Quantifying Regional Benefits from Travel Demand Management

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1. Introduction

Demand Management is a standard component of long term planning in other sectors including water supply (USEPA 2004) and waste management (MfE 2002). A growing body of work internationally demonstrates that demand for car travel can also be managed. Small pilot projects in schools, workplaces and communities have achieved locally significant reductions in car travel, and such projects are beginning to be implemented on a larger scale to generate regionally significant reductions in traffic (UK Department for Transport 2004).

Concern about the worsening environmental, economic and social performance of Auckland's transport system has prompted a major review of Auckland transport planning at central, regional and local government levels. Amendments to the Local Government Act in 2004 required Auckland to prepare and adopt a new Regional Land Transport Strategy (RLTS) by December 2005, and the Land Transport Management Act 2004 set new requirements for the RLTS, including the requirement to include a Demand Management Strategy.

This paper describes a small component of the work undertaken to review Auckland's Regional Land Transport Strategy (Auckland Regional Council 2005). The paper aims to answer the following question:

> What are the benefits of investing in Travel Demand Management initiatives? Can these benefits be compared with the benefits of investing in new major roading projects?

This paper sets out the steps taken to develop an answer to this question.

- Defining low, medium and high levels of TDM
- Developing tools to model TDM investments alongside roading and PT
- Evaluating the results of this modelling for four scenarios:
    - Maximum spending on roads; committed TDM & PT projects only
    - Mix of roading and PT improvements with low TDM
    - Mix of roading and PT improvements with medium TDM
    - Mix of roading and PT improvements with high TDM
- Some conclusions are then presented which interpret the results of this modelling.

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2. Defining levels of TDM

The draft Auckland Regional Land Transport Strategy (RLTS) defines TDM as:

> *A set of tools to offer people better travel choices and to encourage more people to reduce the negative impacts of their travel*

The Strategy is being prepared in the context of a rapidly growing city. By 2016, around 340,000 more people will live in Auckland, and there will be 195,000 more cars. Demand for vehicle travel in Auckland in the morning peak is anticipated to increase by 27%. As well as planning for increased capacity on road and PT systems, the RLTS needed to consider tools to manage transport demand. The Strategy also needs to address a historic underinvestment in public transport in Auckland, and a transport mindset centred around getting everywhere by car (Auckland Regional Council 2005).

A working group convened by the Auckland Regional Council and including representatives of local Councils, the national roading and road safety authorities, advocacy groups and technical experts defined the scope of TDM and developed the components of the TDM package. The scope of TDM is set out in Table 1 below.

Table 1 Scope of Travel Demand Management Activities modelled for Auckland Regional Land Transport Strategy

Reduce need to travel	• Land use – intensification • Mixed use developments • Telecommunications infrastructure
Provide for travel choices	• Allocation of road space (to PT, walking, cycling, high occupancy vehicles) • Improved PT services • **Construction of walking and cycling networks (W/C)**
Influence travel choices	• **School Travel Plans (STP)** • **Workplace Travel Plans (WTP)** • **Community Travel Initiatives (CTI)** • Improved traveller information
Pricing	• Regionally/nationally agreed parking controls • Congestion pricing • Tolling of existing roads

While all of the activities listed in the table are included as TDM in a policy sense, the modelling of TDM activities was based on different levels of investment in the four activities listed in bold type. The other TDM activities listed above were not part of the TDM modelling project, for the following reasons:

- Land use changes, mixed use developments, and telecommunications infrastructure both influence and are influenced by transport investments in complex ways. A truly integrated land use and transport strategy was not achievable for the 2005 RLTS. Instead, the RLTS is based on a predicted distribution of population, employment and dwellings in 2016 which is consistent with the Auckland Regional Growth Strategy. This land use is the same for all transport options modelled.

- Allocation of road space to PT, provision of improved PT services, and PT traveller information are modelled separately from TDM, using the Auckland

Public Transport (APT) model. However they interrelate strongly with TDM; one of the main purposes of School, Workplace and Community Travel Plans is to persuade more people to use PT. In the Auckland RLTS, improved PT services were taken as a prerequisite for TDM projects, which were only modelled as an addition to (not a replacement for) PT investment.

- Congestion pricing and tolling of existing roads were not modelled or considered for this study or for the Auckland RLTS as current NZ legislation does not permit charging for use of existing roads. Parking controls were included only as a component of school, workplace and community travel plans as there are no regionally or nationally agreed parking policies in place.

As well as excluding some activities usually included within TDM, the Auckland RLTS included significant investment in walking and cycling infrastructure as part of the "TDM package". Conceptually, both walking and cycling are modes of transport not subsets of "demand management". However their inclusion in the package serves two purposes:

- In Auckland, our work on School, Business and Community Travel Plans has encountered a groundswell of community pressure to invest in safer cycleways, footpaths and crossings. There is a clear public view (Auckland Regional Council 2005b) backed up by crash statistics (RoadSafe Auckland 2004) that walking and cycling in Auckland is dangerous, and hence that it is neither responsible nor effective to encourage people to walk and cycle except unless safer infrastructure is provided. Our experience to date[1] is that in Auckland, travel plans alone will generate little or no benefit unless linked to infrastructure provision.
- Good data on increases in walking and cycling due to investment in infrastructure is hard to come by. Yet robust international data is available on shifts in travel behaviour achieved through school, business and community travel initiatives (UK Department for Transport 2004).

Hence Auckland's TDM package would be viewed in an international context as two linked packages; a set of "soft measures" aimed at achieving travel behaviour change, and a significant increase in investment in walking, cycling and road safety infrastructure. Each of the components of the packages reflects an Auckland-specific work programme applying an internationally recognised methodology, often informed by local pilots.

The working party then developed three possible levels of investment in non-pricing Travel Demand Management measures. "Low TDM" represented existing & committed projects. This expenditure, of around $120 million over 10 years or 1% of total transport spend, was not expected to result in any benefits significant enough to include in regional transport modelling. Two further packages were developed, representing a "medium" (implementation on a regional scale) and "high" (not cost constrained) level of investment in these measures, as set out in Table 2. Detail of the anticipated costs and benefits of the medium and high options is set out in Appendix 1.

[1] Specifically the Birkenhead Community Travel Plan (2000), New Lynn Community Travel Plan (2003), and the Vauxhall, Bayswater, Brown's Bay, Fruitvale and Henderson South School Travel Plans (2005)

Table 2 Low, Medium and High Travel Demand Management Packages developed for Auckland RLTS

		Low/ Do Minimum	Medium TDM	High TDM	% shift from car by 2016
	10-year investment (millions)	**$120**	**$396**	**$910**	
W/C	Committed Cycle Network improvements	√	√	√	-*
W/C	Committed improvements to walking in town centres	√	√	√	-
STP	Committed Primary School Travel Plans	√	√	√	-
W/C	Construct 50% of planned Cycle Networks		√	√	Increase cycling (to 1.5% of trips)
W/C	CBD walking and cycling improvements		√	√	-
WTP	Workplace Travel Plans for 50% of CBD workers		√	√	15%
STP	School Travel Plans for all Primary schools		√	√	9%
STP	School Travel Plans for all intermediate & secondary schools		√	√	9%
W/C	Walking and cycling improvements in 15 Town Centres		√	√	-
WTP	Workplace Travel Plans for 50% of employees in 15 Town Centres**		√	√	10%
CTI	Community Travel Initiatives for 75% of households in 15 Town Centres		√	√	3%
W/C	Complete planned Cycle Networks			√	Double cycling (to 2% of trips)
STP	Additional infrastructure expenditure to support School Travel Plans			√	+6%
WTP	Workplace travel plans for 50% of employees in additional 29 Town Centres**			√	5%
CTI	Community Travel Initiatives for 75% of households in additional 29 Town Centres			√	3%

*Some "supporting" investments are not calculated to have a net benefit in terms of shift from car

**Adjusted to 36.5% as the town centre comprises only 73% on average of the modelling zone

For each initiative, a % shift in car use is used to calculate the numbers of car trips avoided and hence the inputs to the model. The benefits of school and workplace travel plans and of community travel initiatives are based on a review of documented projects internationally, with a focus on those relevant to the NZ context, undertaken by NZ's transport funding agency (Transfund 2004). The benefit of cycle network investment is taken from the Auckland Regional Cycling Strategy and its associated local strategies.

An external peer review (Steer Davies Gleeve 2005) raised the concern that these benefits may be too low, particularly the 3% for Community Travel Initiatives, and thus that the modelled benefits to the regional transport network may be conservative. A key challenge for the future will be to document the actual shifts obtained in different Travel Plan projects in Auckland, and the actual usage of improved walking and cycling networks. Once we have robust local data this will be used to revise the predictions above and to inform future investment decisions for Auckland TDM.

3. Develop tools to compare TDM investment with Roading and PT

To return to the key question set out in 1) above, we now have three scenarios for TDM investment each of which delivers a different level of benefit in terms of car trips avoided. To enable some comparison with other transport investments, packages with varying levels of PT, TDM and Roading were tested within the Auckland Regional Transport (ART) and Auckland Passenger Transport (APT) models.

The ART and APT models were developed specifically to test the regional and sub-regional transport impacts of roading and passenger transport investments and policies, and have been peer reviewed and found to be fit for this purpose. The testing of the roading and PT components of these packages used the standard features and procedures of the ART and APT models, and is described in technical papers (RLTS TP16 & TP17)

To incorporate the effects of TDM into the ART and APT models, a set of techniques was developed to re-allocate specific numbers of car driver trips to walk, cycle or to non-driver modes (passenger transport, car passenger). The benefits of Travel Demand Management projects are thus an input to the models, in contrast to the benefits of roading and PT investment, which are model outputs. The regional benefits calculated by the model are therefore only as reliable as the input assumptions of additional PT, walk, or cycle trips generated or car trips avoided.

Some sensitivity testing was undertaken, which showed that the modelled benefits of TDM vary in a fairly predictable way with the input assumptions.

Each aspect of TDM is incorporated into the ART morning peak model in a slightly different way[2].

- **Cycle network improvements** have been specified as resulting in a number of additional commuting (journey to work) and school cycle trips over 2001 levels in the AM peak. These increases are in addition to the small increase in cycling already predicted by the model for 2016.

  To create an increase in cycling equal to that predicted, changes are made to the value of the mode specific constant for cycling[3]. This has the effect of increasing the modelled number of people who cycle, and creating a corresponding reduction in other modes (car driver, car passenger, PT or walk). Using a base model (the “low TDM option), an adjustment is made to the mode specific constant for cycling and the model is re-run. Through trial and error an adjustment is arrived at that will, in the absence of any other network changes, give the increase in cycling equal to the prediction. This adjustment is then applied alongside all other network changes in those options which include cycle network improvements.

- **School Travel Plans** benefits have been defined as specified reductions in vehicle trips to schools and corresponding increases in PT trips and walk trips. These have been incorporated into the modelling by reducing the serve passenger vehicle trips (vehicle trips made for the purposes of taking the passengers) to zones with school

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[2] This section is summarised from Appendix 4 of RLTS Technical Paper 18

[3] There is some oversimplification here; in fact the mode specific constant for cycling is set separately for three categories of trip; “choice” trips to work (by those who have access to a car), “captive” trips to work (by those who do not), and trips to school (by a subset of “captive” users). It happens that in the Auckland model, comparing 2001 to 2016, the desired increase in journeys to school was obtained by using the same change to the mode specific constant arrived at for the journey to work; this same change was then also applied to “captive” journeys to work.

rolls in them and increasing the captive walk/cycle and PT trips. The trips removed from the serve passenger matrix are in proportion to the school rolls in each zone.

- **Workplace travel plan** benefits have been defined as reductions in AM peak car driver trips to the CBD, to the 15 town centres with largest employment, and (in the High TDM scenario) to a further 29 employment centres[4]. The reductions are achieved by applying an additional parking cost to these zones for car driver trips. This parking cost increase is arrived at in the same way as the change to the mode specific constant for cycling, that is by re-running the model with different parking costs applied until the specified reduction in car driver trips is achieved. The model itself re-allocates these trips to other modes.

- **Community travel initiatives** are predicted to reduce morning peak car driver trips from and within the target areas, which for simplicity are the same centres used for the Business Travel Plans. The specified trips are extracted from the car driver trips and allocated to other modes using the mode split model.

As a subsequent step, the benefits of two TDM measures, school and workplace travel plans, are included in the APT model by extracting data from the ART model and then including the increased PT trips into the APT modelling procedures. The main purpose of this step is to ensure that the costs of additional bus services, and the revenue from additional fares, are included in calculating the cost of the chosen TDM option.

In the model, improved vehicle flows due to TDM projects in turn generate some shift of PT users back to car travel, and some trips occur in the morning peak which would otherwise be retimed. This “induced traffic” is likely to be a realistic feature of TDM projects on a regional scale and all of the modelled results include this effect.

In all cases the changes to the model are made in order to reflect the predicted benefit of each TDM initiative; these changes (for example increased parking charges in town centres) do not have any meaning in themselves. This is an important point and reinforces the fact that the modelled results are only as accurate as the input predictions.

4. Evaluating the modelled results

The model outputs are then used alongside other more qualitative data to assess the performance of the transport network in 2016. The broad outcomes sought for the Auckland Region’s transport network reflect the Government’s view, as set out in the New Zealand Transport Strategy (NZTS), that the transport system needs to change and to become more integrated, safer, more responsive to community wishes and more sustainable. To assess this, packages are assessed against the following outcomes from the NZTS[5]:

1. Assisting economic development
2. Assisting safety & personal security
3. Improving access and mobility
4. Protecting and promoting public health
5. Ensuring environmental sustainability

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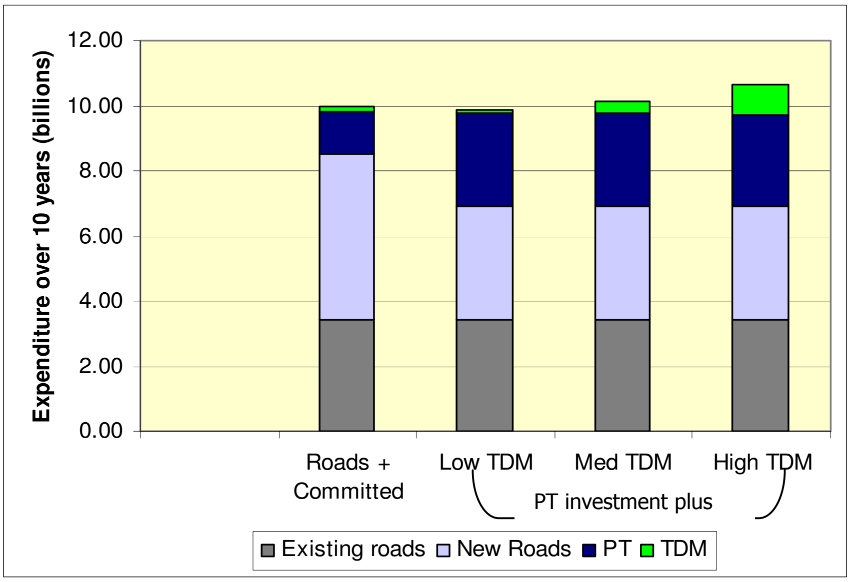
[4] Although these locations need to be specified for modelling purposes, the exact number and the location of these areas has not been agreed as part of the RLTS process; the decision as to where workplace and community travel initiatives will actually take place will be made as part of the preparation of the Auckland Transport Plan.

[5] In the RLTS a sixth, Auckland-specific outcome is included, Supporting the Auckland Regional Growth Strategy

The process and detailed measures used to evaluate all of the options tested in the RLTS against these objectives are set out in detail elsewhere[i]. For simplicity, this paper is based only on modelled data for the morning peak period (7-9am weekdays) in the target year (2016). Other model runs including offpeak modelling were also done as input to the RLTS and the results showed a very similar pattern.

In this paper, a simplified set of four investment packages has been developed to show the contribution that TDM makes to achieving the Region's objectives, as shown in Figure 1.

- "Roads + committed" allocates only $120 million or 1% of available funding to TDM – just enough to complete committed projects. The TDM component of this package comprises mainly pedestrian and cyclist safety retrofits in problem areas, and generates no modelled benefits. This option has a $1.3 billion allocated to PT - only enough to maintain existing routes and services[6]. This option allocates the maximum funding ($8.5 billion) to roading, enough to build all currently planned State Highway developments within 10 years[7].
- "Low TDM" has the same level of TDM as "Roads + committed", but includes a step change in PT services, with a 10-year investment in PT of $2.8 billion or more than double the status quo. The investment in roading is correspondingly less ($6.9 billion).
- "Medium TDM" allocates $396 million to walking and cycling improvements and to school, business and community travel initiatives as set out in Table 2. Roading investments are identical to "Low TDM" but there is a small adjustment to PT costs to reflect extra services, and extra farebox revenue, due to the additional demand.
- "High TDM" allocates $910 million to TDM initiatives.



	Roads + Committed	Low TDM	Med TDM	High TDM
Existing roads	3.40	3.40	3.40	3.40
New Roads	5.11	3.50	3.50	3.50
PT	1.33	2.87	2.85	2.84
TDM	0.12	0.12	0.40	0.91

Figure 1: Cost allocation ($billions over 10 years) for the four options modelled to demonstrate impacts of TDM

[6] This option does allow for some increases in frequency where bus services are operating at capacity.
[7] The "Roads + committed" option does not allow for the construction of the planned Eastern Transport Corridor

In this section, the contribution of Travel Demand Management to each of the six regional objectives is considered in turn, using the results from the modelling. Again, there is some simplification from the evaluation performed in the Regional Land Transport Strategy[8] In all cases the impacts of TDM are beneficial, but the most interesting aspect of the analysis is the comparison of the level of benefit relative to other potential investments or other policy changes.

4.1 Assisting Economic Development

Economic development is the most complex of the objectives to evaluate. The key issue here is congestion – a city's economy depends on the ability to get people to work and to move freight within and between regions, hence traffic congestion is economically damaging.

One of the most difficult aspects of the RLTS evaluation was arriving at an agreed measure of congestion. Eventually, three measures were used:

- vehicle speeds to and between key economic centres
- proportion of trips on congested links
- "travel when required", a measure of retimed trips (trips made before or after the morning peak which, if congestion were reduced, would be made at peak time).

In the "Roads + committed" scenario, vehicle speeds are slower in 2016 than in 2001 on all of the links of interest, as shown in Figure 2. This shows the impact of traffic growth outstripping the capacity to build new roads, and gives support to the widely held view that building roads does not solve congestion. In going from "Roads + committed" to "Low TDM", the impact (on vehicles) of re-allocating $1.5 billion from roading to PT is seen as a very slight drop in vehicle speeds (this is offset by a benefit to PT users).

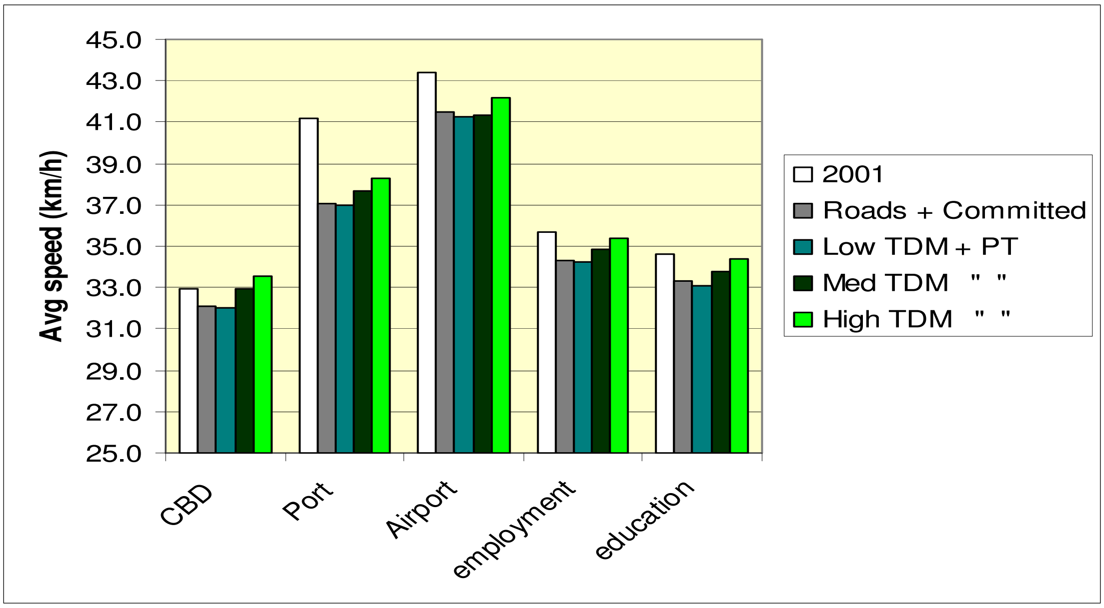


Figure 2: Congestion impacts - Average vehicle travel speeds to/between key economic centres[9] for TDM options in 2016 compared with 2001.
Source=Auckland Regional Transport (ART) model

[8] The full evaluation for the Regional Land Transport Strategy is documented in RLTS Technical Paper 20: Evaluation of Third Round Packages. For each of the objectives, up to six measures are used, with some measures combining multiple modelling results, only the most significant of these measures (ie. those which affected the outcome of the evaluation) are used in this paper.

[9] As defined for the RLTS. The "employment" category represents all am peak trips to the 18 most significant employment centres (after the CBD, port and airport). "Education" represents all trips to the 9 centres with a tertiary education facility. Vehicle speeds are averages for the am peak period (7-9am weekdays). .

By contrast, the impact of "Medium TDM" and "High TDM" on vehicle speeds is noticeable and positive; under the "High TDM" scenario vehicle speeds are close to 2001 levels for trips to the CBD and to centres of employment and education.

The second measure of congestion used for the RLTS was the proportion of vehicle travel on congested links. Again, the "Roads + Committed" scenario performs least well, and the impact of increasing TDM investment on network performance is positive, though the differences are slight. In 2001 79.6% of morning peak travel was on uncongested roads, as shown in Figure 3. By 2016, this proportion had dropped in all scenarios, but the drop is least severe in the High TDM scenario, with 78.3% of travel still being on uncongested roads.

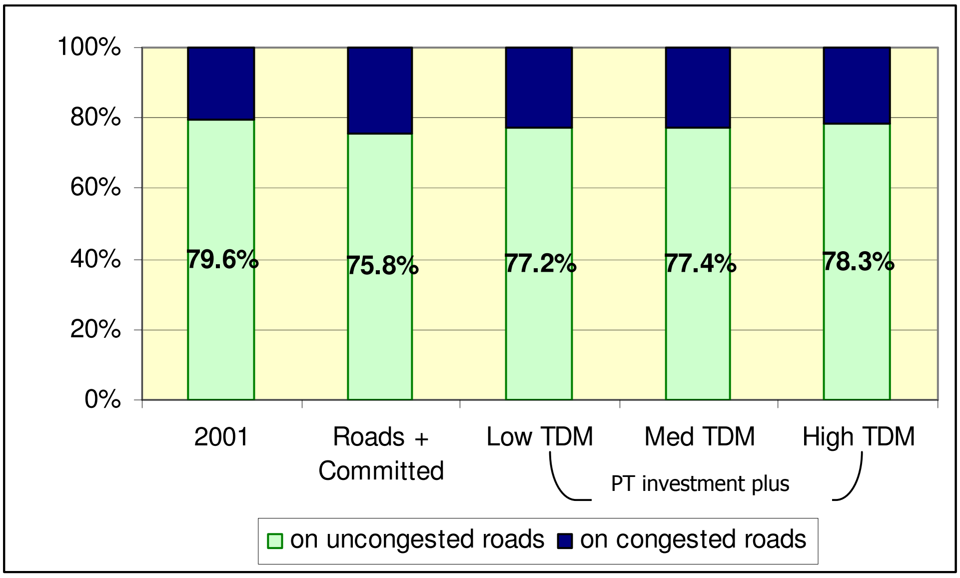


Figure 3: Congestion impacts - Proportion of morning peak travel on uncongested roads for TDM options in 2016 compared with 2001. Source=ART model

The third measure of congestion was the proportion of trips which were retimed, that is they occurred before or after the morning peak but when congestion is reduced these trips shift to occur at peak time. This measure varied very little between options; in 2016, 3.9% of trips were retimed under the "Roads + Committed" option, and 3.5% of trips were retimed under the High TDM option.

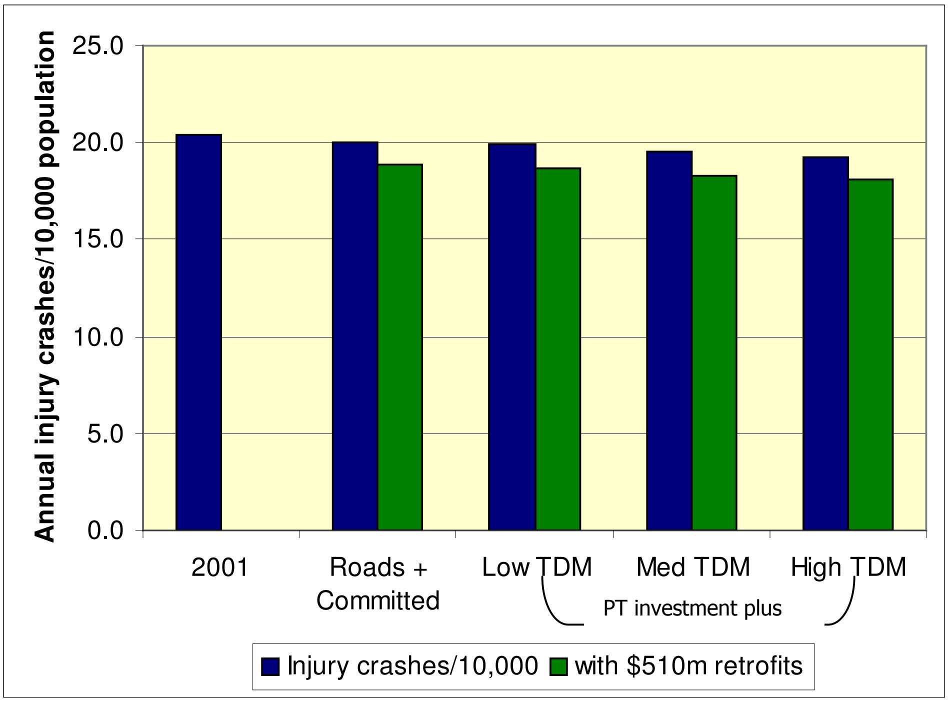
Further analysis of congestion impacts, undertaken since the completion of the draft RLTS, is presented in Section 5 of this paper.

4.2 Assisting Safety and Personal Security

Personal security is a significant issue for pedestrians and cyclists, but is especially difficult to quantify. This section therefore focuses on personal safety and specifically on injury crashes, which are modelled within the Auckland transport models.

Annual injury crashes on the Auckland network are predicted to increase from 2,447 per year to 3,085 for the "Roads + committed" option, due mainly to the 27% increase in traffic[10]. Because population has also increased, the per capita crash rate is about the same. TDM is expected to curb the increase in traffic, but the modelled impact on crashes is slight, as shown in Figure 4.

[10] The crash model is a simple one based on average crash rates by road type (motorway, urban arterial, rural arterial), adjusted for traffic volume and traffic speed.



	2001	Roads + Committed	Low TDM	Med TDM	High TDM
Annual injury crashes	2,447	3,085	3,062	3,004	2,961
Injury crashes/10,000	20.4	20.0	19.9	19.5	19.2
with $510m retrofits		18.8	18.7	18.3	18.1

Figure 4: Safety impacts – Modelled injury crashes for TDM options in 2016 compared with 2001. Source=ART model

A much more significant impact on safety is predicted from allocating $510 million to safety retrofits of urban and rural arterial roads. These safety retrofits are specifically targetted to reduce deaths and serious injury crashes, to achieve a regional target of 670 deaths + hospitalisations annually by 2010 (a 30% decrease relative to the predicted rate of 870 annually). This investment is not expected to have the same impact on minor injury crashes, so the predicted impact on all injury crashes is much less - a 6% reduction in injury crashes per 10,000 population.

The slight relative safety benefit from TDM predicted by the model simply reflects the slight reduction in traffic, and may not be relevant to the actual impacts of converting car trips to walk, cycle and passenger transport. One of the overall goals of TDM is to improve safety for pedestrians and cyclists, and the majority of costs in the TDM packages are safety–related investments, including dedicated cycle infrastructure and improved pedestrian crossings. The intention is that increases in walking and cycling will not lead to increased pedestrian and cyclist crashes. However this is a goal and not a quantitative prediction.

The conclusion is that safety retrofits are a better investment than TDM in terms of contribution to the personal safety objective.

4.3 Improving access and mobility

The access and mobility objective focuses on social inclusion and the need for people of all ages and abilities to have access to employment and/or education opportunities, leisure and services. A key concern is the mobility needs of people with disabilities, and of those who do not drive a car.

The PT network improvements developed for the RLTS have a clear and positive impact on access and mobility. Because these improvements are well defined, their benefits to different geographic communities and to different categories of user can be evaluated.

The “broad brush” TDM measures developed at a regional level are much less useful for defining access and mobility improvements. It is very much the intention of the TDM package to improve access and mobility. School Travel Plans, for example, give voice and choice to one of the most transport disadvantaged groups in society, school aged children. The walking improvement budget enables the provision of safer infrastructure in local communities and improvements to the footpath network to better meet the needs of people with disabilities. But these investments are poorly specified at the moment, so defining how much improvement can be purchased for the allocated funding is a pure guess at present.

Thus the impact of increased TDM investment on access and mobility is positive, but cannot be quantified until a great deal of more detailed planning and monitoring has been done.

4.4 Protecting and promoting public health

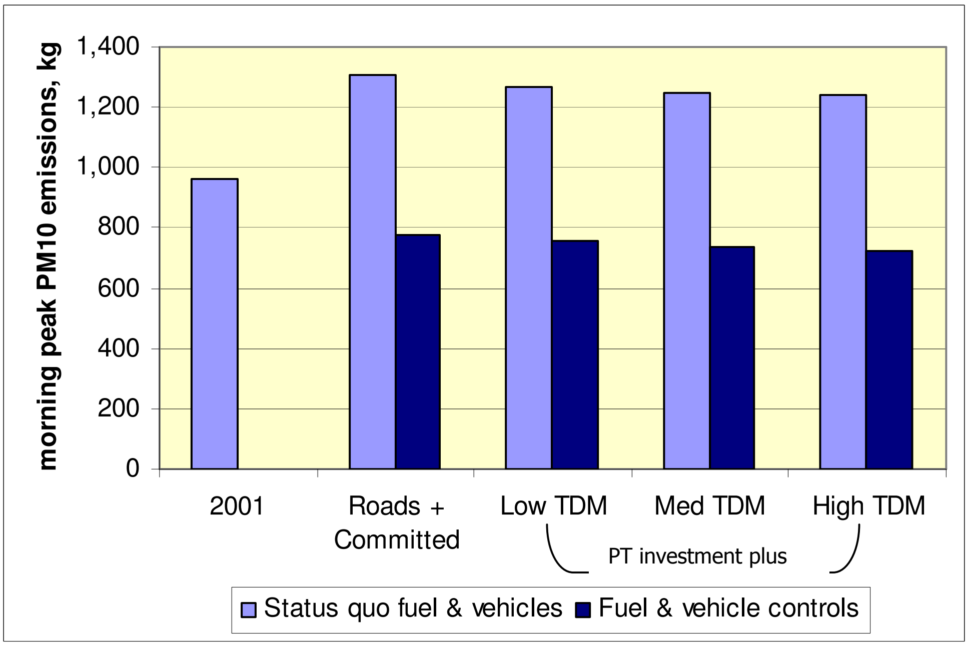
Reducing vehicle trips through TDM can impact on public health in two ways:

- Contributing to improved air quality by reducing vehicle emissions
- Encouraging more active transport modes including walking and cycling

4.4.1 Air quality impacts

The most significant pollutant in terms of health impacts in Auckland is diesel particulate (Ministry of Transport 2002)[ii], quantified here as PM_{10}. TDM initiatives have the potential to reduce emissions, but not by anywhere near enough to outweigh the growth in trips on the network, as shown in Figure 5. Even in the “High TDM” scenario, PM_{10} emissions still increase by 29% relative to 2001; though this is significantly better than “Roads + committed” (35% increase).

To achieve an overall improvement in Auckland’s air quality, improvements to fuels and to vehicles are essential. Figure 5 also shows the impact of planned reductions in the sulfur levels of diesel and of the introduction of emissions controls for imported used vehicles and regular checks for in-service vehicles. Significant reductions in PM_{10} are achieved for all scenarios.



	2001	Roads + Committed	Low TDM	Med TDM	High TDM
Status quo fuel & vehicles	964	1,306	1,270	1,248	1,244
Fuel & vehicle controls		777	755	740	725

Figure 5: Health Impacts - Air Quality. Morning peak PM_{10} emissions for TDM options in 2016 compared with 2001. Source=ART model

4.4.2 More active transport

Inactivity is now recognised as a "silent epidemic" (Ministry of Health 2003) which is driving increases in obesity and other health problems in children and adults. Just 20 minutes of moderate exercise each day is enough to shift someone from the highest risk "inactive" category to "moderately active".

Walking or cycling for regular trips can thus have a significant health benefit. Figure 6 shows the predicted impact of actively promoting these modes; the proportion of morning peak trips which are made by walking and cycling (mainly walking) goes from 14% in the "low TDM" scenario to 17% in the "high TDM" scenario; this equates to 23,000 more walk/cycle trips each morning or 11 million additional active trips each year.

An estimate of the magnitude of this health impact can be calculated based on a quantification of the health benefits of walking ($0.40/km) and of cycling ($0.16/km) prepared as part of the simplified procedure for evaluating these projects in NZ (Transfund 2002). Based on these values, the annual health benefits of the "High TDM" package, relative to "Roads + Committed", are approximately $4.4 million[11].

[11] The calculation is as follows: 22,354 additional walk trips in the morning peak, doubled for the return trip, * 245 annualisation factor = 10.95 million trips each year. The benefit calculation is simplified by assuming that all active trips are by walking (over 90% are) and that the average walk trip length is 1km (consistent with Appendix 1). Hence 10.95*$0.4 = $4.4 million annual benefit.

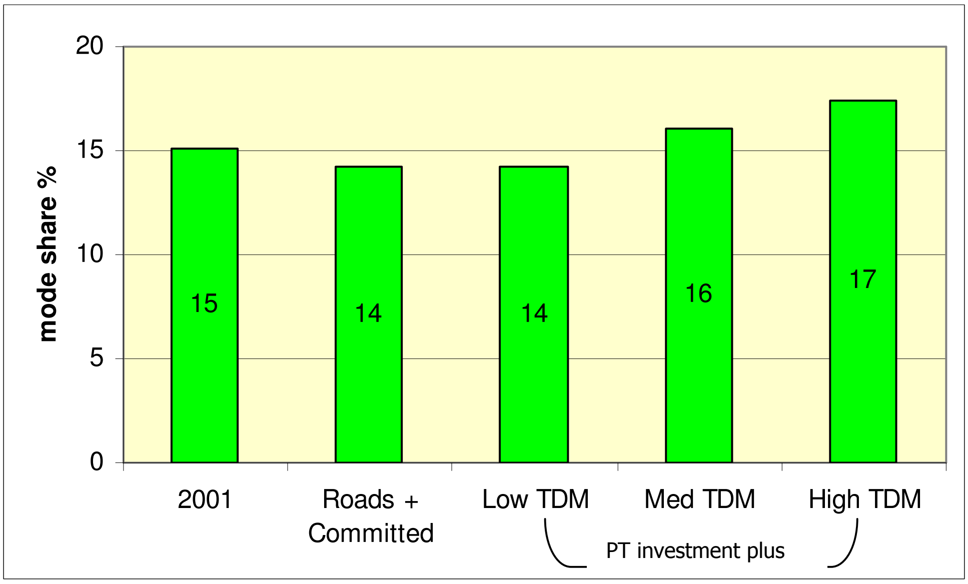


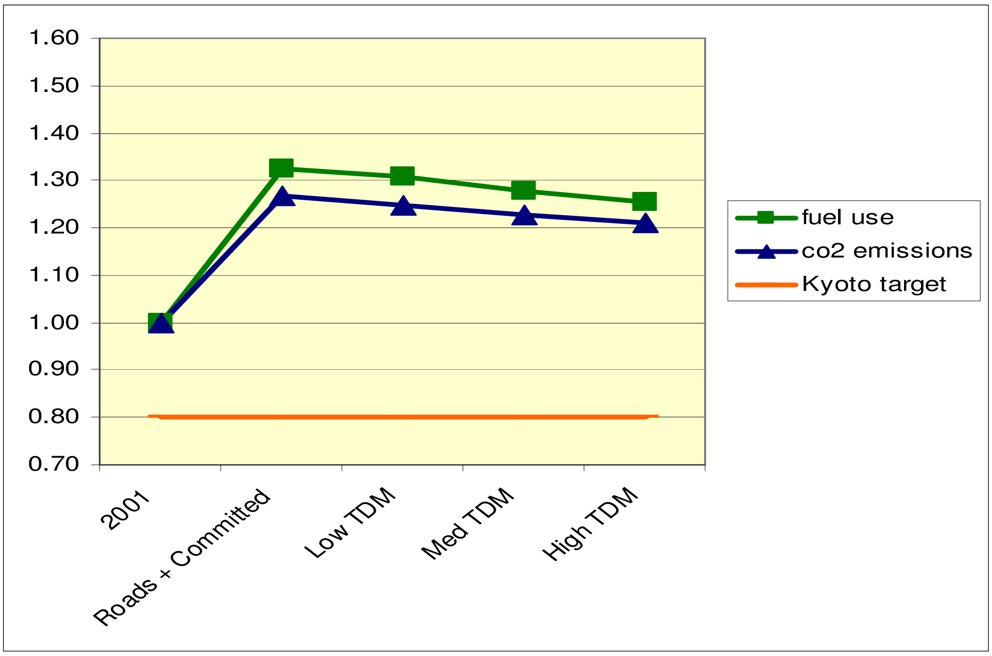
Figure 6: Health Impacts – Active Transport. Walk/Cycle mode share for TDM options in 2016 compared with 2001. Source=ART model

In the case of School Travel Plans, health benefits are likely to be greater than this as the estimated benefit relates simply to the benefits of physical activity. Strong evidence also links air pollution, noise, social capital and social networks to health outcomes (Hosking, 2005). Evaluations of the Auckland Walking School Bus network provide qualitative evidence of wider health benefits, including less pollution and noise at the school gate, stronger social networks, and more independent child mobility (Collins and Kearns 2004, Neuwelt and Kearns in prep).

4.5 Ensuring environmental sustainability

Auckland's growing population and increasing car use mean that environmental targets are particularly difficult to achieve. Vehicle use and vkt are the main drivers of fossil fuel consumption and of CO_2 emissions. Figure 7 shows that despite the relative benefits of the high TDM packages relative to "Roads + committed", there is a worsening of performance relative to 2001.

NZ is a signatory to the Kyoto Protocol and has committed to reducing CO_2 emissions to 1990 levels by 2006. The Auckland transport system is a significant source of CO_2 and emissions increase significantly under all options.

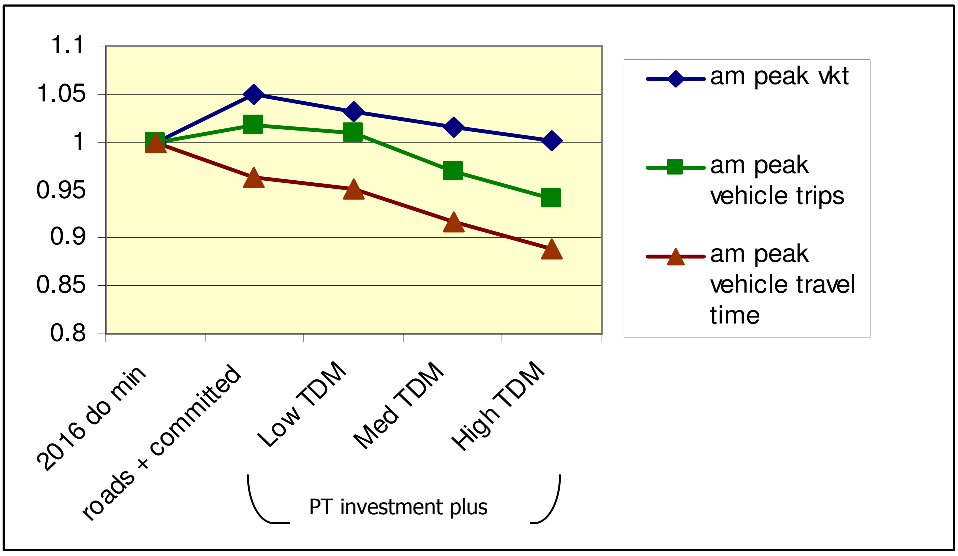


	2001	Roads + Committed	Low TDM	Med TDM	High TDM
vkt	3,316,603	4,360,153	4,285,427	4,217,391	4164,448
Fossil fuel use (annual litres)	460,652	610,644	602,226	588,095	577,438
CO2 emissions, am peak 1000 kg. 1990=1024	1,281	1,625	1,598	1,570	1,549

Figure 7: Environmental performance – CO2 emissions for TDM options in 2016 indexed to 2001=1. Source=ART model

5. Further evaluation of congestion impacts

The most interesting of the above results is the excellent performance of the medium and high TDM packages in terms of congestion benefit, especially when compared with the option which maximises investment in roading. To better understand this effect, a "do minimum" package was created and further modelling was undertaken to compare congestion benefits of the four 2016 packages with the do minimum. The results of this modelling are shown in Figure 8.



	do minimum	roads + committed	Low TDM	Med TDM	High TDM
10-year cost (billions)	5,146.60	10,376.80	10,731.00	10,550.80	11,064.80
am peak vehicle trips	455721	463576	459549	441515	428395
am peak vkt	4155027	4360153	4285427	4217391	4164448
am peak vehicle travel time	8310656	7997615	7900257	7625520	7382433

Figure 8: Congestion impacts - Morning peak vkt, vehicle trips and vehicle minutes for TDM options in 2016 compared with Do Minimum. Source: ART model

This comparison shows that, relative to the 'do minimum', the package which maximises roading investment also results in the greatest increase in vehicle trips and vkt. Vehicle travel times are better than in the 'do minimum' case by around 4% (but slower than 2001).

The PT investment in going from "roads + committed" to "low TDM" has more effect on vkt than on vehicle trips, which is logical given that much of the proposed PT investment is in rail which will be most attractive for longer journeys. The "medium TDM" investment is predicted to achieve a net reduction in vehicle trips[12] of around 3%, with a further 3% reduction in going to "high TDM", however the impact on vkt is much less than this. This reflects the targeting of the TDM package to shorter journeys, especially journeys to school.

The surprising result is that the effect on vehicle travel time of removing short trips due to TDM is greater than the effect of either roading or rail investment. This merits further study, but is likely to be due to targeting TDM investment to schools and town centres. Many of Auckland's schools and all the major town centres are located in places with significant traffic congestion. It is quite believable that shifting short trips to these destinations to walking, cycling and PT has a greater network effect than improving provision for longer trips.

[12] This is the overall net reduction and accounts for induced traffic effects as explained in Section 3

6. Summary and Conclusions

As part of the development of Auckland's Regional Land Transport Strategy, a Demand Management Strategy has been prepared. In the strategy, a set of investments is proposed to reduce reliance on single occupant vehicles, including school, business and community travel initiatives and improvements to walking and cycling environments.

Three scenarios were developed for TDM investment; Low/ Committed ($120 million over 10 years) Medium ($396 million) and High ($910 million). All of the TDM scenarios modelled also included significant improvements to PT. For each scenario, an estimate was made of the resulting reduction in vehicle trips based on the benefits of similar programmes in comparable cities.

To reflect each level of TDM investment within the Regional Transport models, adjustments were made to "take out" trips removed due to TDM. Successive model runs were then used to determine the impact of reduced vehicle trips due to TDM on the regional network. The performance of the regional transport network was then evaluated against a set of broad strategic objectives. The key points from this evaluation are summarised in Table 3 below:

Table 3: Summary of impacts of TDM on the regional transport network

RLTS objective	TDM impact
Assisting economic development	TDM has the potential to manage congestion levels in the context of a 27% increase in person trips
Assisting safety & personal security	Curbs the growth in vehicle traffic which could result in a safety benefit, but safety retrofits have a much larger effect
Improving access and mobility	Impact is positive, but cannot be quantified without more detailed planning
Protecting and promoting public health	Curbs the decline in air quality, but vehicle and fuel standards have a much larger effect. Significant health benefits from increased activity levels.
Ensuring environmental sustainability	Curbs the growth in vkt and in fuel use, but still a worsening of performance relative to 2001. No real progress towards the Kyoto target of reducing CO_2 emissions to 1990 levels

The results of this evaluation run counter to the intuitive view that improving walking and cycling networks and working with schools, businesses and communities to prepare Travel Plans are basically environmental and/or road safety initiatives. These initiatives do generate environmental and safety benefits, but in a city with rapidly growing population and car ownership the effect is simply to slow the rate at which things get worse. For air quality and road safety, other interventions are available which have a much greater overall effect.

By contrast, TDM initiatives have the potential to maintain congestion at 2001 levels on key economic links. This result is significant, because there are so few other options to manage urban congestion. Investing the maximum available funding in road construction does not result in a net congestion benefit, and nor does shifting investment from roads to PT. The combination of PT and TDM investment, alongside priority roading improvements, offers the best hope of managing congestion on Auckland's transport network.

These results support a policy of bringing the management and funding of TDM initiatives closer to the heart of transport planning. Managing demand is integral to the efficient operation of transport networks, especially in the context of population growth and economic development. TDM initiatives therefore need to be developed as part of an integrated transport plan and funded on an equal footing with roading and PT investments.

Appendix 1 – Costs and Benefits of Medium & High TDM options

Initiative	am peak impact Cycle network impact (additional cycle trips)		interpeak impact 9am-4pm Cycle network impact (additional cycle trips)		Annualisation factor Trips /day	Days /year	Annual impact in 2016		Avg trip length, km**	Cost $millions		10-year benefit ***	Cost/ trip		Cost/km		
Cycle network completion	Medium TDM	High TDM	Medium TDM	High TDM			Medium TDM	High TDM		Medium TDM	High TDM		Medium TDM	High TDM	Medium TDM	High TDM	
School cycle trips	1,400	2,200	1,400	2,200		190	532,000	836,000	3.3								
Work cycle trips	2,900	6,200			2	256	1,484,800	3,174,400	5								
Soc/rec cycle trips			440	1,000		365	160,600	365,000	4.9								
							2,177,400	4,375,400		53	107	5	$4.87	$4.89	$1.06	$1.05	Cycle
	Travel Plan impact (car trips avoided)		Travel Plan impact (car trips avoided)														
Primary School Travel Plans	7,800	13,000	7,800	13,000		197	3,073,200	5,122,000	1								
Senior School Travel Plans	4,600	7,600	4,600	7,600		190	1,748,000	2,888,000	5.6								
							4,821,200	8,010,000		111	207	5	$4.60	$5.17	$1.73	$1.94	School
Community travel initiatives	1,500	2,600	2,600	3,700	*	365	2,044,000	3,248,500	8.5	70	165	5	$6.85	$10.16	$0.81	$1.20	Community
Workplace travel plans	3,500	4,500			2	256	1,792,000	2,304,000	10	27	75	5	$3.01	$6.51	$0.30	$0.65	Workplace

*factor used is (peak*2)+interpeak
**Avg trip lengths are from Transfund NZ/EECA Travel Behaviour Change Evaluation Procedures 2004, Appendix 2.
***Benefit is zero in 2006 as the project begins and 100% in 2016, this just represents a straight line between these values

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