IMPROVING PT RELIABILITY ON AUCKLAND'S MOTORWAY

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ABSTRACT
Auckland's Northern Busway has been a great success since its opening around ten years ago. Bus patronage at peak times has increased the number of people crossing the Auckland Harbour Bridge by the equivalent of approximately two lanes of general vehicles, with virtually no additional congestion.

The northbound busway begins nearly 3.5 km north of the Auckland Harbour Bridge, which can result in evening peak buses becoming delayed by the tail of congestion, which propagates down the motorway from further north.

In common with other parts of the Auckland Motorway network, sections of the hard shoulder permit bus-only operation between on-ramps and off-ramps, which allows for a degree of queue jumping. However, buses are required to merge into the traffic stream before every off-ramp and every on-ramp. The effect of this is to introduce delay to both bus services and general traffic, and for a potential reduction in safety.

Currently, the New Zealand Transport Agency (NZTA) is leading and working together with several partners and stakeholders to investigate and analyse the impacts of permitting through running of buses without it being necessary for them to weave in and out of the general traffic lanes at and near interchanges (off and on-ramps). The initiative mainly deals with the modification of interchange layouts especially at ramp merges and diverges, safety aspects, human factors etc. It is anticipated this initiative will improve the journey time reliability of public transport and save thousands of people-hours of journey time every year.

KEYWORDS
Public transport, motorway bus shoulder, optimisation

INTRODUCTION

NZTA's vision is "great journeys to keep New Zealand moving". The aspiration is to become an internationally competitive, prosperous economy that all Kiwis can benefit from and participate in.

NZTA's primary function is to deliver effective transport solutions for a thriving New Zealand. The measure of an effective transport system is to provide access and move people and freight safely and efficiently. Mobility demands on major cities like Auckland, Wellington and Christchurch, as well as other urban areas, which have been growing at a faster rate than expected; traffic volumes are increasing significantly, and peak periods are becoming longer and longer, with increased congestion due to increased mobility demand.

The city centres are the most frequented origins and destinations in the region, generating a high number of passenger trips. Some of the bigger cities in New Zealand do not generate sufficient passenger numbers using public transport to provide significant relief to the road network. Due to the low density and other factors, large expenditure on public transport services and infrastructure is sometimes not justified. A broad range of transport system optimisation initiatives is required for larger cities like Auckland, Wellington and Christchurch as well as in faster growing smaller urban areas such as Hamilton, Tauranga, Dunedin and Queenstown.

Many people have a preconceived belief that some of transport modes such as public transport will not meet their needs. This demonstrates the amount of work required to achieve the vision of the NZTA and Local Authorities to fulfil the Government Policy Statement (GPS).

Public Transport Thinking

Customer journeys, using public transport in Auckland are suffering from long delays on Motorways and at on and off-ramps due to heavy traffic volumes at peak times. During peak periods, many parts of the motorway network and their ramps are operating at or near capacity.

Improving the efficiency of people movements can be achieved by improving movements of high occupancy vehicles like buses. Each bus can carry up to 70 people, which is equivalent to the number of people carried by approximately 50 cars. Creating dedicated space for buses to run on existing motorway shoulders, where possible, can dramatically improve people movements and efficiency across the Auckland motorway network. This step change in managing motorway space will strongly communicate the customer-based approach adopted by NZTA and Auckland Transport (AT) in a highly visible fashion.

As such, NZTA and AT are working in conjunction to understand whether additional bus shoulder running on the motorway network can enable buses to achieve more efficient and reliable journey times.

BUS SHOULDER RUNNING ON AUCKLAND'S MOTORWAY

NZTA have undertaken numerous initiatives to understand the needs of customer and their journeys and to support public transport need of Auckland especially allowing buses on the shoulder of motorways. NZTA have been working with several partners and stakeholders including Auckland Transport, Auckland Transport Operation Centre (ATOC), Auckland Motorway Alliance (AMA) etc. to undertake detailed analysis of the potential to introduce additional bus-only shoulder running on the motorway network.

The motorway network was checked by NZTA in mid-2018 for feasibility regarding through-running (at interchanges) of buses on the hard shoulder, then ranked in terms of effectiveness, value for money and meeting the customer expectations.

The results showed that bus shoulders are needed on several parts of the Auckland Motorway. In

terms of the number of buses per hour and the number of customer impacted, SH1 between the Auckland Harbour Bridge and the start of the existing separated busway at Esmonde Road is the most important part of the network and also considered as the demonstration project.

The main objective of the transport system is to move people and goods safely and efficiency. The success factors of this project are defined as an improved number of people movements during peak periods and the travel time reliability for public transport. In addition, there will be improvements in:

- Customers' satisfaction
- Mode shift (in favour of public transport)
- Public transport travel time (in terms of both journey times and reliability)
- Operating cost savings
- Resilience.

Area and boundary of the study of the project

The area of this work / study is to assess the potential benefits of improved and/or additional bus routeing along shoulder on the Auckland motorway network and bus priority measures at motorway interchanges, and to develop concept treatments.

The areas excluded from the study were where:

- No scheduled bus services operate,
- Improvement works are currently ongoing,
- Sectors which have busways.

Safety Aspect

Bus-only shoulders have been installed along various sections of motorway in Auckland by converting the existing hard shoulder. The issue with their operation is that they are discontinuous, as they terminate before an on-ramp or an off-ramp and they can only be installed where there is sufficient width.

Figure 1 shows the summary of the types of bus crashes (total over last 5 years) along the different State Highway sections in Auckland Region.

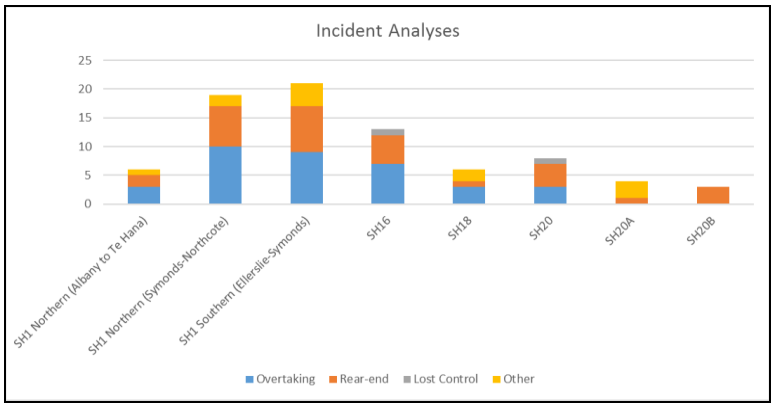


Figure 1 – Crash Incidents by Type 2013-2018

The analysis of crash data shows that the number of bus crashes on each State Highway network is generally low but with the most incidents occurring along SH1 (Akoranga to Ellerslie-Panmure Highway), followed by SH20 and then the rest.

The root cause for most of these accidents was overtaking, which indirectly indicates that, in view of safety, it may be beneficial if buses were designated their own lanes for operation, to minimise the need to overtaking along the main motorway roads. Allowing buses to run on a dedicated lane with fewer traffic could also possibly result in fewer rear-end collisions, which is the next biggest type of incident for buses on the motorway.

Bus Only Shoulder Standards

A few issues with regard to existing bus-only shoulder exist across the motorway network that require standardisation or resolution, they relate to:

- Roadside obstacles (e.g. lighting, bridges, sign structures etc.)
- Materials used for paving shoulders
- Pinch points with limited shoulder width, such as on SH1 under Market Road bridge
- Emergency use of bus shoulder conflicting with bus movement
- Bus only shoulder hours of operations
- Driver awareness of the presence of buses in the shoulder area
- Speed differential between buses on the shoulder and other traffic
- Weaving manoeuvres at interchanges
- Use of shoulder by High-Occupancy Vehicles, trucks and all other traffic

Following table shows the considerations and recommendations to the practical problems in the Auckland motorway network to run the buses on the shoulder:

Issues	Considerations	Recommendations
Speed differential between buses on shoulder and other traffic	Buses travelling along the shoulder may be travelling at higher speeds than general traffic. Bus speeds need to be appropriate for narrow sections and not create the perception of being a hazard to motorists and passengers.	Set a maximum speed differential. Typical maximum acceptable speed differential is 30 km/h. Signs (or ITS) may be needed to help enforce this. Some training of drivers will be necessary to ensure compliance.
Required Shoulder Width	3.0m is generally regarded as the absolute minimum width for buses to run safely along a shoulder; however, the ideal width is 3.5m.	Where existing shoulders are less than 3.0m, widen the shoulder to 3.5m (ideal); otherwise widen to maximum extent possible.
Roadside Obstacles	In narrow shoulder sections (3.0m to 3.5m), the proximity of buses to roadside obstacles (lighting, sign structures, bridges etc.) creates risk of structures being hit.	Ensure roadside obstacles are set back as per design standards to avoid being hit or clipped by buses running on shoulder.
Weaving Movements at Interchanges	Buses may need priority over other motorists along the length of the scheme. Weaving movements at ramp interfaces (general traffic into, out of and through shoulder bus lane) can be reduced by allowing buses to cross the ramp in one movement from the shoulder between ramps to the shoulder on the ramp.	Provide auxiliary shoulder lanes to give sufficient length for vehicles to merge with buses before they merge into general traffic lanes. If necessary, use loops, ramp metering and signals to detect buses and enable general traffic to be warned of the presence of buses on the shoulder.
Pinch Points	Narrow sections with restricted lateral clearance at underpasses	Provide upstream warnings for buses to merge into general

	and bridge piers.	traffic lanes.
Emergency Use of Shoulder	Need to clarify use of the shoulder for emergencies. In the United States it appears common practice that the shoulder is always available for emergencies and that buses are permitted to use the shoulder only during congested periods.	Provide emergency refuge areas. The United States practice would not impose additional costs to widening requirements.
Existing Shoulder Pavements	Shoulder pavements may need strengthening/resealing to be capable of withstanding expected additional heavy traffic now and into the future.	Further test pits are required to confirm this assumption.
Driver Awareness	Need to ensure that motorists understand the shoulder lane operation and are aware when buses are present.	Provide VMS warnings at ramps and along mainline. A public information campaign will be critical.
Use of shoulder by HOVs / trucks / all other traffic	If more than buses use the shoulder, additional pavement strengthening may be required.	Consideration should be made for the use by other vehicles (both now and in the future) as they may prove to be more cost effective. However, the design should be progressed on the assumption that the shoulder is only used by buses for the time being.
Bus Shoulder Operation Times	May impact on ITS requirements.	Resolve at a later stage in the design process.

Table 1: Recommended General Improvements to Shoulder Lanes

HARBOUR BRIDGE TO ESMONDE RD BUS SHOULDER

There is currently a discontinuous facility for northbound buses to use between the Harbour Bridge and Esmonde Road, which obliges buses that do use it to merge and diverge to and from the general traffic stream at four locations.

Northbound bus services currently mix with general traffic from the Harbour Bridge to just after the Onewa Road off-ramp. The shoulder between the off and on-ramps permits bus-only running, but buses must re-join the general traffic before the on-ramp. Buses are permitted to use the shoulder again from after the Onewa Road on-ramp, but they must return to the general traffic lane on the Esmonde Road off-ramp.

From Esmonde Road northwards, buses use the separate busway running alongside the motorway.

The following figure shows the existing and proposed bus shoulder between Auckland Harbour Bridge to Esmonde Road. The red sections indicate the existing bus shoulders and the yellow sections indicate the proposed bus shoulders.

(Google map used)

Figure 2 – Existing and proposed bus shoulder running from AHB to Edmond Rd

Criteria for through running design

Buses using the bus-only shoulder are currently required to merge right into the left lane of the motorway in advance of an off-ramp or an on-ramp, then are permitted to return to the shoulder after the ramp. This results in the buses merging with the lane at its busiest point and where merging manoeuvres from the other side are also occurring. This is compounded by New Zealand having some of the shortest exit lanes in the world, some as short 50m.

INNOVATIVE THINKING IN DESIGN

The challenge has been to permit running of buses along the motorway with the least amount of disruption to their flow. This could have been achieved with a bypass to the Onewa Road interchange in the same manner that has already been constructed in the southbound direction. However, this expensive civil engineering work would cost tens of millions of dollars and would take several years to progress.

The solution has been to keep bus services operating along the shoulder and to extend a ‘virtual’ shoulder through the interchange with little to no additional carriageway construction. Innovative thinking has been used to design the on and off-ramps in order to permit this virtual shoulder to form a continuous bus “lane”. This new innovative concept will significantly improve bus travel times and reliability.

Designing Off-ramp for through buses

By terminating the hard shoulder a specific distance before the exit and providing an auxiliary lane from there to the off-ramp diverge point, a weave length is created whereby traffic wishing to leave the left lane may move left into the auxiliary lane. Only the exiting traffic and the through bus will therefore be in that lane. This reduces the number of manoeuvres and the overall volume in the left lane of the motorway, permitting a smoother flow and allowing the bus to continue its way without hindrance.

The diverge will be akin to a typical lane drop diverge, but with the nose of the painted gore marked for the through passage of buses only onto the hard shoulder beyond.

The illustration below demonstrates a before and after concept for Onewa Road.

(google map used)

Figure 3 – Existing Onewa Road off-ramp gore area

(google map used)

Figure 4 – Proposed Onewa Road off-ramp gore area

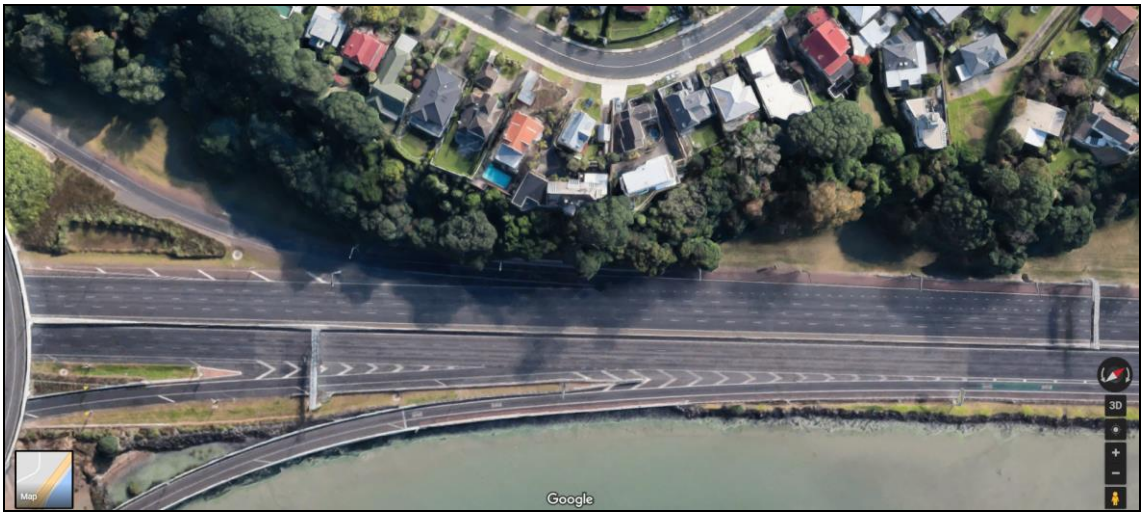
On-ramps

The situation for on-ramps is slightly more complicated than it is for off-ramps. Traffic on the bus only shoulder and the lane entering from the on-ramp will be required to merge into a single stream whilst still effectively on the ramp, in a manner reminiscent to that after ramp signals, before they are permitted to diverge; general traffic onto the motorway general traffic lanes and buses onto the bus only shoulder.

To this end, the bus-only shoulder will be braided 1.8m from the left running lane of the motorway throughout as much of the 175m merge area as possible, which provides a visual cue to drivers that they are not yet merging into the motorway. Drivers should be familiar with double merges, as most ramp signal sites have one or two merges in series on the ramp before traffic is merged onto the motorway mainline. The merge length for traffic onto the mainline will be the standard 265m.

The illustration below shows an early before and after concept for the on-ramp area at Onewa

Road. The diagram below the illustrations is a more refined design.



(google map used)

Figure 5 – Existing Onewa Road on-ramp

(google map used)

Figure 6 – Proposed Onewa Road on-ramp

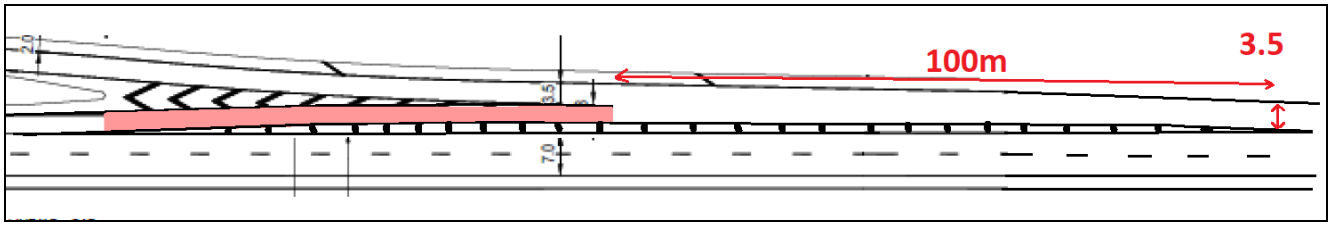


Figure 7 – Proposed Onewa Road on-ramp Drawing

CONCLUSIONS

During peak periods, many parts of the motorway network and their ramps are operating at or near capacity. Improving the efficiency of people movements can be achieved by improving movements of high occupancy vehicles like buses. Bus patronage at peak times has increased the number of

people crossing the Auckland Harbour Bridge by the equivalent of approximately two lanes of general vehicles, with virtually no additional congestion.

In common with other parts of the Auckland Motorway network, sections of the hard shoulder permit bus-only operation between on-ramps and off-ramps, which allows for a degree of queue jumping. However, buses are required to merge into the traffic stream before every off-ramp and every on-ramp. The effect of this is to introduce delay to both bus services and general traffic, and for a potential reduction in safety. The challenge has been to permit running of buses along the motorway with the least amount of disruption to their flow. This could have been achieved with a bypass to the Onewa Road interchange in the same manner that has already been constructed in the southbound direction. However, this expensive civil engineering work would cost tens of millions of dollars and would take several years to progress.

The solution has been to keep bus services operating along the shoulder and to extend a 'virtual' shoulder through the interchange with little to no additional carriageway construction. This thinking has been used to design the on and off-ramps in order to permit this virtual shoulder to form a continuous bus "lane". This new innovative concept will significantly improve bus travel time and reliability.

It is anticipated that this new innovative concept will improve not only customers' journey experiences but also work in favour of public transport (mode shift), reliability of public transport and operational cost savings including environmental benefits.

REFERENCES

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