Evaluation of Linemarking Modifications on the Ted Smout Bridge

Prepared for Department of Transport and Main Roads

Contents

Document history and status

Revision	Date issued	Author	Revision type
1	5/12/2017	C. Munro	Issue-1
2	15/12/2017	C. Munro	Revisions following TMR comments

Distribution of Copies

Revision	Media	Issued to
1	PDF	TMR
2	PDF	TMR

Printed:	12 January 2018
Last saved:	15 December 2017 03:52 PM
File name:	0125 Ted Smout Bridge - Linemarking Evaluation (Issue-1).docx
Project manager:	C. Munro
Name of organisation:	Department of Transport and Main Roads
Name of project:	Evaluation of Linemarking Modifications on the Ted Smout Bridge
Project number:	0125

Executive Summary

CDM Research was commissioned by the Department of Transport and Main Roads (TMR) to evaluate the effectiveness of modifications to the linemarking on the cyclist and pedestrian crossing of the Ted Smout Bridge between Brighton and Redcliffe. The path has a nominal width of 4.5 m with vertical fencing on both sides. Before modification (March 2017) the path was configured as a 2.0 m footpath and 2.5 m bikeway delineated by a solid white line and supported by pavement symbols and signs. There was no centreline on the bicycle path. There had been reports of numerous near-miss events involving bicycle riders in the past, and there has been at least one serious casualty crash involving a bicycle rider colliding with an oncoming rider. In response to these incidents TMR modified the path to instead consist of a 1.2 m footpath and a 2.9 m bikeway with a dashed centreline. The footpath and bikeway are delineated by a 0.4 m green painted buffer with solid edgelines.

The study methodology involved observations of bicycle rider and pedestrian behaviour. No observations of path users were obtained prior to the treatment being implemented. As such, the present analysis makes inferences both about how the path appears to perform currently, and how this may have changed relative to the situation prior to the treatment. The methodology involved a stationary video camera positioned around 50 m onto the bridge from the southern (Brighton) abutment. In addition, three bicycle riders rode over the bridge on a typical Saturday morning period with helmet cameras. The riders followed groups of riders at a reasonable distance behind such that the interactions they had with other path users could be observed.

Our key findings from the observational study are as follows:

- The path carries around 500 riders per day and around 100 pedestrians per day near the southern abutment.
- Most path users stay to their designated part of the path; 94% of bicycle riders and 85% of pedestrians were observed to be travelling entirely within the bikeway or footpath, respectively.
- Most bicycle riders (89%) were observed to travel to the left of the dashed bikeway centreline.
- It was fairly common, particularly during peak cycling periods, to observe southbound bicycle riders tracking along the painted buffer between the bikeway and footpath. This behaviour was usually observed when there were no pedestrians on the footpath.
- Interactions between bicycle riders and other path users did not, in general, appear to involve any surprise or concern among path users; around 90% of interactions observed were in this category.
- In 9% of interactions one or more bicycle riders were observed to be overtaking and/or encountering multiple groups of path users simultaneously. In these instances clearances between users were reduced such that the margin for error (or misunderstanding) was low and some users may have felt somewhat discomforted.

- We rated the remaining 1% of interactions as causing surprise or alarm on the path of one or more path users. There were two events in this category; in one a motorised scooter was drifting unpredictably across the path ahead of two riders who were attempting to overtake, and in the other a southbound bicycle rider drifted onto the footpath into the path of oncoming runners.

Based on the observations in this study we conclude that:

- Overall, we are of the view the design results in more predictable and disciplined positioning of bicycle riders and pedestrians on the bridge.
- The modifications appear, on balance, to have resulted in a safer and more comfortable situation for bicycle riders which we attribute primarily to the introduction of the centreline with secondary contributions from the marginal increase in bikeway width (around 0.4 m) and increased delineation from the footpath.
- It is difficult to ascertain what the impact may have been on walkers and runners; the increased delineation is presumably seen positively, but this may be moderated by the narrower footpath width.
- While on balance the treatment appears likely to reduce the likelihood of path user collisions the total width, user demand and cyclist speeds are such that the margin of error is small. Minor misjudgements or misunderstandings in this situation can quickly lead to significant injury, particularly given that neither bicycle riders nor pedestrians are physically protected in the way that vehicle occupants would be. However, further reducing this risk can probably only be achieved through physically widening the path – which would be cost prohibitive.

Our key recommendations are as follows:

- The modified linemarking should to be retained and maintained in its current condition (with the caveat noted below) unless further incidents or information warrant modification.
- When maintenance and reapplication of the green fill treatment is warranted it is suggested an alternative colour not explicitly associated with bicycle riders may be more appropriate.
- Future major works at other locations, including bridges, should carefully consider the likely user demand and profile and consider an appropriate path width accordingly. Our view is that the 4.5 m width allocated on Ted Smout Bridge is inadequate for the safe operation of the path given the user demand and mix.

1 Introduction

1.1 Background

The Ted Smout Bridge extends over 2.8 km between Brighton and Redcliffe. The bridge opened in 2010 and provides for three southbound traffic lanes and a bi-directional bikeway and footpath on the eastern side of the bridge. When initially constructed the 4.5 m width of the path was divided into a 2.5 m bikeway nearest the roadway (but separated by a concrete barrier and fence) and 2.0 m footpath segregated from the bikeway by a solid white edgeline (Figure 1.1a).

Following a number of near-miss events and anecdotal reports of collisions between bicycle riders, in 2016 two bicycle riders collided in a head-on collision which resulted in one rider incurring serious injuries. In that incident two groups of riders were approaching one another, and the rider who incurred the serious injuries was towards the rear of one of the groups. In response to this collision, and to the reports of near-miss events, TMR redesigned the path with a 2.9 m bikeway, 0.4 m edge strip with solid white edge lines and green infill and a 1.2 m footpath (Figure 1.1b). The modal segregation was reinforced by the use of signs and pavement symbols (with coloured background to enhance contrast). Directional segregation of bicycle riders was encouraged through the use of a dashed centreline and directional arrows above the pavement bicycle symbols.

(a) Original configuration

(b) Modified configuration

■ **Figure 1.1: General layout**

1.2 Objective

The purpose of this study was to evaluate the effectiveness of the modifications, and primarily to determine whether the treatment has reduced the likelihood of conflict and collisions between path users (this includes bicycle riders, pedestrians and runners). It is noted that crashes on paths are heavily under-reported in Police crash statistics, and that the modified treatment had only been installed for about six months when the present evaluation was undertaken, such that crash data would be infeasible as a means of evaluating the treatment.

1.3 Methodology

An observational approach was adopted for the study, involving two methods:

- **Stationary camera** was positioned around 50 m onto the bridge, and
- **Moving observations** from bicycle riders using helmet-mounted cameras riding across the bridge.

The stationary camera provided information on path user behaviour, most notably of "compliance" with the modal segregation and, in the case of bicycle riders, directional segregation on the bikeway. Moreover, the camera provided user counts.[1] The moving observations were used to provide insight into how path users interact with one another on the bridge; we would expect this to be a dynamic process whereby conflicting users see one another and adjust their position (e.g. by drifting left or moving from two-abreast to single file) or speed so as to ensure they pass one another without conflict.

Moving observations were obtained from three bicycle riders who undertook a total of 12 passes across the bridge on the morning of Saturday 4 November 2017. Weather conditions were fine and sunny. The riders individually travelled two to three bicycle lengths behind groups of riders across the bridge such that the positioning of the riders, and their interactions with other path users, could be observed. The riders were instructed to travel behind the group such that they were less likely to affect the behaviour of that group and other path users in the vicinity.

[1] There is an automatic cyclist counter at the southern end of the bridge. Data from this counter is analysed in this report, but this counter does not provide pedestrian counts.

2 Results

2.1 Counts

The automatic counter located at the southern abutment provides an indication of seasonal variation in cyclist and pedestrian demand. During the first half of 2017 (a period which straddles the path reconfiguration) the highest cyclist count was around 300 bicycle riders during the February weekend morning peak hour (Figure 2.1). The busiest periods are early mornings between 6 and 9 am, and most particularly on weekends. The average daily rider count between January and end-June 2017 was 545 riders per day and the maximum was 1,504 riders per day. Average pedestrian demand was 235 per day with a maximum of 786.

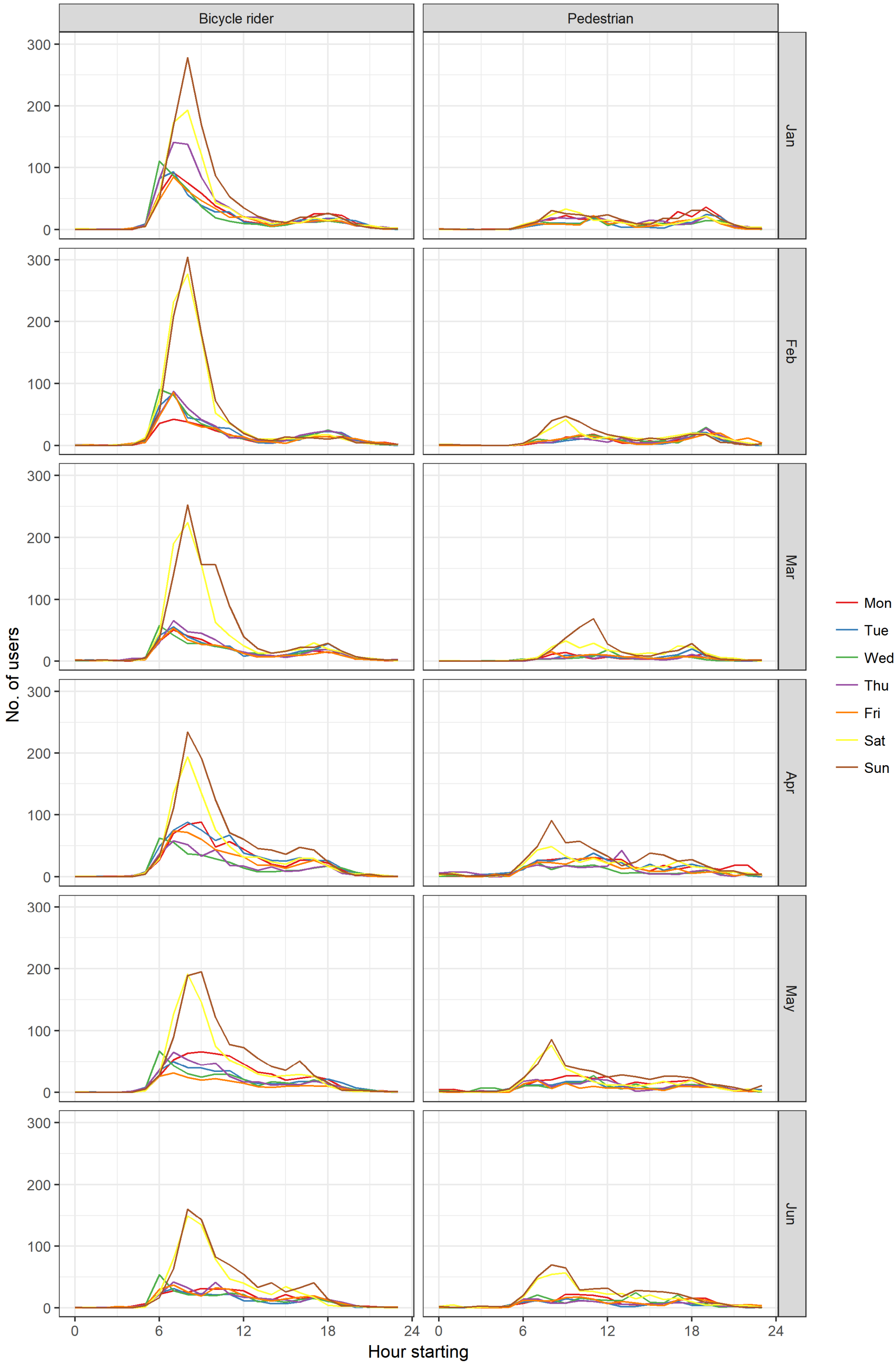
The bridge is used primarily by bicycle riders, most of whom appear to be recreational riders riding for sport or training. Moreover, the bridge provides a long straight path with shallow gradients. The result is that rider speeds are likely to be high relative to other locations on the off-road path network[2].

The stationary camera provided an indication of pedestrian demand, at least near the southern abutment. Over the one week in which the video camera was present an average of 448 riders were observed between 5 am and 8 pm, which is not dissimilar to the 24-hour average of 545 riders measured by the automatic counter for the first half of 2017. On average there were 116 pedestrians using the bridge each day. This is significantly lower than the estimate provided by the automatic counter (235 per day), which we suggest may be due to one or more of:

- seasonal and weather variation during the video observation period which reduced demand to levels below those typical experienced,
- significant pedestrian demand outside the video observation period (5 am to 8 pm), and
- a sensor error resulting in erroneous false positive detections.

Irrespective of the reason for the discrepancy in the pedestrian count the evidence would suggest that between a quarter and a third of bridge users, at least near the abutments, are likely to be pedestrians.

[2] This could be verified from analysis of the speed measurements obtained from the piezoelectric counters used by TMR on the bridge. However, only aggregate counts data was available for this evaluation.



■ **Figure 2.1: Automatic cyclist counts by day of week, month and time of day (southern abutment)**

2.2 Lane compliance

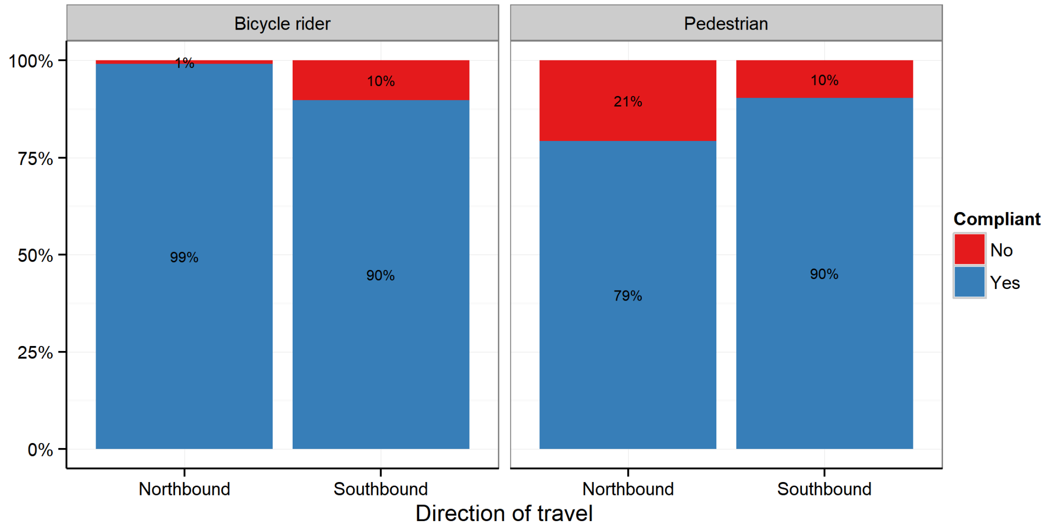
We use the term “lane compliance” as a measure of whether bicycle riders and pedestrians remain within their designated areas on the path. This was measured from the stationary camera positioned on the bridge around 50 m from the southern abutment. A total of 5,125 users were observed over a 7-day period from Monday 6 November to Tuesday 14 November 2017 between 5 am and 8 pm. Most users were bicycle riders (81%) with the remaining 19% being pedestrians, runners or users of wheeled mobility devices that are not bicycles (e.g. skateboards, scooters).

The majority of bridge users complied with the modal segregation (Table 2.1); overall 93% of users did so, with compliance among pedestrians being marginally lower (85%) than bicycle riders (94%).

■ **Table 2.1: Compliance with modal segregation**

	Mode			
	Bicycle rider		Pedestrian	
Compliance	**No.**	**%**	**No.**	**%**
Compliant	3,908	94%	835	85%
Non-compliant	237	6%	145	15%
Total	*4,145*	*100%*	*980*	*100%*

Unsurprisingly, modal compliance was higher when the path user was travelling in the direction that would result in them tending to walk or ride towards the outer edge of the path. In the case of bicycle riders this means better compliance among those heading north (99%) than south (90%) and among pedestrians those heading south (90%) were more likely to comply than those heading north (79%).



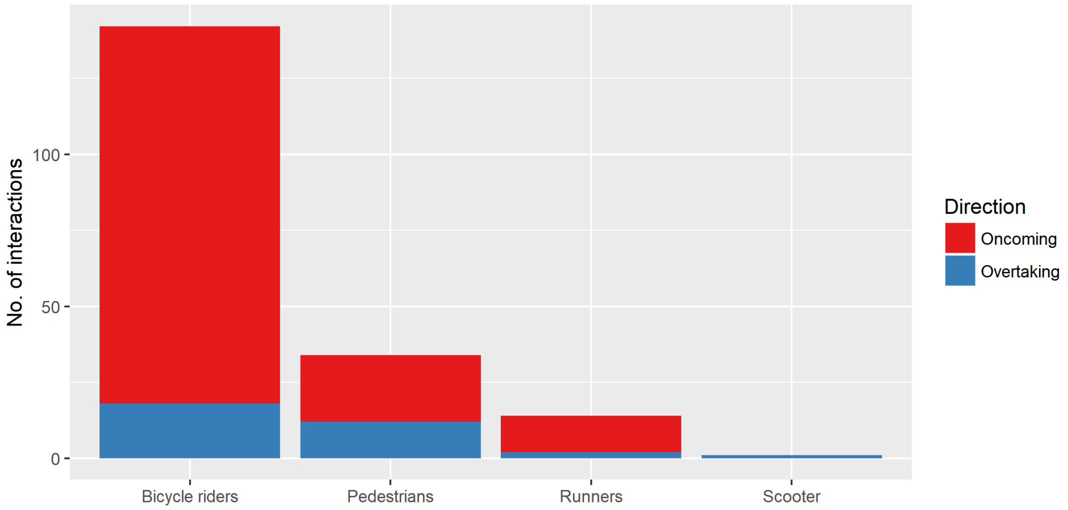
■ **Figure 2.2: Modal compliance by direction of travel**

Most bicycle riders were observed to ride to the left of the bikeway centreline; 89% were observed to do so and the difference in compliance between those heading north (90%) and south (88%) was not significantly different. In almost all instances where a rider was observed to be travelling on the farside of the centreline they were either overtaking another path user or riding alongside another rider as part of a group.

2.3 User interactions

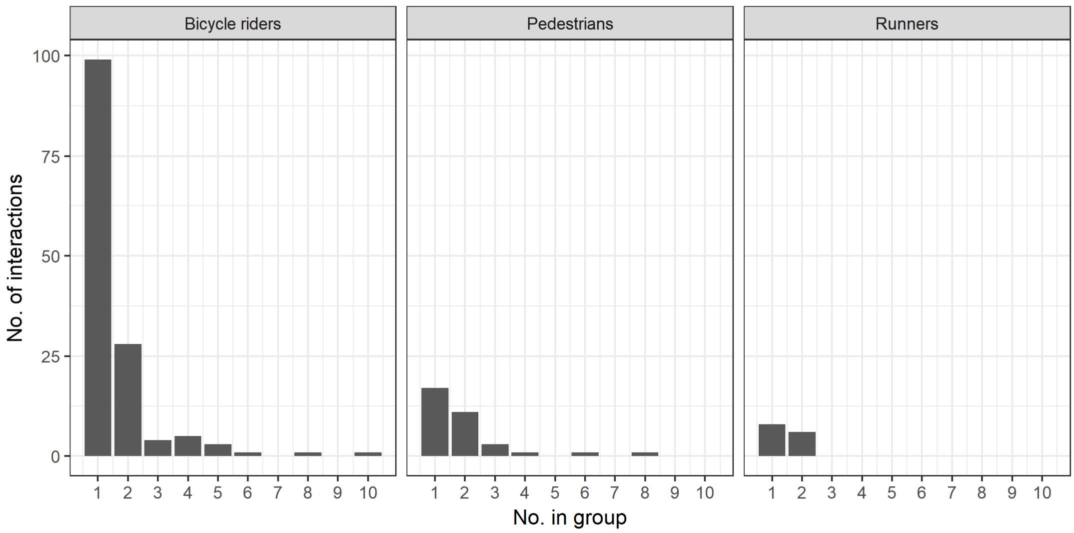
User interactions were measured from the moving rider observations. From the 12 trips across the bridge made by the riders (7 northbound, 5 southbound) there were a total of 191 interactions. The average number of interactions per trip was 16 (minimum 7 and maximum 21). The number of riders in the observed group varied from one to eight, with an average of four per group.

Just under three quarters (74%) of interactions involved one or more bicycle riders, usually coming towards the group of riders (Figure 2.3). Pedestrians represented 18% of interactions and runners a further 7%. There was one interaction with a user of a motorised scooter (who positioned themselves on the footpath).



■ **Figure 2.3: Interactions by mode and direction of travel**

Around 70% of interactions with other bicycle riders involved a single rider, as were half of pedestrian interactions (Figure 2.4). Interactions with groups of three or more bicycle riders constituted only 10% of rider interactions.



■ **Figure 2.4: Interactions by mode and group size**

The following observations are made with regard to the interactions:

- Lane discipline was generally very good:
  - bicycle riders would almost always stay to the bikeway, and then to the left of the centreline,
  - the typical exception to this would be when overtaking another rider, where it was common for the overtaking group to move across the centreline or, in two instances in the northbound direction, into the footpath[3], and
  - all pedestrians and runners were observed to remain within the footpath.
- The vast majority of interactions did not appear to involve any surprise or concern among path users; we rated 90% of interactions in this category.
  - A further 9% of events were rated as having marginally elevated risks; that is, path users may have felt "squeezed" or uncomfortable. While there was no evident sense of surprise from these interactions the margin for error appeared to be low. That is, should a user have moved abruptly to their left or right a collision is likely to have resulted.
  - Two interactions, constituting 1% of all events, were rated as causing surprise or alarm on the part of one or more path users. In one of these a motorised scooter user on the bikeway was drifting left and right and the two bicycle riders who were overtaking had to veer far to their right to overtake (Figure 2.5). In the second incident a bicycle rider drifts left onto the footpath and only notices the oncoming runners at the last minute (Figure 2.6). The rider appears to gesture with their left arm to apologise, while the runners appear to be startled by the interaction.
- It was common to observe bicycle riders travelling south tracking along the edge strip (Figure 2.8). This usually occurred when no pedestrians were present on the footpath and there was one or more oncoming bicycle riders.
- The 2.9 m wide bikeway appeared to be sufficient to accommodate a maximum of three riders across this width. In the few instances where four riders across the path were observed at least one rider was on the edge strip or in the footpath (Figure 2.7). This is consistent with our expectation, where we would normally expect a 3 m path to accommodate at most three riders wide.
- The footpath, although narrow, appeared to accommodate pedestrians or runners two-abreast (Figure 2.7). The pedestrians would tend to gravitate towards the eastern (water) edge of the path, presumably to provide maximum clearance from bicycle riders and to maximise their view of the water.
- It was unusual to observe groups of bicycle riders alter their configuration on the bridge; if they were riding in single file they would maintain this configuration, and similarly most groups riding two-abreast did so even when they encountered other path users. In the (unusual) even that a group of riders travelling two-abreast encountered an oncoming group also riding two abreast if no pedestrians were

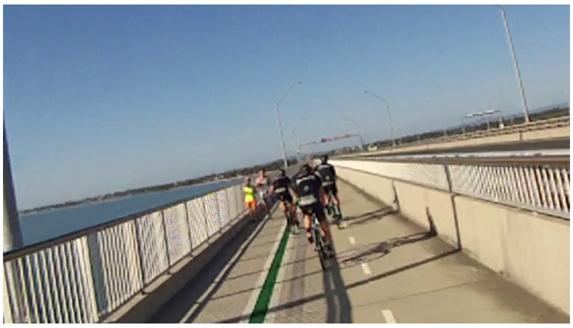
[3] No pedestrians were present in the footpath during these events.

present the southbound group would tend to move into the footpath so both groups could pass without having to change to single file. Only in the relatively unusual situation where there were also pedestrians present would one group move into single file formation.

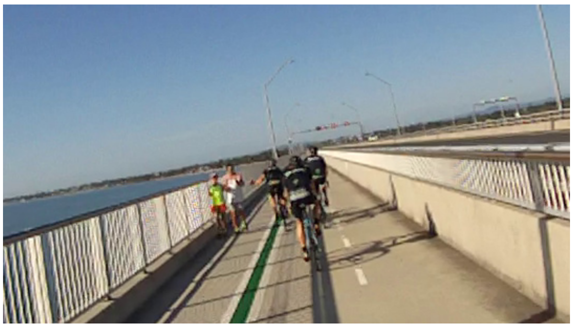
- Bicycle riders were observed to always track to the left of the bikeway centreline except on rare occasions when they would overtake a slower rider by moving across to the farside. We would speculate that this lane discipline is critically important, particularly given that the crash which preceded the modifications involved a head-on rider crash. It seems plausible to argue the absence of a centreline would lead to poorer discipline (that is, riders less likely to stay to the left) and reduce rider awareness of the likelihood of oncoming riders. The centreline, along with the high rider demand, should help reinforce a sense of discomfort or awareness by riders should they move to the right of the centreline.
- While the vast majority of interactions were benign, it was the small minority of complex interactions – often involving groups of riders *and* pedestrians – that appear to pose the greatest risk. Moreover, as illustrated by the example of a distracted rider in Figure 2.6, should there be a misunderstanding or lack of attention paid by one or more riders an otherwise benign interaction could rapidly become a serious collision. The narrow width of the path, combined with the typical rider speeds, leave very little margin for error.

■ Figure 2.5: Motorised scooter veers over path, forcing overtaking riders far to the right

(a) Rider drifts left into footpath



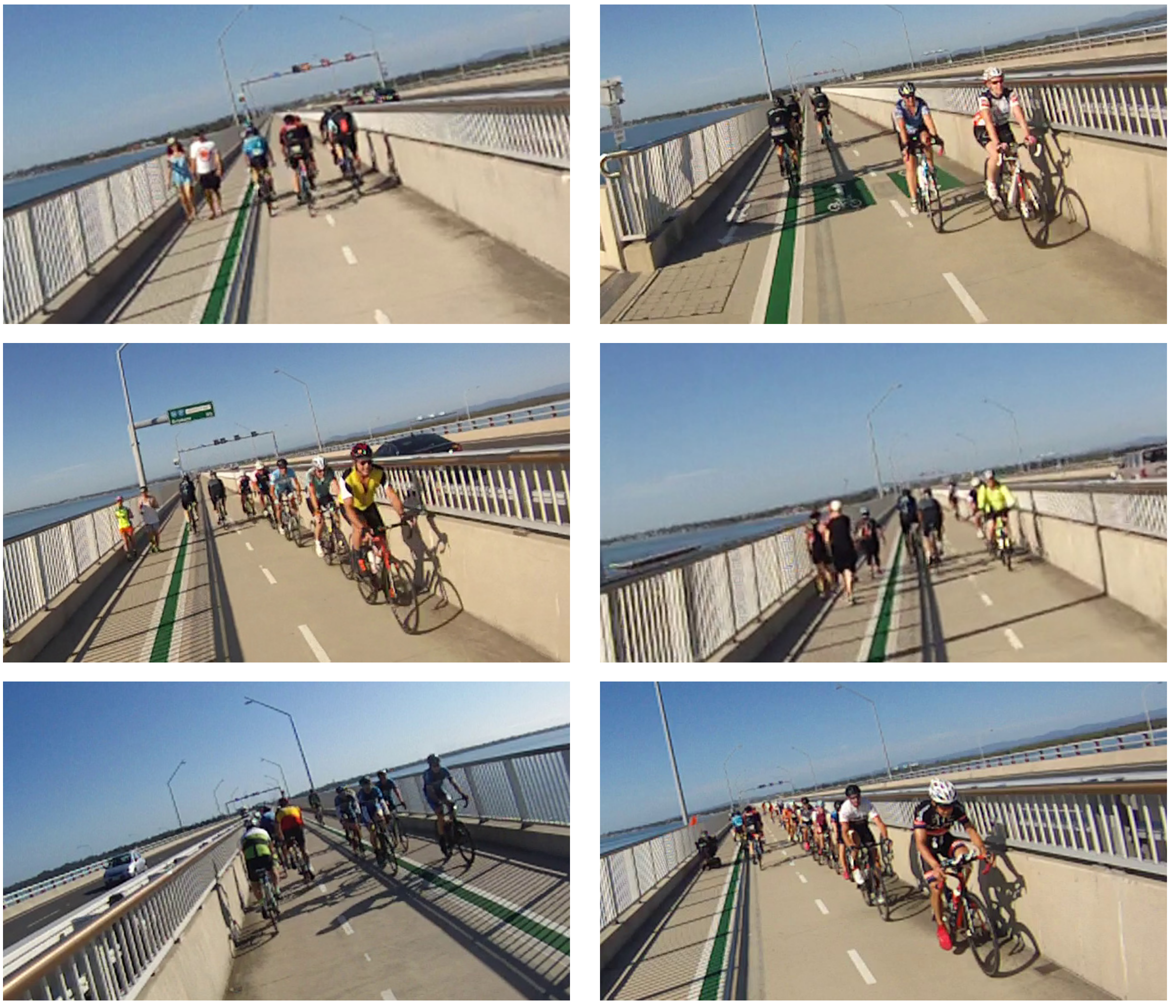
(b) Rider notices runners and quickly veers right



(c) Rider puts out hand seemingly to apologise, runner has hand up defensively

(d) Runners look back at riders

■ Figure 2.6: Close collision event between bicycle rider and runners



■ **Figure 2.7: Interactions involving multiple users spread across the path**

■ **Figure 2.8: Examples of riders travelling southbound tracking along the edge strip**

3 Conclusions

In the absence of observational data prior to the modifications, nor comprehensive crash data pre- and post-modification, we cannot definitively conclude whether the modifications have improved path user safety. However, on balance we suggest the evidence would suggest the modifications have done so:

- path users are tending to stay within their designated areas, the only exception being bicycle riders who occasionally move into the footpath (usually when no pedestrian is present) and pedestrians who encroach into the southbound bicycle lane (usually when no bicycle rider is present),
- the width and visual conspicuity of the edge strip is increasing the modal compliance and providing additional lateral clearance over the previous situation, and
- bicycle riders almost always stay to the left of the bikeway – and more than likely do so more than in the previous situation where there was no centreline.

Given the rider speeds on the bridge we consider these behaviours to be strong indicators of favourable safety outcomes. Moreover, our sense is that the linemarking and pavement symbols are intuitive to pedestrians and bicycle riders alike.

However, we would moderate this conclusion by noting that:

- the margin for error is small, and the consequences of a collision between fast moving bicycle riders and other riders or pedestrians are potentially serious, and
- the use of green within the painted buffer between the footpath and cycleway is inconsistent with the use of green colour elsewhere on the road network, where it is used to define bicycle space.

There appears little prospect of increasing the margin of error given that this would invariably require widening the path at considerable cost. We do however suggest this experience should serve to illustrate the importance of ensuring new facilities elsewhere are designed to accommodate the anticipated user demand, and the type of users, at the outset. Given the bridge was built relatively recently, and there was pre-existing demand on the previous bridge, we suggest it was reasonably foreseeable that user demand would be of the levels that have been observed in practice. Moreover, it was reasonably foreseeable that many riders using the bridge would be sport cyclists – and therefore riding at high speed. Over the economic lifetime of the asset we suggest the additional construction costs associated with a wider path would be compensated by the reduction in crashes over the life of the path. Moreover, it would be much cheaper to construct the path once to an adequate width than have to modify or rebuild at some later point.

We do not see cyclist speed control as an effective or desirable outcome at this location; the length and location of the bridge is such that it will always attract high speed sport cyclists. Slowing down these riders seems counterproductive both from a safety perspective (the physical measures required may present a greater hazard than the speeds) and a policy perspective (of encouraging cycling).

With regard to the use of the green within the edge strip we note that the green serves the opposite purpose to its common use – namely, that riders should avoid this space. While removing and reapplying this colour is unlikely to be justifiable it is suggested that in future another colour that is not associated with cyclists would be preferable.