Practical Compact Roundabouts for Urban Areas

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Introduction

I am a practicing traffic engineer with around 20 years experience, of which a considerable proportion has involved scheme through to construction design for intersection and route improvement projects in urban areas of Auckland. Between 2004 - 2011, I was involved with several research projects funded by the New Zealand Transport Agency (NZTA) which investigated multi-lane roundabouts including a review of international practice, and in particular how cyclists and pedestrians might be better provided for at them (NZTA 2006, 2012a & 2012b). Cyclist safety is also an interest of mine and I am a regular commuter cyclist.

During the course of my work experiences I have been able to put into practice some relatively low-cost measures for speed control at roundabouts. The purpose of this paper is to highlight their usefulness.

Speed Control, Safety, Economics and Vulnerable Road Users

Speed control is a recognised critical factor for road user safety at roundabouts, and most international guidelines will to a varying degree give satisfactory advice on how to achieve this via horizontal deflection (i.e. curvilinear roadway alignment to slow drivers down as they enter the roundabout). However, this can sometimes be a relatively expensive exercise in terms of space requirements, and more difficult to achieve for approach roads on a skewed angle. In many cases jurisdictions will decide it is simply more practicable to install a set of traffic signals, which might not be the optimum solution operationally (especially off-peak but can include peak periods) and which can be a compromise with regard to vehicle injury crashes at cross-intersections in particular (NZTA 2012a).

Each of the following are viable alternatives for speed control at roundabouts, and can be very economic in terms of space requirements:

1. Constrained geometry via narrow lane approaches
2. Vertical deflection devices (e.g. raised platforms)
3. Sight line constraints (note: road trials recommended to further develop)

Vulnerable road users such as cyclists and pedestrians always require special consideration at roundabouts since poor speed control can adversely affect them most of all. The aforementioned three methods can be used in conjunction with conventional facilities such as periphery paths, refuge islands, zebra crossings and signalised crossings - safety performance of which are also influenced by vehicle speeds. Zebra crossings offer special advantage since they give priority to pedestrians over drivers and avoid lengthy delays which can be the case at traffic signals. In terms of visually impaired pedestrians (and relevant to other disadvantaged pedestrian groups), recent United States research indicates raised platforms or special signalised crossings are potential satisfactory treatments for multi-lane roundabouts (TRB 2011).

Constrained Geometry via Narrow Lane Approaches

One significant outcome from research for NZTA which I was involved in between 2004-5 was a viable two-lane roundabout that would satisfactorily reduce driver speeds down to around 30 km/hr and be more amenable to on-road cyclists - the C-Roundabout, or Cyclist Roundabout (NZTA 2006). The concept is simple - narrow approach lanes of around 2.7m wide that require large vehicles to straddle both traffic lanes (refer figure 1), and this can make possible some quite compact designs where necessary (refer figure 2). On-road cyclists ‘take the lane’ and ride through as car drivers would (which is quite tenable when car speeds are in the 30 km/hr range or lower), whilst less confident novice riders or children have the option to use periphery footpaths and cross as pedestrians - lower vehicle speeds make it safer for these crossing facilities as well. Signage and road markings such as 'sharrows' can be used to emphasise that either option might be utilised by cyclists.

Four C-Roundabouts have been successfully installed in West Auckland since 2009 and one site was comprehensively reviewed in a NZTA research project that also includes a guideline for installation (NZTA 2012b). C-Roundabouts in West Auckland are at the following locations: Triangle Road / Waimumu Road; Sturges Road / Palomino Drive; Seymour Road / Parrs Cross Road; and Margan Avenue / Hutchinson Avenue (the latter two are without speed control to 30 km/hr for all approaches). Traffic volumes at each are in the order of 25,000 vehicles per day, with the exception of the Seymour Road / Parrs Cross Road intersection which is around 35,000 vpd (heavy vehicles comprise less than 10% of traffic).

It is acknowledged that minor damage sideswipe type crashes between car users are potentially more likely at a C- Roundabout due to the narrower entry road width, although this appears to be a site specific issue and in the larger context does not present a safety issue of significance. For the five year period 2010 - 2014 there were a total of 13 reported sideswipe crashes for the four C-Roundabouts, one involving minor injury. Just one involved a heavy vehicle (very soon after installation of the C-Roundabout, so was possibly an early driver misinterpretation), the remainder between car users and almost exclusively resulted in very minor paint or panel damage. Five of these 13 incidents occurred at one particular approach leg of the Seymour Road / Parrs Cross roundabout, so the kerb line layout there does justify review (notably all five occurred during off-peak periods).

In terms of vulnerable road users the C-Roundabouts appear to be operating satisfactorily, although not without incident. The Waimumu Road / Triangle Road intersection is the busiest in terms of numbers of cyclists at around 200 movements per day, and between 2010 - 14 experienced two reported minor injury cyclist crashes. The only other reported incident was a cyclist minor injury at the Margan Avenue / Hutchinson Avenue intersection. All three of these occurred during dark or very dim conditions so street lighting is a significant consideration for improvement, and an unconventional cycle lane arrangement at the Waimumu Road location justifies review.

Figure 1: Truck straddling the two narrow lanes on approach to a C-Roundabout. Although fairly intuitive to drivers, advance warning signs are considered desirable with an example used shown inset.

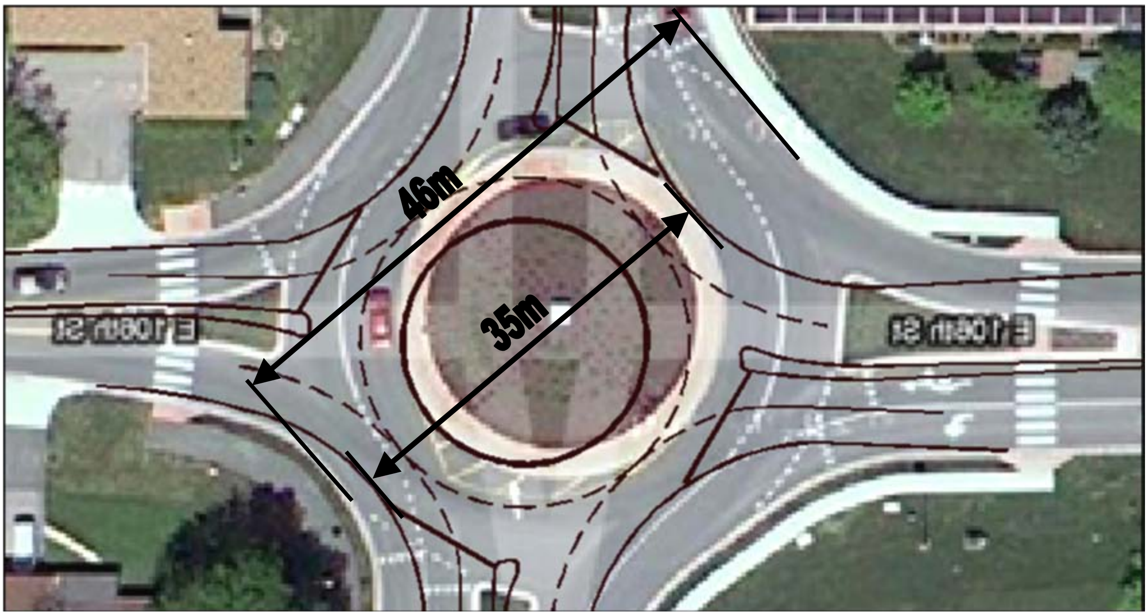

Figure 2: A C-Roundabout alignment atop a typical dual-lane layout from the United States, which is similar to Austroads in terms of space requirements.

Vertical Deflection Devices (e.g. raised platforms)

Vertical deflection devices are not a new concept for speed control, but their use on main roads is much less common outside town centres. In the context of roundabouts in urban areas (as well as other forms of intersection or mid-block applications), they could be more widely used both at pedestrian crossing facilities and/or for speed control to improve driver and cyclist safety. The significant majority of on-road cyclist crashes at roundabouts occur at vehicle entries and involve circulating cyclists being struck by entering vehicles (NZTA 2006), so platforms located where they slow these drivers can be particularly useful in that regard.

If used as a primary means of speed control for roundabout approaches, then some quite compact designs are potentially quite achievable. For example the Vitasovich Avenue / Edsel Street roundabout in West Auckland was originally scheduled for replacement with traffic signals for the purpose of improving pedestrian amenity between two large shopping centres, but a retro-fitted platform scheme was instead installed at approximately one third the estimated cost in 2010 (refer figure 3). The platforms double as both speed control and pedestrian crossing points at this busy small diameter roundabout with traffic volumes in the order of 27,000 vpd. This solution was deemed to be superior to the signal option in terms of traffic safety, capacity, and amenity for pedestrians.

In terms of potential adverse effects for vertical deflection devices, it was found that increased noise from some types of heavy vehicles is the most likely adverse effect of any consequence (NZTA 2012a). This is something to be taken into account with respect to proximity of sensitive activities - for example a location immediately adjacent to residential housing with substantial numbers of passing empty-laden trucks at night would not be an ideal candidate.

Figure 3: 'Directional' platforms were installed in 2010 at the Vitasovich Ave / Edsel St roundabout in Auckland (although not all platforms were constructed to the specified heights).

Sight line Constraints

Sight line limitations can affect driver speeds, and in the United Kingdom are sometimes used as a safety measure for higher-speed rural area roundabouts (DFT 2007). Research in Auckland confirmed that restricted sightlines can reduce driver approach speed, but also demonstrated if opposing driver speeds are too high (relative to the approaching driver) then increased collisions can occur (NZTA 2012a). Analysed in some detail was a four-way single-lane roundabout in Otahuhu, Auckland with very restricted sight lines for three approaches and virtually unimpeded on the fourth (there is a field on one corner). Straight-through 85% vehicle speeds for the former three approaches were measured at some 31 km/hr, with the latter observed at 37 km/hr along with a history of related crashes (these speeds bore no relationship to geometric deflection or other discernible factors). Therefore due care is certainly required if this method is to be applied in practice, and preferably would be backed up by more substantive research.

Although to date research anywhere on this topic is somewhat limited, some ideas have nevertheless been developed and it is anticipated that there is good potential for further experimentation in this area - given the possible adverse consequences this would be done quite methodically. For example figure 4 shows a small diameter roundabout that conceivably could be constructed with minimal or no raised central island - since drivers would have very restricted visibility then low vehicle speeds should be able to be maintained with little need for physical deflection. Such a layout could be useful for example, to avoid turning buses overrunning raised central islands. To this authors knowledge none have been so purpose-built with this in mind, so road trials are recommended to further develop the concept of using sight line constraints as a means of safe speed control. The findings would likely be applicable to other forms of intersection control as well.

Conclusion

Roundabouts can provide a safer and operationally superior solution for urban intersections, but adequate speed control is important to achieve for safety reasons, not least of all for pedestrians and cyclists. This paper gives a brief outline for three methods of economic speed control that can potentially be applied in urban situations, which are often constrained by various factors including available road space. NZTA research reports 476 and 510 (NZTA 2012 a & b) contain some preliminary guidelines that should assist practical application, and combinations of these methods are feasible.

In addition, road trials are recommended as a means of further developing concepts for intersections using sight line constraints as means of safe speed control. This would involve full before and after studies to determine the full impacts of the treatments undertaken.

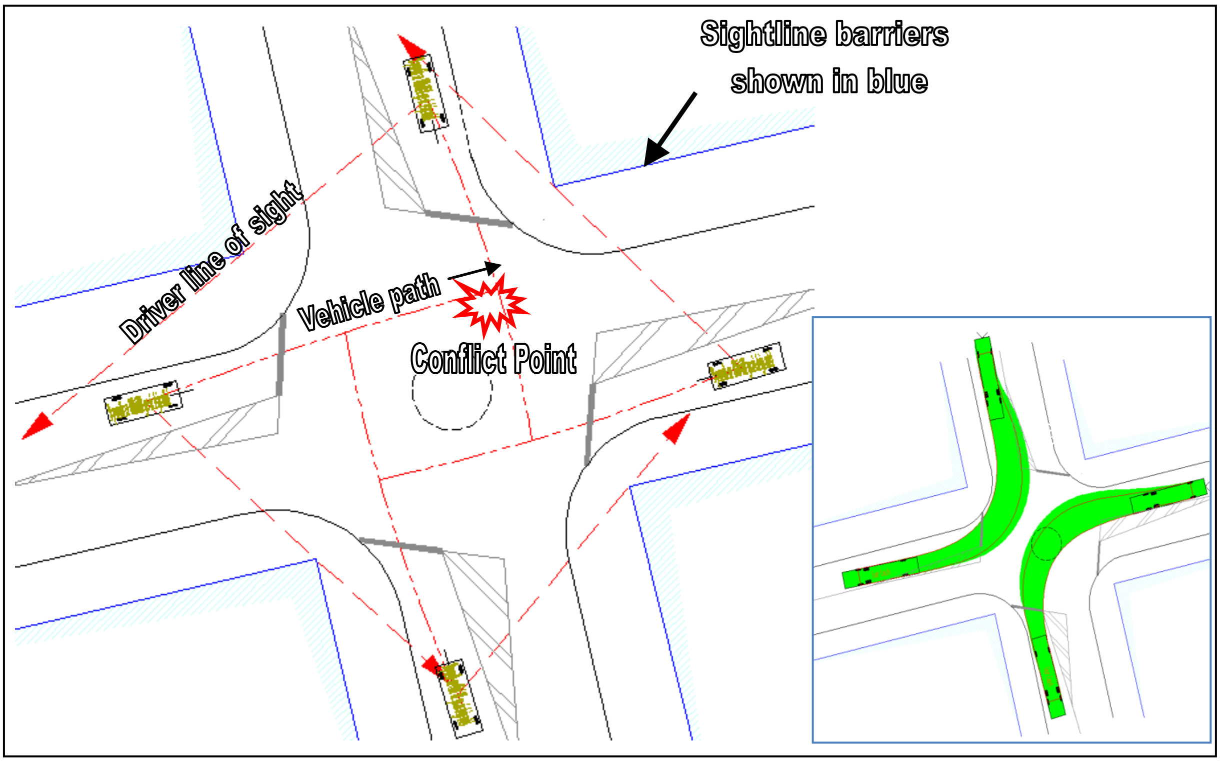

Figure 4: Concept drawing for a single-lane roundabout (outside diameter approx. 20m or smaller) using sight line restrictions with low mountable or flush central island. Inset is shown large bus tracking.

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