Evaluation of Roundabout Improvements at Mountain Hwy / Liverpool Road, The Basin

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Contents

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Executive Summary

This report describes an evaluation of improvements to the roundabout controlled intersection at the Mountain Highway, Liverpool Road and Miller Road in The Basin. The improvements consisted of:

- shared lane markings ("sharrows") on the approach and departure arms to encourage bicycle riders to adopt a central lane position,
- kerbside bicycle lane extending from around 90 m to 40 m behind the hold line on both Mountain Highway approach arms,
- painted kerbside blisters on the approach and departure arms of Mountain Highway to encourage lower motorist speeds, and
- enlargement of the splitter islands on the Liverpool and Miller Road approaches to encourage more tangential approaches and create a greater sense of narrowing than the smaller islands and line marking that previously existed.

The evaluation consisted of before- and after- video observations of bicycle riders on Mountain Highway to measure where they positioned themselves laterally while approaching the intersection and speed measurements of motorists approaching the roundabout from the conflicting directions (Liverpool Road to the northeast and Miller Road to the southwest).

The results of the evaluation were as follows:

- the median cyclist lateral tracking position moved *closer* to the kerb after treatment in the eastbound direction and did not appear to change in the westbound direction,
- the majority of bicycle riders – between 53% at the westbound hold line and 76% at the eastbound hold line – chose to ride within the painted blister after treatment,
- very few riders were observed to take a central lane position approaching the roundabout before and after treatment, and
- speed measurements on the Miller Road and Liverpool Road approaches suggested at most a minor reduction in approach speeds in the order of 1 – 2 km/h.

Our interpretation of these results are as follows:

- motorist speeds, and to a lesser extent volume, are too high for riders to equitably share the general purpose travel lane,
- the geometric changes to the roundabout are insufficient to significantly alter motorist approach speeds from the Liverpool Road and Miller Road approaches, and
- internal inconsistencies in the design – such as the introduction of a short bicycle lane upstream of the intersection – create a confused and counterproductive situation for road users.

Given these results, and our interpretation of these results, our recommendations are as follows:

1. Consider full redesign of the roundabout using a radial design approach that encourages design speeds of around 25 km/h at the roundabout and speeds no higher than 40 km/h around 40 – 50 m behind the hold line. In this option the sharrows on the approach arm would be retained and those on the departure removed.
2. If option 1 is not deemed viable, then consider:
    - removing the sharrows (as they are ineffective at this site as long as motorist speeds remain high and risk reducing their impact elsewhere),
    - further minor geometric modifications on the Miller Road and Liverpool Road approaches to encourage lower motorist approach speeds (namely, straighten the splitter island and install kerbside blisters), and
    - removing the chevron markings within the blisters on the Mountain Highway approaches and formalise these areas as bicycle lanes.

Our overall view is that the design as constructed is inappropriate for this speed environment, at best offers neutral safety outcomes and has possibly created a less safe environment than previously existed. Mechanisms by which this latter outcome could be possible are the additional merging introduced by the bicycle lane and the possibility motorists will not expect to see riders emerge from the painted blisters. Further, we note that the design appears to be contrary to Safe System principles; the roundabout as it currently exists is intolerant of faults that will invariably be made by motorists and bicycle riders and the likelihood of serious or fatal injury is high in such situations.

1 Introduction

1.1 Background

This report describes an evaluation of alterations of an existing roundabout at the intersection of Mountain Highway with Liverpool Road and Miller Road at The Basin. The alterations consisted of the following main treatments:

- the installation of shared lane markings ("sharrows") to encourage sharing of the approach lane on all four intersection approaches (Figure 1.1a); there are three sharrows on each approach at distances approximately 8, 15 and 35 m behind the hold line,
- an angled sharrow marking on the departure to encourage riders to drift back towards the left of the general purpose travel lane (Figure 1.1b),
- marked kerbside bicycle lanes extending from around 90 m behind the hold line to 40 m behind the hold line (Figure 1.2),
- kerbside painted chevron marking and edgeline ("blisters") on the Mountain Highway approaches to encourage riders to share the general purpose traffic lane, and for motorists to take a more radial approach to the intersection (Figure 1.1a), and
- enlargement of the splitter islands on the Liverpool and Miller Road approaches to encourage more tangential approaches and create a greater sense of narrowing than the smaller islands and line marking that previously existed.

The speed limit on all approaches remained at 60 km/h after the alterations.

We understand the motivation for the treatment was, in part, a fatality to a bicycle rider travelling west along Mountain Hwy in June 2013 who collided with a motor vehicle travelling north along Miller Road. The motorist failed to give way to the bicycle rider and the rider subsequently collided with the driver-side doors of the vehicle, incurring fatal injuries as a result. A minor injury crash involving the same combination of rider and motorist movements was also recorded in February 2013.

In response to these crashes, and recent research on providing for bicycle riders at roundabouts (Austroads 2014), VicRoads developed these alterations with the objectives of:

a) encouraging bicycle riders to take a central lane position approaching the roundabout (thereby increasing their likelihood of being seen by motorists on their left),

b) reduce motorist speeds at the roundabout (to provide more time for motorists to look *and* see conflicting traffic[1], as well as reducing the severity of any collision that may occur), and

[1] There is a fairly extensive literature on the "looked-but-did-not-see" phenomena. This literature finds that the issue tends to be that road users look in the general direction of conflicting traffic but fail to *see* the traffic (or, at least, fail to correctly identify and process the risk posed by the conflicting traffic).

c) reduce the casualty risk at the intersection through the above two behavioural modifications.

1.2 Study objectives

The present study had three objectives:

1. determine what, if any, change in motorist approach speeds have occurred on the conflicting streets (i.e. Liverpool Road and Miller Road),
2. assess any changes in cyclist lateral tracking approaching the intersection along Mountain Hwy, and
3. draw conclusions as to the likely safety implications of these behavioural changes.

It is noted that the main rider movement is along Mountain Highway and the main conflict interaction is with a straight-ahead bicycle rider and a motorist emerging from the side street to their left. This crash mode composes around three quarters of all cyclist injury crashes at roundabouts, and as noted above, was responsible for the two casualty crashes which occurred in 2013. For this reason the focus of this study was on rider behaviour on Mountain Highway and motorist behaviour on Liverpool and Miller Roads.

(a) Sharrows and chevron linemarking on approach leg

(b) Angled sharrow on departure leg

- Figure 1.1: Sharrows

(a) Transition from bicycle lane to shared general purpose lane

(b) Start of bicycle lane

- **Figure 1.2: Approach bicycle lane**

1.3 Methodology

The study methodology consisted of:

a) video-based observations of bicycle riders and motorists *before* and *after* the installation of the treatments, and

b) speed measurements of motorists approaching the intersection from the side streets (Liverpool Road and Miller Road).

1.3.1 Video-based observations

Video cameras obtained footage of road users during daylight hours over a period of eight or more sequential days *before* and *after* the treatment was installed. The before-treatment period was from Saturday 8 August to Tuesday 18 August 2015 and the after-treatment period was from Thursday 29 October to Friday 6 November 2015. Both periods were during normal school term periods. The treatment was installed in the first week of October such that around one month had elapsed between installation and the after-treatment observations.

Three locations were selected for observation:

- eastbound approach of Mountain Highway at the hold line (Figure 1.3),
- eastbound approach of Mountain Highway approximately 20 m upstream of the hold line Figure 1.4), and
- the westbound approach of Mountain Highway at the hold line (Figure 1.5).

Screenshots from the video were obtained wherever a bicycle rider passed the observation location. These screenshots were then analysed using a script written in the R statistical programming language and the EBImage image processing library. The script displayed each screenshot in sequence and required a human operator to select each of three reference points with a mouse, the pixel coordinates of which were then saved and transformed to real distances. The reference points were the shoulder edgeline, the location where the back wheel of the bicycle touched the pavement and the edgeline around the splitter island. This method required a degree of judgement by the operator to identify the ground plane and the lateral reference line in a consistent and accurate way so as to minimise measurement errors. While this method is invariably imprecise we do not expect these errors to be biased, and in any case are consistent across the before- and after-treatment cases.

The video record contained several thousand observations at each site; for practical reasons only a subset of around 300 screenshots were selected for analysis. This subset was selected randomly from the video record to ensure no time of day or day of week bias.

- **Figure 1.3: Eastbound approach at hold line ("Eastbound (At)")**

- **Figure 1.4: Eastbound approach upstream of intersection ("Eastbound (Upstream)")**

- **Figure 1.5: Westbound approach at hold line ("Westbound (At)")**

1.3.2 Speed measurements

Motorist speed measurements were obtained on the Miller Road and Liverpool Road approaches, as it is motorists emerging from these approaches which appear to represent the greatest risk to bicycle riders. Motorist (and bicycle rider) speeds will vary dynamically as they approach, transition through and depart the roundabout. Clearly, instantaneous speeds at a specific location behind the intersection will only partially capture the true speed behaviour. As such, two approaches were taken to measure motorist speeds:

1. Instantaneous speed:
    a. Sierzega SR4 radar speed measuring device with a manufacturer stated speed accuracy of +/-3%
    b. The device was installed within a cabinet on existing street furniture and would be expected to be inconspicuous to motorists
    c. The device records vehicle speeds automatically, and the battery allows for 8 – 14 days of recording depending on traffic volumes
    d. The device is incapable of measuring speeds during periods of moderate to heavy rainfall due to inherent limitations of the Ka-band radar
    e. Speeds are obtained over a distance around 25 – 30 m from the intersection along Miller Road and 55 – 60 m from the intersection along Liverpool Road

2. Speed profiles:
    a. Stalker ATS II radar speed gun with manufacturer stated accuracy of +/-1.6 km/h
    b. The device records instantaneous speeds at 42 Hz
    c. The device is handheld, requiring an operator to be present and is potentially conspicuous to road users.

In both cases the data was initially processed within the manufacturers software and then cleaned and analysed using the R statistical software package. In the case of the speed profile data LOESS regression was used to estimate the speed profiles from the speed measurements, and the speed measurements were integrated to estimate the distance behind the hold line at which the measurements were obtained.

1.4 Layout of this report

This report is structured as follows:

- Chapter 2 describes the results of the cyclist lateral tracking observations,
- Chapter 3 describes the results of the speed measurements,
- Chapter 4 discusses the findings and their possible implications for the treatment, and
- Chapter 5 offers our recommendations based on the findings of the evaluation.

2 Cyclist lateral tracking

Summary statistics from the cyclist lateral tracking are provided in Table 2.1. The distributions of tracking positions before and after treatment at each of the three sites are illustrated in Figure 2.1 as a boxplot and in Figure 2.2 as a density distribution. The shoulder was widened at the upstream measurement site in the eastbound direction after treatment and the shoulder edgeline was moved inwards. These alterations complicate any comparison of the cyclist lateral tracking at this site such that comparisons are not presented in this table or figures.

The main results are the following:

- There has been a statistically significant shift in cyclist lateral tracking *towards* the kerb in the eastbound direction at the hold line; the median lateral tracking position decreased from around 2.7 m before treatment to 2.0 m afterwards.
- There has been no significant shift in cyclist lateral tracking in the westbound direction; the median lateral tracking position was around 2.1 m before and after treatment.
- The change in distribution of cyclist lateral tracking positions in both directions at the hold line differs between the sites; in the eastbound direction the standard deviation decreased and in the westbound direction it increased.
- A majority of riders are choosing to ride within the painted blister after treatment; 79% do so on the eastbound approach and 76% do so at the hold line. The proportion riding within the chevron in the westbound direction at the hold line is somewhat lower at 53%.

That the average lateral tracking position, at least in one direction, appears to have moved *towards* the kerb is contrary to the design intent. Furthermore, the proportion of riders occupying a central lane position was rare, and when this was observed it was invariably only when there was a group of riders and usually also in the absence of motorists. Instead, in the vast majority of observations riders were observed to ride close to the kerb (before treatment) or in the painted blister (after treatment). These results are contrary to the design intent, and to the principle proposed in recent research reports (Austroads 2014; CDM Research 2013; CDM Research 2015) of encouraging riders to take a central lane position approaching roundabouts. We discuss these results further in Section 4.

- **Table 2.1: Cyclist lateral tracking summary statistics**

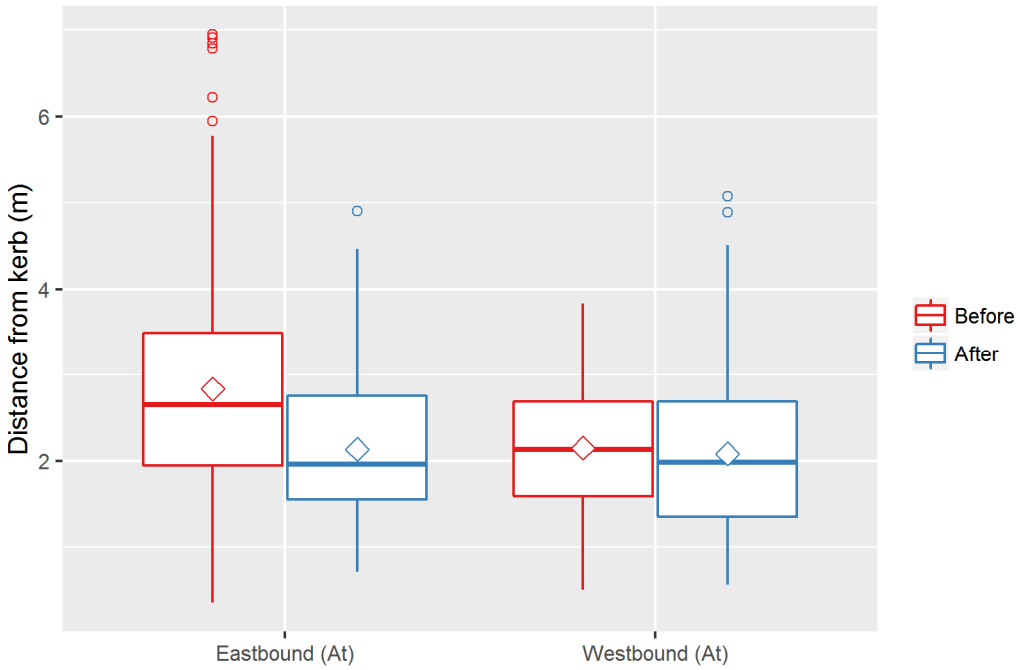
Site	Treatment	No. obs	Lateral offset relative to edgeline			% within blister
			Average (m)	Median (m)	Std. dev. (m)	
Eastbound (upstream) [1]	Before	157	0.52	0.44	0.36	n/a
	After	132	1.80	1.80	0.45	79%
	Difference	–	n/a	n/a	n/a	n/a
Eastbound (at hold line)	Before	300	2.84	2.65	1.28	n/a
	After	152	2.13	1.96	0.83	76%
	Difference	–	-0.71 ** (t=7.04, p<0.00)	-0.69 ** (Z=5.89, p<0.00)	-0.45 ** (F=2.35, p<0.00)	n/a
Westbound	Before	300	2.15	2.13	0.70	n/a
	After	173	2.08	1.98	0.92	53%
	Difference	–	-0.07 (t=0.82, p=0.42)	-0.15 (Z=1.66, p=0.010	+0.22 ** (F=0.58, p<0.00)	n/a

* Statistically significant at the 10% level.

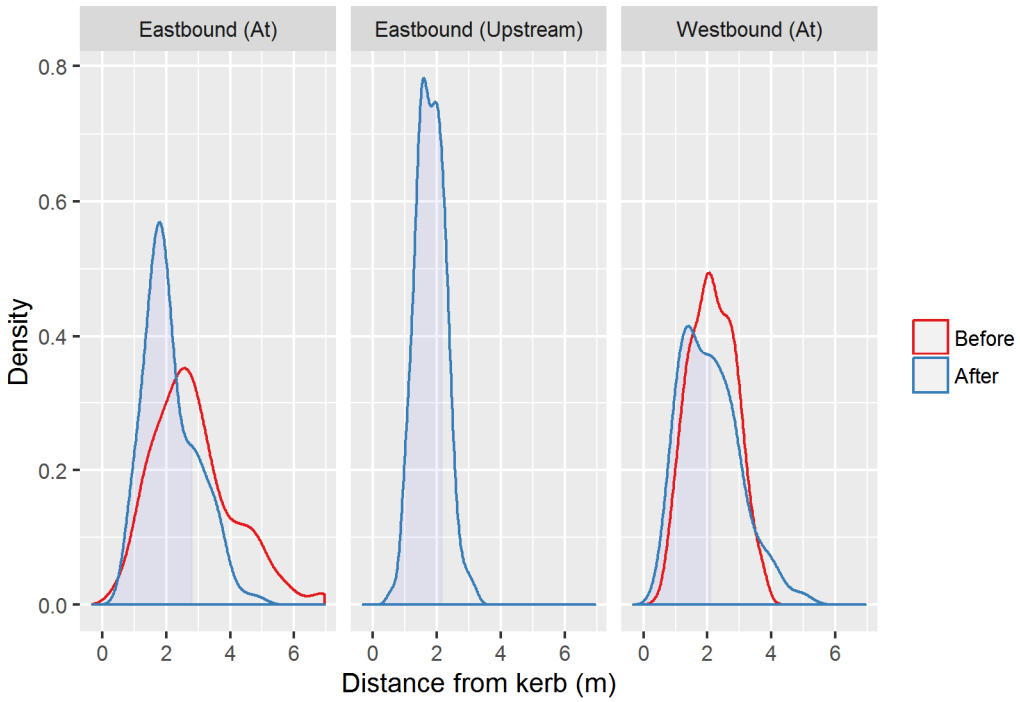
** Statistically significant at the 5% level.

Distances are measured relative to kerbside edgeline.

[1] The road shoulder was marginally widened after treatment and the shoulder edgeline moved towards the centreline such that tracking comparisons at this site are not particularly useful.



- **Figure 2.1: Boxplot of cyclist lateral tracking at the hold line (diamonds are averages)**



- **Figure 2.2: Kernel density distribution of cyclist lateral tracking (shaded areas represent the distribution after treatment riding within the painted chevron)**

3 Motorist speed

3.1 Instantaneous speeds

More than 40,000 vehicle speed records were obtained for each of the two sites in each of the two periods. However, the number of weekday and weekend days varied before and after treatment. As traffic volumes and congestion vary by day of week, so too will the average approach speeds. For these reasons the summary data presented in Table 3.1 are divided into weekday and weekend days[2]. The change in mean and 85th percentile speeds are illustrated in Figure 3.1 and the speed distributions are shown in Figure 3.2. It is noted that the location of the speed measurements at Liverpool Road was farther upstream of the intersection (around 55 – 60 m) than at Miller Road (25 – 30 m), which is likely to explain the significant differences in speeds between sites. We suggest what is relevant is to compare the speeds before and after treatment within each site, rather than across sites.

The key findings from this analysis are as follows:

- there appears to have been a marginal reduction in motorist approach speeds of between 1 and 2 km/h on both approach arms, and on both weekdays and weekends, and
- there has been a marginal reduction in 85th percentile speeds of between 1 and 3 km/h.

These differences are all statistically significant at the 5% level[3]. The speed distributions in Figure 3.2 illustrate a greater likelihood for queuing to exist on the Miller Road approach than along Liverpool Road, both on weekdays and weekends. The effect of the treatment on speeds appears to predominantly be at the upper end of the speed distribution; that is, the proportion travelling above 45 km/h has reduced since the treatment, while the proportion travelling at slower speeds (say 30 km/h) has not changed. This appears to be a desirable outcome insofar as we would expect a small reduction in speed by high speed motorists to be more beneficial than a similar reduction among low speed motorists.

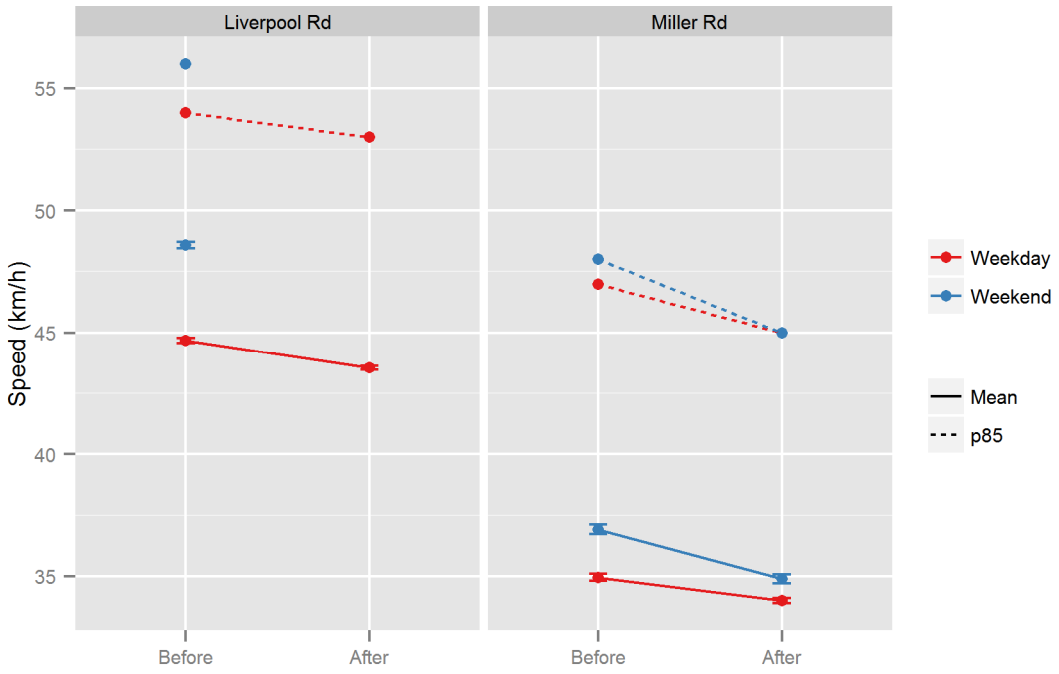
[2] Checks were performed on the data by day of week and found no indication of varying mean or median speeds within each of the day groupings.

[3] This is to be expected given the very large sample sizes.

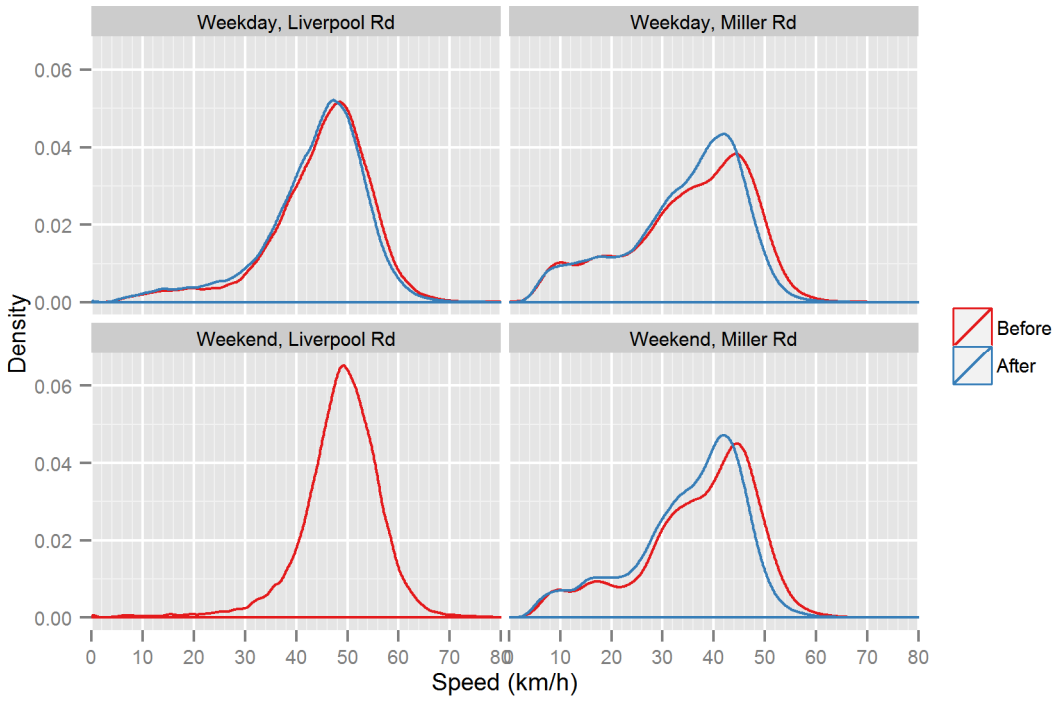
- **Table 3.1: Summary speed statistics**

		Liverpool Road			Miller Road		
		Before	**After**	**Difference**	**Before**	**After**	**Difference**
Weekday	No. obs.	37,899	60,360	–	29,411	47,478	–
	Avg. speed (km/h)	44.7	43.6	-1.1	35.0	34.0	-1.0
	Median speed (km/h)	46	45	-1	37	36	-1
	85th percent. speed (km/h)	54	53	-1	47	45	-2
Weekend	No. obs.	15,828	–	–	14,038	15,098	–
	Avg. speed (km/h)	48.6	–	–	36.9	34.9	-2.0
	Median speed (km/h)	49	–	–	39	37	-2
	85th percent. speed (km/h)	56	–	–	48	45	-3

Notes: Quantile speeds are presented to the nearest whole number, as recorded by the radar device. Average speeds are reported to one decimal point. A power failure precluded weekend data collection after treatment at Liverpool Road.



- **Figure 3.1: Mean and 85th percentile speeds**



- **Figure 3.2: Speed distributions**

3.2 Speed profiles

The dynamic speed profiles were obtained where there was no conflicting movement on the roundabout; in other words, the motorist would be expected to slow gradually approaching the roundabout, observe that there are no road users to their road, and proceed through without needing to stop.

After data cleaning[4] a total of 115 observations were obtained before treatment and 130 observations after treatment (Table 3.2).

- **Table 3.2: Sample sizes**

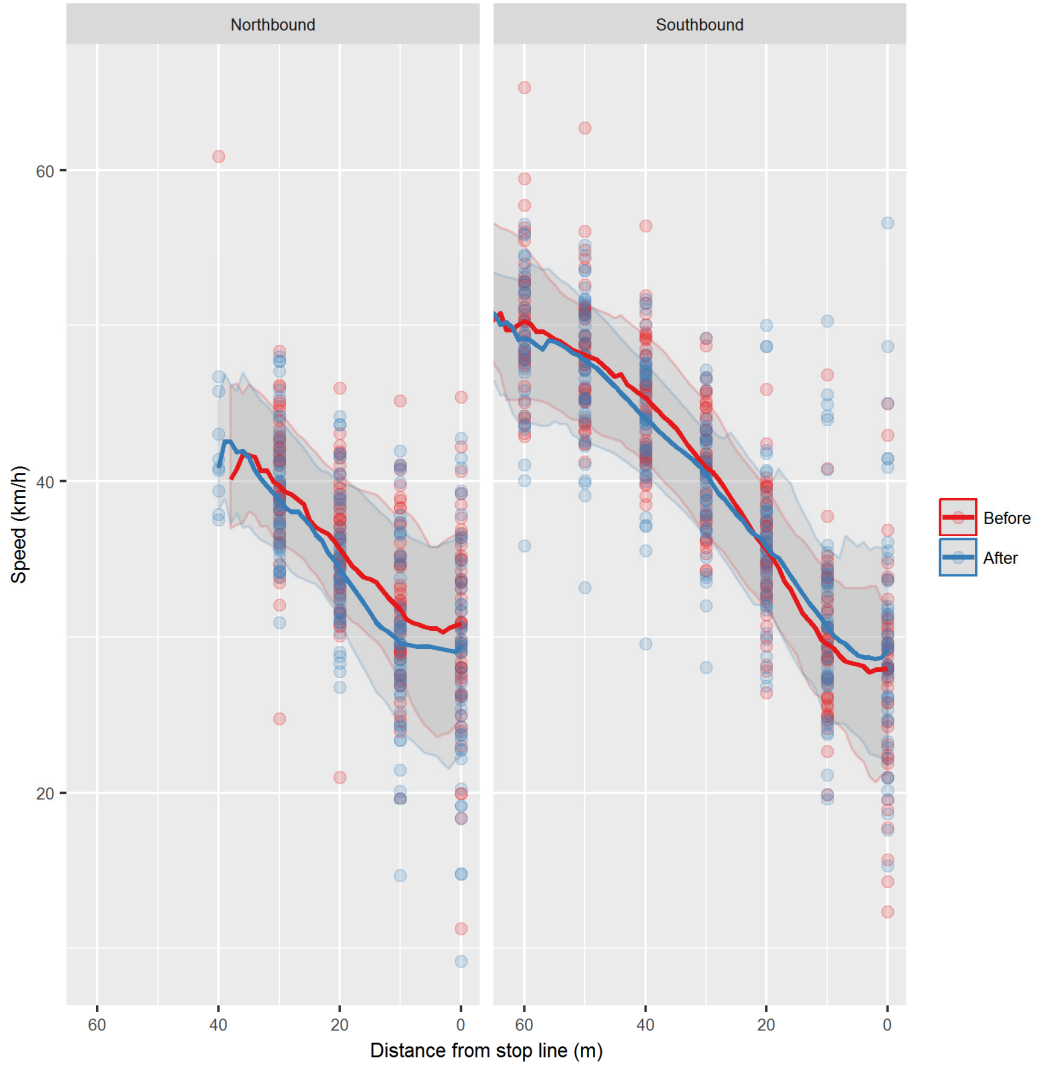
	Period		
Approach	**Before**	**After**	***Total***
Northbound	41	43	*84*
Southbound	74	87	*161*
Total	*115*	*130*	*245*

The data was fitted using LOESS regression with the distance referenced to the hold line at the roundabout. The northbound and southbound approach speed profiles are shown in Figure 3.3. Median speeds are shown as lines and the error bands show the 15th to 85th percentile ranges. An alternative presentation of this data is provided in boxplots in Figure 3.4. These profiles suggest the following:

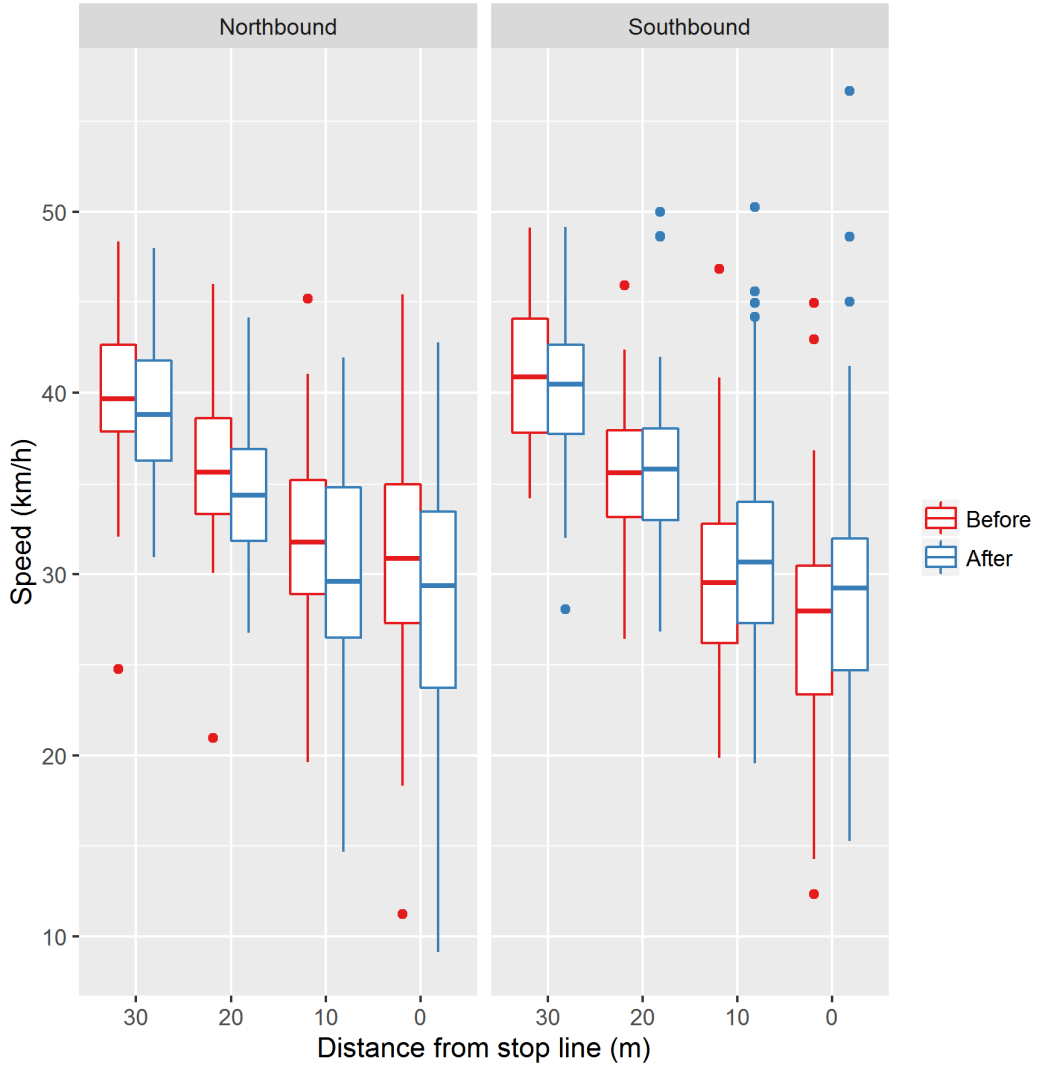
- There is no significant difference in approach speeds across the two directions; at around 30 m from the stop line motorists travel around 40 km/h (85th percentile around 45 km/h) and at the stop line motorists are travelling around 30 km/h.
- There is no significant difference in approach speeds before or after treatment in either direction. While median speeds may have decreased by around 1 km/h in the northbound direction, they have increased marginally (around 0.5 km/h) in the southbound direction. Neither change is statistically significant, and in any case we suggest these differences are more likely to be attributable to sampling bias and instrumentation error than reflecting real changes in motorist speeds.

We conclude from this data that there has not been a detectable change in motorist speed profiles approaching the roundabout from either Liverpool Road or Miller Road.

[4] A number of checks were performed on the raw data, including overall distance (< 100 m), acceleration between points (<0.25 km/h^2) and rate of change of acceleration (<0.04 km/h^2).



- **Figure 3.3: Motorist approach speed profiles (lines are median values at 1 m increments, dots represent individual measurements at 10 m increments, error bands are 15th to 85th percentiles)**



- **Figure 3.4: Box plot of motorist speeds before and after treatment by direction**

4 Discussion

4.1 Introduction

The data obtained in this evaluation would suggest that:

- the treatment has, if anything, encouraged riders to travel closer to the kerb than they would have done previously (at least in the eastbound direction), and
- any impact on motorist approach speeds has been marginal (around 1 – 2 km/h).

What we cannot determine conclusively is whether the treatment represents a safer, less safe or unchanged safety situation for bicycle riders or motorists – or whether the fatality that occurred in 2013 could have been avoided had this treatment been present. However, this limitation is present in almost all road safety evaluations. Instead, it is necessary to speculate based on proxy measures and what is known about crash causation as to the most probable impacts of the treatment.

To guide the discussion that follows we suggest the following are the main implications of this evaluation:

- the treatment is inconsistent with the Safe System principles that guides Victoria's road safety strategy,
- the design intent of encouraging riders to take a central lane position has not been achieved,
- the design intent of reducing motorist speeds approaching the roundabout has not been achieved, and
- the treatment is more likely than not to have had neutral safety impact, and possibly may have led to a marginal overall *decrease* in safety.

We now discuss each of these implications in turn.

4.1.1 Safe System

The Safe System approach which underpins Victoria's road safety strategy is based on the premise that road users will make errors, and that these errors should not result in serious or fatal injury. Translating this to the Mountain Highway roundabout we suggest that:

- motorists will, on occasion, fail to adequately *look* and *see* bicycle riders to their right while approaching the roundabout,
- in failing to adequately see and respond to the presence of a rider the motorist will enter the roundabout, and this will be unexpected by the rider (who, believing they have right of way, will not be anticipating this failure by the motorist), and
- the physical characteristics of any right angled collision that may occur are such that a serious or fatal injury to the rider is possible.

In considering this crash mechanism we offer several points:

- there are fairly well understood limitations to human capacity which contribute to motorists failing to *look* and *see* bicycle riders (and motorcyclists) at roundabouts

(and other intersections); such failings are rarely malicious and in many instances are likely to best be described as an oversight or lack of attention by the motorist,

- to "blame" the motorist in these situations is not likely to be constructive[5] and in any case is inconsistent with the Safe System approach; our interest is in minimising road user errors and ensuring such errors do not result in serious or fatal injury,
- the motorist presents the risk, and therefore is best positioned to control the risk; however, the rider can contribute to reducing the risk by anticipating motorist errors and ensuring they ride at a speed that minimises the consequences of a collision[6], and
- in a manner consistent with the Safe System approach, we need to consider the entire road *system* when designing interventions to avoid these collisions.

Most importantly, we note the Vision Zero objective with the road safety strategy; this vision states that it is immoral to tradeoff safety for retaining mobility or access. In other words, we cannot accept serious or fatal injuries as an inevitable and necessary consequence of permitting motorists to travel with minimum delay through the roundabout. The benefits provided to road users in travel time cannot be considered as sufficient compensation for the injuries they will cause[7]. We suggest there is an implicit tradeoff occurring with the current situation where perceived mobility is being retained at the expense of serious and fatal injuries.

4.1.2 Central lane position

We understand the purpose of the sharrows and, in part, the kerbside painted chevron blister, is to encourage bicycle riders to take a central lane position. In practice, as noted in Section 2, this outcome has not been achieved. Indeed, there is evidence from one of the two directions of travel to suggest the treatment has shifted riders farther towards the kerb. In turn, there were numerous instances where a motorist and bicycle rider were observed to be travelling adjacent to one another approaching and within the roundabout after treatment (Figure 4.1). We note in particular the first of these examples, which shows a truck alongside a bicycle rider at the intersection. We suggest these situations are particularly

[5] Our interest is in preventing such occurrences happening in future; we suggest that penalising the motorist in these situations will have a small to negligible impact on the motorists' future behaviour (after a collision we would expect them to be acutely aware of the issue, adding a penalty would presumably not further increase this awareness) and on other motorists (for whom understanding of the penalty imposed is probably low, except in rare and highly publicised instances).

[6] We are careful here to note that a rider reducing their speed will most likely reduce the likelihood of severe injury more than avoid a collision altogether; human reaction time is such that a rider is unlikely to be able to react once in the roundabout to a motorist entering on an opposing arm before a collision occurs. We speculate it is possible this occurred in the instance of the fatality in 2013; if the motorist entered the roundabout when the rider was near the adjacent splitter island there would be less than 1 s to react before collision (if the rider were travelling at 25 km/h). This would barely be sufficient for the rider to begin to react, let alone apply the brakes.

[7] We would further suggest that the impacts on capacity and travel time from measures that reduce motorist speed at the roundabout would have a negligible impact on overall travel time. That is, they would be so small in magnitude as to be meaningless (a few seconds at most) and would probably be transitory in any case (i.e. any gain in travel time would be "lost" at the next intersection).

risky given the likelihood that the rider will not be visible to the truck driver, thereby increasing the risk of a side swipe or left through collision[8].

- **Figure 4.1: Motorists and bicycle riders travelling adjacent to one another**

[8] The consequences of such a collision, particularly (if as is likely) the truck does not have side underrun protection, are likely to be fatal injuries to the rider at any speed.

We suggest there are three reasons why riders are seemingly so reluctant to take a central lane position:

- *Inequitable speeds:* motorist speeds are around 60 km/h away from the intersection, decreasing to 30 km/h at the intersection; even for the generally fit and committed riders who overwhelming use this road they are unlikely to be able to ride at these speeds (or, at least, not for prolonged periods or while also negotiating the intersection).
- *High traffic volumes:* Mountain Highway has around 9,000 vpd, which clearly makes it more difficult for riders to find a gap and negotiate a central lane position.
- *Kerbside blister provides a "protected space":* we suggest that the chevron along the kerb provides an informal bicycle lane that riders will tend to prefer over the general purpose travel lane.

Our view is that the inequitable speeds is the most significant explanatory factor; riders simply do not feel sufficiently confident or comfortable to claim the lane (and, invariably, to temporarily slow trailing motorists) under these circumstances. The sharrows are insufficient to alleviate this discomfort, or to create a more equitable sense of the road environment as "shared" between motorists and bicycle riders. We note that most applications of sharrows in Victoria to date, and indeed internationally, have been on lower speed inner urban streets where speeds are more equitable (motorists usually having maximum speeds of 50 km/h or lower) and the street environment is more balanced[9]. At this particular location the roadway, and the absence of adjoining street activity, together create a strong sense of motorist priority. We suggest that modest traffic engineering treatments alone cannot rebalance this situation.

While the traffic volumes along Mountain Highway clearly contribute to the unwillingness of riders to share the roadway, we are not confident these volumes in themselves are sufficient to deter riders. Indeed, there are lower speed roads in inner Melbourne with sharrows and similar traffic volumes that appear to operate satisfactorily (CDM Research 2013). However, these streets vary insofar as motorist speeds are generally low and the streetscape is much more mixed between motorists, bicycle riders and pedestrians.

It was observed that bicycle riders tend to ride within the painted blister approaching the roundabout. We suggest this behaviour is not unexpected:

- it serves as a comparatively "protected" space away from motorists, and
- the chevron in both directions is a natural extension of the (short) dedicated bicycle lane that terminates around 40 m from the intersection.

Our view is that the short bicycle lane approaching the intersection (around 40 m in length) sends a contradictory message to bicycle riders (and to motorists). As currently built, a road user is confronted with a mixed traffic environment away from the intersection, transitioning to a dedicated bicycle lane around 80 m from the intersection and then a

[9] Taking this argument more broadly, we would note that even in countries with very high levels of cycling use such as the Netherlands most streets are "shared" between motorists and bicycle riders. However, speed limits are invariably around 30 km/h to make this both practical and safe.

shared lane around 40 m from the intersection (designated with sharrows). This rapid change in expectations as to where a rider should be positioned seems to us to be unnecessarily confusing.

Furthermore, we are concerned the short bicycle lane increases the crash risk overall by encouraging the separation of the modes just when they should be negotiating a line abreast (shared) position on the roadway. Instead, what has been created is a situation that explicitly encourages late transitions. In effect, our view is that the bicycle lane has created an unnecessary additional conflict (transitioning from the bicycle lane to the shared lane) and exacerbates what is already a complex intersection for riders to negotiate. In this situation it seems reasonable to expect riders to choose to continue to stay to the left and use the blister to approach the intersection, which is possibly safer insofar as it avoids the reintegration step.

Finally, we note two other issues:

1. The design features a sharrow on the departure leg that is angled towards the kerb, presumably to encourage riders to drift back towards the shoulder. We do not consider this to be necessary given the natural tendency for riders using this route to ride towards the shoulder in any case. Furthermore, we suggest there is a risk that overusing such symbols (and doing so in an unconventional way) risks diluting the meaning of the symbol where it can best be utilised. In addition:
    a. On the eastbound departure the sharrow is positioned towards the right of the lane, which we suggest is the least likely position a rider would be located[10].
    b. There are sharrows on the departure arms along Liverpool and Miller Roads but no corresponding approach sharrows. It is not clear to us why this would be the case.
2. The preliminary plans (20/5/2015) suggest RRPMs would be installed along the inside of the edgeline, including alongside the chevron blisters. These were not observed to have been installed in November 2015. We suggest RRPMs would present a significant hazard to bicycle riders, particularly given that most were observed to be riding in close proximity to where the RRPMs are proposed for installation. Our view is that these RRPMs should not be installed (if indeed they form part of the final design).

Overall, we reiterate that it is our view that the design intent of sharing the traffic lane cannot reasonably be achieved at this location while motorist speeds remain high. We suggest that using sharrows in this situation is inappropriate and potentially counterproductive if it reduces their effectiveness at other more appropriate locations.

[10] No rider was observed beyond the centre of the departure lane, and the majority crossed the chevron blister on the departure arm.

4.1.3 Motorist speeds

It was observed both from the stationary speed observations (Section 3.1) and speed profiles (Section 3.2) that motorist speeds appear to have reduced on the conflicting arms (Liverpool and Miller Roads) by less than 2 km/h. These reductions are, in our view, insufficient to create an equitable speed environment conducive to sharing between motorists and bicycle riders *and* unlikely to offer substantial safety benefits to road users.

We attribute these modest speed reductions to the perceived narrowing created by the enlargement of the splitter island. It is noted that the splitter island was expanded only to the pre-existing splitter island edgeline and that kerbside road geometry did not alter for motorists travelling along Liverpool Road and Miller Road. In other words, there have been minimal geometric changes to the roundabout approaches from the southwest and northeast – and that these changes have only been perceptual (namely, the expansion of the splitter island to the existing edgelines).

Speed measurements were not obtained along Mountain Highway, as the crash history suggests this is not the direction from which motorists collide with bicycle riders. However, the video observations suggested that motorists continue to select a “racing line” through the roundabout by traversing the painted blister on the approach and departure arms, at least in the absence of bicycle riders (who would usually position themselves within the blister).

We note that the crash history suggests the main crash issue is between bicycle riders travelling along Mountain Highway westbound conflicting with motorists emerging from Miller Road. If it is accepted that lower motorist approach speeds along Miller Road would reduce this conflict then it is unclear how geometric changes to the Mountain Highway approach (in the form of the painted blisters) will slow motorists on Miller Road. Instead, one option would have been to leave the splitter island as it was (or straighten it) and install blisters on the Miller Road approach to encourage a more radial approach.

Overall, the modest changes to the roundabout geometry have had a materially insignificant impact on motorist speeds, which in turn we would expect to have no effect on crash likelihood.

5 Recommendations

The evaluation would suggest the treatment has not achieved its objectives of (a) encouraging riders to take a central lane position, (b) reducing motorist speed, or (c) significantly reducing the risk of rider-motorist collisions. We suggest the key conclusion from this evaluation is that sharing a travel lane between bicycle riders and motorists (as is the design intent of sharrows) is only practical where speeds between the road users are equitable. In practice we suggest this would mean speeds in the transition area of no more than 30 - 40 km/h decreasing to around 25 km/h at the roundabout. While a number of design options exist to achieve these speeds we suggest that one approach would be to redesign the roundabout to a more radial geometry. However, this would have more substantial cost implications as well as raise concerns around travel time and capacity.

If it were determined that full redesign of the intersection cannot be justified, and that motorist speeds cannot be constrained, we suggest the following mitigations:

- the sharrows should be removed, as they are being ignored by road users, are possibly confusing and may reduce their effectiveness at other, more appropriate locations,
- the bicycle lane should extend to the intersection hold line by removing the chevron markings, and
- RRPMs should not be installed on the roadway near where riders would be expected to travel.

We note the second of these recommendations – extending the bicycle lane to the roundabout – is contrary to the recommendations in a recent Austroads research report which explicitly advised against providing bicycle lanes near roundabouts (Wilke, Lieswyn, and Munro 2014). However, we note that report also recommended that single lane roundabouts be designed for equitable speeds. Where this cannot be achieved there are far fewer options available and we would suggest none that meet the Safe System philosophy (with the exception of full grade separation). In such cases bicycle lanes may be appropriate as a “least worst” solution, although the concerns raised in the Austroads report about maximising rider visibility remain relevant.

Finally, we would recommend further consideration be given to ensuring internal consistence of the design elements. As currently configured, the introduction and then rapid termination of a bicycle lane approaching the roundabout seems to us to be inconsistent with the overall design intent.

6 References

Austroads. 2014. “Effectiveness of On-Road Bicycle Lanes at Roundabouts.” Research Report AP-R461-14.

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Wilke, Axel, John Lieswyn, and Cameron Munro. 2014. “Assessment of the Effectiveness of On-Road Bicycle Lanes at Roundabouts in Australia and New Zealand.” AP-R461-14. Austroads. https://www.onlinepublications.austroads.com.au/items/AP-R461-14.