Identifying and treating high risk cyclist crash locations on high speed roads

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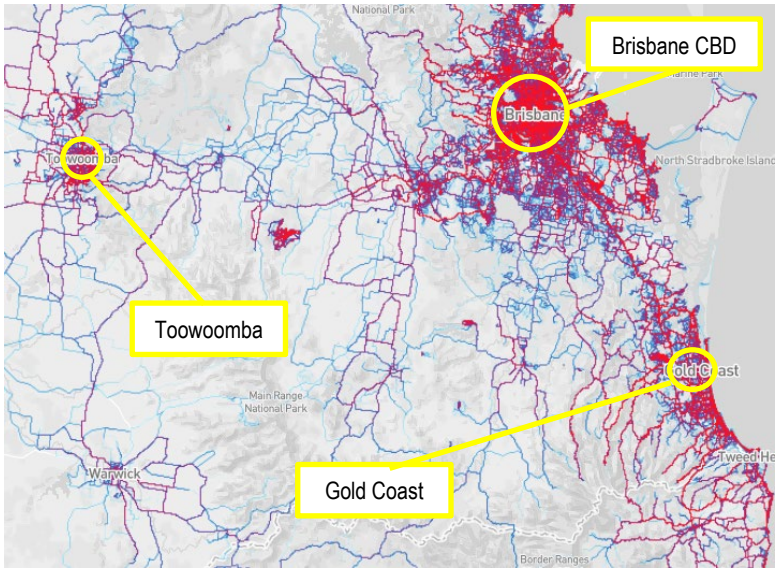
Abstract

Cyclists are considered vulnerable road users with cycling crashes often resulting in serious injury or even death due to the lack of protection offered by apparel, road infrastructure and size and structure of a bicycle in comparison to other vehicles. In Australia between 2010 - May 2018, 276 cyclist fatalities occurred, almost half 120 (43%) occurred on roads with speed limits of 70kph or more (BITRE 2018). Single vehicle cyclist only crashes resulted in 22 fatalities while 98 fatalities involved multiple vehicles whereby the cyclist was struck by another vehicle. Heavy vehicles were involved in 21 of the multiple vehicle fatalities. This identifies the need to attempt to reduce the likelihood of a cyclist being struck by a passenger or heavy vehicle.

Background

Cyclist usage on high speed roads

Cycling is considered and promoted as an active mode of transport (BITRE 2015). The Queensland Cycle Strategy (DTMR 2011) provides a strategic direction for promoting safe cycling across the state and has a target to double cycling's share of commuter trips by 2021 and triple these by 2031. Two recent cycling participation surveys (Austroads 2105, 2017c) found that since 2011 80 – 85% of respondents indicated that their main purpose for riding was for recreation. Strava heat maps (**Figure 1**) identify higher usage on highspeed roads as well as in the city centers, a number of the high speed rural roads indicated to have high usage are part of the Principle Cycle Network Plan (DTMR 2018). Of the roads that are included in Principle Cycle Network Plan (DTMR 2018) a number are high-speed roads that do not currently provide physical separation between cyclists and vehicles, nor off-road paths.



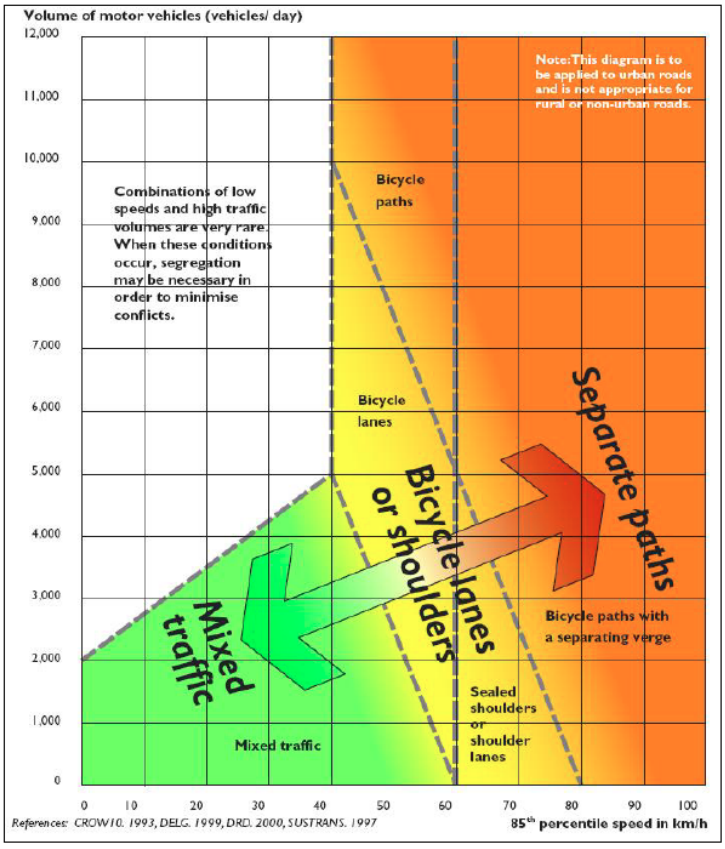
Source: strava.com
Note: Red represents highest usage and light blue the lowest usage.

Figure 1. Cycling heat map, South East QLD

This paper aims to identify the option to provide interim treatments (before physical separation or off-road cycleways can be provided) to reduce cyclist risk on high speed roads (rural, freeways and urban arterials) and provide a method to identify locations where cyclists are most at risk of being struck by a vehicle.

Cyclist guidance for high speed roads

Currently there is not a specific tool or single 'cyclist specific' document that provides comprehensive guidance using a risk-based criteria to assess or identify treatments for cyclists on high speeds. Some guidance to identify what cyclist provisions should be provided is available, however this information is provided across a variety of guides (e.g. Austroads 2014a-b, 2016, 2017b-c). A majority of this information in the former mentioned Guides is collated in one 'cyclist specific' document (Austroads 2017a) however a state specific guidance is provides additional advise also (e.g. DTMR 2015), this may result in confusion for practitioners that are not already experienced in cycling provision requirements. The current guidance mentions required clearances when heavy vehicles are present, however this guidance does not address or provide adequate clearance distances to cyclists when considering the effect of tracking ability on straight path (TASP) of b-double and other larger multi-combination vehicles. None of the former mentioned cyclist Guides provide a risk-based approach to providing treatments.



Source: Austroads 2014a, Austroads 2104b

Figure 2. Cyclist treatments by AADT and Speed

The existing guidance indicates that on a road with posted speeds greater than 40-70 km/h for AADT 4,000 to 2,500 respectively (**Figure 2**) that physical separation or an off-road cycleway should be provided. alternate treatments to mitigate the risk on a high-speed road where either physical separation or off-road cycleways are not provided.

Although physical separation to cyclists and off-road paths are the most effective treatment on high speed roads it is often expensive and may not be a viable option. In the interim, a variety of targeted, low to medium cost treatments may provide an opportunity to reduce crashes and cycling injuries until such time as more expensive, higher order treatments can be provided. This paper aims to identify a method to identify locations where cyclists are most at risk of being struck by a vehicle and to provide guidance on what treatments are required to reduce the risk of a cyclist being struck by a vehicle and then demonstrate the reduction in risk if one or more treatments are provided at a high-risk location. As the selection of treatments are targeted, low to medium cost treatments it is envisaged that these may be implemented through existing maintenance programs, or mass action programs. The cyclist risk matrix was developed based on existing guidance for maintaining road infrastructure condition, road design principles and cyclist facility criteria. This should result in a practitioner without specialist knowledge in the cycling space to enter road information into the matrix to produce a cyclist crash likelihood ranking and select treatments without any specialist training.

Methodology

This paper draws on a project specific methodology which was developed to assess the suitability of a high-speed road for cyclists and identify high-risk locations for consideration of treatment before it was mapped as part of the Principle Cycle Network Plan (PCNP). The methodology consisted of identifying cyclist risk on a high-speed route using established crash risk factors (AusRAP). These high-risk sections were then assessed in greater detail with a conceptual cyclist crash likelihood matrix to isolate locations that presented the highest likelihood of a cyclist being struck by a vehicle due to lack of sight distance from a vehicle to the cyclist and/or reduced separation between a vehicle and cyclist. These locations were then ranked to identify locations for priority treatment, selection of treatments demonstrated a reduction in likelihood of a cyclist being struck by a vehicle.

AusRAP Cyclist Star Rating Score: Identifying cyclist crash risk (likelihood and severity)

The identification and assessment of cycling risk at a route level can be achieved by an analysis of existing road infrastructure, cyclist crash history, speed limit and cyclist volume data using AusRAP. The infrastructure data includes lane and sealed shoulder width, road condition, cyclist treatments, sight lines and intersection and interchange layout type and quality. AusRAP processes the data to establish the AusRAP cyclist Star Rating Score (SRS). Cyclist SRS considers variables including the sealed shoulder width, cyclist treatment, curvature, sight distance, lane width, delineation, curve warning signage, traffic calming, grade, road condition, skid resistance, rumble strips, roadside parking, street lighting intersection layout type and quality. The SRS is available providing the relevant road authority has conducted an AusRAP assessment on their network.

The infrastructure parameters collected to produce the cyclist AusRAP SRS are collected in ranges (e.g. sealed shoulder width 0-1 m, 1- 2.4 m), sightlines are estimated and classified as good/poor (from a desktop review etc.). Collecting and analysing the parameters in ranges, or with a good/poor classification is appropriate for a high-level network wide identification of cyclist risk, however not accurate enough to identify and treat isolated locations where a cyclist is most at risk of being struck from behind by a vehicle due to a sightline restriction, narrow formation width, or both.

The cyclist SRS can be used to identify high-risk sections which require a more detailed assessment, using the cyclist crash likelihood matrix, to identify cyclist specific countermeasure treatments. It should be noted that the AusRAP model does not specifically assess cyclist risk at interchange crossings.

Cyclist crash likelihood matrix: Identifying locations with a high crash likelihood

The matrix was developed to allow practitioners to select treatments from a range of low to medium cost cyclist focused and location specific countermeasure treatments to reduce the likelihood of a cyclist being struck by a vehicle (cyclist risk) on highspeed roads where the speed limit cannot be reduced, and it is not feasible to provide physical separation or off-road paths/cycleways over the length of the road.

The matrix was developed to attempt to reduce the likelihood of a vehicle to cyclist crash by identifying locations where midblock or intersection improvements are required to enable a motorist to:

- identify a cyclist and stop before striking the cyclist (vehicle specific stopping distances including heavy vehicles)
- maintain adequate clearance to a cyclist (including allowances for heavy vehicle trailer rear swing (TASP)).

The likelihood of a cyclist being struck by a vehicle on a midblock section, at an intersection or interchange is determined by assessing location specific features to identify if the criteria in **Table 1** is provided.

The matrix is applied to the high-risk sections as identified by the AusRAP cyclist SRS (e.g. typically where cycling facilities are not already provided) to rank the high-risk locations for priority treatment. This is in recognition that long lengths of road and a high number of intersections are likely to return a poor SRS and present as high-risk, however cannot all be treated. The matrix was developed to isolate the highest risk midblock locations or intersections and rank them to prioritise the need for treatment.

Table 1. Cyclist assessment criteria as per existing guidance

Location	Road infrastructure assessment criteria
Midblock	Physical separation to vehicles, exclusive cycle lane with cyclist warning signs or markings, adequate sealed shoulder width, stopping sight distance.
Intersection	Diverted off-road path around intersection, On-road intersection cyclist treatment, crossing sight distance, stopping sight distance, safe intersection sight distance, right turn lane, dedicated right turn lane phase.
Interchange	Ramp crossing; sufficient shoulder width to crossing location, sufficient refuge width on the shoulder and painted median, sufficient crossing sight distance, Insufficient critical safe gap to cross the ramp during peak hours. Interchange over/under pass through roads; Insufficient shoulder width and no physical separation to cyclists on the through road across the overpass/underpass. Re-direction down the exit ramp and through the interchange; lane width on ramps and roads through the interchange, cyclist intersection or roundabout treatments.

Notes:
- road infrastructure provisions requirements will change based on operating speed, AADT, percentage of heavy vehicles
- criteria as per the guidance identified in Austroads Guides; Road Design series, Traffic management and Cycling Aspects (Austroads 2016, 2017a, 2017b) and DTMR Technical Note 128 (DTMR 2015).

For an intersection or midblock section, the resulting compliance or on-compliance of the road infrastructure compared to the relevant guidance and criteria in **Table 1** is entered into the matrix which provides a likelihood ranking ranging from Rare to Almost Certain to that location. A cyclist risk of Rare is achieved when all of the criteria as per **Table 1** is met, a cyclist risk of Almost Certain is achieved when none of the criteria is met.

For interchanges a cyclist risk ranking was not provided. Given the complexity of sightlines, observation angles, narrow shoulder widths, potential high percentages of heavy vehicles, high traffic and ramp entry/exit volumes and high exit speeds at interchanges a pass/fail criteria was applied as opposed to a Risk Matrix. A Risk Matrix may be able to be developed to access cyclist crash risk at interchanges, however further research and possible observational data of how cyclists and vehicles interact at interchanges would be required.

Treatment identification and mitigation cyclist crash likelihood matrix

As the cyclist crash likelihood matrix identifies short/targeted/isolated high-risk locations, this results in countermeasure treatments to be easily identified. The countermeasure treatments may be implemented through low cost works or changes in maintenance practices or schedules. A practitioner can select achievable treatments (based on budget and time frames) and the matrix provides an indication on the reduction of risk should those selected treatments be implemented. The matrix allows a practitioner to enter one or more countermeasure treatments and demonstrates the incremental reduction in the cyclist crash likelihood ranking at one or more locations.

Midblock countermeasure treatments are generally low cost and could be achieved within existing maintenance activities, minor works remedial packages or mass action plans. Treatments that may be achievable through targeted maintenance activities including; tree trimming to provide sight lines and sweeping gravel from shoulders. Treatments that could be implemented through remedial packages or mass action plans may include; cyclist warning signage/green pavement marking, shoulder sealing, audio tactile linemarking, tree removal and dedicated right turn phase. More expensive treatments may be required to be provided through minor works packages may include diversions to intersection off-road paths and right-turn lanes.

Intersection and interchange countermeasure treatments may also be low cost and may include; sightline improvements, cyclist head starts and shoulder pavement marking or adding dedicated right turn phase, however the most effective treatments are likely to be more expensive e.g. right turn lane, diversion off-road path around intersection or interchange.

When a practitioner selects the desired or achievable treatments within the matrix, the before and after cyclist risk is provided for each midblock location or intersection, as well as identifying the number of locations on a route that demonstrate a reduction in cyclist risk. The high-risk locations, selected mitigation measure treatments and demonstrated reduction in risk can then be exported and used to support further development and implementation of the selected treatments.

Conclusion

The AusRAP risk assessment model and the recently developed cyclist crash likelihood matrix methodology enables popular or designated/mapped cyclist routes on high speed roads to be assessed using established crash risk factors (AusRAP SRS) and compliance of road safety and design principles (cyclist crash likelihood matrix). The matrix does not exclude or attempt to identify that higher order treatments such as physical separation or off-road cycle ways would not be more effective. The matrix identifies critical high-risk locations that require remedial treatments and allows for the selection of risk-based treatments which demonstrate the reduction in the likelihood of a cyclist being struck by a vehicle. The matrix has not yet been developed to demonstrate a benefit cost ratio (BCR), however this could be further developed. Given that a majority of the countermeasure treatments are low - medium cost, targeted and location specific (e.g. 150 m sealed shoulder, cyclist warning signage and tree trimming) the BCRs are expected to be high, particularly if some treatments can be undertaken within existing maintenance programs.

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