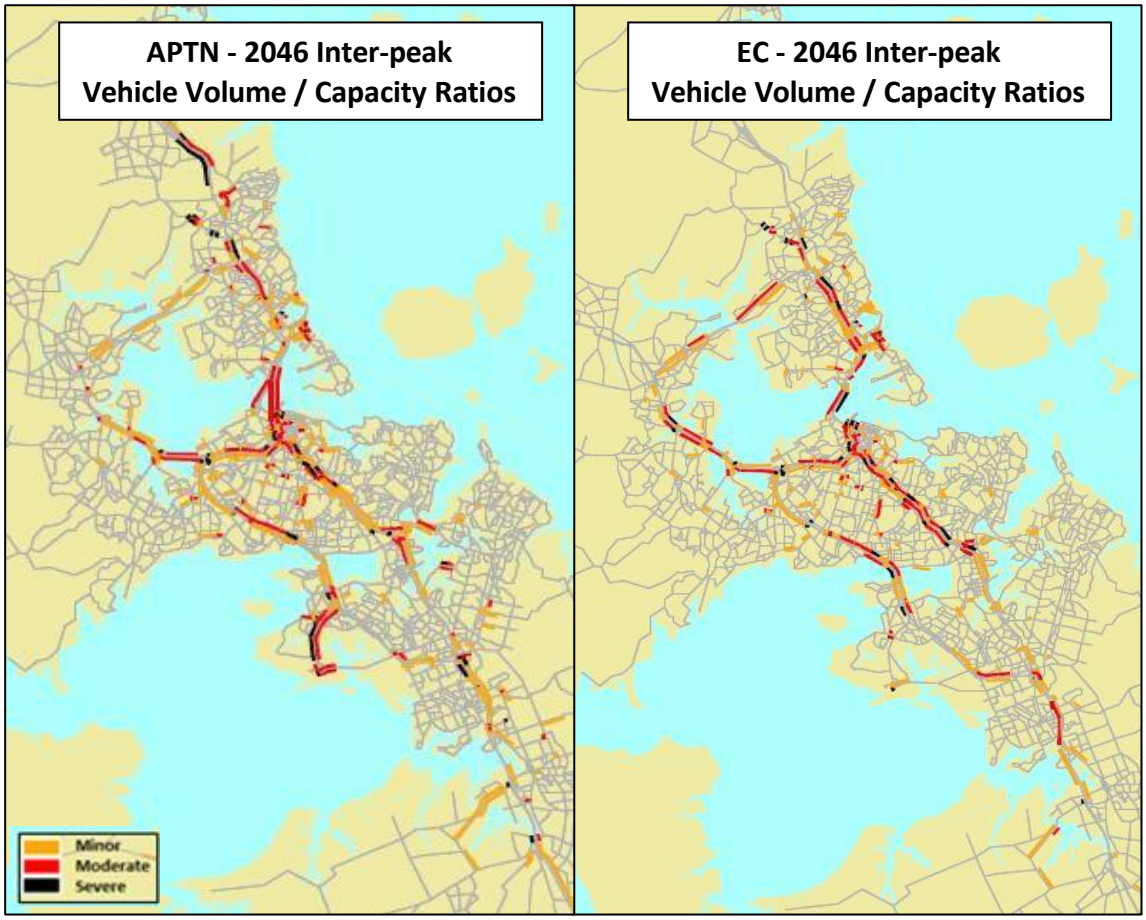


Figure 3.20: Inter-peak vehicle travel demand (Employment Centres and APTN)

Public Transport Mode Share

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

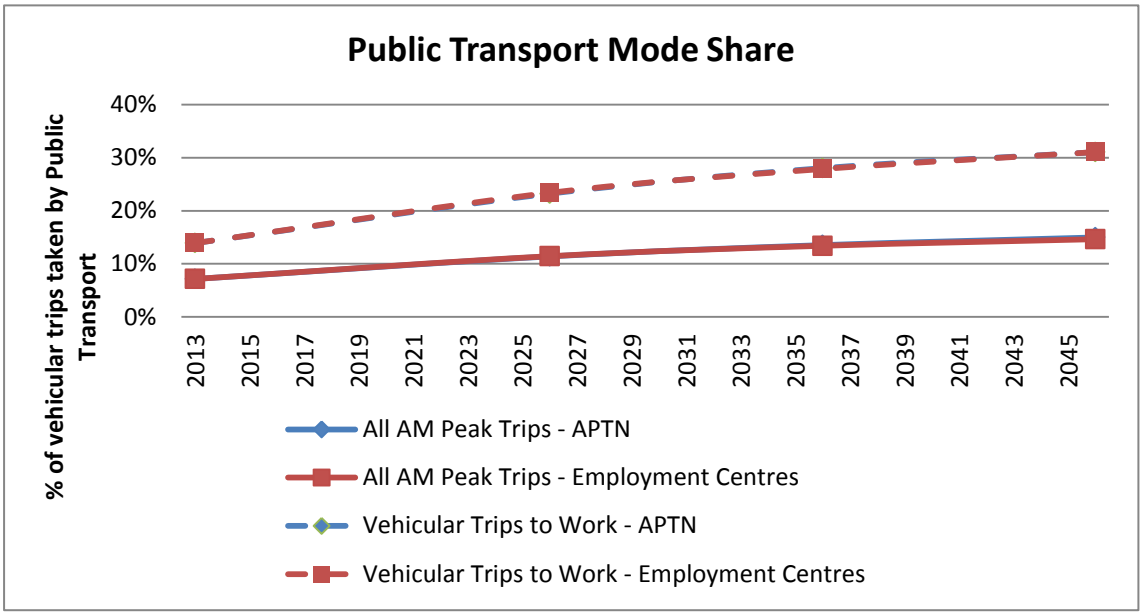


Figure 3.21: Public transport mode share (Employment Centres and APTN)

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

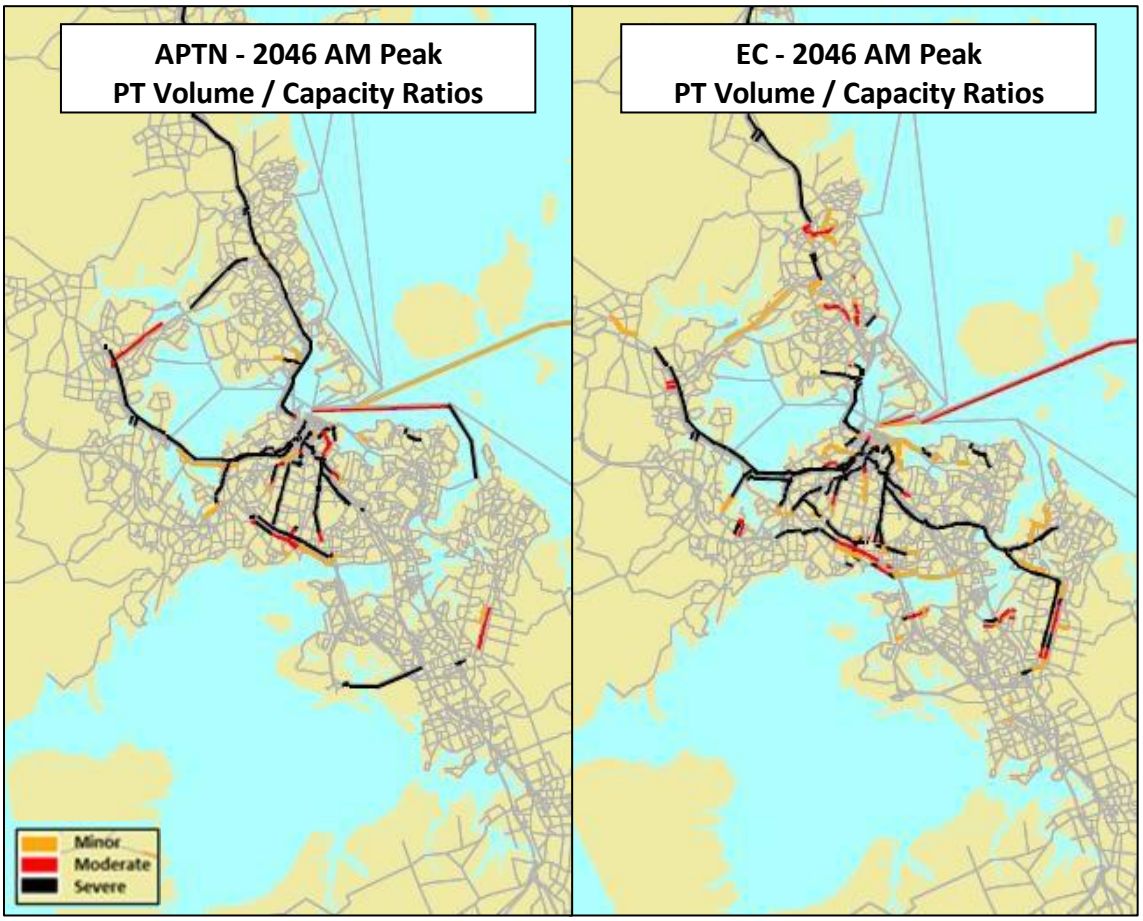


Figure 3.22: Public transport demand in 2046 (Employment Centres and APTN)

Value for Money

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

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

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

3.2.3 Key Learnings

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

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

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

3.3 Smarter Pricing

3.3.1 Tool Description

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

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

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

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

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

Key interventions by time period

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

Table 3.3: Hypothetical variable network-wide pricing system

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

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

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

The total estimated 30-year cost of new capital improvements (excluding renewals) of the Smarter Pricing package is $28.7 billion (in 2016 dollars). Figure 3.23 below provides a breakdown of costs by decade and project type. These estimated costs were identified prior to the revision of project costs in ATAP.

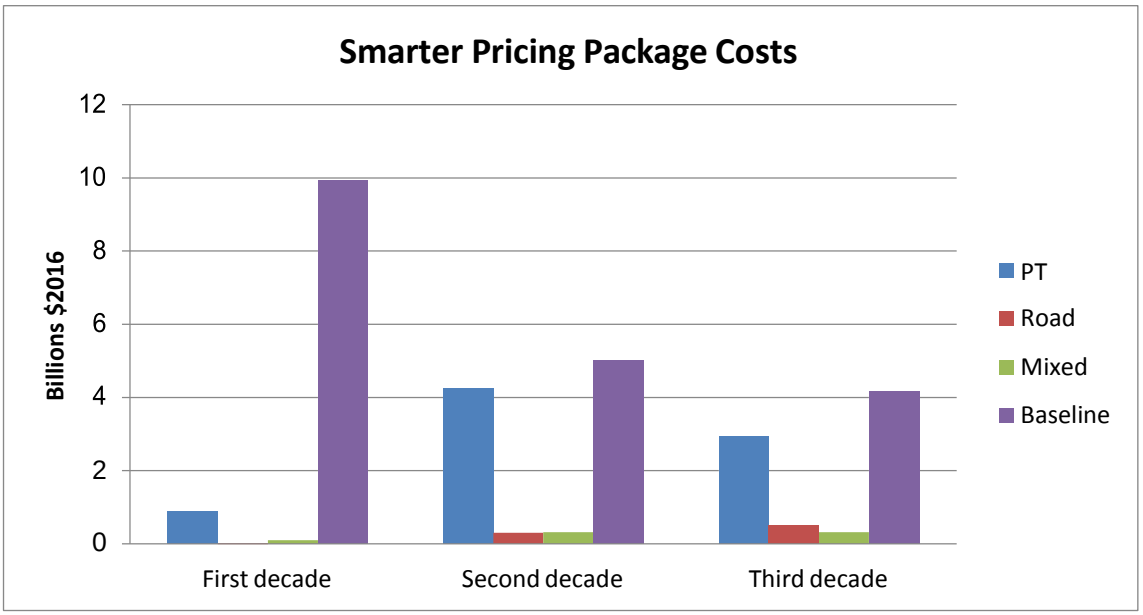


Figure 3.23: Estimated cost of new capital improvements (excluding renewals) of the Smarter Pricing package (2018 – 2048)

Key components of the package over and above the common baseline are outlined in Figure 3.4 below.

Table 3.4: Smarter Pricing key interventions by decade

First Decade (2015-25)	Second Decade (2025-35)	Third Decade (2035-45)
• Network wide pricing system • Northwestern Busway (Westgate to Point Chevalier)	• Penlink • Mt Roskill rail spur • Isthmus light-rail • North Shore rapid transit (city centre to Takapuna) • Rail upgrades to enable Southern Line express trains • AMETI Pakuranga to Botany • Northwestern Busway (Point Chevalier to Newton)	• Extension of isthmus light-rail • Extension of North Shore rapid transit to Albany and Birkenhead

3.3.2 Key Findings

The main effects of the pricing on travel patterns appear to be a slight reduction in trip length made by private vehicles and a mode shift from private vehicle to public transport. There were approximately 39,000 (6%) fewer private vehicle trips and around 16% less vehicle

kilometres travelled at peak times in 2046 compared to current plans. These changes have a profound effect on the transport network's performance.

Accessibility

The number of jobs accessible within a 30 minute car journey during the AM peak increases substantially in this package compared to the APTN. This is due to the pricing system reducing the number of vehicle trips during the AM peak by approximately 6% and reducing average trip length by approximately 5%, thereby reducing congestion and increasing travel speeds (Figure 3.24). Public transport accessibility improves more modestly, potentially due to a more effective mix of interventions combined with bus services that mix in general traffic being able to travel at higher speeds due to lower congestion levels.

Car accessibility has a step change improvement through the introduction of smarter pricing in 2026. The trends in the subsequent decades mirror the projections for APTN.

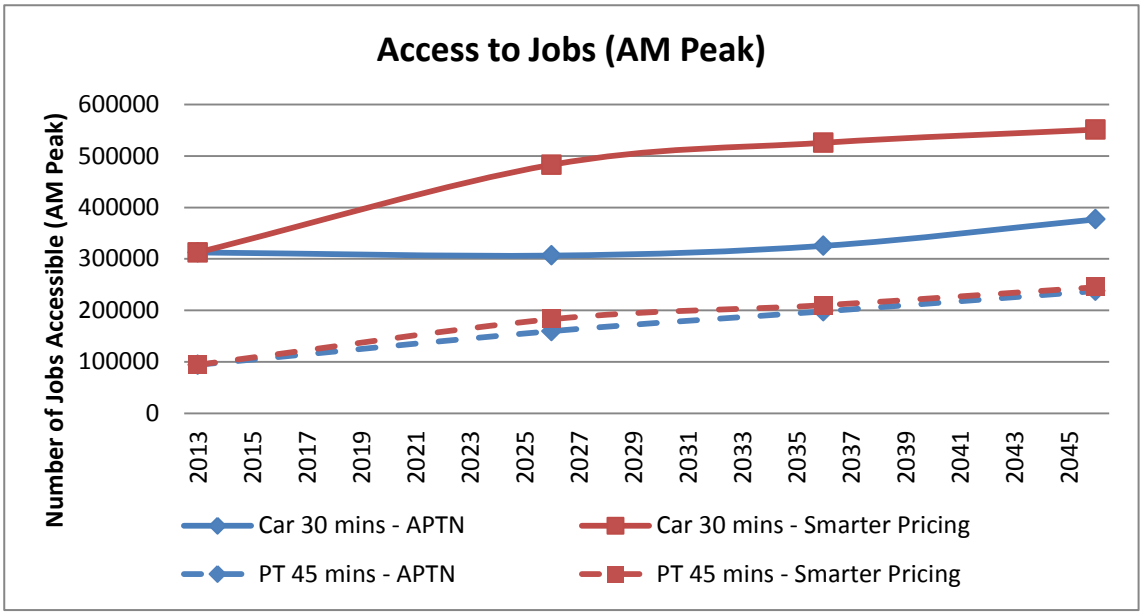


Figure 3.24: Access to jobs (Smarter Pricing and APTN)

On a sub-regional level, improvements in potential job accessibility by car are experienced in the isthmus and the east, as shown in Figure 3.25 below. Decreases in car access are experienced in the west, large parts of the North Shore, and the outer south.

On the other hand, public transport access increases significantly for most areas up to 2026.

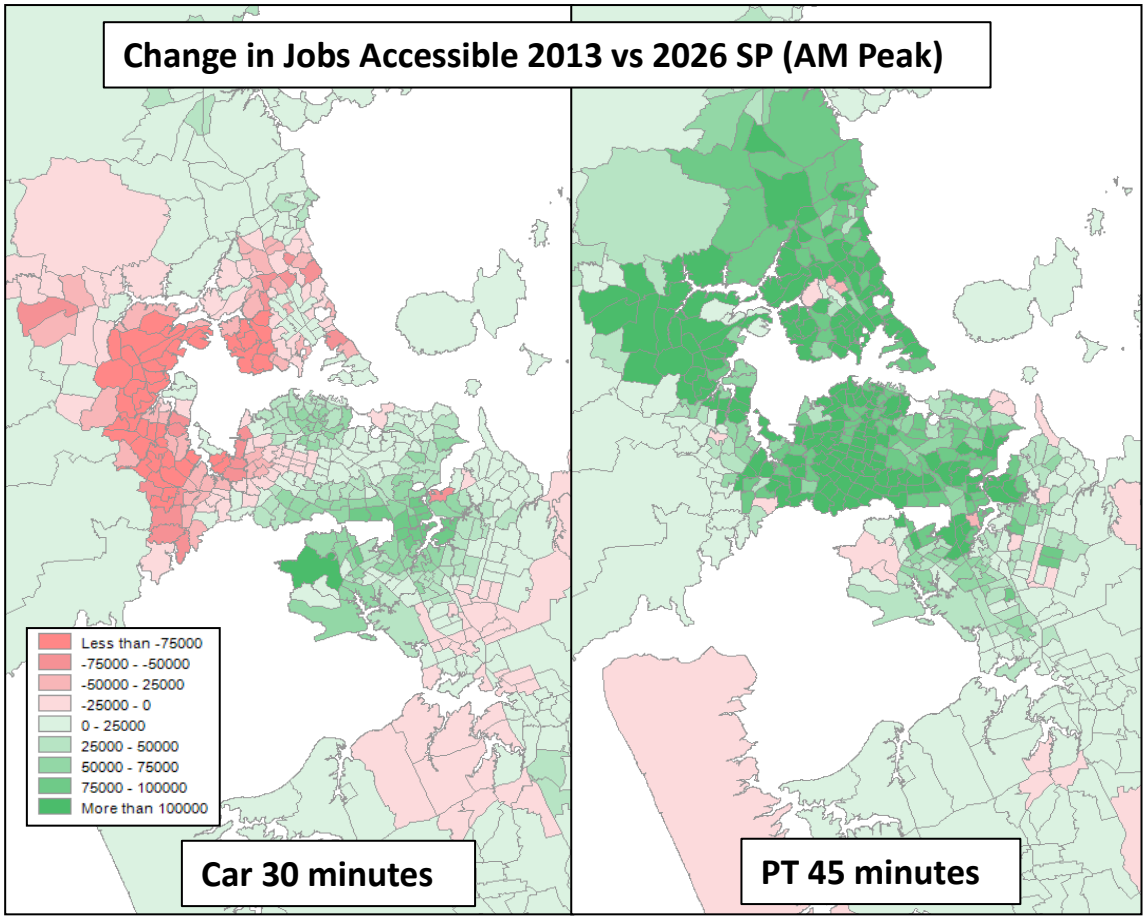


Figure 3.25: Change in jobs accessible 2013 vs 2026 (Smarter Pricing)

Improvements to accessibility continues after 2026 for car and public transport, particularly for the isthmus, northwest, and parts of the south (Figure 3.26). Car access declines for the outer north and the outer south.

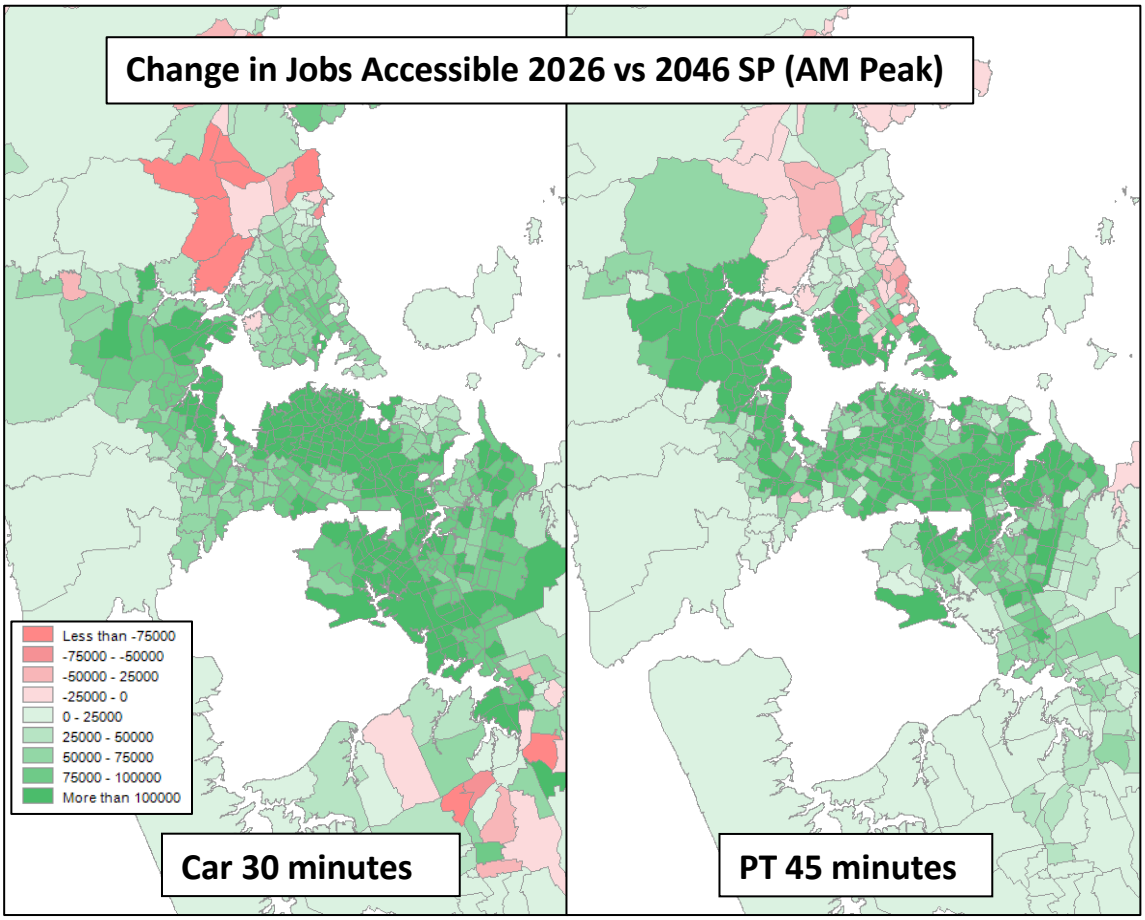


Figure 3.26: Change in jobs accessible 2026 vs 2046 (Smarter Pricing)

Compared to the APTN, car accessibility increases most strongly in the west and south – likely due to faster travel times in these areas bringing them within 30 minutes of the large concentration of jobs in the central area. Public transport accessibility results are more mixed, with the North Shore seeing a decline in access to employment. Upon investigating the reduction in public transport accessibility in the north in more detail, we found that it may have been caused by modelling methodology issues rather than representing a likely future (Figure 3.27).

The improvements in access to employment by car appear to be largely driven by road pricing – a reduction in car trips and shorter trip lengths compared to APTN enables faster travel speeds.

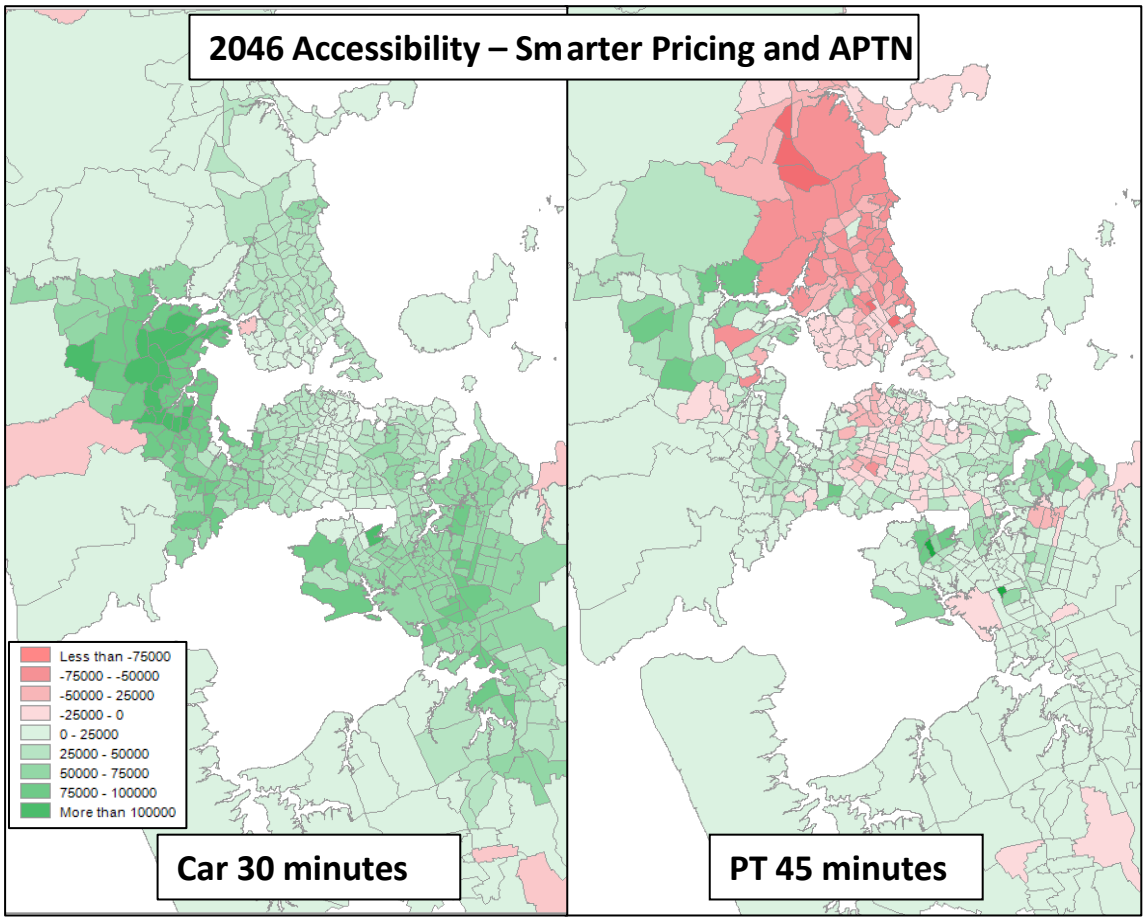


Figure 3.27: Access to jobs in 2046 (Smarter Pricing and APTN)

Congestion

Congestion in the AM peak reduces significantly from 2013 to 2026, due to the implementation of pricing (Figure 3.28). After 2026 there is a modest projected increase although congestion levels are still significantly lower than APTN projections.

Inter-peak congestion is projected to roughly remain at 2013 levels throughout the next 30 years under this package, substantially lower than the APTN projections, which indicate a steady increase over time.

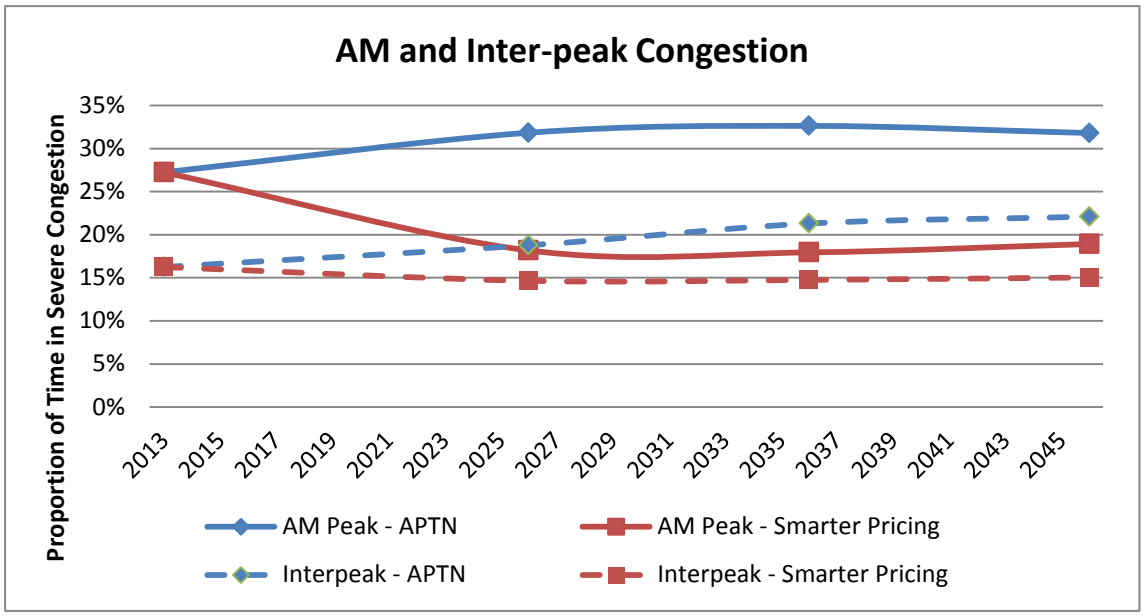


Figure 3.28: AM and inter-peak congestion (Smarter Pricing and APTN)

Freight travel sees similarly large reductions in AM peak compared to APTN (Figure 3.29). In the inter-peak, freight congestion decreases up until 2026, after which it remains constant until 2046. In comparison, inter-peak freight congestion under APTN keeps increasing until 2036, after which it declines slightly.

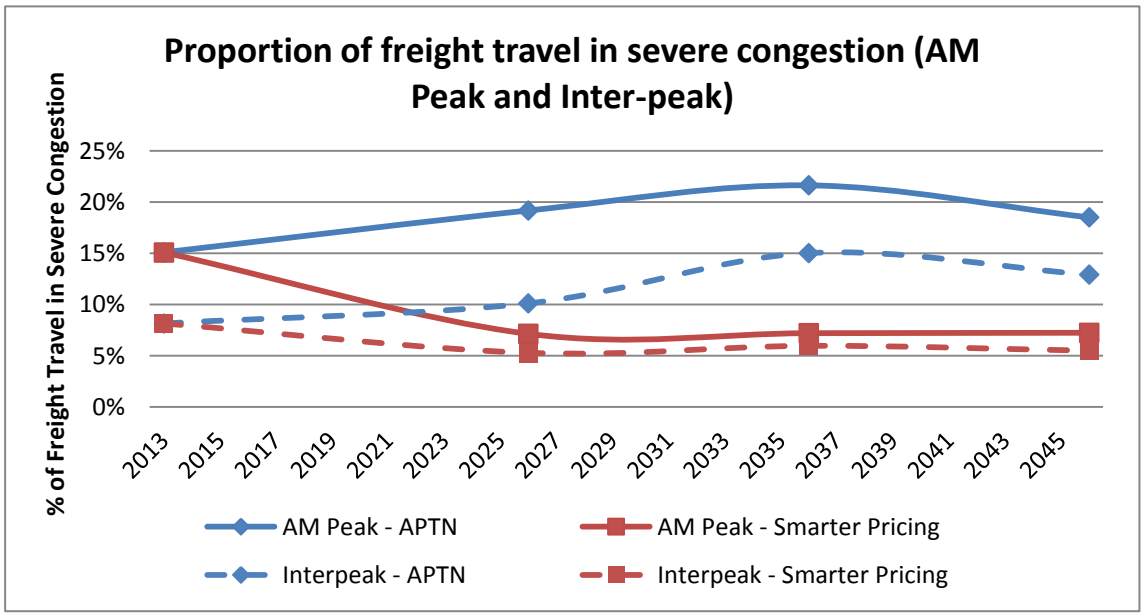


Figure 3.29: Proportion of freight travel in severe congestion (Smarter Pricing and APTN)

Some parts of the roading network still face severe congestion in the AM peak with the implementation of Smarter Pricing, although to a significantly lesser extent than the APTN (Figure 3.30). Severe congestion remains on the Auckland Harbour Bridge (with or without the Additional Waitemata Harbour Crossing) and sections of the Northern Motorway.

Focusing network improvements on areas that would still face congestion after the implementation of pricing provides a good indication of good value.

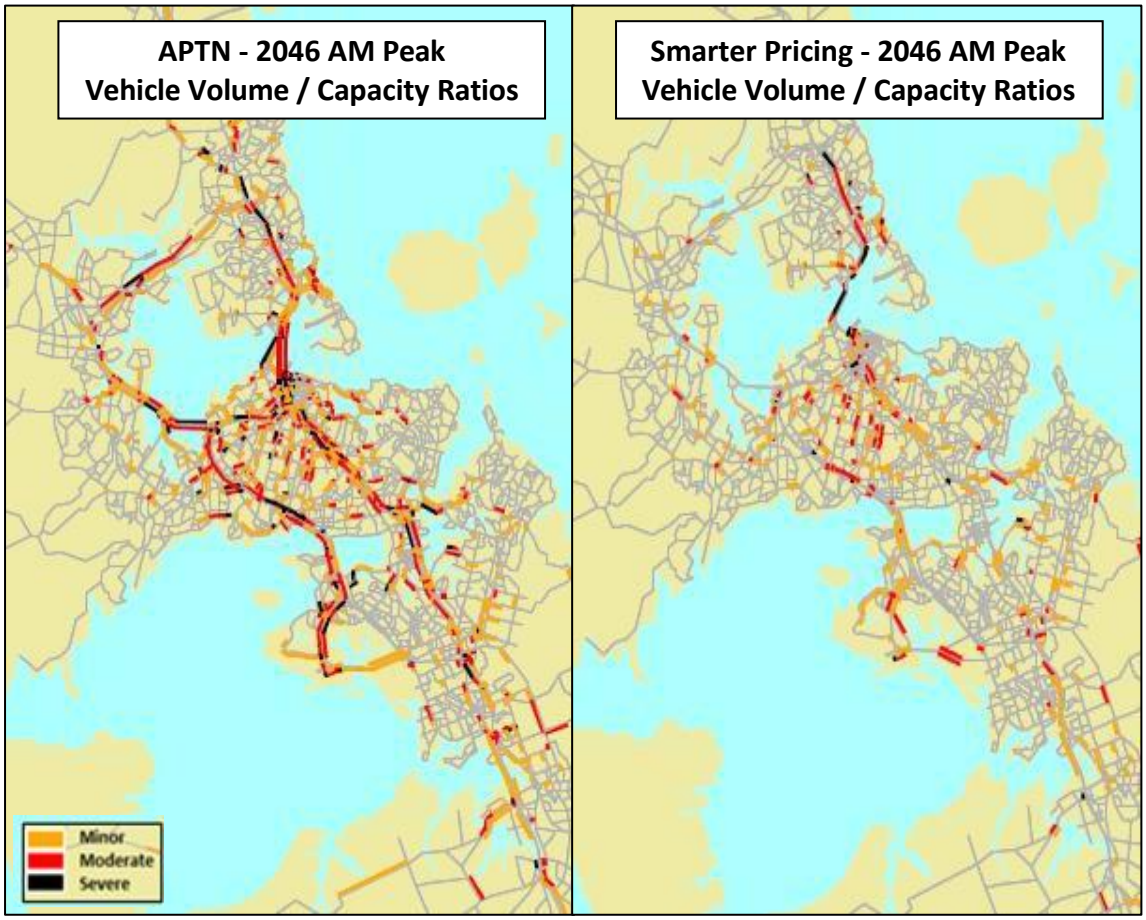


Figure 3.30: AM peak vehicle travel demand (Smarter Pricing and APTN)

Congestion is largely eliminated in the inter-peak under Smarter Pricing (Figure 3.31). While limited severe congestion remains at key pinch points on the network, the removal of even minor congestion suggests that pricing levels may be too high and the scheme applied too broadly.

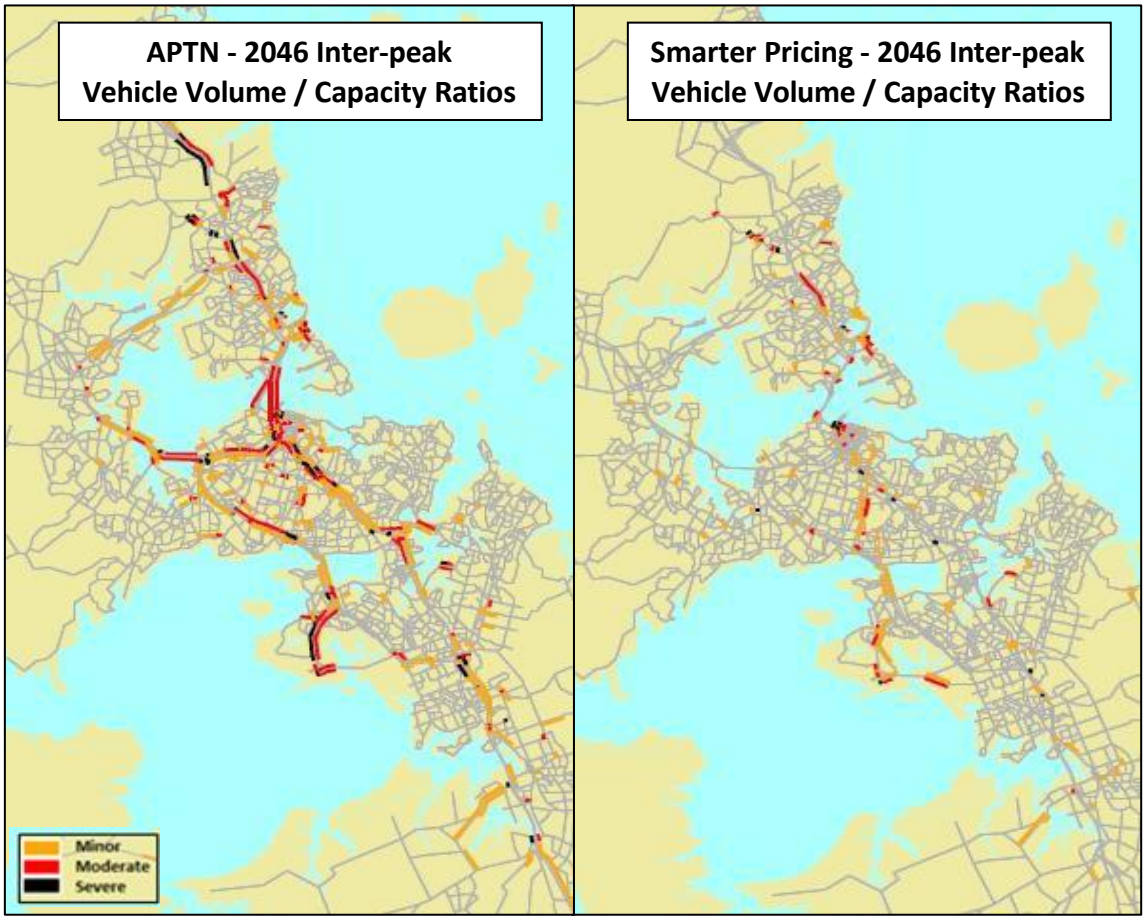


Figure 3.31: Inter-peak vehicle travel demand (Smarter Pricing and APTN)

Public Transport Mode Share

Compared to the APTN, public transport mode share increases substantially in this package, largely in areas where significant public transport investment has taken place (Figure 3.32).

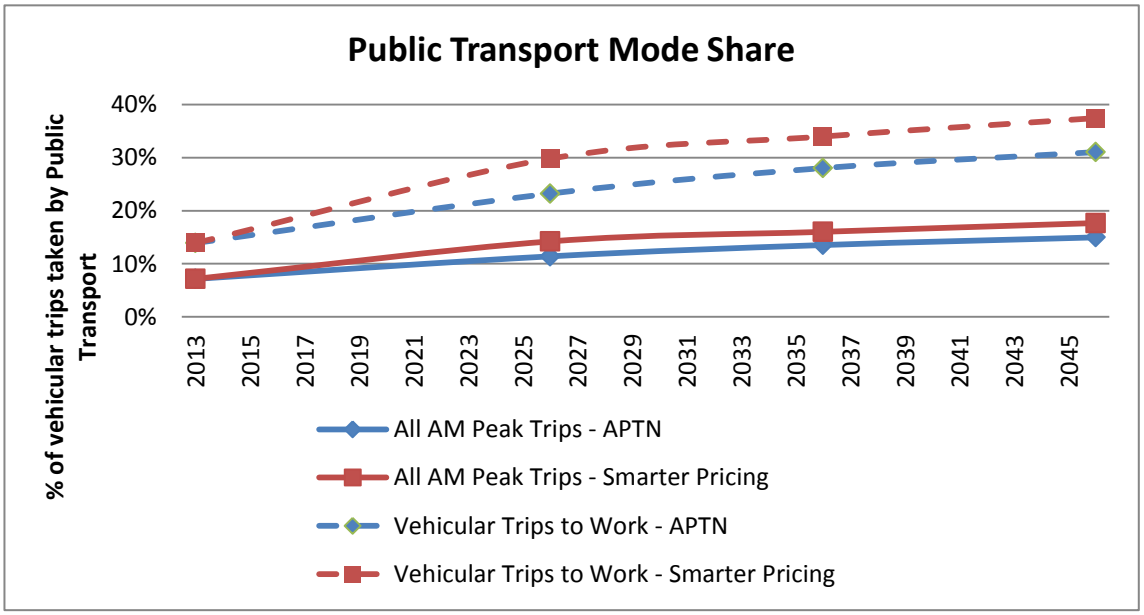


Figure 3.32: Public transport mode share (Smarter Pricing and APTN)

At a sub-regional level, the Smarter Pricing tool shows an increase in public transport mode share in parts of the region up until 2026 (Figure 3.33). By place of origin, this includes the city centre, isthmus, northwest and parts of the North Shore, partly due to the public transport investments occurring in those locations. By destination, the city centre and Westgate see the biggest increase in mode share.

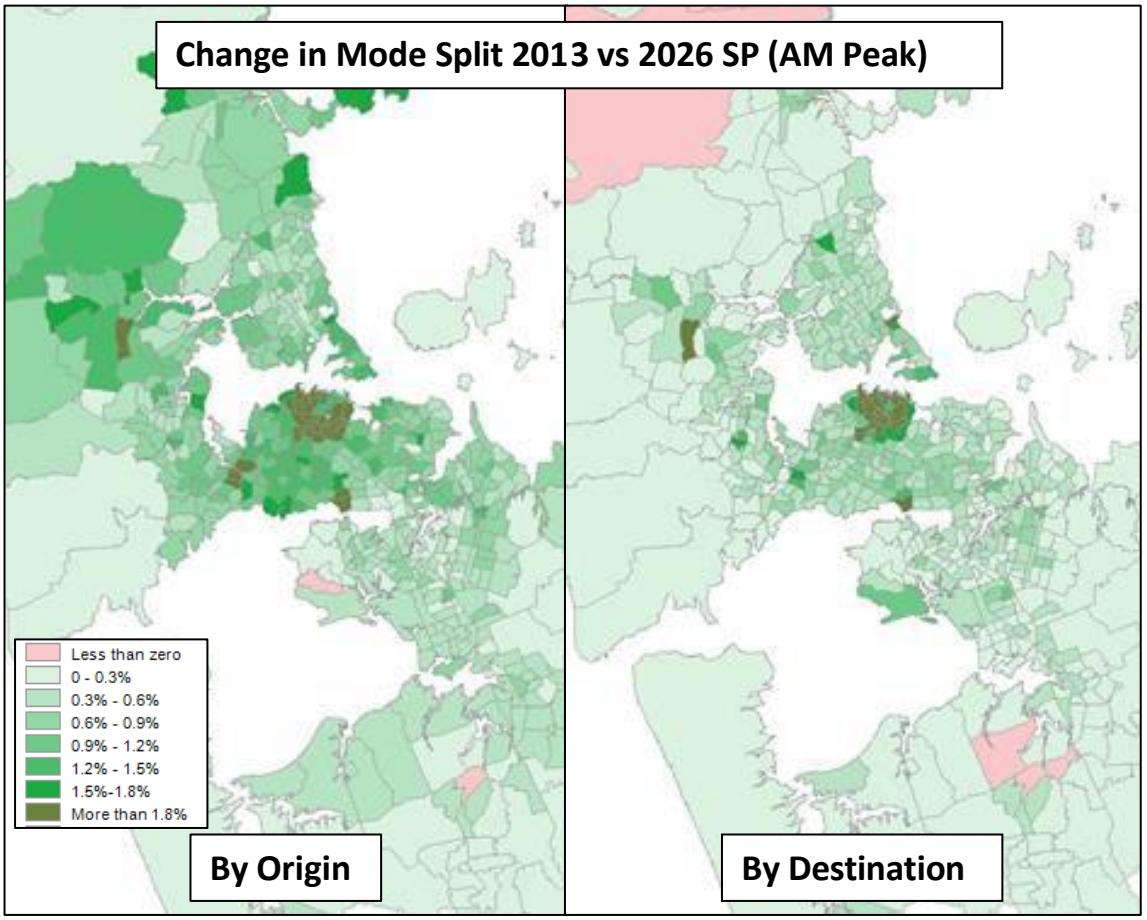


Figure 3.33: Change in mode split 2013 vs 2026 (Smarter Pricing)

Public transport mode share continues to increase after 2026 across the region, although at a lesser rate (Figure 3.34).

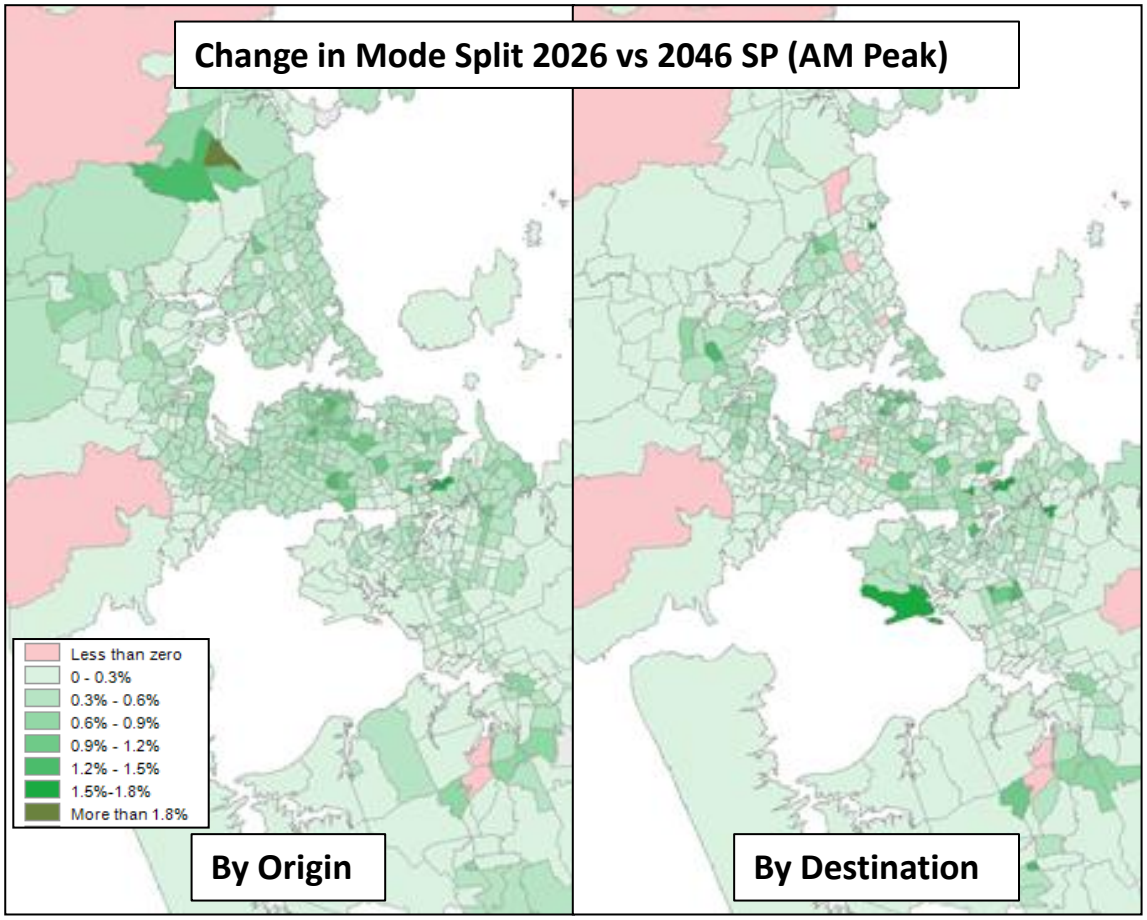


Figure 3.34: Change in mode split 2026 vs 2046 (Smarter Pricing)

While pricing has reduced demand for the roading network, it has substantially increased demand for the public transport network. The volume / capacity plots in Figure 3.35 show that under this pricing regime, much more public transport capacity is required.

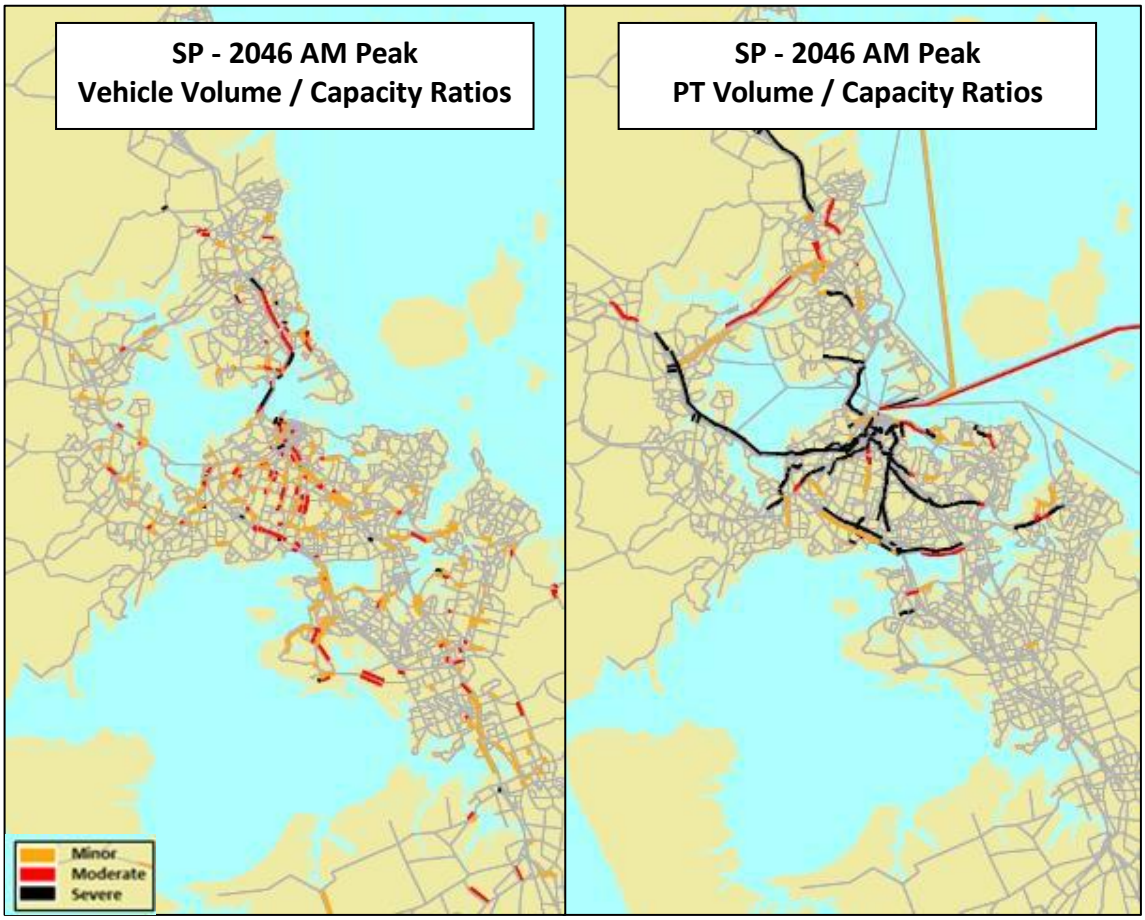


Figure 3.35: Vehicle and public transport demand (Smarter Pricing)

Net Benefits to Users

"Net benefits to users" was estimated because the Smarter Pricing package increases the financial costs of motorists using the transport system. Motorists receive a benefit from the improved network performance (in terms of shorter travel times and lower vehicle operating costs) but also face significantly increased costs from having to pay the network charges (Figure 3.36).

The following map shows the difference in projected generalised costs for motorists in different parts of Auckland in the morning peak in 2046 with Smarter Pricing, compared to the generalised costs in the APTN.

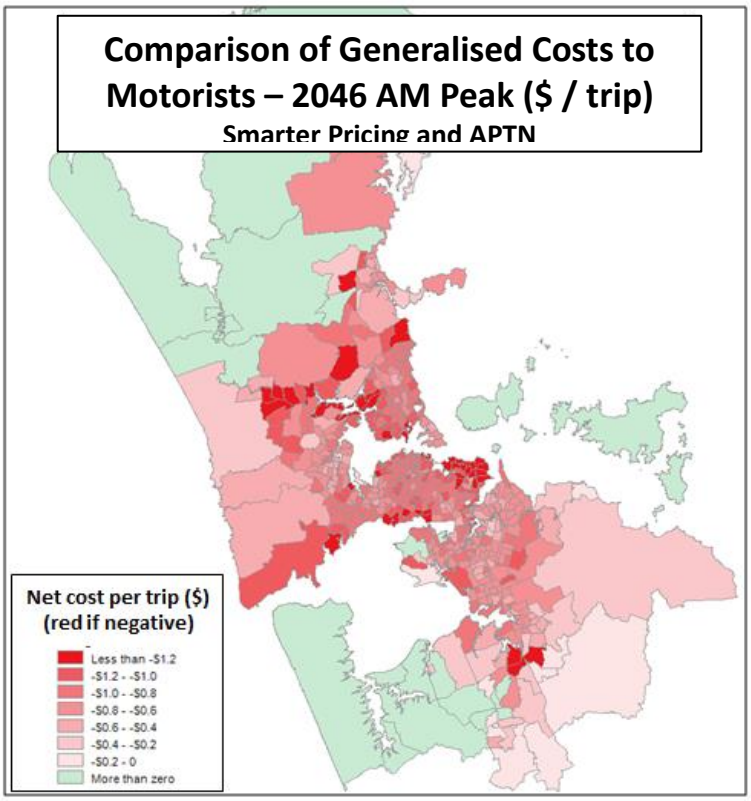


Figure 3.36: Generalised costs to road users - Smarter Pricing and APTN

This analysis balances the network charge that motorists pay against the savings in travel times and lower vehicle operating costs. However, the analysis does not take into account the wider benefits that users of the transport system would gain from increased accessibility and reduced congestion. The increases in net generalised costs above $1 per trip indicate that the price levels set in the morning peak may have been set too high. This assessment helps to inform a pricing level that provides desired demand management effects (i.e. increases in accessibility and reduction in congestion) at a lower financial cost to motorists.

Value for Money

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

The Smarter Pricing package has an estimated $28.7 billion capital expenditure programme over 30 years (excluding renewals) which is projected to result in significantly higher contributions to the ATAP objectives compared to the APTN. The package is projected to result in a higher proportion of jobs accessible by motorists of 62% (compared to 42% in the APTN), the same proportion of jobs accessible by public transport of 27% (also 27% in the APTN), a significantly lower proportion of travel time in severe congestion of 19% in severe congestion in the AM peak (compared to 32% in the APTN) and a higher public transport mode share of 22.1% in the AM peak (compared to 18.6% in the APTN).

3.3.3 Key Learnings

The Smarter Pricing package as a whole is projected to have significantly higher contributions to the project objectives than the APTN package, with a similar sized capital improvement programme, but at a higher average cost to motorists.

Our analysis of smarter pricing showed it offers the potential to achieve a step-change in transport network performance and should therefore form a core part of the strategic approach. However, setting prices at the right levels is extremely challenging as performance improvement, travel time savings and increased travel costs need to be carefully balanced.

3.4 Cross Package Review

3.4.1 Overview

The Capacity Constraints and Employment Centres packages as well as the Smarter Pricing packages were compared against the APTN to understand the extent to which they appear to deliver better returns than current plans. The main findings from the cross package review are listed below:

- Smarter Pricing shows significantly better travel time accessibility, congestion and public transport mode share results. However, at the price level it imposes significant financial costs on many users which may outweigh travel time reductions.
- The Capacity Constraints and Employment Centres packages show relatively similar regional results to APTN, despite a different mix of projects. However, regional results mask some sub-regional differences, with the impacts of most infrastructure investments seen at the sub-regional level.
- Bringing forward motorway widening provides some improvements to congestion in 2036, however only Smarter Pricing provides a major impact on congestion.
- A very large increase in projected bus passengers over the next 30 years is predicted, which will create capacity 'pinch points' with significant challenges to meet demand. It is unlikely that smarter transport pricing and technology will reduce this challenge.
- Care is needed in interpreting public transport results, as the ART model does not take account of crowding. In reality, public transport crowding would result in some users shifting to car, with increased congestion on the road network.
- The next phase of evaluation needs to test whether better results can be obtained by investing more in the first decade. Strategic choices appear to be between demand management and investing more on infrastructure.

3.4.2 Accessibility

Accessibility by Car

Both the Capacity Constraints and Employment Centres packages show slight to moderate improvements compared to the APTN up until 2036, after which accessibility provided under the Employment Centres package plateaus (Figure 3.37). However, Smarter Pricing produces the step-change in car access.

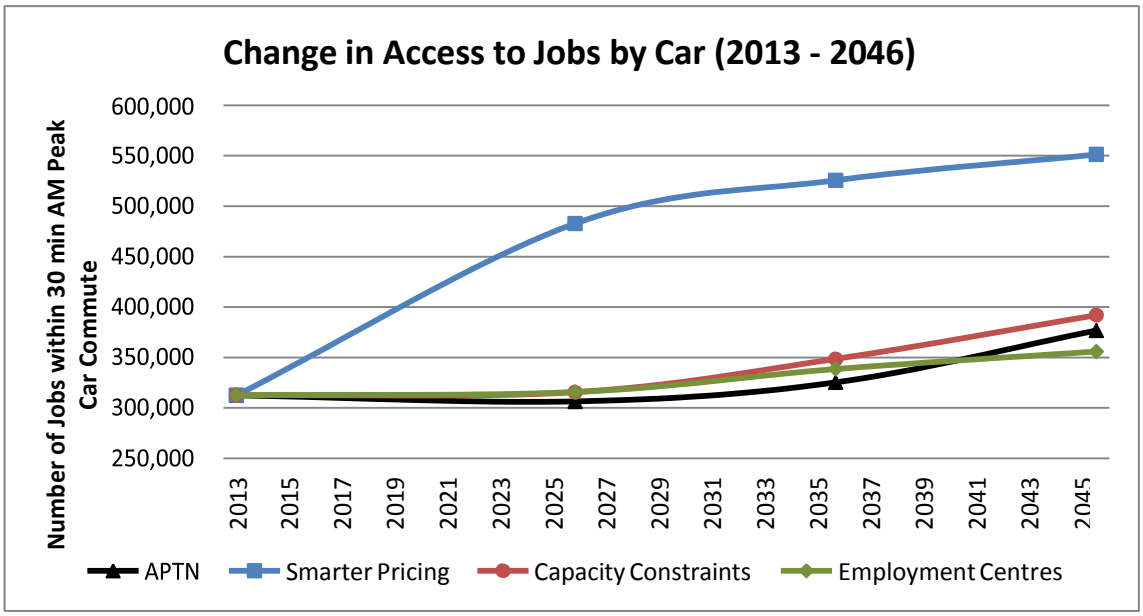


Figure 3.37: Change in number of jobs accessible within a 30 minute car commute AM peak (2013 – 2046)

In terms of public transport access, the Employment Centres package shows slight improvements compared to APTN (Figure 3.38). The Capacity Constraints package performs slightly better compared to APTN up until 2036. Smarter Pricing provides the highest level of public transport accessibility, particularly in the first and second decades, though at a more moderate scale compared to car access.

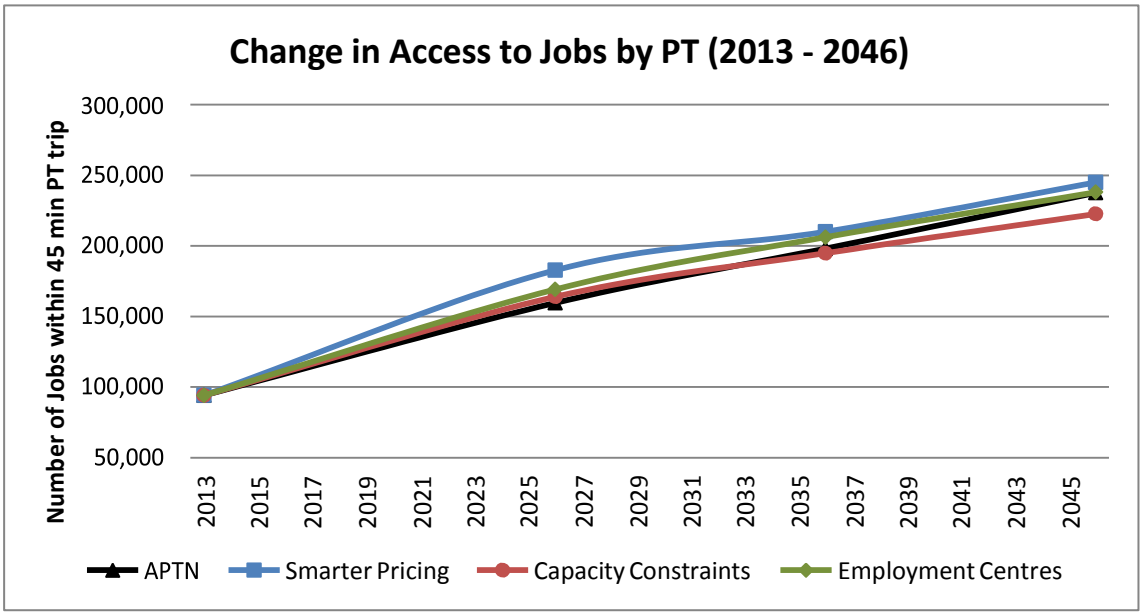


Figure 3.38: Change in number of jobs accessible within a 45 minute PT commute AM peak (2013 – 2046)

Despite having a very different mix of projects, the Capacity Constraints and Employment Centres packages show very similar results to the APTN on a regional level, particularly between 2013 and 2026.

Between 2026 and 2046, car accessibility improves across the region for Capacity Constraints, which has a motorway-widening theme, while public transport accessibility improves in certain parts of the region for Employment Centres, which focuses more on mass rapid transit.

Car accessibility by sub-region

The figures below show the potential accessibility to jobs by car for the four sub-regions. Calculating accessibility based on sub-region shows that smarter pricing provides the highest level of accessibility for all sub-regions.

While changing the mix of investment (through focusing on capacity constraints and employment centres) does not achieve a 'step-change' in regional performance, impacts at a sub-regional level are significant. In particular, improvements for the west and south appear possible through changes to the mix and timing of investment. This is important because these were areas where access challenges were found to be most significant in the first phase of the project.

West:

When assessing the change in car accessibility from 2013 in West Auckland, all three packages tested show better performance can be achieved, especially with Smarter Pricing (Figure 3.39). In comparison, access to employment by car under APTN declines in the first decade and only increases marginally after 2036.

Both Capacity Constraints and Employment Centres increase the number of jobs able to be reached within a 30 minute car commute from the west by around 20% in 2036 compared to the APTN.

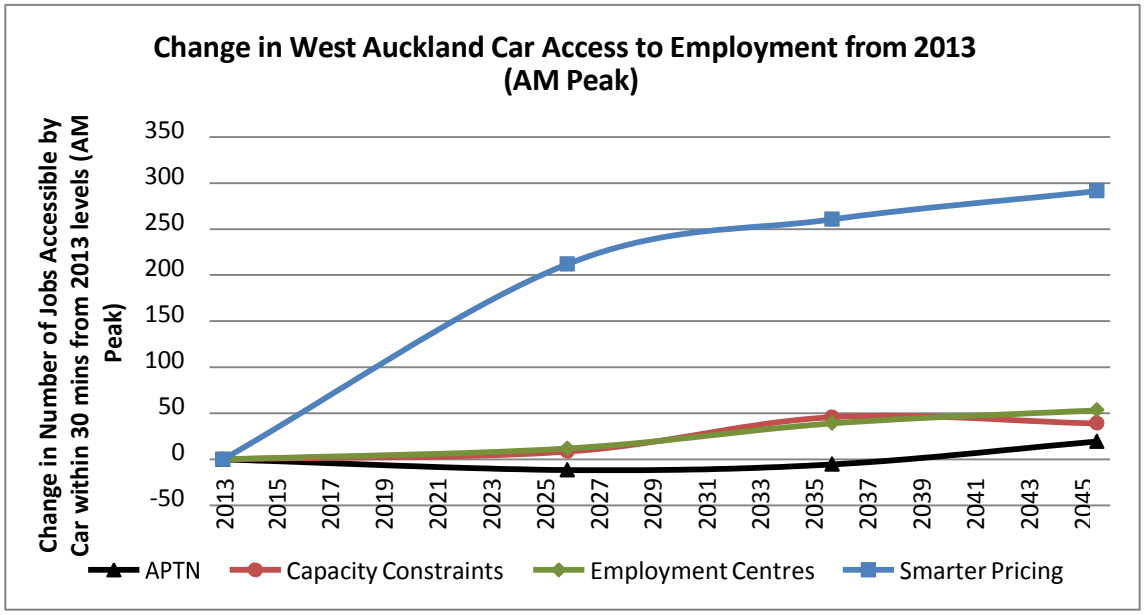


Figure 3.39: Change in West Auckland car accessibility AM peak from 2013

South:

In South Auckland, all three packages show improved performance on accessibility compared to APTN, which declines in the first decade and only improves strongly after 2036 (Figure 3.40). Some of the projects that may have had an impact include the selective widening of SH1, SH20A and SH20 in both the second and third decades.

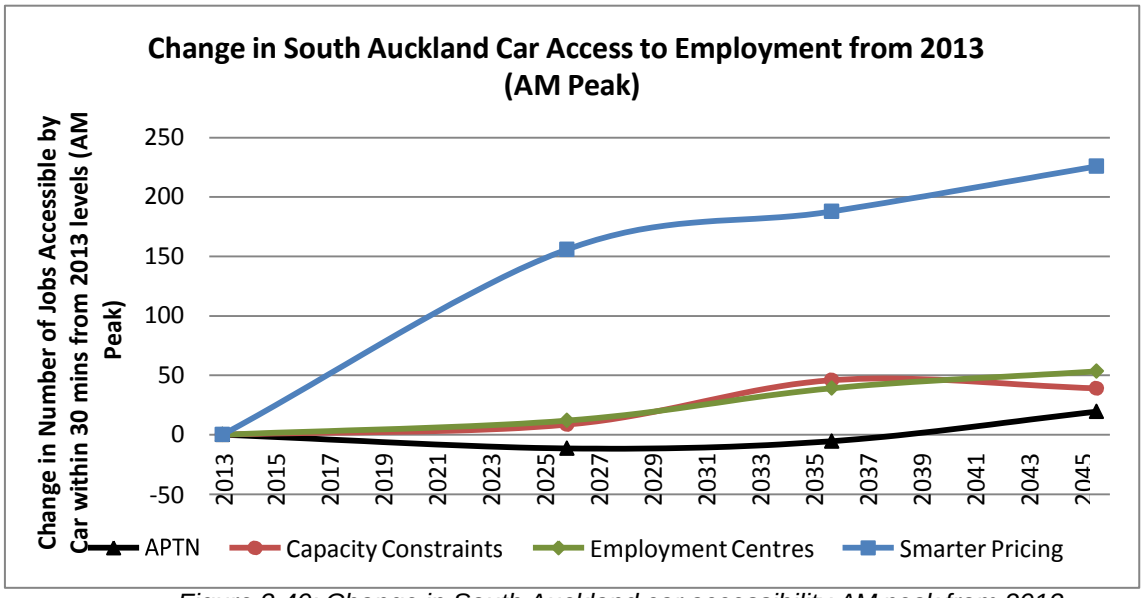


Figure 3.40: Change in South Auckland car accessibility AM peak from 2013

North:

Only Smarter Pricing brings a step-change to performance in accessibility for the north, despite the inclusion of the Additional Waitemata Harbour Crossing in both Capacity Constraints and APTN (Figure 3.41). Both Capacity Constraints and Employment Centres perform similarly to the APTN up until 2026, after which Employment Centres plateaus and Capacity Constraints perform similarly to APTN.

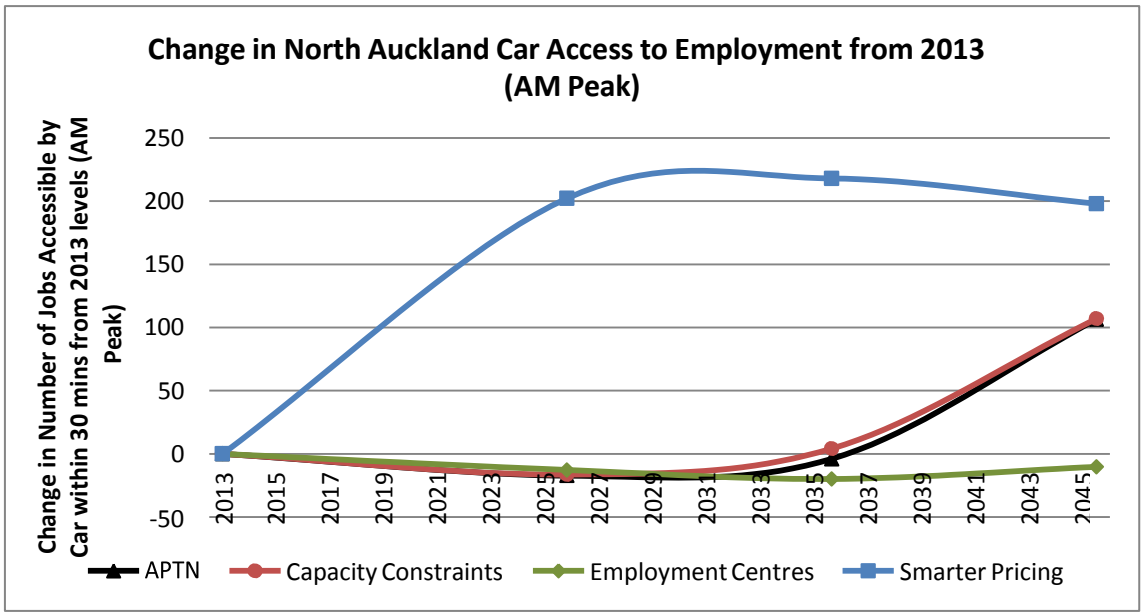


Figure 3.41: Change in North Auckland car accessibility AM peak from 2013

Central:

Central Auckland also sees Smarter Pricing providing the step-change in accessibility (Figure 3.42). Both Capacity Constraints and Employment Centres perform similarly to APTN up until 2026, after which both packages improve. Accessibility provided under Employment Centres plateaus after 2036.

Minor improvements in the central area such as the addition of a northbound lane at the Newmarket viaduct may have led to improved accessibility.

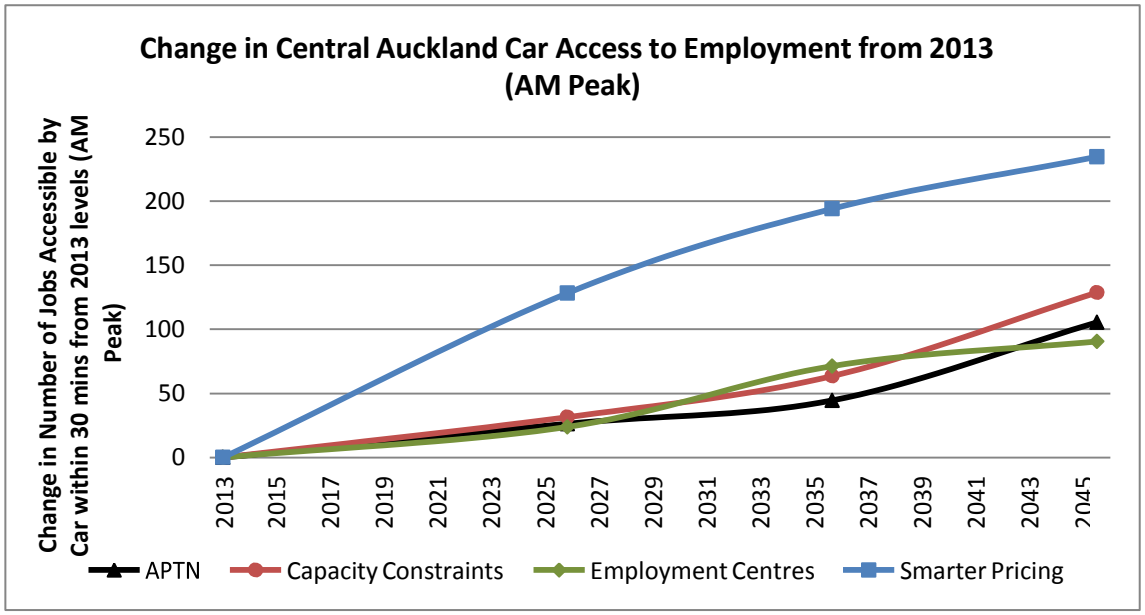


Figure 3.42: Change in Central Auckland car accessibility AM peak from 2013

Spatial analysis of car accessibility

Smarter Pricing increases car accessibility across the region between 2013 and 2026, whereas APTN, Employment Centres and Capacity Constraints largely show increased accessibility on the isthmus, inner south and outer north, and declining accessibility elsewhere (Figure 3.43).

Smarter Pricing continues to show increased car accessibility between 2026 and 2046, except for the area around Albany which sees a decline in accessibility (Figure 3.44). Both APTN and Capacity Constraints see improved accessibility for the North Shore due to the inclusion of the Additional Waitemata Harbour Crossing.

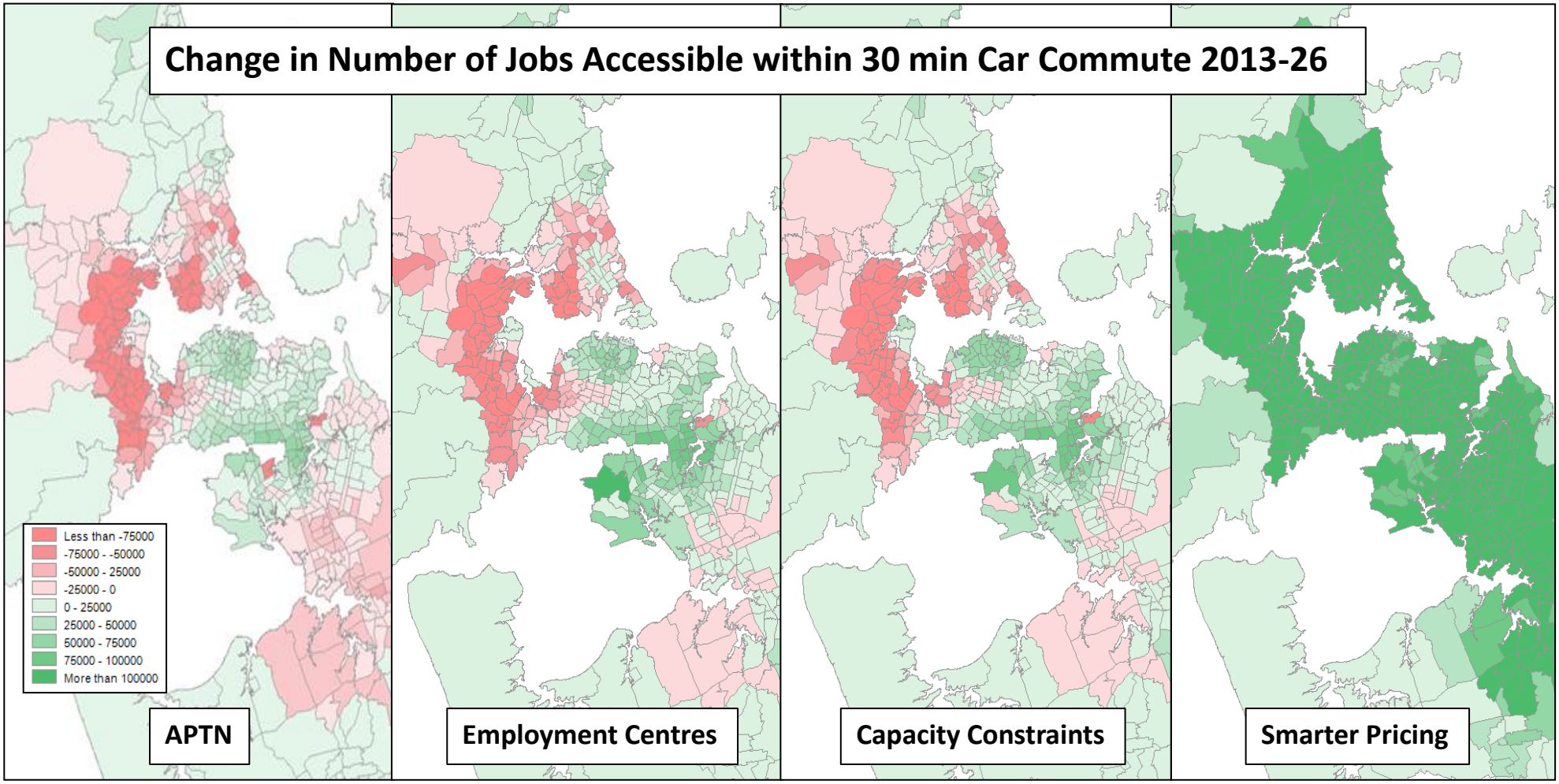


Figure 3.43: Change in number of jobs accessible within a 30 minute car commute AM peak (2013 – 2026)

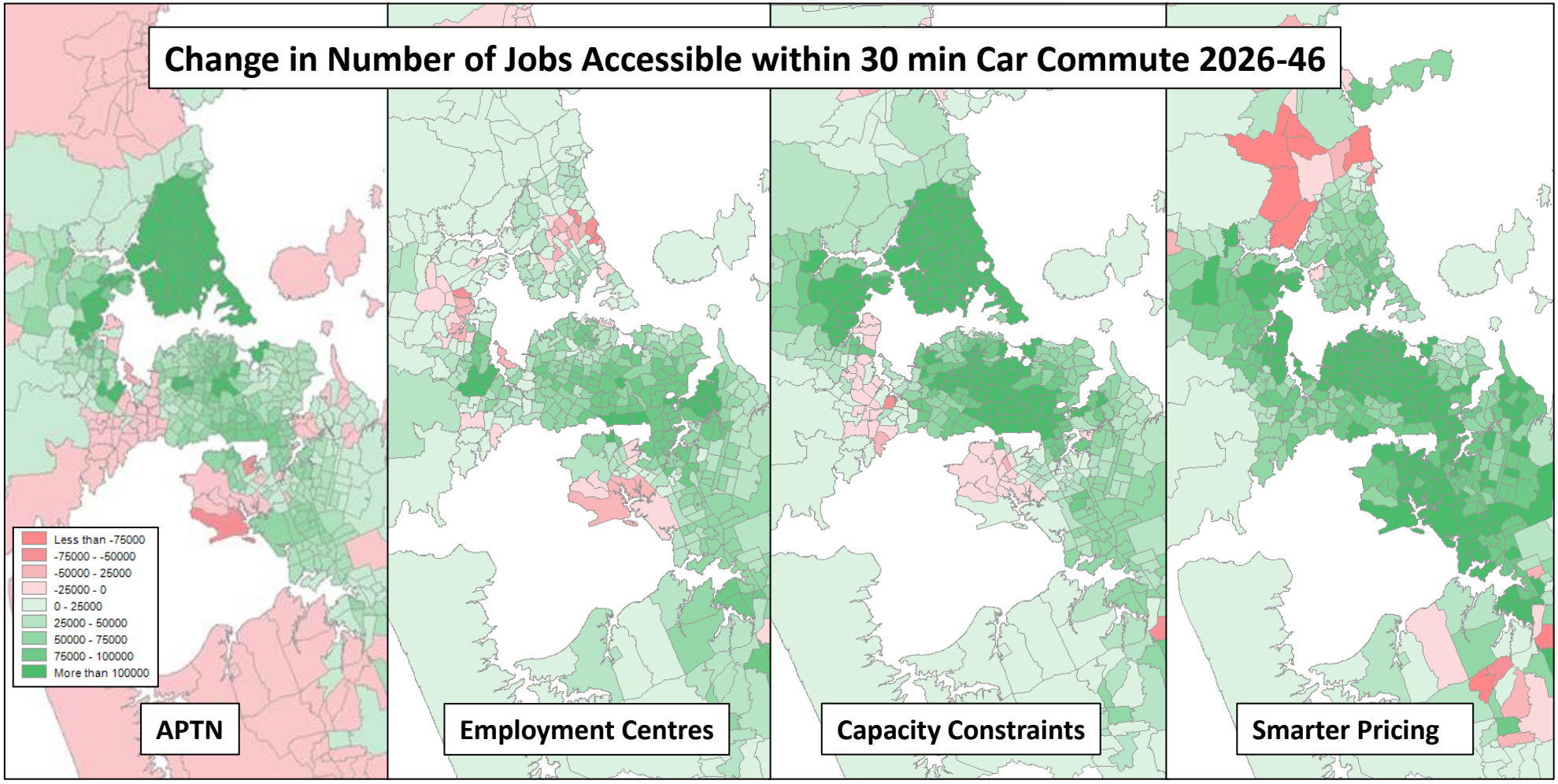


Figure 3.44: Change in number of jobs accessible within a 30 minute car commute AM peak (2026 – 2046)

Public transport accessibility

Public transport accessibility by sub-region

The figures below show the number of jobs able to be reached within a 45-minute public transport commute for each package on a sub-regional level.

The ART3 model is limited by the fact the capacity of public transport vehicles is not constrained.

West:

The west sees the greatest variation in public transport accessibility between the packages analysed (Figure 3.45). As mentioned before, Smarter Pricing and the Employment Centres package provided substantially higher public transport accessibility than the other packages, particularly in 2026 and 2036. Advancing the full Northwestern Busway from Kumeu to the city centre in this package is the main contributor to this improvement.

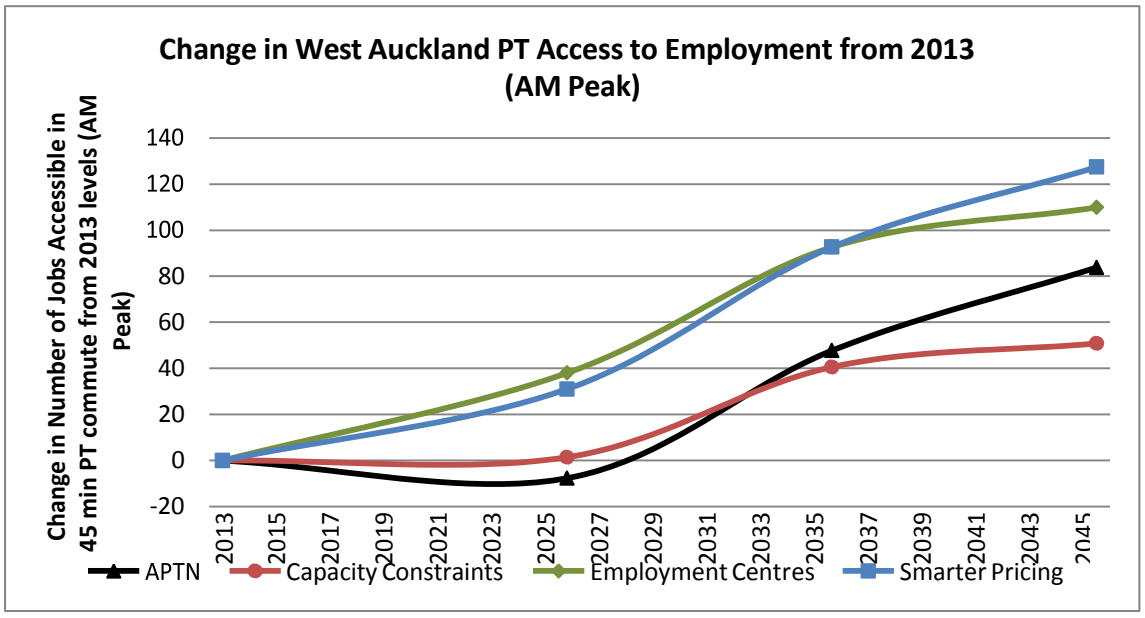


Figure 3.45: Change in West Auckland public transport accessibility AM peak from 2013

South:

In the south, both Capacity Constraints and Employment Centres provide similar levels of public transport access in the first decade compared to APTN (Figure 3.46). Smarter Pricing provides the highest level of accessibility, although the Employment Centres package catches up briefly in 2036. Rail upgrades to enable the Southern Line express trains are likely to be the main contributor to this improvement.

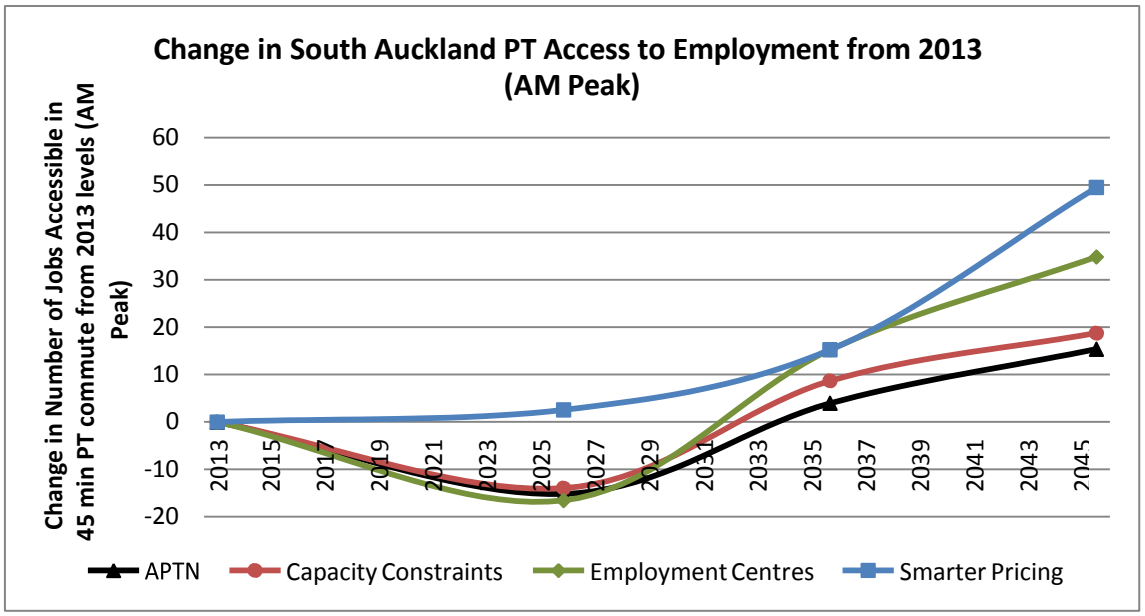


Figure 3.46: Change in West Auckland public transport accessibility AM peak from 2013

North:

In the north, all three packages tested perform better than APTN in the first decade, although the APTN catches up in the final decade (Figure 3.47).

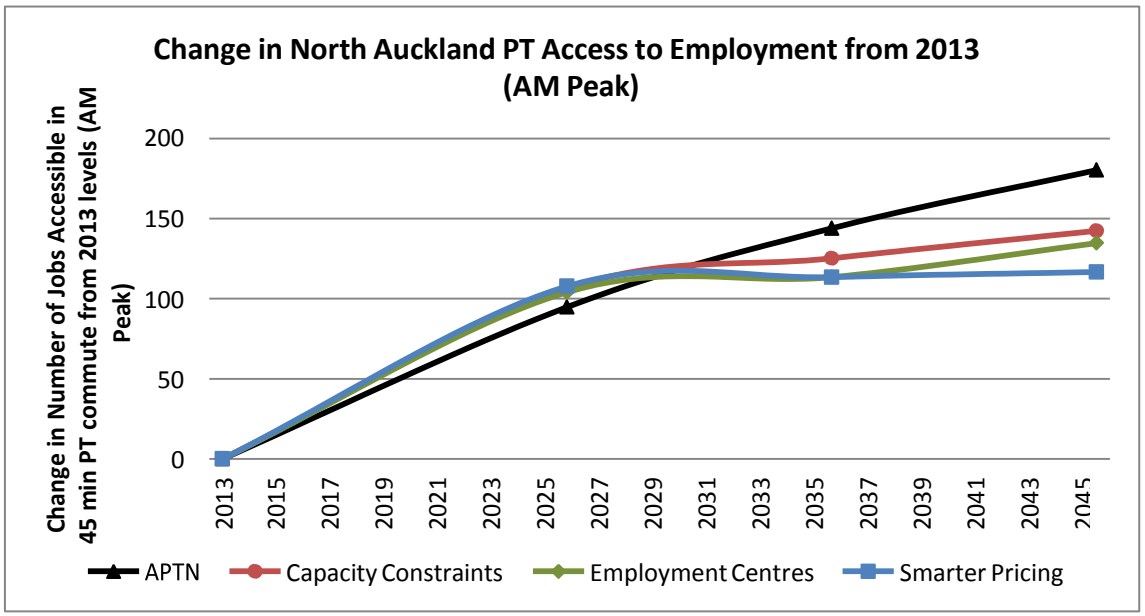


Figure 3.47: Change in North Auckland public transport accessibility AM peak from 2013

Central:

In the central area, Smarter Pricing sees the highest increase in public transport access between 2013 and 2036, largely due to the inclusion of both the isthmus mass transit and Mt Roskill rail spur (Figure 3.48). Capacity Constraints tracks similarly to APTN, while Employment Centres improves after 2026 to reach similar levels of accessibility as Smarter Pricing.

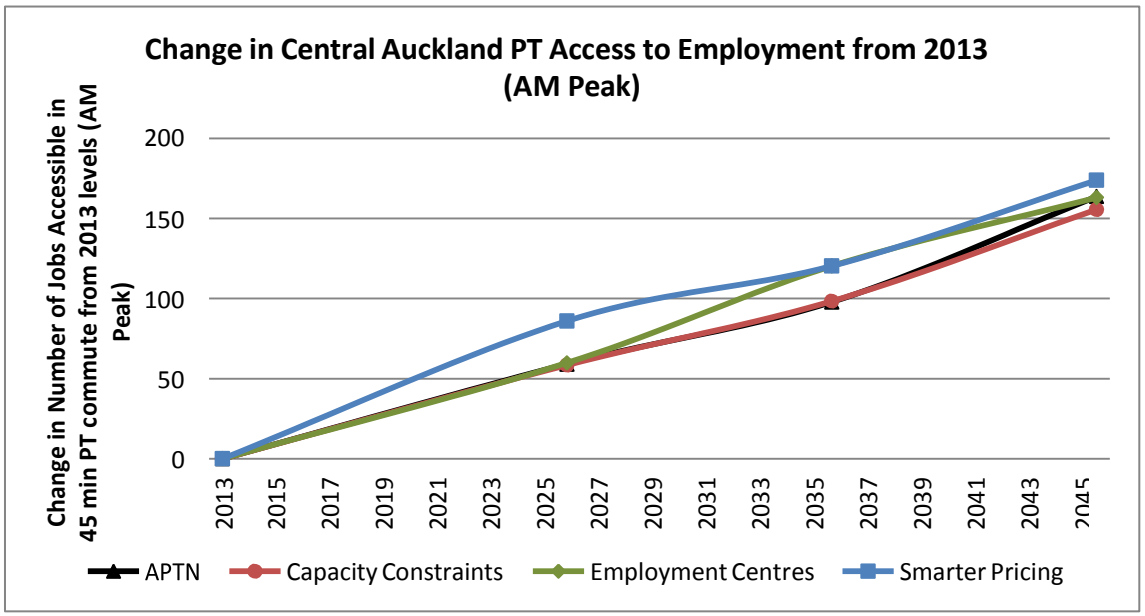


Figure 3.48: Change in Central Auckland public transport accessibility AM peak from 2013

Spatial analysis of public transport accessibility

APTN, Employment Centres, Capacity Constraints and Smarter Pricing all see increases to public transport accessibility across the region between 2013 and 2026, particularly around the isthmus and the North Shore (Figure 3.49). Employment Centres also see improved accessibility in the northwest as a result of the addition of the Northwestern Busway in the first decade.

Public transport accessibility improvements vary between the packages between 2026 and 2046 (Figure 3.50). Smarter Pricing sees the greatest improvement to public transport access, although it also sees decreases to accessibility on parts of the North Shore.

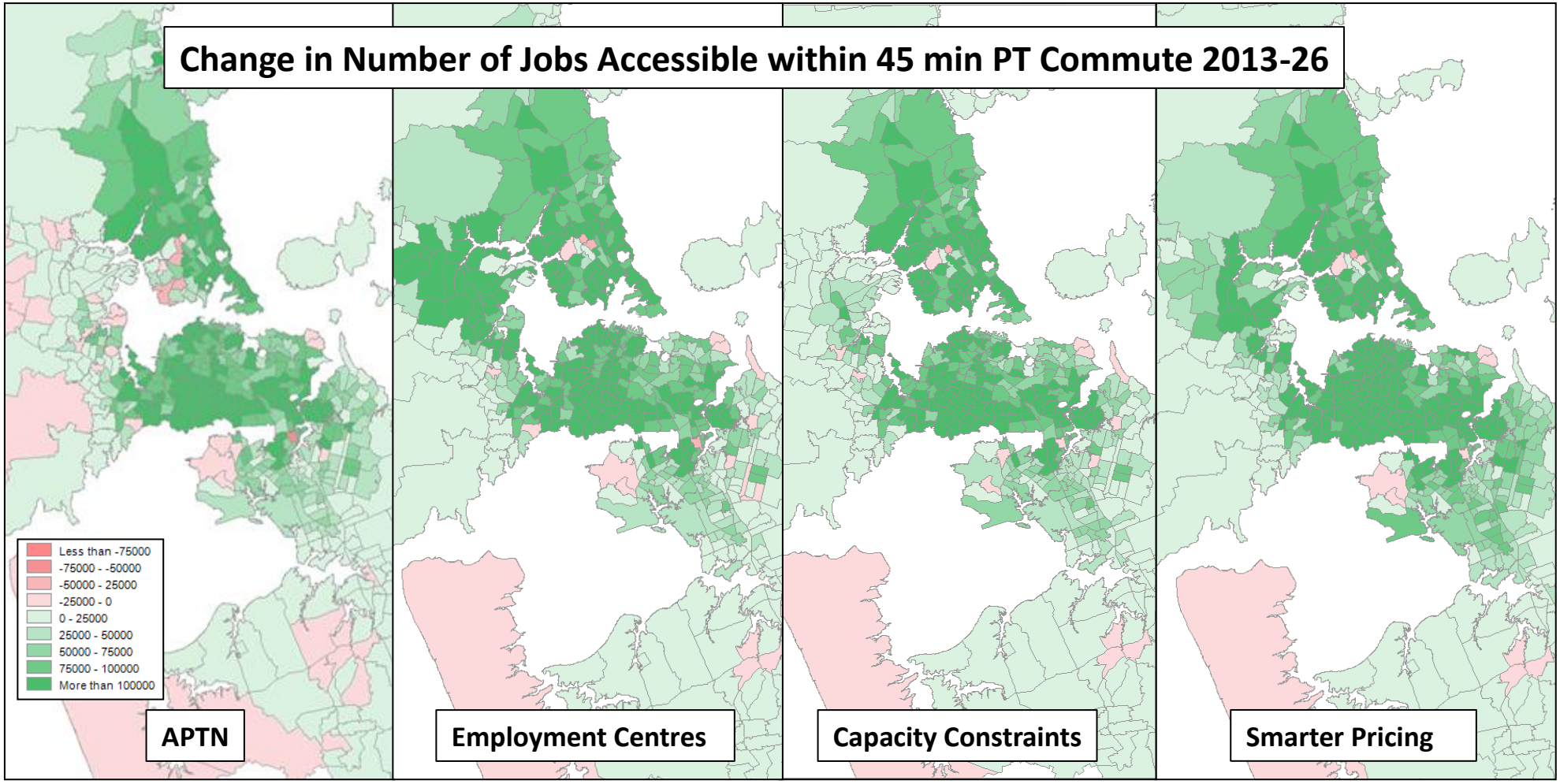


Figure 3.49: Change in number of jobs accessible within a 45 minute public transport commute AM peak (2013 – 2026)

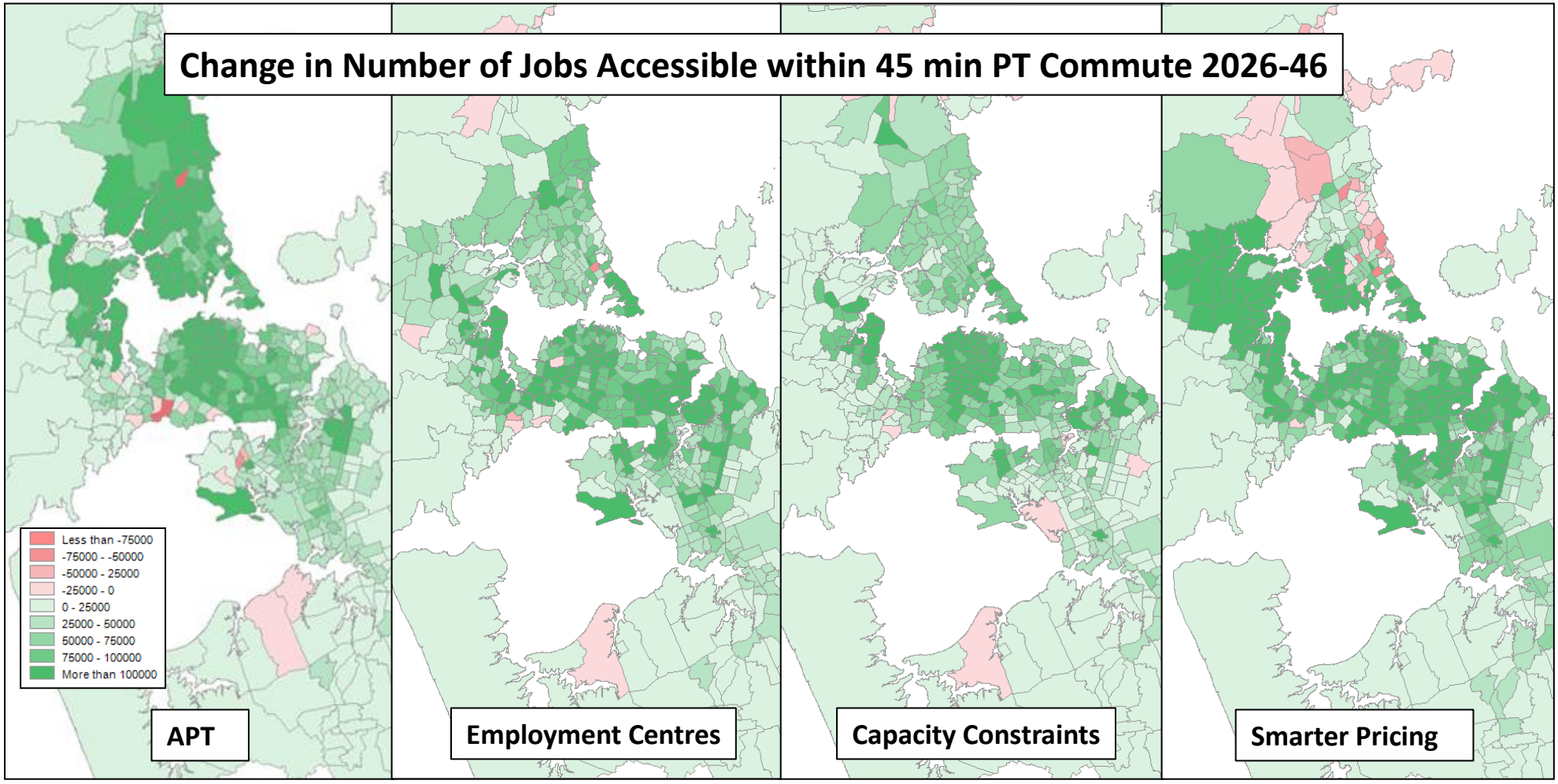


Figure 3.50: Change in number of jobs accessible within a 45 minute public transport commute AM peak (2026 – 2046)

3.4.3 Congestion

Both the Capacity Constraints and Employment Centres packages show small improvements compared to the APTN, particularly within the first decade (Figure 3.51). Congestion levels under Employment Centres gradually increase from 2026 until they reach the same level as APTN in 2046. Congestion levels remain the same under Capacity Constraints between 2026 and 2046. Smarter Pricing is the only option that shows a 'step-change' in congestion alleviation, with the biggest reduction taking effect in 2026.

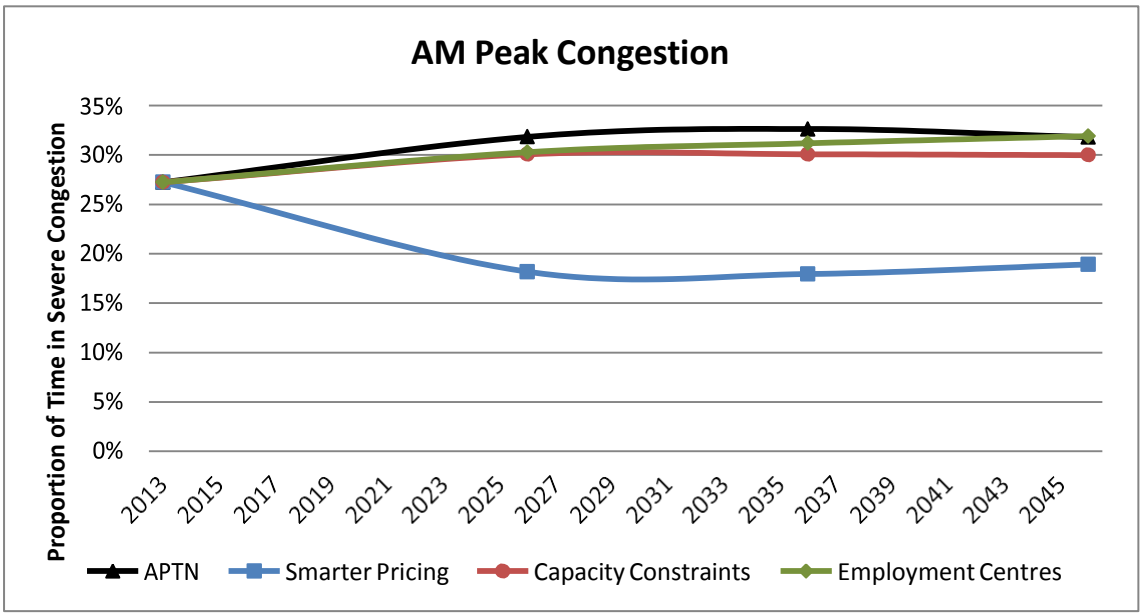


Figure 3.51: AM Peak Congestion (2013 – 2046)

Inter-peak congestion sees similar patterns to the AM peak, with Smarter Pricing showing the biggest reduction in congestion (Figure 3.52).

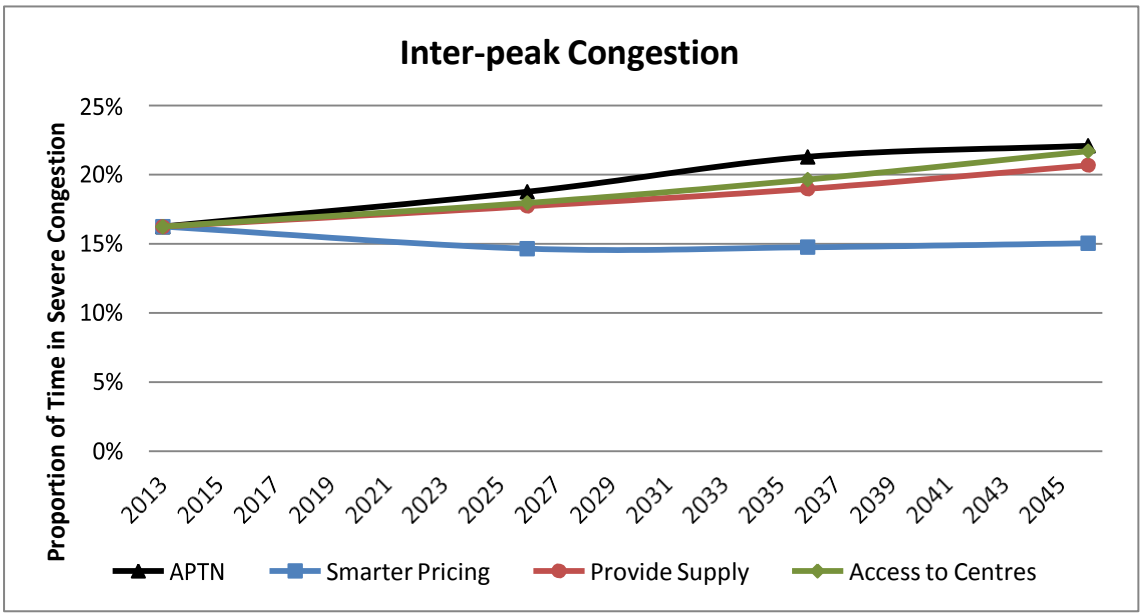


Figure 3.52: Inter-peak Congestion (2013 – 2046)

At a sub-regional level, congestion remains an issue in the 2046 AM peak under the Capacity Constraints package despite motorway widening being brought forward. Severe congestion is seen particularly on SH16, SH20, the Auckland Harbour Bridge and parts of the Northern Motorway (Figure 3.53). Only Smarter Pricing has any discernible impact on congestion, followed by the Employment Centres package.

The inter-peak sees less severe congestion on the network compared to the AM peak, although limited congestion remain on key pinch points (Figure 3.54). All packages see an improvement to inter-peak congestion compared to the APTN, particularly on SH20A and parts of the Northern Motorway. The removal of even minor congestion on the network under Smarter Pricing indicates that pricing levels may be too high.

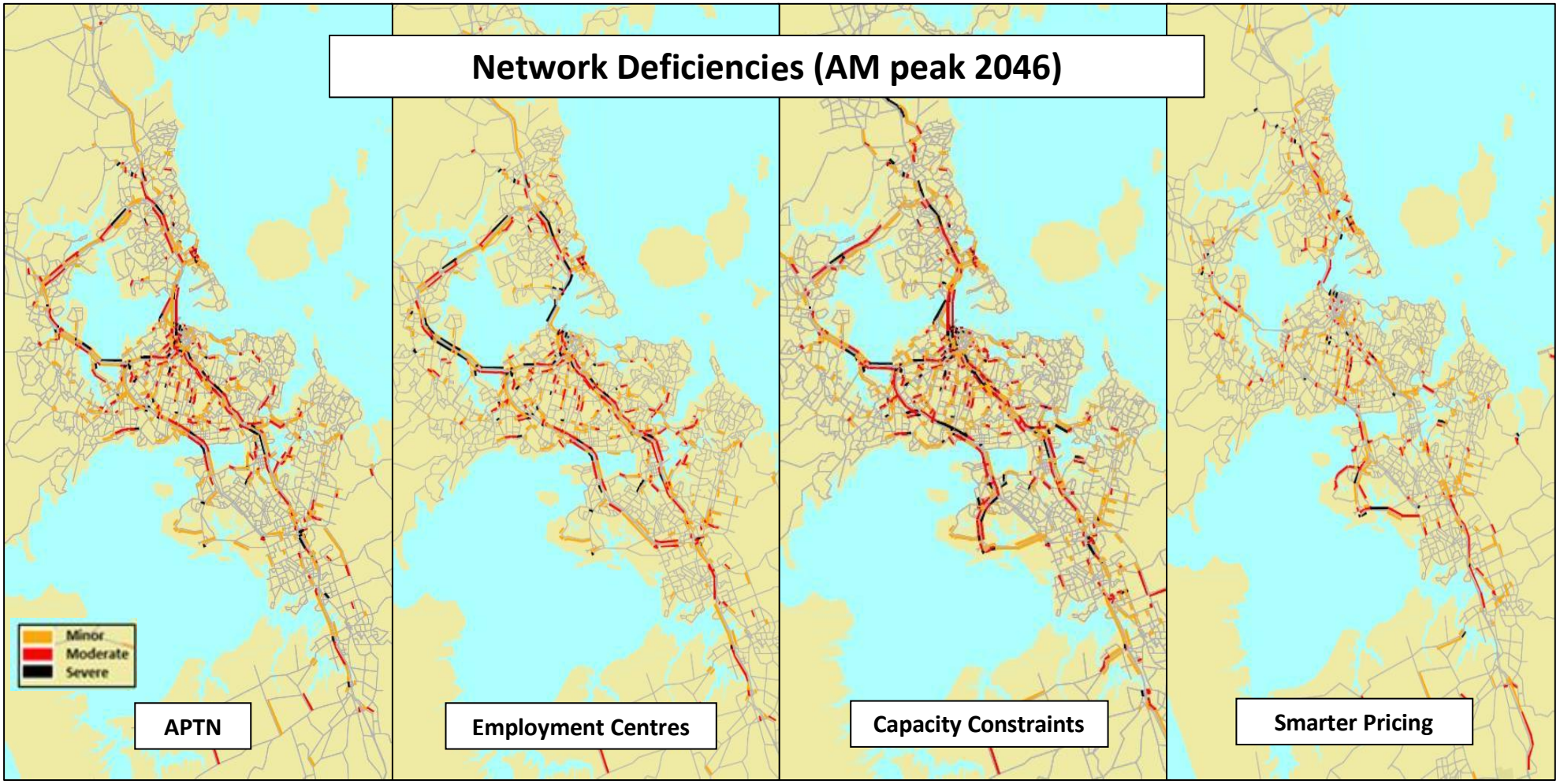


Figure 3.53: Network deficiencies in the AM Peak (2046)

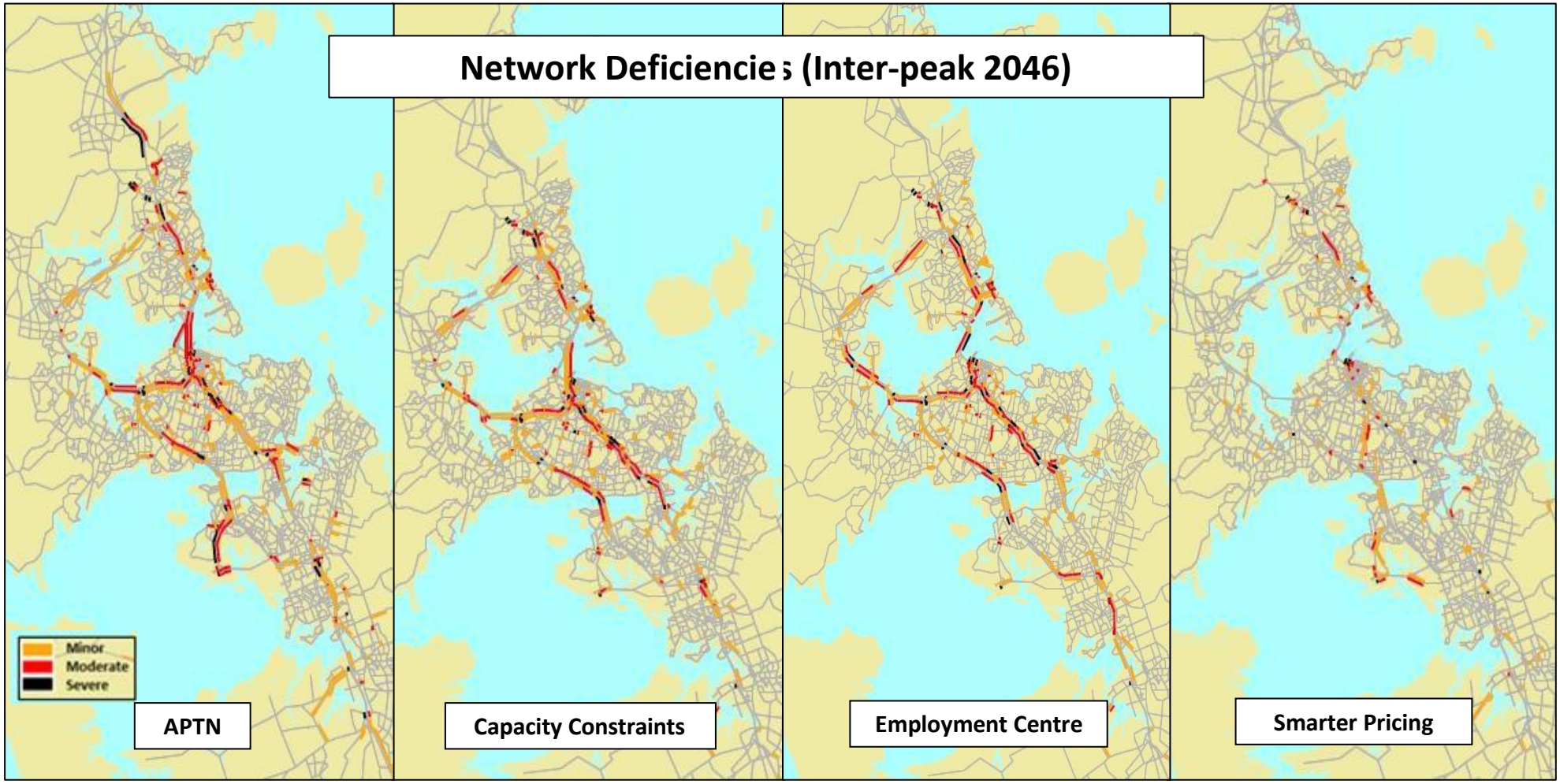


Figure 3.54: Network deficiencies in the Inter-peak (2046)

3.4.4 Public Transport Mode Share

Public transport mode share tracks similarly under APTN, Capacity Constraints and Employment Centres (Figure 3.55). Due to the increased cost of driving resulting from Smarter Pricing, public transport mode share shows moderate improvements.

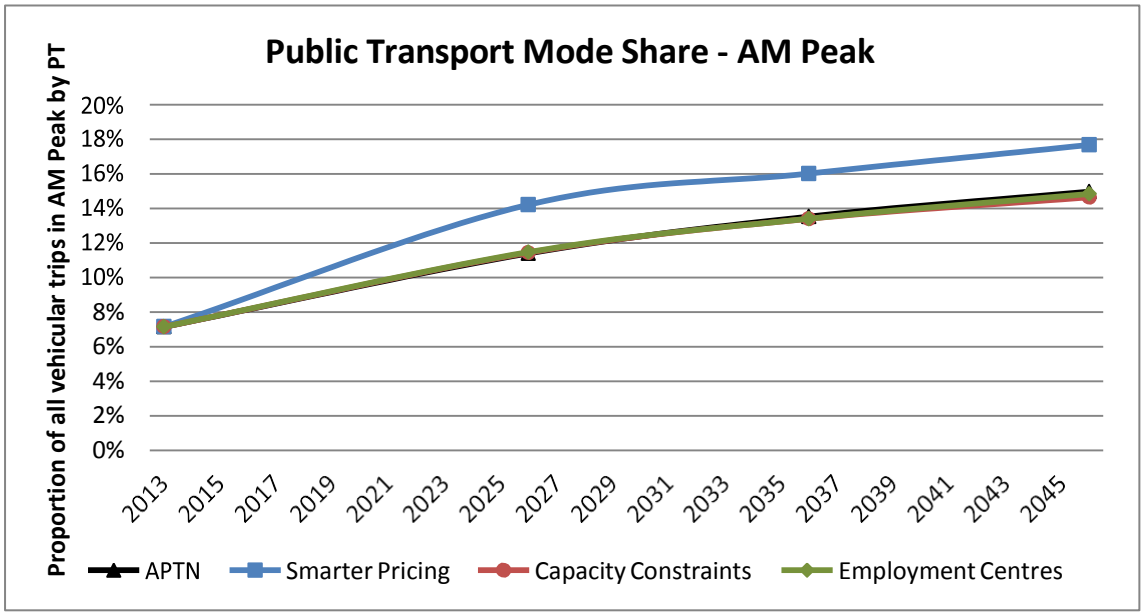


Figure 3.55: Public transport mode share in the AM peak (2013-2046)

Public transport constraints

A very large increase in projected bus passengers over the next 30 years is predicted, creating capacity 'pinch points' with significant challenges to meet demand.

Current bus demand for Symonds Street already exceeds medium capacity, and will exceed high capacity between 2018 and 2023 for all packages (Figure 3.56).[4]

[4] Medium capacity refers to a capacity of 120 buses per hour with 57 passengers per bus. High capacity refers to a capacity of 120 buses per hour with 80 passengers per bus. These are indicative corridor capacities and will vary according to specific circumstances.

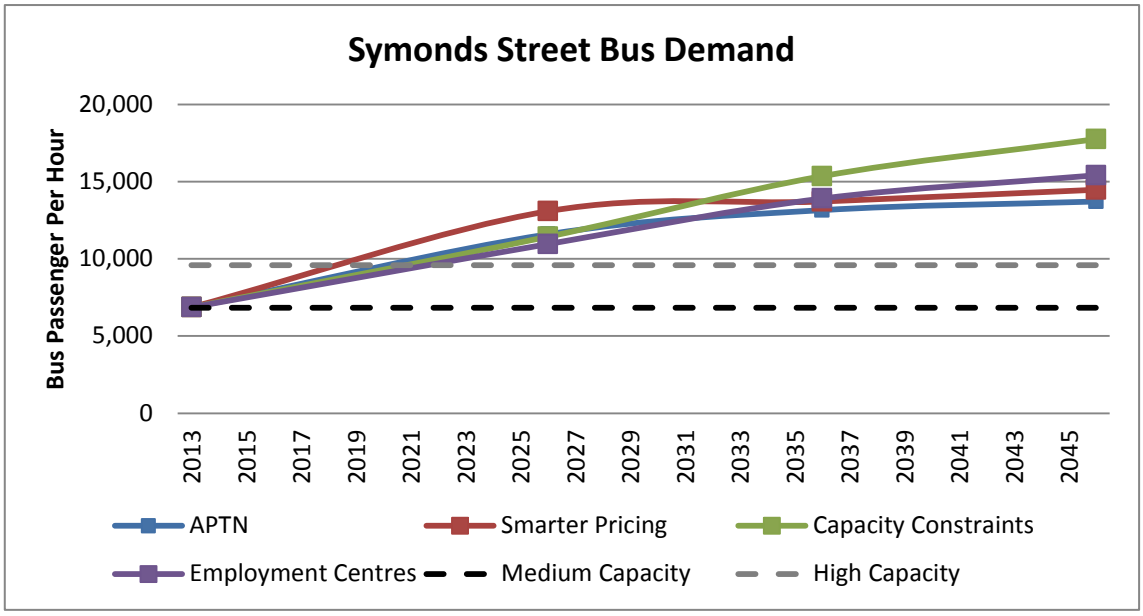


Figure 3.56: Symonds Street bus demand (2013-2046)

Bus demand for Fanshawe Street peaks at 2026 under the Employment Centres and Smarter Pricing packages, reaching medium capacity as a result of the introduction of the North Shore mass transit system (Figure 3.57). Without mass transit, bus demand continues to rise (as seen in the APTN and Capacity Constraints packages) until it exceeds high capacity at around 2036.

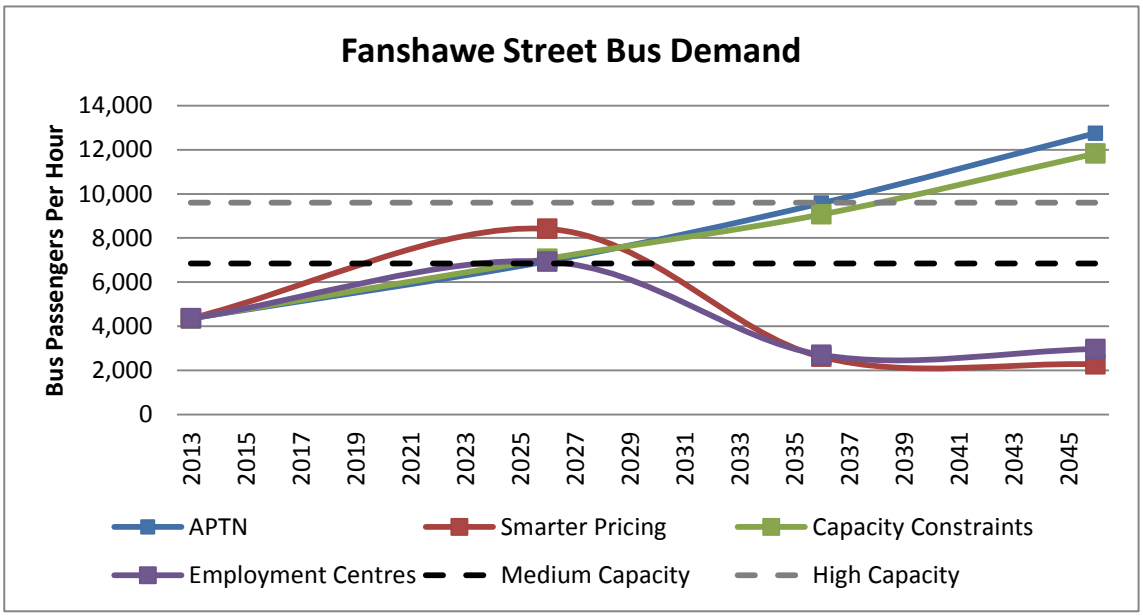


Figure 3.57: Fanshawe Street bus demand (2013-2046)

Bus demand for Karangahape Road reaches medium capacity in 2036 for both the Capacity Constraints and Employment Centres packages (Figure 3.58). High capacity is reached in 2046 with the smarter transport pricing tool.

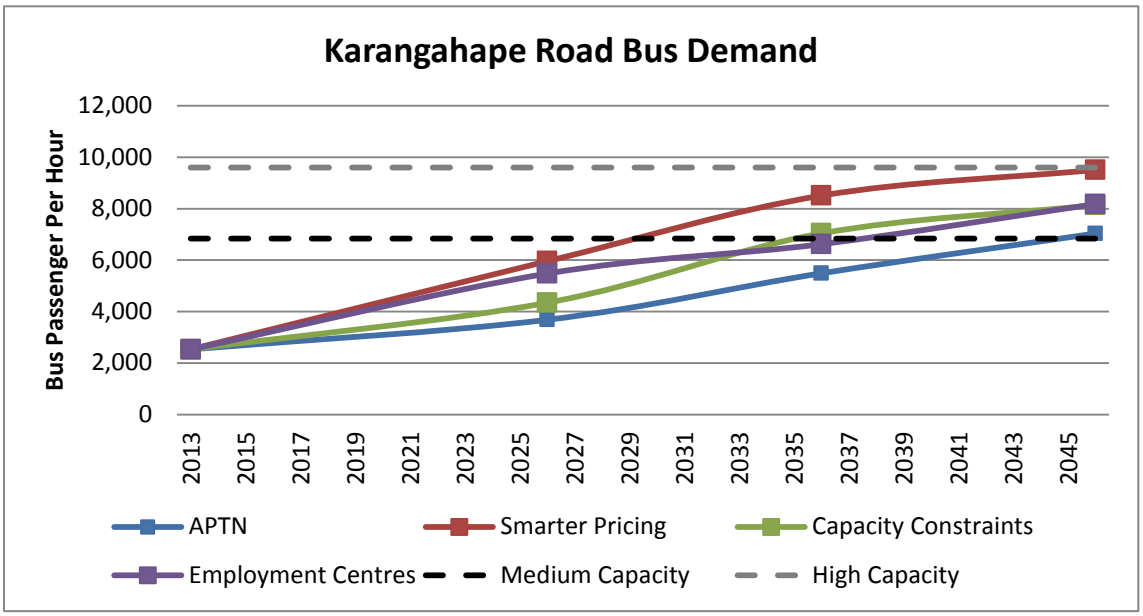


Figure 3.58: Karangahape Road bus demand (2013-2046)

Long-term solutions to these capacity constraints potentially involve substantial investments and have major network-wide implications. A network-wide approach to the planning, timing and funding of these interventions is therefore important to inform investment decisions.

It appears unlikely that smarter pricing and technology will reduce this challenge. Road pricing typically increases public transport demand, further increasing the challenge while any shift to ridesharing away from public transport in accessing the city centre is likely to increase, rather than reduce, congestion levels due to limited street-space.

However, care is needed in interpreting public transport results, as the ART3 model does not take into account the 'crowding off' of passengers from buses due to demand exceeding capacity. In reality, crowding would result in some users shifting to car, with increased congestion. When crowding is taken into account using the APT3 model, predicted bus demand is generally shown to be lower (Figure 3.59).

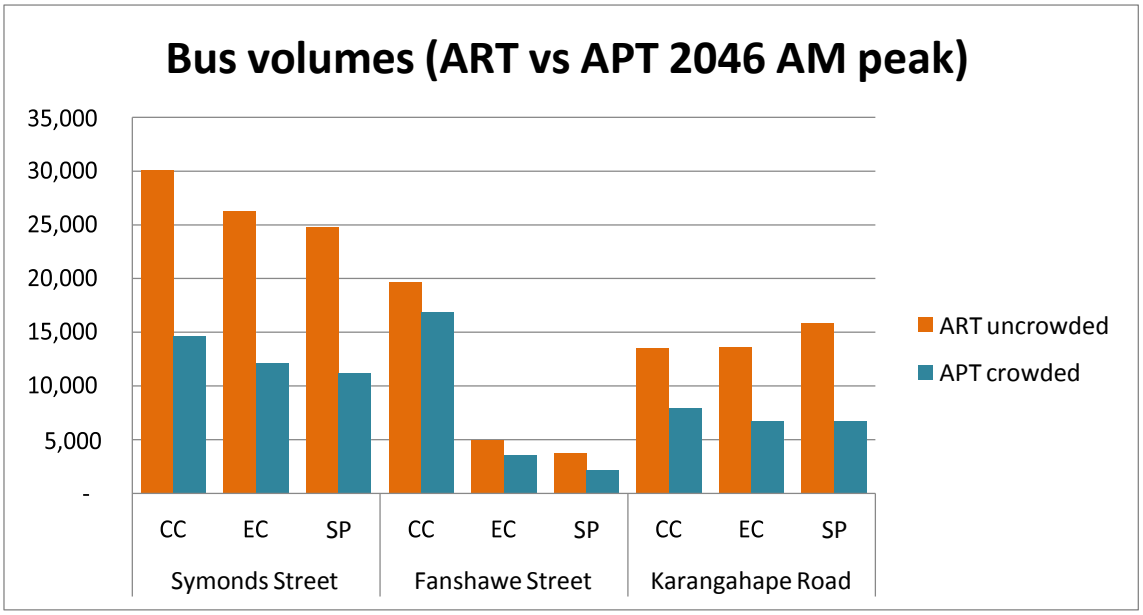


Figure 3.59: Isthmus bus demand ART uncrowded vs APT crowded (2013-2046)

3.4.5 Full Evaluation Results

The following table presents the results of our evaluation of the Capacity Constraints, Employment Centres and Smarter Pricing packages against the evaluation criteria established in the Foundation Report (Table 3.5). All results relate to the 2046 year unless otherwise specified.

Table 3.5: Evaluation framework – headline measures

Objective	Measure	Headline KPI	2013 comparison	Capacity Constraints 2046	Employment Centres 2046	Smarter Pricing 2046	APTN 2046	Comment
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30 minute trip in the AM peak • Jobs accessible by public transport within a 45 minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	312,000 i.e. 51% of available jobs 94,000 i.e. 15% of available jobs 467,000 i.e. 75 % of available jobs	392,000 i.e. 44% of available jobs 223,000 i.e. 25% of available jobs 599,000 i.e. 67% of available jobs	356,000 i.e. 40% of available jobs 238,000 i.e. 27% of available jobs 588,000 i.e. 66% of available jobs	551,000 i.e. 62% of available jobs 245,000 i.e. 27% of available jobs 678,000 i.e. 76% of available jobs	386,000 i.e.43% of available jobs 215,000 i.e. 24% of available jobs 590,000 i.e. 66% of available jobs	The Capacity Constraints and Employment Centres packages increases the number of jobs accessible by car and PT (mainly due to growth) but does not increase the proportion of jobs that could be accessed by car. The Smarter Pricing package significantly increases car and PT accessibility (measured only in relation to travel time, not financial cost) in the morning peak (7-9 am) in 2046, with a moderate increase in accessibility by public transport.
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak	7 hours 22 minutes per person per annum 27.3% AM peak 16.3% inter-peak	11 hours 53 minutes per person per annum 30.0% AM peak 20.7% inter-peak	13 hours 13 minutes per person per annum 31.9% AM peak 21.7% inter-peak	2 hours 49 minutes per person per annum 18.9% AM peak 15.4% inter-peak	13 hours 33 minutes per person per annum 31.9% AM peak 21.9% inter-peak	With Smarter Pricing, projected levels of congestion throughout the day are significantly better than the APTN. Projected levels of congestion for the Capacity Constraints and Employment Centres packages are expected to be similar to the APTN.
	Impact on freight and goods (commercial traffic) congestion	• Proportion of business and freight travel time spent in severe congestion on the strategic freight network (in the AM peak and inter-peak)	15.1% AM 8.3% inter-peak	17.3% AM 11.9% inter-peak	22.2% AM 14.5% inter-peak	7.2% AM 5.5% inter-peak	18.6% AM 12.9% inter-peak	Projected congestion on the strategic freight network varies considerably between the packages. With Smarter Pricing, projected congestion is significantly better throughout the day, compared to the APTN.
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, inter-peak and PM peak.	15% AM peak 6% inter-peak 16% PM peak	18% AM peak 12% inter-peak 24% PM peak	19% AM peak 14% inter-peak 24% PM peak	8% AM peak 5% inter-peak 10% PM peak	19% AM peak 13% inter-peak 23% PM peak	With Smarter Pricing, projected reliability of travel times for motor vehicle trips is expected to be significantly better throughout the day, compared to APTN. Projected reliability for the Capacity Constraints and Employment Centres packages is expected to be similar to the APTN.
Increase public transport mode-share	Public transport mode share	• Proportion of vehicular trips in the AM peak made by public transport	8.5%	18.2%	18.5%	22.1%	18.0%	With Smarter Pricing, projected PT mode share is slightly higher than APTN. Projected PT mode share for the Capacity Constraints and Employment Centres packages is expected to be similar to the APTN.
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 9 km in the AM peak made by public transport	18.3%	26%	27%	35%	31.7%	With Smarter Pricing, it is projected that a higher proportion of longer commute trips would be by PT, compared to the APTN. The proportion of longer commuter trips by PT is projected to be lower with the Capacity Constraints and Employment Centres packages, compared to the APTN.
	Increase vehicle occupancy	• Average vehicle occupancy	1.36 people per vehicle AM peak 1.25 people per vehicle inter-peak	-	-	-	-	It was not possible to model changes in vehicle occupancy. The input assumptions of an average of 1.36 people per vehicle in AM peak and an average of 1.25 people per vehicle in inter-peak remained constant for all packages and all model years.

Objective	Measure	Headline KPI	2013 comparison	Capacity Constraints 2046	Employment Centres 2046	Smarter Pricing 2046	APTN 2046	Comment
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	Not applicable	-	-	-	Not applicable	Financial costs from Smarter Pricing (see pricing schedule in Table 3.3) are assumed to replace road user charges and fuel excise duties. Savings in travel time and vehicle operating costs vary by trip. On average it is estimated that the financial costs exceed the savings in travel time and vehicle operating costs. Better model/tools are required to provide robust quantification of net benefits.
Ensure value for money	Value for money	• Package benefits and costs	-	-	-	-	-	Package benefits include the contributions to objectives as measured in this table. The costs of new capital expenditure (excluding renewals) for the 30 year programmes are estimated in billions of 2016 dollars as follows: Capacity Constraints: $29.5 b Employment Centres: $29.6 b Smarter Pricing: $28.7 b These cost estimates were identified prior to the revision of project costs in ATAP.

In addition to the project objectives, a number of other key outcomes have been evaluated through the evaluation framework in Table 3.6 below.

Table 3.6: Evaluation framework – other key outcomes

Other Key Outcomes	Measure	Headline Key Performance Indicator	2013 comparison	Capacity Constraints 2046	Employment Centres 2046	Smarter Pricing 2046	APTN	Comment
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	Existing transport infrastructure in greenfields is inadequate to support the growth required in the FULSS.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Does not meet timeframes of FULSS.	The same programme in greenfields has been assumed in all three packages.
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled	48 deaths and 3,487 injuries p.a. from motor vehicle crashes. 25 injuries per 10,000 population 28 injuries per 100 million vehicle kilometres travelled	-	-	-	-	Model forecasts can't accurately identify number of deaths and serious injuries.
	Emissions	• Greenhouse gas emissions	8.4 million kg of CO_2 per day	8.1 million kg of CO_2 per day	8.0 million kg of CO_2 per day	7.0 million kg of CO_2 per day	8.1 million kg of CO_2 per day	Model projects 12.5% fewer emissions in the Smarter Pricing package than APTN. This is mostly due to fewer trips and shorter distance of trips. Projected emissions for the Capacity

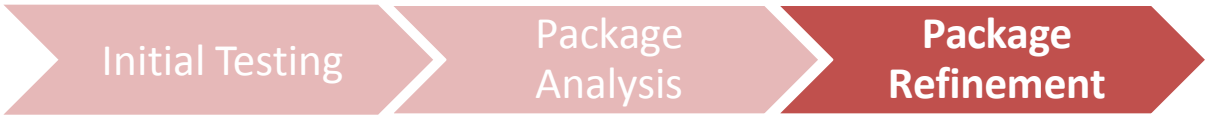
Other Key Outcomes	Measure	Headline Key Performance Indicator	2013 comparison	Capacity Constraints 2046	Employment Centres 2046	Smarter Pricing 2046	APTN	Comment
								Constraints and Employment Centres are similar to the APTN.
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog	In 2015, approximately 1% of the transport network was in a "very poor" condition. This is equivalent to $157 million of backlog. [Source: Auckland Transport's Asset Management Plan 2015-2018]	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog.	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog.	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog.	Similar to these packages	The same maintenance and renewals programme has been assumed in all three packages.
Social inclusion and equity	Impacts on geographical areas	• Access employment in high deprivation areas • Distribution of impacts (costs and benefits) by area	As identified in the Foundation report, high deprivation areas in the south and west have lower access to jobs than other parts of the region. People in the west rely on a congested motorway link to jobs in the isthmus and south. People in the south also experience congestion on motorway links to jobs.	Similar to the APTN, accessibility issues remain in Mangere and parts of the west.	Similar to the APTN, accessibility issues remain in Mangere and parts of the west. Accessibility from high deprivation areas in the North Shore is worse.	Compared to the APTN, accessibility improves for high deprivation areas, but access by motor vehicle is subject to pricing. Motor vehicle accessibility from high deprivation areas in the North Shore is worse than the APTN.	The Deficiency Analysis identified significantly lower levels of access in the south and west.	Accessibility from high deprivation areas is similar to the APTN, except with Smarter Pricing. Generalised costs generally increase as a result of Smarter Pricing.
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network	Vulnerable network due to incomplete State Highway, public transport and cycle networks and lack of capacity at peak times on the strategic road network to cope with disruptions.	Network resilience is similar to the APTN. This package improves resilience through additional roading links such as the Additional Waitemata Harbour Crossing.	Network resilience is similar to the APTN. This package improves resilience through additional roading links such as Penlink and the high capacity rapid transit network.	Network resilience is similar to the APTN. This package improves resilience through pricing of the road network. This reduces trips on the road network by about 10% which could result in less diversion and impact in the event of disruption to the road network. There is high capacity in the rapid transit network, which enables PT to take additional people in the case of disruption.	-	These packages have a similar level of network resilience to the APTN.

3.4.6 Package Analysis Conclusions

Overall, changing the mix of investments to reflect either a focus on addressing capacity constraints or accessing employment centres – with a similar overall level of investment – highlights the potential to achieve minor to moderate improvements in region-wide performance against the project objectives, but not a step-change. Sub-regional changes in performance suggested there was merit in continuing to optimise the timing and priority of investments. In particular, the analysis undertaken of different investment mixes suggests it would be possible to substantially improve employment accessibility in the south and west.

Analysis of smarter transport pricing showed it offers the potential to achieve a step-change in transport network performance and should therefore form a core part of the strategic approach. However, setting price levels is extremely challenging as performance improvement, travel time savings and increased travel costs need to be carefully balanced. While some further work was undertaken to assess different pricing levels, more sophisticated analytical tools will be required to undertake this work before a viable scheme could be developed.

4. Package Refinement



Drawing upon on the assessments undertaken in the package analysis phase, two refined packages were developed for the package refinement phase. These packages were developed differently to the initial ones, particularly because they did not have a "funding limit" placed on them. As the previous phase of analysis had highlighted, a step-change in performance was unlikely to be achieved through a different mix of investment. The refined packages focused on understanding the extent to which a step-change in performance could be achieved via two approaches:

- Focus on Higher Level of Investment (Section 4.1)
- Focus on Influencing Patterns of Travel Demand (Section 4.2)

A cross package review was undertaken in Section 4.3.

The common baseline for both packages was generally similar to that used for the previous packages. It is referred to interchangeably as the ATAP Baseline and the Base Network. The Base Network was refined and narrowed in greenfield growth areas to only include investments that were directly required to enable growth (i.e. local road networks). Other investments in greenfield areas were considered as part of one package or the other.

The common baseline has a capital cost of approximately $19 billion for new improvements (excluding renewals) over the 30-year period. Key components of the Base Network included committed projects (e.g. City Rail Link, East-West link, Puhoi-Warkworth etc.), the Auckland Rail Development Programme(because it cannot be effectively modelled using existing tools) and a variety of other minor investments either unable to be evaluated using current tools or would be expected to occur over the next 30 years (e.g. safety programmes, walking and cycling improvements, and minor road and public transport improvements).

4.1 Focus on Higher Level of Investment

4.1.1 Package description

This package tests the hypothesis that a higher level of investment (particularly in the first 10-20 years) could lead to a step-change in performance. The package tests a significantly higher and earlier level of investment. The focus is on ensuring the road and public transport networks keep up with growth so that levels of service are acceptable.

Compared with the previous packages, this package brings forward most infrastructure projects into the first two decades. It includes a substantial programme to improve the strategic roading network, targeting the most severe capacity issues in the first decade. The package also delivers a strategic public transport network.

The total estimated 30-year cost of new capital improvements (excluding renewals) of the Higher Investment package is $40.7 billion (in 2016 dollars). Figure 4.1 below provides a breakdown of costs by decade and project type.

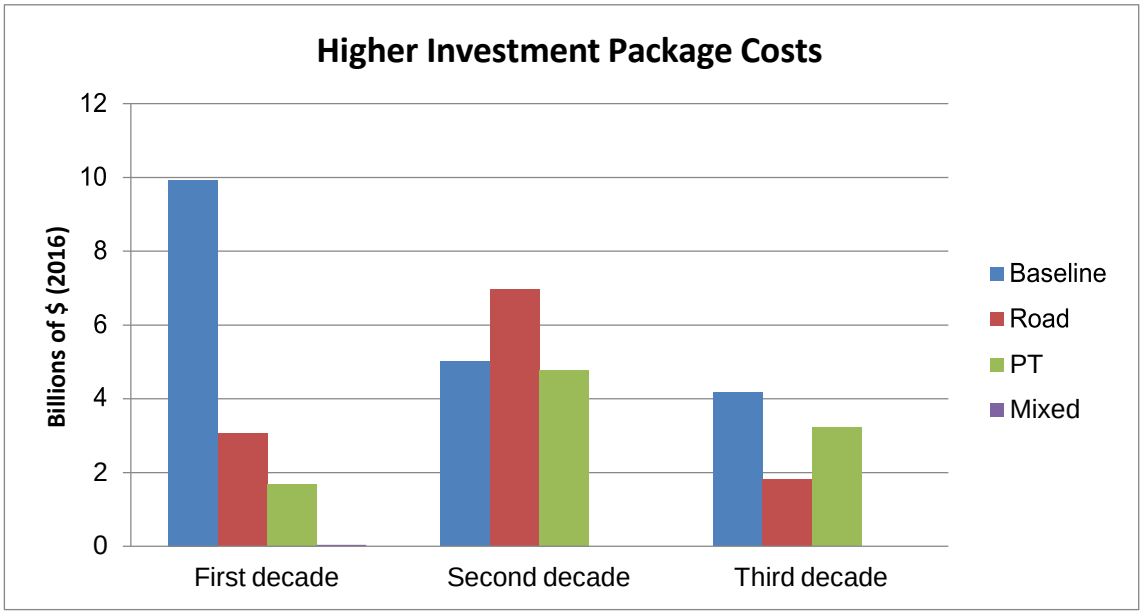


Figure 4.1: Estimated cost of new capital improvements (excluding renewals) of Higher Investment package (2018 – 2048)

Key interventions by time period

Key components of the package over and above the common baseline are included in Table 4.1 1 below:

Table 4.1: Higher Investment key interventions by decade

First Decade (2015-25)	Second Decade (2025-35)	Third Decade (2035-45)
• Northwestern Busway (Kumeu to Point Chevalier) • AMETI Pakuranga to Botany Busway • SH20 targeted widening • Southern Motorway targeted widening and interchange upgrades • Improved access to Port / Grafton Gully	• Northwestern Busway (Point Chevalier to Newton) • Additional Waitemata Harbour Crossing (motorway tunnels) • Isthmus mass transit • North Shore mass transit (city centre to Takapuna) • SH16 targeted widening • Cross isthmus mass transit • Southern Motorway further targeted widening	• City centre bus access improvements • Further SH20 widening • SH20A upgrade • Extension of isthmus mass transit • Extension of North Shore mass transit to Albany • Northern Motorway targeted widening and interchange upgrades • Extension of mass transit to Airport from north • SH20A targeted widening

4.1.2 Key Findings

The Higher Investment package in this phase was compared against both the APTN (to understand the extent to which they appear to deliver better returns than current plans) and the common baseline (to understand the value from additional investment above this baseline).

Accessibility

Access to employment in the AM peak for car travel improves from 2026 onwards compared to APTN and the Base Network, while public transport accessibility tracks very similarly to the APTN up until 2046 (Figure 4.2). Despite the higher level of investment in the first decade, the impacts on accessibility are not seen at a regional level until the 2036.

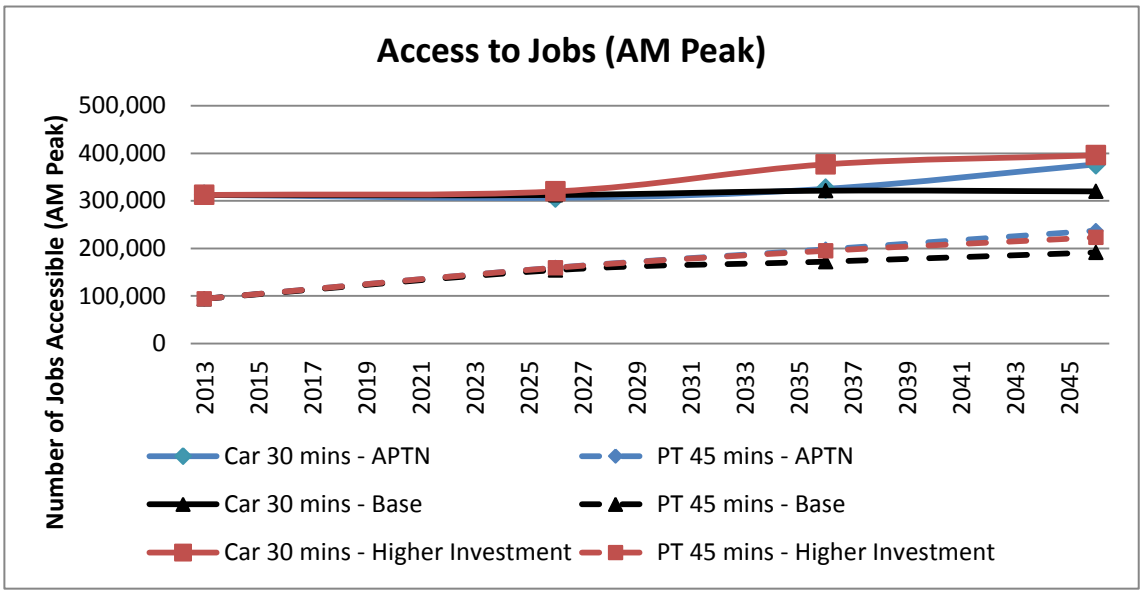


Figure 4.2: Access to jobs AM peak (Higher Investment, APTN and ATAP Baseline)

Regional measures can mask sub-regional differences in performance however, as shown in the accessibility maps below.

On a sub-regional level, car accessibility declines in the west, northwest and parts of the North Shore between 2013 and 2026 under the Higher Investment package (Figure 4.3). However, public transport accessibility increases significantly for most areas in the same period.

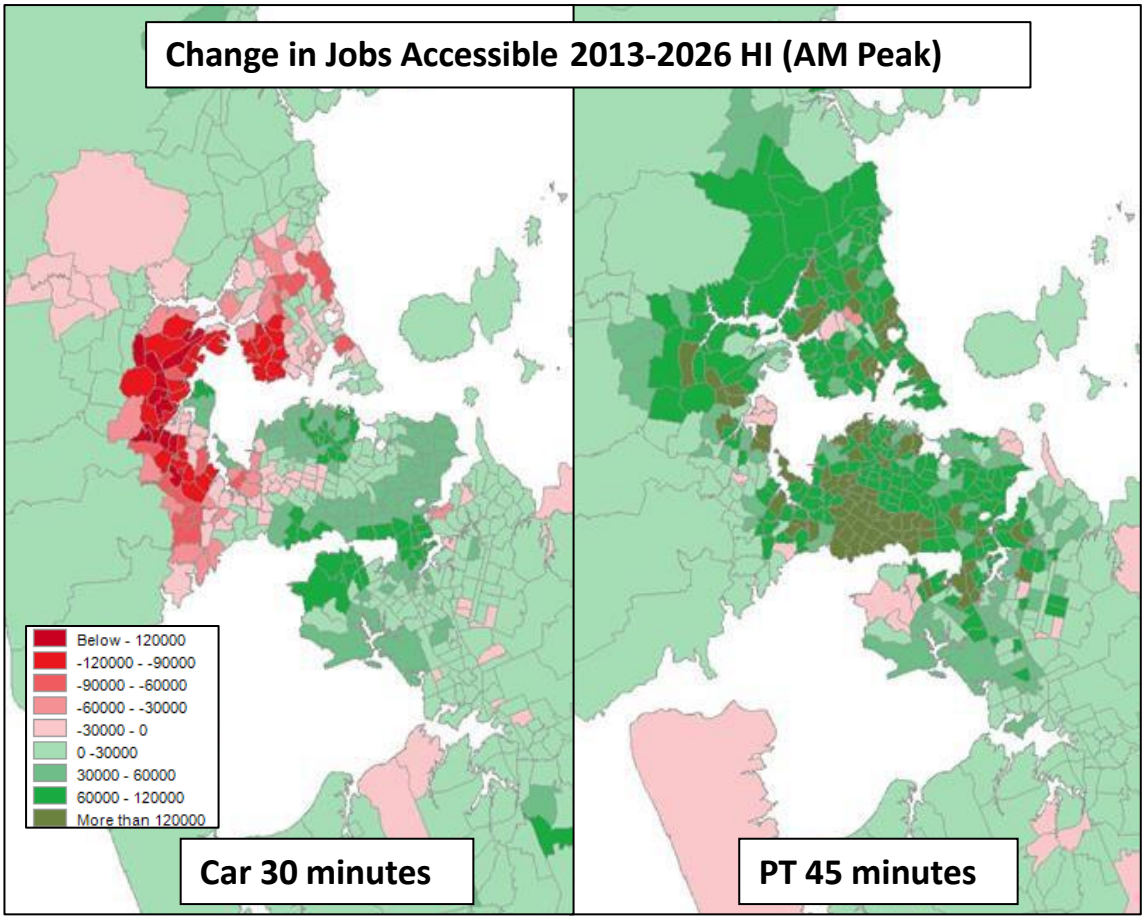


Figure 4.3: Change in accessibility to jobs AM peak 2013 vs 2026 (Higher Investment)

Between 2026 and 2046, car accessibility improves dramatically on the North Shore, northwest, as well as parts of the west and isthmus (Figure 4.4). However, accessibility declines within the inner south, particularly around Mangere and Otahuhu. The decline in accessibility occurs despite upgrades to SH20A and targeted widening of the Southern Motorway.

Public transport accessibility improves to a lesser extent across the region.

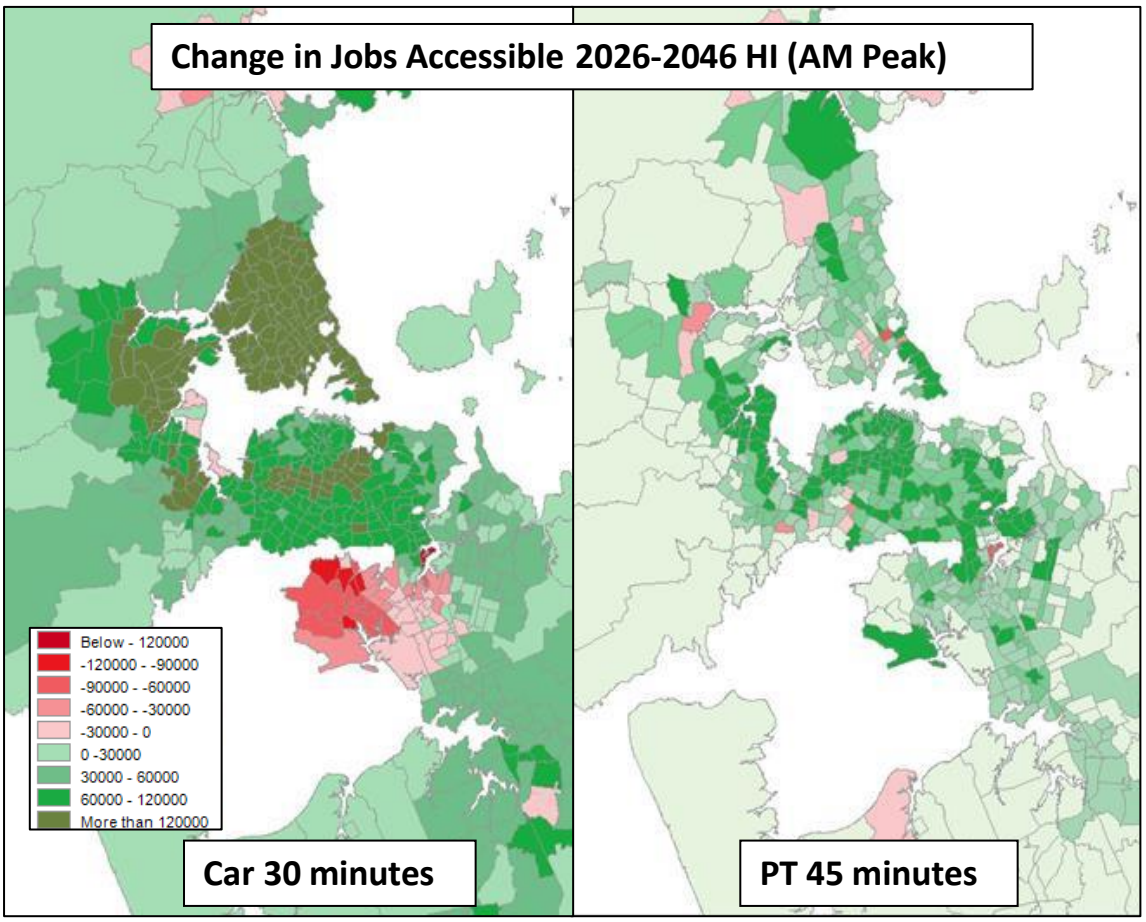


Figure 4.4: Change in accessibility to jobs AM peak 2026 vs 2046 (Higher Investment)

Compared to the Base Network, the Higher Investment package improves accessibility in 2026 for the northwest and parts of the west and outer south (Figure 4.5). These improvements indicate that the specific focus to improve accessibility in the west and south worked, to a certain extent. Accessibility declines in the inner south, despite upgrades to SH20A and targeted widening of the Southern Motorway between Manukau and Otahuhu.

The inner part of Auckland's motorway network falling inside the Western Ring Route currently experiences substantial capacity constraints and congestion, not only at peak times but also throughout the day. Our modelling of further widening in many parts of this network often showed very mixed results, by shifting around bottlenecks and congestion points rather than addressing them at a network level.

In terms of public transport, improvements are seen in largely in the northwest, as a result of the inclusion of a full grade separate right of way Northwestern Busway corridor (rather than the combination of bus lanes and busway as specified in APTN).

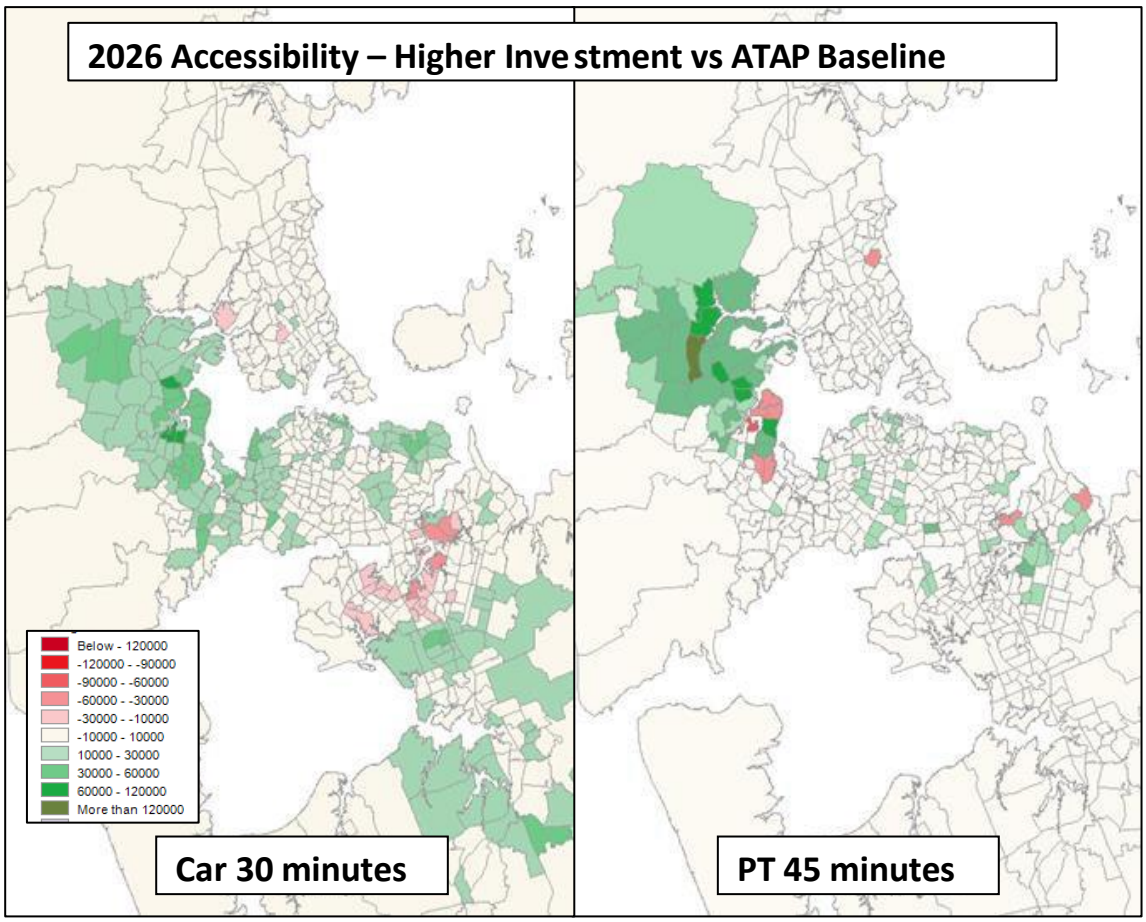


Figure 4.5: Accessibility to jobs AM peak 2026 (Higher Investment vs ATAP Baseline)

The improvements to accessibility in the northwest continue in 2046, spreading to the North Shore and parts of the west and isthmus (Figure 4.6). The inner south continues to experience declining accessibility.

For public transport, improvements to accessibility continue in the northwest and declines further on the North Shore.

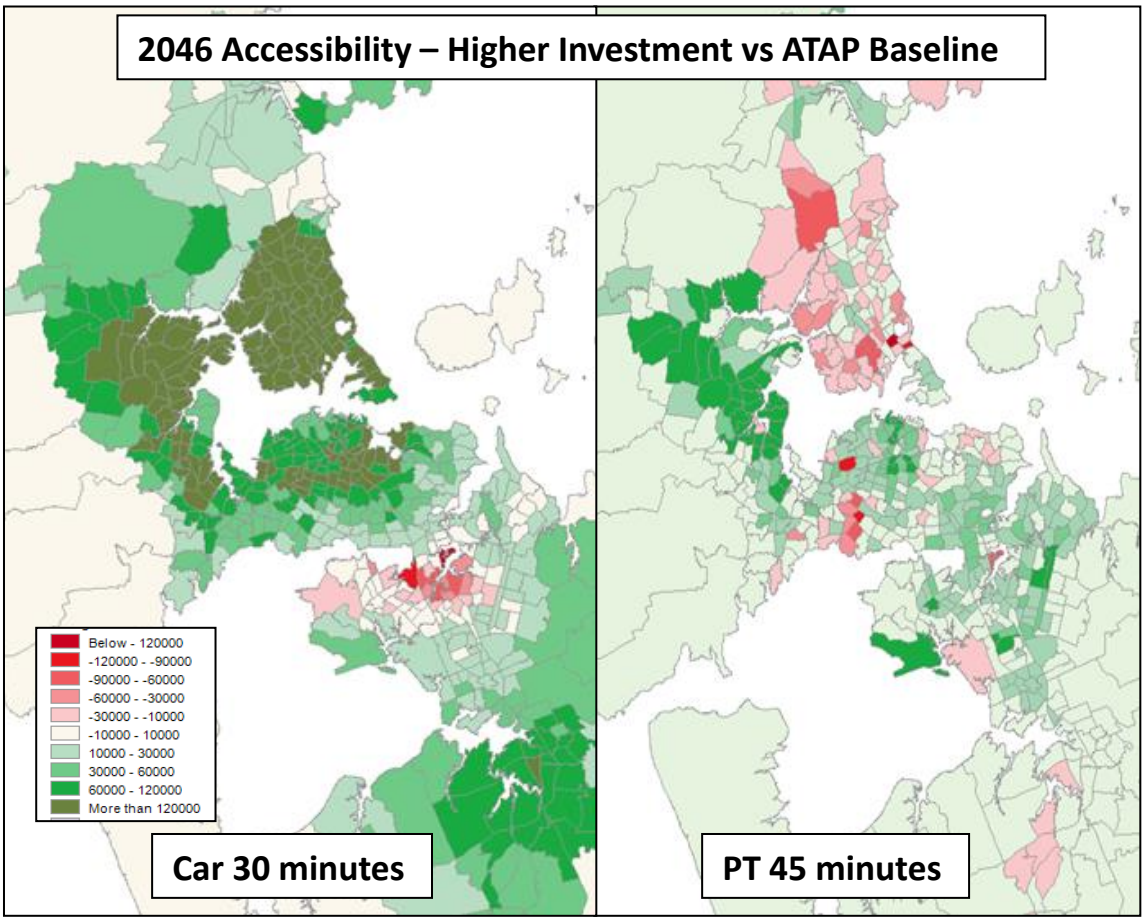


Figure 4.6: Accessibility to jobs AM peak 2046 (Higher Investment vs ATAP Baseline)

Two noteworthy findings are: Under the APTN and Higher Investment packages, people living near the airport area have limited access to employment as the motorways serving this area are congested in both directions at peak times, increasing travel times by car and public transport to jobs outside the airport area. Inclusion of the Additional Waitemata Harbour Crossing project into the second decade of the Higher Investment package creates a significant increase in car accessibility for the North Shore.

Congestion

Congestion levels in the AM peak and inter-peak reduce slightly compared to both APTN and the ATAP Baseline, particularly from 2036 onwards (Figure 4.7). This is considered to arise as a result of earlier investment in additional state highway capacity, compared to the APTN.

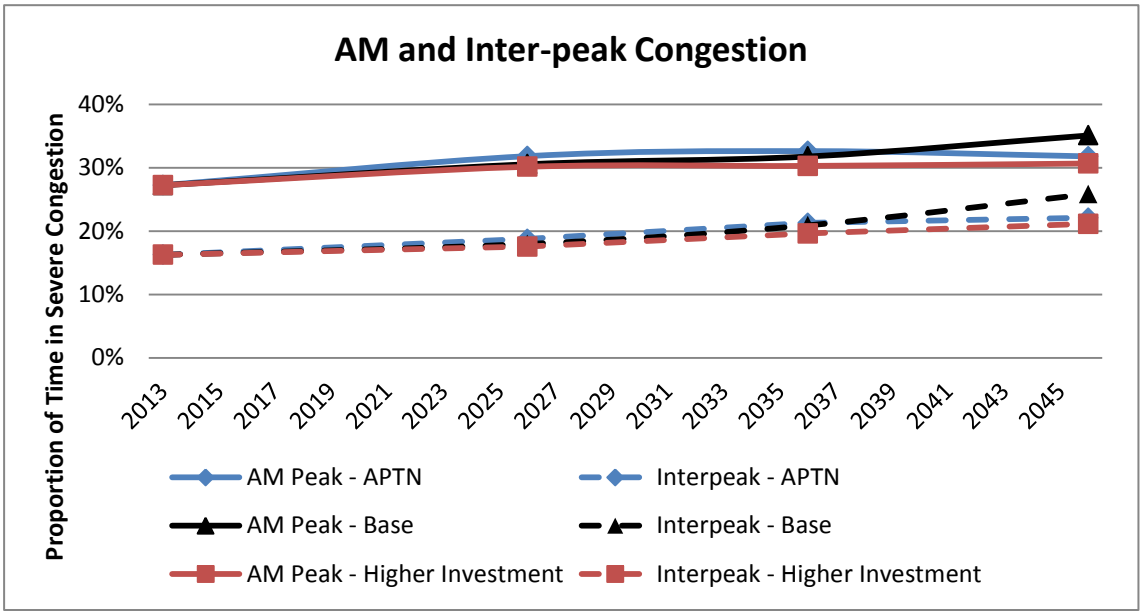


Figure 4.7: AM peak and inter-peak congestion (Higher Investment, APTN and ATAP Baseline)

The freight network under Higher Investment also experiences slight reductions in congestion compared to APTN and the Base Network, particularly in the first two decades (Figure 4.8).

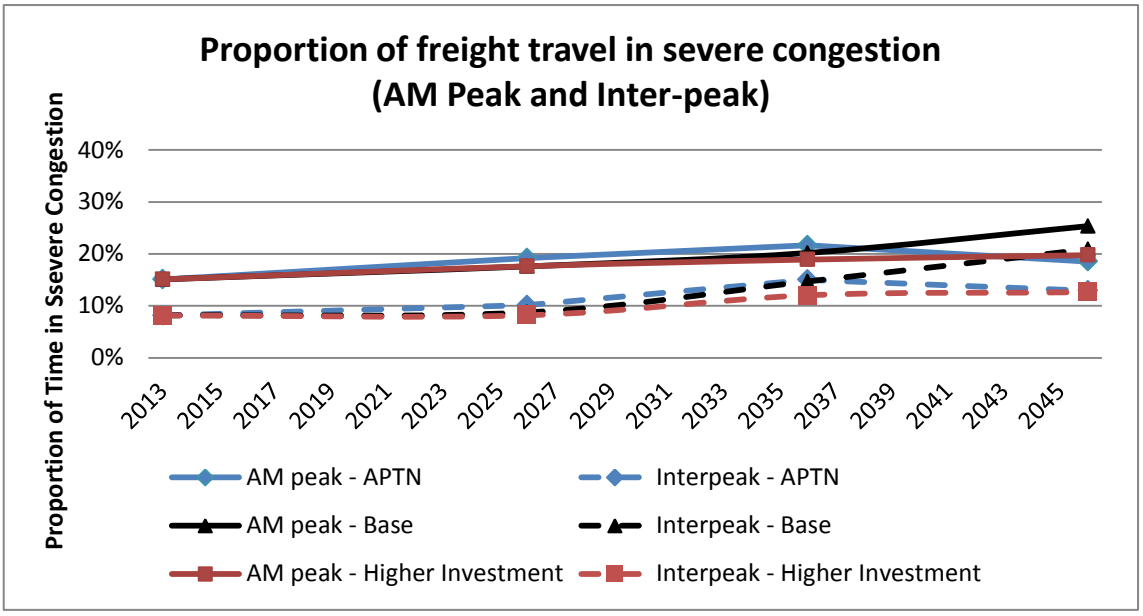


Figure 4.8: Proportion of freight travel in severe congestion (Higher Investment, APTN and ATAP Baseline)

At a sub-regional level, severe congestion is alleviated to a limited extent on parts of the network in the AM peak under Higher Investment, most particularly on SH20A and SH20 (Figure 4.9). However, the majority of constraints remain, most particularly on SH16 and parts of SH1 on the isthmus.

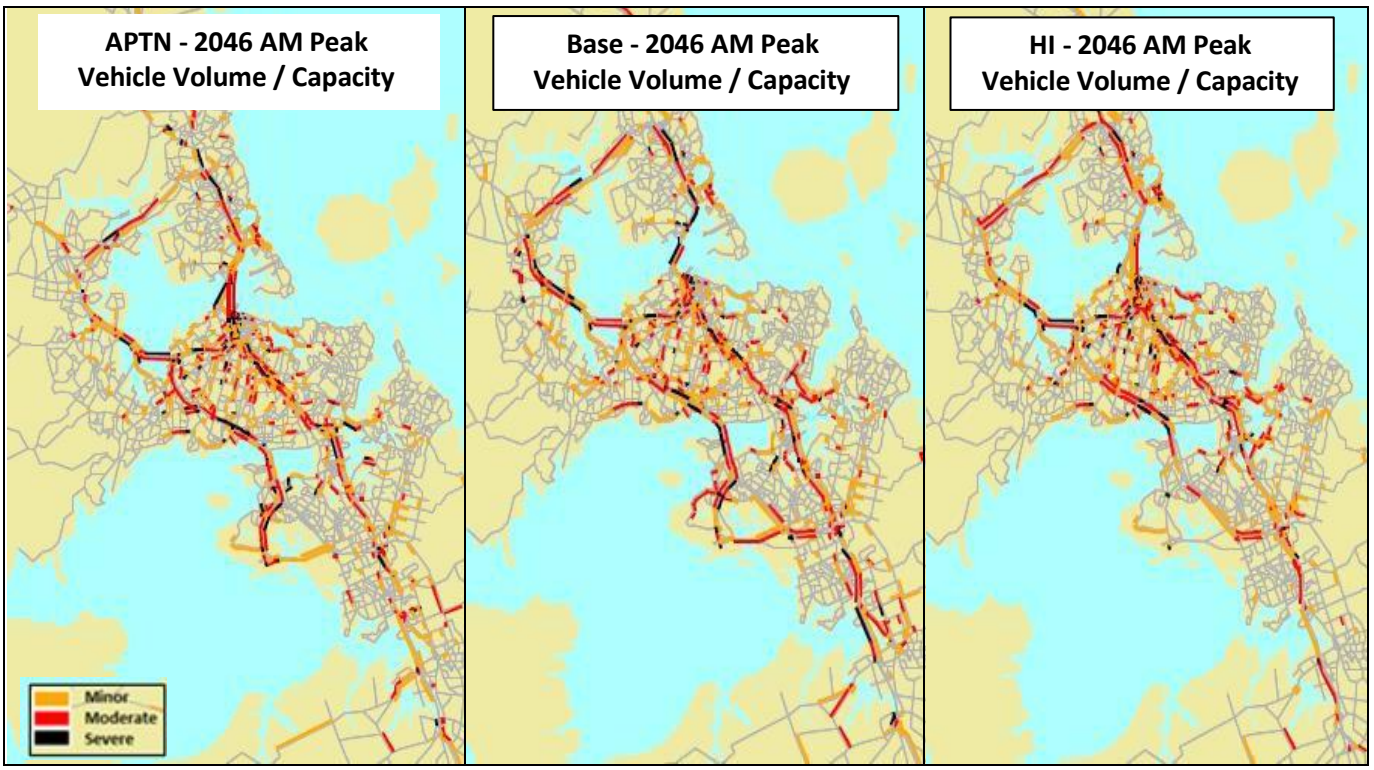


Figure 4.9: AM Peak vehicle volume to capacity (Higher Investment, APTN and ATAP Baseline)

During the inter-peak, severe congestion is eliminated on SH20A (Figure 4.10). However, on the whole, congestion under Higher Investment remains largely similar to APTN in 2046.

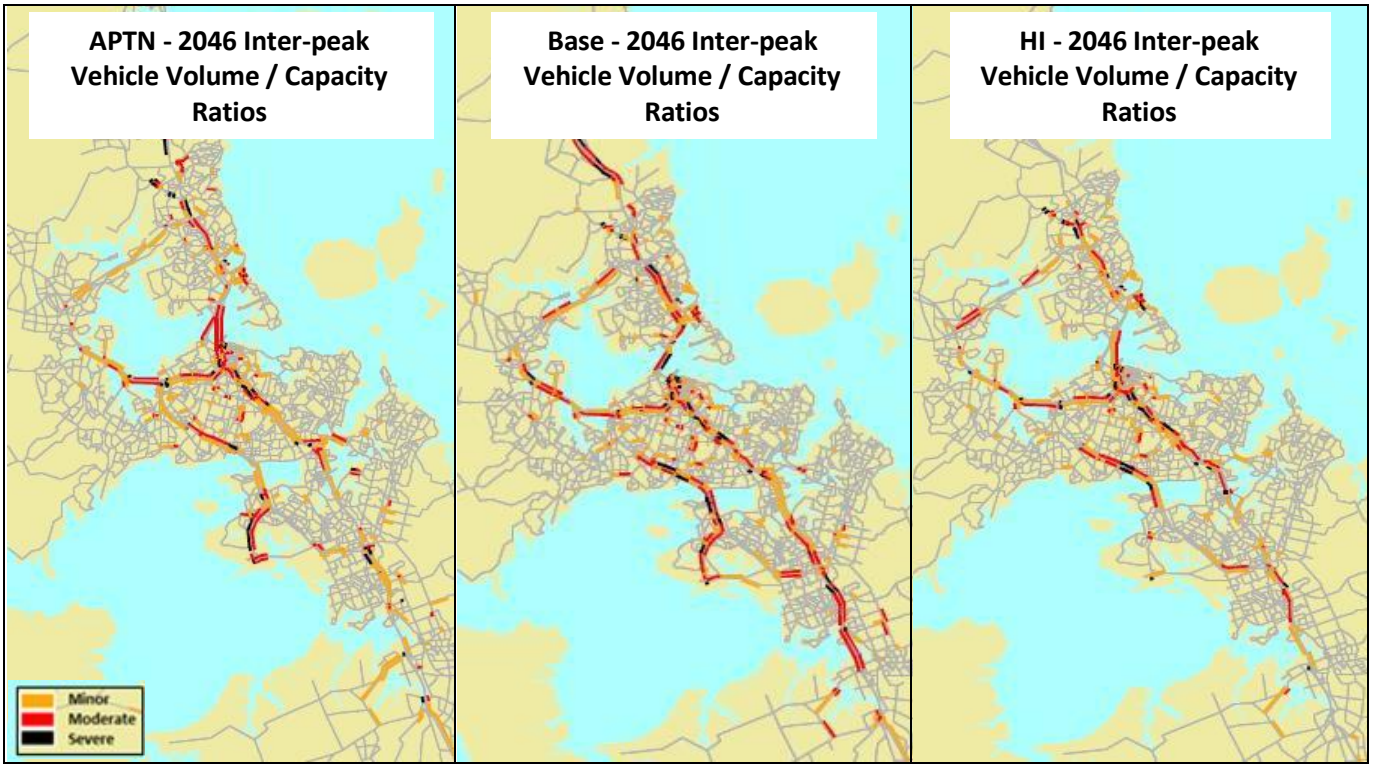


Figure 4.10: Inter-peak vehicle volume to capacity (Higher Investment, APTN and ATAP Baseline)

Public Transport Mode Share

Public transport mode share is virtually identical to the Base Network in 2026 (Figure 4.11). Mode share is slightly lower than under the APTN in the last two decades.

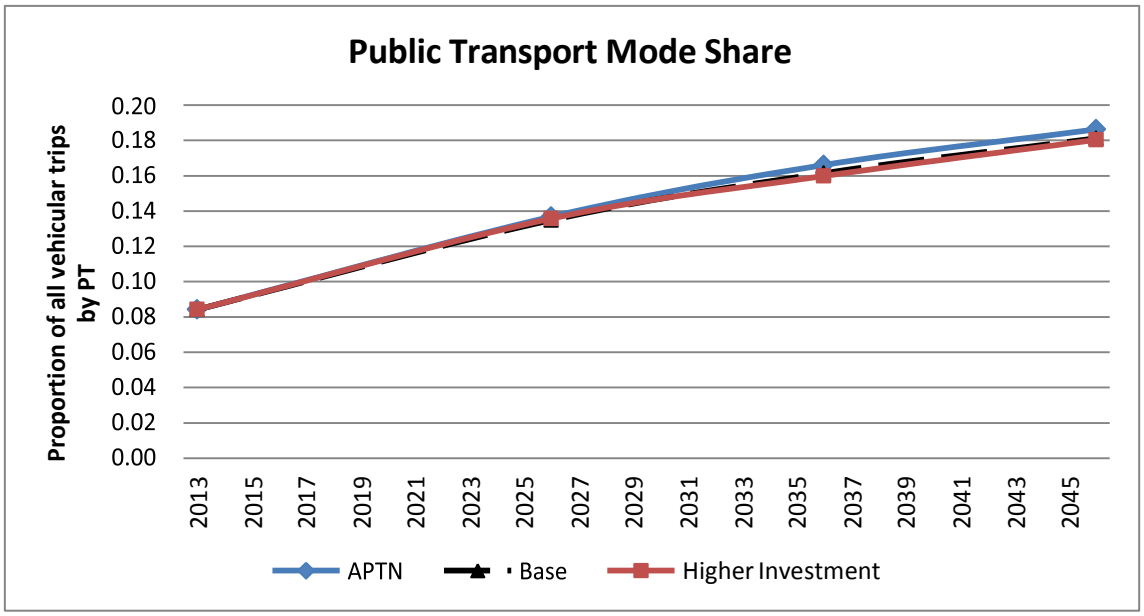


Figure 4.11: Public transport mode share AM peak (Higher Investment, APTN and ATAP Baseline)

Even though the Higher Investment package has a number of additional public transport investments, compared to the APTN, public transport patronage is slightly less than the APTN. Bus demand continues to exceed capacity at parts of the network, broadly to a similar extent as the APTN, although to a lesser extent compared to the Base Network (Figure 4.12). The North Shore mass transit in the Higher Investment package sees greater capacity compared to the Northern Busway under both APTN and the Base Network.

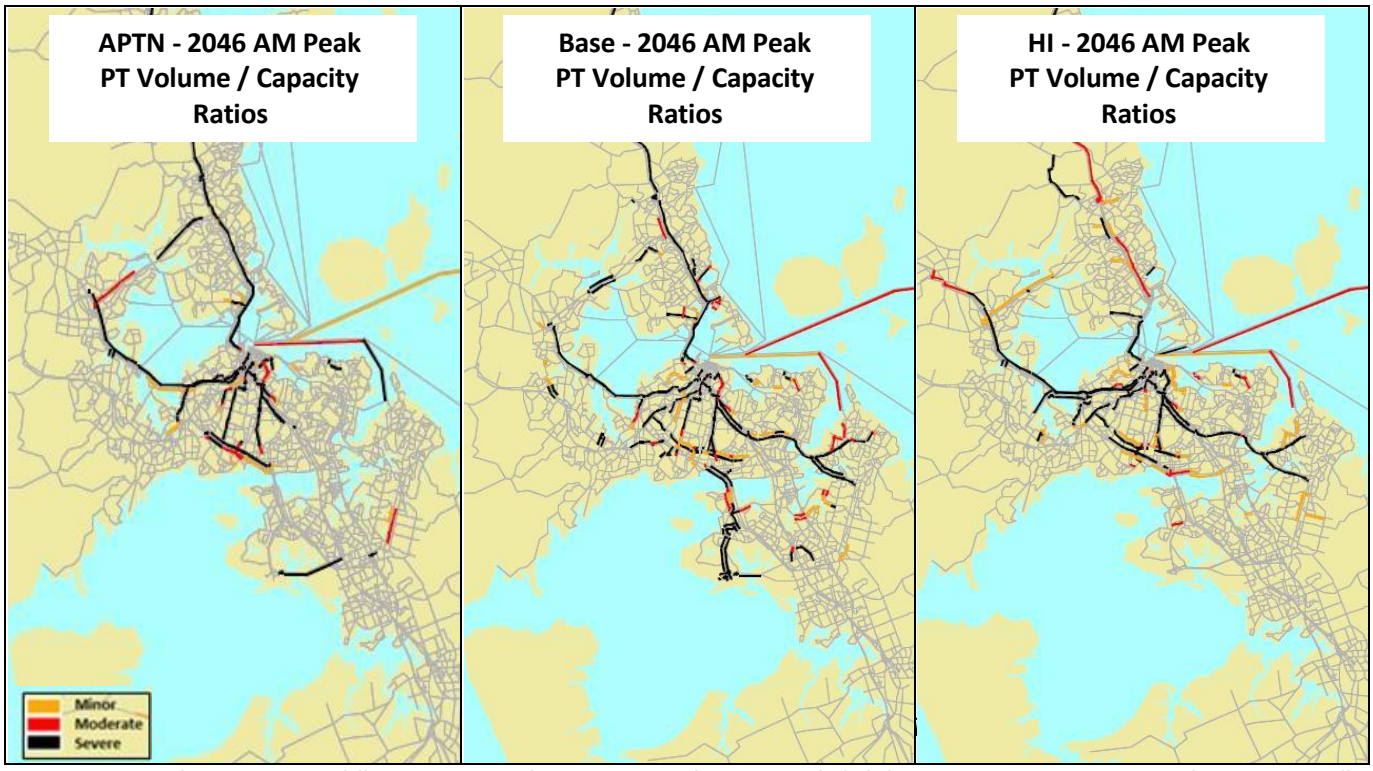


Figure 4.12: Public transport volume to capacity AM peak (Higher Investment, APTN and ATAP Baseline)

Value for Money

The Higher Investment package identified an estimated $40.7 billion capital expenditure programme over 30 years (excluding renewals) which is projected to have similar contributions to the ATAP objectives compared to the APTN. The package is projected to result in a slightly higher proportion of jobs accessible by motorists of 44% (compared to 43% in the APTN), a slightly higher proportion of jobs accessible by public transport of 25% (compared to 24% in the APTN), a slightly lower proportion of travel time in severe congestion of 31% in severe congestion in AM peak (compared to 32% in the APTN) and the same public transport mode share of 18.0% in the AM peak (compared to 18.0% in the APTN).

The Higher Investment package as a whole is projected to have a similar overall contribution to the project objectives as the APTN package, with a significantly larger capital improvement programme.

4.1.3 Key Learnings

Analysis of the Higher Investment package highlights a mix of performance levels, with car access improving compared to APTN. While congestion levels improve for car and freight compared to APTN, public transport mode share is slightly lower.

Additional investment in the first decade did not appear to improve performance against the project objectives at a regional level, but some of these extra investments did have some important sub-regional effects. For example, public transport access increases in the northwest as a result of the Northwestern Busway. Overall however, the Higher Investment package is likely to offer relatively poor value for money.

As such, the development of the Indicative Package in the next phase adopts a more targeted approach to identifying early priorities which both align with the project objectives and appear likely to deliver value for money.

4.2 Focus on Influencing Travel Demand Patterns

4.2.1 Package Description

The Influence Demand package tests the hypothesis that influencing patterns of demand could lead to a step-change in performance. This package tests the effect of variable road network pricing in 2036 and 2046. To support this, earlier investment in the strategic public transport network is provided, together with required improvements to the strategic road network to ensure that levels of service can be maintained.

Some significant road projects have been deferred or excluded. As a result, the Influence Demand package has a significantly lower level of total investment than the Higher Investment package.

The total estimated 30-year cost of new capital improvements (excluding renewals) of the Influence Demand package is $33.2 billion (in 2016 dollars). Figure 4.14 below provides a breakdown of costs by decade and project type.

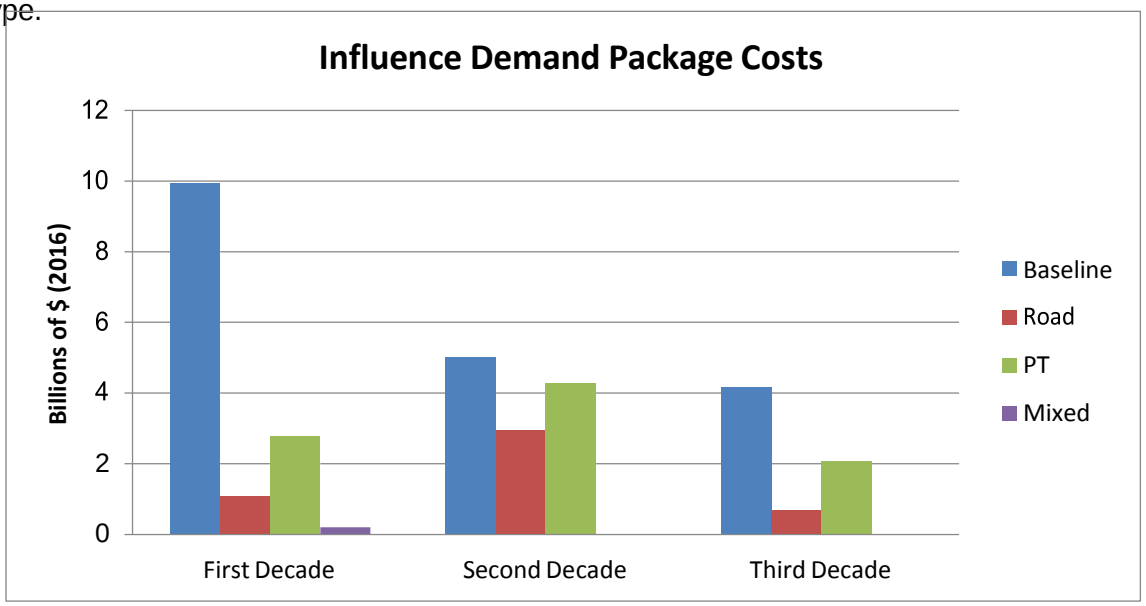


Figure 4.14: Estimated cost of new capital improvements (excluding renewals) of Influence Demand package (2018 – 2048)

Key interventions by time period

The hypothetical network-wide pricing system introduced in the package analysis phase was refined. In developing the Influence Demand package, different pricing levels were tested to better understand the relationship between the cost of travel and changed travel patterns. As a result of this analysis, price levels were reduced by 25% from what was tested in the previous stage. The refined network-wide pricing system maintains the variation in charges across different locations, parts of the network and time of travel (Table 4.2).

Table 4.2: Hypothetical smarter pricing system

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

The refined smarter pricing tool was tested with a complementary intervention package. Key components of the package over and above the common baseline are included in Table 4.3.

Table 4.3: Influence Demand key interventions by decade

First Decade (2015-25)	Second Decade (2025-35)	Third Decade (2035-45)
• Northwestern Busway (Kumeu to Point Chevalier) • AMETI Pakuranga to Botany Busway • Cost to implement Road Pricing Infrastructure • Isthmus mass transit • SH20 targeted widening	• Implementation of smarter pricing • Northwestern Busway (Point Chevalier to Newton) • Cross isthmus mass transit • Extension of mass transit to Airport from north • Additional Waitemata Harbour Crossing (PT only tunnel) • North Shore mass transit to Albany • Southern Motorway targeted widening • Upper Harbour strategic public transport route • TFUG projects*	• Continuation of Isthmus Mass Transit • Southern Motorway further targeted widening • SH18 bus shoulder lanes • Extension of North Shore mass transit to Orewa • TFUG projects^

*Includes Mill Road upgrade and extension, Pukekohe expressway, SH1 widening from Papakura to Drury South, SH16 Kumeu bypass and SH16 to SH18 connection

^ Strategic public transport route from Oteha Valley Road to Grand Drive

4.2.2 Key Findings

Travel Patterns

Average trip time (Figure 4.15) and trip length (Figure 4.16) are projected to reduce under Influence Demand with the introduction of smarter pricing after 2026.

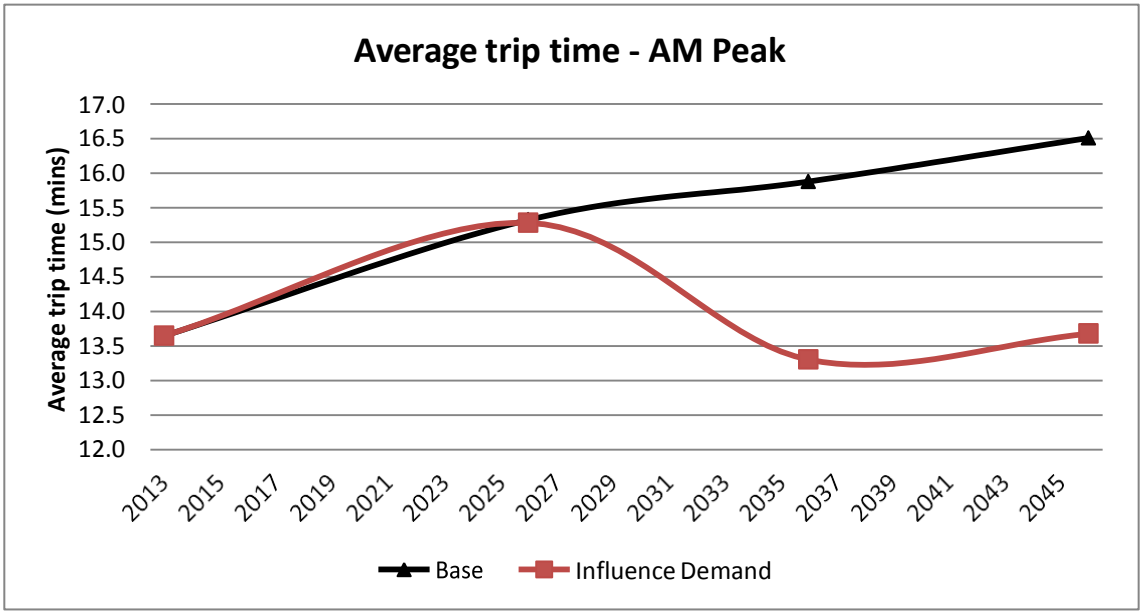


Figure 4.15: Average trip time during AM Peak (Influence Demand and ATAP Baseline)

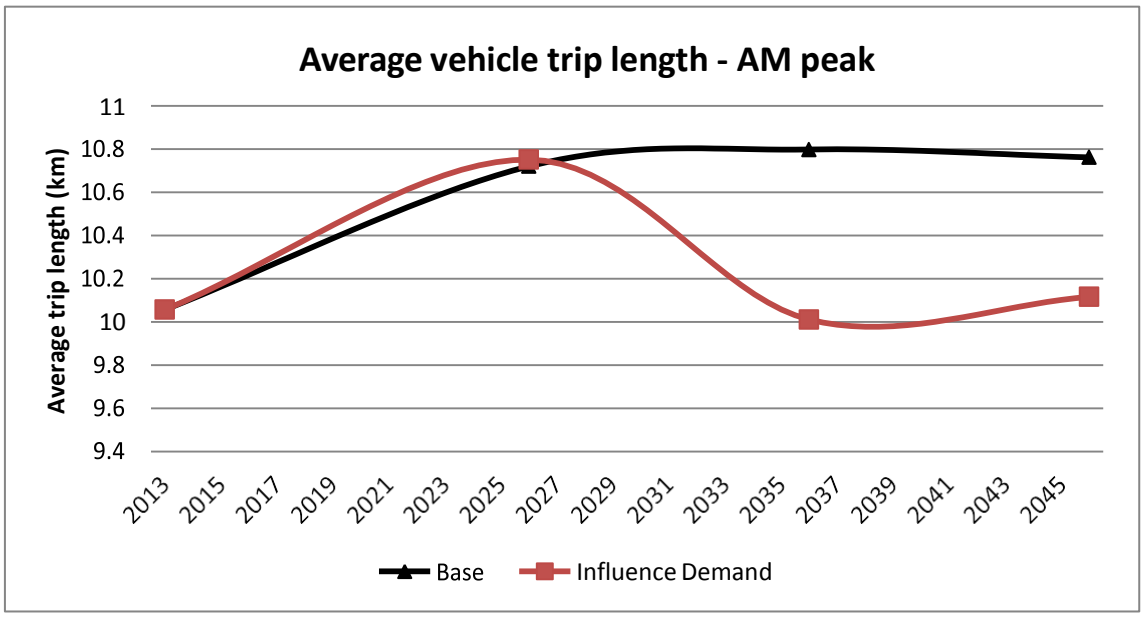


Figure 4.16: Average vehicle trip length during AM Peak (Influence Demand and ATAP Baseline)

Compared to the Base Network, there is a decrease in average travel time for trips originating from the northwest, and increases to the outer south and Howick in 2026 (Figure 4.17). The rest of the region is projected to experience a marginal change in average travel time.

In 2036 and 2046, average travel time is projected to decrease across the region. This is partly due to the reduced level of congestion and partly because travel distances are decreasing with the increased costs of travel.

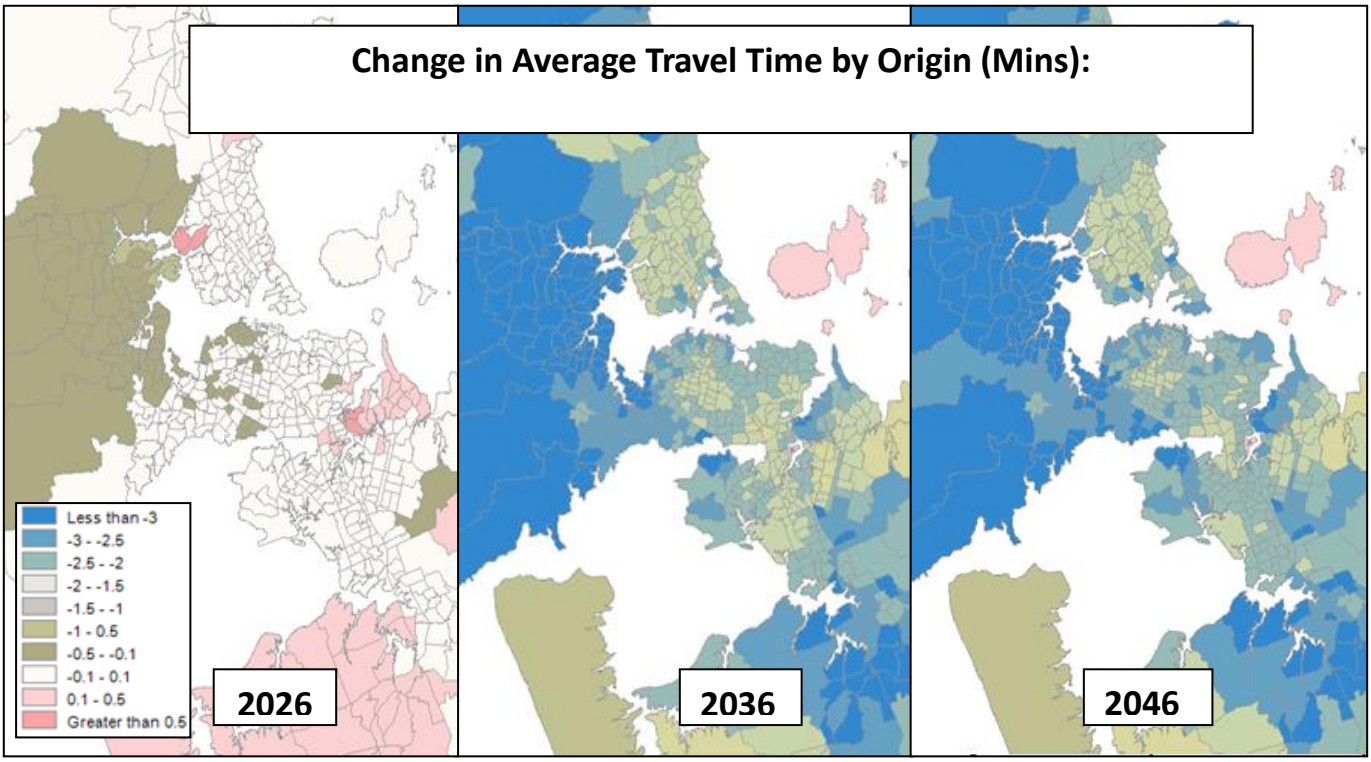


Figure 4.17: Change in Average Travel Time by origin during AM Peak (Influence Demand vs ATAP Baseline in three decades)

In 2026, trips from the isthmus and North Shore are getting shorter but trips from the west and other more peripheral areas are getting longer (Figure 4.18). With the increased costs of travel once smarter pricing is introduced, average trip length decreases across the region from between 2036 and 2046.

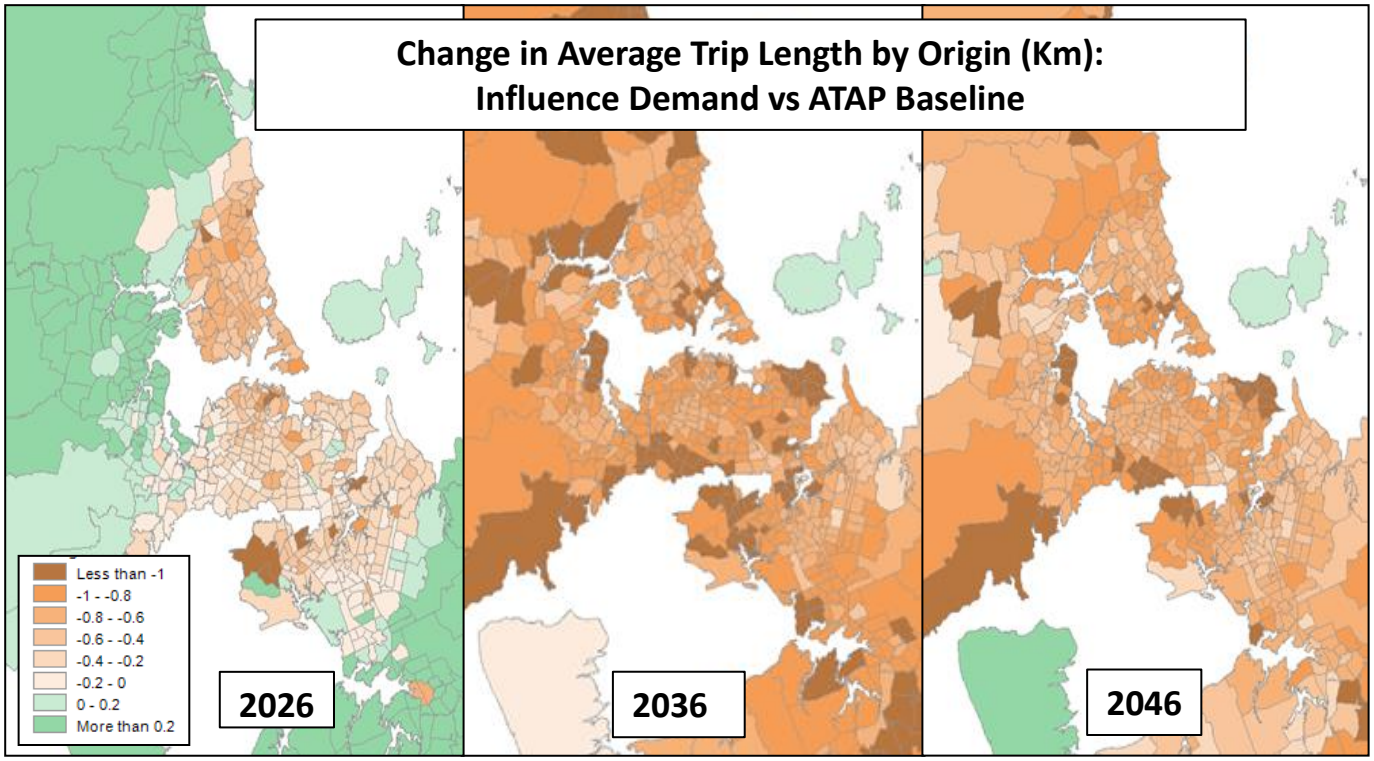


Figure 4.18: Change in Average Trip Length by origin during AM Peak (Influence Demand vs ATAP Baseline in three decades)

Accessibility

Between 2026 and 2036, the number of jobs accessible within a 30 minute car journey during the AM peak increases substantially under Influence Demand compared to APTN and the ATAP Baseline (Figure 4.19). This is due to the smarter pricing system reducing the number of vehicle trips during the AM peak, thereby reducing congestion and increasing travel speeds.

Public transport accessibility tracks very similarly to APTN for the entire duration of the evaluation. Despite the increase in public transport patronage and mode share under Influence Demand, the higher proportion of public transport investment ensures that public transport accessibility is maintained.

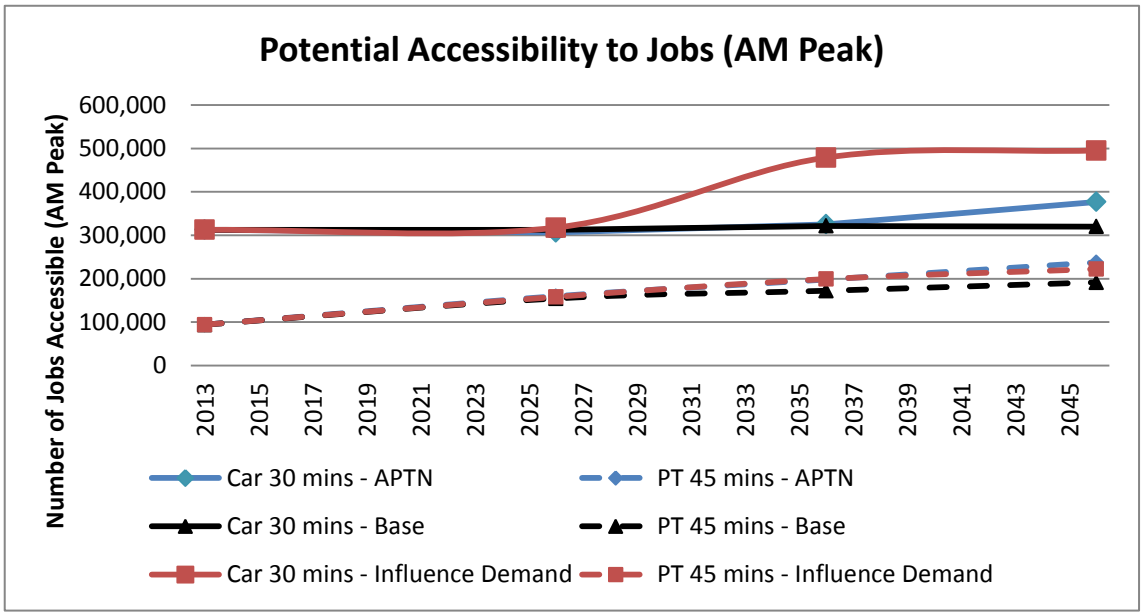


Figure 4.19: Potential accessibility to jobs AM peak (Influence Demand, APTN and ATAP Baseline)

At a sub-regional level, car accessibility improves in the south and the isthmus but declines in the west, northwest and parts of the North Shore between 2013 and 2026 under the Influence Demand package (Figure 4.20). However, public transport accessibility increases significantly for most areas under the same period.

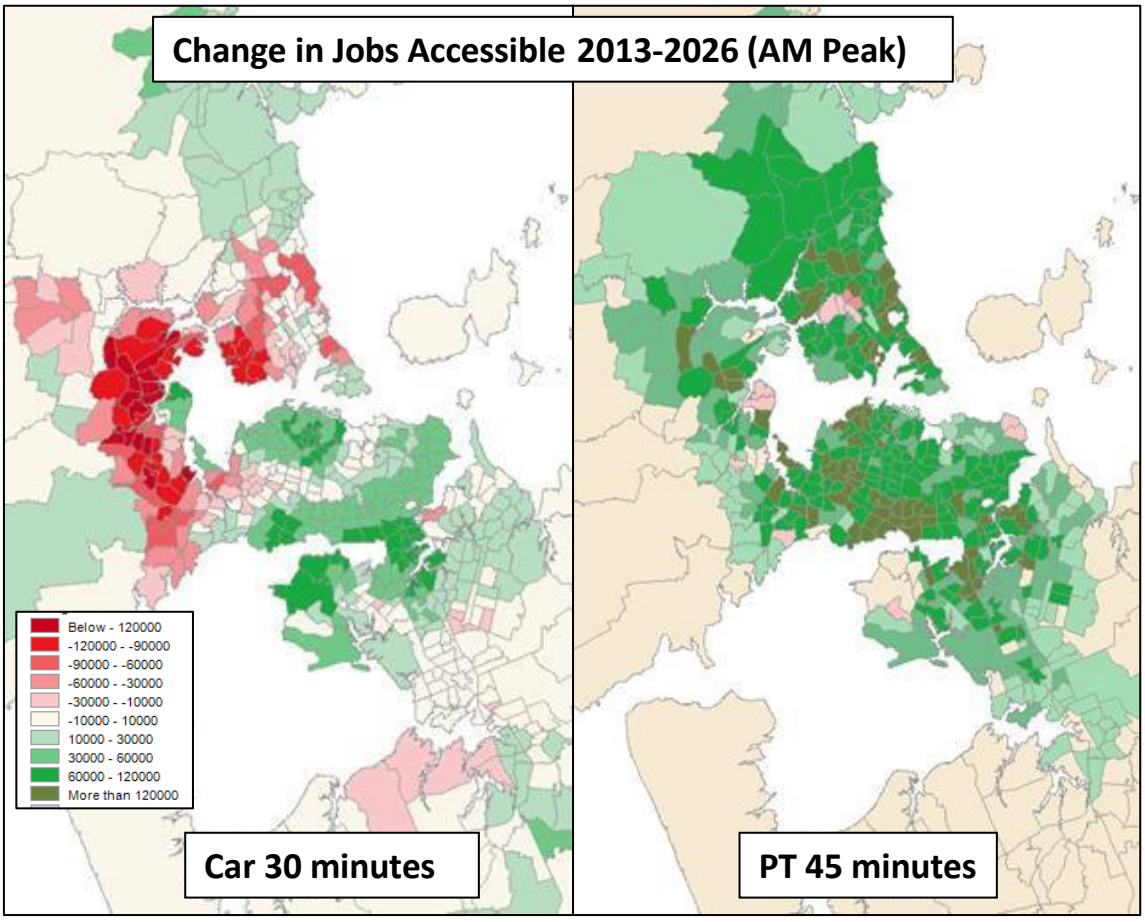


Figure 4.20: Change in accessibility to jobs AM peak 2013 vs 2026 (Influence Demand)

Between 2026 and 2046, as smarter pricing is implemented, car accessibility improves across the region, particularly for the northwest, North Shore and inner south (Figure 4.21). Public transport accessibility improves across most of the region.

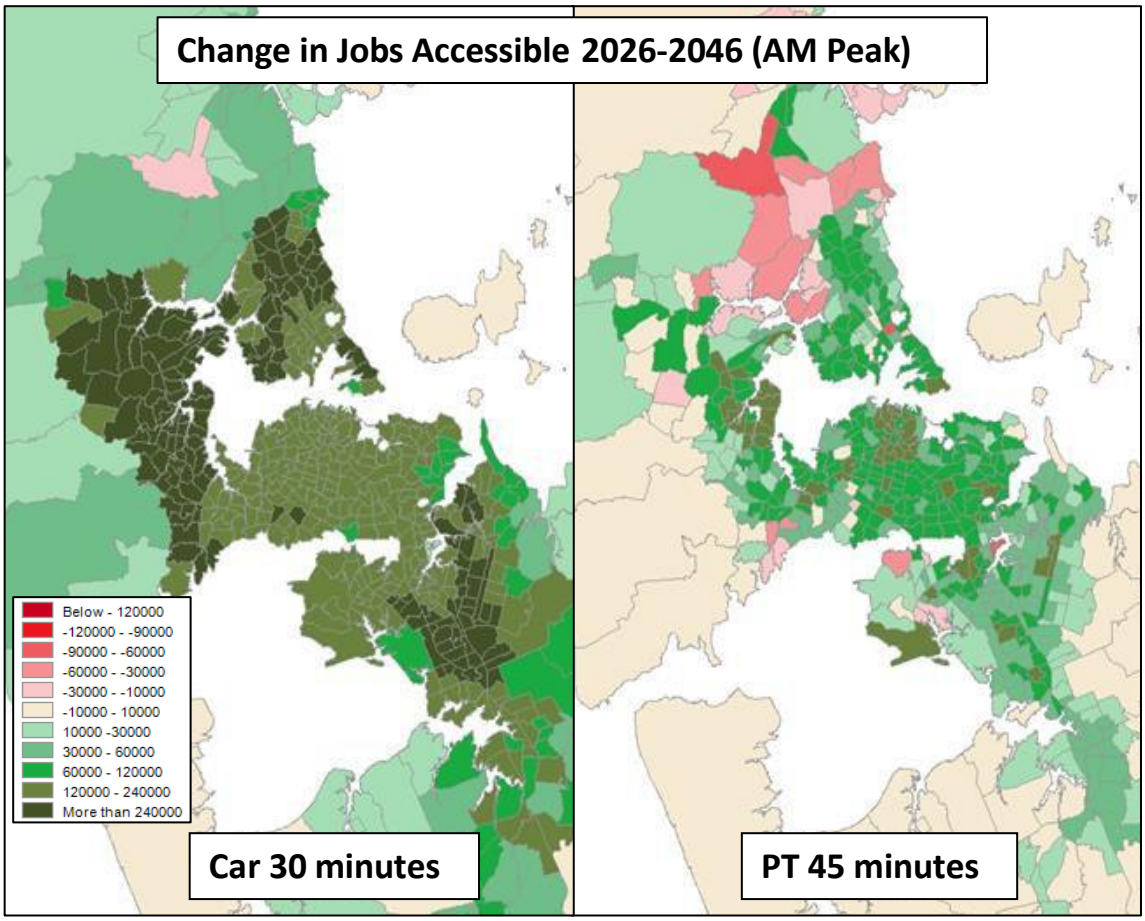


Figure 4.21: Change in accessibility to jobs AM peak 2026 vs 2046 (Influence Demand)

Compared to the Base Network, the Influence Demand package performs better for car accessibility in the northwest and parts of the west, while other parts of the region sees a slight reduction in accessibility, particularly the inner south (Figure 4.22). In terms of public transport, improvements in accessibility are largely seen in the northwest as a result of the inclusion of the Northwestern Busway, and the southeast as a result of the Pakuranga to Botany Busway.

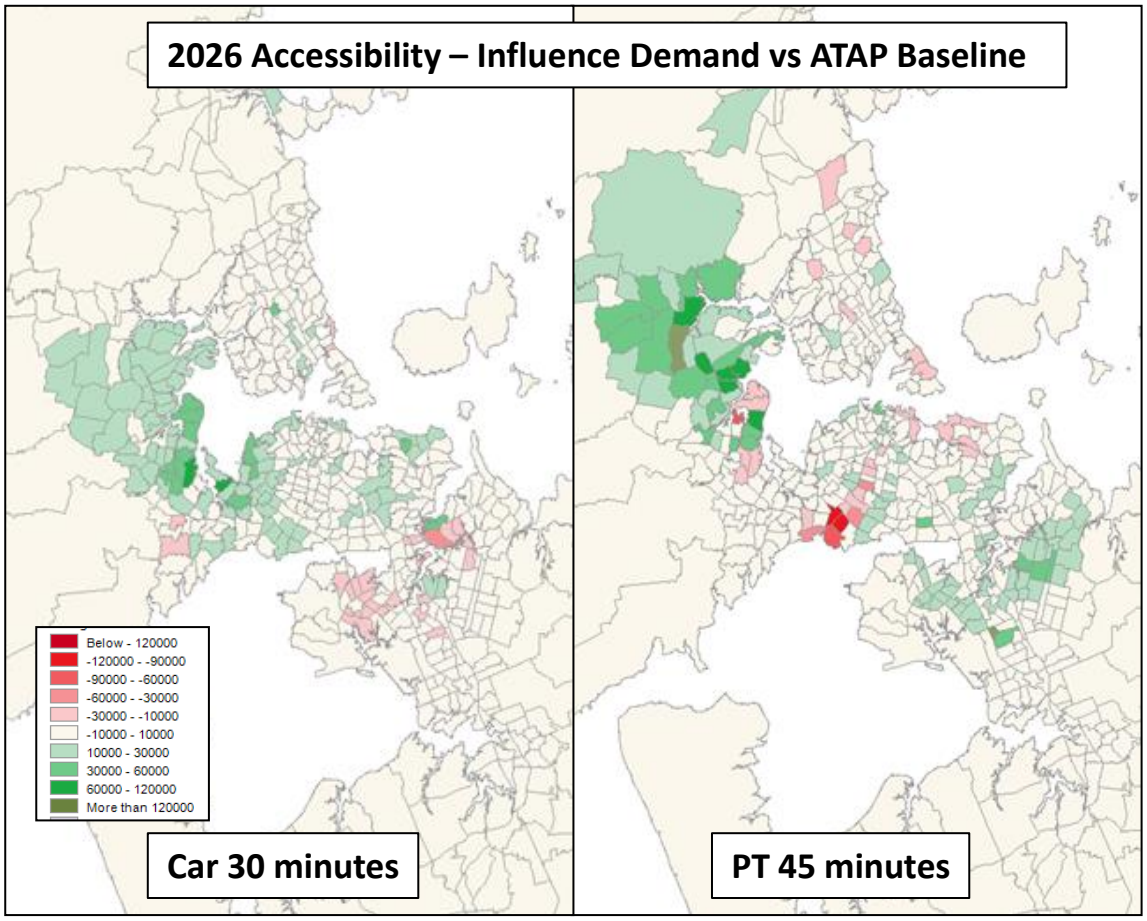


Figure 4.22: Accessibility to jobs AM peak 2026 (Influence Demand vs ATAP Baseline)

There is a dramatic improvement to car accessibility in 2046 compared to the Base Network (Figure 4.23). Virtually all of Auckland sees increased car accessibility, with the highest levels concentrated on the northwest and inner south. Apart from the targeted widening of the Southern Motorway and SH 20, most of the improvements to accessibility stem from the introduction of smarter pricing.

Public transport accessibility improvements are more uneven: improvements are seen in the northwest, and parts of the west, isthmus and inner south, while the upper North Shore sees a reduction in accessibility.

Two noteworthy findings are: Despite the exclusion of the roading element of an Additional Waitemata Harbour Crossing from the Influence Demand package, car accessibility for the North Shore is higher than under the APTN. The northwest and parts of the south appear to experience the greatest accessibility gains from the implementation of smarter pricing. This may be because pricing is particularly effective at reducing congestion along the routes serving these areas, bringing them back within a 30-minute travel time of the substantial employment opportunities in the central area. However, these travel time savings would need to be balanced against the increased direct travel costs from pricing to fully understand access impacts.

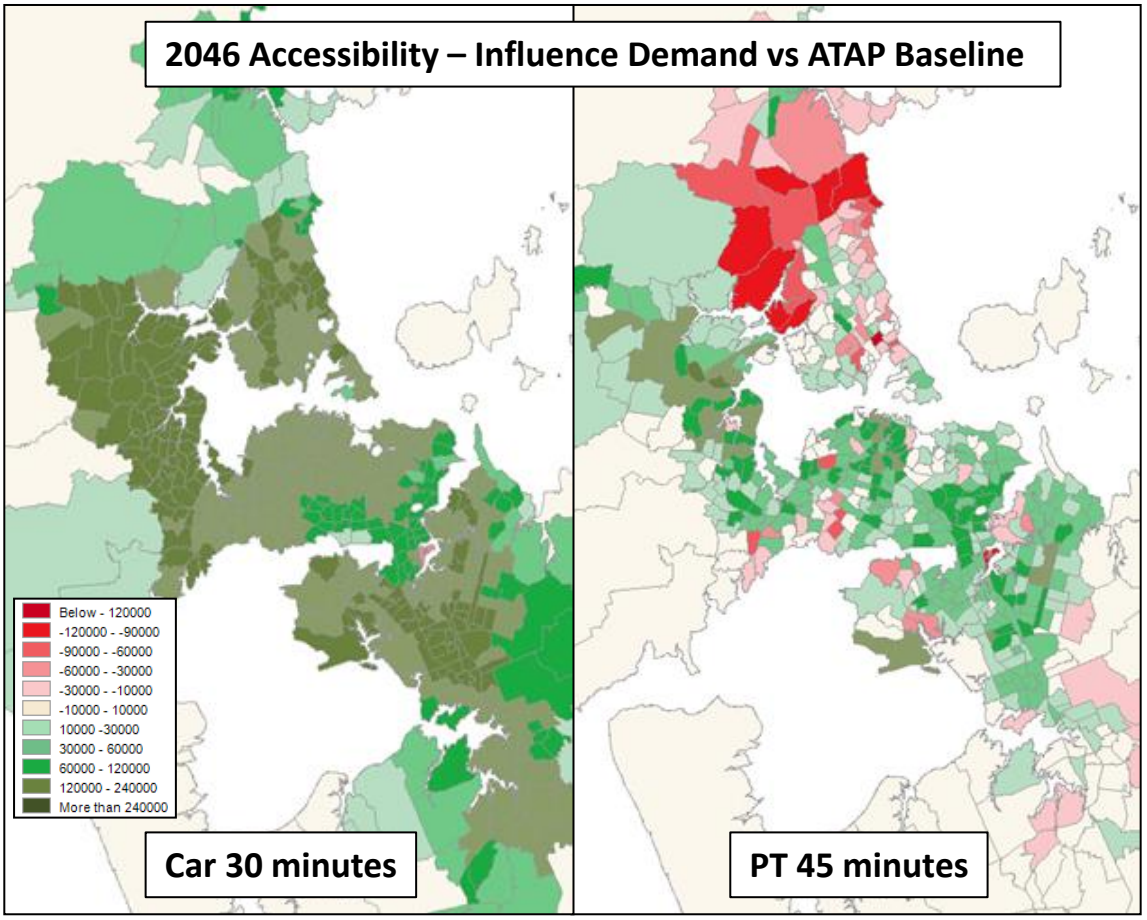


Figure 4.23: Accessibility to jobs AM peak 2046 (Influence Demand vs ATAP Baseline)

Congestion

The progressive introduction of smarter transport pricing in the Influence Demand package is projected to have a step change in reducing congestion levels. This is particularly apparent in the AM peak (Figure 4.24). Most of this change results from a combination of reduced trip lengths and a shift to public transport response to the increased cost of car travel. Inter-peak congestion is also projected to reduce under Influence Demand with smarter pricing. While some patches of congestion remain in the Influence Demand package at 2046, most of the inner motorway network is projected to operate below severe congestion levels in the inter-peak.

The Base Network and APTN perform similarly on congestion up until 2036, after which the Base Network sees an increase in both AM peak and inter-peak congestion while APTN remains largely flat.

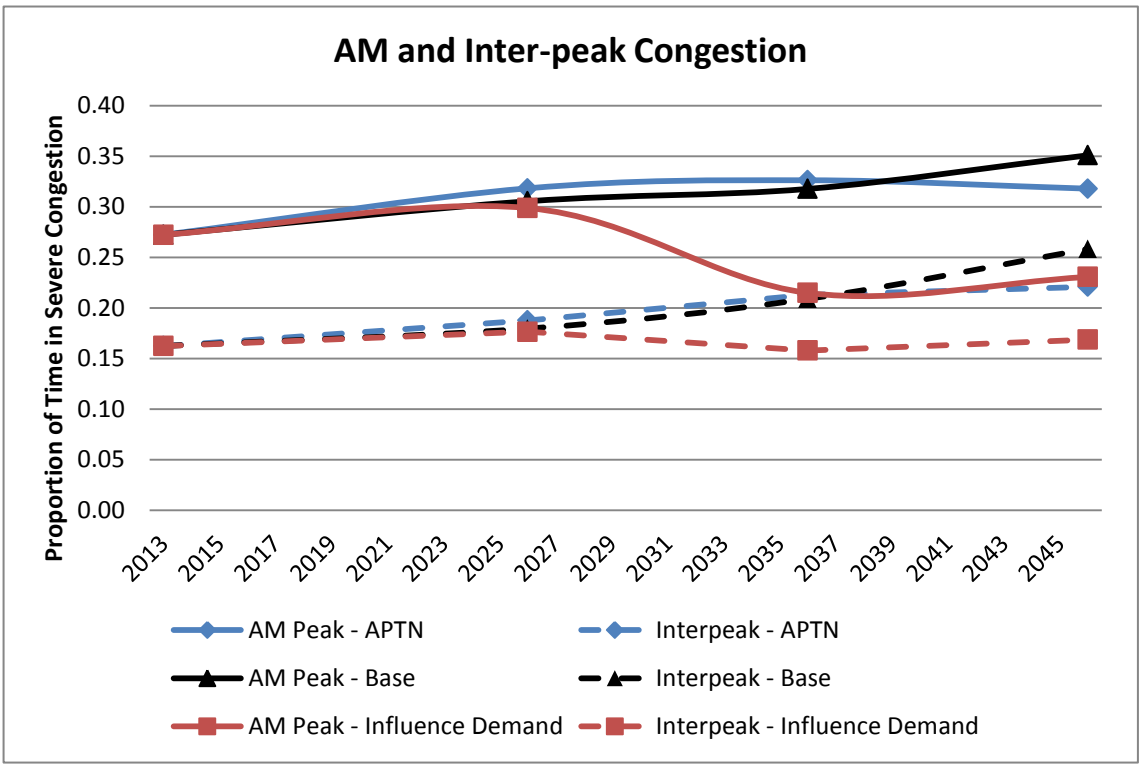


Figure 4.24: AM peak and inter-peak congestion (Influence Demand, APTN and Base Network)

Freight travel sees similar reductions in congestion for both AM peak and inter-peak (Figure 4.25). Inter-peak congestion levels rise significantly from 2026 under the APTN and the Base Network. Under the Influence Demand package however, inter-peak congestion is projected to decline after 2026 and remain below the 2013 congestion level.

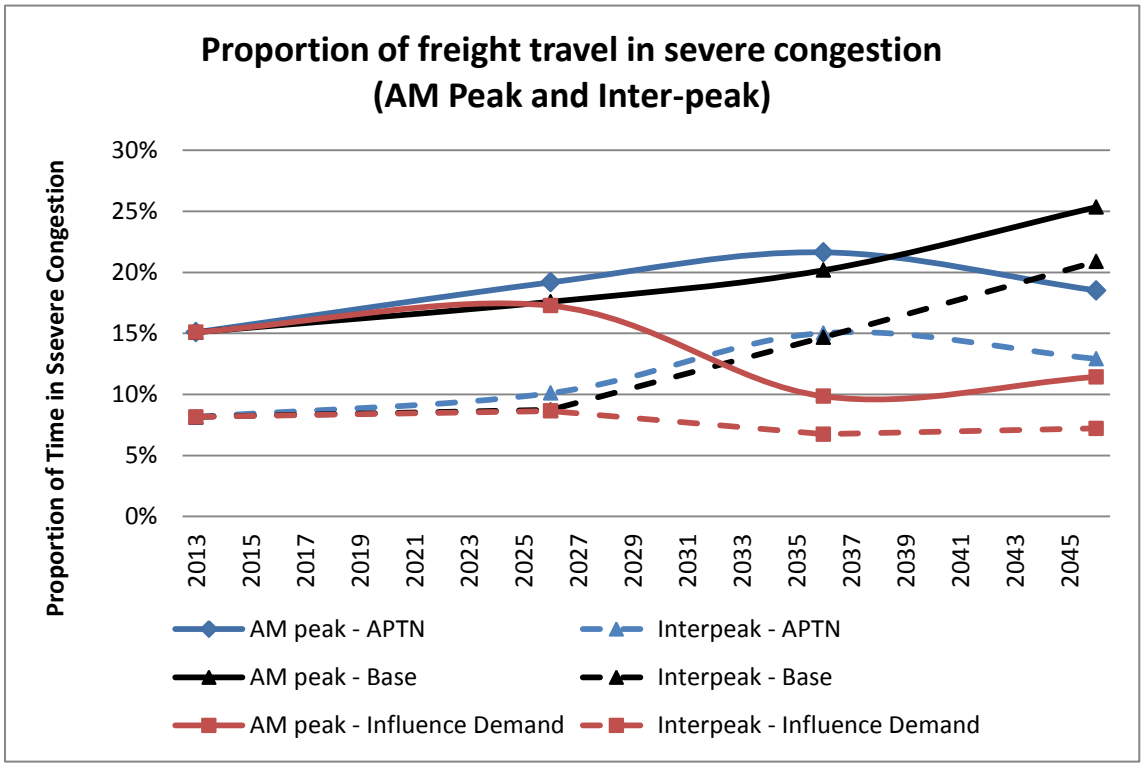


Figure 4.25: Proportion of freight travel in severe congestion (Influence Demand, APTN and Base Network)

At a sub-regional level, capacity constraints in the am peak in 2046 are projected to be alleviated on parts of the network, most particularly on SH20 and SH16 (Figure 4.26). However, constraints remain around the Airport as well as parts of SH1 on the isthmus.

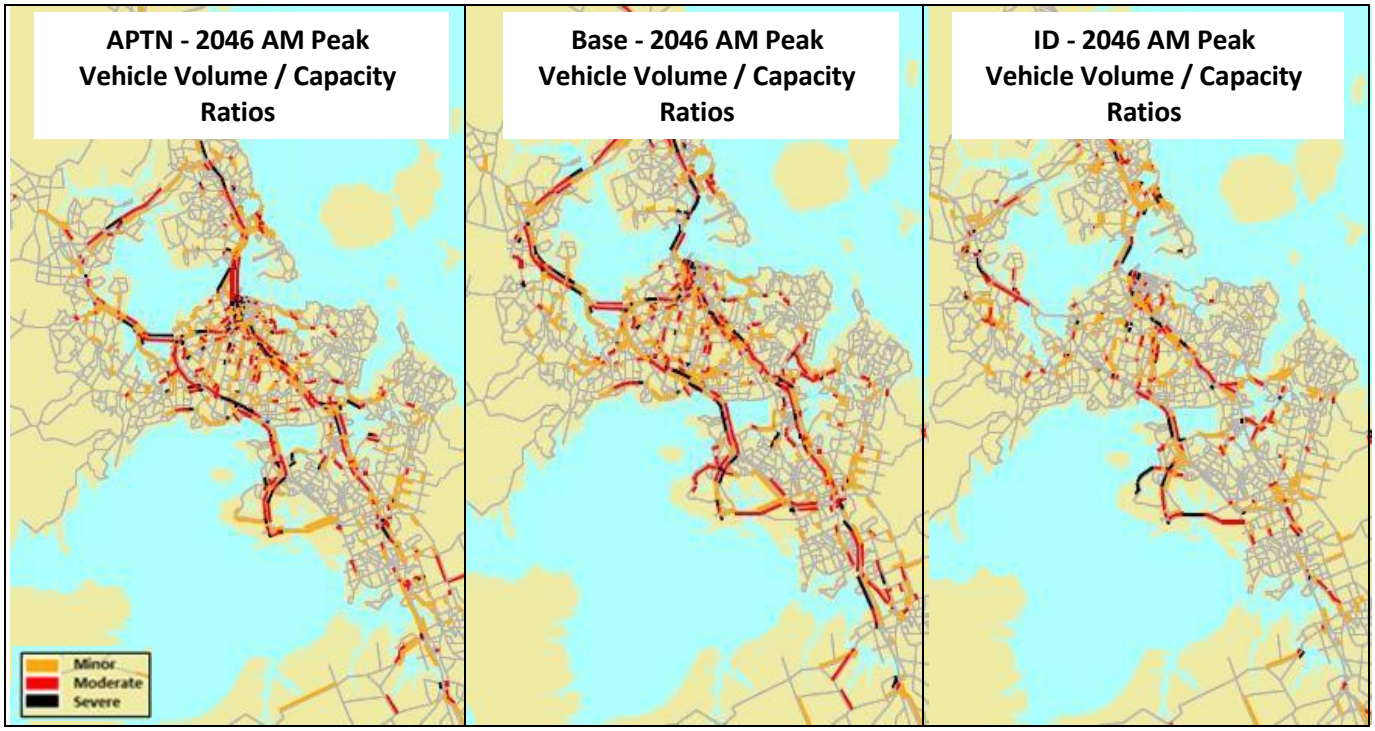


Figure 4.26: AM peak vehicle volume to capacity 2046 (Influence Demand, APTN and ATAP Baseline)

Inter-peak capacity constraints in the am peak are projected to dramatically reduce under Influence Demand, although limited severe congestion remains on the network in 2046 (Figure 4.27). The removal of most capacity constraints in the inter-peak shows that the pricing scheme may have been applied too broadly and that further analysis is required.

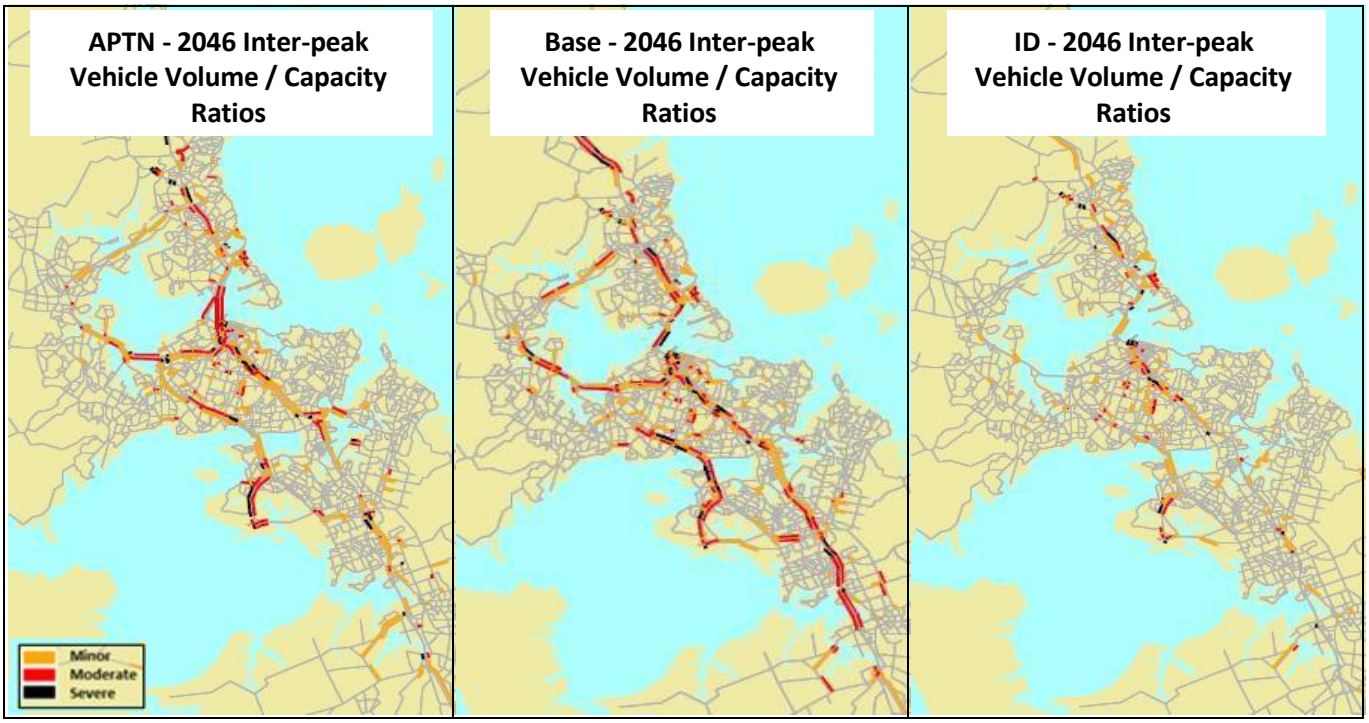


Figure 4.27: Inter-peak vehicle volume to capacity 2046 (Influence Demand, APTN and ATAP Baseline)

Public Transport Mode Share

Public transport mode share increases under Influence Demand as a result of the additional public transport expenditure and introduction of smarter pricing (Figure 4.28). Mode share for the ATAP Baseline and APTN remains largely similar over the 30 year period.

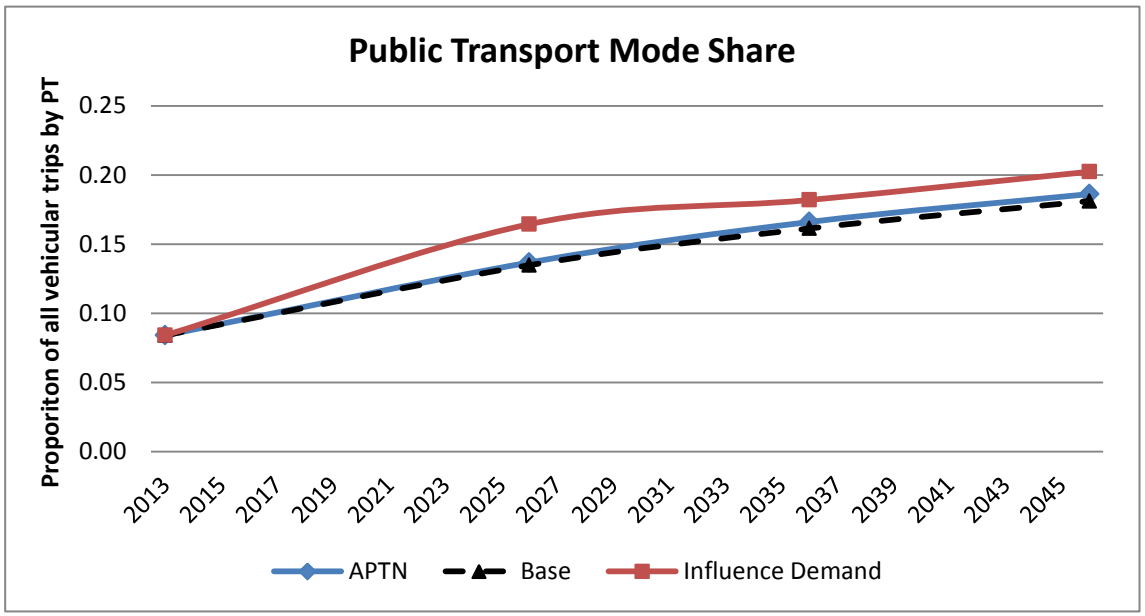


Figure 4.28: Public transport mode share AM peak (Influence Demand, APTN and ATAP Baseline)

While smarter pricing reduces demand for travel on the roading network, it substantially increases demand for the public transport network. Despite additional investments to public transport infrastructure, demand on the rapid transit network for bus continues to exceed capacity at parts of the network, particularly along the Northwestern and cross isthmus corridors, indicating the need for additional services or further investment (Figure 4.29).

Mass rapid transit to the Airport and North Shore, respectively, are projected to be operating within public transport capacity constraints under the Influence Demand package.

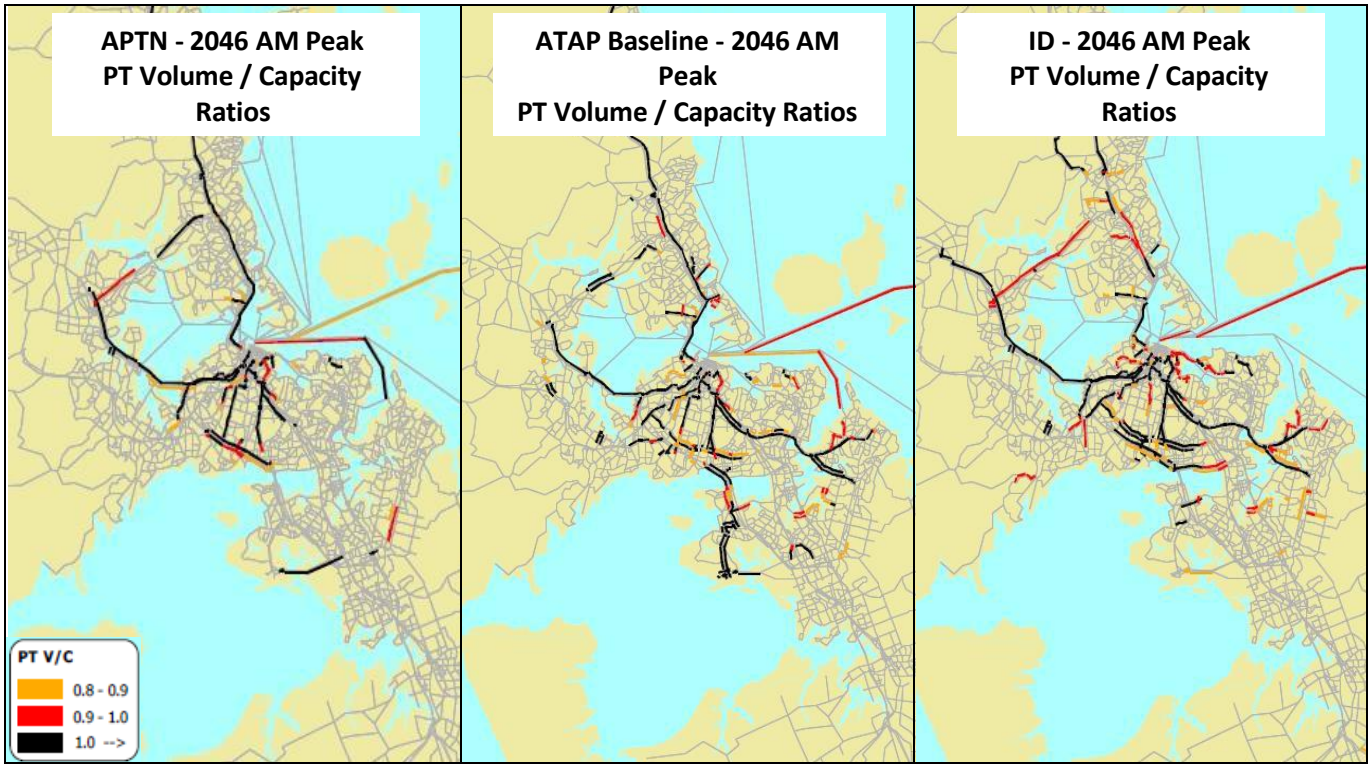


Figure 4.29: Public transport volume to capacity AM peak 2046 (Influence Demand, APTN and ATAP Baseline)

Net Benefits to Users

"Net benefits to users" was estimated because the Influence Demand package increases the financial costs of motorists using the transport system, depending on time of day and the route taken. While our analysis suggests moving to smarter transport pricing would deliver very material gains in travel times and a shift to public transport, it would impose additional cost on many road users. Motorists receive a benefit from the improved network performance (in terms of shorter travel times and lower vehicle operating costs) but also face increased costs from having to pay the network charges.

The following map (Figure 4.30) shows the difference in projected generalised costs for motorists in different parts of Auckland in the morning peak in 2046 with smarter pricing in the Influence Demand package, compared to the generalised costs in the APTN.

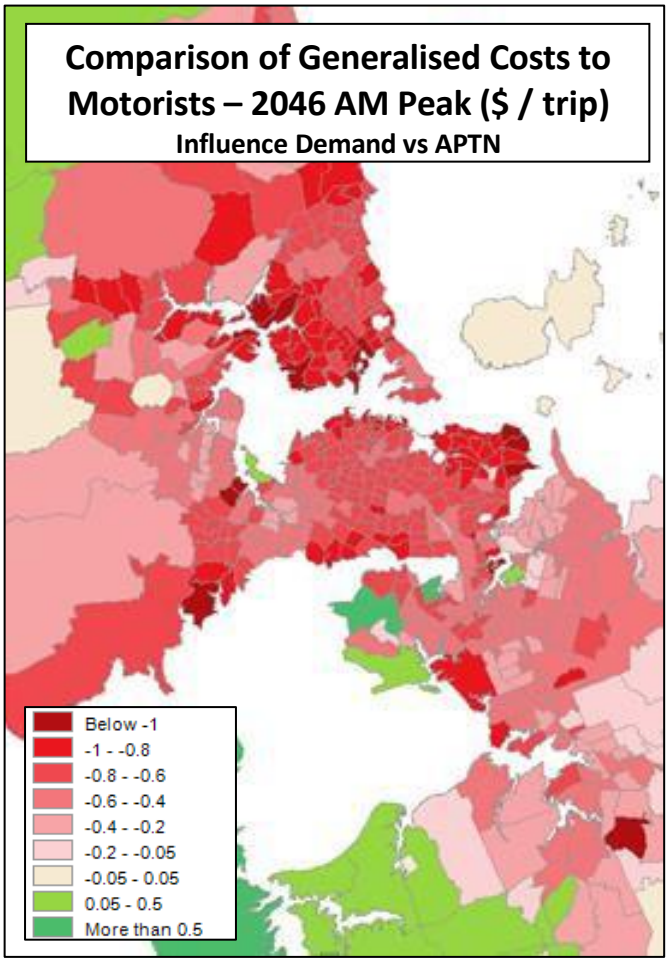


Figure 4.30: Generalised costs to road users AM peak 2046 (Influence Demand vs APTN)

Those generalised costs do not take into account the wider benefits that users of the transport system would gain from increased accessibility and reduced congestion.

Despite the reduction in pricing charges by 25% from the initial pricing scheme, this round of testing continues to impose additional financial costs on many road users, but to a much lesser extent than in the previous round. This analysis suggested that the prices charged would exceed the value of the time gained for the average road user, although for more peripheral regions where levels of congestion and the resulting charges are low, there would be net benefits to motorists.

These findings should be treated with caution. The analysis was a necessarily coarse approximation of how pricing might be applied, which means that some uncongested roads were subject to the same charge as congested routes. Furthermore, our analysis did not consider the likelihood that some users would place a much higher value on time savings than others. Further work, using much more detailed analytical tools, is required to identify efficient pricing levels which effectively address these issues.

We expect that more detailed development and analysis will go a long way towards ensuring overall net user benefits from the introduction of pricing, as prices could be adjusted to lower levels and a finer-grain (e.g. on uncongested counter-peak motorways) and would also be better information about the impacts on users with different values of time could be taken into account.

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

Value for Money

The Influence Demand package has an estimated $33.2 billion capital expenditure programme over 30 years (excluding renewals) which is projected to result in significantly higher contributions to the ATAP objectives compared to the APTN. The package is projected to result in a higher proportion of jobs accessible by motorists of 55% (compared to 43% in the APTN), a similar proportion of jobs accessible by public transport of 25% (compared to 24% in the APTN), a significantly lower proportion of travel time in severe congestion of 23% in severe congestion in the morning peak (compared to 32% in the APTN) and a moderately higher public transport mode share of 20.2% in the morning peak (compared to 18.6% in the APTN).

The Influence Demand package as a whole is projected to have significantly higher contributions to the ATAP objectives than the APTN package, but with a larger capital improvement programme and a higher average cost to motorists.

4.2.3 Key Learnings

The Influence Demand package highlights significant improvements in potential accessibility, congestion and public transport mode share. These are counter-balanced by unclear net benefits to users that would require more detailed analysis.

Due to its significantly better performance against the project objectives, Influence Demand forms the base of the Indicative Package in the next phase of the project.

4.3 Cross Package Review

4.3.1 Overview

The Higher Investment and Influence Demand packages were compared against both the APTN (to understand the extent to which it appear to deliver better returns than current plans) and a common baseline (to understand the value from additional investment above this baseline). The main findings from the cross package review are listed below:

- Additional investment in the first decade did not appear to improve performance against the project objectives at regional level, but some of these extra investments did have some important sub-regional effects. Therefore, development of the Indicative Package in the next phase should adopt a more targeted approach to identifying early priorities which both align with the project objectives and appear likely to deliver value for money (refer to section 5).
- The introduction of smarter pricing in the Influence Demand package has the most significant impacts on the project objectives, but unclear net benefits to users that would require more detailed analysis.
- Because of its significantly better performance against the project objectives, Influence Demand should form the base of the Indicative Package in the next phase of the project.

4.3.2 Accessibility

Car accessibility outputs indicate a very similar situation between 2013 and 2026 across the packages, but with their differences subsequently growing (Figure 4.31). Additional investment before 2026 appears to have a very limited effect on car accessibility. After 2026, once the progressive implementation of a variable network charge has been introduced, car the Influence Demand package provides significantly higher car accessibility than any other package, despite containing around $8 billion less investment than the Higher Investment package.

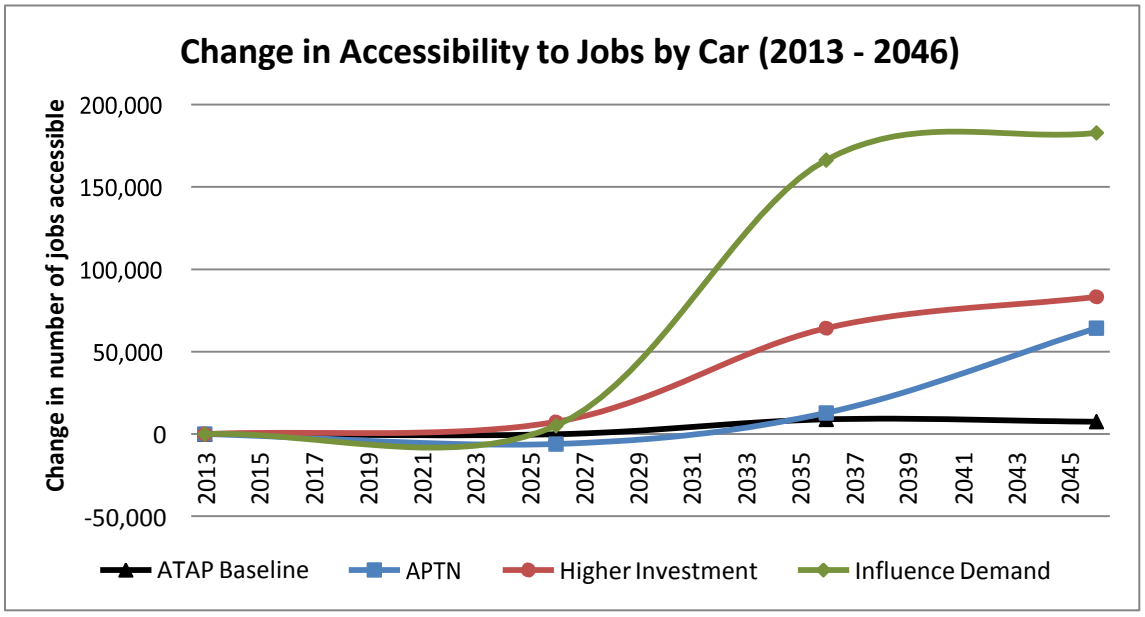


Figure 4.31: Change in number of jobs accessible within a 30 minute car commute AM peak (2013 – 2046)

Public transport accessibility modelling outputs hide some of the differences between packages, due to the limitations of the analytical tools. These limitations almost certainly mean performance of the ATAP baseline and the APTN are substantially over-stated. This is because capacity constraints arising from these packages being reliant on extremely high bus volumes along key corridors were not able to be assessed. The Higher Investment and Influence Demand packages perform very similarly over the 30 years, because the public transport investments in those packages are almost identical, with only the timing varying (Figure 4.32).

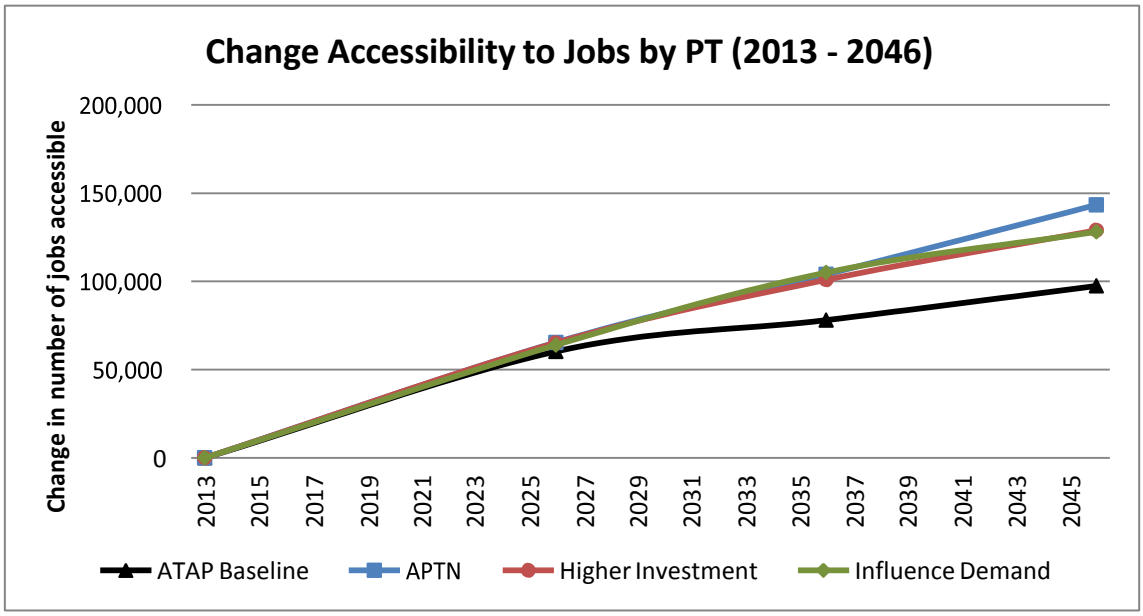


Figure 4.32: Change in number of jobs accessible within a 45 minute PT commute AM peak (2013 – 2046)

At a sub-regional level, all three packages show similar patterns in car access at 2026 (Figure 4.33). The isthmus sees a marginal increase in accessibility, while the northwest, west and North Shore see a reduction in accessibility. Higher Investment increases accessibility for most of the south, while Influence Demand sees relatively similar accessibility patterns to the APTN.

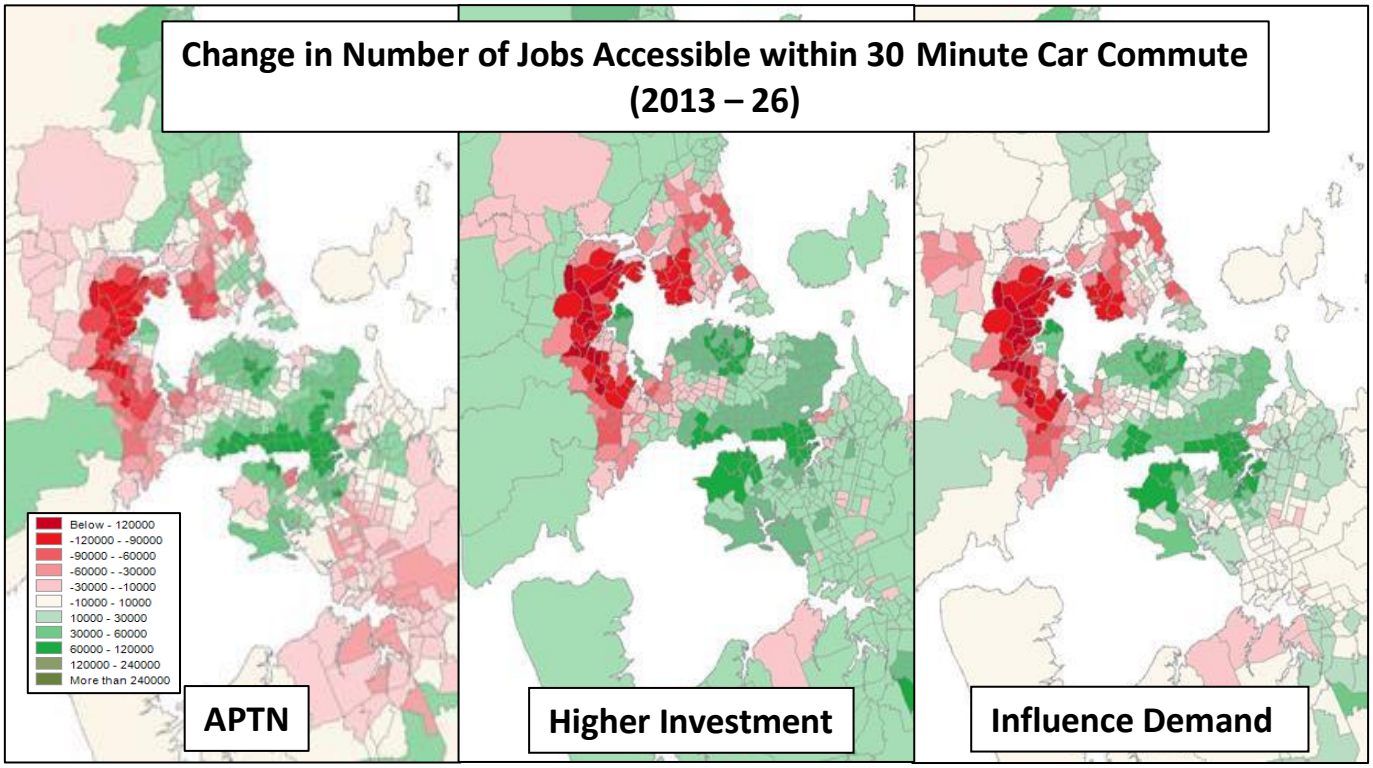


Figure 4.33: Change in number of jobs accessible within a 30 minute car commute AM peak (2013 – 2026)

Car accessibility improves dramatically under Influence Demand with the introduction of smarter pricing. This is reflected sub-regionally under Figure 4.34, with the northwest, North Shore and inner south seeing the greatest increase in accessibility. Higher Investment also experiences an increase in accessibility through most parts of Auckland, though at a smaller scale compared to Influence Demand. The inner south experiences declines in accessibility despite targeted widening in the Southern Motorway network.

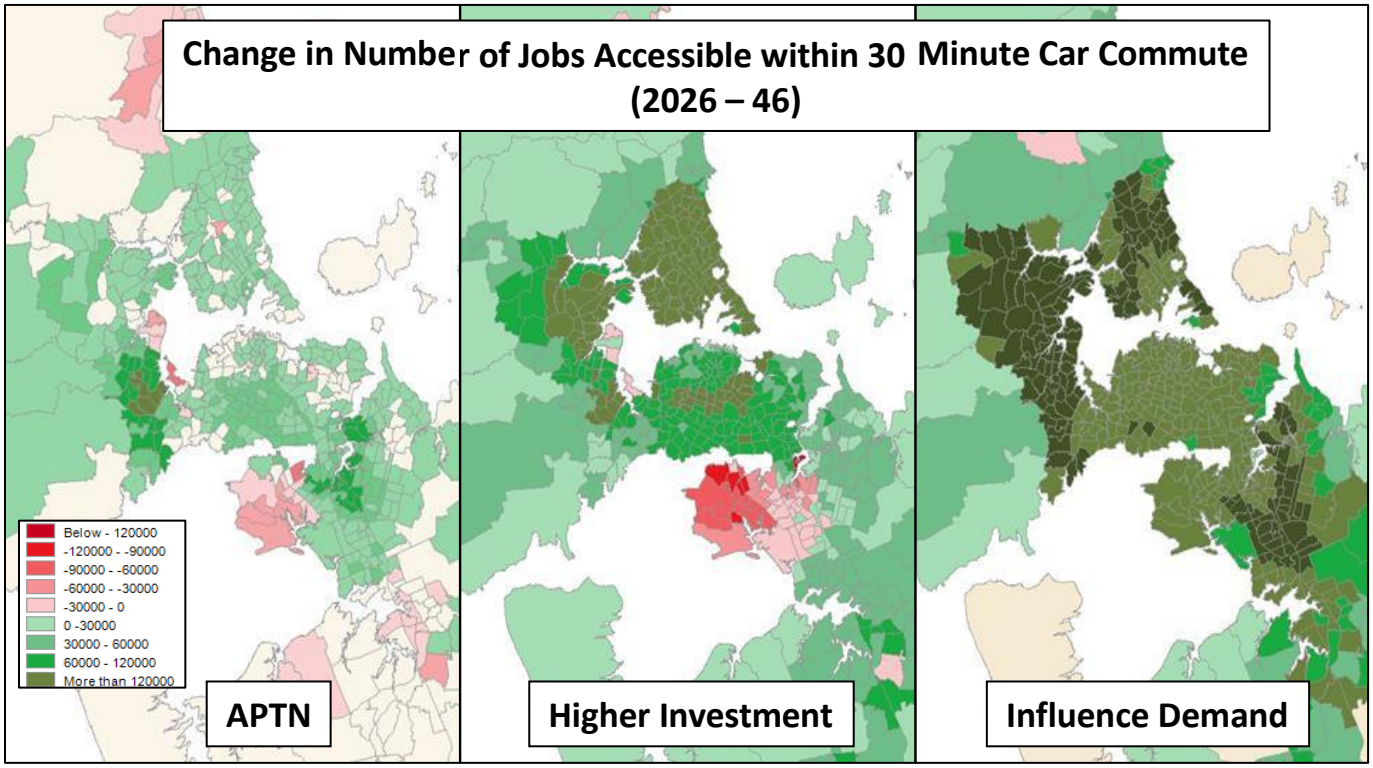


Figure 4.34: Change in number of jobs accessible within a 30 minute car commute AM peak (2026 – 2046)

At 2026, Influence Demand and Higher Investment are projected to have roughly similar patterns in public transport access improvements (Figure 4.35).

Between 2026 and 2046, improvements to public transport access are concentrated on the isthmus and northwest under Influence Demand (Figure 4.36). Accessibility declines on parts of the North Shore.

Higher Investment sees a more even distribution of public transport access improvements across the region, though the improvements are less dramatic compared to Influence Demand.

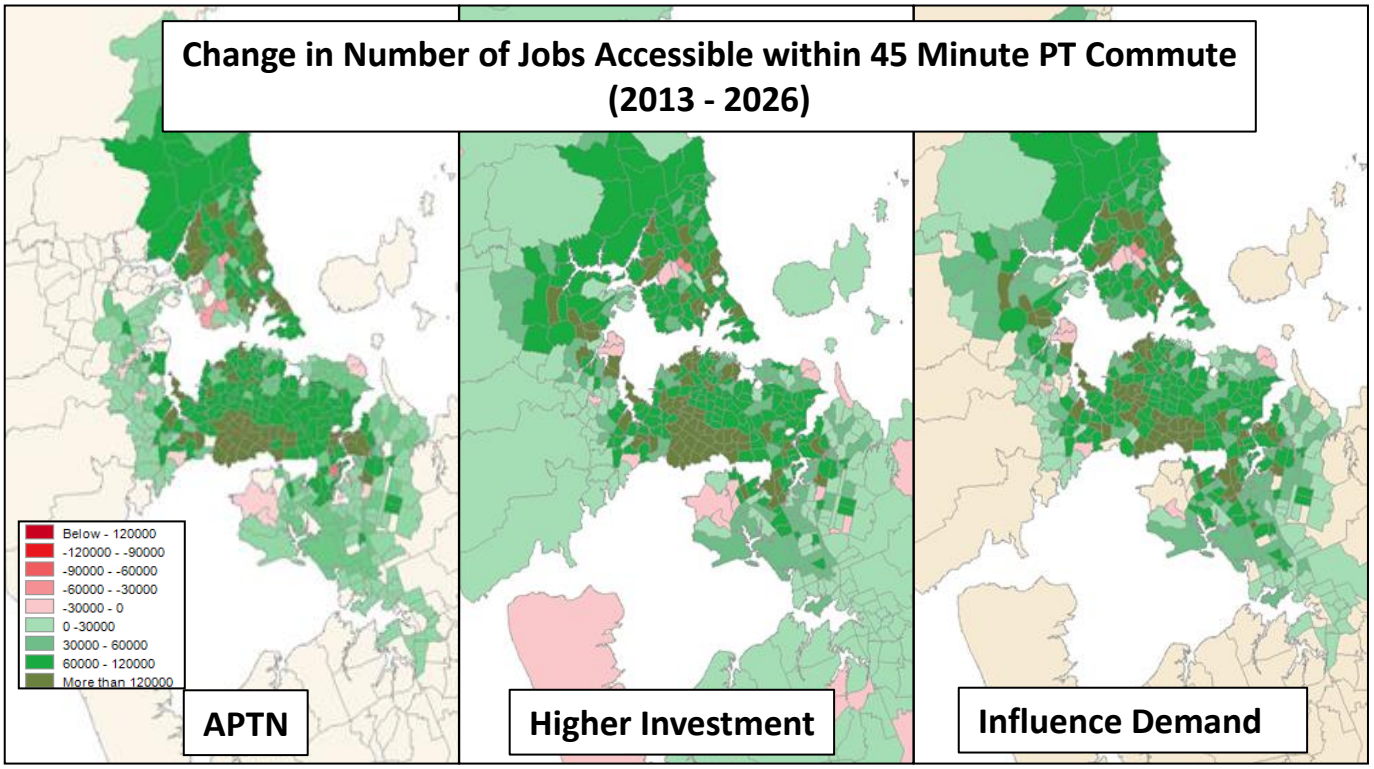


Figure 4.35: Change in number of jobs accessible within a 45 minute PT commute AM peak (2013 – 2026)

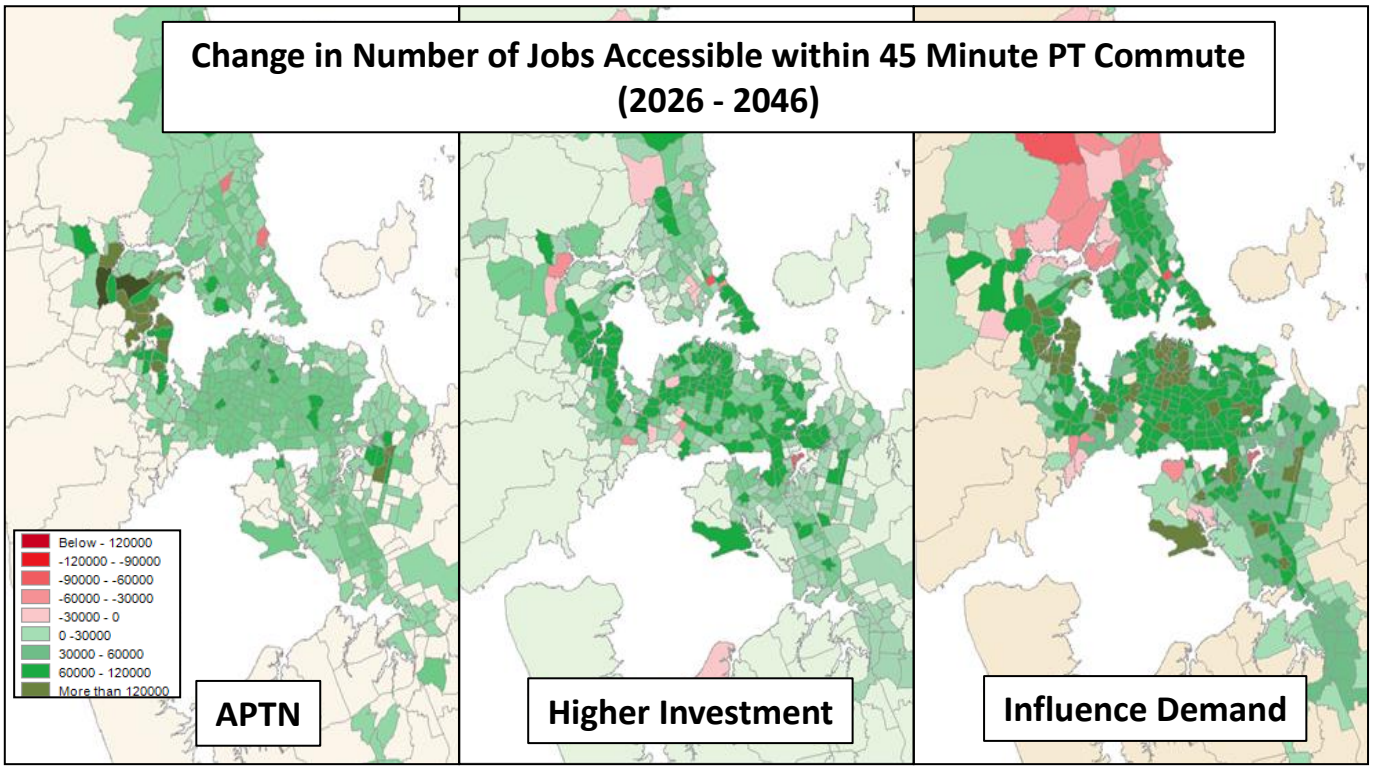


Figure 4.36: Change in number of jobs accessible within a 45 minute PT commute AM peak (2026 – 2046)

4.3.3 Congestion

Analysis of projected congestion levels mirrors the car accessibility outputs discussed above. While the Higher Investment package performs slightly better than the APTN (particularly in 2026 and 2036 as a result of earlier investment in additional highway capacity), it is only the progressive introduction of smarter transport pricing in the Influence Demand package that delivers a step-change impact on congestion levels (Figure 4.37).

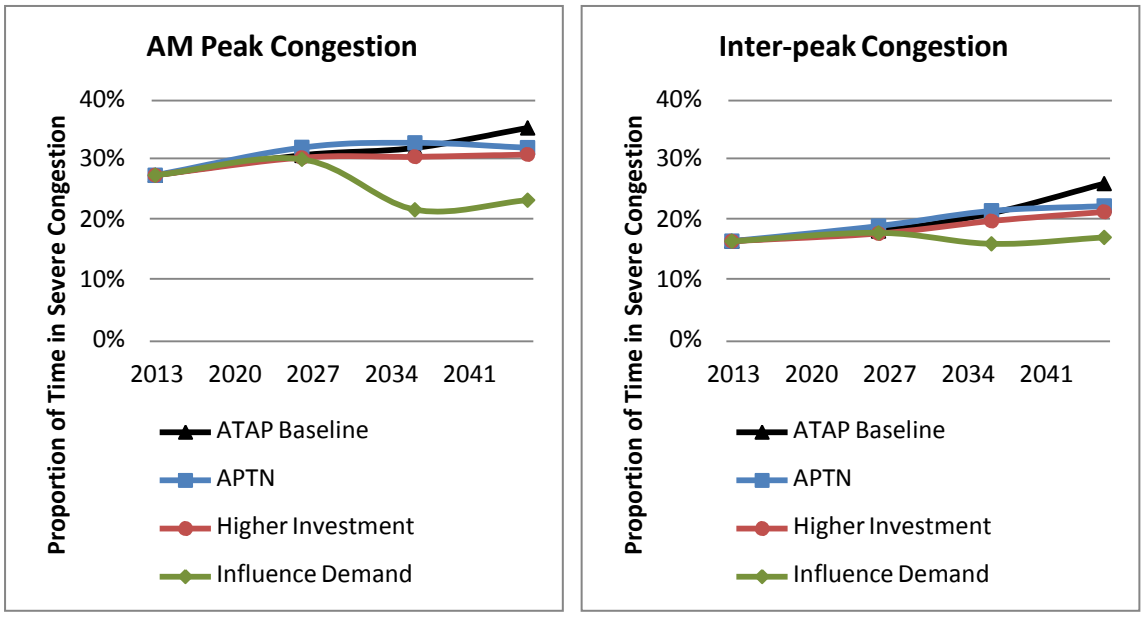


Figure 4.37: AM peak and Inter-peak Congestion (2013 – 2046)

Most of this change results from a combination of reduced trip lengths and a shift to public transport in response to the increased cost of car travel. The lower level of congestion for the Influence Demand package is reflected in the more detailed volume to capacity plots for 2046 (Figure 4.38). Under Higher Investment, key pinch points of the inner motorway network experience the highest levels of congestion.

These plots also indicate various areas of remnant congestion in the Influence Demand package, especially on the Northern Motorway and inner parts of the Southern Motorway. Addressing these areas of congestion informed the development of the Indicative Package, as well as the need to continue to refine the details of the pricing system over time, as changes to the pricing structure could also address these issues.

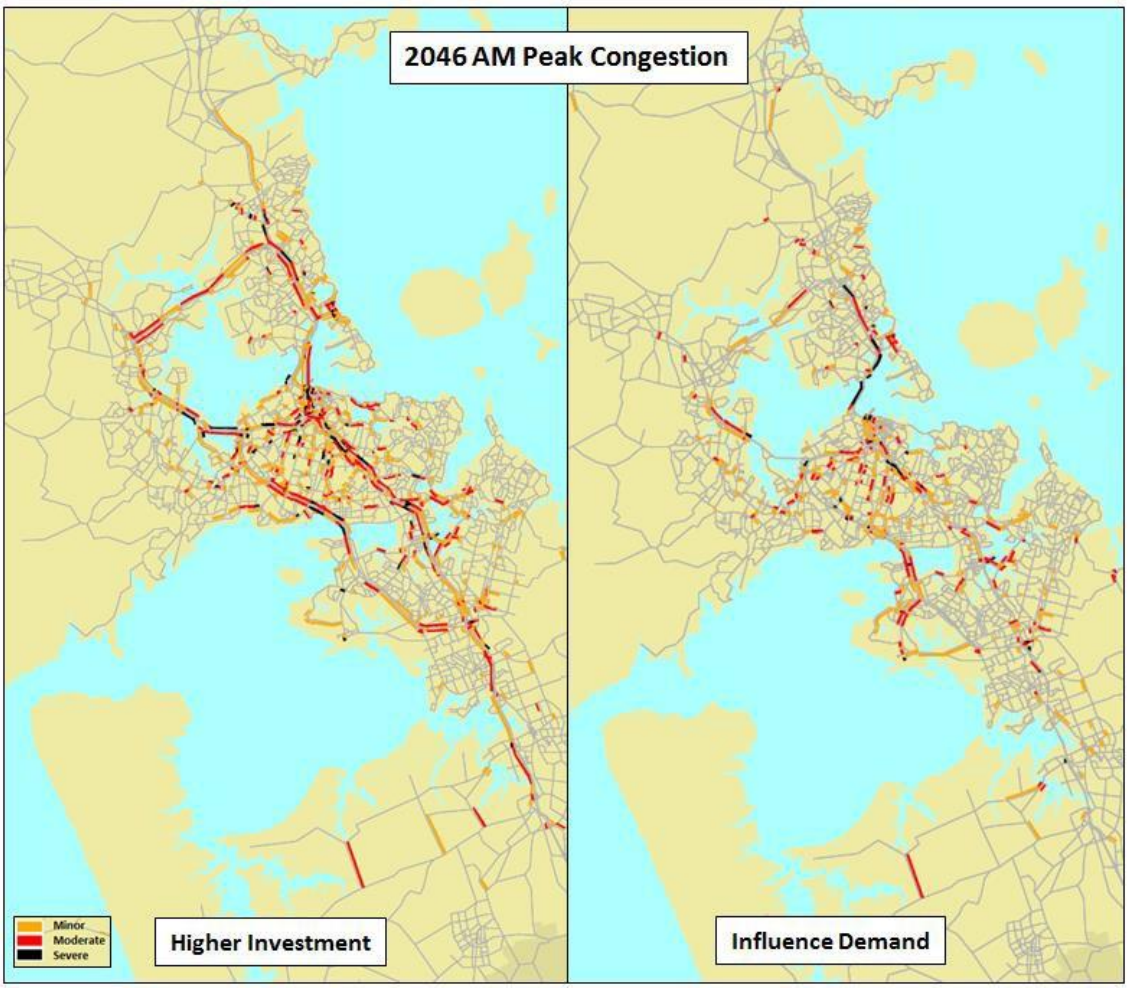


Figure 4.38: AM peak vehicle volume to capacity in 2046 (Higher Investment and Influence Demand)

Inter-peak congestion plots for the two packages also indicate a much lower level of congestion under Influence Demand (Figure 4.39). While some patches of congestion remain in the Influence Demand package, most of the inner motorway network is operating below moderate or severe congestion levels in 2046.

Moderate to severe congestion levels are found under Higher Investment, particularly within the inner motorway network.

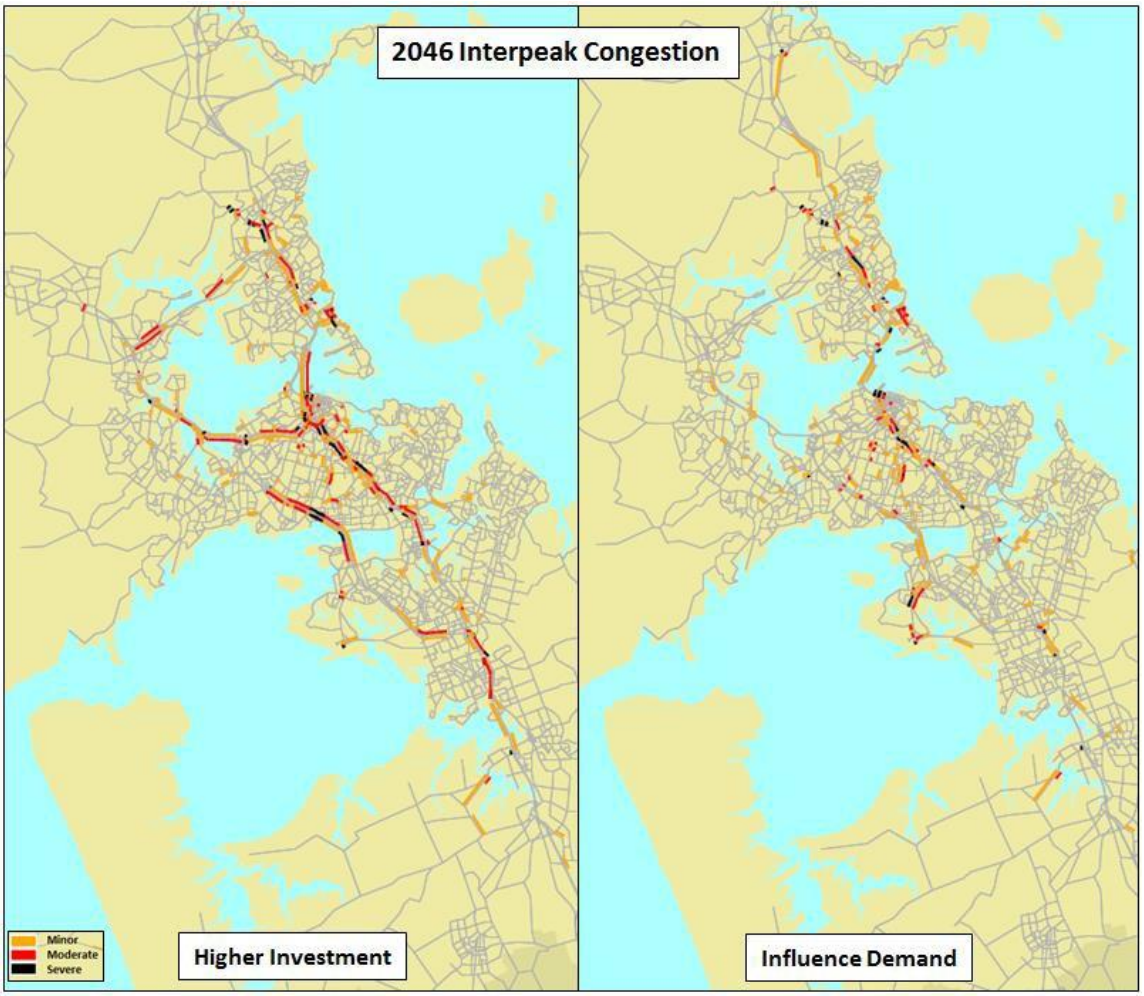


Figure 4.39: Inter-peak vehicle volume to capacity in 2046 (Higher Investment and Influence Demand)

4.3.4 Public Transport Mode Share

Public transport mode share tracks similarly for APTN, Higher Investment and the ATAP Baseline (Figure 4.40). Public transport mode share is projected to be higher under Influence Demand due to the increased cost of driving resulting from smarter pricing and further investment to the public transport network.

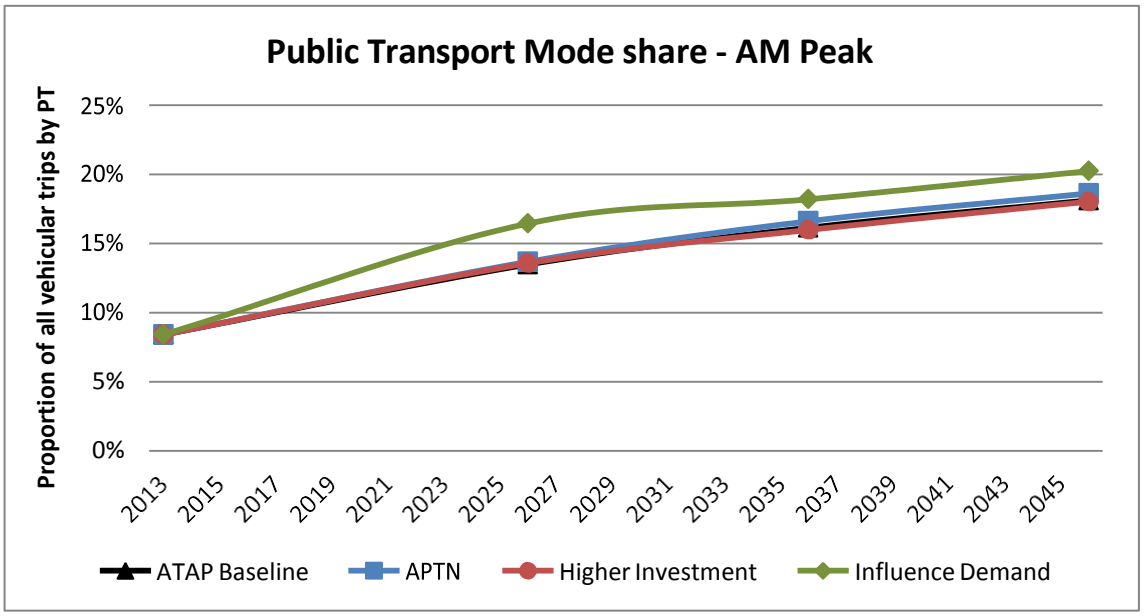


Figure 4.40: Public transport mode share in the AM peak (2013-2046)

4.3.5 Full Evaluation Results

The following table presents the results of our evaluation of the Higher Investment and Influence Demand packages against the evaluation criteria established in the Foundation Report (Table 4.4). All results relate to the 2046 year unless otherwise specified.

Table 4.4: Evaluation framework – headline measures

Objective	Measure	Headline KPI	2013 comparison	Higher Investment 2046	Influence Demand 2046	APTN 2046	Comment
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30 minute trip in the AM peak • Jobs accessible by public transport within a 45 minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	312,000 i.e. 51% of available jobs 94,000 i.e. 15% of available jobs 467,000 i.e. 75 % of available jobs	396,000 i.e. 44% of available jobs 223,000 i.e. 25% of available jobs 593,000 i.e. 67% of available jobs	495,000 i.e. 55% of available jobs 222,000 i.e. 25% of available jobs 655,000 i.e. 74% of available jobs	386,000 i.e.43% of available jobs 215,000 i.e. 24% of available jobs 590,000 i.e. 66% of available jobs	The Higher Investment package increases the number of jobs accessible by car and PT in the morning peak (7-9am) in 2046, but does not increase the proportion of jobs that could be accessed by car. The Influence Demand package increases car and PT accessibility (measured only in relation to travel time, not financial cost) in the morning peak (7-9 am) in 2046.
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak	7 hours 22 minutes per person per annum 27.3% AM peak 16.3% inter-peak	11 hours 58 minutes per person per annum 30.7% AM peak 21.1% inter-peak	4 hours 57 minutes per person per annum 23.1% AM peak 16.9% inter-peak	13 hours 33 minutes per person per annum 31.9% AM peak 21.9% inter-peak	Projected levels of congestion for the Higher Investment package are expected to be similar to the APTN. The Influence Demand package's projected levels of congestion throughout the day are significantly better than the APTN.
	Impact on freight and goods (commercial traffic) congestion	• Proportion of business and freight travel time spent in severe congestion on the strategic freight network (in the AM peak and inter-peak)	15.1% AM peak 8.3% inter-peak	19.8% AM peak 12.6% inter-peak	11.4% AM peak 7.2% inter-peak	18.6% AM peak 12.9% inter-peak	The Higher Investment package's projected congestion on the strategic freight network is similar to the APTN. The Influence Demand package's projected congestion is significantly better throughout the day, compared to the APTN.
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, inter-peak and PM peak.	15% AM peak 6% inter-peak 16% PM peak	19% AM peak 13% inter-peak 24% PM peak	10% AM peak 6% inter-peak 12% PM peak	19% AM peak 13% inter-peak 23% PM peak	Projected reliability of travel times for motor vehicle trips with the High Investment package are expected to be similar to the APTN. The Influence Demand package's projected reliability of travel times is expected to be significantly better throughout the day, compared to the APTN.
Increase public transport mode-share	Public transport mode share	• Proportion of vehicular trips in the AM peak made by public transport	8.5%	18.0%	20.2%	18.0%	Projected PT mode share for the Higher Investment package is expected to be similar to the APTN. The Influence demand package's projected PT mode share is slightly higher than the APTN.
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 9 km in the AM peak made by public transport	18.3%	31.7%	38.4%	31.7%	The proportion of longer commuter trips by PT with the Higher Investment Package is projected to be the same as the APTN. The Influence Demand package's projections shows a higher proportion of longer commute trips would be by PT, compared to the APTN.
	Increase vehicle occupancy	• Average vehicle occupancy	1.36 people per vehicle AM peak 1.25 people per vehicle inter-peak	-	-	-	It was not possible to model changes in vehicle occupancy. The input assumptions of an average of 1.36 people per vehicle in AM peak and an average of 1.25 in inter-peak remained constant for all packages and all model years.

Objective	Measure	Headline KPI	2013 comparison	Higher Investment 2046	Influence Demand 2046	APTN 2046	Comment
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	Not applicable	-	-	Not applicable	Financial costs from smarter pricing in the Influence Demand package (see pricing schedule in Table 4.2) are assumed to replace road user charges and fuel excise duties. Savings in travel time and vehicle operating costs vary by trip. On average it is estimated that the financial costs exceed the savings in travel time and vehicle operating costs. Better model/tools are required to provide robust quantification of net benefits.
Ensure value for money	Value for money	• Package benefits and costs	-	-	-	-	Package benefits include the contributions to Objectives as measured in this table. The costs of new capital expenditure (excluding renewals) for the 30 year programmes are estimated in billions of 2016 dollars as follows: Higher Investment: $40.7 b Influence Demand: $33.2 b These cost estimates were identified after the revision of project costs in ATAP. Better model/tools are required to provide robust quantification of net benefits.

In addition to the project objectives, a number of other key outcomes have been evaluated through the evaluation framework in Table 4.5 below.

Table 4.5: Evaluation framework – other key outcomes

Other Key Outcomes	Measure	Headline Key Performance Indicator	2013 comparison	Higher Investment 2046	Influence Demand 2046	APTN	Comment
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	Existing transport infrastructure in greenfields is inadequate to support the growth required in the FULSS.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	The transport infrastructure in greenfields programme does not meet timeframes of FULSS.	The same programme in greenfields has been assumed in both the Higher Investment and Influence Demand packages. The projects in the greenfields are needed to unlock housing capacity.
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled	48 deaths and 3,487 injuries p.a. from motor vehicle crashes. 25 injuries per 10,000 population 28 injuries per 100 million vehicle kilometres travelled	-	-	-	Model forecasts can't accurately identify number of deaths and serious injuries.
	Emissions	• Greenhouse gas emissions	8.4 million kg of CO_2 per day	8.1 million kg of CO_2 per day	7.3 million kg of CO_2 per day	8.1 million kg of CO_2 per day	Projected levels of greenhouse gas emissions for the High Investment package are expected to be similar to the APTN. The Influence Demand package projects 10%

Other Key Outcomes	Measure	Headline Key Performance Indicator	2013 comparison	Higher Investment 2046	Influence Demand 2046	APTN	Comment
							fewer emissions in the Influence Demand package than the APTN. This is mostly due to fewer trips and shorter distance of trips.
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog	In 2015, approximately 1% of the transport network was in a "very poor" condition. This is equivalent to $157 million of backlog. [Source: Auckland Transport's Asset Management Plan 2015-2018]	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog within 10 years.	Expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears the renewals backlog within 10 years.	Similar to these packages.	The same maintenance and renewals programme has been assumed in both packages.
Social inclusion and equity	Impacts on geographical areas	• Access employment in high deprivation areas • Distribution of impacts (costs and benefits) by area	As identified in the Foundation report, high deprivation areas in the south and west have lower access to jobs than other parts of the region. People in the west rely on a congested motorway link to jobs in the isthmus and south. People in the south also experience congestion on motorway links to jobs.	Compared to the APTN, accessibility improves for high deprivation areas, but issues remain in Mangere.	Compared to the APTN, accessibility improves for high deprivation areas, but access by motor vehicle is subject to pricing. Motor vehicle accessibility from high deprivation areas in the North Shore is worse.	The Deficiency Analysis identified significantly lower levels of access in the south and west.	Accessibility from high deprivation areas is similar to the APTN, except with smarter pricing. Generalised costs generally increase as a result of smarter pricing.
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network	Vulnerable network due to incomplete State Highway, public transport and cycle networks and lack of capacity at peak times on the strategic road network to cope with disruptions.	Network resilience is similar to the APTN. This package improves resilience through additional roading links such as the Additional Waitemata Harbour Crossing.	Network resilience is similar to the APTN. This package improves resilience through pricing of the road network. This reduces vehicle kilometres travelled on the road network by about 10% which could result in less diversion and impact in the event of disruption to the road network. There is high capacity in the rapid transit network, which enables PT to take additional people in the case of disruption.	-	These packages have a similar level of network resilience to the APTN.

4.3.6 Growth Assumptions

Packages have been evaluated based on medium growth assumptions, as set out in Table 4.6 below.

Table 4.6: Population and employment medium growth forecast

	2013	2026	2036	2046
Population	1,471,108	1,871,614	2,064,205	2,279,341
Employment	618,152	722,932	808,839	892,457

A sensitivity test was done in respect of the Higher Investment and Influence Demand package. This was based on high growth assumptions for 2026 only, with a high growth forecast population of 1,889,795 and employment of 751,628 in 2026.

The projected results were similar to the 2026 results under medium growth assumptions, with only slightly worse performance in terms of accessibility and congestion. An additional 3.5% increase in vehicle kilometres travelled corresponds with an increase from 30% to 31% of cars in severe congestion in the AM peak in 2026 under both the Higher Investment and Influence Demand packages. Public transport mode share projections are virtually the same at 2026 under high growth and medium growth assumptions.

This limited analysis suggested that network performance in 2026 would not be unduly affected by high growth in the first decade under those packages.

4.3.7 Package Refinement Conclusions

Key findings from analysing the Higher Investment and Influence Demand packages that informed development of the final package were:

- Additional investment in the first decade did not appear to improve performance against the project objectives at the regional level, but some of these extra investments did have some important sub-regional effects. Therefore, development of the final package should adopt a more targeted approach to identifying early priorities which both align with the project objectives and appear likely to deliver value for money.
- The introduction of smarter pricing in the Influence Demand package has the most significant impacts on the project objectives, but unclear net benefits to users that would require more detailed analysis.
- Because of its significantly better performance against the project objectives, Influence Demand should form the base of the Indicative Package.

Phase 3 – Indicative Package

Drawing upon the analysis undertaken in the previous phase, a package of interventions was developed that is indicative of the project's recommended strategic approach. The Indicative Package was based on the Influence Demand package assessed in the previous phase, with the main focus of additional work on identifying early priority interventions to be progressed over the first decade.

The Indicative Package provides an indication of the types of investments, the overall scale of investment and gives an indication of possible sequencing. It is not an "investment programme" and all investments will need to go through existing statutory processes to proceed.

The APTN package has been updated to reflect changes to the bus network and an adjustment in the ART3 transport model to recognise the effects of bus congestion along bus corridors.

The common baseline (CEE4) in the Round 4 analysis was also refined. Referred to interchangeably as the ATAP Baseline and the Base Network, it is used in the evaluation as a low-cost comparator. CEE4 is broadly similar to CEE3, which was used in the previous phase of the evaluation. The main difference between CEE4 and CEE3 lies in the changes to the bus network. This involved updates to the bus network itself and bus frequencies to better reflect reality.

5. Indicative Package

5.1 Package Description

Key findings from analysing the Higher Investment and Influence Demand packages in Package Refinement phase (see previous section) informed the development of the Indicative Package in this phase. Although additional investment in the first decade did not appear to improve performance against the project objectives at regional level, some of these extra investments did have some important sub-regional effects. As such, the development of the Indicative Package adopted a more targeted approach to identifying early priorities.

Our prioritisation framework considered two broad factors:

- The extent to which investment targets the most significant first decade challenges
- The potential to deliver value for money in the first decade

Due to the stronger performance of the Influence Demand package against the project objectives, it forms the base of the Indicative Package. As discussed, more detailed analysis is required to understand the cost to users caused by the introduction of smarter pricing.

The total estimated 30-year cost of the Indicative Package is $84 billion (in 2016 dollars). Figure 5.1 below provides a breakdown of costs by decade and across major investment types. Unlike previous packages which focused only on capital costs, the estimated cost of this package includes asset maintenance, operations and renewals, net public transport operations and new investments.

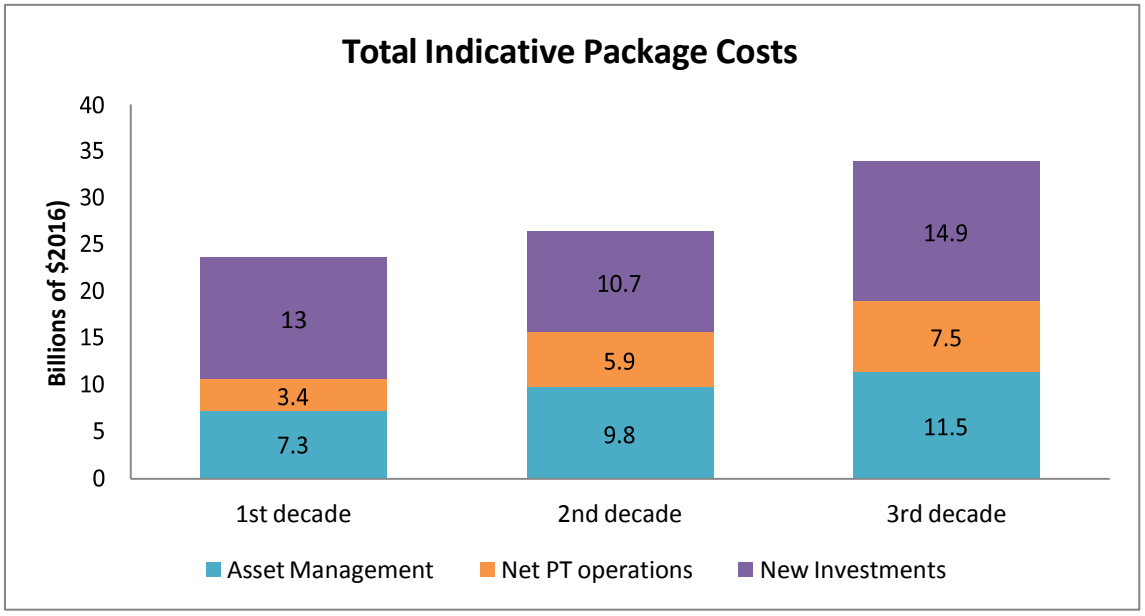


Figure 5.1: Estimated cost of new capital improvements (excluding renewals) of Indicative Package (2018 – 2048)

Of the total package, $38.6 billion (in 2016 dollars) is capital expenditure (excluding renewals). Figure 5.2 below provides a breakdown of those costs by decade and by broad type.

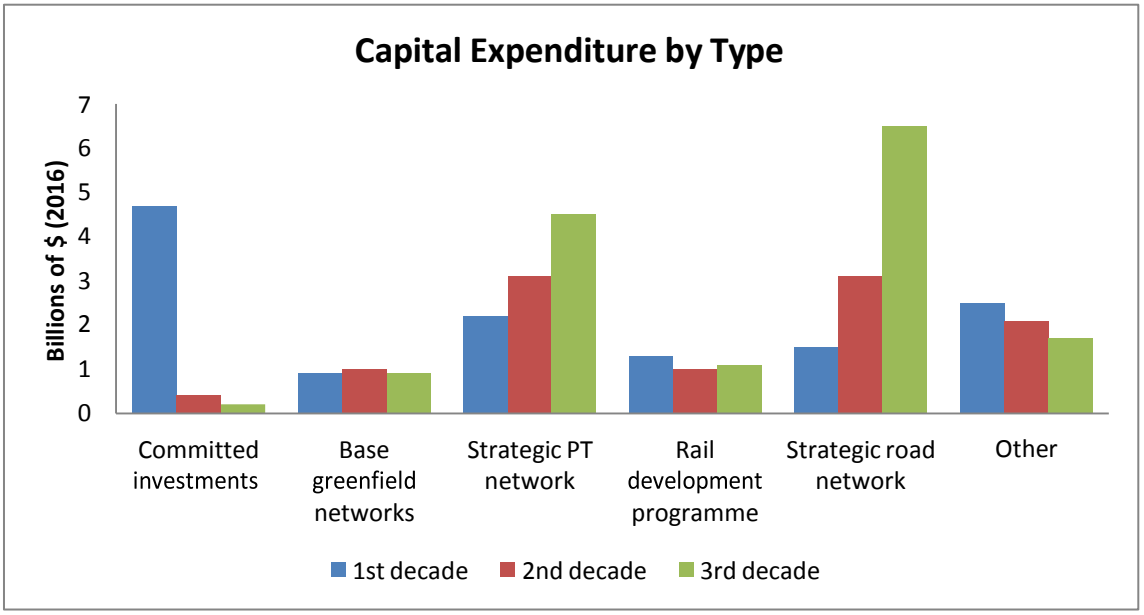


Figure 5.2: Capital expenditure of Indicative Package (2016 – 2046)

Key interventions by time period

Most investments likely to occur in the next decade are already committed or partly committed. This includes the City Rail Link, Accelerated Motorway Package, the Puhoi to Warkworth extension of the Northern Motorway, East West Link and a number of other, smaller projects. The indicative priority of investment additional to current commitments is outlined in Table 5.1 below.

Table 5.1: Indicative Package key interventions by time period

Indicative priorities for major new investments		
Early Priorities (completion in decade 1)	**Medium Term Priorities (completion in decade 2)**	**Longer Term Priorities (completion in decade 3)**
• Northwestern Busway (Westgate to Te Atatu section) • Address bottlenecks on Western Ring Route (SH20 Dominion Rd to Queenstown Rd) and Southern Motorway (Papakura to Drury) • New or upgraded arterial roads to enable greenfield growth in priority areas • Protect routes and acquire land for greenfield networks • Complete SH16 to SH18 connection • Early Rail Development Programme priorities • Upgraded eastern airport access (SH20B) • Investments to enable smarter pricing • Increased investment in Intelligent Network Management • Progress advance works on medium-term priorities	• Continued investment to enable greenfield growth • New strategic roads to Kumeu and Pukekohe • Implementation of mass transit on isthmus and then to the Airport • Bus improvements Airport – Manukau – Botany • Improved access to Port/Grafton Gully • Northwestern busway extensions • Improve connection between East-West Link and East Tamaki • Penlink • Medium-term Rail Development Programme priorities	• Continued investment to enable greenfield growth • Southern Motorway improvements south of Manukau • Southwest motorway (SH20) improvements and improved northern airport access • Northern motorway widening • Waitemata harbour crossing improvements, including mass transit upgrade of Northern Busway • Longer term Rail Development Programme priorities

These early investments were identified following a prioritization using a prioritization framework (Table 5.2).

Table 5.2: Prioritisation framework

ATAP Investment Prioritisation Framework

The purpose of this framework is to agree relative priority of investments for development of an indicative package for the final deliverable.

Items	**Investments**	- Interventions will be grouped by priority area / deficiency focus into future 'investments', which are then prioritised. - Investments will be grouped logically based on the the strategic networks and known deficiency areas.					
	Interventions	- All interventions above $200m will be included. - Interventions relating to the strategic approach will also be included, such as pricing programme, demand management (HOT lanes park and ride etc), technology programmes, optimisation.					
Alignment with objectives	**Objectives**	**First decade focus**	**Targets deficiencies against objectives in first decade**				
	Enable Auckland's growth	Enable housing growth; particularly SHAs and greenfield growth in the northwest and south.	✓✓✓ Direct requirement for new housing in priority greenfield areas (SHAs, Northwest and South).	✓✓ Enables and supports growth in priority greenfield areas (SHAs, Northwest and South).	✓ Enables and supports growth or intensification enabled by the unitary plan.	- Does not support areas identified.	* If an investment detracts from an objective.
	Employment accessibility	Improve employment accessibility; particularly from west and south.	✓✓✓ Addresses AM peak accessibility from the west.	✓✓ Addresses AM peak accessibility from the south, or to city centre, airport, or Westgate / Whenuapai.	✓ Addresses AM peak accessibility in other areas.		
	Congestion	Address severe congestion on the strategic road network, particularly in the interpeak period.	✓✓✓ Impacts areas with: - AM peak V/C ratios > 1.0 - Interpeak V/C ratios > 0.9	✓✓ Impacts areas with: - AM peak V/C ratios > 0.9 - Interpeak V/C ratios > 0.8	✓ Impacts areas with: - AM peak V/C ratios > 0.8	- Impacts areas with: - AM peak or interpeak V/C ratios < 0.8	
	Increase PT mode share	Increase peak person throughput on high volume corridors with targeted PT investment	✓✓✓ Increases PT capacity on corridors with 2-hour AM peak volumes > 10,000 persons.	✓✓ Increases PT capacity on corridors with 2-hour AM peak volumes > 5,000 persons.	✓ Increases PT capacity on corridors with 2-hour AM peak volumes > 2,000 persons.	- Does not increase PT capacity.	
	Overall alignment to objectives	**High** (total score more than ~8)		**Medium** (total score more than ~4)		**Low** (total score of less than or equal to ~4)	
Benefits Evaluation of potential investment benefits	**Measures of potential benefits**	**Indicator**		**Source**		**Method**	
	Amount of housing enabled	Expected growth in number of households		TFUG business case, modelling inputs and FULSS.		This measure applies only to base TFUG networks. Compare before and after housing figures in 2028 and 2048.	
	AM peak throughput	Expected change in AM peak person throughput (PT and road)		Evidence from package evaluation in ATAP Rounds 1, 2 and 3.		Agree key corridors for each investment. Compare forecast impact on key corridor(s) in 2026 between common elements and ATAP package tests.	
	Corridor AM peak speed	Expected change in AM road speeds		Evidence from Rounds 1, 2 and 3 package evaluation. Supplemented by information from projects.		Agree key corridors for each investment. Compare forecast impact on key corridor(s) in 2026 between common elements and ATAP package tests.	
	Corridor interpeak speeds	Expected change in interpeak road speeds		Evidence from Rounds 1, 2 and 3 package evaluation. Supplemented by information from projects.		Agree key corridors for each investment. Compare forecast impact on key corridor(s) in 2026 between common elements and ATAP package tests.	
Estimated cost	**Estimated range as developed for projects**	- Cost information will be sourced from projects where possible.					
	Overall relationship of potential benefit and costs	**High**		**Medium**		Low	
Strategic and project considerations	**Consistency with strategic approach**	Considerations include: - logical sequence to strengthen the strategic roading and public transport networks - whether this investment is sensitive to pricing or technology - sensitivity of an investment to potential changes in land use assumptions					
	Existing project evidence	Evidence on projects will be used including expected impact on deficiencies as well as other data on BCRs, effects on resilience, safety, freight, etc.					
Relative priority	**Reasons for recommendation**	This will be a statement outlining the assessment, based on the evidence presented on alignment with strategic objectives, potential benefits, costs, consistency with strategic approach and existing project evidence.					
	Priority	Bands of priority classified as high / medium / low					

5.2 Key Findings

Travel Patterns

The following is contextual information of projected travel patterns in relation to the Indicative Package, compared to the APTN.

Average trip time in the AM peak is projected to decrease from 2026 with the introduction of smarter pricing, and to plateau between 2036 and 2046 (Figure 5.3). In comparison, the APTN starts off with a lower average trip time which increases in 2026 to a higher level than the Indicative Package and plateaus between 2036 and 2046.

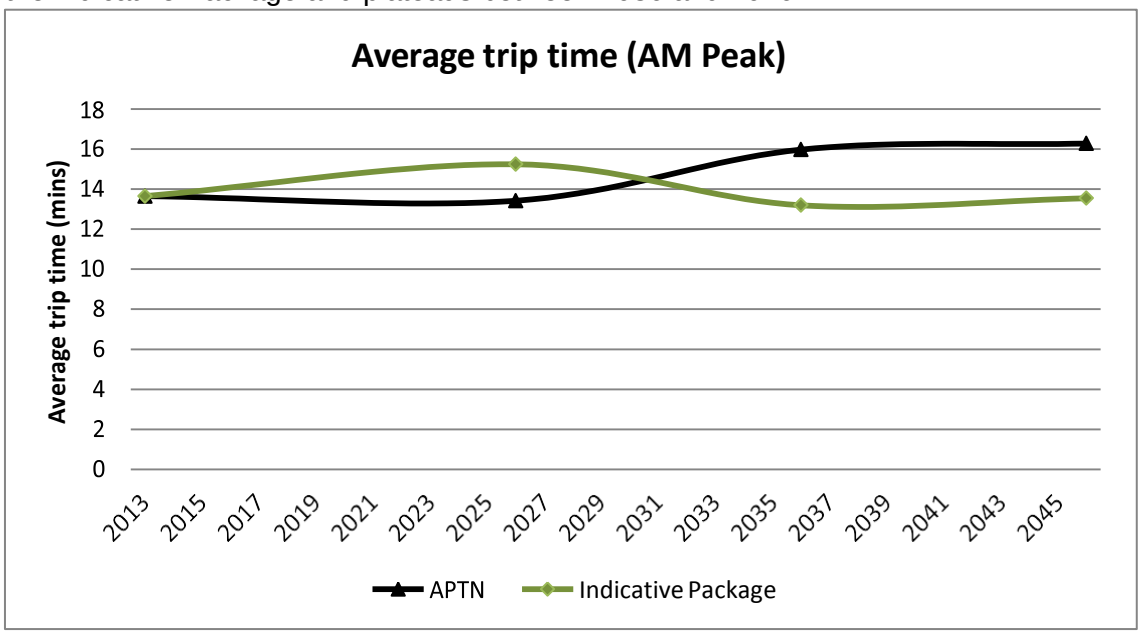


Figure 5.3: Average trip time during AM Peak (minutes)

A significant decrease in average trip length in the AM peak is projected under the Indicative Package, particularly between 2026 and 2036 (Figure 5.4). As smarter pricing is introduced, some trips during the peak period shift to other modes or other times. After 2026, average trip length evens out under the APTN and increases by 1km between 2036 and 2046.

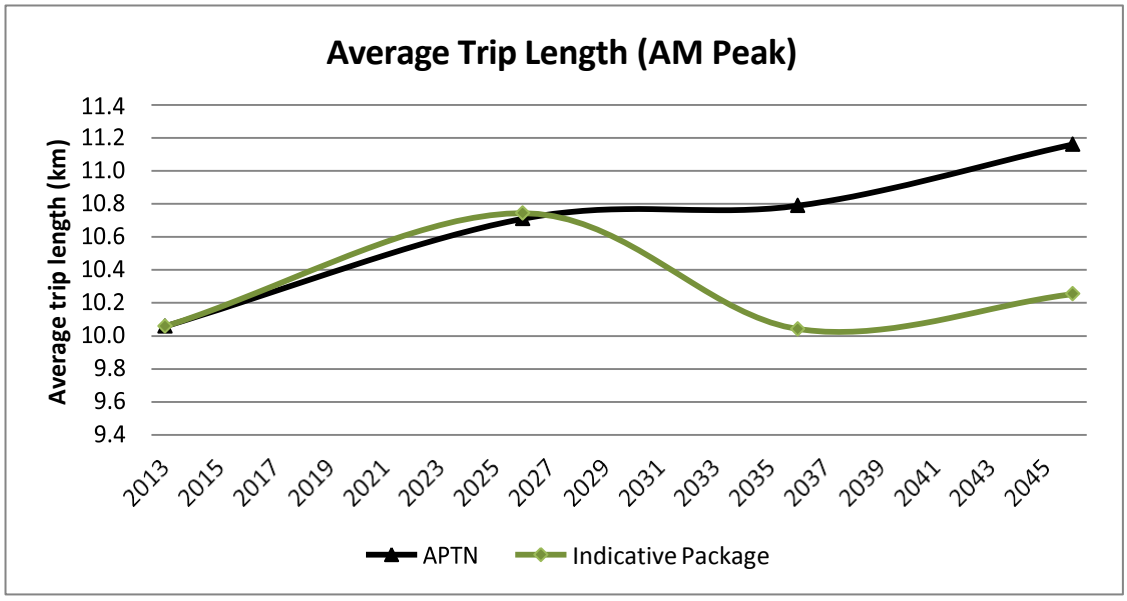


Figure 5.4: Average vehicle trip length during AM Peak (km)

A 3% reduction in the number of car trips taken in the AM peak is projected under the Indicative Package compared to the APTN, starting from 2036 when smarter pricing is in place (Figure 5.5). The number of public transport trips is projected to increase by 11% in 2036 under the Indicative Package.

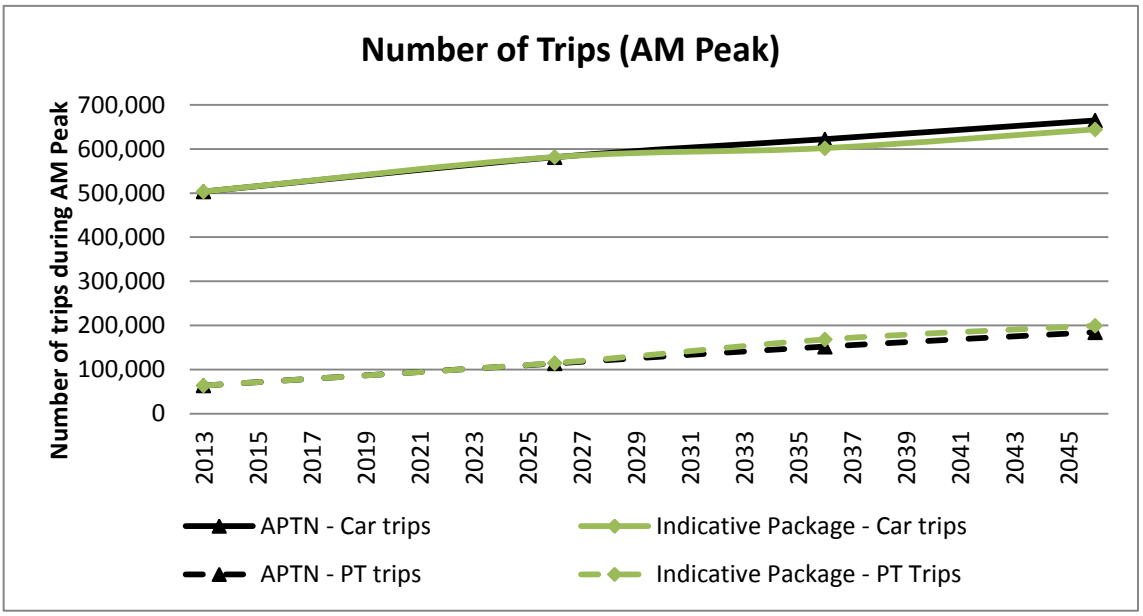


Figure 5.5: Number of trips during AM Peak by car and public transport (Indicative Package and APTN)

As a result of smarter pricing, there is a 10% decline in daily and peak vehicle kilometres travelled under the Indicative Demand compared to the APTN in 2036 (Figure 5.6).

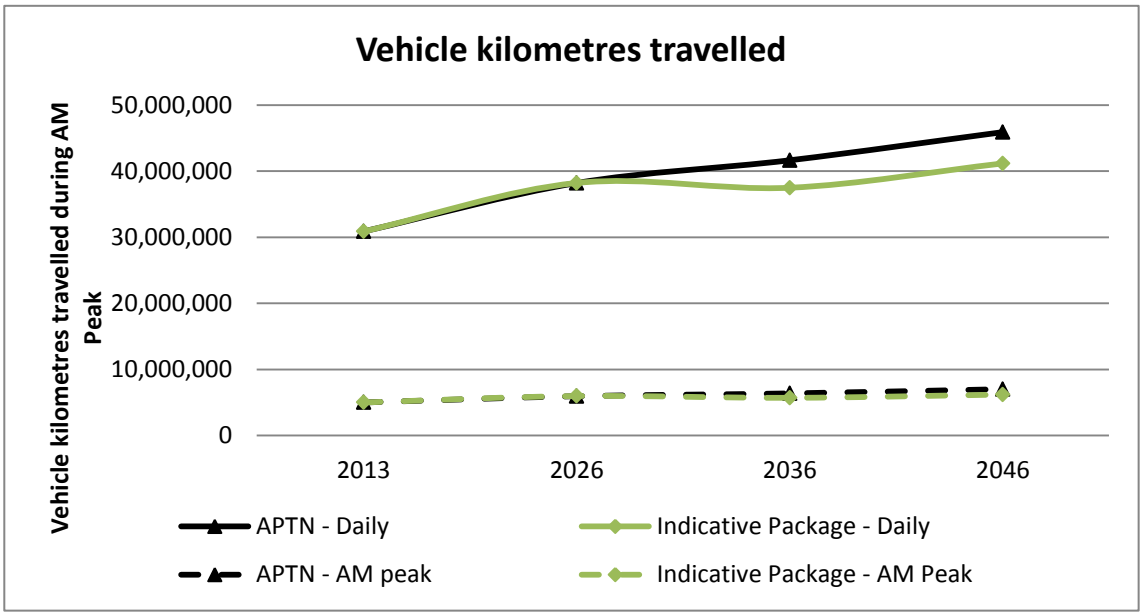


Figure 5.6: AM peak and daily vehicle kilometres travelled (km)
(Indicative Package and APTN)

Accessibility

Accessibility to employment by car under the Indicative Package is projected to significantly increase in the second decade in response to the implementation of smarter pricing. Additionally, third decade investment in the Indicative Package is projected to further increase car accessibility (Figure 5.7).

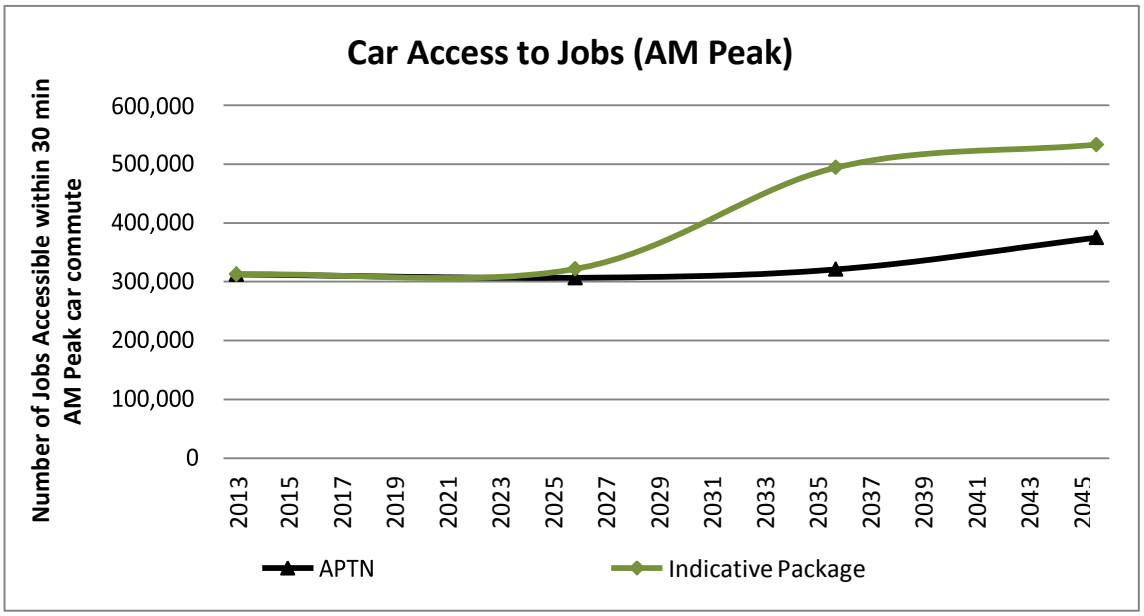


Figure 5.7 Car accessibility to jobs within a 30 minute car commute AM peak (Indicative Package and APTN)

Public transport accessibility is projected to be similar to the APTN (Figure 5.8). However, projections indicate slightly higher public transport accessibility than the APTN while providing for significant growth in public transport use.

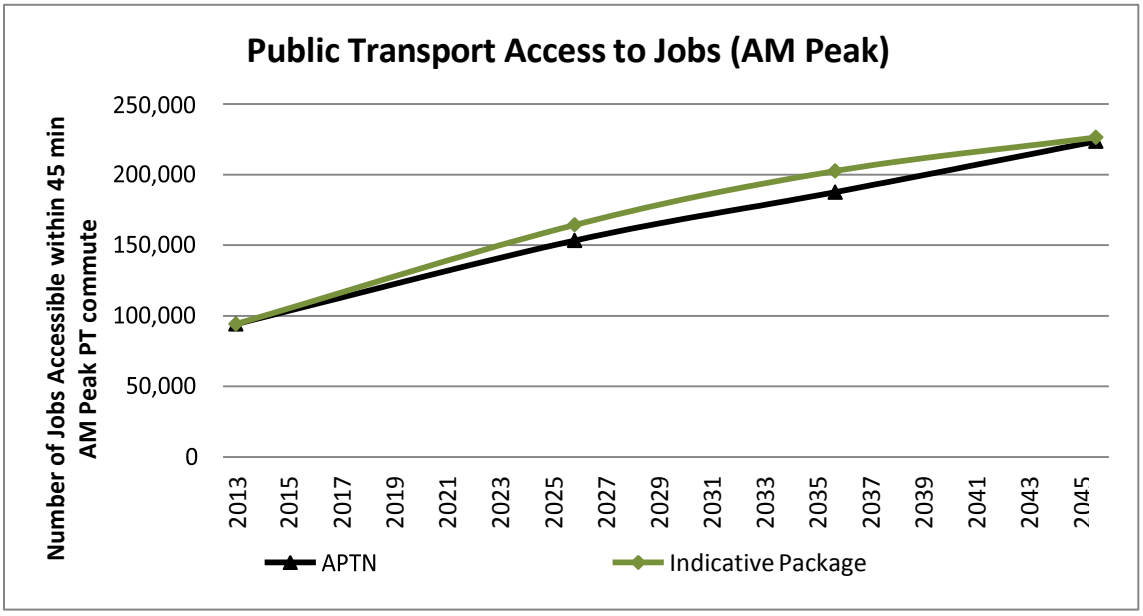


Figure 5.8: Public transport accessibility to jobs within a 45 minute PT commute AM peak (Indicative Package and APTN)

At a sub-regional level, there is a dramatic improvement to car access after 2026 under the Indicative Package as a result of the introduction of smarter pricing (Figure 5.9). Accessibility improves across the region, most particularly in the northwest, North Shore and parts of the south.

Car accessibility improves compared to the Base Network in 2026 particularly for areas outside of the isthmus. The Indicative Package highlights improved car accessibility from the peripheral areas of Auckland, due to motorway improvements to the outer motorway network.

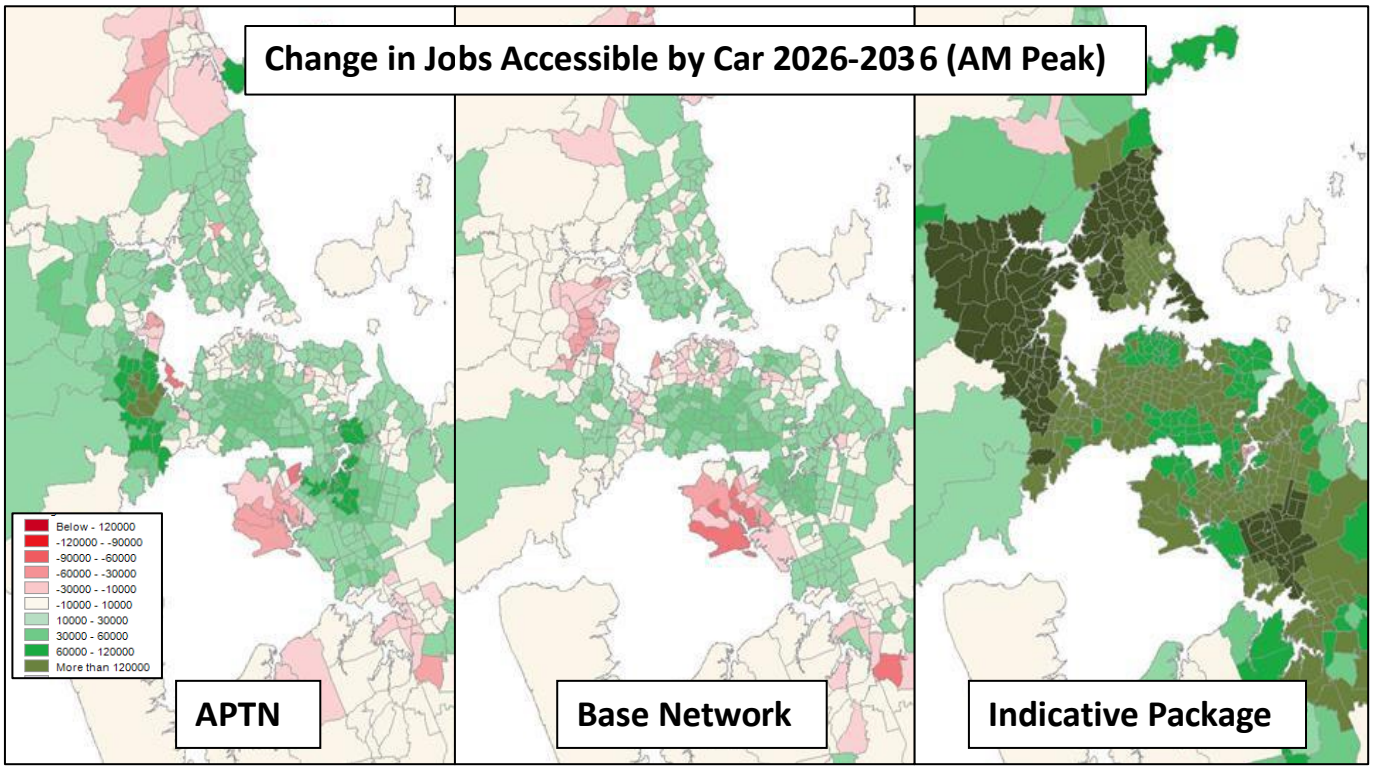


Figure 5.9: Change in car accessibility to jobs AM peak 2026 - 2036 (Indicative Package, APTN and Base)

Despite the increase in public transport use, public transport accessibility also improves in parts of Auckland after 2026 as a result of additional investments, although to a lesser extent compared to car accessibility (Figure 5.10). In particular, improvements are seen in the northwest, parts of the isthmus and parts of the southeast. Projects that would have improved travel times include extensions to the Northwestern Busway, mass transit from the Airport to the city centre, and bus improvements from Airport to Botany.

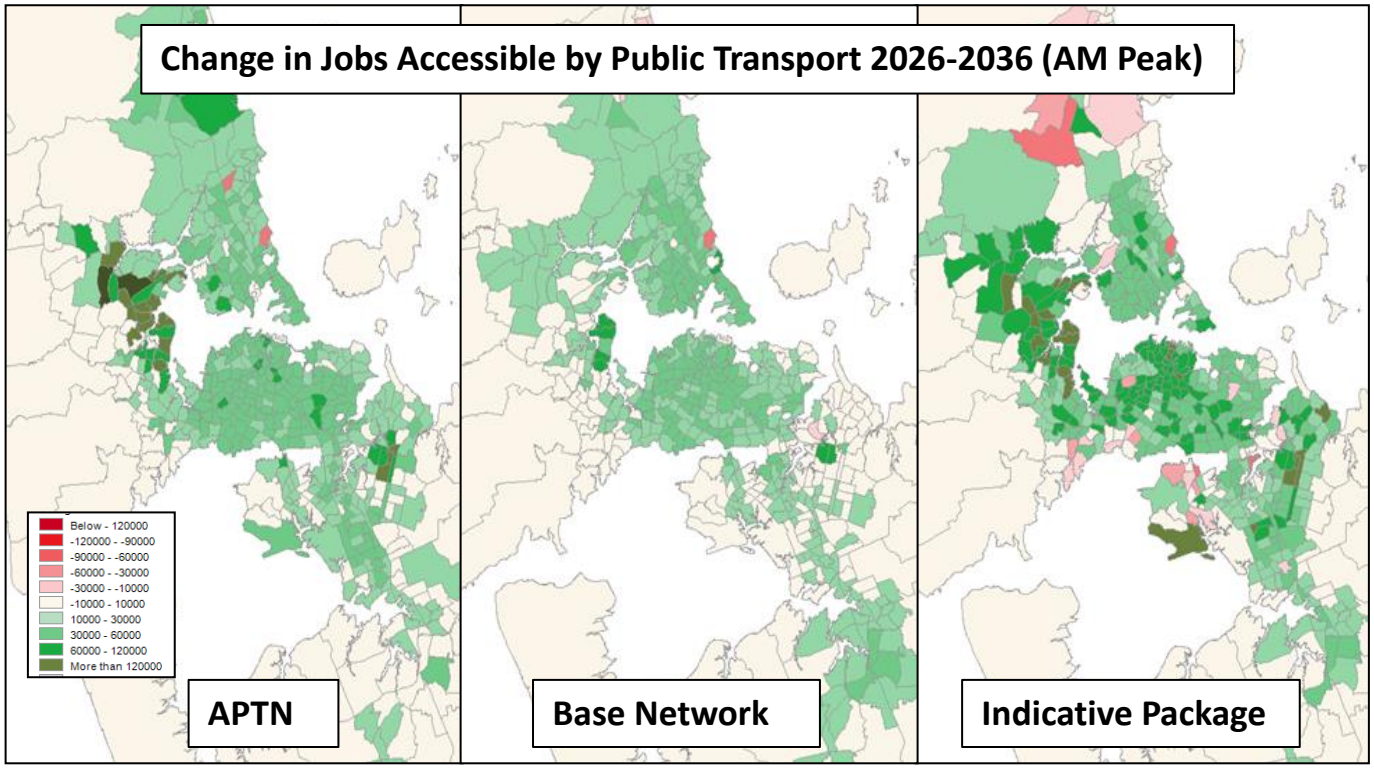


Figure 5.10: Change in PT accessibility to jobs AM peak 2026 - 2036 (Indicative Package, APTN and Base)

Accessibility by sub-region

West:

Car accessibility is projected to get worse in the first decade for both packages, and only just fully recovers by 2046 under the APTN (Figure 5.11). In the Indicative Package, the introduction of smarter pricing is very effective - bringing almost an additional 250,000 jobs within reach of a 30 minute car commute.

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

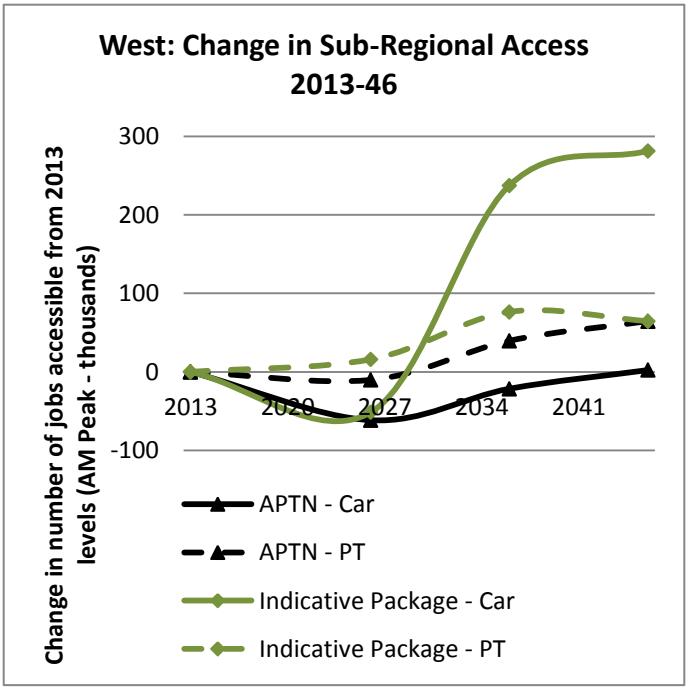


Figure 5.11: Change in sub-regional access to jobs from West Auckland AM peak (APTN and Indicative Package)

South:

The APTN results in poorer access over the first decade and minimal accessibility improvements over the next 30 years for either car or public transport (Figure 5.12).

Under the Indicative Package there is a marked improvement in car accessibility in the second decade, driven by the implementation of pricing. However, public transport access in the south remains low under the Indicative Package, barely increasing at all over time.

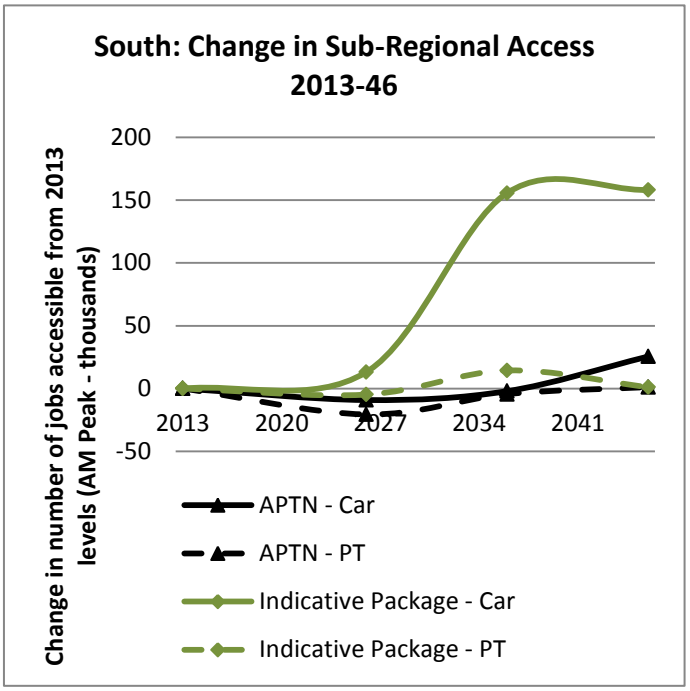


Figure 5.12: Change in sub-regional access to jobs from South Auckland AM peak (APTN and Indicative Package)

North:

Car accessibility for both packages does not improve in the first decade (Figure 5.13). Subsequently, the introduction of smarter pricing significantly improves car access, which is continued to a minor extent in the third decade by construction of a new harbour crossing.

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

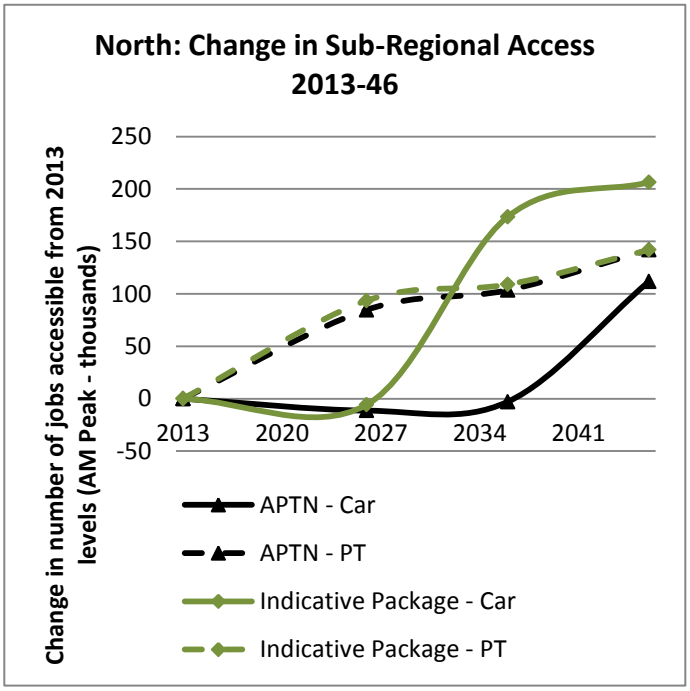


Figure 5.13: Change in sub-regional access to jobs from North Auckland AM peak (APTN and Indicative Package)

Central:

Both car and public transport accessibility steadily increase throughout the 30 year period under the APTN, reflecting the large growth in employment projected in central Auckland (Figure 5.14).

The Indicative Package provides a much greater increase in car accessibility in the last two decades.

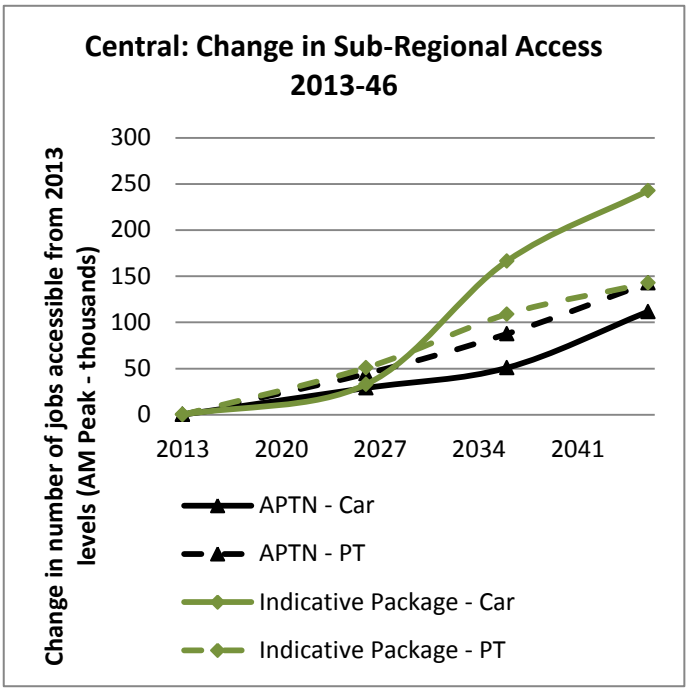


Figure 5.14: Change in sub-regional access to jobs from Central Auckland AM peak (APTN and Indicative Package)

Congestion

The Indicative Package addresses congestion to a greater extent than the APTN. The proportion of travel time in severe congestion during the morning peak, across the whole transport network, is projected to decline from 27% to 21% over the next 30 years (Figure 5.15). This mainly arises due to progressively implementing smarter pricing rather than increasing the level of investment in infrastructure.

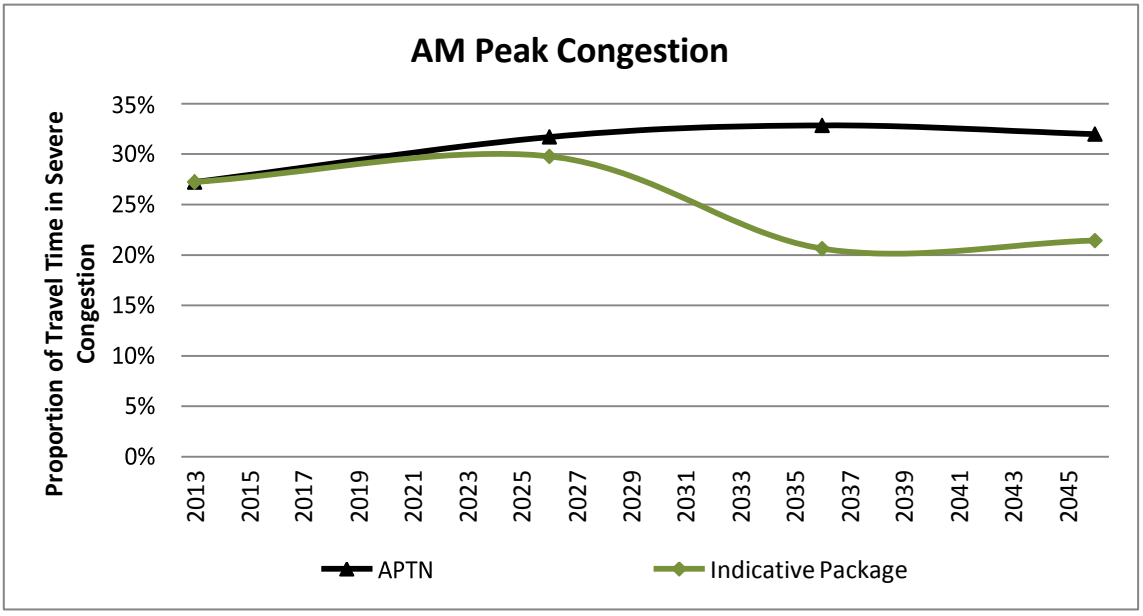


Figure 5.15: AM peak severe congestion (Indicative Package and APTN)

Projected inter-peak congestion shows similar trends, with the introduction of smarter pricing holding congestion at around 2013 levels over the next 30 years, despite population and employment growth (Figure 5.16).

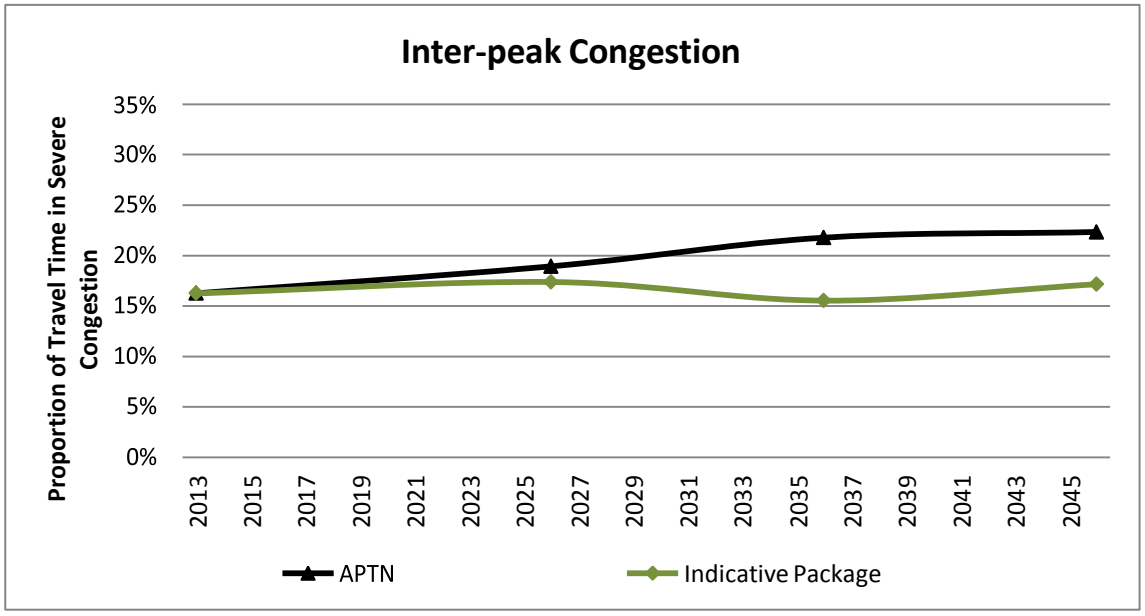


Figure 5.16: Inter-peak severe congestion (Indicative Package and APTN)

Freight congestion is projected to remain at similar levels between 2013 and 2026 under the Indicative Package, after which it reduces significantly between 2026 and 2036 before increasing slightly up until 2046 (Figure 5.17). In comparison, freight congestion increases steadily under APTN until 2036 before reducing, with congestion levels in 2046 remaining higher than 2013.

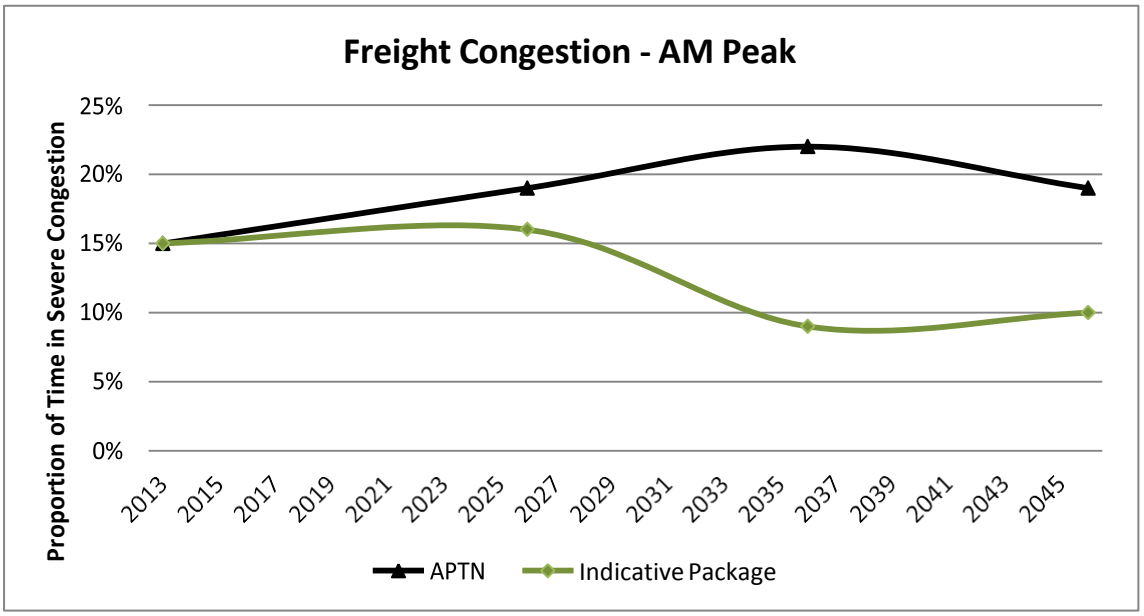


Figure 5.17: Freight AM peak severe congestion (Indicative Package and APTN)

The proportion of time spent in severe congestion for freight during the inter-peak remains significant, though lower compared to the AM peak. After 2026, congestion on the freight network reduces slightly under the Indicative Package and increases sharply under the APTN. After 2036, inter-peak freight congestion increases slightly under the Indicative Package and

reduces under the APTN.

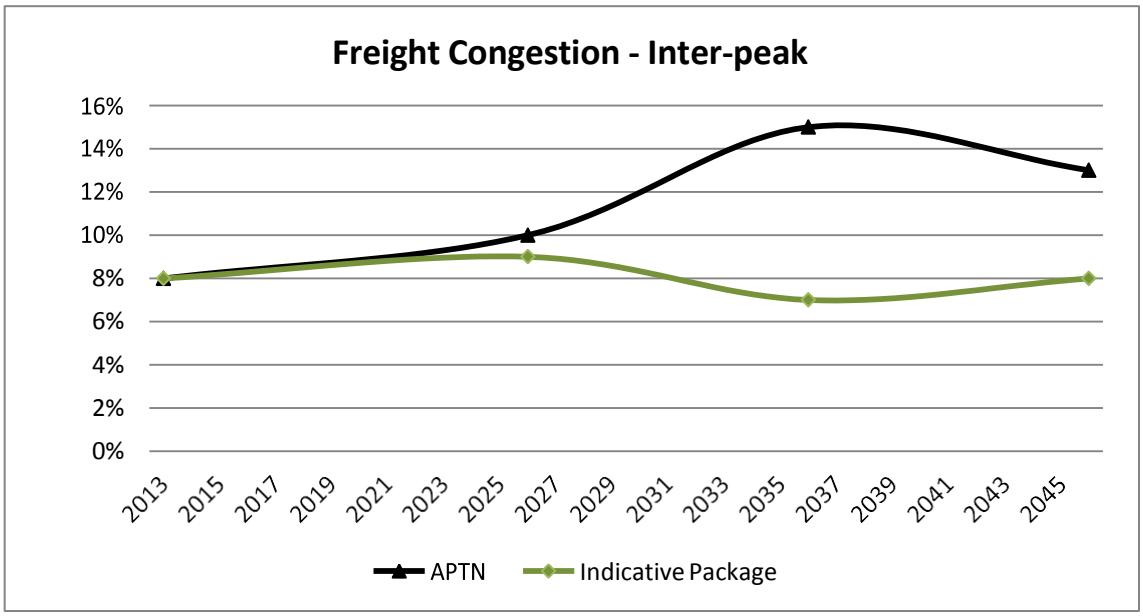


Figure 5.18: Freight inter-peak severe congestion (Indicative Package, APTN and ATAP Baseline)

At a sub-regional level, there are less capacity constraints during the AM peak in the Indicative Package network, compared to the APTN, as illustrated in more detail in the following volume to capacity plots (Figure 5.19).

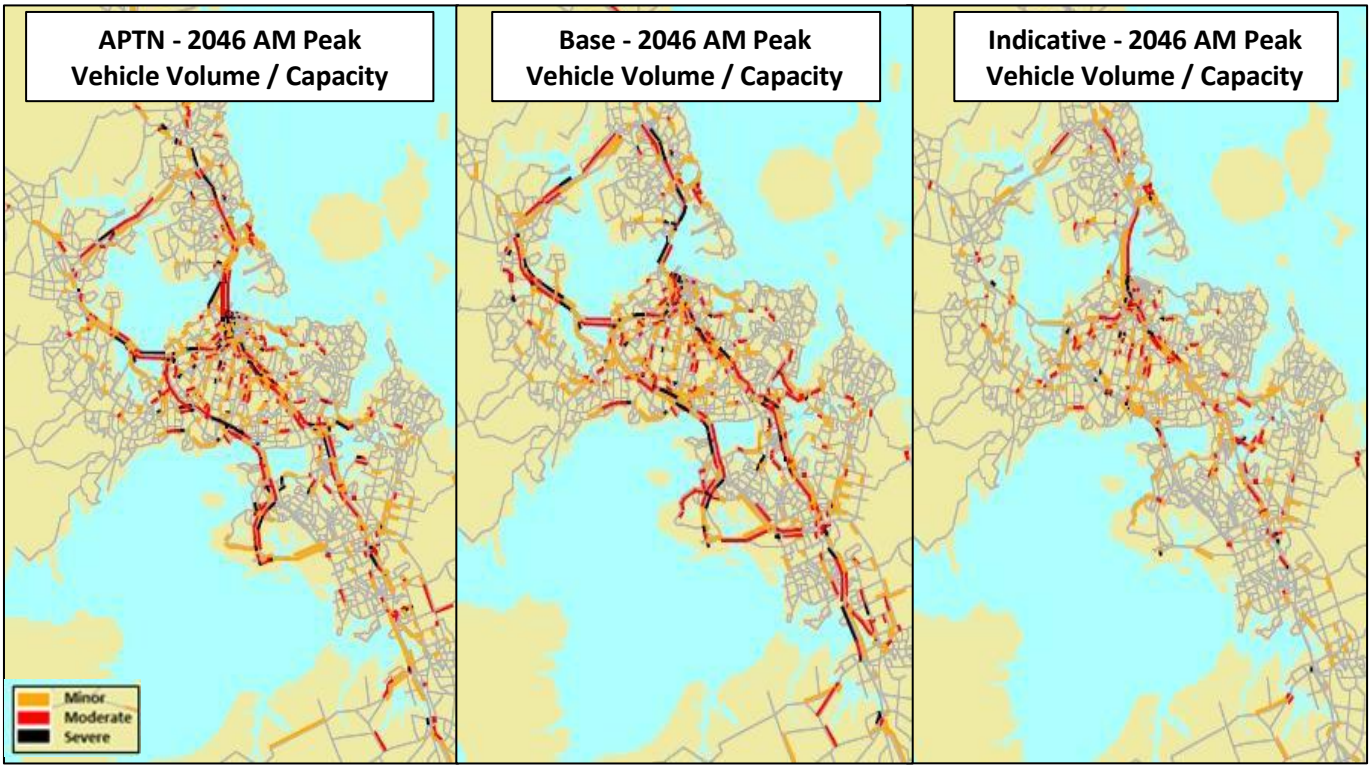


Figure 5.19: AM peak vehicle volume to capacity 2046 (Indicative Package, APTN and ATAP Baseline)

While some pinch points remain under the Indicative Package, most of the network is projected to operate below moderate or severe levels in 2046. In contrast, under the APTN much of the transport network, particularly the motorway network, is projected to experience moderate or severe congestion during peak periods (and increasingly during the inter-peak). With the Indicative Package severe congestion in the inter-peak is reduced to isolated pockets (Figure

5.20).

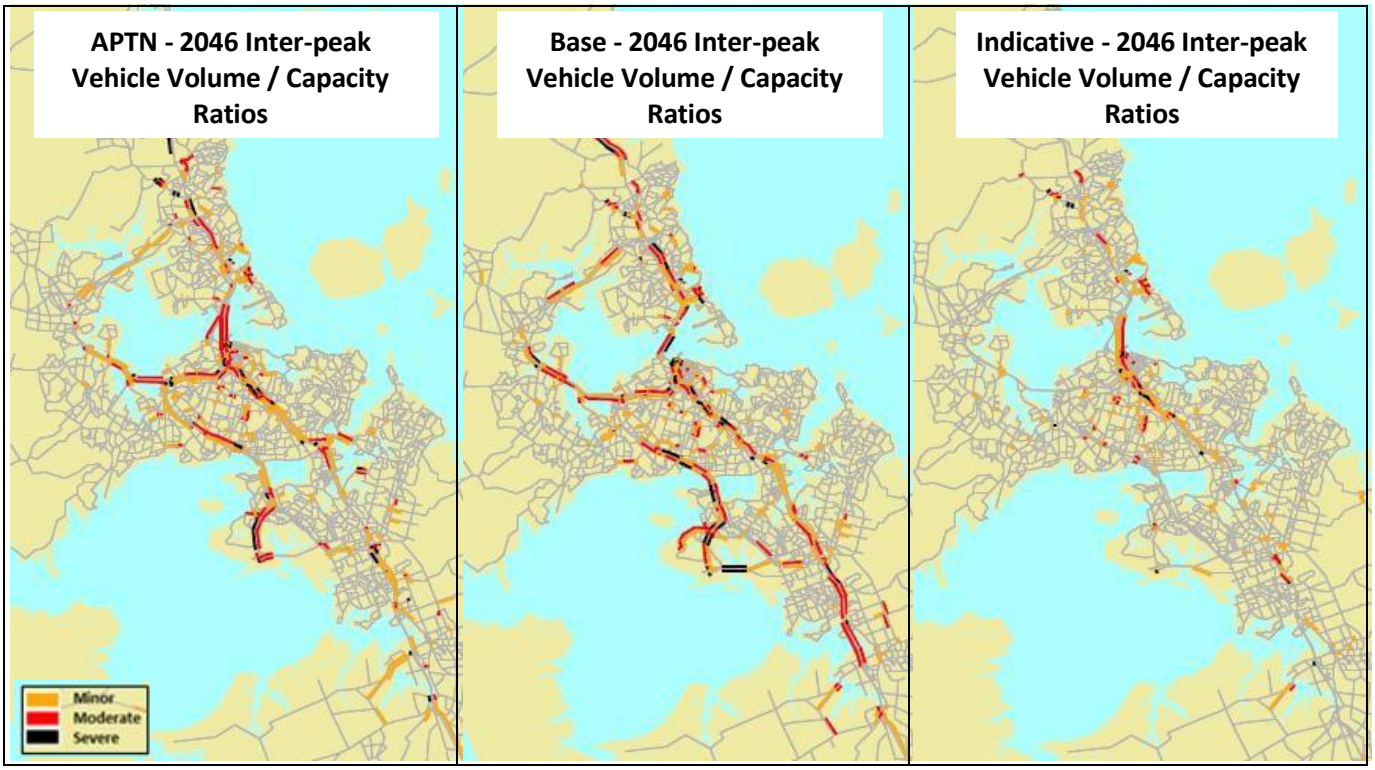


Figure 5.20: Inter-peak vehicle volume to capacity 2046 (Indicative Package, APTN and ATAP Baseline)

Public Transport Mode Share

The Indicative Package increases public transport mode share for all trips in the morning peak from what is projected to occur under the APTN. Between 2013 and 2026, the Indicative Package achieves similar levels of public transport mode share in the AM peak as APTN (Figure 5.21). After 2026, public transport mode share continues to increase under the Indicative Package. Mode share also increases under APTN, although at a slower rate.

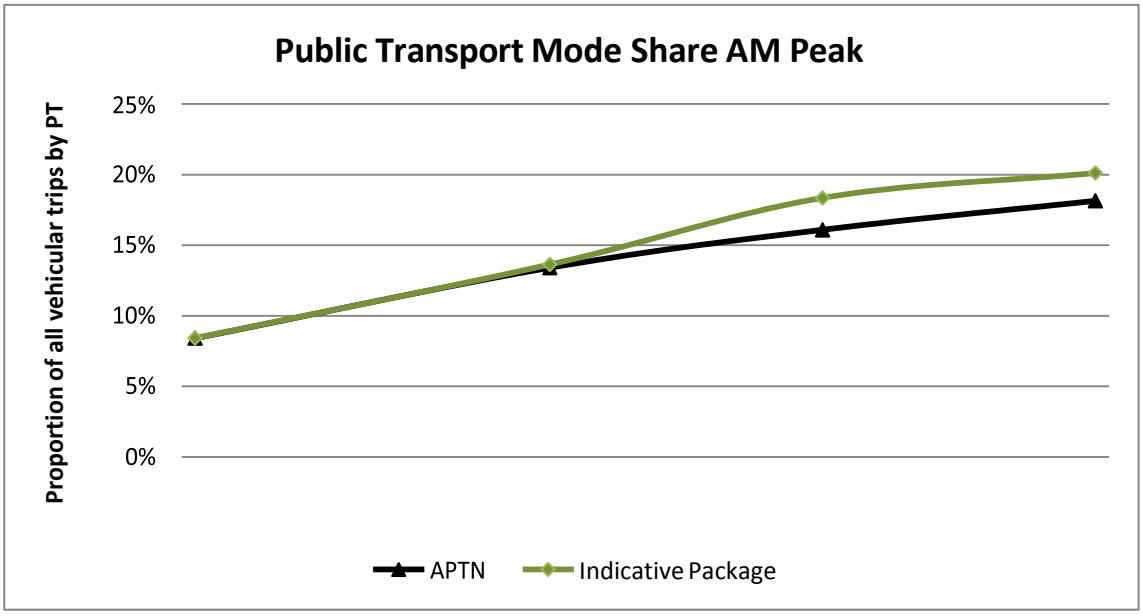


Figure 5.21: Public transport mode share AM peak (Indicative Package, APTN and ATAP Baseline)

Approximately a third of vehicular journeys to work (trips to employment either by public transport or private vehicle) in the morning peak are projected to be taken by public transport by 2046 under the Indicative Package, compared with 29% under the APTN. Combined with population growth, this growth in public transport mode share is projected to increase annual boardings from 83 million (in the year to July 2016) to around 265 million over the next 30 years.

While pricing has reduced demand for the roading network, it is projected to substantially increase demand for public transport services. The additional investment to public transport infrastructure over and beyond that allocated under Influencing Demand has reduced some constraints on the public transport network (Figure 5.22). However, demand on the bus RTN continues to exceed capacity at parts of the network, particularly along the Northwestern Busway and key isthmus corridors, indicating the need for further services or investment. On the other hand, capacity to the Airport, North Shore and southeast improves compared to the Base Network as a result of the inclusion of mass rapid transit in those areas.

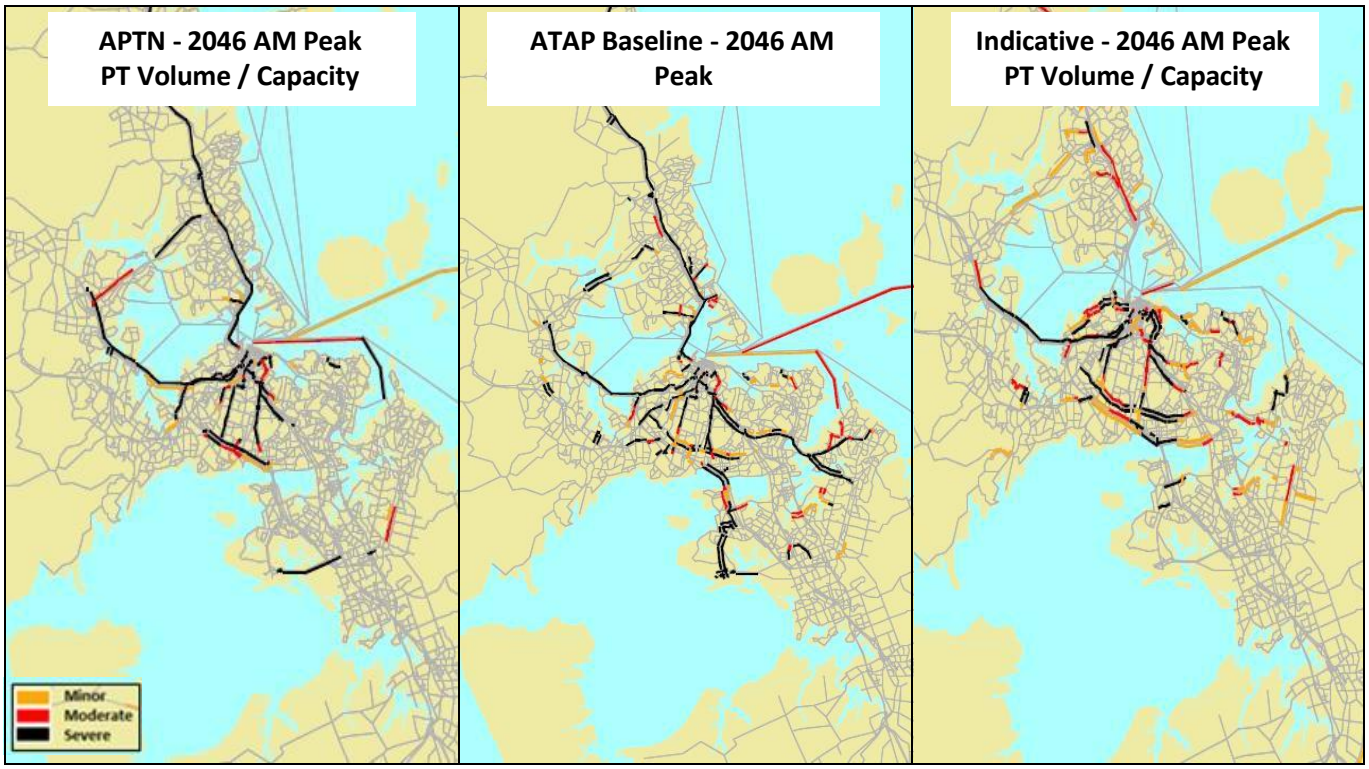


Figure 5.22: Public transport volume to capacity AM peak 2046 (Indicative Package, APTN and ATAP Baseline)

Net Benefits to Users

"Net benefits to users" was estimated because the Indicative Package increases the financial costs of motorists using the transport system, depending on time of day and the route taken. The same variable network pricing system was used in the Indicative Package as was used in the Influence Demand package (Table 4.2).

Motorists receive a benefit from the improved network performance (in terms of shorter travel times and lower vehicle operating costs) but also face increased costs from having to pay the smarter pricing. The estimated difference between those benefits received and the smarter pricing costs are set out in Figure 5.23 below.

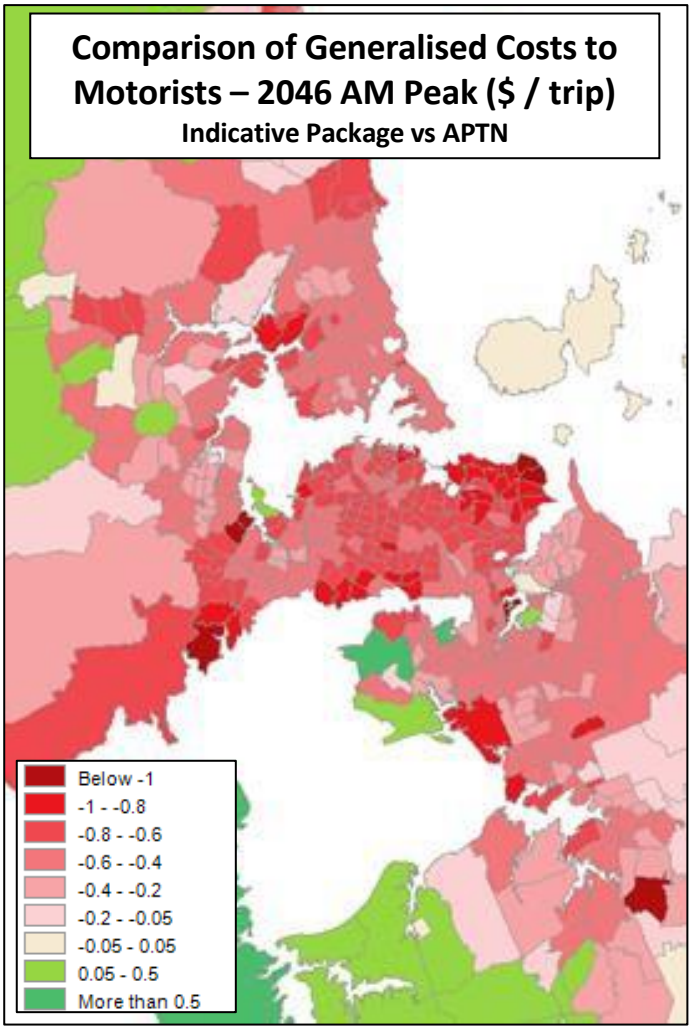


Figure 5.23: Generalised costs to road users AM peak 2046 (Indicative Package vs APTN)

The above calculations do not take into account the wider benefits that users of the transport system would gain from increased accessibility and reduced congestion. However, these findings should be treated with caution. This is a necessarily coarse approximation of how pricing might be applied, which means that some uncongested roads were subject to the same charge as congested routes. Furthermore, our analysis did not consider the likelihood that some users would place a much higher value on time savings than others. Further work, using much more detailed analytical tools, is required to identify efficient pricing levels which effectively address these issues.

As shown in the previous sections, our analysis suggests moving to smarter transport pricing would deliver very material gains in accessibility and reductions in severe congestion.

We expect that more detailed development and analysis will go a long way towards ensuring overall net user benefits from the introduction of pricing. Prices could be adjusted to lower levels and at a finer-grain (e.g. on uncongested counter-peak motorways). With better information, prices could also take into account the impacts on users with different values of time.

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

Value for Money

The project's Terms of Reference require consideration of the costs and benefits of alternative combinations of interventions and whether better returns can be achieved from transport investment than current plans. Value for money is normally assessed through cost benefit analysis, which compares the level of benefits against the size of an investment.

The Indicative Package has an estimated $38.6 billion capital expenditure programme over 30 years (excluding renewals) which is projected to result in significantly higher contributions to the ATAP objectives compared to the APTN, but with a larger capital improvement programme and a higher average cost to motorists.

The Indicative Package is projected to result in a higher proportion of jobs accessible by motorists of 60% (compared to 43% in the APTN), a similar proportion of jobs accessible by public transport of 25% (compared to 24% in the APTN), a significantly lower proportion of travel time in severe congestion of 21% in severe congestion in the morning peak (compared to 32% in the APTN) and a moderately higher public transport mode share of 20% in the morning peak (compared to 18% in the APTN).

In assessing value for money, large differences between benefit-cost estimates at a 'package-wide' level and at a 'project' level became clear. In particular, more refined project level analysis appeared to capture project benefits to a much greater degree than the package-wide analysis. Table 5.3 below identifies the indicative benefit cost ratios of some of the key projects identified for the first decade which supports that conclusion.

Table 5.3: Indicative Benefit Cost Ratios of 1st Decade Projects

Project	BCR	Comments	Source
Existing Commitments			
SH1 Northern Corridor Improvements	3.0	BCR includes busway extension to Albany	NZTA
SH1 Southern Corridor Improvements	6.0-9.0	BCR range depends on the growth scenario used	NZTA Board Paper – March 2015
East West Link	1.9		NZTA
Cycle sea path (AHB to Akoranga)	3.8		NZTA
Puhoi To Warkworth	1.1		NZTA
Major Projects in Indicative Package			
SH20B	1.2	Overall Southwest Auckland and Airport Corridor programme	
TFUG South Northwest North Warkworth Total	 3.5-3.7 2.2-3.4 3.2-3.7 1.1 3.1-3.6	Preferred Programme compared with Do Minimum	TFUG draft Programme Business Case
North-western Busway	1.4	Westgate – City = 1.4 Westgate –Waterview = 1.2 Waterview – City = 1.9	NZTA
Mill Road (Northern section)	2.2	For northern section only	June 2013 Scheme Assessment Report
AMETI - Entire programme	1.5	Includes AMETI Link Road, Reeves Road flyover as well as busway from Panmure to Botany	June 2015 - AMETI Overall Package and Individual Component Economic Evaluation (2015)

Limitations of the strategic modelling tools were considered to be the likely cause of this difference and therefore we did not rely on package-wide benefit cost assessment based on modelling outputs. There are a number of uncertainties associated with a shift to smarter transport pricing that will require further more detailed analysis. Further understanding is required of how users will respond to the smarter pricing, and the social and economic consequences of those responses. Current analytical tools do not enable more detailed socio-economic segmentations in order to have more detailed economic and equity assessments of road pricing. Our analytical tools are not calibrated to assess the detail of a potential pricing system because of the following:

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

Updated and more sophisticated analytical tools, with a particular focus on models that enable better testing of behavioural responses to pricing and technology changes, will be required to enable a more robust assessment of benefits and costs.

We focused on assessing the Indicative Package's value for money in the following ways:

- Ensuring identified 'early priorities' are likely to provide value for money if they are implemented over the next decade. Our prioritisation framework (Table 5.2) assessed the likely relative costs and benefits of major investments.
- A number of identified early priorities have existing value for money assessments indicating they deliver benefits that exceed their costs (Table 5.3).
- Analysis against our evaluation framework showed the Indicative Package will deliver better region-wide outcomes than current plans and significantly better results than a higher investment package that did not include smarter pricing (Table 5.4). This finding suggests that the inclusion of smarter pricing is key to achieving value for money.

Beyond these early priorities it becomes more challenging to assess value for money, as uncertainties relating to project costs, the location and quantum of growth, and the impacts of smarter pricing and new technologies become increasingly significant. Our most substantial uncertainty relates to large, longer-term infrastructure investments. The timing and scope of these investments should be monitored over time, particularly with regard to whether they provide value for money as we shift to a greater focus on influencing demand.

5.3 Full Evaluation Results

The following table presents the results of our evaluation of the Indicative Package against the evaluation criteria established in the Foundation Report (Table 5.4). All results relate to the 2046 year unless otherwise specified.

Table 5.4: Evaluation framework – headline measures

Objective	Measure	Headline KPI	Indicative Package	APTN	Comment in relation to Indicative Package
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30 minute trip in the AM peak • Jobs accessible by public transport within a 45 minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	533,000 i.e. 60% of available jobs 226,000 i.e. 25% of available jobs 656,000 i.e. 74% of available jobs	386,000 i.e.43% of available jobs 215,000 i.e. 24% of available jobs 590,000 i.e. 66% of available jobs	The Indicative Package significantly increases car accessibility (measured only in relation to travel time, not financial cost) in the morning peak (7-9 am) in 2046, with a moderate increase in accessibility by public transport. Car accessibility (measured only in relation to travel time, not financial cost) during the day is at similar levels in 2046 as in 2013.
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak	4 hours 8 minutes per person per annum 21.4% AM peak 17.2% inter-peak	13 hours 33 minutes per person per annum 31.9% AM peak 21.9% inter-peak	Forecast congestion on the road network is significantly better throughout the day, compared to the APTN.
	Impact on freight and goods (commercial traffic) congestion	Proportion of business and freight travel time spent in severe congestion on the strategic freight network (in the AM peak and inter-peak	10.1% AM peak 8.0% inter-peak	18.6% AM peak 12.9% inter-peak	Forecast congestion on the freight network is significantly better throughout the day, compared to the APTN.
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, inter-peak and PM peak.	9% AM peak 7% inter-peak 11% PM peak	19% AM peak 13% inter-peak 23% PM peak	Forecast reliability of travel times for motor vehicle trips is expected to be significantly better throughout the day, compared to APTN.
Increase public transport mode-share	Public transport mode share	Proportion of vehicular trips in the AM peak made by public transport	20.1%	18.0%	Forecast PT mode share is slightly higher than APTN.
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 9 km in the AM peak made by public transport	37.4%	31.7%	It is forecast that a higher proportion of longer commute trips would be by PT in the Indicative Package than APTN.
	Increase vehicle occupancy	• Average vehicle occupancy	-	-	It wasn't possible to model changes in vehicle occupancy. The input assumptions of 1.36 people per vehicle in the AM peak and 1.25 people per vehicle in the inter-peak remained constant for all packages and all model years. The Indicative Package includes programmes to increase vehicle occupancy.
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	-	Not applicable	Financial costs from a variable network charge (see pricing schedule in Table 4.2) are assumed to replace road user charges and fuel excise duties. Savings in travel time and vehicle operating costs vary by trip. This analysis requires better model/tools to provide robust quantification of benefits.
Ensure value for money	Value for money	Package benefits and costs	-	-	Package benefits include the improved contributions to objectives as measured in this table. The total cost of the 30 year programme is estimated as $84 billion (in 2016 dollars).

In addition to the project objectives, a number of other key outcomes have been evaluated through the evaluation framework in Table 5.5 below.

Table 5.5: Evaluation framework – other key outcomes

Other Key Outcomes	Measure	Headline Key Performance Indicator	Indicative Package	APTN	Comment in relation to Indicative Package
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	Approximately half the new bulk transport infrastructure required by FULSS in the Southern and NW greenfields areas is programmed to be in place by 2028. Approximately 20% in the North is programmed to be in place when required by 2038. Almost 100% in Warkworth is programmed to be in place when required by 2038.	Does not meet timeframes of FULSS.	Approximately half of major greenfield network projects are programmed to be in place in accordance with timeframes of the FULSS.
Minimise harm	Safety	• Deaths and serious injuries per capita and per distance travelled	-	-	Model forecasts can't accurately identify number of deaths and serious injuries.
	Emissions	• Greenhouse gas emissions	7.4 million kg of CO_2 per day	8.1 million kg of CO_2 per day	Model forecasts 9% fewer emissions in Indicative Package than APTN. This is mostly due to fewer trips and shorter distance of trips.
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog	The indicative package programme is expected to achieve higher levels of service than in 2016 and similar levels of service to the APTN. This clears any renewals backlog.	Similar to indicative package	The maintenance and renewals programme aims to achieve service levels that reflect the ONRC and AT's goal of attaining a network 'steady state' and achieve consistent levels of service across legacy networks.
Social inclusion and equity	Impacts on geographical areas	• Access employment in high deprivation areas • Distribution of impacts (costs and benefits) by area	Lower levels of accessibility by car and PT are forecast from high deprivation areas in the south and west, compared to the rest of the region. Generalised costs generally increase as a result of road pricing.	The Deficiency Analysis identified significantly lower levels of access in the south and west.	The indicative package has prioritised investment in the first decade to improve access from the south and the west. The evaluation working paper contains graphs showing the geographic impacts of the indicative package.
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network	-	-	The Indicative Package network has a similar level of network resilience to the APTN. Resilience is improved in the Indicative Package in the following ways: Firstly, pricing of the road network reduces vehicle kilometres travelled on the road network by about 10% which could result in less diversion and impact in the event of disruption to the road network. Secondly, there is greater capacity in the PT network. This enables PT to take additional people in the case of disruption. Optimisation of technology provides choice and information during a disruption. There are a similar number of additional crossings in the Indicative Package compared to the APTN.

5.4 Growth Assumptions

The Indicative Package has been evaluated based on medium growth assumptions, as set out in Table 5.6 below.

Table 5.6: Medium growth forecast assumptions for population and employment growth

	2013	2026	2036	2046
Population	1,471,108	1,871,614	2,064,205	2,279,341
Employment	618,152	722,932	808,839	892,457

A sensitivity test was also done in respect of the Indicative Package based on high growth assumptions, as set out in Table 5.7 below.

Table 5.7: High growth forecast assumptions for population and employment growth

	2013	2026	2036	2046
Population	1,471,108	1,889,795	2,208,823	2,508,634
Employment	618,152	751,628	865,491	982,217

An evaluation of the Indicative Package based on high growth assumptions was done in relation to the 2046 model year only (building on the previous sensitivity testing which indicated similar results at 2026 for previous packages). The projected results indicated worse network performance in terms of accessibility and congestion. An additional 9.2% increase in vehicle kilometres travelled corresponds with an increase from 21% to 24% of the proportion of time that cars spend in severe congestion in the am peak in 2046 under the Indicative Package. The inter-peak results are projected to worsen from 17% to 19% in 2046. The proportion of jobs accessible by car within 30 minutes in the am peak in 2046 is projection to be 60% under medium growth assumptions and 56% under high growth assumptions. Public transport mode share projections are virtually the same at 2046 under high growth and medium growth assumptions.

This limited analysis suggested that high growth over the next 30 years would result in reduced accessibility to jobs and higher levels of congestion, compared with medium growth forecasts.

5.5 Indicative Package Conclusions

The Indicative Package is projected to deliver substantially better outcomes against the key project objectives of access to employment, congestion and public transport mode share, when compared to the APTN. The most significant gains are increases to accessibility by car and reductions in peak congestion levels.

The Indicative Package also addresses some of the key sub-regional challenges facing Auckland, although some of the challenges remain. The west achieves the greatest improvement in employment access, with around 280,000 more jobs being accessible compared to the APTN in 2046. However, car access in the west declines in the first decade. In the south, the Indicative Package provides access to around 130,000 more jobs within a 30-minute car ride in the AM peak than the APTN. However, there is little improvement to public transport access in the south.

It is important to emphasise that the step-change in performance against these objectives is largely driven by the introduction of smarter transport pricing, which is assumed to be fully implemented in the second decade. Further analysis is required to assess the impacts of pricing on net user benefits in greater detail. More sophisticated analytical tools will be required to undertake this work before a viable scheme could be developed.

Appendices

Appendix A – Evaluation Framework

1. Introduction

The purpose of this paper is to record and explain the framework used to evaluate transport packages in the Auckland Transport Alignment project to enable a robust and transparent analysis of different transport investments.

This paper outlines how the returns from transport investment over the next 30 years will be assessed. It identifies the objectives and other key transport outcomes (section 2) and key performance indicators (section 3) in relation to those objectives and outcomes.

A full list of key performance indicators is set out at the end of this Appendix.

The evaluation framework will be used for three key tasks:

- Assessing the existing transport programmes to understand where further performance improvements are required and where improved value for money could be obtained.
- Assisting with the initial round of intervention packages where the focus is on understanding the strengths and weaknesses of each intervention, rather than how the interventions compare to each other.
- Assessing refined intervention packages where the focus is on comparing the relative merits of the different packages in achieving the project objectives.

2. Project Objectives

The project's Terms of Reference outline its objectives, with the key focus being to test whether better returns from transport investment (i.e. value for money) can be achieved in the medium and long-term, particularly in relation to the following:

i. To support economic growth and increased productivity by ensuring access to employment/labour improves relative to current levels as Auckland's population grows
ii. To improve congestion results, relative to predicted levels, in particular travel time and reliability, in the peak period and to ensure congestion does not become widespread during working hours
iii. To improve public transport's mode share [relative to predicted results], where it will address congestion
iv. To ensure any increases in the financial costs of using the transport system deliver net benefits to users of the system.

The project objectives alone will not achieve all the broad outcomes sought from transport investment. A number of other key transport outcomes and demand on transport expenditure, such as maintaining existing assets and providing a basic level of infrastructure to enable growth, will require significant investment over the next 30 years and also need to be taken into account in the evaluation process.

The following is an explanation of the above objectives and other key transport outcomes that a transport system is expected to contribute to.

2.1. Improve access to employment and labour

Transport networks support the growth, productivity and success of urban areas and their catchments, by getting people to work, supporting deep, diverse and productive labour markets and allowing businesses within the area to reap the benefits of agglomeration.

This objective focuses on improving access to employment and labour in order to support the ultimate objective of achieving economic growth and increased productivity. The workforce should have access to an increasing number of jobs and proportion of the region's jobs, taking into account an increase in population and jobs over the next 30 years. Similarly, employers should have access to an increasing number of workers and proportion of the region's labour pool, taking into account an increase in population over the next 30 years. Access, in terms of a reasonable travel time and cost, is the important factor relating to this objective.

If people have a higher number of jobs within a reasonable commute time, this will increase their likelihood of finding the most suitable job, make it easier to build on their skills and reduce their vulnerability to long-term unemployment if they lose their job. Similarly, employers with larger labour pools (a greater number of people within reasonable commute time of their location) have a greater likelihood of finding the most suitable employees. For highly specialised employment types, where productivity levels are highest, accessing larger labour pools becomes particularly important.

This objective also focuses on access between business areas during the day to improve productivity and enable Auckland to carry out its freight and service functions efficiently.

2.2. Improve congestion results

This objective aims to achieve better congestion results, compared to the projected level of congestion from previously proposed programmes. The objective requires consideration of a different mix of interventions in the transport system, taking into account projected growth, value for money, and impacts of future changes in technology and travel behaviours.

Some level of congestion is a by-product of a successful city and generally cities with very low levels of congestion are either relatively small or in decline. However, congestion adds significant costs to doing business and moving freight, can reduce accessibility and quality of life and is a key concern for Auckland's travelling public. Congestion also impacts on the reliability of travel, adding costs by forcing travellers to add extra time to their journey to allow for the potential of delay. Therefore, congestion will be measured not only in terms of delay but also the reliability of travel times.

There are many different definitions of congestion. For the purposes of this project, congestion is defined as 'severe congestion', where the flow of traffic breaks down, speeds

drop and stop-start-motoring begins[6]. This is also the point where traffic demand exceeds maximum practical capacity.

2.3. Improve public transport mode share where it will address congestion

This objective aims to achieve better public transport mode share from a transport package, compared to the projected public transport mode share from previously proposed programmes, where it will address congestion. The objective is focused on public transport use at times of the day and on parts of the network where there is congestion. The underlying assumption is that that people using public transport will not exacerbate congestion and therefore will have a positive impact on congested parts of the network.

Public transport carries a significant number of people efficiently along corridors of high demand, using space efficiently when compared to private vehicles. This attribute is particularly important in more intensive locations such as major centres where space is very valuable. Public transport trips are often focused at peak times to major centres of employment (especially the city centre) and are quite long – particularly trips on the rapid transit (rail and bus way) network.

Conversely, public transport often struggles as an attractive, cost-effective transport option in lower density areas, particularly when serving dispersed employment or low-intensity employment areas.

While the total mode share of public transport in Auckland is relatively small, this objective requires an examination of how public transport impacts on congestion.

2.4. Ensure increased financial costs deliver net user benefits

This objective assesses whether further charges to transport users in Auckland generate net benefits for those who will be paying the extra costs.

Policy interventions such as road pricing can achieve improved performance of the transport network through raising the financial cost of travelling, thereby influencing travel demand. It is important to weigh up the costs and benefits of pricing interventions to establish whether the additional costs of a road pricing charge are outweighed by the time savings benefit they provide.

2.5. Ensure value for money

The objective to ensure value for money relates to the overarching objective of the project to achieve better returns from transport investment, compared to forecast returns from current plans. Assessment of the intervention packages will need to demonstrate this outcome.

Developing, maintaining and operating the transport system has major costs – both public costs for Council and Government, and private costs for households and businesses. These costs have increased significantly over the last decade to address Auckland's growing transport demands. However, a decision to invest in upgrading Auckland's network imposes an opportunity cost for taxpayers, ratepayers and transport users. Investment made to

[6] In technical terms, this is Level of Service E, F or worse. It is assumed that reliability of travel times start to deteriorate on parts of the network where the volume to capacity ratio exceeds 0.9 (Source AECOM email 23/11/2015 and JMAC email 4/12/2015).

upgrade the network is money that cannot be invested to fund other government, council or individual priorities.

Assessing value for money will require understanding and measuring the total social benefits of a package of projects and ensuring they exceed the cost of the package. Achieving best possible value for money means that the package offers the greatest possible social benefits relative to its cost.

This project's objectives encompass the bulk of the social benefits that can be expected from transport projects. An understanding of how those objectives are met helps to understand the effects of a particular package of projects. This value for money measure reveals how the benefits stand in relation to the costs.

2.6. Other key outcomes

While the project is focused on the objectives outlined earlier, transport investment also contributes to a number of other important outcomes. These will be tracked to understand where achieving improved performance on the project's objectives may support or undermine achieving these other key outcomes. For example, it is important to ensure that interventions which may improve congestion or accessibility do not result in adverse safety impacts.

The following list of other key outcomes has been identified by the project team, based on long term outcomes contained in strategic planning documents such as the Government Policy Statement on Land Transport 2015 and the Auckland Plan. The Government Policy Statement highlights key focus areas of supporting economic growth and productivity, improved transport safety and ensuring value for money from investment. The Auckland Plan describes the key role of the transport system in facilitating liveability, economic growth and productivity is through creating better connections and accessibility within Auckland, across New Zealand and to the world.

- Support access to housing – Transport networks are expected to be in place to meet the demand for new housing in Auckland.
- Minimise harm – The transport programme is expected to avoid, reduce or mitigate the harmful impacts on people and the environment. Harm from the transport system includes risk of deaths and serious injuries, harmful emissions into the air, waterways and ecosystems, and negative impacts on heritage and communities.
- Maintain existing assets – It is expected that transport assets will be maintained and renewed at the optimal time to ensure a continued acceptable service to users of the transport system.
- Social inclusion and equity – The transport system is expected to be implemented with consideration of the fairness with which impacts (benefits and costs) are distributed and enable a cross-section of society to access everyday activities. This project will need to consider the distribution of benefits and costs arising from proposed interventions (not just those arising from an increase in financial costs as per the fourth project objective).
- Network resilience – The transport programme is expected to contribute to the resilience of the transport network in terms of its vulnerability to disruption and ability to adapt to disruption.

3. Evaluation criteria

This section outlines the indicators relating to the project objectives and other key outcomes. These form an evaluation framework which will be used to test existing and proposed transport intervention packages.

For each objective, measures and key performance indicators (KPIs) have been developed to enable evaluation. For each measure there are headline KPIs that will be reported on and will be used for analysis. Secondary KPIs are identified but may be reported on except where they significantly add value to informing key decisions. A small number of headline KPIs were identified in relation to each objective in order to provide meaningful and objective information that illustrates how well a package delivers on the objective.

Term	Working definition
Objective	What we want to achieve
Measure	How we will demonstrate achieving an objective
KPI	Extent to which we perform against a measure

The full evaluation framework comprises the headline KPIs and secondary KPIs is set out in Appendix A.

The project team will work through how the evaluation framework will be applied to the evaluation of packages. Broadly the intention is to use the information provided by the headline KPIs, and supporting KPIs where relevant, to inform judgements about how each package delivers against the objectives.

3.1. Improve access to employment and labour

This objective measures the extent to which Aucklanders have good access to employment opportunities, employers have good access to the labour pool and good access between businesses.

Measure 1: Access to employment and labour within a reasonable travel time	
Headline KPIs	**Explanation of how measured**
Jobs accessible by car within a 30 minute trip in the AM peak	This is calculated as the number of jobs that can be accessed from all different parts of Auckland within a 30 minute travel time by car in the AM peak. A 30 minute threshold for car trips has been used to broadly reflect existing average commute times in Auckland (approximately 25 minutes in the AM peak in 2014[7]) and a number of international cities as well as providing a good basis for comparing the impact of different interventions.
Jobs accessible by public transport within a 45 minute trip in AM peak	This is calculated as the number of jobs that can be accessed from all different parts of Auckland within a 45 minute travel time by public transport in the AM peak[8]. Travel time includes wait time and transfer penalties for transfers to a public transport service.

[7] MoT Household Travel Survey 2014

[8] It is commonly found in international research that the inclination to commute declines rapidly when commuting times exceed 45 minutes, regardless of gender, transport mode, and socio-economic factors (Sandow, E. and Westin, K Preferences for commuting in sparsely populated areas (2010) Journal of Transport and Land Use). Land use /employment patterns and transport are both expected to affect whether the current proportion of access to jobs across the region would remain the same or increase over time.

Measure 1: Access to employment and labour within a reasonable travel time	
Headline KPIs	**Explanation of how measured**
Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	This is calculated as an employment weighted average of jobs accessible from other jobs within a 30 minute car trip as a proportion of total jobs in the region. The inter-peak period is selected to differentiate commuter trips and to indicate the productivity of trips across the road network between business areas.
Supporting KPIs	**Explanation of how measured**
Proportion of jobs accessible within a 30 minute car trip in AM peak	This is calculated as a population weighted average of the number of jobs within a 30 minute travel time by car in the AM peak as a proportion of total jobs in the region.
Proportion of jobs accessible within a 45 minute public transport trip in AM peak	This is calculated as a population weighted average of the number of jobs within a 45 minute travel time by public transport in the AM peak as a proportion of total jobs in the region.
Average travel time by car or public transport in AM peak	This calculates the average travel time by car or public transport in the AM peak, which can be at the regional and sub-regional level. This helps to quantify the additional travel time to access jobs in the AM peak.
Access to specific origins and destinations e.g. City Centre and rest of region in AM peak	This uses the same calculation as the previous KPI, but differentiates access to/from the City Centre and the rest of the region. This could be further differentiated in terms of access to/from major centres and the rest of the region.

3.2. Improve congestion results

This objective measures the extent to which congestion results can be improved (relative to predicted levels of current plans) by different intervention packages. The measures and headline KPIs give strong consideration to travel time and reliability of travel time in the peak and inter-peak periods[9] as well as business trips caught in severe congestion on the network.

Measure 1: Impact on general traffic congestion	
Headline KPIs	**Explanation of how measured**
Per capita annual delay (compared to efficient throughput)	Annual per capita delay is calculated as the difference in travel time for motor vehicle trips on the road network throughout the day, compared to the travel time estimated if the network operates at an efficient throughput of vehicles (i.e. not free flow), for a year divided by the population. This represents the average time (in minutes) that a motorist is delayed in a year due to congestion. This is an indicator of the additional delay resulting from those parts of the network that are dealing with a throughput of vehicles greater than what is considered efficient (calculated in relation to Level of Service E).

[9] The transport model will not isolate the extent of the duration of peak traffic. The transport model does forecast volumes of traffic and level of congestion for different time periods: the am peak 7.00 to 9.00 am and an inter-peak period 9.00 am to 3.00 pm. The forecast volume of traffic and level of congestion in the inter-peak period may be affected to some extent by a spreading of the period of congestion in the morning. This information is indicative information about how widespread congestion is on the strategic road network. Interpretation is required to analyse the extent to which motorists are deferring trips (shopping, recreational, deliveries, etc) to the inter-peak period in order to avoid congestion in the am peak.

Measure 1: Impact on general traffic congestion	
Headline KPIs	**Explanation of how measured**
Proportion of travel time in severe congestion in the AM peak and inter-peak	This is calculated as the average time spent in severe traffic congestion as a proportion of total trip time travelled on the road network. This will be measured in the AM peak and inter peak periods. This KPI is an indicator of any increase in severe congestion for motor vehicle trips across the road network in the am and inter-peak periods of a working day[10].
Supporting KPIs	**Explanation of how measured**
Throughput of people at key parts of the network in the AM peak and inter-peak	This measures the volume of people travelling by any mode. This calculation will be done on routes to key employment areas including the City Centre and the airport, where there are screenlines at strategic parts of the network. This may be compared to the throughput to an industrial area (e.g. Highbrook). The selection of key parts of the network and routes will be done to help inform a sub-regional analysis of access to employment. This is an indicator of the productivity of corridors, which needs to be considered alongside indicators of congestion.
Proportion of the strategic road network (motorways, primarily arterials) in severe congestion during the AM peak and inter-peak	This measures vehicle kilometres travelled (VKT) in severe congestion as a proportion of total VKT on the strategic road network.
Proportion of VKT spent in severe congestion on state highways or regional arterials	This is a subset of the above KPI - the calculation would be done only in relation to state highways or arterial roads (that are part of the strategic road network).

Measure 2: Impact on freight and goods (commercial traffic) congestion	
Headline KPI	**Explanation of how measured**
Proportion of business and freight travel time spent in severe congestion on the strategic freight network in the AM peak and inter-peak	This is a specific calculation of the time spent by business trips in severe congestion as a proportion of total business trip time spent on the strategic freight network. This KPI is an indicator of any increase in severe congestion for business trips across the strategic freight network in the am and inter-peak periods of a working day.
Supporting KPIs	**Explanation of how measured**
Average travel times along strategic freight corridors	This is calculated as volume of vehicle trips x average speed / distance in relation to the following freight corridors: • Northern boundary to the port • Kumeu to the port • East Tamaki to the port • Metroport to the port

[10] Severe traffic congestion is characterised by slower speeds, longer trip times, unreliable trip times and increased vehicular queuing (i.e. a traffic jam). Austroads explains that traffic congestion is considered severe at Level of Service E (or worse) when the volume of traffic is at this effective capacity limit of the road. Austroads 2013, Guide to traffic management Part 3, Traffic studies and analysis. For modelling purposes, severe congestion is identified on parts of the network where the modelled speed is less than 67 kph on a motorway, expressway or rural highway or less than 25 kph on other roads [Source: JMAC email 4/12/15].

	• Airport to the port • Southern boundary to the airport • Southern boundary to the port. The model output of average travel times for these point to point routes could be calculated in the AM peak and inter-peak.
Proportion of VKT spent in severe congestion on the strategic freight network	This measures VKT in severe congestion as a proportion of total VKT on the strategic freight network.

Measure 3: Travel time reliability	
Headline KPI	**Explanation of how measured**
Proportion of travel time subject to volume to capacity ratio of greater than 0.9 during AM peak, PM peak and inter-peak	This calculates the distance travelled in severe congestion as a proportion of the total vehicle distance travelled. This KPI is an indicator of the proportion of distance travelled which could be subject to variable travel times. Severe congestion is identified as closely associated with the parts of the network where the volume to capacity ratio exceeds 0.9[11]. When traffic volumes are greater than 0.9 of the capacity of a road, travel times begin to become unreliable[12]. In these conditions extra time (buffer) is needed to ensure on-time arrival for trips and most trips are likely to experience variable travel times. This has been developed to reflect the significant monetary costs of congestion on commercial traffic which results in the scheduling of 'buffer' periods that add cost and time.
Supporting KPI	**Explanation of how measured**
Breakdown by motor vehicle and public transport	This measures the proportion of travel kilometres by motor vehicle only i.e. VKT (or by public transport only i.e. PTKT) subject to volume to capacity ratio of greater than 0.9 during AM peak, PM peak and inter-peak (refer to explanation of headline KPI above). This enables an understanding of travel time reliability for motor vehicle trips only or public transport trips only.

Measure 4: Increase vehicle occupancy	
Headline KPI	**Explanation of how measured**
Average vehicle occupancy in the AM peak and inter-peak	Average vehicle occupancy is the average number of people per vehicle for particular trip types and is an input to the model. Current input assumptions about vehicle occupancy vary by trip purpose and time of day[13].

[11] AECOM email 23/11/2015.

[12] Variability of travel times start to occur when the volume to capacity ratio is between 0.8 and 1.0 (equating to Level of Service E) due to day-to-day or unusual fluctuations in demand. Travel times become more variable when the volume to capacity ratio is greater than 1.0 (equating to Level of Service F).

[13] Home Based Trips

Purpose	Prod	AM	IP	SC	PM	OP	24 hr
HBW	From Home	1.10					1.10
	To Home	1.11					1.11
HBE	From Home	2.60	1.22	1.28	1.66	1.47	2.09
	To Home	2.30	1.63	3.35	2.30	1.78	2.57
HB Sh	From Home	1.27				1.63	1.31
	To Home	1.10	1.22	1.35			1.28
HBO	From Home	1.62	1.28	1.54	1.62	1.59	1.48
	To Home	1.09	1.25	2.03	1.69	1.64	1.50

Non-Home Based Trips

Purpose	AM	IP	SC	PM	OP	24 hr
EB	1.08				1.15	1.08
NHBO	1.62	1.32	1.75	1.51	1.66	1.49

Source: Sinclair Knight Merz TIME OF DAY AND VEHICLE DRIVER FACTORS Report 24 January 2007

Supporting KPIs	Explanation of how measured
Average vehicle occupancy in PM peak	This measures average vehicle occupancy in the PM peak only (refer to explanation of headline KPI above). This enables an understanding of travel time reliability at the worst part of the day (currently).
Breakdown of average vehicle occupancy of cars and public transport	This breaks down the measurement of average vehicle occupancy for motor vehicles only and separates the average vehicle occupancy in relation to public transport trips. Out-of-model information may assist in understanding how average vehicle occupancy may be affected by a new mode of mobility service – one that serves a similar function to taxis, but becomes more widespread through technology changes.

3.3. Improve public transport mode share where it will address congestion

This objective will be measured by two headline KPIs to assess the extent to which public transport is used and its contribution to easing congestion on the road network.

Measure 1: Public transport mode share	
Headline KPI	**Explanation of how measured**
Proportion of vehicular trips in the AM peak made by public transport	This calculates the proportion of total vehicular trips in the AM peak that are made by public transport. It is recognised that the ART3 strategic transport model only differentiates motor vehicle trips and public transport trips, because the number of walking and cycling trips is an input to the model.
Proportion of vehicular trips over 9 km in the AM peak made by public transport	This calculates the number of trips made by PT as a proportion of total vehicular trips (in the AM peak) 0-9 km.
Supporting KPIs	**Explanation of how measured**
Proportion of trips in the AM peak made by public transport	This measures PT trips as a proportion of total trips (i.e. vehicular trips and active mode trips) in the AM peak.
Proportion of trips/vehicular trips in the inter-peak made by public transport	This measures PT trips as a proportion of vehicular trips (or total trips) in the inter-peak period. This enables an understanding of the role of PT during the inter-peak period for general trips.
Measure 2: Increase public transport where it impacts on congestion	
Headline KPI	**Explanation of how measured**
Proportion of vehicular trips over 9 km in the AM peak made by public transport	This recognises that long trips on the road network in the AM peak contribute to congestion in multiple parts of the network. The number of long trips taken by public transport would have a direct impact of alleviating congestion. This is calculated as the number of PT trips greater than 9 km as a proportion of total vehicle trips greater than 9 km in the AM peak. The purpose of identifying long public transport trips is to understand the extent to which public transport could potentially be removing trips off several sections of the road network that would otherwise be subject to congestion.

Supporting KPIs	Explanation of how measured
Proportion of vehicular trips made by public transport (rather than contributing to congestion) along severely congested routes	This compares the number of PT trips with motor vehicle trips along congested routes (refer to map of screenlines). It is calculated as the number of trips using public transport at congested parts of the network as a proportion of total trips at those parts of the network in the AM peak and inter-peak. This enables an understanding of the number of public transport trips that are being taken instead of adding to severely congested routes. Selected routes would be those which are severely congested and with motor vehicle and PT connections to a key employment centre (e.g. City Centre, airport, etc). This relies on point to point information from the model (current list is Airport to CBD, Silverdale to CBD, Albany to Highbury, Westgate to CBD, Pukekohe to CBD, Manukau to CBD, Manukau to Airport, Howick to CBD, Howick to Manukau, Botany to Airport, St Lukes to St Johns, Waterview to Manukau).
Proportion of journey trips unaffected by severe congestion	This calculates the journey **time** unaffected by severe congestion as a proportion of the journey time of total trips (PT and motor vehicle) from point to point. This reflects the fact that most bus trips on busways and bus lanes will have some part of the trip on a road affected by traffic congestion. This calculation would be done in relation to a selection of routes where point to point information is available from the model (see list above).
Proportion of vehicular trips made by public transport to major employment centres e.g. City Centre (AM peak and inter-peak)	This is a mode share calculation which shows the proportion of PT trips to total PT and motor vehicle trips to a major employment centre. This provides another indicator of the proportion of public transport trips that are being taken instead of adding to severe congestion.
Proportion of public transport services in the AM peak which are over-crowded or have low use	This is an output from the APT model and indicates services which have low or high demand. This information may assist in understanding which parts of the network have demand for increased service or have a low contribution to easing congestion on the road network.

3.4. Ensure increased financial costs deliver net user benefits

This objective will be measured by the extent to which the cost of travel will vary under different intervention packages. This is particularly relevant to understanding the true costs and benefits from packages that involve pricing schemes for demand management purposes, as these policies improve network performance through increasing the financial cost of travel.

Measure 1: Changes in the cost of travel	
Headline KPI	**Explanation of how measured**
Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	This is calculated as the additional financial cost to users, isolated from financial costs that would be common to users under the different packages. The additional financial cost might be a congestion charge or an increase/reduction in PT fares of a package that is being tested. The total of the additional financial costs to users is divided by the number of trips by those users to calculate the increase in financial cost per trip. This is compared with the change in generalised cost of travel impacted by the proposed congestion charge or increase/reduction in PT fares. This helps to understand the net effects in terms of cost and time.

Supporting KPIs	Explanation of how measured
Total benefits and costs of a scheme as they apply to users	This provides a dollar value of total benefits to users and a dollar value of financial costs incurred by users. These benefits and costs to users are represented in the `generalised cost of travel'. This is the average monetary and non-monetary costs of all journeys. Monetary costs might include a fare on a public transport journey, or the costs of fuel, wear and tear, distance travelled and any parking charge, PT fare, or toll or congestion charge on a car journey. Non-monetary costs refer to the time spent undertaking a journey. Time is converted to a money value using a value of time figure, which in the model varies according to the purpose of the trip only.
Generalised cost of travel for specific trips (i.e. those being charged)	This calculates the generalised cost of travel (as per the first supporting KPI) applied to specific trips being charged e.g. business trips, journeys to work, etc.
Average cost of travel per capita	This calculates the average cost of travel, which is the total financial costs (including the charge) divided by the total population.

3.5. Ensure value for money

Better returns from investment, i.e. value for money, will be measured in a way that will highlight the overall benefits (to the extent that these can be effectively measured) and financial cost of a transport package or programme. Value is measured in the wider sense, in terms of the total societal benefits and impacts of a transport programme.

Measure 1: Value for money	
Headline KPI	**Explanation of how measured**
Package benefits and cost	This compares the financial cost of a package to the monetary value of potential benefits to both users and non-users in terms of: • Travel time savings • Vehicle operating cost savings • Impact on CO_2 emissions • Savings in accident costs • Improved reliability and greater throughout • Increased competition and agglomeration The calculation of benefits will be generally in accordance with NZ Transport Agency's Economic Evaluation Manual and using updated information e.g. value of time. This will enable a comparison of value for money between packages, rather than provide a definitive assessment of value for money.
Supporting KPIs	**Explanation of how measured**
Total cost of a package in current day dollars	30 year costs, both opex and capex, in $2016 values
Net present value of the total cost of a package	30 year costs, both opex and capex, in net present value
Average cost of travel for transport users (including time)	This is a calculation of the average generalised cost of travel for transport users (in terms of financial costs and time).

3.6. Other key transport outcomes

The measures and headline KPIs relate to outcomes outlined in the Government Policy Statement on Land Transport 2015 and the Auckland Plan. These headline KPIs enable consideration of contributions to outcomes that are not directly taken into account in relation to the project objectives discussed above.

Support access to housing

Measure 1: Transport infrastructure in place in future urban zones when required for new housing	
Headline KPI	**Explanation of how measured**
Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	This is calculated outside the model to measure the extent to which transport infrastructure is in place in future urban zones to support new housing in those areas. The timing of transport infrastructure is determined as an input to the model. The timing of these inputs is compared with the time frames identified in the Future Urban Land Supply Strategy. (Note that the Transport for future urban growth project is expected to identify the minimum transport networks required to enable housing to be established in future urban zones and the timing of those networks). The result can be calculated as a percentage of transport infrastructure that is provided within the timeframes. Because the common elements include the basic level of transport infrastructure and services supporting the future urban zones, this KPI would help to distinguish packages that apply different timing or amounts of additional transport infrastructure and services supporting the future urban zones. Another way to calculate this is a percentage of future urban zones that have transport infrastructure and services in place at the required time to support the future urban zones.
Supporting KPIs	**Explanation of how measured**
Cost of networks in future urban zones	This is calculated outside the model and comprises capital and operating costs relating to transport infrastructure and services that are modelled to service the future urban zones (residential and commercial). The costs could be calculated in current dollars and net present value to enable a comparison of packages.
Proportion of jobs accessible from future urban zones (30 minutes by motor vehicle, 45 minutes by public transport) in AM peak	This uses the same calculation as the headline KPI relating to access to employment. However, the calculation is applied to access from future urban zones only. The three future urban zones are in the southern, western and northern parts of Auckland as identified in the Future Urban Land Supply Strategy.

Reduce harm

Measure 1: Safety Emissions	
Headline KPI	**Explanation of how measured**
Deaths and serious injuries per capita and per distance travelled	This is a calculation made outside of the transport model, based on forecast data about travel speeds, vehicle kilometres travelled on different roads and the effects of the safety programme. The transport model provides a forecast estimate of future crashes (resulting in deaths or serious injuries) based on modelled travel speeds and total kilometres travelled on different road types. Two metrics are then calculated: per capita (usually per 100,000 population) and per vehicle kilometres travelled.

Supporting KPIs	Explanation of how measured
Number of deaths and serious injuries walking and cycling per capita and per distance travelled	This is a calculation made outside of the transport model, based on forecast data about travel speeds, number of trips by walking and cycling and the effects of the safety programme.
Cost of safety programme	This is a calculation of the total capital and operating costs of the safety programme.

Measure 2: Greenhouse gas emissions	
Headline KPIs	**Explanation of how measured**
Greenhouse gas emissions	The model provides a forecast estimate of greenhouse gas emissions based on vehicle kilometres travelled, changes in fuel efficiency and extent of travel in congested conditions. Emissions are largely dependent on the uptake of electric vehicles and improvements in vehicular efficiency and vehicle occupancy. This is a daily figure.

Maintain existing assets

Measure 1: Effects of maintenance and renewals programme	
Headline KPIs	**Explanation of how measured**
Asset condition levels of service	This is estimated outside of the model, based on the level of investment in maintenance and renewals and the level of service targeted in that programme.
Renewals backlog	This is estimated outside the model. The renewals backlog is calculated as the dollar value of the renewals programme that is deferred at the end of the 30 year period as a result of the level of investment in maintenance and renewals.
Supporting KPI	**Explanation of how measured**
Cost of maintenance and renewals programme	This is a calculation of the total capital and operating costs of the maintenance and renewals programme.

Social inclusion and equity

Measure 1: Fairness of distribution of impacts (benefits and costs)	
Headline KPIs	**Explanation of how measured**
Accessibility from high deprivation areas	This is a series of calculations of access from high deprivation areas to employment (AM peak) and employment areas (inter-peak) and the generalised cost of those trips. The following decile 10 areas have been selected to apply this calculation: West: Ranui; Central: Glen Innes; South: Mangere Central, Otara East, Rowandale, Papakura South. This provides a contrast to figures of accessibility at the regional level, which are calculated in relation to the headline KPI for access to employment. The generalised cost would be calculated and mapped across the region to identify differences.
Distribution of impacts (costs and benefits) by area	This draws from headline KPIs relating to other objectives and applies these to the four sub-regional areas i.e. north, west, central and south. This is expected to highlight any uneven distribution of costs and benefits of a transport programme. This geographical analysis will take into account a social deprivation index map to understand potential social impacts.

Supporting KPIs	Explanation of how measured
Impact on low deprivation areas	This uses the same method of calculation as the first headline KPI, but in relation to low deprivation areas (in the north and central areas) to provide a comparison of the range of access to employment and generalised costs between the low and high decile areas.
Access to important social services e.g. hospitals, education, shops	This calculates travel time by different modes to key destinations from high deprivation areas (as identified above).

Network Resilience

Measure 1: Network vulnerability and adaptability	
Headline KPI	**Explanation of how measured**
Impact in the event of disruption at vulnerable parts of the network	The headline KPI could be applied to key locations in the transport network where there is vulnerability to disruption. These locations would be on strategically significant routes and could be any mode. For example, Auckland Harbour Bridge, Crossings of Tamaki River, rail line, State Highway 1 at Drury. Travel times by an alternative route and volume of trips could be calculated to indicate the impact if a disruption occurs at a key location. The likelihood of a disruption could also be considered e.g. high likelihood of an accident or breakdown and low likelihood of a catastrophic failure. This KPI would enable packages to be compared to the extent that packages provide alternatives or ability to adapt to a disruption at these key locations. This could be calculated in different ways: using non-model information about travel times following incidents at these key locations; using modelled information about volumes and travel times on an alternative route; calculating travel time on an alternative route by switching off a key piece of infrastructure in the transport model.
Supporting KPI	**Explanation of how measured**
Composite index of economic and social indicators e.g. risk of disruption, transport choice (modes and routes), etc.	Research by NZ Transport Agency regarding measurement of economic and social impacts of resilience is underway and may add to the analysis as a supporting KPI. This research was not available for use during the ATAP.

Full list of key performance indicators

Objective	Measure	Headline KPI	Supporting KPI
Improve access to employment and labour	Access to employment and labour within a reasonable travel time	• Jobs accessible by car within a 30 minute trip in the AM peak • Jobs accessible by public transport within a 45 minute trip in AM peak • Proportion of jobs accessible to other jobs by car within a 30 minute trip in the inter-peak	• Proportion of jobs accessible within a 30 minute car trip in AM peak • Proportion of jobs accessible within a 45 minute public transport trip in AM peak • Average travel time by car or public transport in AM peak • Access to specific origins and destinations e.g. City Centre and rest of region in AM peak
Improve congestion results	Impact on general traffic congestion	• Per capita annual delay (compared to efficient throughput) • Proportion of travel time in severe congestion in the AM peak and inter-peak	• Throughput of people at key parts of the network in the AM peak and inter-peak • Proportion of travel time in severe congestion on the strategic road network during the AM peak and inter-peak • Proportion of VKT spent in severe congestion on state highways or regional arterials
	Impact on freight and goods (commercial traffic) congestion	• Proportion of time spent in severe congestion on the strategic freight network in the AM peak and inter-peak	• Average travel times along strategic freight corridors • Proportion of VKT spent in severe congestion on the strategic freight network
	Travel time reliability	• Proportion of total travel subject to volume to capacity ratio of greater than 0.9 during AM peak, PM peak and inter-peak.	• Breakdown by motor vehicle and public transport
	Increase vehicle occupancy	• Average vehicle occupancy	• Breakdown of average vehicle occupancy of cars and public transport
Increase public transport mode share	Public transport mode share	• Proportion of vehicular trips in the AM peak made by public transport	• Proportion of trips in the AM peak made by public transport • Proportion of trips/vehicular trips in the inter-peak made by public transport • Proportion of kilometres travelled by public transport (peak and inter-peak) • Proportion of vehicular trips by journey length during the AM peak made by public transport
	Increase public transport where it impacts on congestion	• Proportion of vehicular trips over 9 km in the AM peak made by public transport	• Proportion of vehicular trips made by public transport (rather than contributing to congestion) along severely congested routes during the AM peak • Proportion of vehicular trips made by public transport to major employment centres e.g. City Centre (peak and inter-peak) • Proportion of length of public transport trips unaffected by severe congestion • Proportion of public transport trips which are over-crowded or have low use
Increased financial costs deliver net user benefits	Net benefits to users from additional transport expenditure	• Increase in financial cost per trip compared to savings in travel time and vehicle operating cost	• Total benefits and costs of a scheme as they apply to users • Generalised cost of travel for specific trips (i.e. those being charged) • Average cost of travel per capita
Ensure value for money	Value for money	• Package benefits and costs	• Total cost of packages – 30 year costs, both opex and capex, in $2015 values and/or NPV • Average cost of travel for

			transport users (including time)
Other Outcomes	**Measure**	**Headline KPI**	
Support access to housing	Transport infrastructure in place when required for new housing	• Transport does not delay urbanisation in line with timeframes of Future Urban Land Supply Strategy	• Cost of networks in future urban zones • Proportion of jobs accessible from future urban zones (30 minutes by motor vehicle, 45 minutes by public transport) in AM peak
Mitigate harm	Safety	• Number of crashes per capita and per distance travelled	• Number of deaths and serious injuries walking and cycling per capita and per distance travelled • Cost of safety programme
	Emissions	• Greenhouse gas emissions	
Maintain existing assets	Effects of maintenance and renewals programme	• Asset condition levels of service • Renewals backlog	• Cost of maintenance and renewals programme
Social inclusion and equity	Distribution of impacts (costs and benefits) by area	• Accessibility from high deprivation areas • Distribution of impacts (costs and benefits) by area	• Impact on low deprivation areas • Access to important social services e.g. hospitals, education, shops
Network resilience	Network vulnerability and adaptability	• Impact in the event of disruption at vulnerable parts of the network	• Composite index of economic and social indicators e.g. risk of disruption, transport choice (modes and routes), etc.

Appendix B – Model Input Assumptions

This memo outlines changes to ART3 input assumptions that have been considered by the ATAP project team and are being recommended to JMAC for implementation as at 24th November 2015.

Recommended changes to input assumptions are noted below – along with supporting evidence where input assumptions have been checked or changes are recommended.

ART input assumptions grouped under the following headings:

- Land Use Inputs
- Policy/Economic Inputs
- Transport Infrastructure and services
- TDM Assumptions
- Safety (factors added post ART model run)
- Emissions and fuel use (factors applied post ART model run)

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions For ATAP
Land Use Inputs			
Zonal land use inputs	Scenario H High growth	Scenario I8B Medium	Use land-use **i9 medium growth**.
Development of future 'Regional Growth Strategy' centres Affects the mode choice to access the identified centres. Relates to the TDM inputs listed below. Refer to ART3 User Manual – Feb 2009 (page 40) for details on how the trip end are effected with regard to RGS and non-RGS areas.	Scenario H	Auckland Plan Scenario I	Use existing assumptions.

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions for ATAP
Policy/Economic Inputs			
GDP/capita growth rate Affects the number of heavy vehicle trips, the value of time and future parking charges.	1.8% pa	1.8% pa	**Advice from MoT and Treasury:** Use 1.5% real GDP growth pa (from 2013 onwards). **2006 – 2013 GDP growth**: Use 0.5% real GDP growth pa (from 2006 – 2013).
Value of Time	Escalated wrt GDP/Capita growth (1.8% pa), with elasticity of 1 on work travel and 0.8 for non-work travel (Ref:UK DfT - TAG)	Escalated wrt GDP/Capita growth (1.8% pa), with elasticity of 1 on work travel and 0.8 for non-work travel (Ref:UK DfT - TAG)	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa
Private vehicle operating costs	Lower growth based on forecast fuel price and estimate of improved fuel efficiency (Ref:RLTS2010 WP5-Price Forecasts for Transport Fuels and other Delivered Energy Forms, MoT)	Lower growth based on forecast fuel price and estimate of improved fuel efficiency (Ref:RLTS2010 WP5-Price Forecasts for Transport Fuels and other Delivered Energy Forms, MoT)	Price updated based on NLTF revenue spreadsheet provided by MoT (based on VFEM and Fuel forecast)
Integrated ticketing – effect on speed of boarding	Assumed faster bus boarding times than 2006 base – as per RLTS (Assume 10% improvement in boarding time; net effect of Integrated Ticketing and increased loading)	Assumed faster bus boarding times than 2006 base – as per RLTS (Assume 10% improvement in boarding time; net effect of Integrated Ticketing and increased loading)	Use existing assumptions.
Public Transport Fares From ART3 Input Review work undertaken by Ian Wallis Associates Ltd May 2011. Refer "PE2" in report "ART3InputsReview-IWallis1328 May 1 Update Table 1.doc" attached below: Fare increase = $(GDP/Capita)^{0.25}$ "*With the GDP/cap forecast increase of 1.8%pa, this results in an average fare increase of c.0.45%pa: this is midway between the RLTS assumption and the NZTA*"	Increased wrt to GDP/Capita with elasticity of 0.25	Increased wrt to GDP/Capita with elasticity of 0.25	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa
PT fare system	Stage based (matches current system). Calculated based on a: • Boarding fare + • Distance based fare	Stage based (matches current system). Calculated based on a: • Boarding fare + • Distance based fare	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa

Integrated fares	Assumed removal of second boarding fare for transferring passengers but with 2c/km increase in all fares to retain same overall revenue and average fare	**Basic** Assumed removal of second boarding fare for transferring passengers but with 2c/km increase in all fares to retain same overall revenue and average fare **APTN** As above but no additional 2c/km	Use existing assumptions
Parking Costs	Escalation wrt GDP/Capita with elasticity of 1.2 for commuter travel and 1.0 for non-commuter travel. (Parking costs location and as per attached maps)	Escalation wrt GDP/Capita with elasticity of 1.2 for commuter travel and 1.0 for non-commuter travel. (Parking costs location and as per attached maps)	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa Update 2006 and 2013 costs based on CPI adjusted 2013 data
Toll and road pricing	Toll in ALPURT and in other projects as per the Auckland Plan scenarios. Toll values escalated at CPI.	Toll in ALPURT, Penlink. Toll values escalated at CPI. Specific network charges as per IAB specifications to be provided.	Use existing assumptions
External trips (to/from Waikato and Northland)	3% per annum increase in the number of trips per annum (increasing from 2006 observed figure)	3% per annum increase in number of trips (increasing from 2006 observed figure)	Use 1.3% pa increase for Auckland-Waikato and Auckland-Northland external trips. **Evidence base:** Projected growth in the Auckland region is downloaded from statistics NZ. Spreadsheet was downloaded 5th of November 2015.
Flight related trips Creates trips to and from Auckland Airport. Also affects interregional trips (i.e. from Northland and Waikato to AIAL).	Private vehicle model only based on vehicle counts at Airport in 2006.	Based on 2011 observed data and escalated over time based on the increase in the number of air passengers as advised by AIAL. Includes private vehicle, taxi, taxi shuttle and bus along with people who fly and associated “farewellers” and “greeters”.	Use pre-existing assumptions **Evidence base:** Growth from January 2009 to August 2015 shows a cumulative increase of 3.6% per annum (Domestic: 3.4%, International: 3.8%). This aligns with pre-existing assumptions of 3 - 4% growth pa.
HCV Growth	Employment plus GDP multiplier (elasticity of 0.23) (Ref: NZTA - Additional Waitemata Harbour Crossing 2011)	Employment plus GDP multiplier (elasticity of 0.23) (Ref: NZTA - Additional Waitemata Harbour Crossing 2011)	Use existing assumptions – although please note that GDP/capita growth rate reduced to 1.5% pa

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions for ATAP
Transport Infrastructure and services			
Rail, Bus and Ferry services	As agreed for each scenario	As per specification. Increased level of service in APTN compared to Basic.	To be specified for each modelling run
Road network	Auckland Plan	As agreed for Committed, Basic, APTN programmes.	To be specified for each modelling run
Interchange penalties (and quality of rail / busway stations)[14]	Assumed all upgraded to 'medium' quality	Assumed all upgraded to 'medium' quality (unless otherwise stated)	Specified for each model run

[14] The impact of having to interchange is modelled via 'time penalties' in ART. Penalties are modelled as follows:

1. A time penalty related to the quality of the interchange facility. This component of the penalty is modelled as follows:
    - 10 minute time penalty at low quality interchanges (and other places on the network where interchange is required between PT services)
    - 8 minute time penalty at designated medium quality interchanges
    - 5 minute interchange penalty at designated high quality interchanges
2. Plus a time penalty to reflect the waiting time required for the second service. This component of the penalty is calculated based on whether the interchange is planned or unplanned, and the frequency of the services.

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions for ATAP
TDM Assumptions			
Working from home	60% of RLTS 2010 assumptions *	**Basic** 60% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	Working group agrees to use existing assumptions and to include the basic investment package as part of 'common elements'. High investment TDM packages will be tested during refined packages stage.
Assumptions for behaviour change from Work Place Initiatives (WTI): Reduction in car trips to work – CBD	60% of RLTS 2010 assumptions*	**Basic** 30% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	
Assumptions for behaviour change from Work Place Initiatives (WTI): Reduction in car trips to work – RGS Centres	50% of RLTS 2010 assumptions*	**Basic** 25% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	
Assumptions for behaviour change from Work Place Initiatives (WTI): Reduction in car trips to work – Non-RGS Centres	60% of RLTS 2010 assumptions*	**Basic** 40% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	
Assumptions for behaviour change from Education TDM initiatives	100% of RLTS 2010 assumptions*	**Basic** 100% of RLTS 2010 assumptions **APTN** 60% of RLTS 2010 assumptions	
Assumptions for behaviour change from Community TDM initiatives	25% of RLTS 2010 assumptions*	**Basic** 25% of RLTS 2010 assumptions **APTN** 100% of RLTS 2010 assumptions	

Input	2012 Auckland Plan scenario	2014-15 ITPv2 / IAB	Decisions
Safety (factors added post ART model run)			
Crash rate Number of crashes are based on vkt on each road type x the crash rate for each road type	Injury crashes by road type (Urban Arterials, Rural Arterials & Motorways), based on VKT. Crash rates and associated rate reduction through time is based on NZTA Economic Evaluation Manual.	Injury crashes by road type (Urban Arterials, Rural Arterials & Motorways), based on VKT. Crash rates and associated rate reduction through time is based on NZTA Economic Evaluation Manual.	Use existing assumptions
Emissions and fuel use (factors applied post ART model run)			
Fuel use, NOX, CO2, PM10 particulate Assumption relating to engine efficiency improvements, take up of electric vehicle etc have been included as part of this work by UoA. Report attached: Model and spreadsheets available upon request (not included due to size)	Based on report titled “Vehicle Emission Prediction Model version 4” and associated spreadsheet model. Prepared for NZTA and AC by Energy & Fuels Research Unit, Department of Mechanical Engineering, The University of Auckland.	Based on report titled “Vehicle Emission Prediction Model version 4” and associated spreadsheet model. Prepared for NZTA and AC by Energy & Fuels Research Unit, Department of Mechanical Engineering, The University of Auckland.	Use existing assumptions