Reducing Speed: The C-Roundabout

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ABSTRACT

A major New Zealand Transport Agency (NZTA) research project was undertaken: "Evaluation of the C-Roundabout – an improved multi-lane roundabout design for cyclists" to evaluate the safety and capacity of a multi-lane C-Roundabout. The C-Roundabout (cyclist roundabout) is a new type of two-lane roundabout designed to reduce vehicle speeds (to around 30km/hr,18.6mph) specifically for the benefit of cyclists, but also to improve pedestrian and driver safety. The main objective of this paper is to introduce the C-Roundabout as a means of making multi-lane roundabouts more cyclist-friendly.

Also, a single lane roundabout can easily be converted to a C-Roundabout at minimal cost using approximately the same road reserve and results in a significant increase in capacity. This may not necessarily be to the benefit of the cyclist as single lane roundabouts are safer for the cyclist than multi-lane roundabouts.

Multi-lane roundabouts have a higher proportion of cyclist crashes in relation to other types of intersections such as traffic signals and priority intersections (stop or give-way, yield, controlled) and are viewed by cyclist to be less safe. In order to encourage cycling on roads, cyclists need to be better catered for at multi-lane roundabouts.

The C-Roundabout is a very compact design only designed for two cars to negotiate without driving over kerbs. Larger vehicles such as trucks and buses must straddle both approach and circulating lanes of the roundabout. Articulated trucks may need to drive over mountable areas, but buses will not to ensure a comfortable ride for the bus passengers.

A C-Roundabout was constructed in April 2009 and since then two further C-Roundabouts have been installed in Auckland. The road users (car drivers, pedestrians, cyclists) at the new C-Roundabout were surveyed. Feedback from the cyclist survey has been very good with the majority of cyclists wanting to see more C-Roundabouts. They find them safer and are now not so intimidated by other vehicle drivers that overtake and sometimes force them off the road.

Car drivers were not so enthusiastic to the introduction of the C-Roundabout as it is tighter and slower and they appear to prefer the wider, faster roundabouts. With the introduction of two further C-Roundabouts car drivers seem to have become accustomed to them and there has been little negative feedback for the two new ones.

The tight geometry of the C-Roundabout has little impact on the capacity of a multi-lane roundabout provided truck numbers are low, which is usually the case in peak periods.

INTRODUCTION

This project is a follow up to the 2005 Land Transport New Zealand project "Improved Multi-lane Roundabout Design for Cyclists", and potentially gives Road Controlling Authorities a tool to improve safety for cyclists and pedestrians. This previous research showed that adult commuter cyclists (whom are generally more able and confident riders), would prefer to stay on the road rather than use some kind of off-road facility – provided that vehicle speeds were around 30 km/h (18.6mph) or less. The C-Roundabout uses European-style confined geometry to achieve this low speed environment, and consequently requires larger vehicles such as trucks or buses to travel through single file straddling both lanes. Cyclists are not provided with a separate facility; instead they are expected to travel through as if they were a car user in the specifically designed narrow traffic lanes of around 2.7 metres (8.9 ft) wide. As the cars, buses and cyclists are all travelling at around 30 km/hr (18.6mph) the cyclist is less intimidated and is not overtaken or forced off the road as can occur on normal roundabouts. It is now easier for the cyclists, to make turns at the C-roundabout due to the lower operating speeds (around 30km/hr, 18.6mph) and tighter design of the C-Roundabout.

Also, a single lane roundabout can easily be converted to a C-Roundabout at minimal cost using approximately the same road reserve and results in a significant increase in capacity. This may not necessarily be to the benefit of the cyclist as single lane roundabouts are safer for the cyclist than multi-lane roundabouts.

A C-Roundabout was constructed in November 2009 at the Palomino Drive/Sturges Road intersection in Waitakere, Auckland and has been road-tested and evaluated.

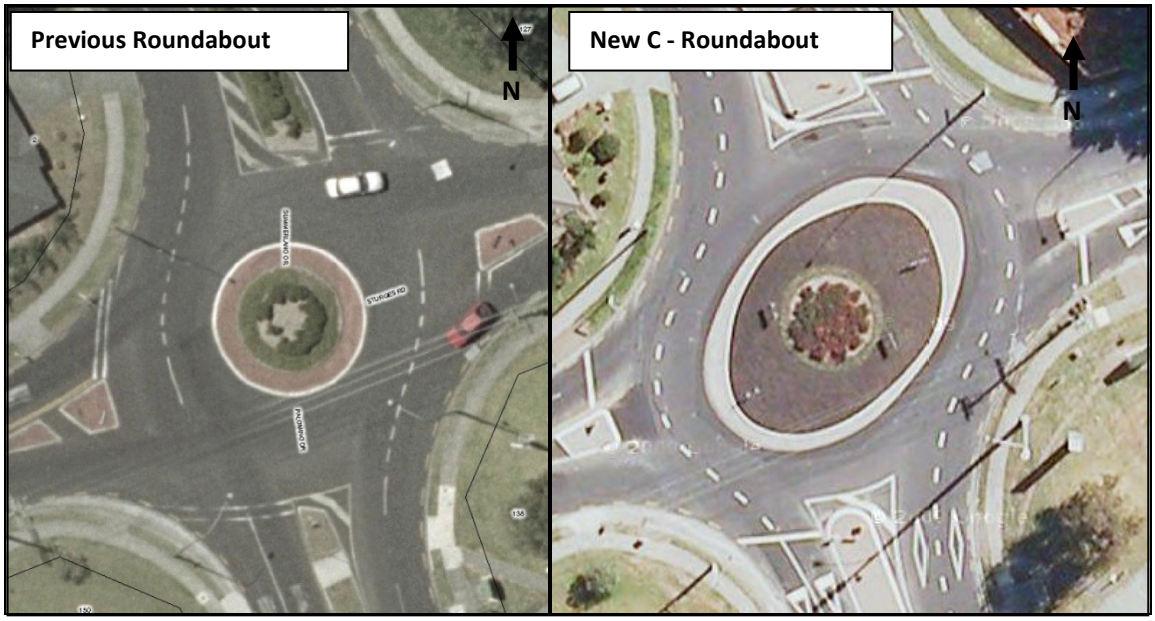


Figure 1: Aerial photos for the Palomino Drive/Sturges Road roundabout prior to reconstruction, and after new C-Roundabout configuration installed in 2009.

BENEFITS OF THE C-ROUNDABOUT

The C-Roundabout concept is potentially applicable to any multi-lane roundabout design, and is expected to substantially improve the road environment for cyclists. The following benefits can also be attributed to other road users:

- Pedestrians – the lower speed environment means that any pedestrian facilities in the vicinity of the roundabout should be safer. This includes zebra crossings, pedestrian traffic signals and informal crossing points at roundabout throat islands.

- Vehicle drivers – even though well-designed roundabouts generally have a good safety record in terms of injury-related crashes, an even lower speed environment means that any crashes that do occur will be less severe.

SAFETY OF CYCLISTS

Cyclists are most vulnerable at the entry to the roundabout where a fast vehicle enters the roundabout and hits a cyclists travelling through the roundabout (that is entering vehicle vs. circulating cyclist). Refer for figure 2 for crash data for cyclists at multi-lane roundabouts in Auckland. Addressing the 68% of cyclist crashes at the entry of the roundabout would then make the multi-lane roundabout the safest type of intersection for cyclists.

Many roundabouts have been designed with high entry speeds of more than 50 km/hr (31 mph) and this makes the roundabout particularly unsafe for cyclists. Most of the time this is done to save costs as it can become very expensive to achieve the required deflection to keep the operating speeds of the roundabout less than 50km/hr (31mph).

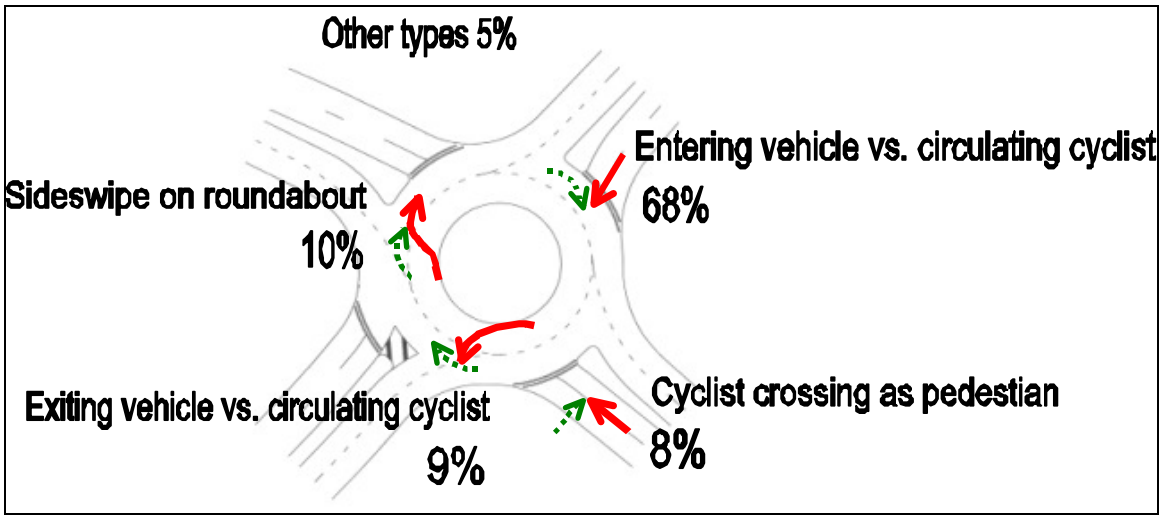


Figure 2: Summary Diagram of crash data for cyclists at multi-lane roundabouts in Auckland (non-injury and injury) 1995 to 2004 (59 reported crashes)[1]. Note that the 'entering vehicle versus circulating cyclist' is the most prevalent crash type, and is considered to be best addressed by an overall decrease in the traffic speed environment. The C-Roundabout is an attempt to achieve this.

VISUALLY IMPAIRED PEDESTRIANS

The C-Roundabout will be better for the visually impaired pedestrians as it drops speeds at entry where crossing facilities are located to around 30 km/hr (18.6mph). To address the conditions for the visually impaired it has been suggested for multi-lane roundabout to assist pedestrians crossing the road that:

- A signalised crossing facility be required, or
- A speed table be used at the location where the pedestrian crosses that drops speeds to an appropriate level.

In light of the above, a C-Roundabout may be adequate to meet the requirements for visually impaired pedestrians.

[1] Land Transport New Zealand Authority Report 287 (2005) Multi-lane Roundabout Designs for Cyclists

WHERE TO USE THE C-ROUNDABOUT DESIGN

The C-Roundabout was developed to meet the needs of cyclists on cycle routes. There are currently no adequate cyclist-friendly design solutions for multi-lane roundabouts, cycle facilities typically stop prior to any multi-lane roundabouts on cycle routes. Cyclists are then left to negotiate the multi-lane roundabouts on their own without any improvements to the roundabouts. This results in gaps in the cycle facilities provided on the cycle route. With the C-Roundabout design, the multi-lane roundabout can be converted to C-Roundabouts and provide cycle facilities for the entire cycle route.

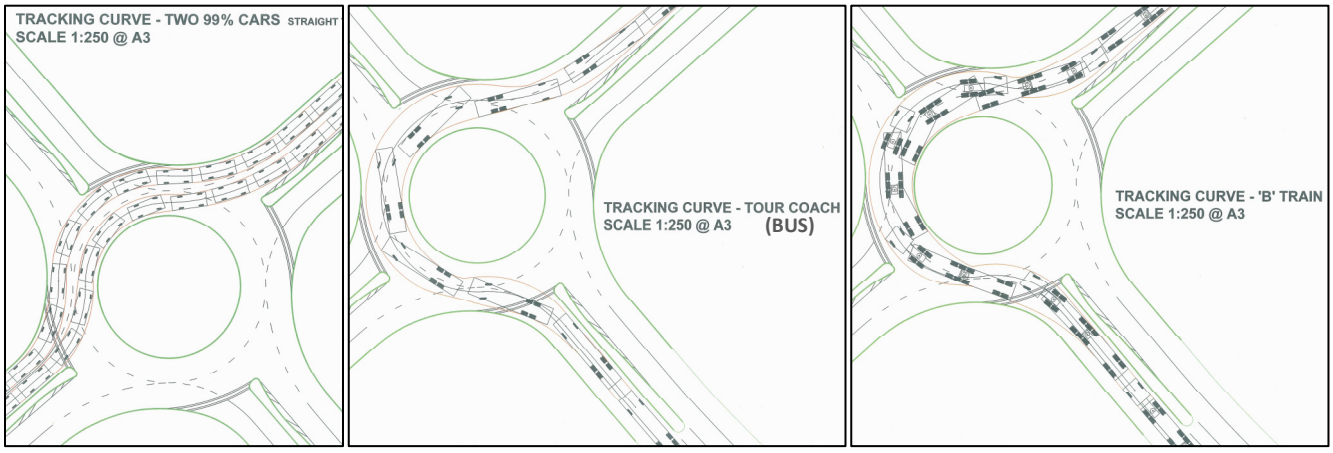
Other possible applications of the C-Roundabout design:

- At an existing multi-lane roundabout where there are a large number of cyclist crashes or a need to improve cyclist safety; the multi-lane roundabout could be converted to a C-Roundabout.
- At a site where an existing single lane roundabout is going to be converted to a multi-lane roundabout for improved capacity, but there are concerns for the safety of cyclists; a C-Roundabout could be installed instead to provide a more cyclist-friendly alternative. It is also likely that the cost of the C-Roundabout will be lower as there is usually only minimal changes to the geometrics required.
- At a site where a priority intersection is going to be converted to a multi-lane roundabout for improved capacity, but there are concerns for the safety of cyclists; a C-Roundabout could be installed instead to provide a more cyclist-friendly alternative.
- At a site where a signalised intersection has a crash problem and a multi-lane roundabout is being considered; a C-Roundabout could be installed instead to provide a cyclist-friendly option and also a low speed design (with speeds of around 30km/hr (18.6mph) there are unlikely to be fatal crashes).
- At a single lane roundabout where there are cyclists crashes or a need to improve cyclist safety; the C-Roundabout concept of increasing vehicle deflection to reduce vehicle speeds could be applied to all the roundabout approaches. This is the application of the principle of the C-Roundabout design to a single lane roundabout.

TRACKING CURVES

The C-Roundabout is a very tight design designed for the tracking curves of two 99 percentile cars, as shown in figure 3. Buses must straddle both approach and departure lanes when driving through the roundabout as shown in figure 3. For a smooth ride for passengers buses are not expected to drive over any mountable kerbs. For the articulate vehicles it is expected that they will straddle both lanes on the approach and departure and through the roundabout but may drive over the mountable area of the roundabout.

Figure 3: Tracking curves (not to scale)



TYPICAL LAYOUT OF C-ROUNDABOUT

Figure 4 shows the geometric and horizontal deflection curves required to maintain speeds to around 30km/hr (18.6 mph) through the C-Roundabout. Figure 5 shows the road marking and signs required for C-Roundabouts. Of note is the approach warning speed sign of 30km/hr (18.6 mph), the truck and car lane usage and the cycle symbol road markings.

Figure 4: C-Roundabout: typical configuration (Note: all units are given in metres)

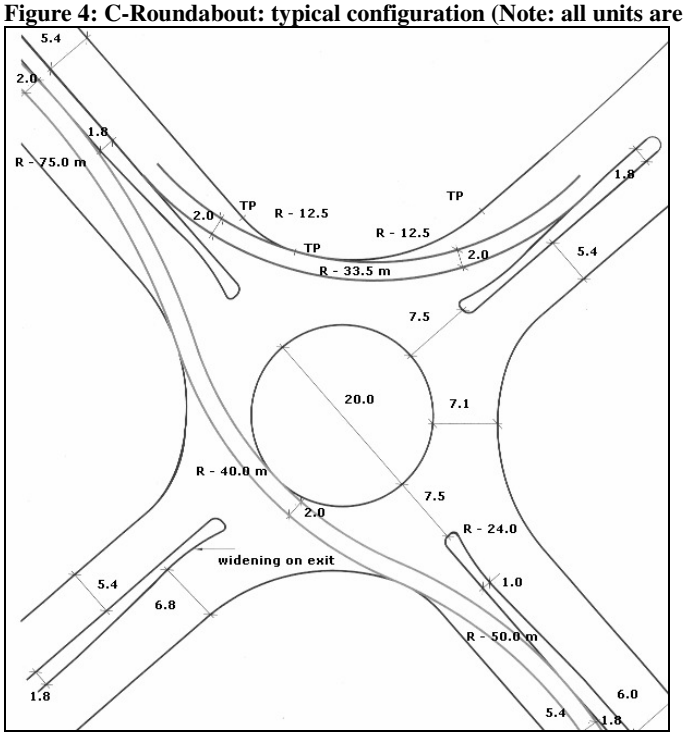
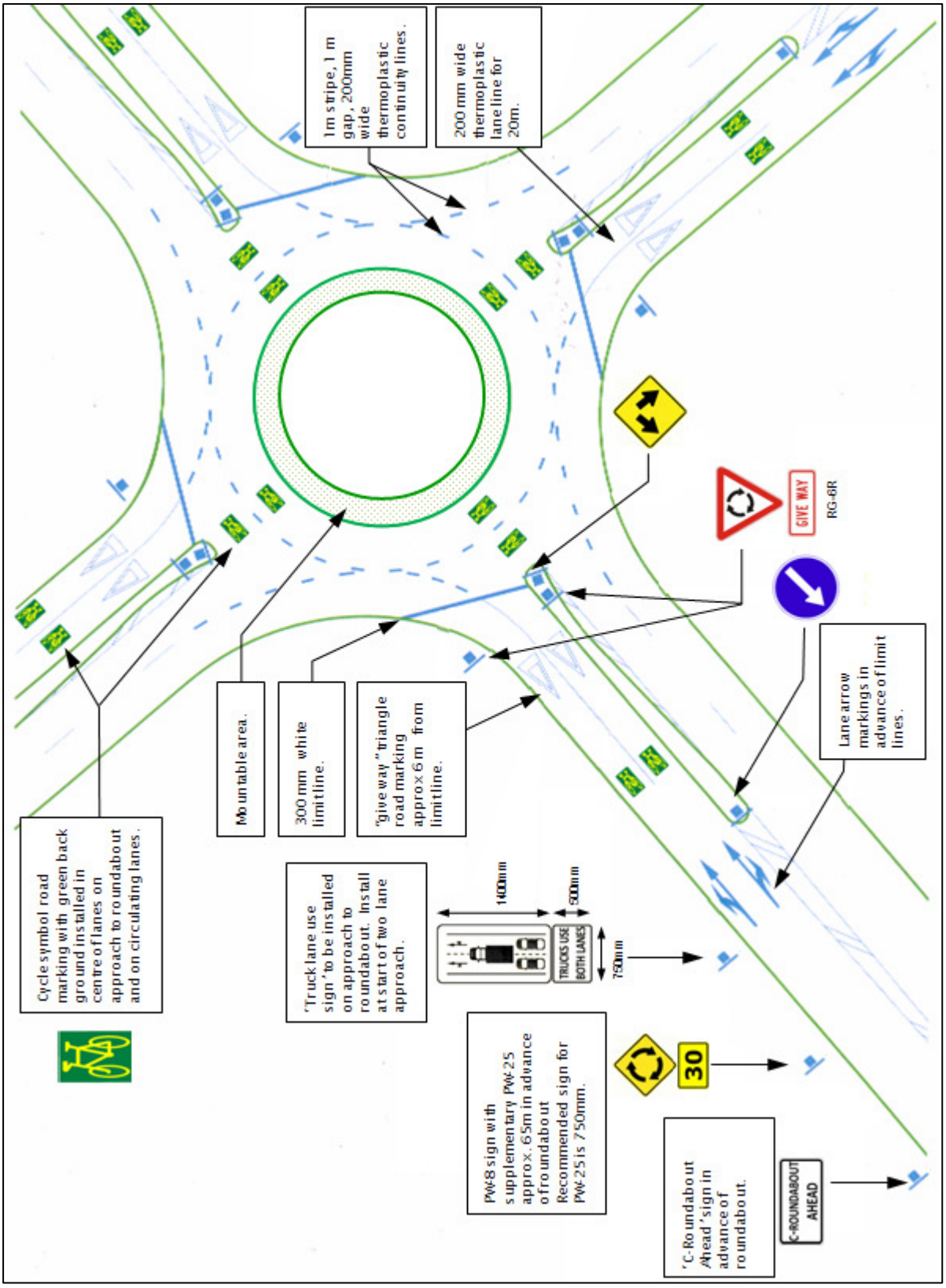


Figure 5: C-Roundabout road marking and signs



Notes: (a) All kerbs within 30 m of the roundabout are to be painted reflective white
(b) ADS and prominent IDS are recommended on all approaches
(c) RRPM's should be used for improved night time and wet weather operation
(d) All road marking should be done in thermoplastic to ensure adequate visibility at night time and during wet weather

CAPACITY

The installation of the C-Roundabout at the trial site (converting a standard multi-lane roundabout to a C-Roundabout) had little impact on capacity (based on SIDRA and on-site measurements). The trial site was an uncongested roundabout with low truck and bus flows.

SIDRA modelling indicates that, for an uncongested roundabout, converting it to a C-Roundabout has very little impact on the average delay (7.5sec/veh before, 8.1sec/veh after), the degree of saturation (0.579 before, 0.568 after) and the design life (12 years before, 12 years after). Sidra was shown to adequately assess the capacity of the C-roundabout where the design had adequate spare capacity and truck numbers were low.

Delays measurements indicated that converting the multi-lane roundabout to a C-Roundabout had no significant impact on the delays.

Further research is proposed on the C-roundabout to further improve its design and review its impact when at capacity and with high large vehicle numbers.

SINGLE LANE ROUNDABOUT

Single lane roundabouts can be converted to narrow two lane roundabouts for improved capacity (almost doubling the capacity depending on lane utilisation) at little cost (25%) compared to the standard design. Further research needs to be undertaken on the safety implication of this conversion as single lane roundabouts are usually safer for cyclists.

PALOMINO DRIVE / STURGES ROAD ROUNDABOUT EVALUATION RESULTS

Since the roundabout was changed to a C-Roundabout during 2009, an analysis of video-taped operation during peak hours indicated that the C-Roundabout is operating very well. Signs have been erected in order to educate large vehicle drivers that they should use both approach lanes, and in combination with the narrow lanes these appear to be working well.

Comparison of unopposed through-vehicle speeds before and after the roundabout was converted to a C-Roundabout were undertaken and showed that 85% operating speeds have been reduced to between around 30 kph (18.6 mph). This demonstrates that the key objective of the C-Roundabout project has been achieved, which is to provide a low speed environment for cyclists to be able to share the road safely with car drivers.

The results of a cyclist survey undertaken indicated that cyclists like the C-Roundabout installed at Palomino Drive/Sturges Road intersection and 93% (13 out of 14 responses) said they would like to see more C-Roundabouts installed (7% were indifferent).

Figure 6: Photo showing information sign to motorists indicating that large vehicles should straddle both lanes.

Figure 7: Photo showing a bus straddling both lanes whilst waiting at the roundabout limit line to turn right.

Figure 8: Photos showing a cyclist travelling through the C-Roundabout using the middle of the traffic lane as desired.

TRAFFIC FLOWS

The C-Roundabout is able to operate successfully in low and high flow intersections as shown in figures 8 to 10 where flows vary in the peak hours from 1700 to 2800 vehicles per hour (ADT 20,000 to 30,000 veh/day).

The C-Roundabout can be very small or large as shown in figures 9 to 11.

Seymour Road/Parrs Cross Road roundabout is a very small roundabout as seen in figure 10. This was a priority intersection before where vehicles had difficultly exiting Seymour Road with a crash problem that needed addressing.

Waimumu Road/Triangle Road roundabout was on a major cycle route along Triangle Road. The existing roundabout was converted to a C-Roundabout that slowed all vehicles down to 30km/hr giving a slow cycle route through the roundabout. Cycle paths normally finish on the approach and start on the departure side of a roundabout.

Palomino Drive/Sturges Road roundabout was where the trial was done. This was already a roundabout that was converted to a C-Roundabout. The flows through the roundabout were low, as shown in figure 9, they were 1,700 veh/hr in the peak periods. This site was near a school.

C-ROUNDABOUTS OPERATING ON-SITE

TRIAL SITE: PALOMINO DR/STURGES RD, AUCKLAND

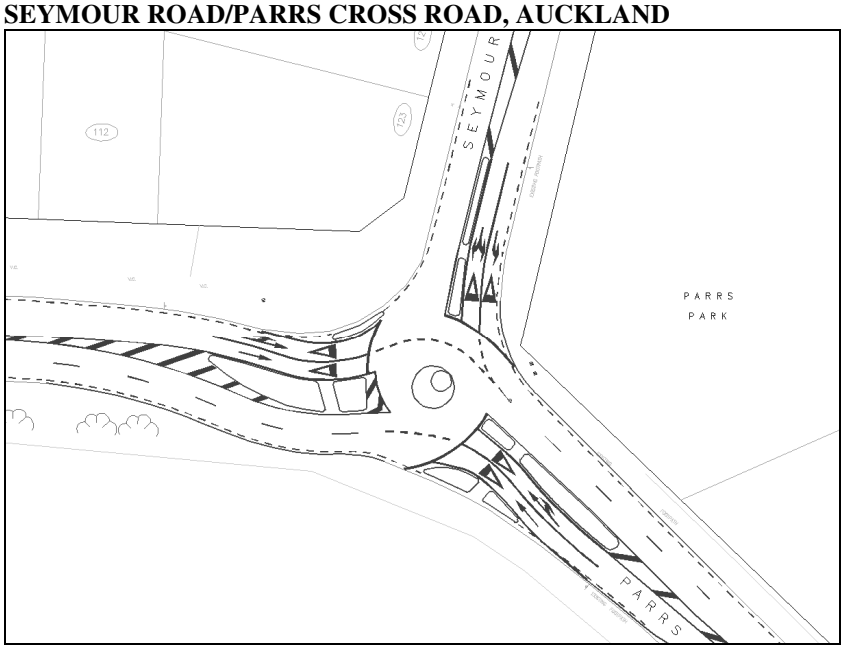
Peak hour flow = 1,700 veh

ADT = 20,000 veh

Figure 9: Aerial of C-Roundabout at Palomino Dr/Sturges Rd

OTHER C-ROUNDABOUTS

SEYMOUR ROAD/PARRS CROSS ROAD, AUCKLAND

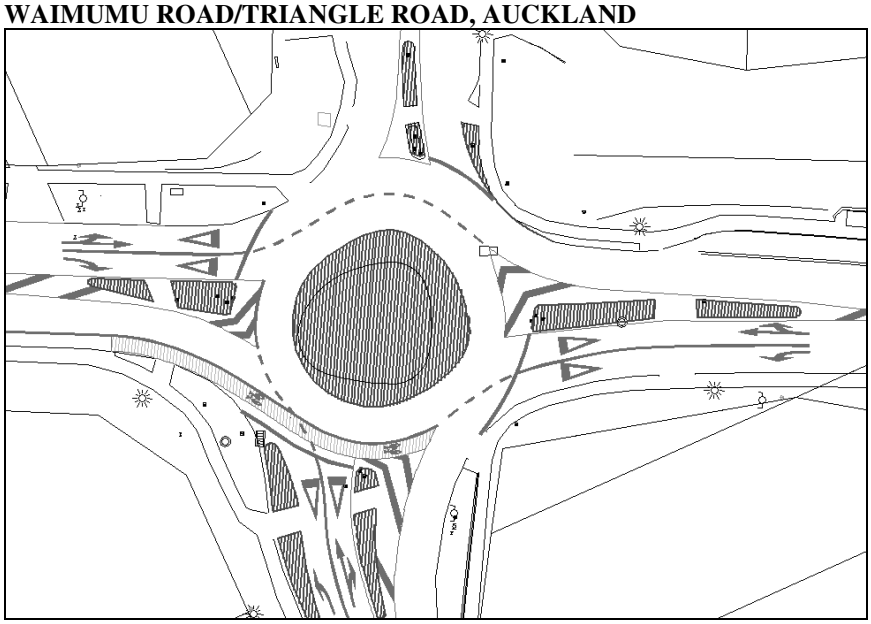


Peak hour flow = 2,800 veh

ADT = 30,000 veh

Figure 10: Seymour Road/Parrs Cross Road roundabout

WAIMUMU ROAD/TRIANGLE ROAD, AUCKLAND



Peak hour flow = 2,700 veh

ADT = 27,000 veh

Figure 11: Waimumu Road/Triangle Road roundabout

CONCLUSIONS

It is concluded that:

- More C-Roundabouts should be installed as they are cyclist-friendly and safe multi-lane roundabout designs that are liked by cyclists. Further research and refinement of the C-Roundabout design should be undertaken.
- Single lane roundabouts can be converted to narrow two lane roundabouts (with no reduction in design speed, that is not C-Roundabout design) for capacity reasons at low cost compared to the standard design. Further research needs to be undertaken on the safety implication of this conversion.