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In reply please quote: ST1870 – Infrastructure improvements to reduce motorcycle casualties

Your Reference: *Stakeholder consultation*

10 February 2014

To whom it may concern

Dear Colleague

Research into Infrastructure improvements to reduce motorcycle casualties

ARRB has over the 18 months has undertaken research work for Austroads (Project ST 1870) on seeking ways to improve infrastructure to reduce motorcycle casualties.

The research investigates the influence of road infrastructure elements in motorcycle-related crashes, and to identify countermeasures that have the potential to reduce the incidence and/or severity of such crashes. Road infrastructure has an influence on motorcycle safety, particularly through issues such as road design elements (e.g. horizontal alignment and intersection design), road surface friction, roadside hazards and maintenance condition.

The research to date includes an international literature review, crash data analysis and review of various motorcycle specific road safety audits and motorcycle safety guides in Australasia to identify causal and crash severity factors.

A number of findings from a crash analysis and crash likelihood and severity factors identified in various motorcycle specific road safety audits and motorcycle safety guides have been identified. These are provided in the attached summary.

It is requested that as a member of Project Working Group you collaborate with your colleagues in the disciplines of road design, asset management, maintenance and road safety to review the attached findings and provide comment in the questionnaire provided. The questionnaire is focused on identifying infrastructure related motorcycle crash likelihood factors. The details of the questionnaire are provided at the end of this communicate.

The results of the questionnaire will be included in a working paper. This working paper will detail the findings from the research completed to date including the findings from the stakeholder consultation.

The Project Working Group will review the working paper at a workshop in the first week of May 2015, this workshop will discuss and finalise the mitigation measures.

I would be most grateful if you could return the questionnaire before the 17th of April.

Yours sincerely

David Milling
ARRB Project Team Leader

Austroads Project – Infrastructure improvements to reduce motorcycle casualties – Preliminary Findings

Background

Motorcycle crashes are a significant contributor to deaths and serious injury on our roads. In Australia, motorcycle riders made up 16 percent of all fatalities in 2012, and 22 per cent of serious injury casualties despite representing only a very small percentage of total traffic volume (one per cent of VKT). The Australian National Road Safety Strategy has identified a clear upward trend in motorcycle crashes in recent years, and the situation is similar in New Zealand.

Road infrastructure has an influence on motorcycle safety, particularly through issues such as road design elements (e.g. horizontal alignment, intersection type), road surface friction, roadside hazards and maintenance condition. The purpose of this study is to identify the infrastructure-related causation and contributory factors to motorcycle crashes, and identify mitigation options.

The outcomes from this research would be used to provide guidance to practitioners, including potential updates to the Guides to Road Design, Traffic Management, Road Safety and Asset Management. The project may also assist in meeting several of the objectives from the Australian National Road Safety Strategy 2011-2020, including safety improvements on popular motorcycle routes (an action for the first three years) and providing advice ahead of plans to introduce motorcycle black spot/black length programs in all jurisdictions (a ‘future’ action).

Preliminary findings

<u>Literature Review</u>

Of the publications reviewed some linked infrastructure to motorcycle crashes. The infrastructure related issues identified were road side objects (trees, safety barriers, power poles, drainage structures etc.), poor or inconsistent delineation, surface hazards (potholes, patch repairs and audio tactile or raised markings), poor surface grip (oil and loose gravel), poor surface texture (also effects perceived performance by rider, particularly during wet weather), shoulder type and surface (width, sealed/unsealed and material on the shoulder). Of the publications reviewed none identified any of the issues as collective risk that may increase motorcycle crash risk when one or more issues are co-located.

A number of crash analysis publications were reviewed, these separated crashes by road type, urban and rural areas, multiple (motorcycle/motorcycle or motorcycle/other vehicle) and single motorcycle crashes. From the crashes reviewed it was shown that the proportion of motorcycle fatalities was curves (39%), Intersections (38%) and straights (23%). These crashes were shown by multiple and single vehicle crashes however were separated by curves, straights and intersection but not by crash time (recreational and commuting).

It was identified that in multiple vehicle crashes there was a high instance of the other driver (vehicle driver) not seeing the motorcyclist. At intersections 85% of right-of-way violations are as a result of the motorists not identifying the motorcycle. In multiple vehicle crashes the motorists was at fault for intersection and lane change crashes 71% and 21% of the time respectively.

<u>Crash analysis</u>

Crash data for the period 2001 – 2011 in Queensland, South Australia and New Zealand was analysed. These crashes were separated by road feature (curve, straight and intersection) and analysed by single or multiple vehicle crash and crash period (recreational and commuting).

The analysis showed that in SA and Qld more motorcycle crashes occur on a curve then for passenger vehicles, in NZ it is equal. Of the motorcycle crashes the proportion of crashes by road feature are shown in the table below.

	Vehicle crashes only						Total
	Curve		Straight		Intersection		
Queensland	17870	15%	51291	42%	53679	44%	122840
South Australia	6449	10%	30209	49%	25311	41%	61969
New Zealand	30501	31%	41552	42%	25956	26%	98009

	Motorcycle crashes only						Total
	Curve		Straight		Intersection		
Queensland	3142	20%	5576	35%	7281	46%	15999
South Australia	1087	21%	2351	45%	1795	34%	5233
New Zealand	3158	31%	3890	38%	3128	31%	10176

The motorcycle crashes were then separated further by the crash period. The crash period was separated into two categories, commuting (Monday – Friday) and recreational (weekends and public holidays). The results showed that a higher proportion of motorcycle crashes occurred in the commuting period. This demonstrates that motorcycle crashes are not limited to weekend recreational riding and should be catered for on rural connector roads and urban roads to allow a suitable road environment for commuting motorcyclists.

Motorcycle crashes only				
	Road Feature	**Commuting**	**Recreational**	**Total % of crashes**
Queensland	Curve	9%	11%	20%
	Straight	25%	10%	35%
	Intersection	34%	11%	45%
	Total	**67%**	**33%**	**100%**
South Australia	Curve	10%	11%	21%
	Straight	31%	14%	45%
	Intersection	25%	9%	34%
	Total	**66%**	**34%**	**100%**
New Zealand	Curve	14%	17%	31%
	Straight	25%	13%	38%
	Intersection	22%	9%	31%
	Total	**60%**	**40%**	**100%**

Further analysis of the data shows the distribution of crashes by road feature, commuting/recreational periods and single/multiple vehicle crashes, this is shown in the table below. This table shows that the distribution of crashes by road feature for single and multiple vehicle crashes is similar for each crash period with the exception of multiple vehicle crashes on straights and intersections during the commuting crash period, these crashes accounted for 39 – 46 % of motorcycle crashes in each state.

Motorcycle crashes only						
	Road Feature	**Commuting**		**Recreational**		**Total % of crashes**
		Single	**Multiple**	**Single**	**Multiple**	
Queensland	Curve	6%	3%	8%	3%	20%
	Straight	6%	18%	4%	6%	35%
	Intersection	7%	26%	4%	8%	46%
	Total	**20%**	**48%**	**16%**	**17%**	**100%**
South Australia	Curve	3%	6%	4%	7%	21%
	Straight	7%	24%	4%	10%	45%
	Intersection	3%	22%	2%	7%	34%
	Total	**13%**	**52%**	**10%**	**24%**	**100%**
New Zealand	Curve	8%	5%	12%	6%	31%
	Straight	6%	18%	5%	8%	38%
	Intersection	0%	21%	0%	9%	31%
	Total	**15%**	**45%**	**18%**	**22%**	**100%**

Midblock Crashes

From the crash analysis of Qld, SA and NZ data the following was identified for midblock crashes;

- *Horizontal geometry*
  - 20 – 30% of crashes occurred on a curve.
  - 35 – 45% of crashes occurred on a straight, a large proportion of these were multiple vehicle crashes.
- *Crash period*
  - Single vehicle crashes are more likely to occur on a straight during the commuting period and on a curve during recreational period in Qld and SA, in NZ a single vehicle crash is most likely on a curve and in both periods.
  - Multiple vehicle crashes have the same likelihood of occurring on a curve during both periods however are 2-3 times more as likely to occur on a straight during the commuting periods.
  - Of the multiple vehicle crashes that occurred during the commuting period on a straight the following crash groups were most frequent; rear end, side swipe, right angle, turning versus same direction and overtaking and lane change.

Intersection Crashes

From the crash analysis of Qld, SA and NZ data the following was identified for intersection crashes;

- *Intersection type*
  - The intersections in order of highest to lowest number of crashes is as follows; T-junction, cross intersection, roundabout, exchange, median opening and railway crossing.
  - The majority of crashes involving motorcycles occurred at T-junction (50%), cross intersection (25-40%) or roundabout (5-17%).

- *Intersection control*
  - A larger proportion of intersection crashes occurred at intersections where no controls were in place, the representation of off-carriageway, out-of-control, rear-end, lane-changes and parallel-lanes-turning crash types is high compared with intersections that have an intersection control method.
  - The following crash groups are higher on T-junction when no controls are in place; opposing-turns, adjacent-approaches, rear-end, off-carriageway (curve and straight) and out-of-control (curve and straight).
  - at signalised intersections the following crash groups in order of most frequent to less frequent occurred at each intersection type; T-junction (opposing vehicles turning, rear end and intersection from adjacent approaches), Cross intersection (opposing vehicles turning, intersection from adjacent approaches and rear end).

- *Single or multiple vehicle crash*
  - Single vehicle crashes were higher at T-junctions and roundabouts then other intersection types.
  - Multiple vehicle crashes were higher at T-junctions and cross intersections.
  - The proportion of crashes for multiple (M) vehicle or single (S) vehicle crashes at a T-junction (M 75%/ S 25%), cross intersection (M 86%/ S 14%), and roundabout (M 62%/ S 38% respectively.
  - There were a high number of single vehicle crashes at intersections in QLD. There were very few in NZ and SA.

- *Crash period*
  - Multiple vehicle crashes: there were 2 – 4 more multiple vehicle crashes at intersections in the commuting period then the recreational period.
    - The ratios for each intersection type in QLD and SA were approximately; T-intersections (3:1), cross intersections (3:1) and roundabouts (4:1). In NZ the ratios were T-intersections (3:1), cross intersections (3:1) and roundabouts (2:1).
  - Single vehicle crashes: there were 1 – 2.7 more single vehicle crashes at intersections in the commuting period then the recreational period.
    - The ratios for each intersection type in QLD and SA were approximately; T-intersections (4:1), cross intersections (3:1) and roundabouts (2:1).
    - In NZ the number of crashes for single crashes during the commuting and recreational period were the same.

Identification of motorcycle contributory and causal factors

The research to date has identified a number of causal and contributory factors that influence the likelihood of a crash and a number of roadside hazards that affect the severity of a crash. More significantly it was identified that a number of these factors co-located at a site increases the likelihood of a crash.

The factors contributing to the likelihood of a crash and those contributing to the severity of a crash are shown in the tables below. The contributory and causal factors are listed as likelihood factors and are presented in road element categories in the table below. A second table is provided to show some of the roadside hazards that affect the severity of a crash if struck.

A number of diagrams and images are provided to show the head-on zone, late detection of a hazard and the introduced risks of changing a riding path and the combination of a number of contributory and causal factors at one location.

<u>Midblock Crash Likelihood</u> – Contributory and causal factors affecting crash likelihood	
Road design or infrastructure element	**Description**
Sight distance	Good sight distance allows a rider to identify and safely negotiate the upcoming road alignment, a hazard or deficiency on the road or a vehicle that has crossed the centre line. If any of these come as a surprise to a rider emergent braking and weaving may be required, this increases the risk of the bike destabilising and a crash occurring (Figure 1). The rider may not see a road surface deficiency or hazard, traversing it may redirect the path of the bike or destabilise it. Similarly a rider may not identify another user early enough to avoid the conflict point, resulting in multiple vehicle crash.
Road alignment	<u>Horizontal</u> – A motorcycle is required to use the full width of the lane and lean the bike over whilst navigating a curve, this reduces the ability to brake heavily and redirect the riding path, this is more prevalent on a reverse or compound curve. On a curve the motorcycle is highly reliant on a smooth, consistent and debris free road surface with adequate surface texture to remain upright, if one or more are not present the likelihood of a crash increases. An errant motorcycle on a curve is likely to continue on a tangent into the opposing lane (left curve) and shoulder (right curve). A rider that selects a riding path close to the centre line on a right curve is at risk of a head-on crash, particularly leaning on a small radius curve, with narrow lanes. A repetition of curves increases the likelihood of an error, particularly when closely spaced (reverse curve). <u>Vertical</u> – steep downgrades result in braking and turning being a laborious task physically and mentally, errors can easily occur. The risk in increased in wet conditions due to the effects of surface texture or perceived surface texture (more in travel lane surface texture).
Travel period and traffic volume	During the commuting period, typically traffic volumes are higher. On multilane roads this increases the likelihood of a multivehicle crash (side-swipe, change lane etc.). On single lane roads this increases congestion, namely or rural connector roads, placing an emphasis on overtaking provisions to reduce the likelihood of risky overtaking manoeuvres.
Travel lane surface texture, condition and hazards	The travel lane surface condition influences the ability of motorcycles to maintain a riding path, effectively brake and maintain traction on curves. The surface texture or perceived surface texture (namely asphalt in the wet) and changing surface textures have an effect on the stability of a motorcycle on a curve and effects the stopping distance. Material on the road such as plat debris, gravel, fuel/oil, crack sealant, steel service covers and bridge joins causes a loss of grip between tyre and the road surface. Hazards on the road such as potholes, ruts, construction and patch repair joins, depressed or raised service pit covers, shoving will result in a rider heavily braking and redirecting the bike introducing the likelihood of loss of control, or if struck may redirect the riding path of the motorcycle.
Shoulder surface hazards	A hazard on a sealed shoulder reduces the usable formation width, resulting in a reduced recovery width for an errant motorcycle. Loose material on the shoulder is hazardous to an errant motorcycle that may be braking heavily. Overgrown grass on the shoulder blocks delineation on guard rail or guide posts.

<u>Midblock Crash Likelihood</u> – Contributory and causal factors affecting crash likelihood	
Road design or infrastructure element	**Description**
Formation width	A wide lane allows a rider to select a safe riding path whilst maintaining a buffer to vehicles in the opposing lane (left curve) or the shoulder (right curve). This buffer is particularly important on curves and is known as the 'head-on zone' (Figure 2). The shoulder provides additional width for an errant motorcycle to recover if it leaves the lane (notably on a right curve). It can also act as additional lane width to use if evasive action is required to avoid a surface hazard or vehicle. The width of the shoulder affects the likelihood of a motorcyclist striking a safety barrier or sign or power pole on the edge of the formation.
Signage and delineation	Signage and delineation provides information that allows a rider to make safe and informed decisions about travel speed and riding path selection. This reduces the need for heavy braking and re-directive manoeuvres which increase crash risk.
Curve quality	Guide posts, edge lines and centre lines are used by a rider to predict the upcoming alignment. On high speed, low radius curves (moderate to sharp curves) the motorcycle is leant over, edge lines (left curve) and centre lines (right curve) are used by a rider to follow the alignment. This is due to the rider scanning the road surface for hazards and the guideposts being out side of the field of vision.
Average speed and overtaking provisions	Inadequate overtaking provisions such as frequent passing lanes, stopping bays, over safe lengths of broken barrier line result in rider frustration, particularly when the terrain is such that a motorcycle would have a faster average speed (within the speed limit) than that of other vehicles over a length of road. This leads to unsafe overtaking manoeuvres at legal overtaking locations and illegal overtaking locations.
Road works	Road works introduce a number of hazards to motorcyclists, these include steel plates over trenches, longitudinal grooves from roto-milling, differences in road surface height creating longitudinal and perpendicular ledges, long temporary kerbing may not be attached securely or delineated, raised reflective pavement markers may be in the centre of a temporary lane.
Combination of factors	At a location where a number of factors the riding task becomes complex, a rider may miss read the alignment, the road environment may not allow a motorcycle to safely negotiate a chosen riding path, undergo heavy braking or evasive re-directive manoeuvres, see Figures 3 and 4.

Intersection Crash Likelihood – Contributory and causal factors affecting crash likelihood	
Road design or infrastructure element	**Description**
Visibility	Motorcycles are susceptible to not being seen at intersections both when on the through road or waiting in the queue or through or side road to turn. The presence of motorcycle on the through road is less conspicuous when the intersection is located on or over a crest and on the inside of a curve.
Intersection type	Roundabouts – adverse cross fall on curves, surface water from blocked central island drains and irrigation systems. A motorcycle is requires to accelerate on the curve which is risky when surface grip is not available, particularly on an adverse cross fall. Entry and exit design speeds on roundabouts are designed for vehicles, they will not by design reduce the speed of a motorcycle. Sight lines are designed assuming a motorist will slow and yield at the roundabout entry, a motorcycle can approach at speed and continue through the roundabout at speed, as can a vehicle on multilane roundabouts. T-intersection – this intersection has fewer conflict points then a cross intersection however the turning manoeuvres are less complex, as a result vehicles often turn at speed whilst only glancing to check for vehicles, a motorcycle is less likely to be seen. Cross intersection – the issues for a motorcyclist are the same as for vehicle crashes Centre median – a centre median along a midblock section is likely to have debris in it, may not be wide enough for a motorcycle to store or stop midway through a U-turn manoeuvre.
Turning provisions	A motorcycle making a right turn from the through road or side road at an un-signalised or signalised filter right turn is left exposed to through traffic Motorcycles may not be identified on a through road by a motorist making a right turn on a right filter or signalised right turn. Motorcyclists may not be seen when in the inside lane of a dual lane turn and cut off by a vehicle that crosses the continuity/turn line markings.
Horizontal geometry	Due to the braking and handling characteristics of a motorcycle an intersection conflict point located on a curve (through road, slip lane or roundabout) is more difficult for a motorcycle to evaded and stay upright.
Advance signage	A lack of advance directional or warning signage or indeed unclear or cluttered signage does not allow a motorcycle to identify an upcoming intersection. This may lead to heavy breaking, lane changes or re-directive manoeuvres which all introduce crash risk
Line of sight	Safe intersection and Approach sight distance allow a motorcyclist to reduce speed to yield or scan for a vehicle. Dependent on the road surface condition and the motorcycles braking technology and riders experience the design stopping distance may not be sufficient to avoid a conflict, if the line of sight does not provide the minimal distance as per design standards the risk of loss of control or a collision with another vehicle is increased

Intersection Crash Likelihood – Contributory and causal factors affecting crash likelihood	
Road design or infrastructure element	**Description**
Travel lane surface texture, condition and hazards	The issues are the same as for the midblock however more critical in the event braking or re-directive manoeuvre is being under taken to avoid a collision.

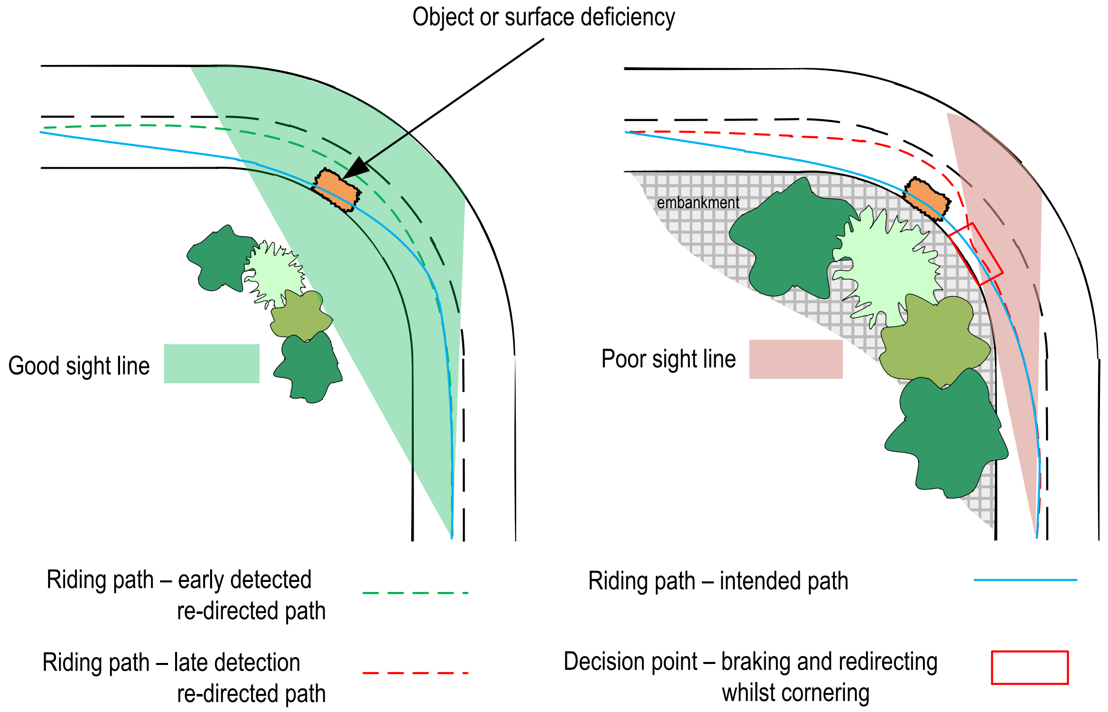

Figure 1: Identifying an object early on a curve for a safe, consistent riding path

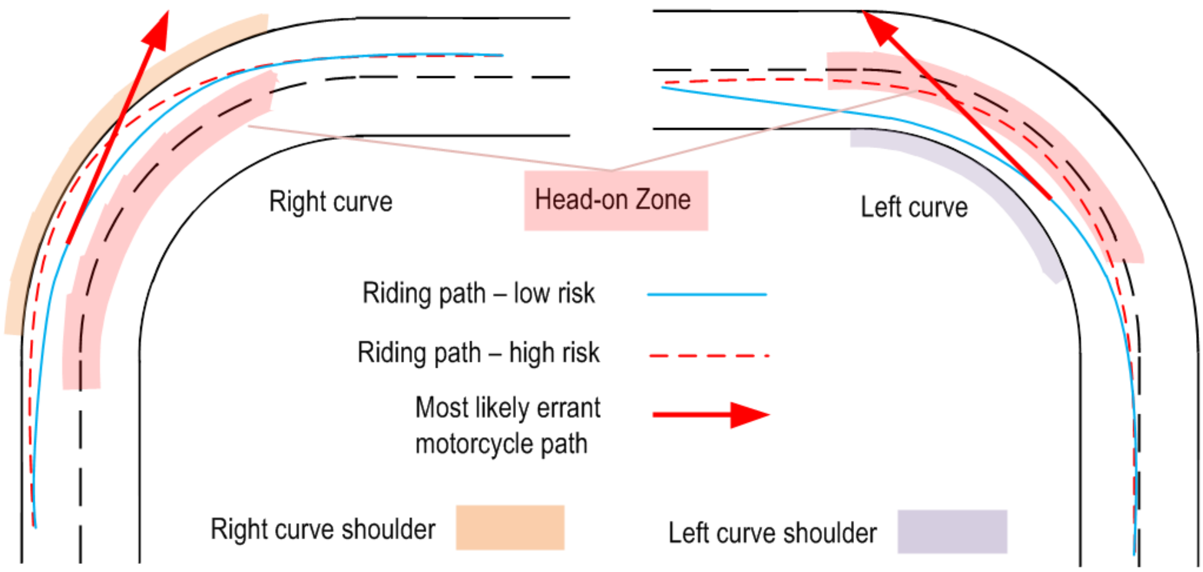

Figure 2: Low risk and high risk riding paths for left and right curves

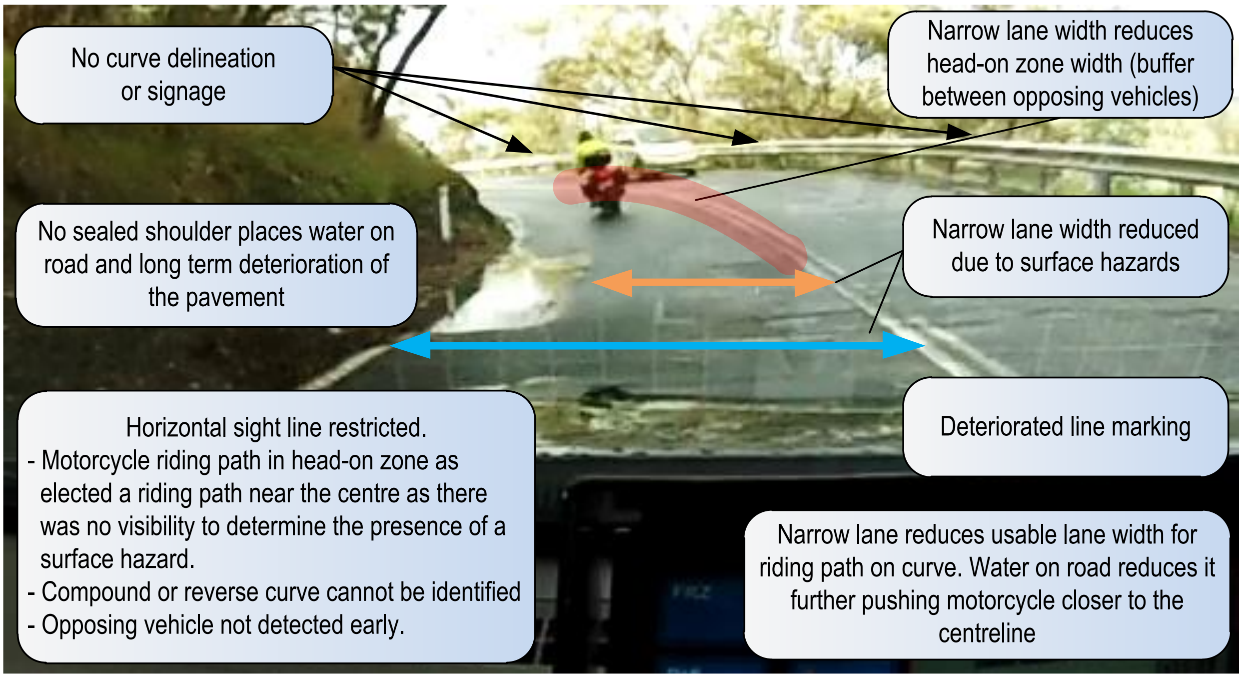

Figure 3: Example of a combination of causal and contributory factors at one location.

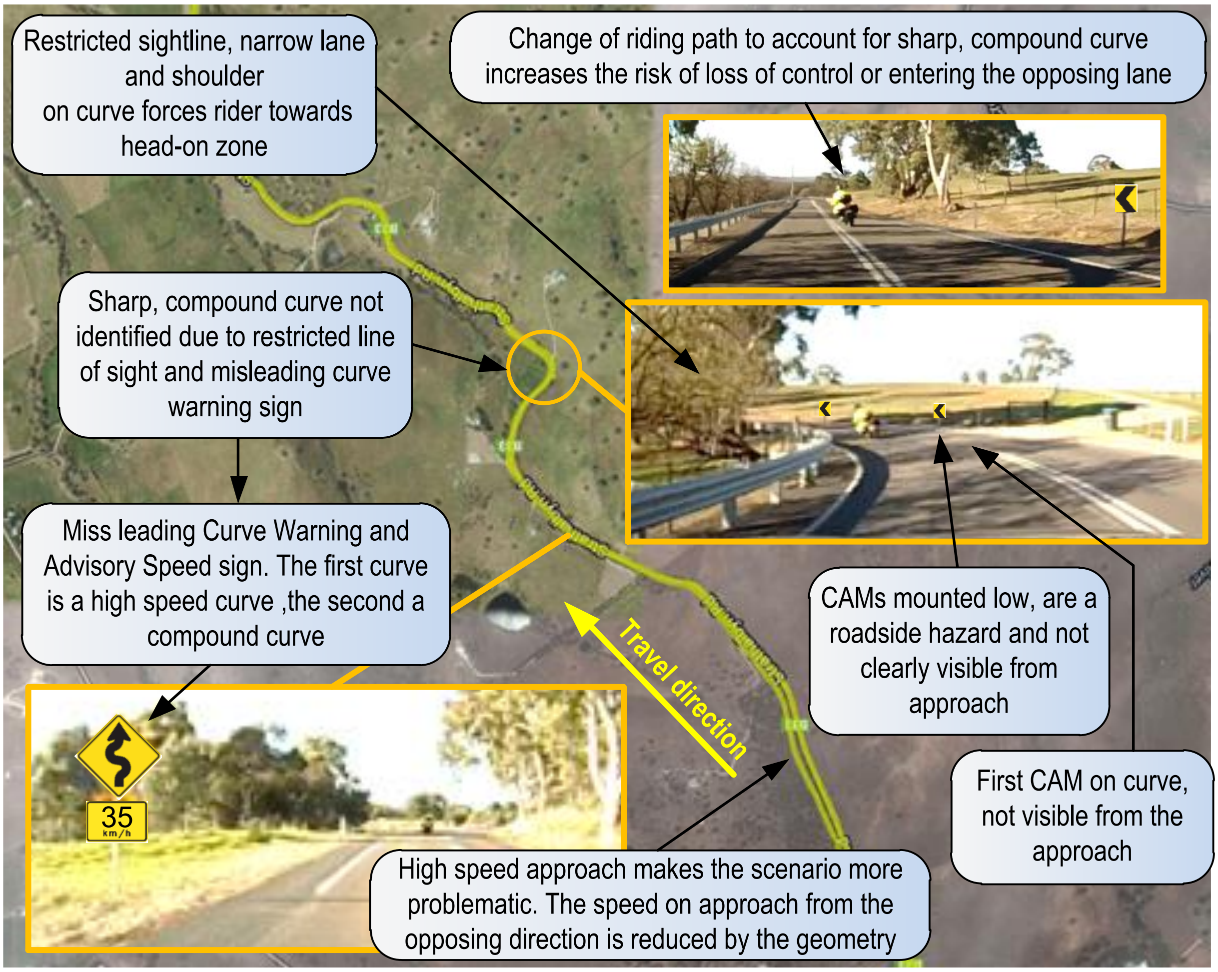

Figure 4: Example of a combination of causal and contributory factors at one location.

Austroads Project – Infrastructure improvements to reduce motorcycle casualties – Stakeholder Consultation

Feedback sought

ARRB welcomes feedback on your local experiences with motorcycle safety. Any additional information on contributory or casual factors that affect crash likelihood would be greatly appreciated.

This is your states opportunity to contribute to motorcycle safety. The results of this project will most likely lead to a change in practice in design, asset management and maintenance practices. It is anticipated that asset management and maintenance funding and management will benefit from this project if the right stakeholder input is achieved.

Please collaborate with your colleagues to spend 30 - 45 minutes of your time perusing the attached questionnaire. The questionnaire gives an opportunity for input from the asset management, maintenance and design disciplines.

Please complete the questionnaire in the attached excel file. Alternatively, send comments to David, the Project Team Leader at david.milling@arrb.com.au or call him on 07 3260 3500 or 0438 859 779 if you wish to discuss further.