

# IMPROVED MULTI-LANE ROUNDABOUT DESIGNS FOR ALL ROAD USERS

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## Abstract

The purpose of this paper is to report some findings of a recently completed two-year research project for NZTA, two of the projects five main topics being:

- Which is the safer design for a main road intersection - traffic signals or a multi-lane roundabout? This research demonstrates that roundabouts are significantly safer overall, and a nationwide 'Roundabout First' policy is being recommended for adoption on this basis. In practice this could mean that Road Controlling Authorities would have to justify an alternative form of intersection control if a roundabout is a feasible option at a particular location.
- How should pedestrians be safely catered for at a multi-lane roundabout? Pedestrian safety and amenity can be a motivating factor to install traffic signals in urban areas, but this research demonstrates that with appropriate facilities and adequate speed control pedestrians can be safely catered for at a roundabout. Preliminary guidelines have also been developed to assist traffic engineers design safe pedestrian crossing facilities at roundabouts.

## 1.0 Introduction

The type of control to install at an intersection can be one of the most important decisions to be made by road planners and traffic engineers, one which can have major safety and capacity implications for the sustainability of a road network. Until recently large roundabouts have largely been ignored as a design option in mainland Europe and the United States. However they are now being increasingly used there, in large part due to the growing recognition that roundabouts can experience fewer serious injury and fatal crashes than traffic signals (for example Persaud et al 2000). In the United Kingdom they have historically been a default design option, and are sometimes fully or partially signalised for capacity reasons. However in New Zealand their installation in larger cities is declining, and a major reason is safety concerns for cyclists and pedestrians.

A two-year research project has recently been completed for NZTA which had objectives to evaluate the difference in safety performance between multi-lane roundabouts and traffic signals, and to assess the available design options for roundabouts to improve their safety and operation for all types of road user. This report is expected to be published around mid 2011. The intention of this conference paper is to present the projects main findings on the following two topics:

1. Comparison of safety performance between multi-lane roundabouts and traffic signals.
2. Pedestrian facilities at multi-lane roundabouts.

## 2.0 Comparison of Safety Performance between Multi-lane Roundabouts and Traffic Signals

### 2.1 Literature review

A comprehensive literature review showed the following findings:

- There are clear indications that for most intersections a roundabout will experience substantially fewer injury crashes than traffic signals by around 25 – 74%, and especially the more serious type that may involve fatality or hospitalisation. This difference in safety performance will be greater for intersections with four arms or more and/or in high speed environments (Australia - Corben 1989, Austroads 1993; United Kingdom – Hall and Surl 1981; Belgium – Wallonne 2005; United States - Nambisahn and Parimi 2007, Persaud et al 2000; The Netherlands - Schoon and van Minnen 1994; Norway - Giaever 1992). In terms of fatal and serious crashes, studies from the United Kingdom, the United States and Belgium demonstrated between 25 – 66% savings at roundabouts (Hall and Surl 1981, Elvik 2003, Wallonne 2005).
- With regard to non-injury vehicle crashes, there are some indications that roundabouts may experience more of these than traffic signals, but this is not well proven mainly due to under-reporting of these types of incidents. (Elvik 2003, Elvik and Vaa 2004, Persaud et al 2000). In particular three-leg intersections may possibly experience higher non-injury crash rates at roundabouts compared to signals (Elvik 2003).
- For pedestrians the relative safety performance between roundabouts and traffic signals is not well proven to significantly differ, and the chances of injury being incurred are relatively small for each control type in any case. However, the lower speed environment of a well designed roundabout means that any collisions with a pedestrian might be expected to be less severe than at traffic signals and New Zealand nationwide statistics do seem to reflect this - a search of the New Zealand Crash Analysis System (CAS) showed that nationwide there has been no pedestrian fatality (and 24 serious injury) at any urban roundabout for the five year period 2004-2008, compared to 11 fatal (and 160 serious injury) at urban traffic signal intersections.
- Traffic signals are significantly safer for cyclists than multi-lane roundabouts at present in New Zealand and overseas (NZTA 2005). The predominant crash type for cyclists at roundabouts involve collisions between circulating cyclists and vehicles entering the roundabout - in New Zealand this figure is about 50% (Harper and Dunn 2003) and an evaluation of multi-lane roundabouts in Auckland found some 69% of cyclist injury crashes involved this manoeuvre (NZTA 2005). Measures to either reduce driver entry speed or physically separate cyclists from vehicle traffic are expected to substantially improve this, and a new type of low speed multi-lane roundabout designed specifically to improve safety for cyclists called the C-Roundabout is currently being evaluated as part of a NZTA research project due for publication in 2011 (as of late 2010 the results so far are positive). Signalised roundabouts can also substantially improve safety for cyclists (Lines 1995, IHT 2005)
- Crash rates at roundabouts can be influenced by design elements such as deflection, entry width, and visibility to the right for loss of control crashes (Maycock and Hall 1984). Crash

rates at traffic signals can be influenced by design elements such as number and size of displays, red light cameras and banning of filtered turns (Ogden 1994, ITE 2004, Elvik 2004, Retting and Ferguson 2003, Aeron-Thomas and Hess 2005). Crash modelling appears to offer potential for making direct comparisons between intersection control for a particular location and which could potentially take these factors into account.

- Several jurisdictions in North America have introduced 'Roundabout First' policies, based foremost on traffic safety, but also for vehicle delay and environmental reasons (NYHDM 2006, BC 2007, VDOT 2010, ADOT & PF 2010, Weber 2008).

## **2.2 Statistical Comparison of Matched Auckland Sites**

The purpose of this section of the research was to make a local comparison of arterial road multi-lane sites in Auckland, and compare the results with the conclusions of the literature review above, that is, roundabouts are an overall safer form of junction control.

### Methodology

Two sets of twenty matched urban sites were selected relatively randomly on the basis of (i) intersection geometry, i.e. number of approach legs; and (ii) daily traffic volumes through each site. Traffic volume data was sourced from either publically available traffic count data in proximity to the site, intersection count data, or from SCATs data provided from the Auckland TMU (Traffic Management Unit). Crash data for each site was based on reported crashes from 2003 – 2007 within a 50 metre radius of the junction. Crash reports were reviewed and any non-intersection related crashes were excluded (such as turning manoeuvres into driveways etc). Fuller details of this analysis will be included in the 2011 NZTA report.

### Results and Statistical Analysis

The results from the 40 Auckland sites studied did demonstrate a statistically significant difference between the roundabout and traffic signal sites, with roundabouts experiencing some 47% fewer vehicle injury crashes including 67% fewer serious and fatal types.

Using a simple Binomial Test, the total number of crashes for each set of twenty sites was compared. The important statistically significant results as shown below in Table 1 are in relation to vehicle crashes only, since pedestrian and cyclist volumes were not counted. Total vehicle injury crash savings of 47% were demonstrated for the roundabout sites, and for serious and fatal vehicle injury types there was a 67% saving. A Wilcoxon signed rank test was also applied in order to examine the differences between the two groups of paired data, which also indicated statistically fewer vehicle injury crashes (at the 0.01 level) and also total number of crashes at the roundabouts compared to traffic signals.

Note that all of the 12 vehicle serious injury and fatal crashes at traffic signals involved speed as a major factor (2 involved fatality). Five crashes were right-angle crossing incidents involving red light running, four involved loss of control or head-on, and three involving right-turn against crashes at a green light filter.

**Table 1: Comparison of crashes at signals and multi-lane roundabouts at 20 matched sites in Auckland for the period 2003-7. Only the significant results of binomial test comparisons are shown. Note that the total injury figures include pedestrian and cyclist casualties.**

	Total Injury	Total Serious	Total Minor	Vehicle Injury	Total Vehicle Serious + Fatal	Total Vehicle Crashes
<b>ROUNDABOUT SITES</b>	74	6	68	49	4	642
<b>TRAFFIC SIGNAL SITES</b>	123	17	104	92	12	706
<b>Degree of significance</b>	0.0006	0.0371	0.0076	0.0004	0.0800	0.0860
<b>% crash saving at RBTs</b>	40%	65%	35%	47%	67%	9%

## 2.3 Crash Model Analysis

Beca Ltd in New Zealand was engaged to model a number of main road intersection scenarios for a comparison of expected injury rates for roundabouts and traffic signals, these models being based on accumulated crash data from large numbers of intersections in main cities nationwide. Some of their published works include "Accident Prediction Models" (NZTA 2000b), "Predicting Accident Rates for Cyclists and Pedestrians" (NZTA 2006), and "Roundabout Crash Prediction Models" (NZTA 2009).

### Methodology

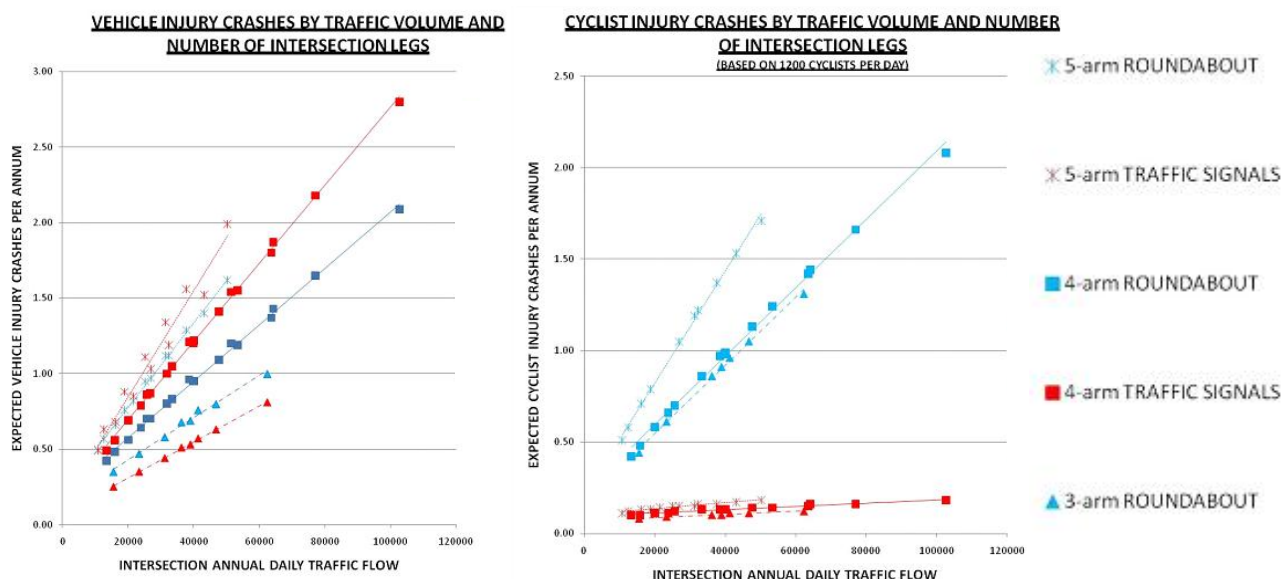
The Beca APM Toolkit was used to estimate injury crashes at a selection of existing 3, 4 and 5-leg roundabout sites in Auckland. Each of the above sites were modelled as a roundabout and a signalised intersection, with cyclist traffic volumes of 1200 cyclists per day. Pedestrian crashes were not evaluated as the Beca APM Toolkit is not able to model these for roundabout scenarios. Fuller details of this analysis will be included in the 2011 NZTA report.

### Results

Figure 1 below demonstrates the results, the main conclusions being as follows:

- For four and five-leg intersections, roundabouts will generally experience fewer vehicle injury crashes than traffic signals. The models also indicate that the margin of difference does increase with increased traffic volumes.
- For three-leg intersections traffic signals will generally experience fewer vehicle injury crashes than roundabouts, though the models do indicate that the difference may taper off with increased traffic volumes.
- For cyclists, traffic signals are much the safer intersection control for all situations. However the proven effect of 'safety in numbers' (NZTA 2006; Davies et al 1997; Department For Transport 2003) is likely to mitigate this to a reasonable degree in the case of roundabouts especially, so the difference in practice would likely be less exaggerated. Nonetheless, it is clear that cyclist safety is a valid concern at roundabouts.

Note that these models are general only, and would not take into account particular site variations such as filtered right-turn movements at traffic signals or roundabouts built with inadequate deflection.

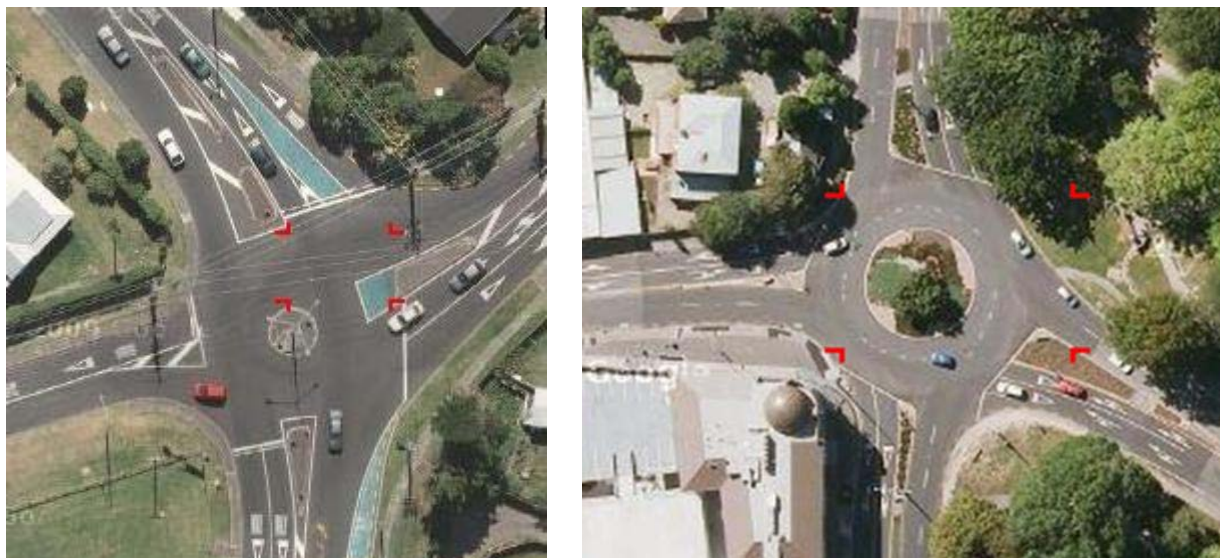


**Figure 1: Results of the Beca APM analysis comparing various scenarios for traffic signals or roundabouts. Diagram on the left shows expected vehicle injury crash rates in New Zealand by intersection type and daily traffic volumes. Diagram on the right shows expected cyclist injury crash rates by intersection type and daily traffic volumes, assuming 1200 cyclists per day.**

## Discussion

The Beca APM Toolkit appears to indicate that whilst there is a difference in safety performance between traffic signals and roundabouts, it is much less significant than overseas studies have concluded. Indeed for three-arm junctions in New Zealand, traffic signals would appear to be the safer form of control which is the most contrary finding. The authors' postulate that a major contributing factor in New Zealand is that speed control (i.e. deflection) for roundabouts is often deficient, even for recent installations. The authors' have frequently seen evidence of this and a few examples with significant crash histories are shown below in Figure 2.

A study from the United Kingdom found that roundabouts with no deflection had crash rates about 8.5 times those with maximum deflection (Maycock and Hall 1984). A New Zealand study undertaken in 2000 found that 17% had inadequate deflection on roundabout approaches (NZTA 2000a) and a further 18% had deflection that was described as 'adequate'. In addition, 7 of the 20 Auckland multi-lane roundabouts in the matched intersection study had clearly inadequate deflection on at least one major road movement. It is therefore considered by the authors' that a substantial minority of sites is likely to be disproportionately influencing roundabout crash statistics nationwide, and by default the crash rates produced by the Beca APM Toolkit as well as crash rates being used in the New Zealand Economic Evaluation Manual (NZTA 2010).



**Figure 2: Two examples where roundabouts have been built with minimum regard to speed control for some approaches, and both with significant crash histories. The example on the left is at the intersection of Glenfield Road and Coronation Road in Auckland with some 37 crashes including 6 injury from 2004-2008. The example on the right is at the intersection of Riccarton Road and Deans Avenue in Christchurch with some 45 reported crashes including 7 injury from 2004-2008.**

## **2.4 Conclusions**

There is ample overseas evidence to demonstrate that a well designed roundabout should experience significantly fewer injury crashes (especially serious and fatal injury type) than if the intersection was controlled by traffic signals (for example Corben 1989, Persaud et al 2000). Crash statistics for a given location can depend on traffic volumes, number of legs and traffic lanes, and other features particular to that site. Affirming the relevance to New Zealand, an analysis of 40 intersections in the Auckland region undertaken as part of this research demonstrated a 47% reduction in vehicle occupant injuries – and some of the overseas studies show even larger savings than this. Thus it has been concluded that in order to reduce nationwide injury crash statistics at urban intersections, roundabouts should be the preferred choice over traffic signals and particularly so for intersections with four arms or more.

Crash model work undertaken in New Zealand by Beca Ltd seemed to give some contrary results to most overseas research which showed an appreciable reduction in vehicle user injury crashes for roundabouts compared to traffic signals for all intersection configurations. These crash prediction models (which are based on nationwide data) appeared to demonstrate that although roundabouts at four-arm intersections in New Zealand are safer than traffic signals, the difference is somewhat less than many overseas studies indicate, and at three-arm intersections traffic signals are marginally safer. However the authors' believe these results are being influenced by a lack of adherence to proper speed control at roundabouts in New Zealand (this is supported by a nationwide survey, NZTA 2000a), which is in turn adversely affecting their safety performance. The New Zealand Economic Evaluation manual (NZTA 2010) will also be over-estimating crash rates for roundabouts on this basis as they use the same crash models.

This research did not conclusively find a significant difference in safety performance for pedestrians between multi-lane roundabouts and traffic signals, but there is some evidence from nationwide crash statistics to suggest that roundabouts may be a safer form of control for these users.

The safety and amenity of cyclists at multi-lane roundabouts does justify attention, as evidence does indicate that these vulnerable users in particular can be adversely affected at these types of intersections. However measures to either reduce roundabout vehicle entry speed or physically separate cyclists from vehicle traffic are expected to substantially address this, as the majority of cyclist crashes at roundabouts involve the circulating cyclist being hit by a driver entering the roundabout (NZTA 2005). A new type of cyclist-friendly multi-lane roundabout called the C-Roundabout has been developed in New Zealand and results so far are promising. Signalised roundabouts in the United Kingdom have also demonstrably improved cyclist safety.

## **2.5 Recommendations**

Key recommendations of the research are:

- NZTA adopt a 'Roundabout First' type policy similar to several North American precedents. The primary motivator for such a policy is traffic safety, but may also include vehicle delay and environmental reasons. In practice this would require Road Controlling Authorities to justify when an alternative intersection control is proposed if a roundabout is viable to install.
- Engineers and safety auditors who are responsible for considering the design details of roundabouts, must implement best current design practice particularly in relation to adequate speed control. This is a critical design factor which is not always being appropriately adhered to in New Zealand.
- Current crash rates for roundabouts in the NZTA Economic Evaluation Manual should be revised to better represent current best design practice that includes adequate speed control. The crash rates used are based on nationwide data that include many roundabouts designed with inadequate deflection, and this reduces the economic viability for roundabouts.
- Pedestrian crash rates at roundabouts and traffic signals should be better determined, as some evidence is suggesting that well designed roundabouts are a safer form of intersection control for these users than traffic signals. This applies particularly to pedestrian fatal and serious crashes.
- The field of crash modelling should be further continued based on crash data from intersections incorporating best current design practice, so that practitioners can (for example) better compare the expected safety performance between a roundabout and traffic signal for a particular location.



### 3.0 Pedestrian Facilities at Multi-lane Roundabouts

#### 3.1 Literature Review and Evaluation of Overseas Practice

Overseas practice with pedestrian crossing facilities was researched and evaluated in the context of multi-lane roundabouts. More vulnerable pedestrians at roundabouts include children, elderly and mobility or visually impaired and most of the identified treatments should improve the situation for them.

It was found that ‘Hawk’ (refer Figure 3 below) and ‘Pelican’ crossings which reduce pedestrian signal walk times (i.e. and reduce disruption to roundabout traffic flow) are feasible for use in New Zealand, although some law changes are required to allow flashing signal operation which is used in these facilities. On-road pedestrian detection technology which can extend or cut short walk times does also offer potential in this regard, but its practicality would need to be better demonstrated in New Zealand.

Improvements to zebra crossings that have demonstrable benefits are activated flashing road studs or signs (Parevedouros 2001, Van Derlofske et al 2002, Hakkert et al 2002, Huang et al 1999), and the road studs in particular have already been successfully trialled in Auckland and Christchurch (Smith et al 2008). Signalised roundabouts which have recently been installed in small numbers in New Zealand can also effectively deal with pedestrians, and their part time operation (which is currently illegal in New Zealand) is also deemed worthy of consideration. Raised speed platforms are also an option that could also be considered for many situations, and preliminary guidelines for the application of vertical deflection devices on main roads will be contained in the NZTA report expected to be published mid 2011.



Figure 3: a Hawk signal at a two-lane entry to a roundabout in Michigan, the United States. The HAWK can optionally be set up so pedestrians have the discretion of either crossing the road as at a regular zebra crossing or push the button to call up the signal phase.



### 3.2 Safety performance of some pedestrian facilities at multi-lane roundabouts in Auckland

As a means of assessing the safety performance of pedestrian facilities at multi-lane roundabouts in New Zealand, crash histories were reviewed at eleven busy arterial road roundabouts in Auckland and Waitakere City. Pedestrian and rear-end crashes associated with pedestrian crossing facilities were evaluated, and several sites were chosen for closer evaluation via video observation of pedestrian and driver behaviour. Reported pedestrian crashes for the ten years between 1999 – 2008 were analysed for each of the eleven roundabouts, and individual Traffic Crash Reports (TCR's) were reviewed (an example site with one of the more interesting crash histories is shown in Figure 4 below). Fuller details of this analysis will be included in the 2011 NZTA report.

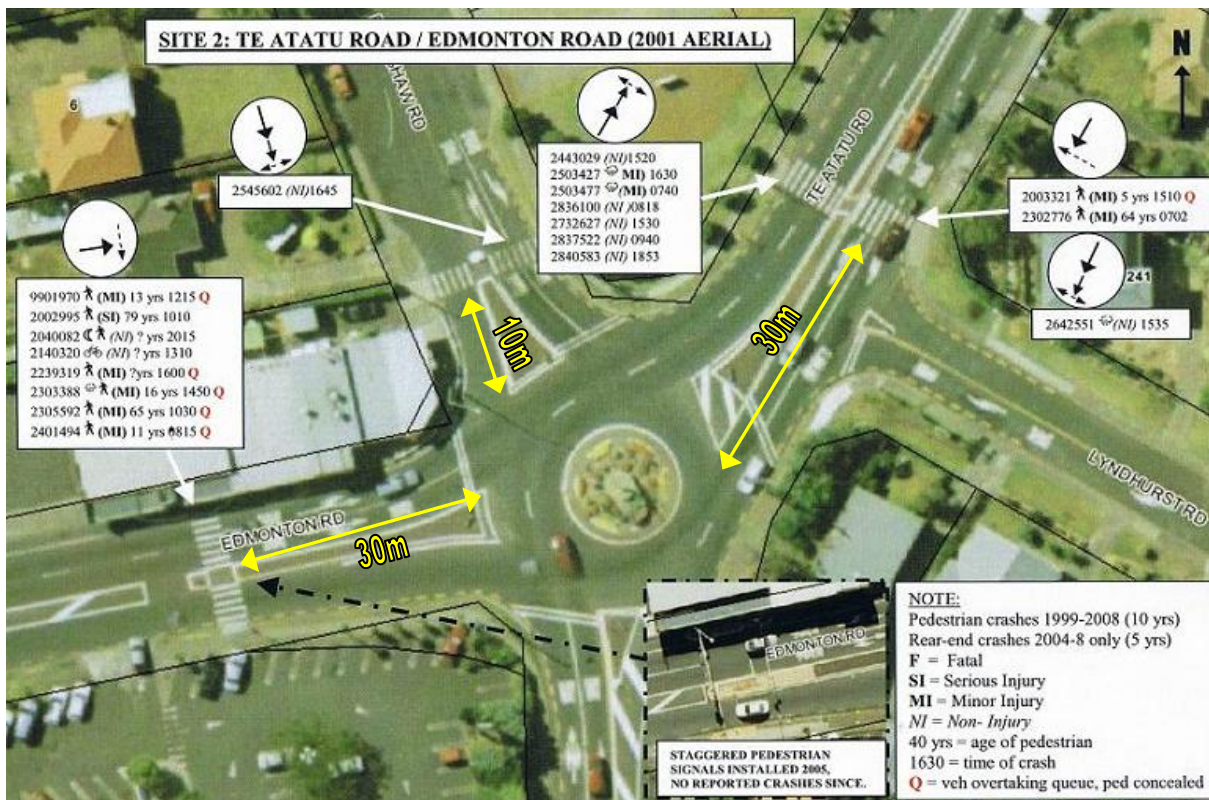


Figure 4: One of the eleven multi-lane roundabouts in Auckland that were studied in detail, Te Atatu Road / Edmonton Road intersection in Waitakere. Staggered pedestrian signals installed in 2005 addressed the significant crash history that had previously been occurring at the Edmonton Road zebra crossing. Northbound rear-end crashes at the Te Atatu Road zebra crossing could be addressed by either high friction road surfacing and/or flashing road signs/road studs, and for the southbound direction the pedestrian safety could be improved by either relocating the crossing closer to the roundabout and/or high friction surfacing and/or flashing road signs/road studs.

## Zebra Crossings

In general the zebra crossing sites did not demonstrate any significant pedestrian safety problems that could not be addressed. Summary of the crash types is shown in Table 2 below.

Based on the analysis, the following observations were made:

- Zebra crossings on dual-lane roundabout entries located 20 metres or closer to circulating lanes experience far fewer pedestrian crashes than those further away, with a total of just three reported pedestrian injury crashes at eleven crossings over a period of five years. A separation of around one to two vehicles from circulating lanes appears to be the optimum location. Sixteen (84%) of the 19 reported crashes on dual-lane entries occurred at five zebra crossings located 25 metres or further from roundabout circulating lanes. This corresponds to an average pedestrian crash rate of some 3.2 crashes per site every five years, which is considerably higher than for crossings located closer to the roundabout. Twelve of these 16 crashes involved collisions with pedestrians crossing in traffic queues – highlighting that this is the main safety issue being experienced by pedestrians at multi-lane crossings.
- Single lane crossings appear to operate reasonably safely, but inadequate speed control through the roundabout may still have an adverse effect on pedestrian safety.
- Additional measures to improve safety at multi-lane or higher speed locations could include flashing signs, flashing road studs (refer Figure 5), raised platforms and high friction surfacing.
- The use of lane arrows on roundabout approaches can contribute to uneven lane queuing behaviour from drivers that can be detrimental to pedestrian safety in multi-lane situations.

**TABLE 2: Table showing reported pedestrian injury crashes from 1999-2008 at zebra crossing facilities for the eleven sites studied in Auckland. NB: F = Fatal, S = Serious Injury, M = Minor Injury**

<b>ZEBRA CROSSINGS SUMMARY</b>			
	<b>Single-lane Exit</b>	<b>Double-lane Exit</b>	<b>Double-lane Entry</b>
<b>Ped Injury Crashes</b>	2S, 5M @ 15 crossings = 0.46/site/5 yrs	7M @ 5 crossings = 1.5 /site/5 yrs	1F, 3S, 15 = total 19 ped injury @ 16 crossings = 1.19 / site / 5 yrs
<b>Crashes involving overtaking in traffic queues</b>	N/A	4M or 57% of total. Three occurred at Royal Oak crossing 30m from rbt.	Twelve (11M & 1F) or 63% of total. All 12 occurred at crossings > 25m from rbt
<b>Comments</b>	One crossing had 2 injury crashes, the remaining 14 crossings had 4 injury crashes combined.	Two crossings had 3 injury crashes each, the remaining 3 crossings had just 1 injury crash combined.	Sixteen of the 19 ped injury occurred at 5 crossings, all located 25m or more from roundabout = 3.2/site/5yrs  Just 3 ped injury occurred for the 11 crossings located 20m or less from rbt = 0.27/ site/5 yrs

## Pedestrian Signals

In general the pedestrian signal sites did not demonstrate any significant safety issues that could not be addressed.

Of the seven reported pedestrian incidents between 1999-2008 at the four signalised crossing sites, three involved red-light running with the remaining four being pedestrians crossing heedless of the traffic signal. Therefore in order to improve safety at these locations:

- Visibility of signal displays to approaching drivers is an important consideration for reducing run red incidents. Overhead signal displays are recommended in multi-lane situations.
- Pedestrian wait times should desirably be set at not greater than around 30 seconds each crossing stage, in order to reduce the jaywalking that will inevitably occur and potentially adversely affect safety statistics. Anticipatory call-up of opposite cross phases at staggered island layouts is also recommended practice.
- All-red times could be increased to reduce the chance of late-runners hitting pedestrians. This is more viable for staggered island crossings.
- Active advance warning measures such as flashing road studs or signs could potentially assist drivers perceiving there is a red light ahead.



**Figure 5: Driver view when exiting the Royal Oak roundabout of the Mt Albert Road zebra crossing fitted with amber flashing road studs. The approximate stud locations have been added for additional emphasis, as they are less discernible in sunny conditions when this photo was taken. The studs were installed in 2006, and it is entirely likely that with improved LED technology their visibility in daytime conditions would improve.**

## **3.3 Conclusions**

Well designed multi-lane roundabouts are able to safely accommodate pedestrians, and should be a viable alternative to a traffic signalised intersection for these users. Some preliminary guidelines for pedestrian crossing facilities at roundabouts have been developed, and will be included in the 2011 NZTA research report.

Zebra crossing facilities offer the greatest mobility to able-bodied pedestrians, although they can

have some disadvantages to visually impaired users. A review of zebra crossings at multi-lane crossing points in Auckland demonstrated that they can be relatively safe if located less than 20 metres from the roundabout, mainly due to the lower approach vehicle speeds near circulating lanes. Note this finding seems to be affirmed by design guidelines in the United Kingdom which recommend zebra crossings are not located between 20 – 60 metres from roundabout limit lines (Department for Transport 2007). However, zebra crossings at multi-lane locations where vehicle speeds are higher (such as greater than 20 metres from the roundabout) can invariably experience safety problems and additional measures or even alternative crossing facilities may be desirable. This is particularly relevant at locations where vehicle queues from the roundabout regularly extend through the crossing. Appropriate speed control at the roundabout is a most important consideration, and active warning devices such as flashing signs or flashing road studs, staggered island arrangements or raised pedestrian platforms will also improve pedestrian safety at zebra crossing facilities.

Pedestrian signals near roundabouts are a viable alternative to zebra crossings, but pedestrian wait times need to be set low enough to reduce the 'jaywalking' that may otherwise occur which in turn may compromise pedestrian safety. Staggered signalised crossing arrangements can reduce disruption to vehicles as crossing times are shorter for each direction.

'Hawk' and 'Pelican' crossings as used overseas are simple signalised crossing alternatives that can reduce disruption to traffic flow with no apparent compromise to pedestrian safety. However, as they have flashing displays they are not currently legal to use in New Zealand. Pedestrian detection technology as used with 'Puffin' crossings in the United Kingdom could feasibly achieve a similar objective, although their reliability would need to be better proven in New Zealand.

Signalised roundabouts can also satisfactorily incorporate pedestrian facilities, and have demonstrable safety benefits for cyclists as well (Department for Transport 2009). However compared to an un-signalised roundabout, vehicle delays may be substantially higher during off-peak periods and would need to be taken into account. Part-time signal operation as used overseas which might address this is not currently legal in New Zealand.

### **3.4 Recommendations**

Key recommendations of the research are:

- The preliminary guidelines which will be included in the 2011 NZTA research report be referred to by Road Controlling Authorities for design of pedestrian facilities at roundabouts.
- The legal use of flashing signal displays such as used at 'Pelican' and 'Hawk' type signal crossings is considered for adoption in New Zealand. These types of facilities can reduce the disruptive effects of signalised crossings to traffic flow, including at roundabouts.
- The legal use of part-time signals is considered for adoption by NZTA. This is particularly relevant to signalised roundabouts or metered signals on roundabout approaches, whereby signals could feasibly be switched off as a means of reducing driver delay during off-peak periods.
- Current design guidelines in New Zealand require the use of lane arrows at multi-lane approaches, for roundabouts but not at traffic signals. These lane arrows can potentially have adverse effects for pedestrian safety at multi-lane crossing points, and it is recommended that this requirement be amended to an optional measure only as per United Kingdom practice.

- The current standard size for Belisha Discs used at zebra crossings in New Zealand is only 400mm diameter. The MOTSAM standard should be amended to include a 750mm diameter option or similar which would make the Belisha discs of similar visibility to those alternatives used by several countries overseas.

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