A bicycle friendly roundabout: Designing to direct cyclists to ride where drivers look

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Abstract

Installing a roundabout typically improves road safety by reducing speeds and by reducing the number and severity of conflict points. This paper examines why roundabout safety benefits don't extend to cyclists and how roundabouts might be changed to reduce roundabout crashes involving cyclists.

Conflict points and "conflict paths" are considered. A comparison is made between cycling in the centre of the lane (along the primary conflict path) versus cycling along the left edge of the lane. If on the edge, a second conflict path is created, which may easily be overlooked in a one-lane environment.

The literature review confirms that many researchers have concluded that the outer edge of roundabouts is a dangerous place to ride, and notes various strategies which aim to get cyclists to ride in the centre of lanes when approaching and negotiating roundabouts.

All roundabout crashes occurring at Victorian roundabouts from 2005-2009 are assessed, with DCAs recategorised into roundabout crash types. The most common crash is "entering-circulating", accounting for 48% of all crashes. For crashes involving bicycles, they account for 82%, while no other crash type accounts for more than 4%. An entering car striking a circulating cyclist accounts for nearly a quarter of all roundabout crashes in Victoria.

Austroads and VicRoads design guidelines promote use of bicycle lanes through roundabouts. They appear to overlook both the published safety research and their own conceptual advice.

Cyclists are most likely to be seen if they ride in the middle of the driving lane. This maximises visibility to cars, maintains a simple one-lane conflict point environment, and reduces the likely speed of impact if a collision does occur.

The "C1 Roundabout" is a new bicycle friendly design which provides clear cues to cyclists to move out from the kerb to the middle of the lane – to facilitate cyclist positioning along the "conflict path" where drivers are most likely to look. If cyclists are more likely to be seen, they are less likely to be crashed into.

Treatments are proposed which slow approaching, entering and circulating vehicles and align entering vehicles for improved visibility to the right. It is recommended that road authorities review the research about the dangers for bicycles in the outside edge of roundabouts and revise design guidelines, with circulating bicycle lanes prohibited rather than recommended.

Keywords: Roundabouts; cyclists; conflict points; road safety; looked but failed to see; LBFTS; roundabout crash analysis.

1.0 Introduction

Installing a roundabout typically improves road safety. By reducing speed and reducing the number and severity of conflict points, roundabouts tend to lessen the number and severity of crashes. However, if cyclists are considered separately, crash numbers and severity sometimes increase (Daniels et al 2008; FHWA 2000).

The proportion of crashes involving cyclists tends to be much higher at roundabouts than elsewhere. Inner Melbourne municipalities experience close to 50% of roundabout crashes involving cyclists, contrasting with less than 10% of all crashes involving cyclists. For all of Victoria, during the five years 2005-2009, 4% of all reported crashes involved cyclists. At roundabouts, however, 24% involved cyclists.

"Entering-circulating" is the most common crash type at roundabouts – where an entering vehicle crashes into a vehicle already circulating. This type accounts for 48% of all crashes, but 81% of crashes involving bicycles, typically with an entering car striking a circulating cyclist.

Reflecting after a crash, it is not uncommon for the cyclist to report that they saw the driver look, and for the driver to state that they looked, but that "the cyclist came from nowhere" (Herslund & Jorgensen 2003). Such a scenario is described in the literature as a "looked but failed to see" crash. Such reporting suggests that there may be value in a study of the precise location where drivers look. Conflict point theory, which considers precise locations of vehicles as they move through intersections, is used as a tool to examine bicycle-car interactions at roundabouts.

This paper examine the question of "what causes entering drivers to drive into circulating cyclists?" through (1) logical thinking about conflict points and "conflict paths", (2) a literature review and (3) a case study of all reported Victorian roundabout crashes (2005-2009) – the source of the figures quoted above.

2.0 Conflict point theory, roundabouts and bicycles

Traffic conflicts occur when paths of two vehicles coincide. Conflict points are danger points - the physical locations where vehicles might collide. A conventional cross-road has 32 conflict points (figure 1a), whereas a 1-lane roundabout has only 4 (figure 1b). Roundabouts

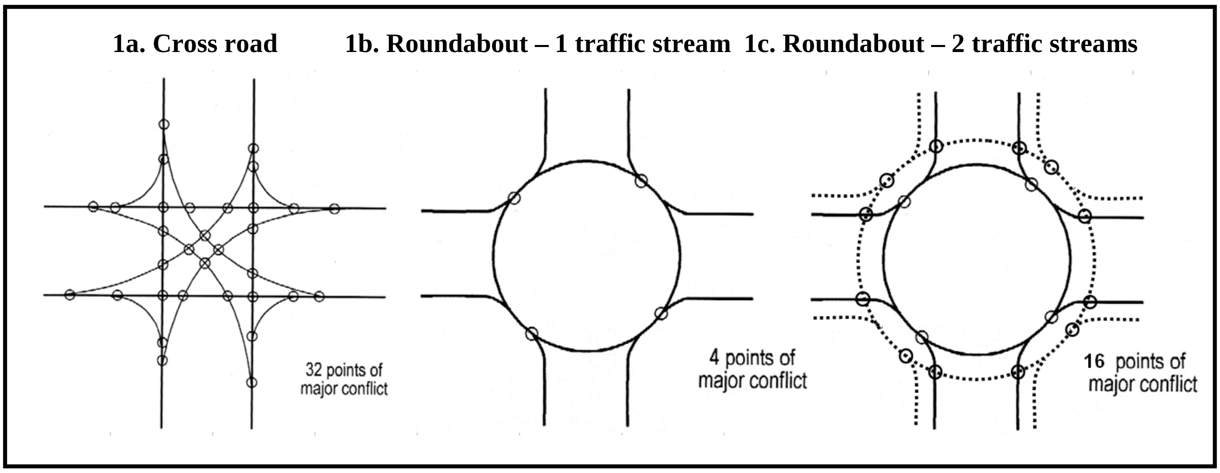


Figure 1: Conflict points at intersections (adapted from Austroads 2007 p.157).

experience fewer crashes than cross-roads because (1) there are fewer conflict points and (2) physical deflection forces drivers to travel slowly. With fewer conflict points to attend to, less effort is required to negotiate a roundabout than a cross road. Figures 1a & 1b from Austroads (2007) are conflict point maps which illustrate why roundabouts are simpler to negotiate than cross roads.

Figure 1c, by the author, shows what happens when a second traffic stream is added to a roundabout, such as at a roundabout with two lanes. Instead of 4 conflict points, now there are 16, a major step backwards in terms of simplicity. 2-lane roundabouts have many more conflict points for drivers to attend to, so require more attentive driving than 1-lane roundabouts. The author believes that drivers know that 2-lane roundabouts are more complex, so tend to approach them with extra caution.

If a cyclist enters a 1-lane roundabout from the middle of the lane and follows the same path as a car, the situation is illustrated by figure 1(b). If they enter from adjacent to the kerb, their path through the intersection no longer coincides with a car's path, leading to a more complex conflict point map. If they stick to the left edge of the lane, the situation is illustrated by figure 1(c) (with the dashed line representing the cyclist path and the solid line for the car path) – very similar complexity to a 2-lane roundabout.

Thus, cyclist choice of lateral positioning on the road when approaching a roundabout influences the complexity of the conflict point environment they enter. *Riding bicycles on the outside edge creates a 2-lane conflict environment within a 1-lane roundabout.*

Most drivers probably approach 1-lane roundabouts assuming that there is just one conflict path to attend to, as in figure 1(b).

Figure 2 illustrates a typical roundabout scenario. If a driver approaches the roundabout from (A) assuming just one conflict path, they will look to the right towards (I) hoping for a gap (no primary path conflicts), but prepared to slow to avoid a conflict at (C) if required. If they see an empty space to the right along the primary path they enter the roundabout - with complete ignorance of the possibility of secondary path conflict points.

If a kerbside cyclist approaches from (O), they may remain unseen because the driver looked along the primary path towards (I) and not along the secondary path towards (O). If the timing of the cyclist leads to a conflict, the crash occurs at (B) – potentially several metres before the expected driver's conflict point at (C).

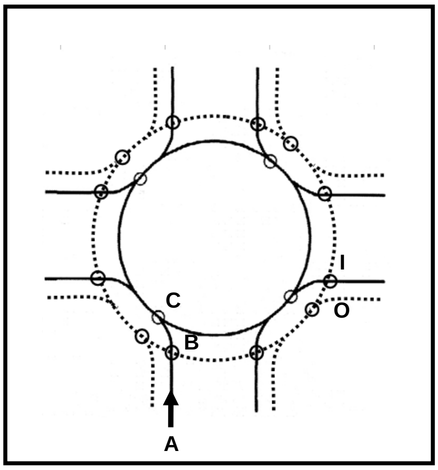


Figure 2: Traffic flows leading to a common roundabout crash.

If the driver is decelerating, they will be moving faster at the point of impact (B) than their planned speed at the anticipated conflict point (C) possibly resulting in more sever injuries.

If this scenario correctly describes (a significant proportion of) crashes at roundabouts, it follows that: (1) cyclists maximise their chances of being seen if they follow the path most likely to be scanned by drivers (i.e. the path that cars would follow); and, (2) cyclist entering-circulating crashes could be reduced by ensuring that cyclists approach and enter roundabouts from the middle of the lane, following the path expected by drivers.

2.1 Primary and non-primary conflict paths

The number of conflict points is not the only factor needing consideration. Drivers learn where hazards are likely to be and selectively consider just those locations in order to keep attention for other aspects of the driving process and for other non-driving tasks.

Consider a common car-bicycle crash - a left turning car "cuts off" the path of a through cyclist, or a left turn side-swipe. A driver wishing to turn left must wait for a gap in the traffic stream to their right on the road they are turning into. Conflicts with this traffic stream are obvious, so drivers typically pay attention to this flow of cars, waiting for a gap so they can turn. They may give occasional attention to whether pedestrians wish to cross their left-turning path. While they are busy trying to judge a gap in traffic coming on their right, many drivers may give little or no attention to the possibility of a cyclist on their left, either stationary or approaching. If they judge a gap on their right, then proceed to turn without checking for cyclists, most often no cyclist is there so there is no problem. Occasionally a cyclist is there, and the car strikes the cyclist.

The above description is very similar whether a driver is turning left at an unsignalised cross-road or at a roundabout, or if they are going straight at a roundabout. In all three cases, traffic from the right can be thought of as the primary conflict path; primary because it obviously must be attended to for the driver to proceed without a crash. The crossing pedestrians and kerbside cyclists can be thought of as secondary or tertiary conflict paths because conflicting pedestrians and kerbside cyclists are usually not present.

If the primary conflict path is the only conflict path considered, then crashes with road users not on the primary conflict path become a matter of chance, with their probability varying with the degree of usage of secondary and tertiary conflict paths. For any given area, left-turn crashes with pedestrians or (parallel) cyclists would thus be proportional to the quantity of pedestrians or cyclists present in that area.

Bicycle lanes provide lateral separation from cars, which "feels safe" to cyclists. However, if bicycle lanes separate cyclists from the path that drivers check before entering roundabouts, "feeling safe" may be at the cost of real safety. Bicycle lanes ensure that roundabouts are complex multi-traffic stream environments (like in fig. 1c) rather than simple single-traffic stream environments (like in fig. 1b).

Cyclist choice of lateral positioning for entry has a strong affect on the complexity of the roundabout conflict point environment. *Bicycle circulating lanes and/or bicycle lanes on approaches remove that choice and ensure a complex, dangerous conflict point environment.*

3.0 Literature review

3.1 Roundabout Designs

"Roundabouts operate as a series of separate T-intersections (Austroads 2009 p.90)," with the top of the T having just one-way flows. Two common categories of roundabouts are illustrated in figure 3. Radial designs with their right angle entries and exits are like a series of T-junctions whereas tangential designs are more like a series of Y-junctions.

Fay Patterson (2010) presents a review of roundabout design practice from an Australian perspective. A major point of difference is that UK, Sweden, New Zealand and Australia favour tangential (flared) entries which keep speeds high to increase capacity, while Germany, France, Denmark and Netherlands favour radial entries which slow vehicles and improve visibility for greater safety.

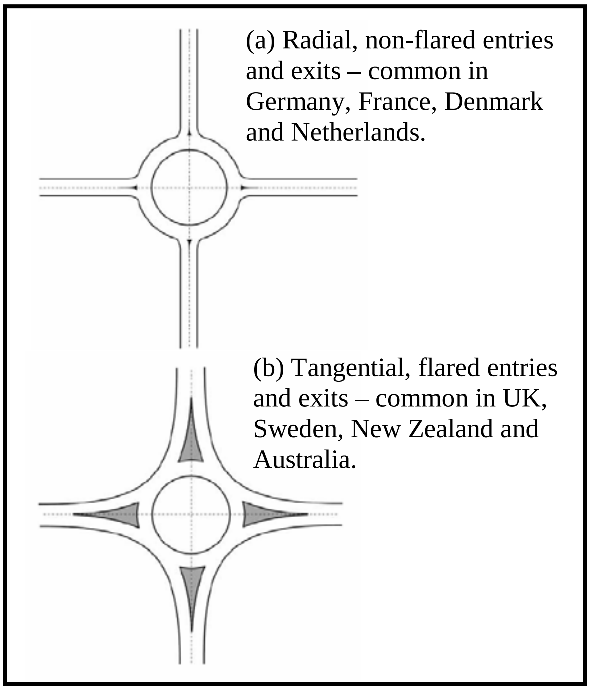


Figure 3: Roundabouts designs. (Patterson 2010)

German roundabout design rules prohibit cyclists on the dangerous outside edge of circulating areas. Schnull et al (1993) found that bicycle lanes and tracks increase risk over no treatment. Similarly, a UK study by Allott and Lomax Ltd. (1991) showed that the outer 1.5m of a roundabout is dangerous for cyclists. Flared entries and wide circulating lanes are also identified as hazards for cyclists. Hyden & Varhelyi (Sweden, 2000) encourage small single-lane roundabouts, with cyclists merging with cars into a single traffic stream well before roundabout entries.

Patterson (2010) concludes that Austroads and VicRoads recommendations for adding bicycle lanes to roundabouts appear to conflict with published safety research.

3.2 Cyclist Behaviour

Video research conducted at roundabouts has shown that a large proportion of cyclists ride on the dangerous outside edge of the circulating lane (Arnold et al 2010 (California); Hyden & Varhelyi 2000 (Sweden); Sakshaug et al 2010 (Sweden)). In order to encourage cyclists to control the lane, all three articles suggest terminating bicycle lanes well before roundabouts. Arnold et al (2010) suggest installing "Cyclists Allowed Full Use of Lane" signs on roundabout approaches.

The New Zealand 2-lane C-roundabout, developed by Campbell et al (2006) uses tight geometry to slow all vehicles to 30 km/h, and encourages central positioning of bicycles with centrally positioned bicycle logos.

3.3 Crash Analyses and Crash Types

Elvik and Vaa (2004) reviewed 34 studies from Northern Europe, Australia and the US about the effect on crashes of converting an intersection into a roundabout. Roundabouts reduced injury crashes by 10 to 40%. The reduction in serious injury crashes was generally larger than for less serious injury crashes. For cyclists, however, roundabouts did not have the same crash reduction effect. (Campbell et al 2006; Herslund & Jørgensen 2003; Jørgensen & Jørgensen 1994, Schoon & van Minnen 1994). After researching 91 Belgium roundabouts, Daniels et al (2008) concluded that installation of a roundabout increased cyclist injuries by 27% and serious or fatal bicycle crashes by 41%.

Most researchers agree that: (1) official statistics under-represent actual cyclist crash numbers; (2) crashes involving cyclists are higher at roundabouts than elsewhere; and (3) entering drivers failing to give way to circulating cyclists is the most common crash type involving cyclists.

Swedish researchers (SNRTRI, 2000) report that changing roundabout geometry to reduce speeds can reduce cyclist crash numbers and severity.

3.4 Applying Conflict Point Theory to Roundabouts with Circulating Bicycles

While many researchers identify the outside edge of roundabouts as hazardous, the author was unable to find anything written specifically about conflict point theory as applied to the two traffic streams created by bicycles riding on the outer edge of circulating lanes.

3.5 "Looked But Failed to See" Phenomenon

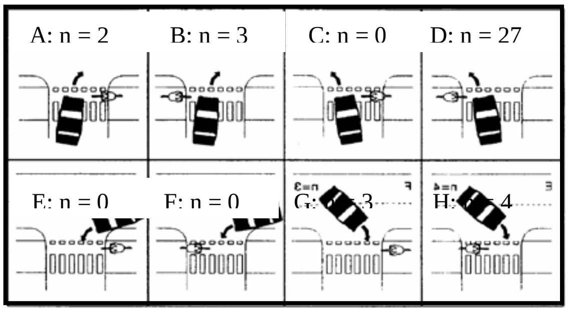


Figure 4: Bicycle-car collisions, by type. (Reversed for clarity to left-side drivers) (Summala et al 1996)

Looked-but-failed-to-see (LBFTS) crashes occur when a driver looks in the general direction of an oncoming hazard but does not notice it or give way. These commonly occur when pulling out into a priority roadway, before switching lanes, or overtaking another vehicle (White & Caird 2010), and commonly involve two-wheeled vehicles (Koustanaïa et al 2007). Figure 4 illustrates long-term European video research examining turning drivers crossing a two-way cycle path prior to an intersection. The highest count is (D), with 27 collisions between left-turning drivers and cyclists from the left. This compares to a count of zero for collisions with cyclists from the right. Hidden cameras observed how left turning drivers scanned to the left much less frequently and later than those turning right. (Summala et al 1996). While this is not identical to roundabouts, it supports the hypothesis that drivers are looking for a gap to fill rather than scanning for hazards.

After conducting in-depth interviews with cyclist and driver survivors of LBFTS crashes Herslund & Jørgensen (2003) confirmed that car drivers look in the direction of cyclists without perceiving them. Herslund & Jørgensen videoed cars and cyclists at roundabouts and noted that bicycles are often located in drivers' peripheral vision. They suggest that experienced drivers use fast search strategies such as concentrating on where cars usually are, so may be more prone to LBFTS collisions than less experienced drivers. They conclude that cyclists are less likely to be overlooked if they merge with cars and enter roundabouts from where car drivers search for cars.

The conclusion that, prior to entering roundabouts, drivers tend to look mainly for cars and thus miss circulating cyclists is shared by many researchers. (Jørgensen and Jørgensen 1994; Herslund & Jørgensen 2003; Hyden & Valhelyi 2000; Räsänen and Summala 1998, 2000; Summala et al 1996).

LBFTS explanations are consistent with the conflict point scenario described above. Drivers focus on the primary conflict path (maybe waiting for an appropriate gap) and fail to scan other possible conflict paths. Two-wheeled vehicles are smaller than cars, so less visible.

Also, they are often located away from the primary conflict path.

4.0 Case Study

4.1 Crash History Victoria 2005-2009

Victoria's official crash data was analysed for the 5 year period 2005-2009. Bicycle casualty crashes accounted for 4% of all crashes in Victoria, but were higher for inner-urban Melbourne[1] with 18%. Crashes at roundabouts accounted for 8% of all crashes (6% inner urban), but disproportionately involved bicycles. The proportion of roundabout crashes involving cyclists is 24% (48% inner urban).

4.2 Crash Types

Australian Definitions for Classifying Accidents (DCAs) do not include roundabout-specific categories. For this analysis, each DCA was assessed and reclassified into roundabout crash-types as described in Appendix A. All crashes at roundabouts were similarly reclassified. Figure 5 shows roundabout crashes by crash-type for all vehicles, then split into car-car crashes and car-bicycle crashes. The distribution of crash types is similar to statistics reported by other research (Turner et al 2006 & Jurisich et al 2010). The distribution for crashes involving cyclists is quite different to that for non-cyclist crashes - "entering-circulating" accounts for the vast majority (81%), with no other crash type accounting for more than 4%. "Entering car strikes circulating cyclist" describes 20% of all roundabout crashes during the 5-year period, or a total of 408 crashes.

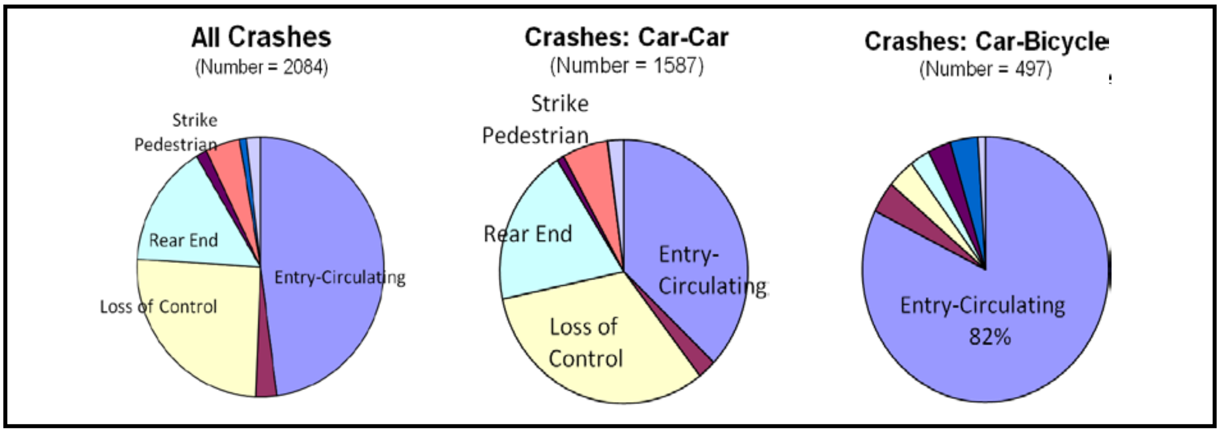


Figure 5: Roundabout Crashes, Victoria 2005-2009 (VicRoads CrashStats, DCAs adapted by Bob Cumming)

4.3 Regional Comparison

The statistics were compared between four areas: Melbourne city, inner suburbs, outer suburbs and non-metropolitan. The major differences in crash-type distributions were: (i) Melbourne city experienced more exit-circulating conflicts than the other areas (all-13%, cyclists-16%), possibly because a large proportion of the roundabouts are multi-lane roundabouts; (ii) 8% of outer suburbs bicycle crashes involved cyclists from the driveway or footpath; and (iii) outer suburbs and non-metro experienced more loss of control car crashes.

[1] Melbourne, Darebin, Maribyrnong, Moonee Valley, Moreland, Port Phillip, Stonnington & Yarra local government areas.

A summary of the data, by region is included in Appendix B.

The biggest difference between the areas was the proportion of roundabout crashes involving cyclists, shown in figure 6. It is possible that this correlates with the amount of cyclists on the roads – the author believes that bicycles account for a much larger proportion of vehicles on inner suburban roads than on outer suburban roads. If correct, this would provide support for the hypothesis that drivers looking only at the primary conflict path strike cyclists at roundabouts largely due to chance, and that the chances of collisions are greater where cyclist numbers are greater. The prevalence of bicycles has not been properly assessed, but would be a good subject for future research.

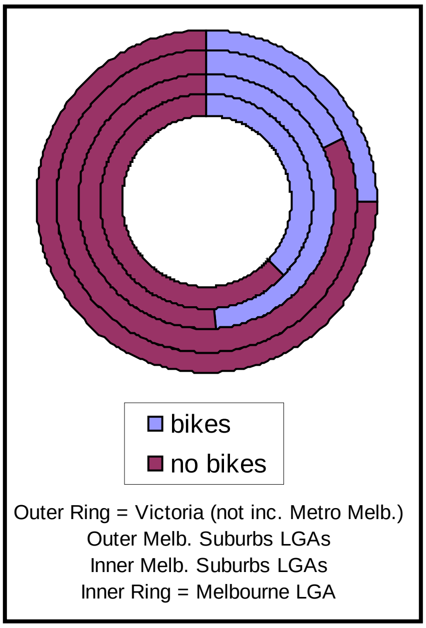


Figure 6: Proportion of roundabout crashes involving cyclists, by area. Victoria 2005-2009 (VicRoads CrashStats)

4.4 Cyclist Behaviour

The author informally interviewed 25 cyclists about how they negotiate roundabouts. Responses included: ride straight ahead; keep to the left; start on the left, allow arriving cars to proceed first, then go through like a car; and, unsure what to do, so avoid roundabouts. None of the cyclists surveyed mentioned central lane positioning.

4.5 Driver Behaviour

In January 2010, the author observed motorists at two 1-lane roundabouts in Melbourne inner suburbs, one with bicycle lanes to the hold lines. It was observed that: (1) most drivers diverted their eyes from the road ahead to the right and not to the left; (2) most looked to the right only very briefly; and (3) most drove across bike lanes to reduce their deviation and maintain speed, on entry or exit or both.

What is in motorists' minds as they approach roundabouts? It is theorised that motorists approach roundabouts with the goal of slowing as little as possible and with assumptions that: (1) they probably won't stop, (2) only conflicts from the right need be considered, and (3) potential conflicts can be assessed with a brief glance to the right.

5.0 Australian Roundabout Design Guidelines

VicRoads (2005) states that crashes involving bicycles at roundabouts are a problem in Victoria, citing various Australian and European research. They note that radial entries result in lower speeds and roundabouts that are safer for cyclists and pedestrians. However, *their typical layout illustrations all have tangential rather than radial entries*. It is unclear why their design guidelines do not incorporate this safer geometry.

To reduce cyclist entering-circulating roundabout crashes, one of Austroads suggestions is to "use the minimum number of circulating lanes (2009 p.92). This advice is not followed when they recommend adding bicycles circulating lanes.

Austroads (2007, 2009) and VicRoads (2005) encourage adding circulating green-painted bicycle lanes to roundabouts, especially in locations believed to be a hazard for cyclists. Austroads (2009 p.50) qualifies that "the benefit of the treatments suggested to improve the situation for cyclists has not necessarily been confirmed through appropriate studies".

European research (Allott and Lomax Ltd. 1991; Hyden & Varhelyi 2000; Schnull et al 1993; Schoon & van Minnen 1993) suggests that circulating bicycle lanes reduce rather than improve cyclist safety.

6.0 Proposed Single-lane Roundabout Design

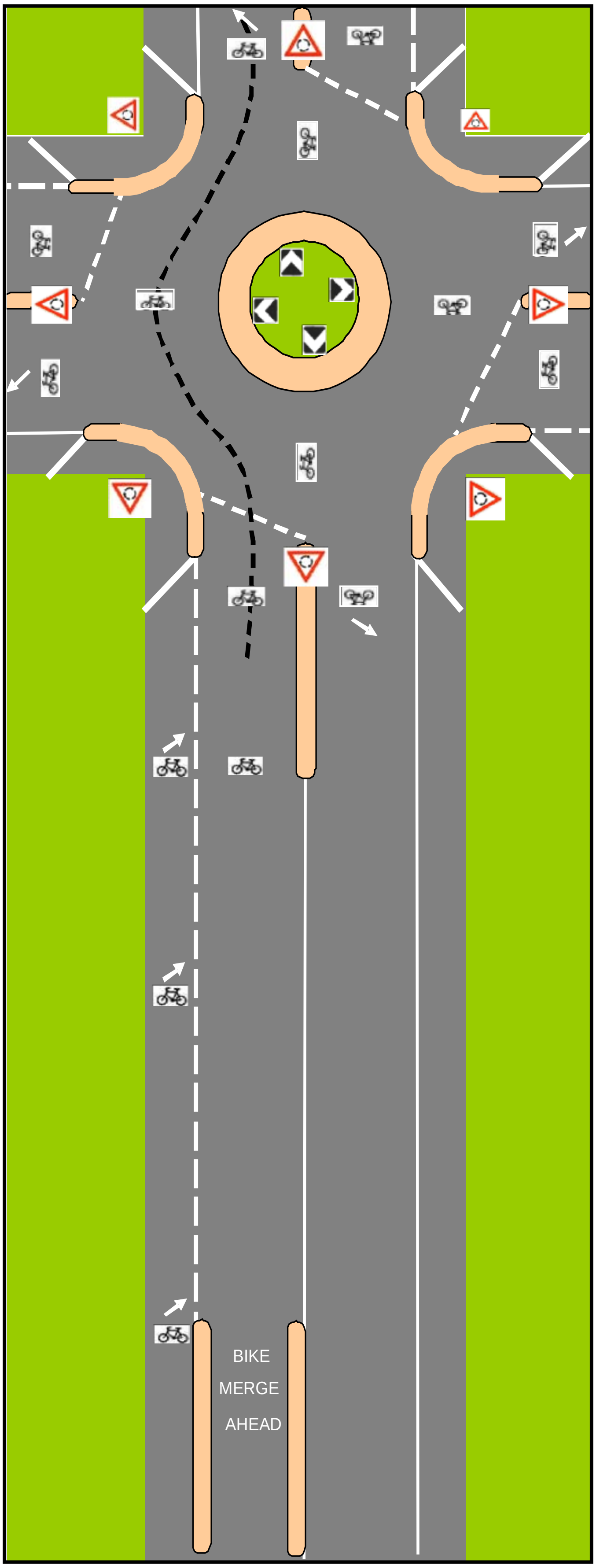
Cyclist safety will improve if we ensure that cyclists follow the primary conflict path– i.e. the middle of car lanes. Roundabout designs should: (1) make it clear to cyclists that the centre of the lanes is the place to be; (2) make it obvious to drivers to expect cyclists in the centre of lanes; and (3) make it safe for cyclists to merge to the middle.

These are similar to the goals adopted by designers of the New Zealand 2-lane C-roundabout.

In the proposed design, illustrated in figure 8, bicycle logos positioned centrally on approaches and circulating lanes show cyclists where to ride and show drivers where to expect cyclists.

Radial entries maximise driver visibility to the right (like T-junctions rather than Y-junctions) and ensure greater slowing – necessary for safe bicycle merges.

Narrow radial entries with minimal entry flaring are created with parallel splitter islands and raised mountable kerb extensions.



Approaching vehicles are slowed with "BIKE MERGE AHEAD" pavement signs and, on higher speed roads, upstream lane narrowing for the car lane. Through the bicycle merge zone, bicycle lane lines are dashed and bicycle symbols with diagonal arrows direct cyclists to merge.

On low volume, low speed, local roads without bicycle lanes, the treatment could be simplified by omitting "BIKE MERGE AHEAD" and reducing the number of bicycle logos on approaches, but keeping at least one kerbside logo with arrow on each approach and one mid-lane logo at each entry to provide th

Figure 7: Proposed treatment for bicycle safety at single lane roundabouts.

move to the centre of the traffic lane.

Many existing roundabouts could be inexpensively improved by installing raised kerb extensions, together with the suggested pavement marking changes. In some cases, rebuilding splitter islands parallel rather than triangular may also be necessary to improve visibility of circulating flows and to reduce speeds.

Multi-lane roundabouts have different issues which are beyond the scope of this report. However, the author is impressed by the New Zealand C-roundabout described in Campbell et al (2006) and Jurisich et al (2010).

Detailed consideration of capacities is beyond the scope of this report. However, intuitive concerns about reduced capacities of "slow speed" roundabouts may be somewhat allayed by knowing that with lower speeds, vehicles can safety travel closer together. In addition, bicycles take up less road space than cars. Increasing the attractiveness of cycling encourages a mode-shift to cycling, which frees up road capacity.

7.0 Conclusions

Cyclists are involved in a high proportion of crashes at roundabouts – mostly where an entering car strikes a circulating cyclist. The proportion of roundabouts crashes involving cyclists appears to correlate with the amount of cycling in the area. This correlation lends support to the idea that chance plays a significant role in roundabout crashes with bicycles – more bicycles in an area leads to more chance of bicycles being struck.

Many researchers have found that the outside edge of circulating carriageways is a dangerous place for bicycles. If cyclists ride near the kerb, they create a second potential traffic stream in a 1-lane environment. To the extent that drivers are primarily looking for a gap where cars might be (in the middle of the lane), they overlook cyclists riding near the edge of the lane. Cyclists can increase their chances of being seen by riding where drivers look for a gap – in the middle of the lane on approach and while circulating. Because outer edges are dangerous, circulating bicycle lanes are rejected, as is continuing bicycle lanes to hold lines.

Efforts to improve safety for bicycles at roundabouts should focus on getting cyclists to ride in the centre of approach and circulating lanes. Suggested strategies to achieve this include the use of bicycle pictograms in the middle of lanes; approach and entry lane narrowing to slow drivers to assist merging with bicycles (and to physically eliminate the space for two traffic streams in one lane); and the use of radial designs which position drivers for better visibility to the right.

An innovative engineering treatment is proposed for single-lane roundabouts which improves cyclist visibility, slows cars and facilitates cyclist merging and central lane positioning using pavement marking, raised mountable kerb extensions and geometry adjustments.

It is recommended that authorities responsible for design guidelines review the literature in relation to the hazards of the outer edges of roundabouts, and revise design guidelines accordingly, removing treatments which direct cyclists to this dangerous location.

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Appendix A: Roundabout crash-types. (VicRoads CrashStats, 2010)

Roundabout Crash-Type	Corresponding DCAs
Entry-circulating	110,111,113,114,116,117,119,121,123,124
Exit-circulating	134-139,153
Loss of control	120,150,170-179,180-189
Rear end	130-132

Lane side swipe	133
Pedestrian	100-109
Bike from driveway or footpath	147-148
Others	All other DCAs

Appendix B: Crash data – Victoria 2005-2009

All Reported Crashes - All Vehicles

Crash Type		CrashStats, 2005-2009 Victoria - non-Melb LGAs	Outer Metro LGAs	Inner Metro LGAs*	Melbourne LGA
% which occcur at roundabouts		3	3	4	3
% with bicycle casualties		6	3	17	21

Crashes at Roundabouts - All Vehicles

Crash Type	Ardnt 1998 (Queensland)	Campbell 2003 (New Zealand)	(injury crashes) Turner et al 2006b (New Zealand 1999-2003)	CrashStats, 2005-2009 Victoria - non-Melb LGAs	Outer Metro LGAs	Inner Metro LGAs*	Melbourne LGA
Entering-circulating	51	68	51	55	42	62	39
Exiting-circulating	6		4	1	3	2	13
Loss of control	18		19	21	29	18	18
Rear end at entry	17		11	14	17	11	15
Lane side swipe	3		2	1	2	2	3
Pedestrian			8	6	4	3	6
Vehicle from Driveway/Footpath				0	1	0	1
Others	5		5	2	2	1	4
Number of Crashes	492			536	1199	282	67
% with bicycle casualties			25	25	18	49	37

All Crashes Involving Cyclists

Crash Type		(injury crashes) Turner et al 2006b (New Zealand 1999-2003)	CrashStats, 2005-2009 Victoria - non-Melb LGAs	Outer Metro LGAs	Inner Metro LGAs*	Melbourne LGA
% which occur at Roundabouts		9%	12%	8%	7%	3%

Roundabout Crashes Involving Cyclists

Crash Type		(injury crashes) Turner et al 2006b (New Zealand 1999-2003)	CrashStats, 2005-2009 Victoria - non-Melb LGAs	Outer Metro LGAs	Inner Metro LGAs*	Melbourne LGA
Entering-circulating		79	88	77	85	68
Exiting-Circulating		6	2	4	5	16
Loss of Control			3	4	4	4
Rear end at entry			3	3	2	0
Lane side swipe			2	4	2	8
Pedestrian			0	0	0	0
			2	8	0	4
Others		15	0	1	1	0
Number of Crashes			132	203	137	25

*Darebin, Maribyrnong, Moonee Valley, Moreland, Port Phillip, Stonnington & Yarra local government areas.