greater WELLINGTON
REGIONAL COUNCIL

RLTS Modelling Report

Contents

1. Executive Summary

This transport modelling report has been carried out to inform the development of the Regional Land Transport Strategy (RLTS) 2010-2041 which aims to provide a sustainable transport network based on environmental, economic and mobility criteria.

There are many influences to demand for the transport system that are outside the control of decision makers. Modelling work has been undertaken to understand how some of these external influences affect important outcomes for our transport system performance. Relating possible futures of growth, car costs, and land use density to different types of network form, some strong conclusions can be drawn.

Futures

Growth is the largest single influence on transport system performance. As economic and demographic growth increases, challenges to road and PT mobility increase, affecting mode share, public transport usage, congestion and emissions.

Car travel cost is also a large influence on the transport system. Lower car travel cost increases car use, while higher car travel cost means fewer and shorter car trips. These changes will affect mode share, public transport usage, congestion and emissions.

Increasing car travel cost helps reduce the relative gap between car and public transport cost which can increase public transport mode share and trips.

Higher density land use helps reduce CO_2 emissions and increases active mode use as it is assumed to place people closer to workplaces and other attractions.

Network form

A Base network 'do minimum' approach might be suitable under a lower growth and higher travel cost scenario, but does not do enough to address issues around congestion and CO_2 under a medium or higher scenario. Investing in primarily Roads can address congestion issues, but does not encourage modal shift to more sustainable and safer modes. It also does not address CO_2. Public transport focused investment encourages some modal shift and increases overall PT demand. However, it does not significant improve overall congestion or CO_2.

A Mixed investment scenario combines PT and road projects to maximise individual project benefits and add system-wide synergy. This scenario provides improvements across more of the objectives than any other of the non-pricing scenarios. In particular, it holds the line on congestion (which the PT scenario doesn't), and it shows significant improvement on PT-related indicators (which the roading scenario doesn't). This option does not however address the issue of CO_2.

Road pricing scenarios are the most effective across all of the indicators, showing either a very significant improvement or (in the case of CO_2) holding the line compared with 2006. Road pricing can also defer road infrastructure investment but there must be sufficient public transport capacity in place to accommodate the mode shift. Targeted road investment can help ease severe congestion in the short and medium term. Adding road pricing to targeted road investment can help ease severe congestion in the long term.

A mixed investment scenario provides the most balanced approach to improvements on all outcomes. It will not be sufficient however to deal with demand for the transport network under higher growth scenarios, so depending on the level of growth, a pricing mechanism (such as road pricing) could be introduced to provide the level of improvements desired, or to defer significant capital investment. Under a lower growth option less investment will be required to hold the line.

2. Context

This transport modelling report has been carried out to inform the development of the Regional Land Transport Strategy (RLTS) which seeks to provide a sustainable transport network based on environmental, economic and mobility criteria.

The transport model tested various options to determine the upper and lower bounds of future possibilities based on regional growth, car travel cost, and land use density, as well as the transport network form. This exercise shows how a range of variables affects transport system outcomes. These outcomes should promote and sustain the RLTS objectives.

3. RLTS Objectives

The RLTS objectives are listed below. Those objectives that this modelling can address include the relevant variables considered and indicators that can be scored. Those objectives that are not addressed in this exercise are listed in *italics*:

Objective	Variables considered	Indicators scored
1. Assist economic and regional development	Land Use Density, Households , Employment	Mode share, PT trips, Congestion, Emissions
2. Assist safety and personal security		*Not Modelled*
3. Improve access, mobility and reliability	Network form	PT Trips, mode share, Congestion
4. Protect and promote public health		*Not Modelled*
5. Ensure environmental sustainability	Land use, network form, technology	Mode share, PT trips, Congestion, Emissions
6. Ensure that the regional transport programme is affordable for the regional community.		*Not Modelled*
7 Freight efficiency	Network form	Congestion, Emissions

Table 3.0.1 RLTS Objectives, Indicators and Variables

4. Methodology

The Wellington Transport Strategic Model (WTSM) is a multimodal strategic model of the Wellington region, which forecasts changes in the transport system given changes in demographics, employment, transport-related costs, infrastructure, and the public

transport system at a strategic level. A transport model for the region was initially developed in the 1980s, and has been continually updated as better information has become available (typically every five years to coincide with the Census).

- The time frame chosen was 2041 based a 30 time frame requirement by the Land Transport Management Act 2003 section 74.1.a. as amended in 2008.

- Nine scenarios were developed using 3 Future demand variables – 'Growth', 'Car Travel Cost' and 'Land Use Density', to determine how these combinations affect performance indicators based on 6 different transport Network forms. A wide range of performance indicators measure progress against the RLTS objectives. The 'best' Strategic Option (3 Future variables plus network form) is one that satisfies all or the maximum number of indicator criteria as fully as possible.

- For modelling purposes, projects that could not be modelled in WTSM (i.e. safety barriers, maintenance projects, minor local road improvements, active mode initiatives) were removed from the scenario project lists. Therefore this analysis does not include changes in network performance from safety improvements, minor projects, or agglomeration.

- Benchmarks values for this exercise are based on 2006, taken from the 2006-07 Annual Monitoring Report and/or the 2007-2016 RLTS. 2006 is the 'base' year of the WTSM model.

5. Future Scenarios

The RLTS considers how certain factors affecting transport will change and grow into the future. The factors chosen are the Future variables – 'Growth', 'Car Travel Cost' and 'Land Use Density'. Upper and lower bounds ranges for these variables were determined, based on existing range information (in the case of population and employment) or asserting ranges to test.

5.1 Futures Growth Rates

5.1.1 Households, Population, Employment

Demographics are based on Statistics New Zealand 2031 TA population/employment projections. Model values for 2041 are extrapolated from 2031 delivered inputs using the Statistics NZ projections.

Future household size changes as the population ages and the definition/makeup of a family unit changes. This results in a larger increase in the number of households than population (Figure 5.1.1), creating increased demand on the transport network resulting from more individual household trips. Table 5.1.1 show numeric and percent change for households, population, employment, GDP, and car ownership. Figure 5.1.2 show the relationship between population and employment from 2006 to 2041 for low, medium, and high growth scenarios.

Low Growth	2006	2016	2026	2041		2006	2016	2026	2041
Population ('000)	450.0	461.0	464.7	447.9		0%	2%	3%	0%
Households ('000)	166.9	179.7	190.3	191.6		0%	8%	14%	15%
Person/Household	2.70	2.57	2.44	2.34		0%	-5%	-9%	-13%
Real GDP/Capita (Index 2006=100)	100.0	116.1	134.7	168.4		0%	16%	35%	68%
Employment ('000)	233.6	259.6	258.0	250.4		0%	11%	10%	7%
Cars ('000)	257.2	287.7	310.9	321.1		0%	12%	21%	25%
Cars/Person	0.57	0.62	0.67	0.72		0%	9%	17%	25%
Medium Growth									
Population ('000)	450.0	480.7	504.4	523.0		0%	7%	12%	16%
Households ('000)	166.9	186.9	205.4	222.1		0%	12%	23%	33%
Person/Household	2.70	2.57	2.46	2.36		0%	-5%	-9%	-13%
Real GDP/Capita (Index 2006=100)	100.0	119.5	142.9	186.7		0%	20%	43%	87%
Employment ('000)	233.6	269.2	283.2	296.8		0%	15%	21%	27%
Cars ('000)	257.2	301.6	340.1	377.0		0%	17%	32%	47%
Cars/Person	0.57	0.63	0.67	0.72		0%	10%	18%	26%
High Growth									
Population ('000)	450.0	500.8	545.1	595.2		0%	11%	21%	32%
Households ('000)	166.9	194.5	221.1	251.3		0%	17%	32%	51%
Person/Household	2.70	2.58	2.47	2.37		0%	-4%	-9%	-12%
Real GDP/Capita (Index 2006=100)	100.0	123.1	151.5	207.0		0%	23%	52%	107%
Employment ('000)	233.6	280.1	304.4	335.1		0%	20%	30%	43%
Cars ('000)	257.2	314.1	368.9	434.1		0%	22%	43%	69%
Cars/Person	0.57	0.63	0.68	0.73		0%	10%	18%	28%

Table 5.1.1 Households, Population, Employment and car ownership change to futures

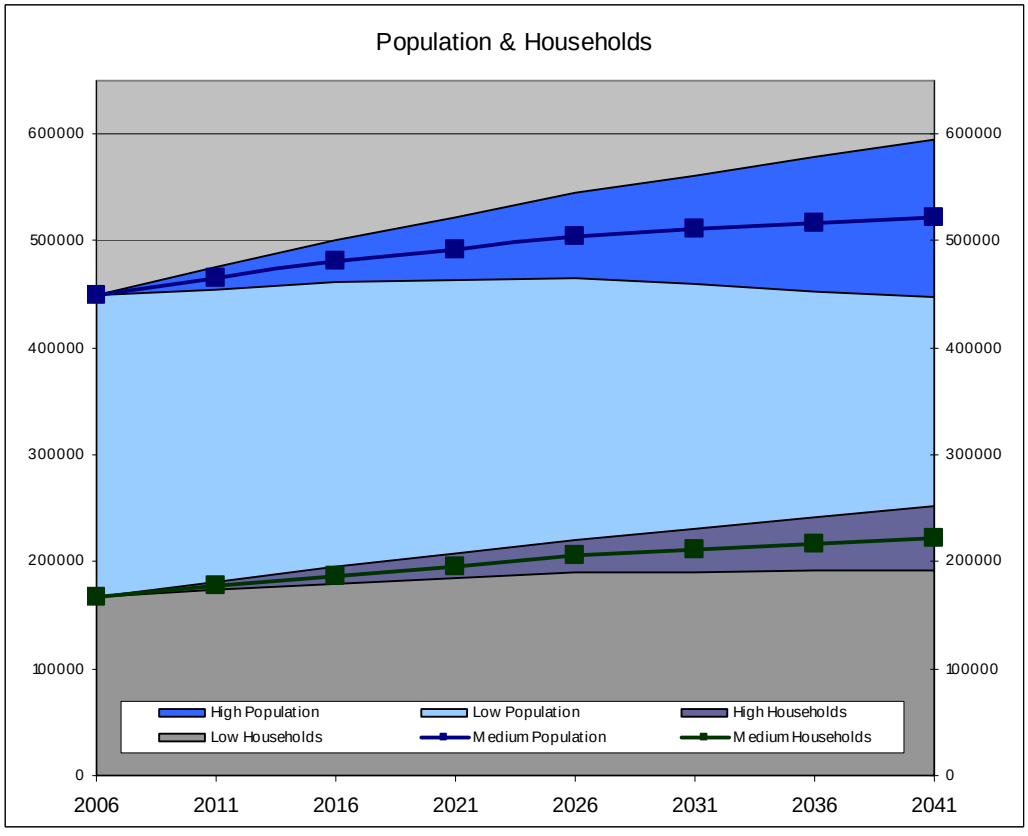
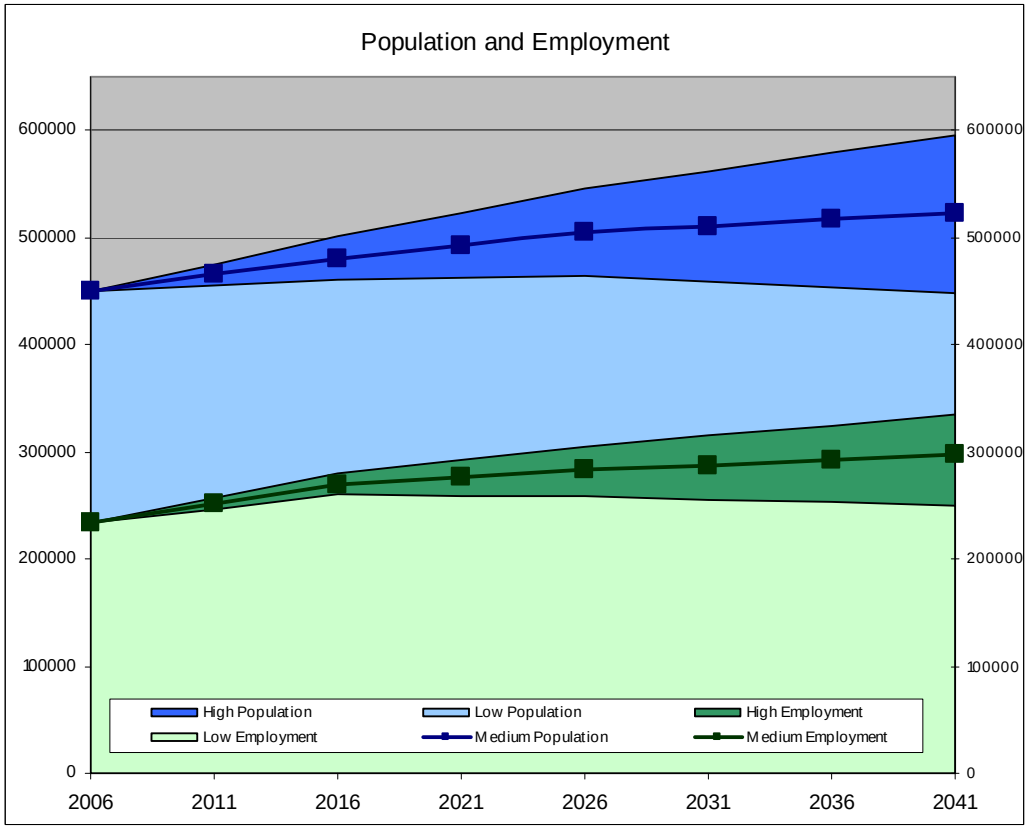


Figure 5.11 Population & Employment change to futures



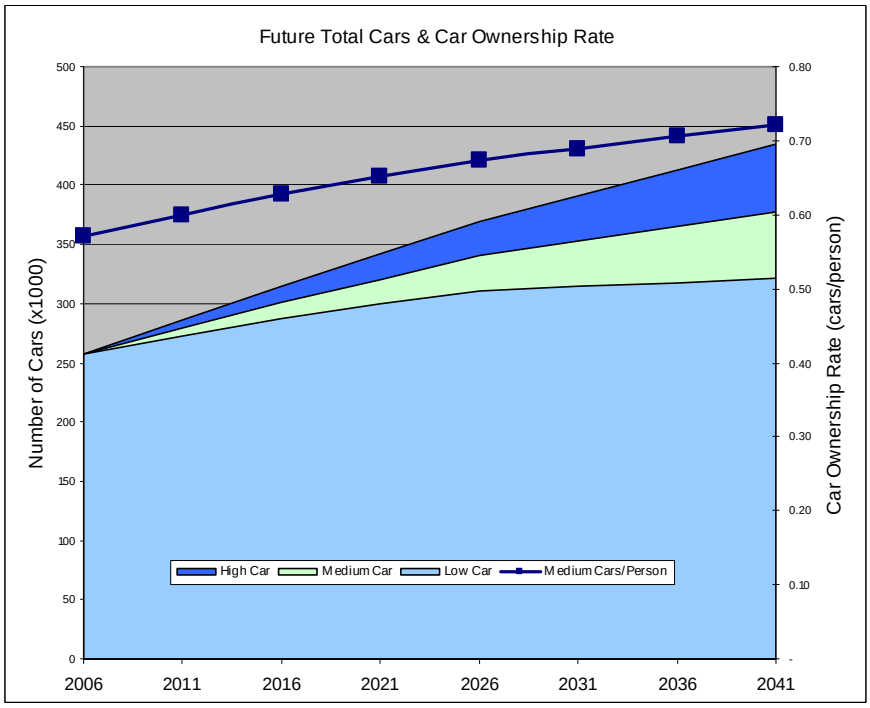
5.1.2 GDP

Growth in real Gross Domestic Product (GDP) per capita is assumed to be 1.8% per annum based on historical time series data, which in turn affects the employment data, car ownership and HCV demand. A higher growth rate was assumed to be 2.1%, and lower growth was set to 1.5%. Whilst current levels of GDP are lower than the historical average, the current recession is seen as being a fairly short-term event compared with the longer timeframe of a 30-year horizon considered here. Table 5.1.1 includes GDP values for future model years.

5.1.3 Vehicles (Cars)

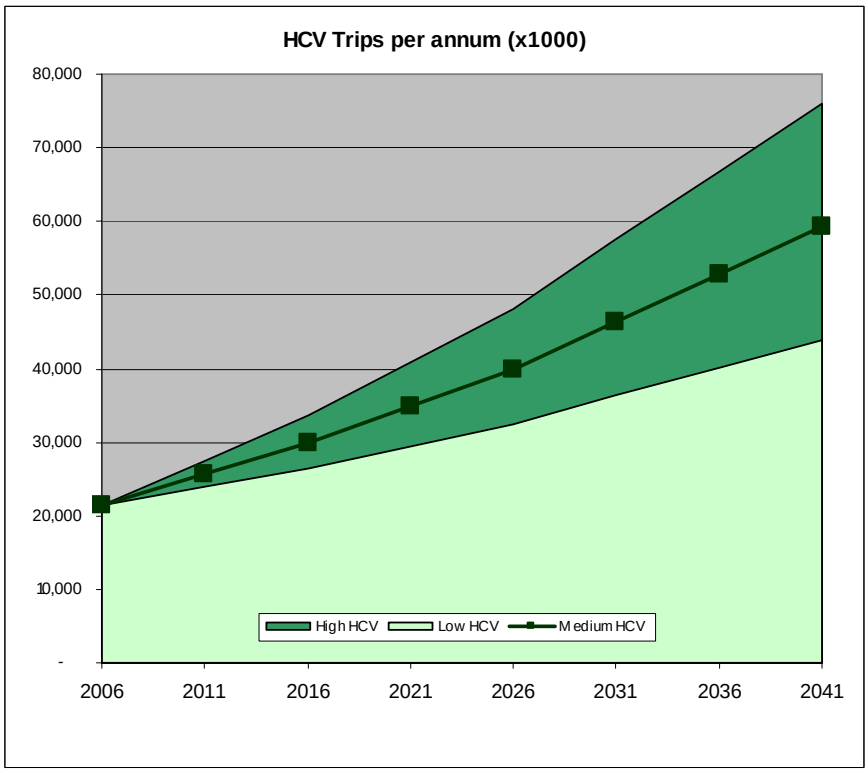
Car ownership rates per person increase into the future, and are linked to GDP growth. Car ownership growth rates exceed the rate of GDP growth. The graph below shows car ownership rate as cars/person as well as total increases in the number of cars. The cars/person rate begins levelling off going into the future with saturation expected at a rate of about 0.75 cars/person. Table 5.1.1 includes projected total cars and car ownership rates for future model years.

MOT projections indicate a different fleet mix of vehicles and fuels used going into the future including an uptake of electric vehicles, technology advances and petrol fleet fuel efficiency. This is discussed further in section 5.2.



5.1.4 Heavy Commercial Vehicle's

HCVs increase at a higher rate than GDP based on historical time series and informed by the National Freight Demand Study (September 2008), which indicates that to 2031, freight tonnes and tonne-kilometre's are projected to increase by around 2.7%pa compounding. The modelling assumes that under a medium growth scenario the growth in HCV trips are of a similar order – around 2.9%pa out to 2041. The graph below shows growth in HCV trips per year, for low, medium and high futures.

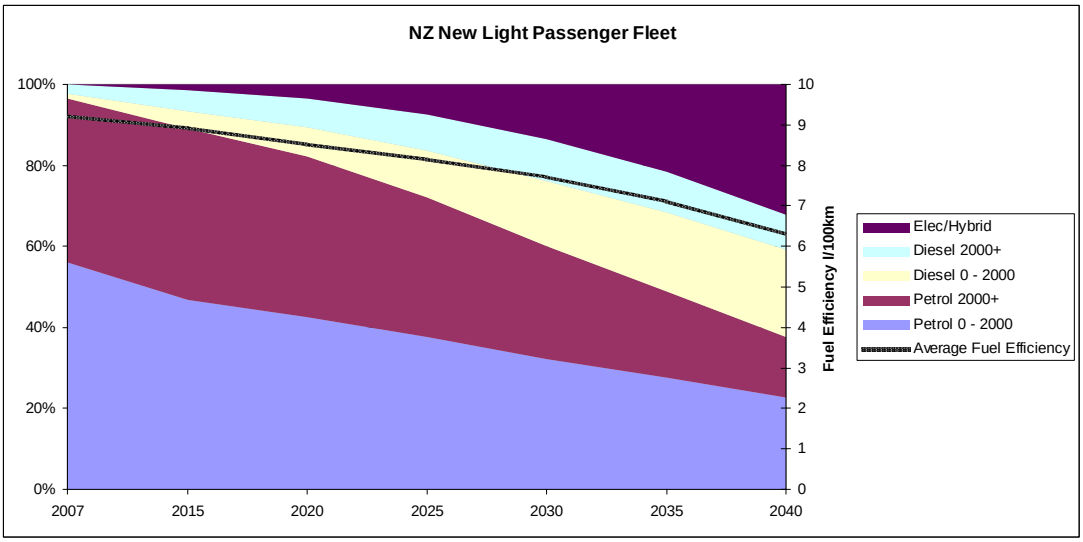


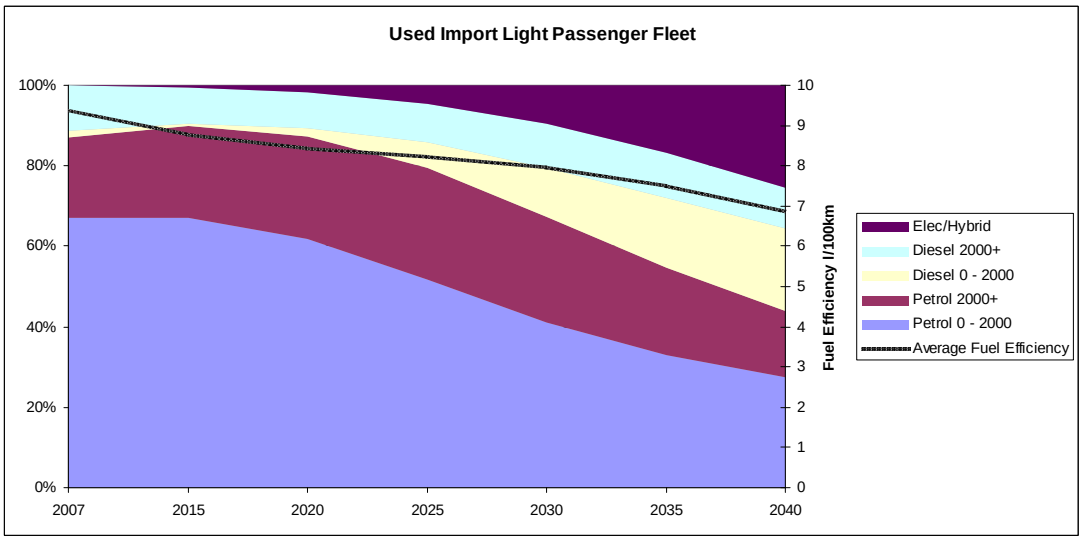
5.2 Futures Car Travel Cost

WTSM can model changes in transport costs. Travel cost variables that can be adjusted include PT fares and car travel cost. PT fares rose around 20% above 2006 levels to 2009. It is assumed that future PT fare changes will be at inflation rate (0% increase) resulting in a total 20% increase above 2006 by 2041. Any additional PT fare increase in real terms is likely to suppress PT demand, with industry-standard elasticities of PT boardings to fare of around -0.2 to -0.4 (i.e. a 10% increase in fares will lead to a 2%-4% reduction in PT boardings).

The Ministry of Transport supplied information on the possible future composition of the private vehicle fleet, which in turn was used to determine future average fleet vehicle efficiencies compared with the current situation. Future efficiencies are primarily used to adjust CO_2 generation from the private fleet by factoring estimated fuel use.

The fleet mix in 2041, as defined by MOT, includes a significant proportion of hybrid electric, electric and plug-in electric vehicles. The change in car fleet mix is shown for NZ new and Imported cars in the graphs below, with up to 30% of the fleet being comprised of electric and hybrid vehicles by 2041. The change in fleet mix is estimated to result in a fleet where an average vehicle uses around two-thirds of the fuel currently used today.





Because of uncertainties about the future make-up of the fleet and in particular the process for charging for road usage, rather than explicitly modelling an increase in fuel prices (which may or may not have an impact depending on the type of technology people use), the modelling was undertaken assuming changes in overall car travel costs per km. A higher cost per km tests a scenario where peak oil might occur, and technological advances have not developed sufficiently to address the increased price at the pump. It may also represent a future scenario where the full cost of externalities of road use is taken into account through pricing. A lower car cost might reflect a lower increase in fuel prices, but also continued technological advances.

Car travel cost increases modelled are:

- Low – no change in the cost per km of running your vehicle from today in real terms

- Medium – a 35% increase in the cost per km of running your vehicle from today in real terms

- High – a 70% increase in the cost per km of running your vehicle from today in real terms

While these scenarios might seem conservative, underpinning these increases is the assumption that fuel efficiency will improve. Also note the relationship between fuel prices/peak oil and technology development, where higher fuel prices may stimulate a faster uptake of new technology, thus suppressing the impact of fuel prices.

5.3 Futures - Land Use Density

To show the effect of land use, three residential land use densities are included, ranging from lower density 'sprawl' to a higher density around corridors and nodes, as compared with the 'central case' current projections.

Changes to lower and higher density land use are made by increasing forecast households by 75% in targeted areas at the expense of all other areas of the Territorial Authority (TA) such that TA totals remain the same. Targeted areas for higher density growth are typically around areas of high employment (such as the Wellington CBD and regional centres) and PT nodes and corridors while lower density growth is

generally in green field areas. Under 2041 medium growth, this implies an increase of 38,500 households in higher density areas, and 35,500 households increase in lower density areas under the two scenarios.

The land use density shift of 75% was chosen as a strong target to ensure that results of the shift would be clear.

5.4 Futures – Scenario Overview

Of the factors considered, 3 independent 'Futures variables' were determined that can be implemented in the model. These are:

Growth -> growth in population/employment/households, vehicle growth and GDP

Car Travel Cost -> growth in road user costs, car operating costs, fuel

Land Use Density -> changes in location and density of residential housing within TAs

The three 'Scenario variables' are arranged into 9 Futures Scenarios combinations.

Growth	Car Travel Cost	Land Use Density	Expectation
Low	Low	Lower	Potential lower PT demand
Low	Low	Higher	
Low	High	Lower	
Low	High	Higher	Potential lower road demand
Medium	Medium	Central	Central case
High	High	Higher	Potential higher PT demand
High	High	Lower	
High	Low	Higher	
High	Low	Lower	Potential higher road demand

6. Network Form

Six network forms representing strategic options were developed for this exercise:

- Base – The selection of projects was constrained to reflect a do minimum network – typically committed projects and high priority RLTP projects.
- Roads - A very strong focus on road-only projects.
- PT - A very strong focus on PT-only projects.
- Road Pricing - Base projects only while introducing peak period, peak direction road pricing at selected locations.

- Mixed – A combination of road and PT projects are chosen based on their performance in standalone scenarios (note that this does not include all PT and all road projects from above scenarios).

- Mixed plus Road Pricing – A combination of road and PT projects along with peak period, peak direction road pricing at selected locations. Note that 'Mixed' in this context is not the same as the Mixed network form, as some road investment may not be required.

The 9 Future Scenarios were tested on each of the six network forms. Overall, 54 model runs were completed.

Network projects included in the modelling were based on the 2009 RLTP project list, Implementation and Corridor Plans, the Wellington Regional Rail Plan and other projects that could be in place by 2041. Networks are coded as described in table 6.0.1.

Network Form	Base	PT	Road	Road Pricing	Mixed	Mixed & Road Pricing
Regional Travel Behaviour Change Programme	✓	✓	✓	✓	✓	✓
Rail Infrastructure – Electrify & Double Track MacKays to Waikanae	✓	✓	✓	✓	✓	✓
Real Time Passenger Information System	✓	✓	✓	✓	✓	✓
Bus Priority Scheme	✓	✓	✓	✓	✓	✓
Bus Service Improvements	✓	✓	✓	✓	✓	✓
Rail Scenario 1	✓	✓	✓	✓	✓	✓
Paraparaumu and Waikanae Station Upgrades	✓	✓	✓	✓	✓	✓
Adelaide Road capacity improvements	✓	✓	✓	✓	✓	✓
SH1 Basin Reserve upgrade	✓	✓	✓	✓	✓	✓
Dowse to Petone Interchange	✓	✓	✓	✓	✓	✓
Melling Interchange	✓	✓	✓	✓	✓	✓
SH2/SH58 (Haywards) Interchange	✓	✓	✓	✓	✓	✓
Western Link Road Stage 1	✓	✓	✓	✓	✓	✓
Western Link Road Ihakara Extension	✓	✓	✓	✓	✓	✓
Western Link Road Stage 3	✓	✓	✓	✓	✓	✓
Western Link Southern Connection	✓	✓	✓	✓	✓	✓
Integrated Ticketing		✓			✓	✓
Rail Electronic Ticketing		✓			✓	✓
Rail Scenario 2		✓			✓	✓
Rail Scenario A		✓			✓	✓
Rail Scenario B		✓				
LRT WGTN Station - Hospital		✓			✓	✓
LRT J'ville - Airport		✓			✓	✓
LRT Melling loop WTRL- MELL-WGTN		✓			✓	✓
4 lane Ruahine St and Wellington Rd			✓		✓	
Mt. Victoria Tunnel duplication			✓		✓	
Inner City Bypass Upgrade			✓			
Terrace Tunnel duplication			✓		✓	
Remove 1L ea way from waterfront route			✓		✓	
Waterloo Quay capacity improvements			✓		✓	✓
SH1 Ngauranga-Aotea peak period tidal flow lanes & Hutt Rd bus lanes			✓		✓	✓
Ngauranga Gorge Upgrade			✓			
Karori Tunnel Duplication			✓			
Johnsonville Road capacity improvements			✓		✓	✓
SH2 widen ->3L ea way Petone-Ngauranga			✓			
SH2 Kennedy Good Interchange			✓		✓	✓
SH2 Upper Hutt bypass upgrade (2L ea way)			✓			
SH2 Rimutaka Hill Rd ongoing upgrades			✓		✓	✓
SH58 widen to 2L ea way Expway E&W of TG			✓			
Grenada-Gracefield Western			✓		✓	✓
Grenada-Gracefield Eastern			✓			
Akatarawa Road upgrade			✓			
SH1 widen -> 3L ea way Tawa to Gorge			✓			
SH1/Whitford Brown Interchange			✓			
SH1 Waikanae Grade Separation			✓		✓	✓
SH1 Pukerua Bay Bypass			✓			
SH1 Otaihanga interchange			✓			
SH1 Kapiti Expressway Project			✓		✓	✓
Transmission Gully			✓		✓	✓
Western Link Road Stage 2			✓		✓	✓
Targeted Road pricing / Congestion pricing				✓		✓

Table 6.0.1 Activity List for Network Forms

7. Results

For analysis purposes, a group of four output indicators serve as the primary index to show how well a particular combination works. The indicators are:

- Increased annual PT trips (Total PT boardings split as peak and offpeak).
- Increased PT mode share for work trips (Home to Work PT mode share).
- Less severe road congestion (AM peak period congestion seconds per km).
- Reduced greenhouse gas emissions (annual CO_2).

While the previous RLTS had stretch targets for 2016, in this exercise, the performance scores are intended to show only change relative to 2006 conditions (Table 6.5.1).

Results are firstly reported on the effect of the futures scenarios on outcomes and then the effects of network form on outcomes, so the impact of each future or network form can be distinguished.

Strategic Options are a combination of futures and network form. Outcome performance scores are reported by these combinations to provide central case and potential ranges of outcomes.

7.1 Futures Impact on Outcomes

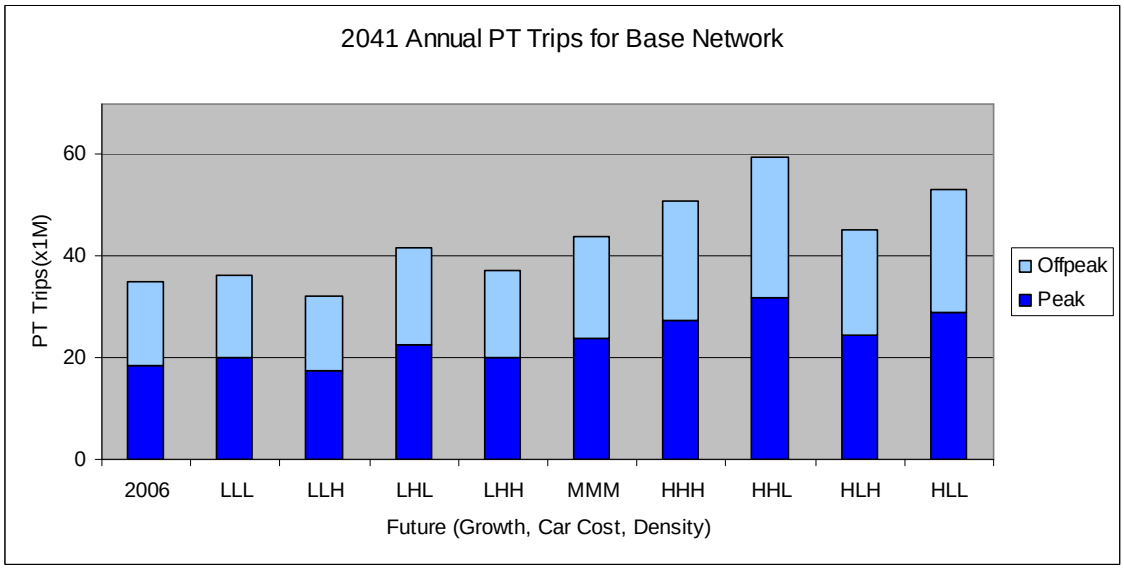
This section examines the impact of the future scenarios on the outcomes, which is best understood by comparing the futures on one network.

7.1.1 PT Trips

There is large variability in the number of PT trips depending on which future we assume. Growth has the largest impact on trips, driven by increased demand for the transport network. Growth also puts pressure on the road network, and so encourages modal shift when road investment is not made. Daily PT trips grow, on average, from low to medium growth by about 20%, while high growth is about 40% higher than low growth.

Another significant driver of PT trips is the competing cost of road travel, where a higher car cost future generates a significant increase in PT trips compared with a lower cost, as shown when comparing an ‘LLL’ future with an ‘LHL’ for example.

PT trip results between land use density scenarios show a counter-intuitive result, where PT trips reduce under a higher density scenario compared with a lower density. However, in the higher density futures, alternatives such as active modes are more viable while lower density mode choices are car and PT only. Also, as the number of households in the Wellington CBD and its fringes increase, these households will take on CBD employment from other areas that would typically take public transport to the CBD.



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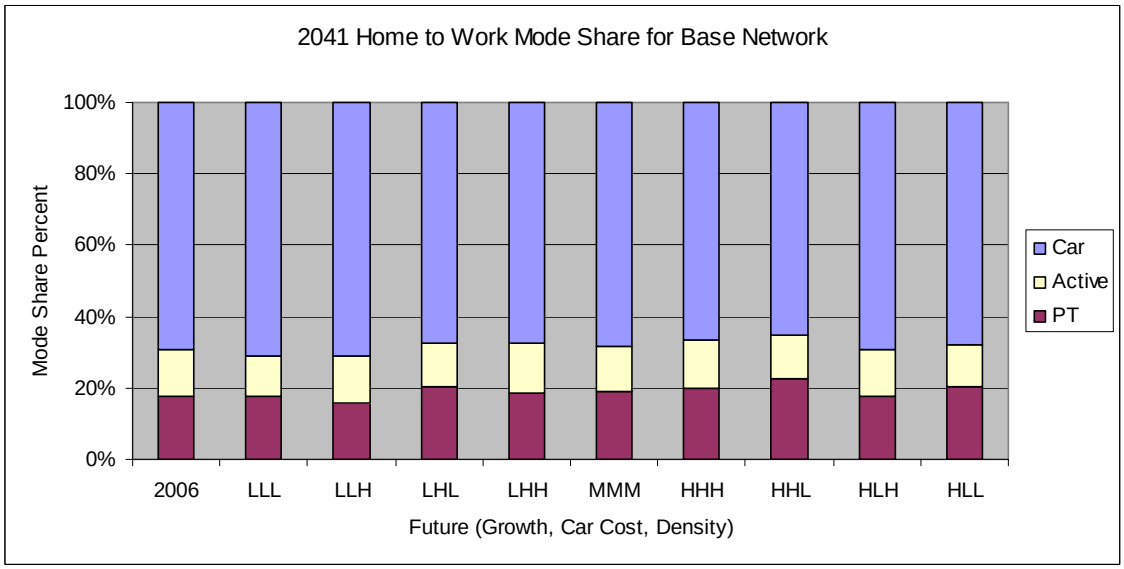
7.1.2 PT Mode Share

PT mode share is sensitive to growth from low to medium to high as increasing road activity (congestion) generates a mode shift to PT (compare 'LLL' to 'HLL').

Changes in PT mode share also occur when the relative gap between total car travel cost and total PT travel cost is reduced, making PT more competitive. As car travel cost increases, the relative cost difference between mode choices (Car/PT) reduces and PT becomes a more viable choice, increasing PT mode share.

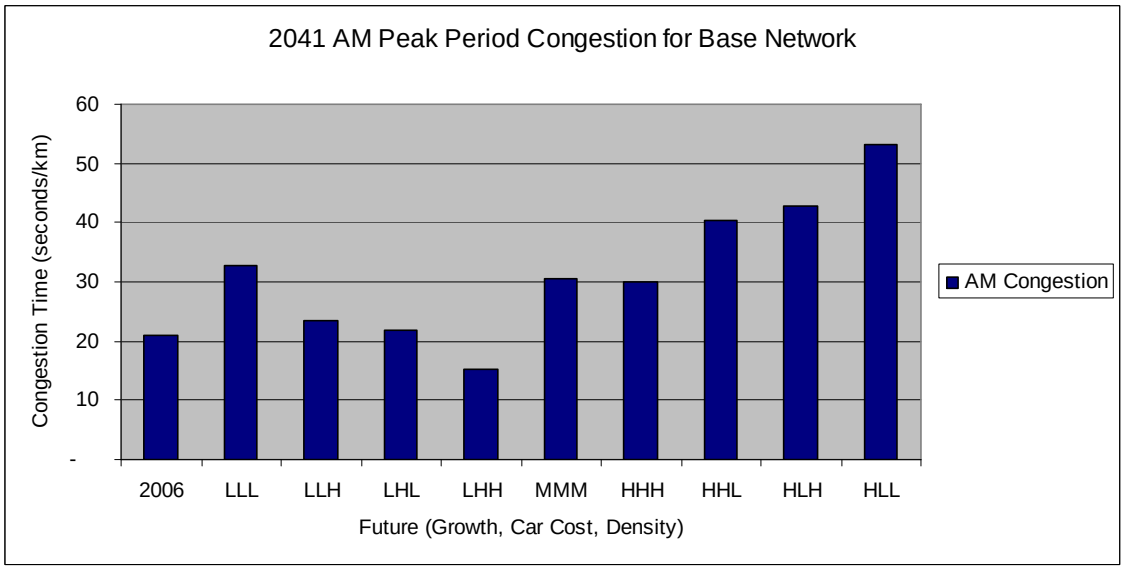
In lower density areas, the population is more spread out so the travel choices are largely car or PT. As car choice becomes less desirable (due to factors such as car travel cost, congestion, travel time) the PT choice becomes more desirable. Active mode is not a viable choice for most trips in a lower density environment.



7.1.3 Congestion

Increased growth leads to higher activity in all modes. Increased growth in road activity leads to increased congestion, contributing to reduced overall network performance and reduced freight efficiencies.

Higher car travel cost means fewer trips and shorter trips than lower car travel cost which can significantly reduce congestion ('LLL' vs 'LHL'). Moving from lower to higher density land use can also significantly reduce congestion, depending on the location of the land use.



7.1.4 CO_2 Emissions

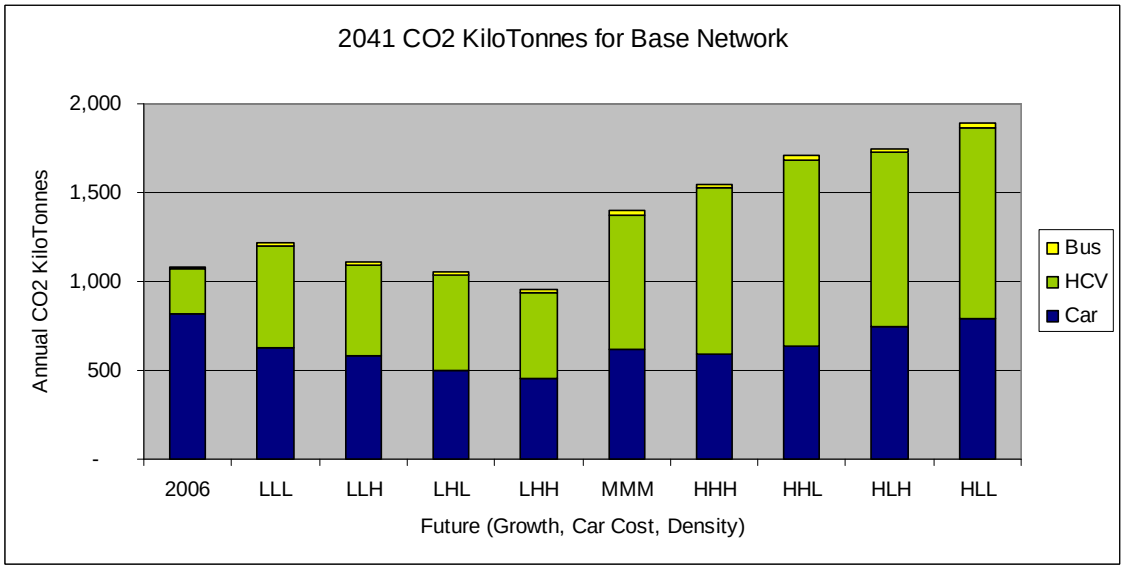
HCV CO_2 emissions rates (fuel use per km) remain the same as 2006 because we do not have enough information to make assumptions going forward concerning how they might change to 2041. Also, freight mode choice in the model is not sensitive to transport cost. The HCV fleet is likely to be less sensitive to road cost changes than car users, through the ability to pass on additional travel costs to the customer.

Based on economic and demographic growth, HCV trips expand significantly to 2041 depending on the GDP growth assumptions used, which is further exacerbated by HCV emissions rates remaining at 2006 levels. The effect of this is the HCV share of emissions (about 25% in 2006), increases to over 50% (low growth), about 56% (medium) and over 60% (high) in 2041. Due to the estimated future fuel efficiency improvements of the car fleet, all futures show a significant reduction in car-generated CO_2, with higher growth scenarios showing less of a reduction compared with 2006.

CO_2 emissions are affected by car travel cost. Higher car travel cost, creates fewer trips and shorter trips than low car travel cost, resulting in lower car CO_2 emissions. Higher car travel cost reduces congestion by moving cars off the road to other modes, allowing more efficient freight movement and so reducing HCV CO_2 emissions.

Higher density versus lower density land use has a lesser but similar effect of moving cars off the road to other modes, allowing more efficient freight movement and so reducing HCV CO_2 emissions.

PT fleet diesel buses contribute only 1-2% of CO_2 total emissions across all scenarios.



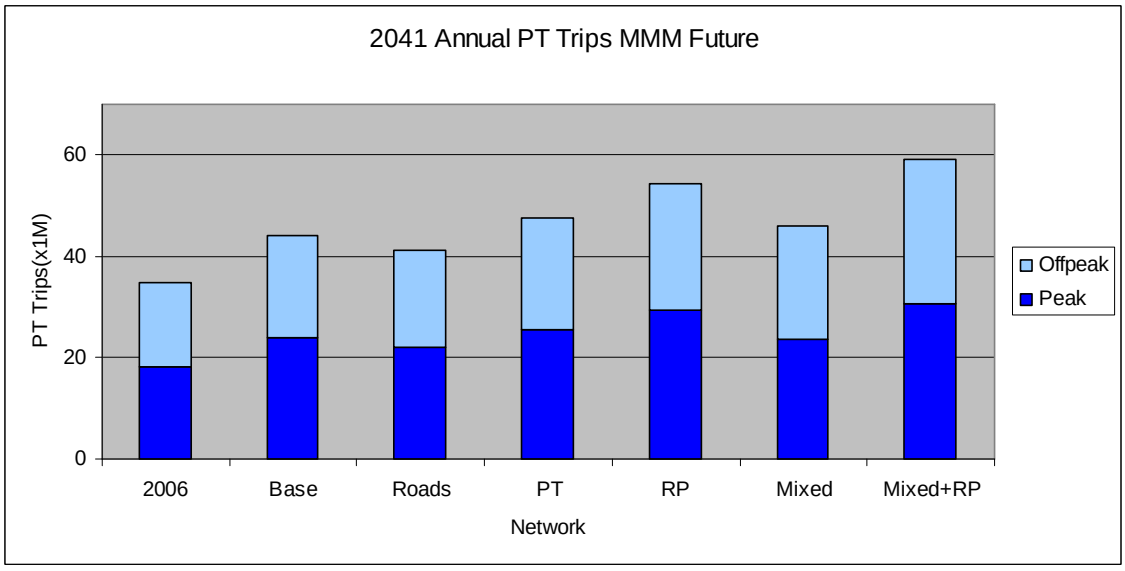
7.2 Network Impact on Outcomes

This section examines the impact of the network form on the outcomes, which is best understood by comparing the networks for one future scenario.

7.2.1 PT Trips

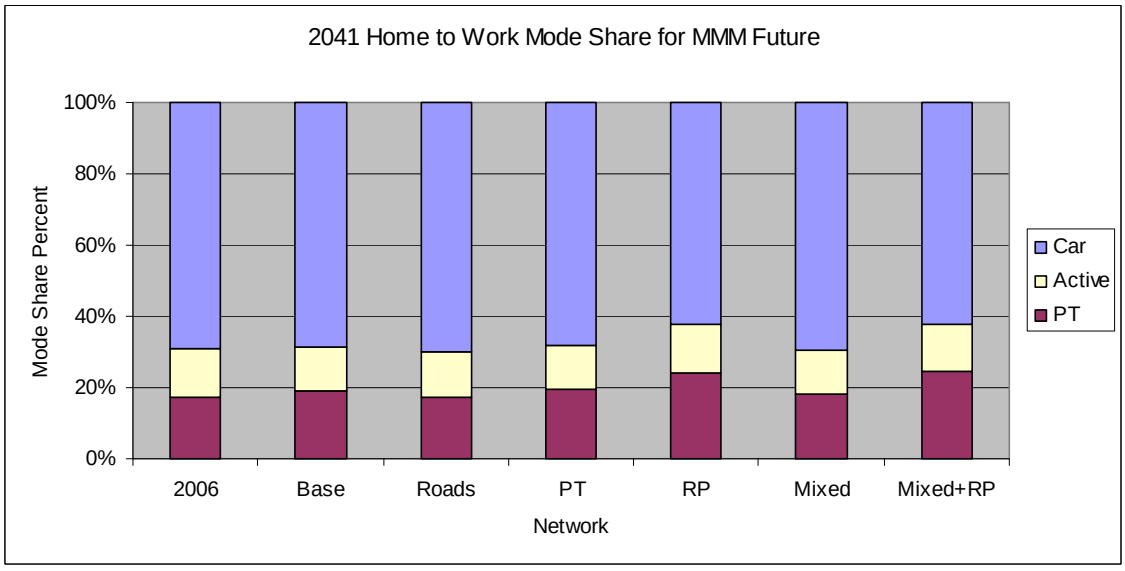
Compared to the base network, investing in a public transport focused network increases PT trips as measured by boardings. However the increase is not as marked as might be expected due to some of the PT initiatives reducing the amount of transfers in the PT network, and hence the boardings. A roads-focused network reduces PT boardings, whilst a mixed portfolio lies between the roads and PT focussed.

Scenarios including road pricing give the largest impact; in particular the mixed + RP network, which shows a larger impact than the sum of the mixed and RP effects on their own. This highlights the importance of a carrot and stick approach to encourage modal shift.



7.2.2 PT Mode Share

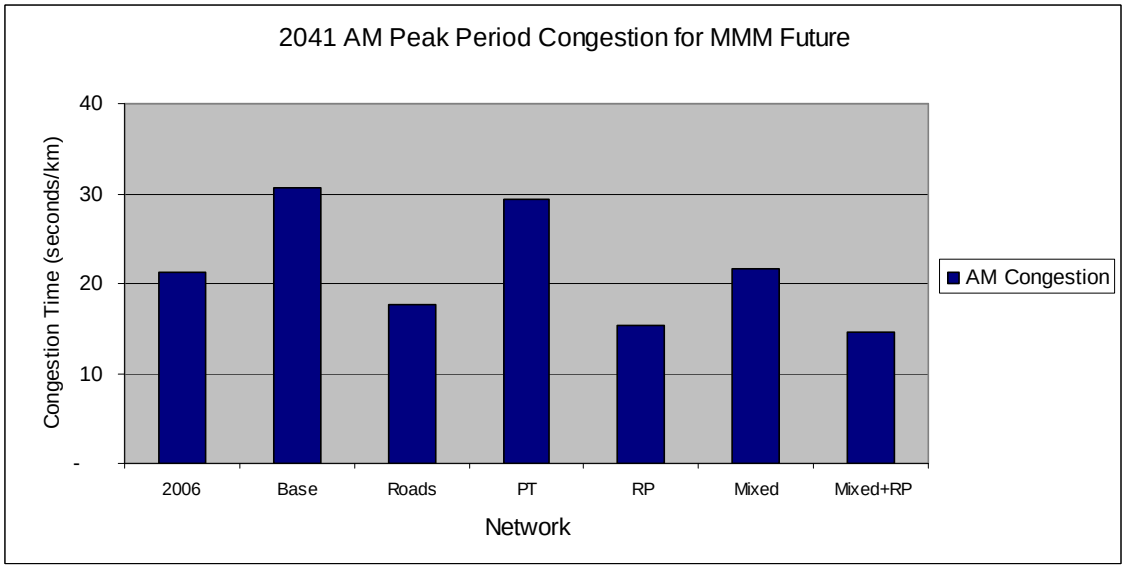
The network forms in general have little impact on home to work PT mode share, as they do not significantly change the relative costs of road and PT travel within key work corridors. All networks show an increase in PT mode share from 2006, with scenarios including road pricing having by far the largest impact. This is mostly due to the design of the road pricing scenario, which focuses pricing on areas of higher road congestion which also have strong PT levels of service.



7.2.3 Congestion

Under a 'MMM' future, network congestion in the AM peak is predicted to worsen under a base network. Investing in PT slightly reduces congestion levels against the base, whilst a road investment approach brings congestion to below 2006 levels. A mixed scenario broadly holds the line to 2006.

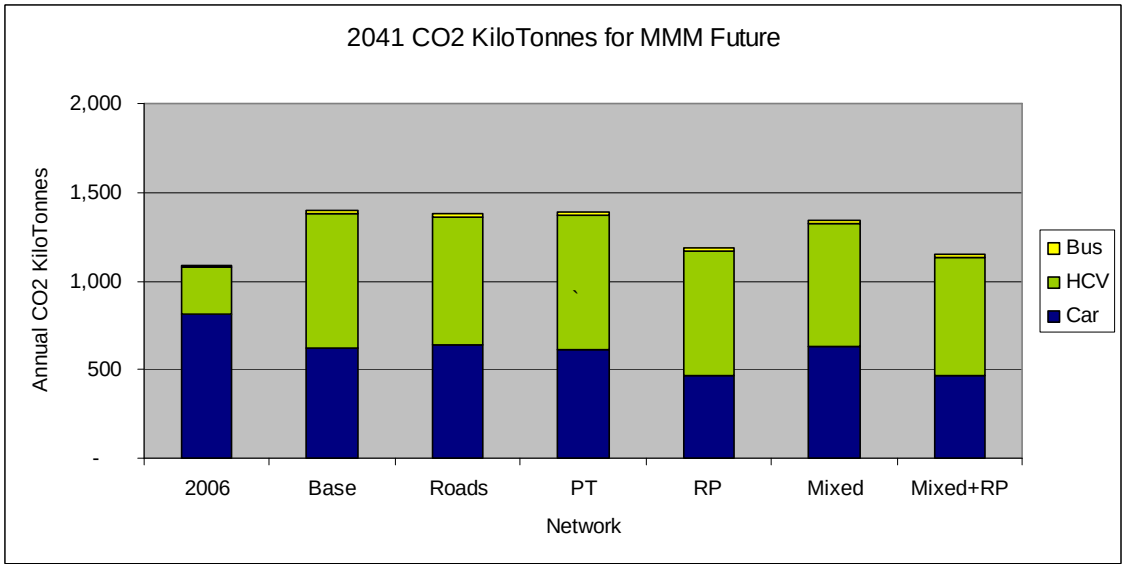
Road pricing is an effective network management tool to reduce congestion, in this case to better than a road investment scenario. This highlights in particular that road pricing could be used as a mechanism to defer or replace future large scale road investment as a congestion management tool.



7.2.4 CO_2 Emissions

The largest change to emissions occurs with road pricing in place, increasing the car travel cost over and above other car travel costs. Increased car travel cost moves cars off the road to other modes reducing car CO_2 emissions and allowing more efficient freight movement which reduces HCV CO_2 emissions.

Other network forms have little impact of CO_2, although it is interesting to note that the impact of the mixed network is greater than the sum of the roads and PT, showing the synergies of a mixed investment approach.



7.3 Outcome Performance Scores

Outcome performance scores are reported on in the Outcomes Scores table below. The assessment of reported results against the RLTS targets uses the following scores comparing values to 2006. Tolerances have been chosen to give reasonable differentiation between Futures:

✓✓✓	Very significant improvement
✓✓	Significant improvement
✓	Minor improvement
0	Neutral -no significant improvement over current outcome
×	Minor negative contribution
××	Significant negative contribution
×××	Very significant negative contribution

Note: Tolerances are symmetric, so 50% increase tolerance same as 50% decrease

Future Key:
yearxyz
x=Growth (Low, Medium, High)
y=Road Cost (Low 0%, Medium 35%, High 75%)
z=Density (Lower - more rural, Medium, Higher - more urban)

Indicator	Network	Future									
		2006MMM	2041LLL	2041LLH	2041LHL	2041LHH	2041MMM	2041HHH	2041HHL	2041HLH	2041HLL
Total PT Boardings	Base	○	○	○	✓	○	✓✓	✓✓	✓✓✓	✓✓	✓✓✓
	Roads	○	○	×	✓	○	✓	✓✓	✓✓✓	✓	✓✓
	PT	○	✓	○	✓✓	✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓
	Road Pricing	○	✓✓	○	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
	Mixed	○	○	○	✓✓	✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓
	Mixed +Rd Pricing	○	✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
HBW PT Modeshare	Base	○	○	××	✓✓	✓	✓	✓✓	✓✓✓	○	✓✓
	Roads	○	×	××	✓✓	○	○	✓	✓✓	×	○
	PT	○	○	×	✓✓	✓	✓✓	✓✓	✓✓✓	○	✓✓✓
	Road Pricing	○	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
	Mixed	○	○	××	✓✓	✓	○	✓✓	✓✓✓	○	✓✓
	Mixed +Rd Pricing	○	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
AM Congestion	Base	○	××	○	○	✓	××	××	×××	×××	×××
	Roads	○	○	✓✓	✓✓	✓✓	○	○	×	×	×××
	PT	○	××	○	○	✓	××	××	×××	×××	×××
	Road Pricing	○	✓	✓	✓✓	✓✓	✓	✓	○	○	××
	Mixed	○	○	✓	✓	✓✓	○	○	××	××	×××
	Mixed +Rd Pricing	○	✓✓	✓✓	✓✓	✓✓	✓	✓	○	○	○
Annual CO2	Base	○	○	○	○	○	×	××	××	××	×××
	Roads	○	○	○	○	○	×	××	××	××	×××
	PT	○	○	○	○	○	×	××	××	××	×××
	Road Pricing	○	○	○	○	✓	○	×	××	××	××
	Mixed	○	○	○	○	○	×	××	××	××	××
	Mixed +Rd Pricing	○	○	○	○	✓	○	×	×	×	××

Performance Indicators	Tolerances (above percentage value)			
	Neutral	Minor	Significant	Very Significant
PT Boardings	0%	13%	25%	50%
HBW Modeshare	0%	5%	10%	20%
AM Congestion	0%	19%	38%	75%
CO2	0%	19%	38%	75%
	○	✓	✓✓	✓✓✓
	Neutral	Minor	Significant	Very Significant

Focusing on the central case (MMM) compared with 2006:

- Base network scores well on the PT indicators, but does not address congestion or CO_2
- Roads network scores broadly neutral on the PT indicators, holds the line for congestion, but does not address CO_2
- PT network scores very well on the PT indicators, but does not address congestion or CO_2
- Mixed network scores well on the PT indicators, holds the line on congestion, but does not address CO_2
- Road pricing scenarios are the most effective across all of the indicators, showing either a very significant improvement or (in the case of CO_2) holding the line compared with 2006.

Given other futures, a lower growth scenario in general shows less improvement in the PT indicators, but also indicates less of an issue around congestion and CO_2. Conversely, the higher growth scenarios show very strong PT indicators, offset by significant issues of congestion and CO_2.

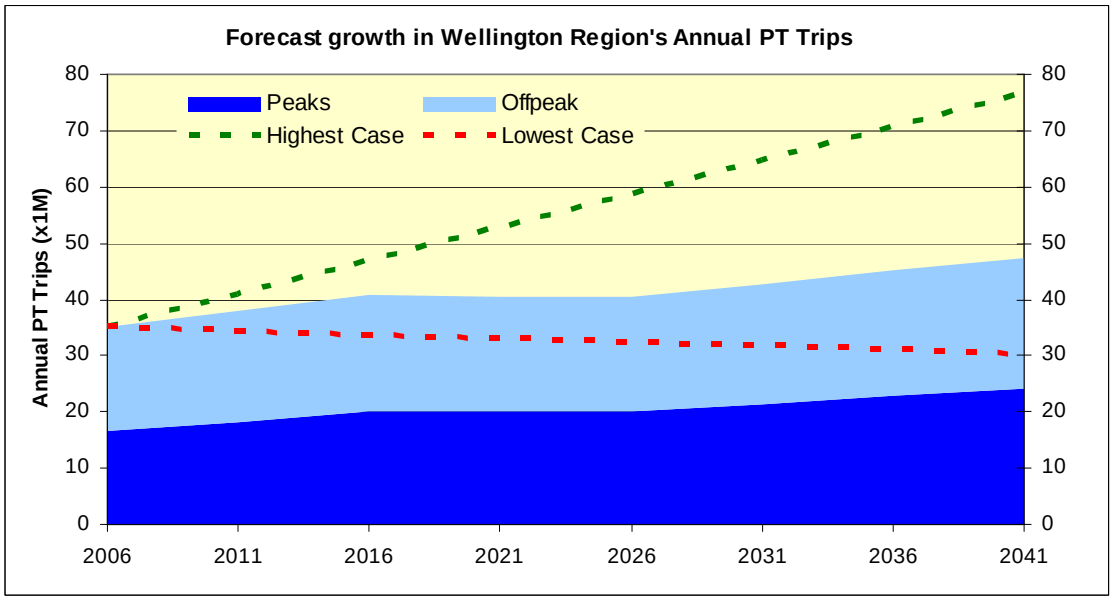
A mixed investment scenario seems to provide the most balanced approach to improvements on all indicators. Clearly it will not be sufficient to deal with demand for the transport network under higher growth scenarios, so depending on the level of growth, a pricing mechanism could be introduced to provide the level of improvements desired. Under a lower growth option less investment will be required to hold the line.

7.3.1 Outcome Results Ranges

The graphs in this section provide the central case and lower and upper bounds for the outcomes modelled under all the scenarios. In most cases the ranges are large, which represents the uncertainty around many of the key drivers of transport demand that are outside our control.

Outcome Results Ranges – PT Trips

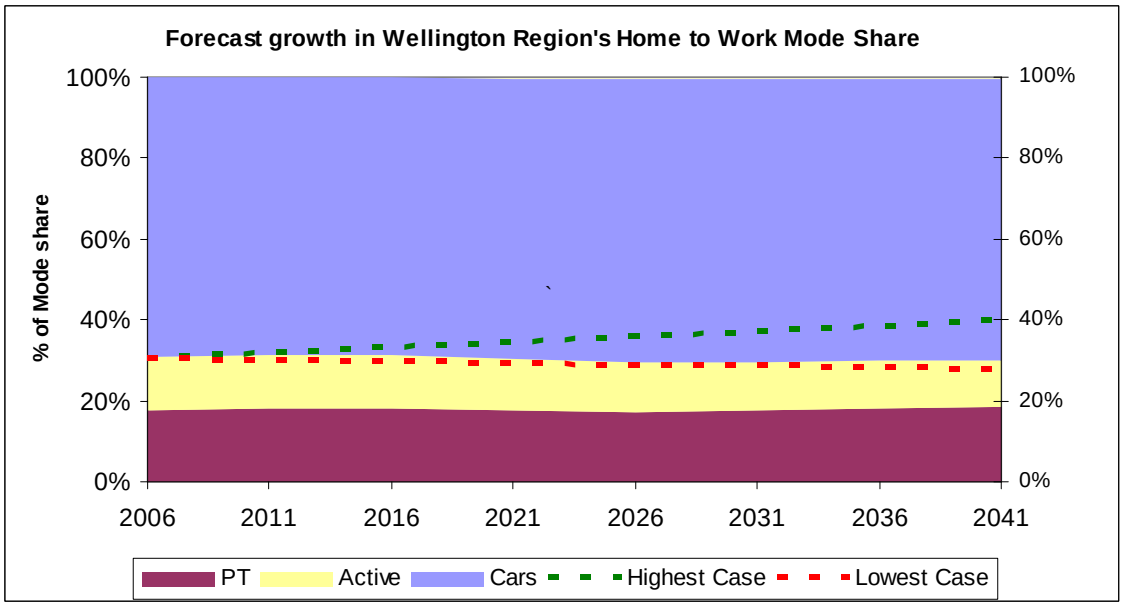
The central case shows some 50mppa by 2041 under a mixed investment network, with possible ranges of up to 80mppa under a higher growth mixed+road pricing to a 30mppa (lower than 2006) when growth and car costs are low.



Annual PT Trips		Growth	Car Cost	LU Density
Lowest Case	Roads	L	L	H
Medium	Mixed	M	M	M
Highest Case	Mixed +Road Pricing	H	H	L

Outcome Results Ranges – PT Mode share

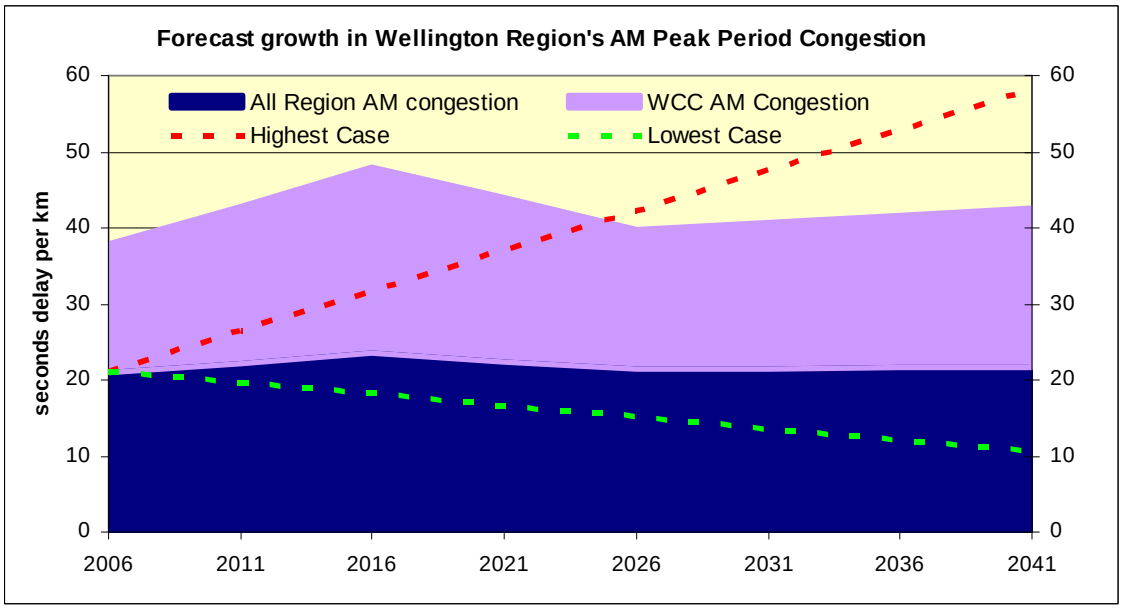
The range of PT mode share is smaller, due to being a relative measure rather than an absolute. PT mode share is likely to remain similar to the current situation under a lower and central scenario. When growth and car costs are higher, and road pricing is introduced, there is the potential to significantly increase mode share.



PT mode Share		Growth	Car Cost	LU Density
Lowest Case	Roads	L	L	H
Medium	Mixed	M	M	M
Highest Case	Mixed+Road Pricing	H	H	L

Outcome Results Ranges – AM Period Congestion

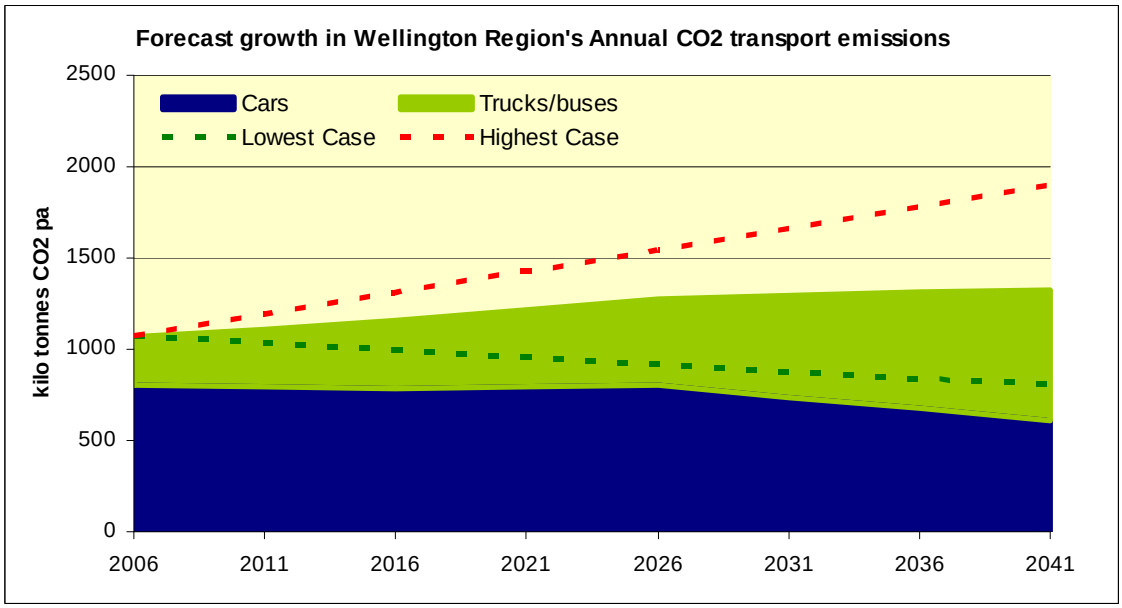
The central case shows levels of congestion broadly holding the line compared with 2006 for both the whole region and Wellington city (where most of the congestion occurs). The most optimistic case is where growth is low, densities are higher, and road pricing is introduced with a mixed investment. The highest case occurs when little future investment in the network occurs, to deal with higher levels of growth and lower car costs.



AM Peak Period Congestion		Growth	Car Cost	LU Density
Lowest Case	Mixed+Road Pricing	L	H	H
Medium	Mixed	M	M	M
Highest Case	Base	H	L	L

Outcome Results Ranges – CO_2 Emissions

The central case shows levels of CO_2 higher than 2006 due primarily to significant increases in emissions from HCV's (as a result of GDP and no improvements in future vehicle fuel efficiency). CO_2 could remain below 2006 levels under a lower growth and high car cost scenario, but this would require the future car fuel efficiencies assumed to happen. Conversely, a higher growth lower car cost scenario will result in significantly more HCV and private car movements.



CO2 transport emissions		Growth	Cost	LU Density
Lowest Case	Mixed+Road Pricing	L	H	H
Medium	Mixed	M	M	M
Highest Case	Base	H	L	L

7.4 STRATEGIC OPTION RESULTS

This section summarizes how each of the various strategic options affects key goals of the Regional Land Transport Strategy.

7.4.1 Base

The Base selection of projects was constrained to reflect a 2041 do minimum scenario (Table 5.0.1).

		Future									
Indicator	**Network**	2006MMM	2041LLL	2041LLH	2041LHL	2041LHH	2041MMM	2041HHH	2041HHL	2041HLH	2041HLL
Total PT Boardings	Base	○	○	○	✓	○	✓✓	✓✓	✓✓✓	✓✓	✓✓✓
HBW PT Modeshare	Base	○	○	××	✓✓	✓	✓	✓✓	✓✓✓	○	✓✓
AM Congestion	Base	○	××	○	○	✓	××	××	×××	×××	×××
Annual CO2	Base	○	○	○	○	○	×	××	××	××	×××

Assist economic and regional development

Improvements to encourage economic and regional growth are not considered in this option.

Improve access, mobility and reliability

Low growth Base PT scores show neutral to minor improvement. The trigger for change appears to be car travel cost, and to a lesser degree, trips moving to active mode in a high land use density setting. Score change is muted because of the flat growth.

Low growth Base congestion scores worsen when car travel cost and land use density are low (LLL) as people move to car mode generating more trips, and in turn more congestion and emissions. Scores see minor improvement with high car travel costs and high land use density (LHH). Score change is muted because of the flat growth.

Medium growth Base PT scores are significantly better with about 30% more peak PT trips and about 20% more offpeak trips than 2006.

Medium growth Base congestion score is significantly worse. AM Congestion delay/km increases by 45% as the limited selection of projects can't meet the increased demand for trips despite the increase in PT trips and a small increase in active mode trips. Car trips are up 20% while HCV trips are up over 170%. Congestion increases are reflected in vehicles hours travelled (VHT) increasing at a higher rate than vehicle kilometres travelled (VKT) (more time for same distance).

High growth Base PT scores are primarily significant to very significant. A neutral home to work PT mode share score (HLH) is due to the combination having similar home to work mode share as 2006 though volumes are up by 30%. PT trip increases appear to occur as a result of very significant worsening performance of the road network.

High growth Base congestion scores are very significantly worse. Congestion delay/km increases significantly as the limited selection of projects cannot meet the increased demand for trips. Low density land use and low car travel cost influence road indicators, worsening congestion and emissions.

Ensure environmental sustainability

It is assumed that the car fleet change to 30% electric vehicles and other advances in technology reduce car emissions while HCVs have no similar emissions reductions assumed.

From Low Growth where CO_2 emissions are mostly neutral, emissions continue to grow rather than decrease. Medium growth and high growth are both significantly worse than 2006.

This trend to increasing CO_2 emissions is in large part due to the assumption of no improvement in HCV fleet efficiencies. This leads to increasing HCV CO_2emissions at a time when a growing car fleet has CO_2 emissions that are reducing based on assumptions about car fleet efficiencies.

In 2006 HCV CO_2 emissions are about 25% of total CO_2 emissions. For Base Low Growth this doubles to about 50%, while Medium growth is 56% and High growth is about 60% of total CO_2 emissions.

The real value of car CO_2 emissions falls in all Base Futures. The medium growth reduction to 75% of 2006 value (60% -lowest in low growth, 95% highest in high growth) is achieved while car trips, kilometres, and time travelled are increasing.

7.4.2 Road

The Road selection of projects has a very strong focus on road-only projects (Table 5.0.1).

		Future									
Indicator	**Network**	2006MMM	2041LLL	2041LLH	2041LHL	2041LHH	2041MMM	2041HHH	2041HHL	2041HLH	2041HLL
Total PT Boardings	Roads	○	○	×	✓	○	✓	✓✓	✓✓✓	✓	✓✓
HBW PT Modeshare	Roads	○	×	××	✓✓	○	○	✓	✓✓	×	○
AM Congestion	Roads	○	○	✓✓	✓✓	✓✓	○	○	×	×	×××
Annual CO2	Roads	○	○	○	○	○	×	××	××	××	×××

Assist economic and regional development

The road focus of this option is intended to sustain economic growth to 2041, reduce congestion and emissions, improve freight efficiency and improve reliability of the road network.

Improve access, mobility and reliability

With limited PT improvements in this option, low growth Road PT scores range from somewhat negative to minor positive improvement. The trigger for change appears to be car travel cost, and, to a lesser degree, trips moving to active mode in a high density land use setting.

Low growth Road congestion scores are significantly better for congestion. Scores improve under low growth as a relatively modest increase in cars numbers gets road focused projects.

Medium growth Road PT scores are neutral, with an increase in the number of PT passengers as growth increases, but no change in mode share.

Medium growth Road congestion score is neutral as congestion delay reduces by less than 20%.

High growth Road PT scores are mostly positive, from minor to very significant as a result of the road improvements being insufficient on their own to meet the high growth demands.

High growth Road congestion scores are generally negative, with congestion increasing by 25%to over 50%, particularly with a combination of lower density land use and low car travel cost.

High growth scenarios are generally worse, as the road improvements cannot meet the increased demand on the network. The unimproved PT system must carry the additional demand, contrary to the intention of the option.

Ensure environmental sustainability

Low Growth CO_2 emissions are on average, neutral relative to 2006 values. Medium growth emissions (plus 27%) and high growth (plus 57% avg.) follow a similar pattern of increase and are both significantly worse than 2006. Transport demand grows as the region grows, and the demand cannot be met by a network form focused only on roads.

In 2006 HCV CO_2 emissions are about 25% of total CO_2 emissions. For Roads Low Growth this doubles to an average 50%, while Medium growth is 54% and High growth is an average 58% of total CO_2 emissions.

Real values for HCV CO_2 emissions increase by an average 95% for low growth, increasing by 178% to medium growth, and an average 270% for high growth relative to 2006. Since HCV are about 5-10% of traffic (2006), the change in emissions is softened overall by the greater percentage of cars on the road and the reduction in car emissions. The Future scenario variable that most affects emissions is congestion.

The real value of car CO_2 emissions falls in almost all Roads Futures based on car fleet efficiencies. The medium growth reduction to 78% of 2006 value (57% -lowest in low growth, 100% highest in high growth) is achieved while car trips, kilometres, and time travelled are increasing.

7.4.3 PT

The PT selection of projects has a very strong focus on only PT-only projects (Table 5.0.1).

Indicator	Network	Future									
		2006MMM	2041LLL	2041LLH	2041LHL	2041LHH	2041MMM	2041HHH	2041HHL	2041HLH	2041HLL
Total PT Boardings	PT	○	✓	○	✓✓	✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓
HBW PT Modeshare	PT	○	○	×	✓✓	✓	✓✓	✓✓	✓✓✓	○	✓✓✓
AM Congestion	PT	○	××	○	○	✓	××	××	×××	×××	×××
Annual CO2	PT	○	○	○	○	○	×	××	××	××	×××

Assist economic and regional development

The PT focus of this option is intended help sustain economic growth to 2041 by increasing PT use (peak and offpeak) and community connectedness, increasing PT mode share, reducing car mode share and car emissions, and improving PT reliability.

Improve access, mobility and reliability

Low growth PT public transport peak period trips increase on average about 22% with no change in home to work mode share. As PT peak trip growth increases from low to medium (plus 40%) to high (avg. plus 70%), home to work PT mode share sees very little change for low or medium growth and some change in high growth, as most high scenarios reach over 20% mode share. The trigger for change appears to be car travel cost and, to a lesser degree, changes in land use density.

Low growth PT road congestion scores are mostly neutral. Scores are more negative when car travel cost is low, generating more congestion. Scores improve more as car travel costs increase. Average score change is muted because of the flat growth.

Medium growth PT road congestion score is significantly worse since the road network form is the Base 'do minimum'. Medium growth congestion is 40% worse than 2006, and this contributes to increased PT passenger numbers at a medium car travel cost.

High growth PT road congestion scores range from significant very significantly negative, as the lack of road improvements cannot meet the demands on the network. Congestion is significantly, affected by growth and to a lesser degree by land use density and car travel costs. Congestion delays increase by about 40% to about 140% in the worst case (average 90%).

Ensure environmental sustainability

Low growth emissions growth is neutral as HCV emissions increase by about 100%, while car emissions decrease by about 35%, for a net overall increase of about 0%.

Medium and high growth emissions are significantly and very significantly worse. Medium growth sees a 25% decrease in car and a 192% increase in HCV emissions (real values) for a net increase of about 30% in total emissions over 2006. High growth sees a 300% increase in HCV and a 16% decline in car emissions for a net average increase of 58% over 2006 values. As demands for positive transport changes grow and as the region grows, this growth cannot be met by a PT focused network form.

Bus emissions receive little mention since the bus fleet generates only 1%-2% of total

daily emissions.

7.4.4 Road Pricing

The Road Pricing option is focused on reducing car mode through road user charges. In this option, the road user charge is a peak hour peak direction tool at selected locations on the Base network form (Table 5.0.1). This option is generated by laying the road pricing scheme on the 'do minimum Base option.

Road Pricing is a surcharge system for motorists, as a traffic management tool for travel behaviours that have a negative contribution to the RLTS objectives. Road pricing in this work is in the peak period, in the peak direction, focusing on trips to (AM) and from (PM) the Wellington CBD. The 2005 Road Pricing Study scheme was followed, with road pricing locations and pricing set as follows:

- SH1 S of Tawa interchange including adjacent roads $1.00
- SH2 S of SH58 interchange including adjacent roads $1.00
- SH2 S of Petone toward CBD only $2.00
- SH1 S of Ngauranga interchange including adjacent roads $1.50
- Mt Victoria screenline including Mt Vic Tunnel, Oriental Parade, Constable St, Manchester St including adjacent roads $3.00

Parallel routes are included in road pricing to prevent 'rat-running' to avoid road pricing.

Indicator	Network	Future									
		2006MMM	2041LLL	2041LLH	2041LHL	2041LHH	2041MMM	2041HHH	2041HHL	2041HLH	2041HLL
Total PT Boardings	Road Pricing	○	✓✓	○	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
HBW PT Modeshare	Road Pricing	○	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
AM Congestion	Road Pricing	○	✓	✓	✓✓	✓✓	✓	✓	○	○	××
Annual CO2	Road Pricing	○	○	○	○	✓	○	×	××	××	××

Assist economic and regional development

The Road Pricing strategy introduces an additional cost to car travel that should generate a mode shift to PT trips, thus reducing peak period car trips. The reduction in car trips reduces congestion and emissions and increases freight efficiency (reduced congestion).

Improve access, mobility and reliability

Low growth Road Pricing PT daily trip scores range from neutral to very significantly positive (average 27%) versus an average 5%increase in the Base option which this option is based upon. Peak periods trips increase by an average 32% (10% in Base). Home to work PT mode share increases by an average 30% (3% in Base), reflecting strong PT mode share change generated by road pricing.

Low growth Road Pricing road congestion scores show significantly decreased (average

34%) congestion relative to 2006, as the road pricing generates strong peak periods mode share change from car trips to PT trips. As comparison, the Base option Low growth congestion had an average 11% congestion increase.

Medium growth Road Pricing PT daily trip scores are very significantly better (55%) than the 26% increase in the Base option medium growth. Peak period trips increase by 60% (30% in Base). Medium growth Home to work PT mode share increases by 38% in the peaks periods (9% in Base), reflecting the strong PT mode share change generated by road pricing.

Medium growth Road Pricing road congestion scores significantly positive with a 27% reduction in congestion relative to 2006 and against a 45% increase in congestion for the Base option medium growth. The significantly better congestion score is important as this score is achieved on the Base 'do minimum' network, and is better than the Roads congestion score which would involve major road improvements.

High growth Road Pricing PT daily trip scores are very significantly better (avg. 77%) than the 49% increase in the Base option high growth. Peak trips increase by an average 81% (54% in Base). Home to work PT mode share increase is significant as mode share reaches an average 25% versus just over 20% in Base and 17.5 % for 2006 reflecting strong PT mode share change generated by road pricing.

High growth Road Pricing road congestion scores are mostly neutral. The congestion scores of neutral and marginally better are important as these scores are achieved on the Base 'do minimum' network, and are better than the Roads congestion scores which would involve major road improvements.

Ensure environmental sustainability

Low Growth CO_2 emissions have neutral to positive scores, decreasing by an average 11% relative to 2006 values. Medium growth emissions are neutral, increasing about 10% and high growth is significantly worse at an average 40% increase from 2006.

In 2006 HCV CO_2 emissions are about 25% of total CO_2 emissions. For Low Growth Road pricing, this increases to an average 55%, while Medium growth HCV is 55% and High growth is an average 65% of total CO_2 emissions.

Real values for HCV CO_2 emissions increase by an average 95% for low growth, increasing by 174% to medium growth, and an average 270% for high growth relative to 2006. HCVs are a small proportion of traffic (typically 5-10% (2006)), so the increase in HCV emissions is softened overall by the greater percentage of cars on the road and the reduction in car emissions.

7.4.5 Mixed

The Mixed option delivers a combination of road and PT projects chosen on their performance in standalone options (Table 5.0.1).

Indicator	Network	Future									
		2006MMM	2041LLL	2041LLH	2041LHL	2041LHH	2041MMM	2041HHH	2041HHL	2041HLH	2041HLL
Total PT Boardings	Mixed	○	○	○	✓✓	✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓
HBW PT Modeshare	Mixed	○	○	××	✓✓	✓	○	✓✓	✓✓✓	○	✓✓
AM Congestion	Mixed	○	○	✓	✓	✓✓	○	○	××	××	×××
Annual CO2	Mixed	○	○	○	○	○	×	××	××	××	××

Assist economic and regional development

The Mixed options are a combination of PT and road enhancements to deliver increased freight efficiencies, increased road and PT reliability whilst accommodating economic growth to 2041.

Improve access, mobility and reliability

Low growth Mixed PT daily trip scores are neutral to significantly positive, averaging a 13% increase in daily trips. Peak periods trips increase by an average 18% while offpeak trips increase at about 8% for low growth. Medium and high growth scenarios see significant increases in daily trips (35% medium, 57% high) driven largely by growth. Home to work mode share change is mostly neutral across all growth scenarios. Network improvements to both PT and road make a shift to better PT scores more challenging.

Mixed option road congestion scores range from neutral in medium growth to significantly positive in low growth and significantly negative in high growth. This indicates that in the medium growth, the road network might perform in a similar way to the 2006 road network for congestion, while the Mixed option cannot meet demands on the network with a high growth scenario.

Ensure environmental sustainability

Low Growth CO_2 emissions have quite neutral scores, decreasing by an average 2% relative to 2006 values. Medium growth emissions are somewhat negative, increasing by about 25%, while high growth is significantly worse at an average 52% increase in emissions from 2006.

The real value of car CO_2 emissions falls in almost all Mixed options based on car fleet efficiencies. The medium growth reduction of 23% of 2006 value (44% -lowest in low growth, 0% highest in high growth) is achieved while car trips, kilometres, and time travelled are increasing

HCV CO_2 emissions are about 25% of total CO_2 emissions in 2006. For Low Growth Road pricing, this increases to an average 48%, while Medium growth HCV is 53% and High growth is an average 57% of total CO_2 emissions..

7.4.6 Mixed +Road Pricing

The Mixed +Road Pricing option combines most of the Mixed combination of road and PT projects along with road pricing. Some Mixed road projects near road pricing locations are removed based on observed network performance in the Road Pricing option, notably Terrace Tunnel Duplication and Mount Victoria Tunnel Duplication (with Ruahine Dr. 4L) (Table 5.0.1).

		Future									
Indicator	**Network**	2006MMM	2041LLL	2041LLH	2041LHL	2041LHH	2041MMM	2041HHH	2041HHL	2041HLH	2041HLL
Total PT Boardings	Mixed +Rd Pricing	○	✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
HBW PT Modeshare	Mixed +Rd Pricing	○	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
AM Congestion	Mixed +Rd Pricing	○	✓✓	✓✓	✓✓	✓✓	✓	✓	○	○	○
Annual CO2	Mixed +Rd Pricing	○	○	○	○	✓	○	×	×	×	××

Assist economic and regional development

The Mixed +Road Pricing options are based on but not the same as the Mixed options and add road pricing, which will further increase a mode shift to PT trips, reduce peak period car trips, reduce congestion and car emissions, and increase freight efficiency. The removal of selected Mixed improvements is expected to have a minimal impact because they are near road pricing locations. This can significantly reduce costs.

Improve access, mobility and reliability

Mixed +Road Pricing PT daily trip scores are significant to very significantly positive in all growth scenarios. Daily trips increase by 45%(L), 72%(M) and 95%0(H) as the road pricing charge in the peak periods increases overall car travel cost, moving more trips to PT mode. The road pricing is less effective in scenarios where car travel cost is low.

PT peak periods trips see a greater increase than offpeak which is in part due to the road pricing scheme operating during in the peak direction during peak periods only.

Home to work PT mode share sees very significant increases in all growth scenarios as the effect of the road pricing mode shift. The increase in mode share is 35-40% above 2006 levels, averaging a 24% mode share across all 9 futures (17.5% 2006).

Low growth Mixed +Road Pricing road congestion score is improved by over 35% compared to 2006. The combination of road projects plus road pricing has a major impact on the network operation in a low growth environment.

Medium growth Mixed +Road Pricing road congestion score is improved by about 30% compared to 2006. This result is significant since it occurs with medium growth and no duplication of the Terrace Tunnel and Mt. Victoria Tunnel.

High growth Mixed +Road Pricing road congestion scores are neutral compared to 2006, from 7% higher to 20% lower depending on the scenario. This result is significant since it closely matches 2006 performance while dealing with high growth and with no duplication of the Terrace and Mt. Victoria Tunnels.

Ensure environmental sustainability

Low growth CO_2 emissions improve from 2006 levels by an average 16%. HCV

emissions increase near 85%, while car emissions decrease near 50% compared to 2006.

Medium growth overall emissions are neutral at a 6% increase over 2006. Car emissions are down over 40% from 2006 while HCV emissions increase by over 150% from 2006 with increased fleet size and increased activity.

High Growth overall emissions see a minor to significantly worsening, though less than most other options. Car emissions are down 35% from 2006 while HCV emissions increase by about 240% from 2006 with increased fleet size and increased activity. The increase in emissions relative to improving congestion scores indicates that this network does not deal as well with high growth as might be desired.

8. Conclusions

There are many influences to demand for the transport system that are outside the control of decision makers. Modelling work has been undertaken to understand how some of these external influences affect important outcomes for our transport system performance. Relating possible futures of growth, car costs, and land use density to different types of network form, some strong conclusions can be drawn.

Futures

- **Growth** (population, employment, economic) is the largest single influence on transport system performance. Growth has a positive impact on PT outcomes as it generates more PT travel, and results in more congestion which in turn encourages mode switching. Growth however has a negative impact on congestion and CO_2 due to increased levels of car and HCV demand.

- **Car travel cost** is also a large influence on the transport system performance. Higher car travel costs positively affect mode share (PT trips), congestion and emissions. Moving from low to high car travel cost can generate up to 30% reduction in congestion depending on the network form.

- **Land use density** can have an impact on transport network performance. Higher density land use scenarios generate lower levels of congestion compared with lower density scenarios. Active mode share increases with higher density land use, where people have improved access by active modes to activities. However this can come at the expense of PT usage.

Outcomes

- **Public transport trips** increase primarily due to growth, or when the gap between car and PT travel cost is reduced. When road network performance deteriorates significantly (ie. congestion increases), PT trips (and mode share) increase as drivers switch to PT. Investing primarily in PT provides more growth in patronage, whilst under a mixed investment scenario, the growth in PT trips is lower. Road pricing is a mechanism for providing a significant increase in PT trips, particularly if targeted at areas of strong public transport level of service.

- **PT mode share** increases when car travel costs increase, or when road pricing is introduced. Higher growth can also increase PT mode share, particularly when investment in the road network is not maintained. Active mode share increases with high density land use because of closer proximity to workplaces and other amenities, which can come at the expense of PT mode share.

- Reductions in **congestion** delay (delay/km) are possible in most low growth scenarios. In medium growth, retaining congestion at 2006 levels or reducing congestion becomes more challenging. In high growth situations, only options with road pricing are able to hold the line or reduce congestion. Network form can also have an impact on congestion, with investment in PT resulting in a smaller improvement, and roads having a much larger improvement. A mixed

scenario could hold the line to 2006 levels under a central case, and would require some form of road pricing under a higher growth/demand scenario.

- **CO_2 emissions** for the car fleet can be significantly reduced, through technology advances reducing fleet fuel efficiency, despite growth in the car fleet size and number of trips. HCV fleet CO_2 emissions increase significantly due to no improvements assumed in HCV fleet efficiency, and the strong linkage between HCV movements and economic growth. Network form generally has little impact on emissions, with only scenarios involving road pricing providing significant improvements.

Strategic Options Summary

- The **Base option**, representing a 'Do minimum' approach, does not sustain all the RLTS objectives examined here, in particular relating to congestion and CO_2, especially under a central and higher growth scenario.

- The **Road option's** focus on road-only improvements cannot meet the demands of high growth, and matches status quo for medium growth. This option does not sustain all the RLTS objectives.

- The **PT option** shows improvements in the PT-related indicators across all futures, but does little to address congestion or CO_2 issues. With strongly negative road indicators and other options scoring better on PT, this option is not able to sustain all the RLTS objectives.

- The **Mixed option** combines PT and road projects to maximise individual project benefits and add system-wide synergy. This scenario provides improvements across more of the objectives than any other of the non-pricing scenarios. In particular, it holds the line on congestion (which the PT scenario doesn't), and it shows significant improvement on PT-related indicators (which the roading scenario doesn't). This option does not however address the issue of CO_2.

- The **Road Pricing option** adds a peak hour peak direction road pricing scheme at select locations on the base network form. This increases PT mode share and reduces congestion (and emissions) by increasing car travel costs in the most congested peak periods. Emissions scores are neutral to negative (HCVs). Congestion scores are mostly neutral and some positive scores. This option has potential to support or sustain the RLTS objectives.

- The **Mixed +Road Pricing option** join the benefits and synergy of the Mixed option with the additional car travel cost of the Road Pricing option. This option scores strongly positive for low and medium, and best manages the high growth demands. This option is best able to support or sustain the RLTS objectives.

A mixed investment scenario seems to provide the most balanced approach to improvements on all indicators. Clearly it will not be sufficient to deal with demand for the transport network under higher growth scenarios, so depending on the level of growth, a pricing mechanism (such as road pricing) could be introduced to provide the

level of improvements desired, or to defer significant capital investment. Under a lower growth option less investment will be required to hold the line.