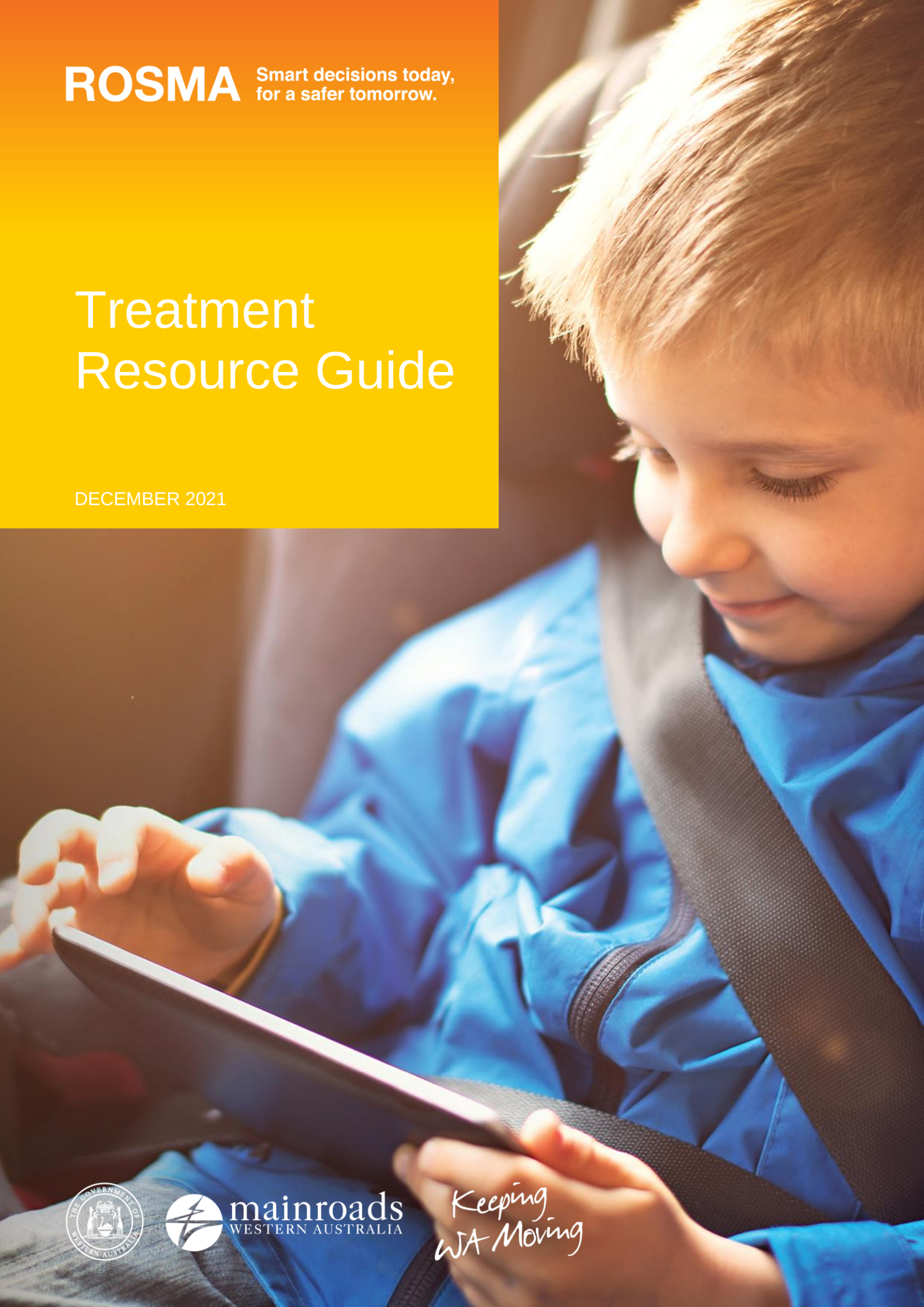
ROSMA Smart decisions today, for a safer tomorrow.

# Treatment Resource Guide

DECEMBER 2021



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# Document Control

| | |
|---|---|
| Owner | Road Safety Branch |
| Custodian | Manager Road Safety Branch |
| Document Number | D15#68384 |
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| Review Frequency | Continuous |

# Amendments

| Revision Number | Revision Date | Description of Key Changes | Section / Page No. |
|---|---|---|---|
| Issue 1 | 29/06/2016 | First live version on RM (TRIM) | All |
| Issue 2 | 02/08/2016 | Changes made to CRF estimation examples; KSI crash reduction for flexible barriers presented separately | 4.5 & 7.6 |
| Issue 3 | 02/09/2016 | Caveat added to 2 m sealed shoulder KSI CRF's. | 7.7 |
| Issue 4 | 16/10/2017 | Rural Cross Section Maps added | 6.3 |
| Issue 5 | 23/01/2019 | Links enabling access to key documents and tools from outside Main Roads added. | |
| Issue 6 | 19/12/2019 | Additional Lanes Added | 7.9 |
| Issue 7 | 18/03/2020 | Change to Lowering Speed Limits | 7.13 |
| Issue 8 | 23/12/2021 | Extensive review of CRFs, cost ranges and treatment life. Inclusion of several new countermeasures and associated information. Inclusion of new pictures. | Sections 4.1, 6, 7.1, 8.1 to 8.39 |

# 1 Purpose

This document provides a list of road safety treatments and countermeasures that are known to reduce KSI (Killed and Serious Injury) crashes. It should be used as reference document when determining appropriate road treatments in the Assess, Select and Develop phases of proposed road infrastructure projects and during development of route strategies.

# 2 Scope

This document forms part of the ROSMA (Road Safety Management) system as shown in Figure 1.

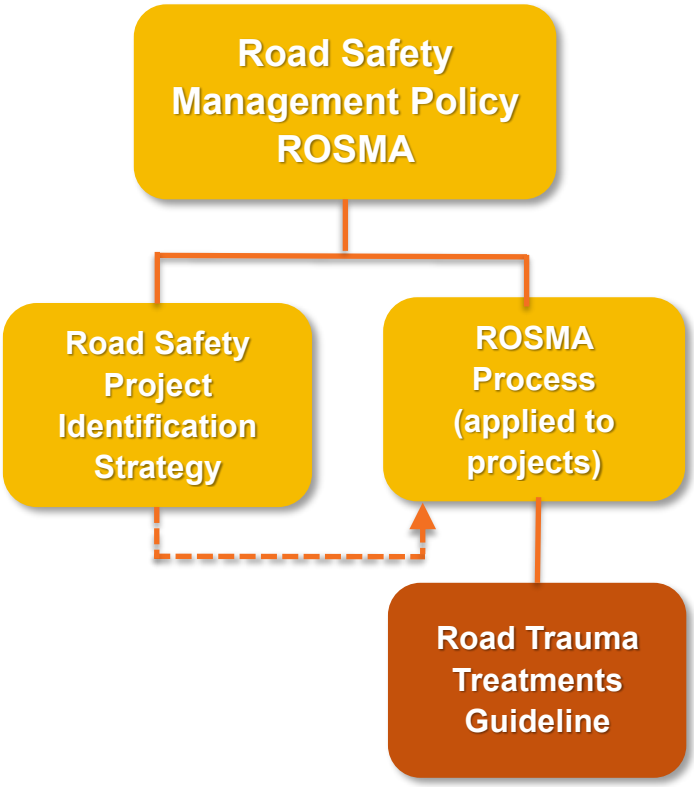



Figure 1: The ROSMA document tree

This document, the Road Trauma Treatment Guideline, must not be used in isolation to determine KSI Crash treatments. Before considering the treatments and countermeasures presented in this document is necessary to understand the factors contributing to KSI Crashes at the location. Without this assessment, inappropriate, unsatisfactory or even unsafe treatments may be proposed. Detailed analysis will help to determine whether a single or combination of treatments is most appropriate given the prevailing and expected circumstances.

The Road Trauma Reduction Guideline[1] describes the process of KSI Crash Investigation which itself is based on Austroads Guide RS08-15 "Guide to Road Safety Part 8: Treatment of Crash Locations".

[1] Users external to Main Roads can download the Road Trauma Reduction Guideline from this page: https://www.mainroads.wa.gov.au/OurRoads/RoadSafety/Pages/managementsystem.aspx

This document is a living document, with treatments and countermeasures being added and amended from time to time[2]. It is therefore important to use the up-to-date version of this document, which is accessed from this link: Road Trauma Treatment Guideline or from this page:

https://www.mainroads.wa.gov.au/technical-commercial/road-safety/management-system-rosma/ (scroll down to *Road Trauma Treatments* link). As this is a living document, users of this guideline are encouraged to submit information about treatments and countermeasures to roadsafety@mainroads.wa.gov.au to enable continuous improvement. Although not mandated, a template for submitting an update is presented in Appendix A.

It is acknowledged that not all possible treatments and countermeasures are included in this document. If a suitable treatment or countermeasure cannot be sourced from this document, then reference should be made to Section which contains links to other available documents and resources.

# 3 Definitions

Definitions of acronyms and terms used in this document can be found below.

| Term | Definition |
|---|---|
| BCR | Benefit cost ratio |
| CARS | Crash Analysis Reporting System, was superseded by Crash Map in 2021. |
| Crash Modification Factor (CMF) | A factor used to compute the expected number of crashes after implementing a given treatment. For example, if there are 10 crashes before the implementation of a treatment with a Crash Modification Factor of 0.8, there would be expected to be 8 crashes following treatment (during an equivalent period of time). (See Section 4.3)<br>CMF = 1 - (CRF/100) |
| Crash Reduction Factor (CRF) | The percentage reduction in crashes resulting from the implementation of a treatment. For example, if there are 10 crashes before the implementation of a treatment with a Crash Reduction Factor of 20%, there would be expected to be 20% less crashes following treatment, in this case 8 crashes (during an equivalent period of time). (See Section 4.3)<br>CRF = (1 - CMF)*100 |
| Casualty Crashes | Includes medical, hospital and fatal severity crash outcomes |
| Countermeasure | A physical measure or operational change implemented to counter the frequency of KSI crashes |
| KSI Crash | Killed and serious injury crash |
| Treatment | Either a single or suite of countermeasures |

[2] Refer to the ROSMA Continuous Improvement Plan for information about what treatment monitoring.

# 4 KSI Crash Reductions

## 4.1 Derivation

This treatment resource has been compiled using evidence based assessments of treatments and countermeasures with known crash reduction potential.

Given the objective of the Safe System approach is to eliminate death and serious injury, it is important to understand the effect that different interventions have on fatal and serious outcomes (i.e. KSI crashes).

Much of the research on intervention effectiveness provides information on casualty reduction (i.e. reduction in deaths, serious injury and minor injury combined) or on change in all crashes (including non-injury). This is an important distinction, and it is unfortunate that information on fatal and serious outcomes is so scarce.

Although it is desirable to minimise all crash types, including crashes that do not result in injury, an overall reduction in fatal and serious injury is paramount. Safety professionals should not be put off using interventions that have a neutral effect on minor and non-injury crashes, and there may actually be situations where such crashes will increase (typically through a reduction in severity of the crashes that do continue to occur at a treated location).

The expected reduction in fatal and serious crash outcomes is often higher than the reduction in all casualties. As an example, BITRE (2012) found the impact on crashes from installation of roundabouts to be greater for higher severity outcomes:

- effect on property damage only: 52% reduction
- effect on casualties: 71% reduction
- effect on fatalities: 79% reduction

Similar trends were seen in a European study by Jensen (2013). Therefore, using the casualty reduction will often lead to a conservative value for the expected reduction in fatal and serious injury[3].

In the absence of information on the effect of interventions on fatal and serious crash outcomes, information on casualty reduction has been used as a starting point for determining the likely KSI crash reductions that are presented in this guideline.

In some cases there is a range or, worse still, contradictory information about crash reduction quoted in various studies. Where this is the case, a best estimate has been arrived taking into account the quality of the source information. For example, a general reference to crash reduction (e.g. in a table or figure) is given less weighting than a study that reports on KSI crash reduction by type of KSI crash in a context that is applicable to Western Australia. Inevitably an element of engineering judgement has also been applied to arrive at the KSI crash reductions quoted in this guideline.

In 2020/2021 MRWA and Australian Road Research Board (ARRB) reviewed the CRFs contained in this document and the Crashmap spreadsheets under the Western Australian Road Research Innovation Program (WARRIP). The project was undertaken over a number stages and the project report (ARRB 2021 *[D21#1302684[4]]*) should be reviewed to understand the origin of the CRF figures contained within both documents. The project included a literature review, review of other Australian jurisdictions' recommended CRFs and workshop with MRWA's and Western Australian road safety experts. In some instances, where a particular source was the primary evidence to support the adoption of a particular CRF that source has been included as well. However, for individuals wishing to understand the origins and process in deriving the CRFs contained in either document it is key they refer to the project report (ARRB 2021 *[D21#1302684]*).

[3] http://roadsafety.piarc.org/en/planning-design-operation-intervention-selection/intervention-selection

[4] MRWA document reference number. For missing appendices, see: D21#1302687, D21#1302691, D21#1302693, D21#1302696, D21#1302701, D21#1302706, D21#1302709 and D21#1302712.

## 4.2 Applicability

It cannot be stressed enough that the KSI crash reductions quoted in this guideline are only applicable where the treatment or countermeasure is matched to the problem identified. There is no substitute to carrying out detailed crash investigation, focusing on casualty crashes where recorded.

For example, KSI crashes in the vicinity of a horizontal curve may be the result of any or many of the following contributory factors:

- Horizontal geometry out of context with the adjacent road section
- Vertical profile compatible with the horizontal
- Inappropriate superelevation
- Lack of adequate surface texture

If that is the case, then a package of countermeasures comprising only improved sight distance and curve warning markers are unlikely to lead to the full KSI crash reductions quoted in this guideline.

## 4.3 KSI Crash Reduction Factors

This document presents KSI crash reduction factors. These should not be confused with KSI crash modification factors.

A Crash Reduction Factor (CRF) is the percentage reduction in crashes resulting from the implementation of a treatment or countermeasure. For example, if there are 10 crashes before the implementation of a treatment with a Crash Reduction Factor of 20%, there would be expected to be 20% less crashes following treatment during an equivalent time period, in this case 8 crashes.

Crash Modifications Factors (CMF), a term often used interchangeably with CRF although not technically the same, is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure. For example, if there are 10 crashes before the implementation of a treatment with a Crash Modification Factor of 0.8, there would be expected to be 8 crashes following treatment during an equivalent time period.

Therefore, the relationship between CRF and CMF can be expressed as follows;

$$CMF = 1 - (CRF/100)$$

For example, if a particular countermeasure is expected to reduce the number of crashes by 23% (CRF = 23%), the CMF will be 1 - (23/100) = 0.77.

It is important to note that a CRF (or CMF) represents the long-term expected reduction; the actual reduction may vary. For more information see Section 4.6 (on page 45) of the Austroads Guide to Road Safety Part 8: Treatment of Crash Locations (ACRS08-15).

## 4.4 Multiple countermeasures – Combining KSI Crash Reduction Factors

Where a treatment comprises two or more countermeasures applied at the same location for example with CRF of 20% and 30% respectively, the total benefit is 44% (not 50%).

The 20% reduction associated with one treatment reduces the frequency of KSI crashes to 80% of their original level and the 30% reduction associated with the other treatment reduces that 80% by a further 30% to 56% of the original level. This equates to a reduction of 44%. Therefore;

$$\text{Combined CRF} = 1 - ((1-\text{CRF Countermeasure1}) \times (1-\text{CRF Countermeasure 2}))$$

Note: the order of the Crash Reduction factors makes no difference to the outcome of this calculation.) For more countermeasures, continue to multiply 1 minus the CRF for all treatments.

For more information see Section 4.6 (on page 45) of the Austroads Guide RS08-15 "Guide to Road Safety Part 8: Treatment of Crash Locations". In addition the Reduction Target Tool[5] includes a simple tool for combining the CRFs for up to 13 multiple countermeasures (see the "estimators" worksheet).

## 4.5 Estimating KSI Crash Reduction Factors

There are occasions where it may be necessary to estimate the crash reduction factor associated with a countermeasure. For example;

- The measure is novel
- There are no reliable studies
- The KSI casualty reduction is highly dependent upon the context of the implementation of the countermeasure

A good approach to estimating the reduction is to consider how the countermeasure will affect the number of KSI crashes by considering its impact on;

- Frequency of the underlying cause
- Probability that the underlying cause will lead to a crash
- Whether or not the Severity of the crash is altered

Example 1 (Frequency)

Scenario: Fencing considered as a countermeasure for animal hit crashes.

Fencing would be expected to reduce the frequency of animals on the carriageway, but would not affect the probability or severity of the crash (when the animal is on the road).

When considering how the frequency will be changed, consideration could be made of the effectiveness of fencing in similar situations. Other factors that could be considered are how well the fencing is likely to be maintained and how effective it is likely to be in relation to different types of animal.

For example, if it is shown that in a similar context it has been 80% effective at reducing the frequency of livestock on the road a CRF of 80% can be used. However if the crashes occurring involve Kangaroos, which can eaily jump over fences, then a more conservative value of 20% may be more appropriate for this treatment.

Example 2 (Probability):

Scenario: vehicle activated warning signs considered as a countermeasure for right angle crashes at a rural intersection.

In this case the underlying frequency of the crash risk is not altered. (Vehicles still enter the intersection at the same rate resulting in the same number of interactions.) However, by alerting drivers to the likelihood of other vehicles at the intersection the probability of collision reduces. Therefore, it is now necessary to estimate how the probability will change.

Example 3 (Severity):

[5] Users external to Main Roads can download the Road Target Tool from this page: https://www.mainroads.wa.gov.au/OurRoads/RoadSafety/Pages/managementsystem.aspx

Scenario: Cushioning of existing barrier posts as a countermeasure for motorcycle KSI crashes.

In this example, only the severity of the crash is reduced and this change only applies to motorcycle crashes. Therefore the CRF should only be estimated in terms of the reduced severity of the outcome of the crash.

# 5 Other Treatments and Countermeasures

Table 1 contains a list of resources that can be used to identify other treatments and countermeasures not covered by this document.

Table 1: Treatments and countermeasure resources

| Resource | Notes and links |
|---|---|
| iRAP Road Safety Toolkit | A web-based tool that allows users to identify treatments, road users, crash types and management policies.<br>www.toolkit.irap.org |
| Crash Modification Clearing House | A web based tool that allows users to identity treatments and countermeasures. (Note the use of CMF and not CMR)<br>http://www.cmfclearinghouse.org/ |
| High-risk Rural Road Guide (New Zealand Transport Agency) | The High-risk rural road guide was developed to assist road controlling authorities in targeting rural roads (i.e. those with a posted speed limit of 80 km/h or more)<br>https://www.nzta.govt.nz/resources/high-risk-rural-roads-guide/ |
| High-risk Intersections Guide (New Zealand Transport Agency) | The guide introduces a new way to identify high-risk intersections and, using the Safe System approach, provides best practice guidance on reducing deaths and serious injuries at high-risk intersections.<br>https://www.nzta.govt.nz/resources/high-risk-intersections-guide/ |
| Rune Elvik – Handbook of Road Safety Measures – Second Edition (2009) | The second edition of the "Handbook of Road Safety Measures" (previously published in 2004) gives state-of-the-art summaries of current knowledge regarding the effects of 128 road safety measures. It covers all areas of road safety including: traffic control; vehicle inspection; driver training; publicity campaigns; police enforcement; and, general policy instruments. |
| Austroads Research Report AP-R509-16 “Safe System Assessment Framework” | Includes a treatment hierarchy highlighting examples of Safe System solutions addressing each of the key crash problem types. |
| PIARC Countermeasures | This catalogue presents a set of common design errors and suggests a range of measures to overcome them; it also indicates the comparative countermeasure costs to help prioritise the work.<br>http://www.piarc.org/en/order-library/6458-en-PIARC%20Catalogue%20of%20design%20safety%20problems%20and%20potential%20countermeasures.htm |

# 6 Crashmap Crash Reduction Factors (CRFs)

Below are links to Crashmap CRFs for both Intersection and Road Section Treatments –

Intersection – D19#710570

Road Section – D19#710579

-- CrashMap -- Intersection CRFs ---

-- CrashMap -- Road Section CRFs -

Where a discrepancy is found between the CRF quoted in the Crashmap documentation and the ROSMA Treatment Resource Guide, the Treatment Resource Guide will take precedence.

# 7 Using this Guideline

## 7.1 Format of Factsheets

Information on treatments and countermeasures are presented in series of factsheets using the format as described in Table 2.

Table 2: Factsheet Format

| **Name of Treatment or Countermeasure** | **KSI crash type icon:** |
|---|---|
| | **Side Impact**  **Run off Road**  <br>**Head on**  **Rear end**  <br>**Pedestrian**  **Motorcycle**  <br>**Cyclist**  |

| | |
|---|---|
| Description | A description of the treatment or countermeasure |
| Type | A description of each type of countermeasure (if applicable) |
| KSI Crash Reduction | The KSI crash reduction associated with the treatment or countermeasure. |
| Application | Information about the applicability of each treatment or countermeasure. |
| Issues | Information about issues associated with each treatment or countermeasure. |
| Other Benefits | Information about other benefits associated with each treatment or countermeasure. |
| Cost | Indicative costs either per km for midblock or per intersection.<br><br>$ – Low – Less than $100,000<br>$$ – Low to Medium – $100,000 to $500,000<br>$$$ – Medium – $500,000 to $1,000,000<br>$$$$ – Medium to High – $1,000,000 - $2,000,000<br>$$$$$ – High – Higher than $2,000,000 |
| Benefit Cost Ratio | ✓ Low<br>✓✓ Average<br>✓✓✓ Good<br>✓✓✓✓ Very Good<br>✓✓✓✓✓ Great |
| Treatment Life | The expected treatment life |
| References/ Further Information | Other information and further reading |

## 7.2 Rural Cross Section Maps

This section contains the the Rural Cross Section Maps. It is important for Project Managers to refer to these maps as part of their project considerations to ensure that consistency of formation; seal and line marking elements of projects are achieved across the state.

These maps have been produced to maximise the safety benefits from cross sectional elements of the road environment taking into account prior safety performance, the future traffic volume (2031), and current cross sectional configuration. These maps will also assist in meeting organisational, state and national road safety targets

The maps provide the following details for all rural high-speed state roads:

- seal and formation width
- audible center and edge lines
- selected use of 1 meter painted audible centerlines.

The maps can be found by clicking on the following link –

https://www.mainroads.wa.gov.au/technical-commercial/technical-library/road-traffic-engineering/guide-to-road-design/mrwa-supplement-to-austroads-guide-to-road-design-part-3/#mcetoc_1ebkd0nacq6d

Or via the Main Roads WA website by clicking on:

1. *Technical and Commercial* tab (at top of screen)
2. *Technical Library* tab
3. *Road Traffic Engineering* (from list on left side of screen)
4. *Guide to Road Design* (from list on left side of screen)
5. *Road Design Part 3* (fourth down on list on left side of screen)
6. Scroll down to section 4 *Cross Sections*

# 8 Countermeasure Factsheets

## 8.1 Edge Delineation

<table>
<tr><th colspan="3">Edge Delineation</th></tr>
<tr><td>Description</td><td colspan="2">Provision of painted or audible tactile markings at the edge of the traffic lane.</td></tr>
<tr><td rowspan="2">Types</td><td>Painted Edgeline a painted line at the edge of the traffic lane.</td><td>  </td></tr>
<tr><td>Audio Tactile Line Marking (ATLM) Edgeline, also known as an audible edge line (ATLM edgeline), this treatment provides audible and tactile feedback to road users. Includes profile edge lining, Edge line (shoulder) rumble strip, or shoulder grooving</td><td>  </td></tr>
<tr><td>KSI Crash Reduction</td><td colspan="2">REDUCTION IN RUN OFF ROAD KSI CRASHES
<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">Treatment</th></tr>
<tr><th>Painted</th><th>ATLM Edge Line*</th></tr>
<tr><td rowspan="2">Existing</td><td>No Edgeline</td><td>25%</td><td>40%</td></tr>
<tr><td>Painted</td><td>–</td><td>10%/15%/20%<br>(when accompanied by 0.5 m/1.0 m/1.5 m sealed shoulder respectively)</td></tr>
</table>
*If you are increasing sealed shoulder width in conjunction with ATLM edgeline treatment use figures in section 4.7.*</td></tr>
<tr><td>Crash Map Spreadsheet Reference</td><td colspan="2">231–235</td></tr>
<tr><td>Application</td><td colspan="2">Edge lines help to delineate the edges of the traffic lanes, discouraging drivers from driving on the shoulder, and providing clear delineation of the road's edge. This provides a guide of the alignment of the road which can help to make driving safer and more comfortable and is especially useful under adverse weather conditions and at night.<br><br>ATLM edgelines may replace or supplement standard edge-line markings on-road sections where:<br>• traffic volumes are high;<br>• there is a significant number of run-off-road crashes in which fatigue or driver inattention is identified;<br>• there are specific site problems such as poor visibility, frequent or heavy rain, or night-time crash history<br><br>As run-off-road crashes resulting from fatigue or other factors can occur anywhere along a route, audio tactile edge-lines should be installed as a corridor treatment rather than be localised.</td></tr>
</table>

| **Edge Delineation** | |
|---|---|
| **Issues** | Issues with the treatment may include:<br>• ATLM edgelines may present a hazard to cyclists and motorcyclists.<br>• They should be implemented over a continuous length rather than isolated sites.<br>• The auditory and tactile effect is less noticeable for heavy vehicle drivers.<br>• Can cause noise disturbance for adjoining land users. |
| **Other Benefits** | Reduced unsealed shoulder maintenance costs.<br>Many lane-departure warning systems within newer vehicles rely on the visual cue of an edge line to work. Potential for safety benefits above and beyond what is recognised currently as this technology becomes more commonplace. |
| **Cost** | $ (Low) |
| **Benefit-Cost Ratio** |  |
| **Treatment Life** | 5 years |
| **References/ Further Information** | See Main Roads guidance on the implementation of ATLM edgelines (contact RTE branch).<br>Austroads 2012, *Effectiveness of Road Safety Engineering Treatments*, AP-R422-12, Austroads, Sydney, NSW.<br>Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW.<br>WARRIP 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

## 8.2 Median delineation and audio-tactile treatments

<table>
<tr><th colspan="2">Median Delineation and Audio-tactile Treatments</th></tr>
<tr><td>Description</td><td>Median delineation provides road users with a clear appreciation of the road alignment, including the severity of any horizontal curves in the road ahead and thereby helps to reduce the likelihood of Head-on and overtaking KSI crashes.<br><br>Driving on a road with inadequate delineation reduces the visual cues needed to assist the driver in choosing an optimal speed and path along the roadway.</td></tr>
<tr><td rowspan="4">Types</td><td>A Centreline is used to separate opposing streams of traffic.<br><br>Barrier lines (solid double lines) are a particular form of separation line that prohibit drivers from using the opposing traffic lane(s) to overtake.<br><br>  </td></tr>
<tr><td>Audio Tactile Line Marking (ATLM) Centreline can be used to replace or supplement standard centreline markings on sections of road where traffic volumes are not high enough for median barrier treatments<br><br>  </td></tr>
<tr><td>Painted/Flush Medians are continuous painted areas marked with white diagonal lines that are marked down the centre of the road. Narrow flush medians can be used simply to separate opposing traffic in a similar way to wide centrelines, however are typically only used in urban environments.<br><br>  </td></tr>
<tr><td>One Metre Wide Centre Line Treatment (WCLT) with Audio Tactile Line Marking (ATLM) combines the enhanced separation of opposing traffic streams provided by a flush median with the audio-tactile warning of line marking to both alert drivers they are deviating from the intended travel path and give them additional time to react.Typically these are only used in rural environments.<br><br>  <br>Source: ARRB</td></tr>
</table>

## Median Delineation and Audio-tactile Treatments

**Raised Reflective Pavement Markers (RRPM),** provide excellent night-time delineation. They enable the alignment of the road to be seen from a greater distance than painted markings alone, particularly under wet conditions.

They also provide tactile and audible warnings to drivers when vehicles cross over the markers. They are typically used to supplement barrier lines and median treatments.

**Internally illuminated pavement markers (IIPMs),** also known as LED raised pavement markers or intelligent road studs, are a similar concept to RRPMs, but are self-illuminating. This serves to provide enhanced delineation, or delineation when RRPMs are not considered fully effective.

**KSI Crash Reduction**

REDUCTION IN HEAD ON KSI CRASHES

| | | Treatment | | | |
|---|---|---|---|---|---|
| | | Painted | ATLM centerline | Flush Median[1] | WCLT with ATLM |
| Existing | No Lines | 20% | 35% | 45% | 50% |
| | Painted | – | 15% | 28% | 30% |
| | | RRPMs | | IIPMs | |
| | No Markers | 15% | | 10% | |

REDUCTION IN RUN OFF ROAD KSI CRASHES

| | | Treatment | | | |
|---|---|---|---|---|---|
| | | Painted | ATLM Centreline | Flush Median[1] | WCLT with ATLM |
| Existing | No Lines | 10% | 23% | 25% | 30% |
| | Painted | – | 13% | 20% | 18% |

REDUCTION IN PEDESTRIAN KSI CRASHES

| | | Treatment |
|---|---|---|
| | | Flush Median[1] |
| Existing | No Lines | 35% |
| | Painted | 35% |

*Note 1: Applies to flush medians in urban environments*

** : Where WCLT is less that 1 m CRF's shall be proportionate on this difference between ATLM centerline and WCL.*

| **Median Delineation and Audio-tactile Treatments**  | |
|---|---|
| **Crash Map Spreadsheet Reference** | 225 (RRPM), 236 – 243 |
| **Application** | Australian Standards recommend that centrelines are provided on two-lane sealed pavements (including bridges) which are 5.5 m or more wide and where the traffic volumes are significant.<br>When installing a flush median, it should be ensured that sufficient seal width is available, so they can be installed without unduly compromising sealed shoulder width. Central hatching can be installed over a continuous length of road or at specific points – for example, along horizontal curves.<br>For maximum effectiveness, these treatments should be implemented in a continuous and consistent manner. |
| **Issues** | Audio-tactile centreline marking may present a hazard to cyclists and motorcyclists if centreline is crossed. The audible noise they produce when crossed can be a nuisance to adjacent land use/residences. The audio and tactile response is also much less effective for heavy vehicles.<br>Increasing width of flush medians can provide greater separation between opposing streams, but care should be taken to ensure that they are not so wide as to allow drivers to (illegally) use them as overtaking lanes and so as that there is still sufficient space for wider vehicle, such as trucks, to travel within the through traffic lane without overriding the median.<br>There have been some issues with theft of IIPMs when used in high pedestrianised areas. |
| **Other Benefits** | Clearer delineation through road sections and intersections can result in improved (more intuitive) driver responses to the road environment. |
| **Cost** | RRPMs, IIPMs, Painted and ATLM centreline: $ - Low<br>Flush median, WCLT and WCLT with ATLM: $$ - Low to Medium |
| **Benefit Cost Ratio** | ✅✅ |
| **Treatment Life** | IIPMs: 5 years<br>All other treatments: 5 years |
| **References/ Further Information** | Accident Reduction Guide, RTA Technical Direction for Road Safety Practitioners TD2004/RS01; March 2004;<br>Austroads 2010, Road Safety Engineering Risk Assessment Part 6: Crash Reduction Rates, AP-T151-10, Austroads, Sydney, NSW.<br>Austroads 2016, Guidance on Median and Centreline Treatments to Reduce Head-on Casualties, AP-519-16, Austroads, Sydney, NSW.<br>IIMP/RRPM: Austroads Unpublished Project No. SS1959;<br>AP-R442-11(C3.2/C4.2)<br>"The Safety Benefits of Continuous Narrow Painted Median Trial – Preliminary Findings (www.tmr.qld.gov.au)<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.3 Median physical non-barrier treatments

## Median Physical Non-barrier Treatments

**Description**

Physical separation between opposing traffic streams. (For Median Barriers refer to Factsheet 8.4)

A range of lower-cost median solutions aimed at retrofitting existing undivided roads are also available.

**Types**

**Continuous raised (kerbed) median**

This treatment provides physical separation between opposing traffic streams.

**Flexible bollards,** also known as safe-hit posts, provide a visual separation and physical obstacle between opposing streams of traffic. They are a possible treatment where there is insufficient road space for the installation of a traditional median or median barrier and are often installed in conjunction with barrier kerbs. The features are fully flexible and are not designed to physically prevent vehicles from crossing the median.

**Median plantations** can provide a visual separation of opposing traffic providing a shield from headlight glare. Median plantations should be continuous to prevent intermittent dazzling of drivers from glare. They shall also be frangible to ensure they do not present a hazard to errant vehicles.

**KSI Crash Reduction**

REDUCTION IN KSI CRASHES

| | | Treatment |
|---|---|---|
| | | Raised Median |
| Crash Type | Pedestrian | 20% |
| | Head-on | 90% |
| | Intersection | 90% |
| | Rear-end | 50% |

**Crash Map Spreadsheet Reference**

244

| **Median Physical Non-barrier Treatments**  | |
|---|---|
| **Application** | Provision of a road median is usually associated with a major road upgrade or a duplication of carriageways.<br>Even narrow medians (e.g. dividing strips) limit the turning and property access options along a road section and provide opportunities to redirect these movements to safer locations. Medians may include turning facilities where appropriate. These treatments are valuable where frequent property access results in an increased crash frequency.<br>In many cases, narrowing of the through traffic lanes or removing a parking lane may be necessary to create adequate width for the median. In the restricted cases, a very narrow median may be provided in place of an existing barrier centreline, especially if non-compliance with barrier line is a significant problem. |
| **Issues** | Availability of sufficient road width is necessary and determines the extent and type of median solution. In some cases, road widening may be required to implement this treatment. Community acceptance of the medians that restrict turning movements may be an issue. Regular gaps may need to be provided, along with sheltered turning lanes.<br>Very narrow medians often cannot accommodate signs, traffic signals hardware, or provide staging for pedestrians. Providing adequate roadside lighting for a narrow median may be an issue if the carriageways are wide. |
| **Other Benefits** | The following benefits may be gained from installing a raised median:<br>• separation of opposing traffic flows<br>• simpler traffic movements leading to less opportunity for conflict<br>• redirection of turning movements to safer locations<br>• protection for turning traffic<br>• staged crossing by pedestrians<br>• space for the provision of important signs. |
| **Cost** | Cost depends on length, width, and need for road widening.<br>Flexible bollards (1km of treated road section): $ - Low<br>Raised median and median plantations (1km of treated road section): $$ Low to Medium |
| **Benefit Cost Ratio** | ✅✅ |
| **Treatment Life** | Flexible bollards and median plantations: 10 years<br>Raised median: 20 years |
| **References/ Further Information** | Austroads 2015, Guide to Road Safety Part 8: Treatment of Crash Locations, AGRS08-15, Austroads, Sydney, NSW.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.4 Median Barrier

## Median Barrier

**Description**

Median barriers physically separate opposing traffic lanes and minimise the possibility of errant vehicles travelling into opposing traffic. Median barriers are provided on high speed and high volume roads where conditions or median width requires physical separation. They can be used in both urban and rural areas.
Median barriers work by dissipating the kinetic energy of a vehicle crash into a more manageable form of energy such as:

- Heat through friction
- Deformation or fracture of barrier and/or vehicle
- Controlled displacement of the barrier and/or vehicle

**Types**

**Rigid median barriers** are generally constructed from concrete and absorb little energy on impact which may result in a more severe crash when compared to semi-rigid or wire rope median barriers.

**Semi-rigid median barriers** provide some deflection to dissipate energy from an errant vehicle. They are generally constructed from beams such as W-beam, three-beam or tubular beam supported by posts.

**Wire rope median barriers** are a form of **flexible barrier** that deflects as errant vehicles collide with them. These barriers are constructed from collapsible posts and tensioned steel cables that absorb energy, contain errant vehicles and direct them back towards the road way.

**KSI Crash Reduction**

REDUCTION IN KSI CRASHES

| | | Treatment | |
|---|---|---|---|
| | | Rigid Median Barrier | Flexible or Semi-rigid Median Barrier |
| Crash Type | Head-on | 70% | 90% |
| | Run-off-road (to right) | 70% | 91% |

| **Median Barrier** |  |
|---|---|
| **Crash Map Spreadsheet Reference** | 253–254 |
| **Application** | Median barriers are most appropriate on separated high volume and high-speed roads where crash severity is likely to be high from errant vehicles crossing into opposing traffic lanes.<br>Warrants for the installation of median barriers are published on the MRWA Supplement to the Austroads Guide to Road Design Part 6.<br>Rigid barriers are used in locations where there is a need to contain large vehicles.<br>Rigid barriers and semi-rigid barriers are used where median space is limited as they deflect little on impact.<br>Wire rope barriers are used in locations where the median is wide enough to safely accommodate the design deflection envelope of the wire rope barrier |
| **Issues** | The selection of appropriate end terminals needs to be made for all median barriers.<br>Consideration of motorcyclist safety is required when selecting the type of median barrier, especially in situations where there is a significant number of motorcyclists. The barrier post edge, in particular its sharpness, is the most harmful factor in a motorcyclist impact. Rub-rails can be installed to w-beam barriers to reduce the severity of motorcycle crashes.<br>Rigid barriers may create issues for stormwater drainage and can be difficult to see at night due to the lack of contrast with road pavement.<br>Wire rope barriers require a high level of maintenance as every collision, even minor ones; require repairs with extensive traffic control, safe access for maintenance crews needs to be considered. |
| **Other Benefits** | Median barriers limit turning options for vehicles and can shift these movements to safer locations. They also prevent pedestrians from crossing in unsafe locations. |
| **Cost** | Cost depends on length of barrier required, the number and type of terminals and the traffic management required.<br>Rigid (1km of treated road section): $$$ – Medium<br>Flexible or Semi-rigid (1km of treated road section): $$$ – Low to Medium |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | Rigid: 20 years<br>Flexible or Semi-rigid: 10 years |
| **References/ Further Information** | AS/NZS 3845.1:2015: *Road safety barrier systems and devices part 1: Road safety barrier systems*.<br>Austroads 2010 *Guide to Road Design Part 3: Geometric Design*, 2nd edn, AGRD03-10, Austroads, Sydney, NSW.<br>Austroads 2012, *Effectiveness of Road Safety Engineering Treatments*, AP-R422-12, Austroads, Sydney, NSW.<br>Austroads 2014, *Improving Roadside Safety Summary Report, AP-R437-14*, Austroads, Sydney, NSW.<br>Austroads 2018. *Guide to Road Design Part 6: Roadside Design Safety and Barriers*, Austroads, Sydney, NSW.<br>*MRWA Supplement to the Austroads Guide to Road Design Part 6.*<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

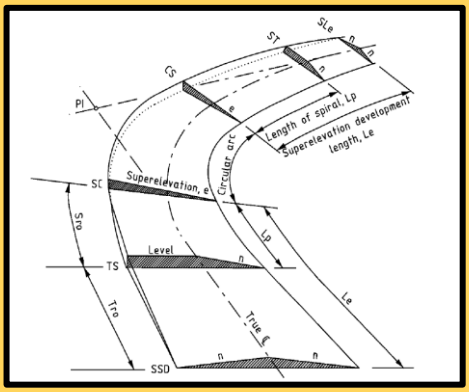
# 8.5 Alignment Improvements

| **Alignment Improvements** | |
|---|---|
| **Description** | Alignment Improvement is a long term, high-cost alternative for improving the safety of a road section several kilometres long. It provides the opportunity to create a solution that incorporates the latest national and WA-based road design and road safety guidelines of good practice.<br><br>The chosen alignment should make the best use of the natural terrain in order to provide a pleasing drive for the motorist that will deliver consistency, improved safety, as well as interest. A boring road can lead to the onset of tiredness and inattention. Even in flat terrain, a gently curvilinear alignment can add interest and stimulation.<br><br>Due to past (now superseded) design and construction practices, horizontal curves on many roads in undulating terrain are preceded by a vertical crest. The main characteristic of this situation is greatly reduced sight distance affecting the driving task and some unanticipated dynamic effects (combined horizontal and vertical displacement) – particularly for heavy vehicles.<br><br>Controlling the vehicle becomes much less predictable due to the interaction of centrifugal and gravity forces. The drivers approaching a curve may not be aware of the crest located just beyond the limit of available sight distance. Trimming the Crest can improve sight-distance and enable easier negation of subsequent bends (see below). |
| **Types** | **Ease Selected Substandard Curves (to Austroads Guide to Road Design (AGRD) Part 3)**<br><br>In a rural context, the speed adopted by a driver is most affected by their perception of the horizontal alignment of the road ahead than by any other single design feature.<br><br>  <br><br>Accordingly, it is very important to ensure that whenever curves are required that the chosen radius is sufficiently large to facilitate travel speeds that are consistent with the approach speed and associated visual cues. Also, it helps to ensure curve radii are consistent along the road. Increasing the radii of unusually tight curves reduces the need for a driver to slow down considerably before entering it in order to navigate the turn.<br><br>It also reduces the need for a driver to brake within the curve and/or take a larger radius by encroaching into the opposing lane. Such sudden corrective actions increase the risk of loss of control, skidding and a crash into the roadside, or an oncoming vehicle. |
| | **Trim Crest**<br><br>This treatment will improve sight distance without realigning the existing infrastructure, and will also improve overtaking opportunities.<br><br>  |

## Alignment Improvements

**Reconstruct superelevation (to AGRD Part 3)**

Superelevation is one of the key design components of horizontal curves. Inadequate or adverse superelevation can be severely detrimental a vehicles ability to safely navigate a curve




*Source: AGRD Part 3.*

**KSI Crash Reduction**

| | | Treatment | | |
|---|---|---|---|---|
| | | Ease Selected Substandard Curves (to AGRD Part 3) | Trim Crest | Reconstruct Superelevation on curve |
| Crash Type | Pedestrian | | 20% | |
| | Head-on | 50% | 15% | 50% |
| | Run-off-road | 80% | 15% | 50% |
| | Rear-end | | 15% | |
| | Other Sight distance related crashes | | 25% | |

**Crash Map Spreadsheet Reference**

227, 229–230

**Application**

A realignment or full reconstruction is normally required when an existing road asset has reached its “use-by” date due to:

- greatly increased traffic (particularly heavy vehicles);
- substandard alignment that was based on earlier standards;
- the pavement reaching the end of its operational life.

Because realignment is usually an expensive option, the full range of other available countermeasures described in this guide should be considered first.
Analysis should determine the full range of factors that may be contributing to the safety problem. These may include: limited visibility to the curve in question, inadequate curve warning signage, inadequate road surface friction, narrow seal, and the presence of roadside hazards, nearby intersections or driveways. Often the problem can relate to a poor combination of vertical profile and horizontal geometry where the former obscures the approaching curve.

Curve realignments can be highly effective and provide long lasting benefits. Care should be taken to prioritise consistency of curves. Multiple substandard curves are typically less of a safety concern than a single substandard curve in isolation. This is due to drivers becoming familiar with curve quality and adjusting their behaviour accordingly as opposed to being ‘surprised’ by a single substandard curve.

Crest re-profiling is limited to lower trafficked roads due to the high cost of traffic management during construction.

From a road safety perspective, road widening over a crest with deficient sight distance is likely to be a more cost-effective mitigation countermeasure than crest flattening to increase sight distance.

| **Alignment Improvements** |  |
|---|---|
| **Issues** | A newly constructed road can encourage higher speeds which may become problematic on adjacent road sections that are yet to be improved. That is undertaking a treatment or countermeasure at one location may influence the road safety risk either side of the treatment zone. This effect is referred to as Crash Risk Migration and is fully described in Austroads Report AP-T147/10.<br><br>Accordingly, the analysis should encompass the road section for a minimum of one kilometre upstream and downstream of where curve easing is being considered. Curves on a significant downgrade will generally appear easier to negotiate and increased entry speeds can be expected.<br><br>Crest trimming can be an expensive option, especially if the reason for the crest is the presence of rock. |
| **Other Benefits** | Increased operational capacity. Potential reduction in travel time and vehicle operating costs are a result of removing a speed change |
| **Cost** | Reconstruct superelevation on curve: $$$$ – Medium to High<br>Ease selected curves and trim crest: $$$$$ – High |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | 30 years |
| **References/ Further Information** | Austroads 2016. *Guide to Road Design Part 3: Geometric Design* , Austroads, Sydney, NSW.<br><br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.6 Verge Treatments

<table>
<tr><th colspan="2">Verge Treatments</th></tr>
<tr><td>Description</td><td>Crashes between vehicles which leave the road and roadside hazards are a major safety problem, especially in the rural environment. Clear zones are areas either-side of the carriageway where roadside hazards have been removed. Roadside barriers are designed to prevent vehicles from impacting roadside hazards that remain.</td></tr>
<tr><td rowspan="5">Types</td><td>Roadside Barriers<br>These are designed to redirect the vehicle and have a lower severity than the roadside hazard they protect.<br>There are three main types of safety barrier:</td></tr>
<tr><td>Flexible barriers are made from wire rope supported between frangible posts. Flexible barriers may be the best option for minimizing injuries to vehicle occupants.<br>  </td></tr>
<tr><td>Semi-rigid barriers are usually made from steel beams or rails. These deflect less than flexible barriers and so they can be located closer to the hazard when space is limited.<br>  </td></tr>
<tr><td>Rigid barriers are usually made of concrete and do not deflect. Rigid barriers should be used only where there is no room for the deflection required for a semi-rigid or flexible barrier. Much of the benefit from the use of barriers comes from a reduction in crash severity. Although a crash may still occur, hitting a guardrail is likely to have a safer consequence than colliding with the object that the barrier is protecting.<br>  </td></tr>
<tr><td>Concrete barrier or semi-rigid barrier with motorcycle rub-rail<br>It is noted that the upright posts can present a particular hazard to motorcyclists who are sliding after falling from their vehicle. Concrete barriers and semi-rigid barriers fited with rub-rail provide a smoother surface in the event of contact and can help reduce the severity of motorcyclist/barrier collisions.</td></tr>
<tr><td>Increase distance to roadside hazards<br>(Clear zones)<br>These are roadside areas free from hazards, starting at the outer edge of the trafficable lane, available for use by errant vehicles.<br>The intent of a clear zone is to provide a driveable space for the driver of a vehicle that runs off the road to regain control while sustaining minimum damage to the vehicle and its occupants.<br>Widening a clear zone involves removal or relocation of unforgiving hazards.<br>  </td></tr>
</table>

## Verge Treatments

### Frangible/slip-base/impact absorbent poles

Fixed objects within the roadside present a hazard to errant vehicles, however some infrastructure such as lighting, sign posts etc. may be necessary. Replacing solid objects with frangible (breakable) or slip base (disconnect at the base when struck) alternatives can help reduce the severity of run-off-road crashes.

**KSI Crash Reduction**

REDUCTION IN RUN OFF ROAD KSI CRASHES

| | | Treatment | | |
|---|---|---|---|---|
| | | Flexible/ Semi-rigid barriers | Rigid Barriers | Frangible/slip-base/impact absorbent poles |
| Crash Type | Run-off-road | 91% | 73% | 40% |
| | | Rub-Rail/Rigid Barrier from other barrier type | | |
| | Run-off-road (motorcy-clist only) | 20% | | |

REDUCTION IN RUN OFF ROAD KSI CRASHES

| | | Treatment | | |
|---|---|---|---|---|
| | | Clear Zone 2 – 4 m | Clear Zone 4 – 8 m | Clear Zone > 8 m |
| Existing | Clear Zone 0–2 m | 18% | 45% | 50% |
| | Clear Zone 2–4 m | | 18% | 28% |
| | Clear Zone 4–8 m | | | 5% |

**Crash Map Spreadsheet Reference**

245-252, 255-256

**Application**

Roadside Barriers: the appropriate barrier type should be applied for the context. Flexible barrier systems are the most forgiving to passenger vehicles in particular however should only be applied where there is sufficient deflection zones behind the barrier. More rigid barriers may be required where this is not possible.

Generally speaking, continuous lengths of barrier are more effective than isolated sections protecting specific hazards.

It is acknowledge that roadside barriers themselves can be a hazard, especially to motorcyclists. Care should be taken on routes known to be frequented to ensure an appropriate barrier system is chosen and that the risk posed by the barrier does not exceed that of the hazard it is designed to protect road users from.

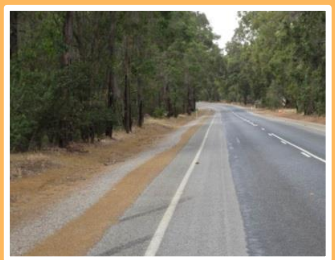
Clear Zones: Provision of clear zones is particularly important near intersections or bends, where the complexity of the driving task and interaction with other vehicles add to the likelihood of run-off-road crashes.
Side slopes should preferably be no steeper than 1:6 on embankments and 1:3 in cuttings.

It is noted that clear zones should not be seen to eliminate the risk of run-off-road crashes. Rollover crashes, even on flat terrain, are still possible and a larger component of road safety risk than traditionally thought.

Frangible/slip-base/impact absorbent poles should be used in locations where critical infrastructure cannot be removed entirely. Such infrastructure can include street lighting and road signage.

| **Verge Treatments** | |
|---|---|
| **Issues** | Roadside Barriers are hazards in themselves. They are designed to reduce the severity of a collision but may also increase the collision frequency because they are closer to the roadside than the hazard being protected and often extend over a longer length than the hazard being protected.<br>Roadside barriers can redirect traffic back into the live traffic lane and even into opposing traffic. The length of need must be adequately calculated and designed for. Adequate end treatments are crucial to ensure the barrier ends do not become significant hazards.<br>Barriers can have significant maintenance costs that need to be compared with expected benefits.<br>Clear zones are difficult to provide in many situations as full-width requires space outside most road reservations. Further, recent research shows that errant vehicles often travel greater lateral distances than originally thought and can strike objects behind a 'full' clear zone. Additionally, risk of vehicle roll-over increases with increasingly large clear zones, even on flat terrain.<br>It can be high cost to clear the area and in some instances may not be practical especially in urban environments.<br>Reducing the operating speeds instead may be a more appropriate solution in some instances.<br>Comparative costs and benefits of roadside barriers should be considered as road side barriers are often more effective and less expensive. |
| **Other Benefits** | |
| **Cost** | Clear Zones: $$$ - Medium (depending on context)<br>Barrier cost depends on length of barrier required, the number and type of terminals and the traffic management required.<br>Rigid Barriers (1km of treated road section): $$$ – Medium<br>Flexible or Semi-rigid Barriers (1km of treated road section): $$ – Low to Medium<br>Frangible Poles: $$ – Low to Medium |
| **Benefit Cost Ratio** | Clear Zones:  <br>Roadside Barriers:  |
| **Treatment Life** | Clear Zones, and Flexible or Semi-rigid or Rub-rail: 10 years<br>Rigid and Frangible Poles: 20 years |
| **References/ Further Information** | Austroads 2014*, Improving Roadside Safety Summary Report*, AP-R437-14, Austroads, Sydney, NSW.<br>Austroads 2020 *Guide to Road Design Part 6: Roadside Design Safety and Barriers*, Austroads, Sydney, NSW.<br>https://www.mainroads.wa.gov.au/BuildingRoads/StandardsTechnical/RoadandTrafficEngineering/GuidetoRoadDesign/Pages/MRWA_Supplement_to_Austroads_Guide_to_Road_Design___Part_6.aspx<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

## 8.7 Shoulder Sealing/Widening and Audible Edge Lines

| **Shoulder Sealing/Widening and Audible Edge Lines** | | |
|---|---|---|
| **Description** | A **sealed** or **unsealed shoulder** (or more usually a combination of the two) provides drivers with an appropriate surface on which to regain control of an errant vehicle.<br><br>Sealed shoudlers should be accompanied by ATLM edgelines, a low-cost treatment that significantly enhances the safety performance of sealed or widened shoulders. Therefore, ATLM edgelines are highly recommended to be included as part of any shoulder sealing/ widening project and CRFs are provided for the combined treatments. |  |

## Shoulder Sealing/Widening and Audible Edge Lines

**KSI Crash Reduction**

RUN OFF ROAD KSI CRASHES

| Existing | Treatment | CRF |
|---|---|---|
| No Shoulder | 0.5 m Sealed Shoulder + ATLM edgeline | 49% |
| | 1 m Sealed Shoulder + ATLM edgeline | 76% |
| | 1.5 m Sealed Shoulder + ATLM edgeline | 79% |
| | 2 m Sealed Shoulder + ATLM edgeline | 83% |
| 0.5 m Unsealed Shoulder | 0.5 m Sealed Shoulder + ATLM edgeline | 15% |
| | 1 m Sealed Shoulder + ATLM edgeline | 44% |
| | 1.5 m Sealed Shoulder + ATLM edgeline | 51% |
| | 2 m Sealed Shoulder + ATLM edgeline | 59% |
| 1 m Unsealed Shoulder | 1 m Sealed Shoulder + ATLM edgeline | 37% |
| | 1.5 m Sealed Shoulder + ATLM edgeline | 45% |
| | 2 m Sealed Shoulder + ATLM edgeline | 54% |
| 1.5 m Unsealed Shoulder | 1.5 m Sealed Shoulder + ATLM edgeline | 44% |
| | 2 m Sealed Shoulder + ATLM edgeline | 50% |
| 0.5 m Sealed with 0.5 m Unsealed Shoulder | 1 m Sealed Shoulder + ATLM edgeline | 39% |
| | 1.5 m Sealed Shoulder + ATLM edgeline | 47% |
| | 2 m Sealed Shoulder + ATLM edgeline | 56% |
| 0.5 m Sealed with 1 m Unsealed Shoulder | 1.5 m Sealed Shoulder + ATLM edgeline | 44% |
| | 2 m Sealed Shoulder + ATLM edgeline | 54% |
| 1 m Sealed with 1 m Unsealed Shoulder | 2 m Sealed Shoulder + ATLM edgeline | 48% |

*Note: Sealed shoulders should include the provision of Audio tactile edgelines.*

**Crash Map Spreadsheet Reference**

263-281

| **Shoulder Sealing/Widening and Audible Edge Lines** | |
|---|---|
| **Application** | WA practice has been to provide for a consistent shoulder width based on traffic volumes and the proportion of heavy vehicles. It is necessary to target seal widening to locations of greatest risk-taking into account road function, crash history, alignment and roadside hazards.<br>The aim should be to provide shoulders of 1.5 m to 2 m wherever possible and up to 2.5 to 3 m on higher volume roads.<br>The greatest benefits are likely to come from widening shoulders on horizontal curves – particularly on the outside of curves.<br>Edge delineation is normally provided/reinstated at the time of upgrading the shoulder (especially when sealing), thus providing an important safety benefit of improved delineation. |
| **Issues** | Consideration needs to be given to not providing too wide a shoulder as this could be interpreted and used as an additional lane. |
| **Other Benefits** | Allows drivers to pull off-road in emergencies or for emergency vehicle access.<br>The shoulder also provides essential support to the adjacent pavement area that is trafficked by vehicles.<br>The chances of stopping or recovery will increase if the shoulder is sufficiently wide and can provide adequate wheel traction. Shoulder treatments that promote safe recovery include shoulder widening and shoulder sealing.<br>Reduces edge break and water ingress – hence lengthens pavement life.<br>Enhances car driver comfort by enabling greater "wriggle room" when encountering a very large, oncoming heavy vehicle.<br>Sealed shoulder can be used by cyclists and pedestrians. |
| **Cost** | Sealing only 0.5 to 1.5m: $$ - Low to Medium<br>Widening and sealing 0.5m plus additional sealing 0 to 1.5m: $$$ - Medium<br>Widening and sealing 1 to 2m plus additional sealing 0 to 1m: $$$$ - Medium to High<br>All costs assume 1km of treated road section |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | 20 years |
| **References/ Further Information** | Austroads 2011, *Improving Roadside Safety – Stage 2: Interim Report*, AP–R387/11, Austroads, Sydney, NSW.<br>Austroads 2012, *Effectiveness of Road Safety Engineering Treatments*, AP-R422-12, Austroads, Sydney, NSW.<br>Austroads 2014, *Improving Roadside Safety Summary Report*, AP-R437-14, Austroads, Sydney, NSW.<br>Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.8 Widen Lane

## Widen Lane

**Description**

**Widen Lane**
Lane widening of an existing narrow lane width can result in crash reduction and traffic flow benefits. It is particularly useful to widen the lane on curves to aid heavy vehicles.

**KSI Crash Reduction**

RUN OFF ROAD AND HEAD ON KSI CRASHES

| | | New Lane Width | | |
|---|---|---|---|---|
| | | 3 m | 3.3 m | 3.6 m |
| Existing Lane Width | 2.7 m | 15% | 35% | 40% |
| | 3 m | | 20% | 25% |
| | 3.3 m | | | 5% |

**Crash Map Spreadsheet Reference**

259-261

**Application**

For very low volumes with limited numbers of heavy vehicles, lane widths as low as 3.1 m are acceptable. 3.5 metres is the optimum rural safe lane width where the volumes – in terms of passenger car equivalents – exceeds 500 per day. Very wide lanes should be avoided.

Because road shoulders are also highly beneficial the optimum allocation of sealed road space between the lane width and the sealed shoulder width should also be considered (see Fact Sheet 8.7).

On horizontal curves, lane widening can address the issue of heavy vehicles requiring a greater pavement width to accommodate rear wheel tracking on the inside of the curve. In addition, the wider lanes reduce the risk of the overhanging front of the vehicle colliding with oncoming traffic.

By widening the traffic lane, all drivers have more space within their lane to manoeuvre their vehicle through the curve, and more room for driver error without serious consequences.

Widening traffic lanes to 3.5 m on straight sections of multi-lane roads can reduce the incidence of sideswipe crashes. Again, the additional road space allows drivers more margin for error.

**Issues**

New Zealand research indicates that the safety benefits are from the overall carriageway width increase irrespective of whether it is in the lane width or the shoulder (see Fact Sheet 8.7).

Increasing lane width (with the exception of widening on curves) can increase vehicle speeds and therefore should only be used if there is an existing crash record related to narrow lane widths.

**Other Benefits**

Improved traffic flow, especially if there is a large proportion of heavy vehicles.

**Cost**

$$ – Low to Medium

**Benefit Cost Ratio**

**Treatment Life**

20 years

| **Widen Lane** |  |
|---|---|
| **References/ Further Information** | iRAP toolkit (http://toolkit.irap.org/default.asp?page=treatment&id=12)<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.9 Additional Lanes

## Additional Lanes

**Description**

Adding an additional lane to an existing carriageway to improve traffic flow and reduce crashes.

**KSI Crash Reduction**

| | | Treatment |
|---|---|---|
| | | Additional Lane |
| Crash Type | Overtaking | 25% |
| | Rear End | 25% |

**Crash Map Spreadsheet Reference**

N/A

**Issues**

New Zealand research indicates that the safety benefits are from the overall carriageway width increase irrespective of whether it is in the lanes, lane width (see Fact Sheet 8.7.) or the shoulder (see Fact Sheet 8.7.).

Increasing carriageway width through the addition of lanes can increase vehicle speeds by allowing vehicles to straddle multiple lanes.

**Other Benefits**

Improved traffic flow/increased capacity.

**Cost**

$$$$$ - High

**Benefit Cost Ratio**

**Treatment Life**

30 years

**References/ Further Information**

http://toolkit.irap.org/default.asp?page=treatment&id=3

ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]*

# 8.10 Duplication

## Duplication

**Description**

**Duplication of single carriageway**

A **duplication** involves changing a single carriageway undivided road into a dual carriageway divided road.

A divided road comprises two carriageways separated by a central median. It is generally required when there is a need to provide high-speed road infrastructure for traffic exceeding 8,000 vehicles per day (rural) or 12,000 vpd (urban).

In the past, a 15 m wide vegetated median has been incorporated, but in more recent years a barrier and narrower median have been adopted to reduce the land footprint and to address the risk of head-on crashes caused by vehicles crossing through the median into the opposing carriageway (see Factsheet 8.4).

**KSI Crash Reduction**

| | | Treatment |
|---|---|---|
| | | Additional Lane |
| Crash Type | Pedestrian | 20% |
| | Run-off-Road | 30% |
| | Head-on | 90% |
| | Rear-End | 24% |

*Note: Use the above figures for a duplication involving a wide central median with no barriers. Features such as grade separation and median barriers will provide greater reductions.*

**Crash Map Spreadsheet Reference**

262

**Application**

A crowned cross-section can be used but this will result in the drainage being discharged into the median and require an expanded central drainage capability. In addition, a crowned pavement may be disconcerting to motorists when changing lanes.

Where allowance needs to be made in the median for a future rail facility, a minimum rail reserve (viz median width) of 15.2 m is required with a minimum of 22.2 m where stations may be required. (Note that for planning purposes, the preferred widths are 22.2 m and 28.4 m respectively). For more information refer to PTA Standard Drawing 00-C-04-0056 Rev B.

**Issues**

Openings in median are undesirable as they may lead to traffic conflicts when a vehicle turns. They should be limited to intersections or selected locations to permit U-turns and/or access to properties. Good sight distance is essential.

High travel speeds can lead to crashes occurring at intersections because of the difficulty in choosing a suitable (safe) gap in the traffic stream on the major road. Grade separation of Intersections mitigates this risk. Roundabouts could also be considered.

**Other Benefits**

Overtaking sight distance need not be provided on a divided road. The focus should primarily be on the provision of safe stopping sight distance.

**Cost**

$$$$$ - High

**Benefit Cost Ratio**

**Treatment Life**

30 years

| **Duplication** |  |
|---|---|
| **References/ Further Information** | ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.11 Passing Opportunities

<table>
<tr><th colspan="2">Passing Opportunities</th></tr>
<tr><td>Description</td><td>Treatments relating to the management of passing/overtaking opportunities</td></tr>
<tr><td>Types</td><td>A Climbing lane (overtaking lane) is provided to reduce traffic “bunching”, improve traffic flow over a section of road and allow faster vehicles to overtake slower vehicles without the need to venture into the opposing (oncoming) traffic lane.<br><br>Climbing lanes are considered to be a special type of overtaking lane that are provided on inclines to enable drivers to pass a slow-moving vehicle — such as a heavy vehicle — on a steep gradient.<br><br>  <br><br><br>Overtaking Bans prohibit overtaking for a section of road. They are often used where sight distance is limited by the road geometry or other factors, where safe overtaking is not possible<br><br>  <br></td></tr>
<tr><td>KSI Crash Reduction</td><td>
<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">Treatment</th></tr>
<tr><th>Overtaking Lanes</th><th>Overtaking Ban</th></tr>
<tr><td rowspan="3">Crash Type</td><td>Head-on</td><td>30%</td><td></td></tr>
<tr><td>Side-Swipe</td><td>10%</td><td></td></tr>
<tr><td>All</td><td></td><td>8%</td></tr>
</table>
</td></tr>
<tr><td>Crash Map Spreadsheet Reference</td><td>304, 308</td></tr>
<tr><td>Application</td><td>The termination points form a critical aspect of overtaking lanes as this is a conflict point where two lanes of vehicles, travelling at high speed, merge into one lane.<br><br>Locations where additional lanes may be required for overtaking include road sections with high overtaking frequency, or where there are no road sections suitable for safe overtaking and heavy traffic in both directions. Overtaking lanes between 1070 metres and 1500 metres excluding tapers would be expected to provide maximum benefits in Western Australian conditions for 110 km/h speed zones. These lengths are a guide only, and the actual length should be chosen depending on the conditions at the desired site.<br><br>Advance signage advising motorists that a passing lane is ahead will reduce the likelihood of drivers making passing manoeuvres in less safe areas. Sight distance considerations and the length of tapers need to be considered in relation to the operating speeds.<br><br>In order to provide a slower moving vehicle the opportunity to pull over and be overtaken, a turnout – a very short section of paved shoulder or added lane – has been provided in other jurisdictions e.g. in NSW. These may be more appropriate than overtaking lanes in areas of low traffic volume or where construction costs would be very high.<br><br>The location of climbing lanes is determined by the speed of trucks, length and gradient of inclines, the crash history attributed to trucks and where trucks enter the traffic stream on an incline.</td></tr>
<tr><td>Issues</td><td>There are areas where passing or climbing lanes should not be installed including sites that include significant intersections and access ways and sites within poor geometry immediately downstream of the passing or climbing lane.</td></tr>
</table>

| **Passing Opportunities** | |
|---|---|
| | Sight distance considerations and the length of tapers need to be considered in relation to the operating speeds. |
| **Other Benefits** | Reduced risk of overtaking and weaving crashes.<br>For overtaking and climbing lanes:<br>Reduced driver frustration and stress.<br>Improved traffic flow. |
| **Cost** | Overtaking ban: $ - Low<br>Climbing lane: $$$$$ - High |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | Overtaking ban: 10 years<br>Climbing lane: 30 years |
| **References/ Further Information** | ARRB 2011: *Road Safety Risk Report No.15 Safety on rural roads: run-off-road, head-on and intersection crashes*<br>Austroads 2019, *Passing Lanes and Safety Performance*, Austroads, Sydney, NSW.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.12 Speed Limit Reduction

## Speed Limit Reduction

**Description**

A **speed limit reduction** involves changing the regulatory speed limit of the road.

Speed is one of the four pillars of the Safe System. A speed limit should be appropriate for the design and use of the road. If the road environment is unable to support the current speed limit safely, and addressing the issues through other means such as improved infrastructure is not possible, lowering the speed limit may be an appropriate solution.


**KSI Crash Reduction**

PEDESTRIAN KSI REDUCTION

| Existing Road Speed limit (km/h) | New Speed (km/h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 |
| 110 | 10% | 20% | 30% | | | | | |
| 100 | | 11% | 23% | 34% | | | | |
| 90 | | | 14% | 29% | 42% | | | |
| 80 | | | | 19% | 39% | 56% | | |
| 70 | | | | | 27% | 47% | 62% | |
| 60 | | | | | | 29% | 43% | 60% |
| 50 | | | | | | | 24% | 57% |
| 40 | | | | | | | | 53% |

INTERSECTION KSI REDUCTION

| Existing Road Speed limit (km/h)_ | New Speed (km/h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 |
| 110 | 23% | 44% | 62% | | | | | |
| 100 | | 29% | 53% | 72% | | | | |
| 90 | | | 40% | 66% | 82% | | | |
| 80 | | | | 46% | 77% | 91% | | |
| 70 | | | | | 63% | 82% | 89% | |
| 60 | | | | | | 37% | 56% | 76% |
| 50 | | | | | | | 40% | 92% |
| 40 | | | | | | | | 99% |

## Speed Limit Reduction

HEAD-ON KSI REDUCTION

| Existing Road Speed limit (km/h) | New Speed (km/h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 |
| 110 | 14% | 28% | 42% | | | | | |
| 100 | | 17% | 34% | 49% | | | | |
| 90 | | | 23% | 44% | 60% | | | |
| 80 | | | | 31% | 56% | 74% | | |
| 70 | | | | | 40% | 64% | 79% | |
| 60 | | | | | | 42% | 59% | 74% |
| 50 | | | | | | | 26% | 60% |
| 40 | | | | | | | | 35% |

OTHER KSI REDUCTION

| Existing Road Speed limit (km/h) | New Speed (km/h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 |
| 110 | 14% | 26% | 37% | | | | | |
| 100 | | 14% | 26% | 38% | | | | |
| 90 | | | 16% | 30% | 43% | | | |
| 80 | | | | 17% | 32% | 45% | | |
| 70 | | | | | 19% | 36% | 50% | |
| 60 | | | | | | 22% | 33% | 40% |
| 50 | | | | | | | 24% | 38% |
| 40 | | | | | | | | 17% |

**Crash Map Spreadsheet Reference**

77-97 (Intersection)
282-302 (Midblock)

**Application**

When proposing to change any speed limit, it is essential to first consult with relevant staff within Main Roads.

The Main Roads website provides guidance on reductions in speed limits at higher-risk locations.

The Safe System recognises that humans have limited capacity to absorb forces generated in a crash and as such has recommended maximum speeds be considered in a variety of road environments.

Although these speeds have been extensively researched and proven to prevent a high number of serious and fatal crash outcomes, they are not always practical to implement on the state network due to factors such as network efficiency and the reliance on voluntary compliance by drivers.

| **Speed Limit Reduction**  | |
|---|---|
| | Notwithstanding the above, where speed limits could be set in accordance with Safe System principles these should always be considered.<br><br>Design and standards of roads across Australia vary considerably. Some roads are not of an appropriate standard for their current speed limit. This results in inconsistent levels of crash risk, and as a result, increased frequency of serious crashes on some roads. Identifying and applying more appropriate speed limits on such roads is a necessary measure to improve their safety performance.<br><br>There are many reasons why a speed limit may need to be reviewed. These could include: increased numbers of pedestrians, changes to roadside development, road upgrade, change in road function, presence of traffic calming devices and in some cases, a poor road safety record. All these characteristics need to be taken into account when a speed limit review is conducted. |
| **Issues** | Reducing speed limits must be considered as part of an overall trauma reduction plan not an isolated treatment solely relied on to reduce the potential for KSI crashes. Often additional features are required to reinforce the need to reduce the speed limit accordingly. A major factor to achieve a desired trauma reduction is to ensure that the speed limit is appropriate for the driving environment and will be met with acceptance and compliance by drivers over time.<br><br>Community resistance is highly likely due to the inaccurate perception that reducing the speed limit will dramatically increase journey time. Education and community engagement is important to gain the support of the community, and to explain that reducing the speed limit will add little to overall journey times. |
| **Other Benefits** | Vulnerable road users' level of safety increases with lower speed limits. Could lead to reductions in fuel consumption, noise and $CO_2$ emissions. |
| **Cost** | $ - Low |
| **Benefit Cost Ratio** | ✅✅✅✅ |
| **Treatment Life** | 10 years |
| **References/ Further Information** | ARRB 2021, CRF Review and Update (ROSMA & CARS) *[D21#1302684]* |

# 8.13 Speed Management: Technology

## Speed Management: Technology

**Description**

Managing the speed of vehicles through signs that are activated when a speed threshold has been exceeded or when traffic conditions have changed.

**Types**

**Vehicle activated signs (speed)** are electronic signs that display a message when approached by a driver exceeding a speed threshold. They are typically used to warn the motorist of an upcoming hazard, (eg an intersection, tight horizontal curve, a worksite or railway crossing) and are commonly utilised in many other states.

Sensors detect approaching vehicles and if that vehicle exceeds a pre-set trigger the sign is activated.


**Variable speed limits (VSL)** are dynamic road signs displaying variable enforceable speed limits depending on prevailing traffic, weather and road conditions.

There are three main types of VSL: speed harmonisation, speed buffering and speed reduction. Speed harmonisation VSL reduce speed differentiation between vehicles and lanes; speed buffering VSL produce gradual reduced speed zones and are mainly applied in cases of downstream congestion; speed reduction VSL reduce or lower speeds to match prevailing conditions (weather, road and traffic, e.g. congestion).


**Variable speed limit and lane use management** signs are dynamic signs which can display variable statutory speed limits and lane use aspects (i.e. they have the capability to sign lane closer, typically using a red 'X' or a lane divert, using an arrow). They often form part of a wider ITS strategy and Managed Freeway projects.

**KSI Crash Reduction**

KSI CRASH TYPE DEPENDS UPON CONTEXT

| | | Treatment | |
|---|---|---|---|
| | | Variable speed limit sign | Vehicle activated signs (speed) |
| Existing | Traditional reflective signs | 8% | 35% |

*Note: No CRFs were specifically noted for the use of lane management systems.*

**Crash Map Spreadsheet Reference**

N/A

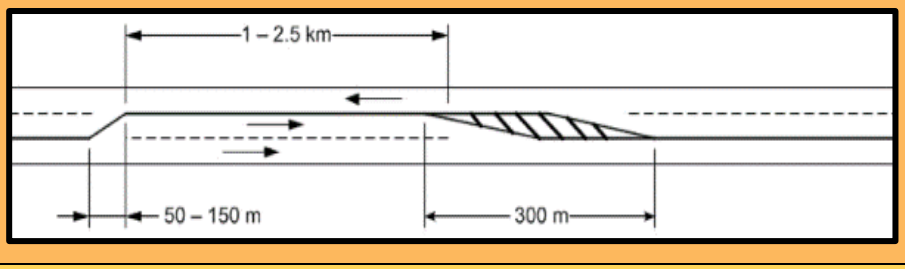
| **Speed Management: Technology** | |
|---|---|
| **Application** | Vehicle activated signs (VAS) triggered by speed are mainly installed in locations with known/identified speeding problems or speed-related crash history or in instances where the use of standard static speed and warning signs has not been effective in lowering travelling speeds or altering driver behaviour.<br><br>The main objective of VAS is to alert the targeted driver to the hazard so that they adjust their behaviour accordingly (ie reduce their speed). The signs have the advantage of being blank (i.e. black) when not activated, thereby targeting relevant road users and limiting their visual intrusion on other drivers.<br><br>VAS are used to highlight and draw drivers' attention to a particular type of hazard at a site where standard reflectorised warning signs have been tried and have been found not to be sufficiently effective in warning drivers to reduce their speeds in order to safely negotiate the hazardous site.<br><br>Variable Speed limits are applied where there are variable traffic conditions and traffic mix, e.g. in high pedestrian activity areas where there is potential for conflict between pedestrians and vehicles.<br><br>Lane use management signs are typically used on managed motorways to warn drivers of upcoming hazards in the lane. They can be used in combination with variable speed limits. In some instances they are also used to alter the directional flow of traffic in a lane so as that the capacity of the road can be better aligned with the direction of peak flow. |
| **Issues** | The signs are prone to vandalism.<br><br>Power supply in rural areas can be problematic. Solar-powered devices are available but are also subject to theft and vandalism.<br><br>The variable speed limit should not change too frequently as this might cause confusion.<br><br>Enforcement is needed to encourage/promote compliance. |
| **Other Benefits** | Vehicle activated signs (speed) can be used to collect speed data for monitoring, although only on sign approach, not at the hazard.<br><br>Variable Speed limits can help to improve traffic flow. |
| **Cost** | Vehicle Activate Signs (speed) and Variable Speed Limits (VSL): $ - Low<br>Variable speed limit and lane use management: $$$$ - Medium to High |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | 10 years |
| **References/ Further Information** | Austroads 2016. *AP-R514-16 Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice* Austroads, Sydney, NSW.<br><br>ARRB 2021, CRF Review and Update (ROSMA & CARS) *[D21#1302684]* |

# 8.14 '2+1' Treatment

## '2+1' Treatment

### Description

A **'2+1' Treatment** is a three lane road formation with two lanes in one direction and one in the other. The outside lanes serve as a general traffic lane and the centre lane serves as an overtaking lane for one direction of traffic, alternating every 1–2.5 km, with a transition zone of up to 300 m. The opposing traffic directions are separated by a wire rope barrier.




### KSI Crash Reduction

| | | Treatment |
|---|---|---|
| | | 2+1 |
| Crash Type | Run-off-road | 55% |
| | Head On | 55% |
| | Motorcycle | 40–50% |

*Note: Also note that a 75% reduction in fatal crashes has been recorded on 110 km/hr roads. An 80% reduction fatal crashes has been recorded on 90 km/hr roads.*

### Crash Map Spreadsheet Reference

N/A

### Application

Austroads Guidance on Median and Centreline Treatments to Reduce Head-on Casualties (see References/Other Information section) recommends:

- 2+1 are used on roads with a speed limit of 90 km/h or higher with a history of overtaking head-on crashes but insufficient traffic volume to warrant dual divided carriageway.
- This treatment be considered for roads with traffic flow of up to 1200 veh/h in one direction.
- Implementation of 2+1 must be done in sections no shorter than 5–10 km and should start and end at clearly defined locations to help reduce driver confusion.

### Issues

Wire-rope median barrier restrict property access and create a perceived restriction in carriageway width for manoeuvring.

Wire rope barriers require a high level of maintenance as every collision even minor ones require repairs which require extensive traffic control, safe accessibility for maintenance crews needs to be considered.

Provision may be required for heavy vehicle breakdown on the single lane sections. That is, they should have room to pull off the lane.

| **'2+1' Treatment** |  |
|---|---|
| **Other Benefits** | 2+1 treatment provides additional traffic capacity while improving safety of a particular road section.<br>This treatment limits turning options for vehicles and shift these movements to safer locations. |
| **Cost** | $$$$$ - High |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | 30 years |
| **References/ Further Information** | Austroads 2009, *Evaluation of the safety impact of centre-of-the-road wire rope barrier (WRB) on undivided rural roads*. AP-T135-09 Austroads, Sydney, NSW.<br>Austroads 2016, *Guidance on Median and Centreline Treatments to Reduce Head-on Casualties*. AP-R519-16 Austroads, Sydney, NSW.<br>ARRB 2021, CRF Review and Update (ROSMA & CARS) *[D21#1302684]* |

# 8.15 Convert Giveway/Stop Intersection to Signalised

## Convert Giveway/Stop Intersection to Signalised

**Description**

Installation of a traffic signal at an intersection previously controlled by a stop or give-way sign.

The installation of traffic signals is used to control and separate conflicts between vehicles, pedestrians and cyclists to enable safer and more efficient operations. Various options exist for how the signal phasing is undertaken including **no turn arrow** which requires right-turning traffic to pick their own gaps (also known as a filtered turn), a **leading right turn** which initially gives right-turners a dedicated turn phase before 'dropping' the turn arrow and requiring a filtered turn and **fully controlled right turns** where all right turning traffic is controlled by turn arrows.

**KSI Crash Reduction**

| | | Treatment | | |
|---|---|---|---|---|
| | | New traffic signal (no turn arrow-filtered) | New signal with leading right turn (with filter) | New signal with fully controlled right turns |
| Crash Type | Pedestrian | 30% | 30% | 60% |
| | Rear-End | −20% | −20% | −20% |
| | Right Angle | 65% | 65% | 65% |
| | Right Turn Thru | 10% | 28% | 70% |
| | Other | 6% | 20% | 64% |

**Crash Map Spreadsheet Reference**

10-12

**Application**

By providing clear right-of-way procedures at intersections, many of the more serious intersection conflicts can be managed at signalised intersections.

Traffic signals should not be installed at locations with speed limits over 80 km/h. When signals are deemed necessary in locations where the speed limit is over 80 km/h, the speed limit will need to be lowered ahead of the approach to the intersection.

Visibility of traffic signals needs to be considered in busy urban environments. Mast arms may be used to increase signal visibility. 'See through' problems (where motorists attend to downstream signals instead of the nearest signal) need to be considered and addressed.

Where signal visibility is low, use of warning signs or vehicle activated signs may be required in advance of the intersection.

Reference should be made to the Austroads Guide to Traffic Management and Main Roads WA's supplement guides for traffic signals applications and warrants (See 'Reference and Other Information' section).

**Issues**

When traffic signals are warranted and properly designed, they will typically reduce overall crash numbers. However, these overall reductions are sometimes accompanied by an increase in specific crash types (e.g. opposing turn crashes and rear-end crashes). Rear-end crashes are generally of lower severity than other intersection related crashes, there is still a significant net decrease in KSI crashes following this treatment.

**Other Benefits**

Can provide for pedestrian and cyclist safety by introducing dedicated phases.

**Cost**

$$$$ - Medium to High

**Benefit Cost Ratio**

| **Convert Giveway/Stop Intersection to Signalised**  | |
|---|---|
| **Treatment Life** | 20 years |
| **References/ Further Information** | Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations, AGRS08-15*, Austroads, Sydney, NSW.<br><br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.16 Speed Cameras

<table>
<tr><th colspan="2">Speed Cameras</th></tr>
<tr><td>Description</td><td>Automated speed limit enforcement through camera technology</td></tr>
<tr><td rowspan="3">Types</td><td>Fixed speed cameras are positioned permanently at one location and operate overtly. These cameras use laser technology to track and detect vehicle speed over multiple lanes simultaneously.<br>  </td></tr>
<tr><td>Mobile speed cameras are mounted in the back of a vehicle or set-up on road sides and can easily be relocated to target speeding in specific locations.<br>This treatment is generally deployed for a specified period, in locations that have a history of speed related crashes.<br>Mobile speed cameras can be used overtly where the location of the speed camera is not concealed or hidden or covertly where the location of the camera is not promoted and attempts are made to hide the camera from passing vehicles.<br>  </td></tr>
<tr><td>Point-to-point cameras work by capturing images of vehicles as they pass two points a known distance apart. The timestamps of the images can then be checked to calculate the average speed of the vehicle between the two points. Number plate recognition technology is used to identify vehicles. The two cameras can be located anywhere from a few hundred metres to many kilometres apart.<br>  </td></tr>
<tr><td>KSI Crash Reduction</td><td>
<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="3">Treatment</th></tr>
<tr><th>Fixed Overt</th><th>Mobile Overt</th><th>Mobile Covert</th></tr>
<tr><td rowspan="2">Road Environment</td><td>Rural</td><td>30%</td><td>40%</td><td>20%</td></tr>
<tr><td>Urban</td><td>30%</td><td>40%</td><td>20%</td></tr>
</table>
</td></tr>
<tr><td>Crash Map Spreadsheet Reference</td><td>N/A</td></tr>
</table>

| **Speed Cameras** | |
|---|---|
| **Application** | Mobile speed cameras are applicable across many locations including local distributor roads and freeways. Consideration needs to be given to the safe operation of mobile speed cameras in all locations.<br>Fixed speed cameras are applicable for highly trafficked urban freeways and rural highways. |
| **Issues** | These are not a treatment that an asset owner arranges the implementation. They are prioritised for site selection and implementation by other groups through RTTA.<br>Mobile speed cameras located on the side of a road present a danger to the operator during set-up/pack-up and to passing traffic. |
| **Other Benefits** | Speed cameras are a cost-effective alternative to other enforcement options that require police officers. |
| **Cost** | $ - Low |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | 10 years |
| **References/ Further Information** | Austroads 2012, *Point-to-point Speed enforcement*. AP-R415-12 Austroads, Sydney, NSW.<br>Austroads 2016, *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice*. AP-R514-16 Austroads, Sydney, NSW.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.17 Red-light Camera

<table>
<tr><th colspan="2">Red-light Camera</th></tr>
<tr><td>Description</td><td>The red-light camera system can capture information such as vehicle make, lane, time, date and location to allow for the issuing of fines to drivers who disobey the red signal.<br><br>Red-light speed cameras perform two functions; they photograph vehicles that run red lights and vehicles that speed through the intersection at any lighting phase.<br><br>  </td></tr>
<tr><td>KSI Crash Reduction</td><td>
<table>
<tr><th colspan="2">Treatment</th></tr>
<tr><th>Red-light Camera</th><th>Red-light Speed Camera</th></tr>
<tr><td>5% (except rear end collisions)</td><td>37%</td></tr>
</table>
</td></tr>
<tr><td>Crash Map Spreadsheet Reference</td><td>N/A</td></tr>
<tr><td>Application</td><td>Red-light speed cameras are applicable at signalised intersections where there is a history of speed-related crashes.</td></tr>
<tr><td>Issues</td><td>Installation of red-light cameras may lead to an increase in rear-end crashes. This can often be avoided if combined red-light/speed cameras are used instead.</td></tr>
<tr><td>Other Benefits</td><td></td></tr>
<tr><td>Cost</td><td>$$ - Low to Medium</td></tr>
<tr><td>Benefit Cost Ratio</td><td>✅✅</td></tr>
<tr><td>Treatment Life</td><td>10 years</td></tr>
<tr><td>References/ Further Information</td><td>Austroads 2004, Guidelines for setting-up and operation of signalised intersections with red light cameras. AP-R247-04 Austroads, Sydney, NSW.<br><br>Austroads 2015, Investigation of Key Crash Types: Rear-end Crashes in Urban and Rural Environments AP-R480-15 Austroads, Sydney, NSW.<br><br>Austroads 2015 . Investigation of Key Crash Types: Rear-End Crashes in Urban and Rural Environments, Austroads, Sydney, NSW.<br><br>Budd, L., Scully, J. & Newstead, S. (2011). Evaluation of Victoria’s fixed digital speed and red light cameras. Monash University Accident Research Centre. Report #307 [2011].<br><br>Website: http://www.monash.edu/muarc/research/our-publications/muarc307<br><br>ARRB 2021, CRF Review and Update (ROSMA & CARS) [D21#1302684]</td></tr>
</table>

# 8.18 Traffic Signal Phase Improvements

| Traffic Signal Phase Improvements | | |
|---|---|---|
| **Description** | Changing/Improving the phases at an existing Traffic Signal | |
| **Types** | **Modifying signals – right turn arrow (with filter)** also known as partially controlled right turn phases (PCRT), these treatmensts are provided at signalised intersections to provide safe right turn crossing opportunities when there are insufficient opportunities for filtered right turns only. This method may reduce the number of unsafe right turn movements by providing drivers with reassurance that a safe crossing opportunity will be imminent. |  <br>*Source: Makwasha and Turner (2017)* |
| | **Modify signals – fully controlled right turns** also known as fully controlled right turn phases, this treatment removes right turn filtering at signalised intersections.<br>This treatment significantly reduces through-right crashes at signalised intersections. It can also be considered where there is right-turn traffic conflicts with pedestrian crossing.<br>This treatment can be installed on one approach leg but is generally provided in pairs of opposing approaches and requires six-display lanterns.<br>Fully controlled right turn will improve safety but reduce the intersection efficiency so capacity analysis is important when considering fully controlled right turn phase. | |
| | **New Pedestrian Phase (with priority)**<br>Dedicated pedestrian phases allocate time to pedestrians for them to cross the road without coming into conflict with vehicles. This can significantly improve pedestrian safety outcomes. |  <br>*Source: Makwasha and Turner (2017)* |
| | **Provide turn pockets** Marking a specific area on the road for vehicles to turn right gives them dedicated space to store while waiting for a suitable gap in traffic or their dedicated turning phase.<br>This separates turning traffic from through traffic and can help reduce rear-end conflicts. |  |

## Traffic Signal Phase Improvements

**Ban right turn movements during am & pm peaks**

During peak periods, it may be difficult for filtering traffic to pick suitable gaps to undertake right-turns. If there is insufficient intersection capacity to accommodate dedicated right-turn phases, one option is to ban right-turning traffic during these tiems.

**Signalised Left Turn slip lane(Fully controlled left turn) phase**

Left turn slip lanes allow vehicles to undertake left turns at higher speed which can lead to potential conflicts with pedestrians. Signalisng these left-turn lanes can help manage these conflicts.

**Exclusive pedestrian all-walk a**lso known as a 'Barnes Dance' or scramble crossing, this type of signal phasing allows pedestrians to cross in all directions (including diagonally) while stopping all vehicles. It combines all pedestrian movements into a signal phase.

*Source: Makwasha and Turner (2017)*

**Dwell-on-red (or rest-on-red)** treatment involves programming an additional phase into signalised intersections and pedestrian crossings so that an all red phase is displayed when there is no traffic or pedestrian demand. The signals only switch to green when a vehicle or pedestrian activates the change, either through vehicle detection, or through manual activation by pedestrians at a crossing point.

*Source: Makwasha and Turner (2017)*

**Turn Arrow Holds**

There may be high demand both for pedestrians and turning vehicles. The green pedestrian light indicates pedestrians have right of way over turning vehicles. However, at some intersections there is benefit in reinforcing pedestrian priority by introducing a red turn arrow hold.

The turn arrow hold stops turning vehicles from crossing the holding line while pedestrians begin their crossing. Once pedestrians are on the crossing and priority is clearly reinforced, the arrow may black out to allow vehicles to begin their turning manoeuvre once the crossing has cleared.

This treatment helps to reinforce pedestrian priority at intersections where pedestrian/vehicle conflicts are common. It may be applied to both left- and right-turning vehicles.

This is the standard approach undertaken in Western Australia, as such no specific CRFs are recorded for this treatment and this is provided for information purposes only.

## Traffic Signal Phase Improvements

**KSI Crash Reduction**

| Treatment | Crash Type: Pedestrian | Rear-end | Right Angle | Right Turn Thru | Other right turn | Other |
|---|---|---|---|---|---|---|
| Modify signals – install right turn arrow (with filter) | | | | 35% | 35% | |
| Modify signals – fully controlled right turns from no control | 30% | | | 50% | 80% | |
| Modify signals – new pedestrian phase (with priority) | 50% | | | | | |
| Modify signals – reconstruct intersection (without right turn arrows but add turn pocket) | | 30% | 10% | 10% | 10% | |
| Modify signals – ban right turn movements during am & pm peak (operational hours crashes only) | 10% | 40% | 50% | 50% | | 50% |
| Modify signals – prevent right turn filter (for existing right turn arrows with filter) | | 40% | | 25% | 25% | |
| Modify signals – signalise left slip (from stop or give way control, crashes associated with slip lane only) | 30% | 40% | 70% | | | |
| Exclusive Pedestrian All Walk | 10% | | | | | |

**Crash Map Spreadsheet Reference**

13- 20

**Application**

Fully controlled right turn phase is applicable at signalised intersections where:

- a history of through-right crashes has been recorded
- two or more lanes turning right at one approach (double right turn)
- two or more right turn lanes on the opposite approach
- right turning traffic opposed by two or more through lanes of traffic
- high operating speeds in two or more opposing through traffic lanes
- a service road adjacent to the opposing approach is continuous through the intersection (i.e. not truncated)
- restricted horizontal and/or vertical sight distances.

The typical reasons for considering PCRT phasing include:

- a high number of through-right casualty crashes over several consecutive years
- two or more right turn lanes on the opposite approach
- right turning traffic opposed by two or more through lanes of traffic
- high operating speeds in two or more opposing through traffic lanes.

| **Traffic Signal Phase Improvements**  | |
|---|---|
| **Issues** | Fully controlled right turn phase reduces the efficiency of an intersection. Capacity analyses should be conducted prior to implementing fully controlled right turn phase.<br><br>Providing or increasing capacity of right turn lanes may be needed to compensate for the reduced efficiency of the intersection. This could be achieved by providing dual right turn lanes or increasing the length of right turn lane.<br><br>The overall safety benefits of PCRT are much lower than that achieved by fully controlled right turns, but both treatments have a similar cost. The greatest road safety gains would be made at sites with a high crash rate from right-turning vehicles and a low rear-end crash rate.<br><br>Turning vehicles held during the start of an intersection phase may result in unnecessary delays for through traffic. The practitioner could consider a green phase for turning vehicles immediately prior to the pedestrian crossing/vehicle turn hold phase. This phase could serve to clear turning vehicles that may obstruct the passage of through traffic during the pedestrian phase.<br><br>Banning right-turning movements to address safety issues during peak periods may redistribute to other intersections with similar safety issues, resulting in no net benefit. Consideration of nearby intersections should be given when considering this treatment type. |
| **Other Benefits** | Benefits associated with fully controlled right turn phase are:<br>• substantial reduction in through-right crashes<br>• reduction in severity of crashes throughout the intersection<br>• reduction in vehicle-pedestrian conflict potential<br>• removal of conflict between right turners and pedestrians crossing the intersection road.<br><br>Turn arrow holds at signalised intersections provide the following benefits:<br>• reinforce pedestrian priority during pedestrian crossing phase<br>• provide greater security for more vulnerable pedestrians<br>• reduction in pedestrian/vehicle collisions. |
| **Cost** | Prevent right turn filter or Ban right turn movement during am & pm peak: $ - Low<br><br>Exclusive pedestrian all walk, New pedestrian phase, Install right turn arrow, Fully controlled right turn or Signalise left slip: $$ - Low to Medium<br><br>Reconstruct intersection (without right turn arrows but add turn pocket): $$$ - Medium |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | 10 years |
| **References/ Further Information** | Austroads 2012, *Effectiveness of road safety engineering treatment*. AP-R422-12 Austroads, Sydney, NSW.<br><br>Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW.<br><br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.19 Traffic Signal Conspicuity

## Traffic Signal Conspicuity

**Description**

Traffic signals need to be clearly seen to be able to serve their purpose as an active form of traffic control. The following treatments help to improve the conspicuity of signals.

**Types**

**Overhead mast arms** allow for the installation of traffic signals directly above the traffic lanes. This makes the signals more obvious as they are located within the driver's centre of vision and not easily obscured. Overhead signals have greater clarity over a greater distance as they are usually not cluttered with other signage or objects.

**Improved signal backboards** assist in the identification of traffic lights, particularly at night. This involves the use of highly reflective sheeting surrounding the backboard. This aims to highlight the signals by making the signal stand out from the surrounding lights.

It is also important to have a strong contrast between the signal and the backboard.

**Advanced Warning Flashing Signals (AWFS)** are used in various situations to increase the conspicuity of the sign or signal. This can include various hazards such as railway corrsings, school zones, low clearance signs, traffic signals, advanced warning signs \ etc.


**KSI Crash Reduction**

| | | Treatment | | |
|---|---|---|---|---|
| | | Overhead mast arms | Improve backboard | AWFS |
| Crash Type | Rear End | 20% | 15% | −15% |
| | Right Angle | 16% | 15% | 13% |
| | Right Turn Thru | 20% | | 20% |

**Crash Map Spreadsheet Reference**

21-22

**Application**

Mast arms are best implemented in conjunction with traditional pole-mounted signals. Drivers typically expect to see pole-mounted signals while overhead signals provide greater clarity from clutter and over a greater distance.

It is important to have a strong contrast between the signal and the backboard.

| **Traffic Signal Conspicuity**  | |
|---|---|
| **Issues** | Mast arms for overhead signals are rigid structures and hence should be positioned appropriately to avoid creating a further hazard. It is also noted that excessive signals add to the clutter and confusion around intersections. Excessive signage should be avoided and implemented further up the road, ensuring the driver has time to read and understand the sign before approaching the reason for the signage.<br>When driving at night there are numerous lights that may be confused with traffic signals. Therefore it is important to take background lighting conditions into consideration. |
| **Other Benefits** | |
| **Cost** | Overhead mast arms: $$ - Low to Medium<br>Improved signal backboards: $ - Low |
| **Benefit Cost Ratio** |  - Gantry<br>  - Backboard |
| **Treatment Life** | Improved signal backboards: 5 years<br>Overhead mast arms: 10 years |
| **References/ Further Information** | Advanced Warning Flashing Signals, Main Roads Western Australia (https://www.mainroads.wa.gov.au/technical-commercial/technical-library/road-traffic-engineering/traffic-management/traffic-signals/advance-warning-flashing-signals/)<br>*An assessment of conspicuous traffic signals: mast arms*, 2009, LN Wundersitz http://casr.adelaide.edu.au/publications/researchreports/casr042.pdf<br>Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW.<br>*Road Safety Performance Associated with Improved Traffic Signal Design and Increased Signal Conspicuity*, Miska, Ed, et al http://mutcd.fhwa.dot.gov/pdfs/miska_02.pdf<br>ARRB 2021, CRF Review and Update (ROSMA & CARS) *[D21#1302684]* |

# 8.20 Roundabouts

| Roundabouts | |
|---|---|
| **Description** | Roundabouts are circular controlled intersections involving single direction traffic around a central point or island. Utilised in both urban and rural areas, roundabouts have a better crash record than similar-sized signalised intersections. Drivers are forced to slow down through the intersection due to the horizontal deflection thereby reducing the severity of a crash. The number of vehicle conflict points is also reduced, thereby reducing the likelihood of a crash. Roundabouts can serve to minimise the delay associated with traffic signals, up to a limit. |
| **Types** | **Roundabout – 1 lane** are the simplest form of roundabout and are generally suited to urban or semi-urban locations<br>  <br>*Source: Makwasha and Turner (2017)* |
| | **Roundabout 2 – lane** are a larger, slightly more complex version of a single lane roundabout. Two lane roundabouts are generally implemented where traffic flows are required to be larger than that which a standard single lane can manage. Sideswipes are more common in two lane roundabouts.<br>  |
| | **Turbo roundabouts** are multilane roundabouts are roundabouts where vehicles are required to be in a specific lane prior to entering the roundabout depending on which exit they wish to take. Raised line markings can be used to discourage drivers from changing lanes within the roundabout and slow speeds.<br>Turbo roundabouts require some vehicles to give way to two lanes of traffic when entering.<br>  |
| | **Eggabouts** or oval roundabout is an elongated roundabout designed to allow better flow through traffic to a particular through axis.<br>Eggabouts can be used to accommodate misalignment of intersection approaches that would otherwise require an alternative intersection type. No specific CRFs for eggabouts are recorded here and instead the CRFs for a one- or two-lane roundabout should be used (as applicable).<br>  |

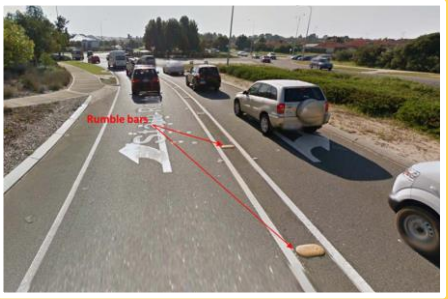
## Roundabouts

**Fully signalised roundabouts** have permanently operating signals.

This treatment is usually only implemented at roundabouts that have experienced a significant change in volume, unbalanced flow or high traffic speeds.


**Pavement bars between dual lane approaches at existing roundabout**

Pavement bars (also referred to as safety bars or rumble bars) are raised blocks. Although traversable, they provide a very strong audio-tactile response, discouraging drivers from crossing them except in an emergency. For roundabouts with dual-lane approaches, they can help to reinforce lane discipline and reduce instances of vehicles straddling both lanes to maintain speed on roundabout approaches, rather than following the alignment of the reverse curves.




**Modify roundabout approaches to achieve safe operating speeds**

Speed on approach to roundabouts is typically managed through horizontal deflection (i.e reverse curves). If this deflection is insufficient, or none is provided, speeds may exceed safe operating levels (also known as the Safe System threshold), allowing for high severity crashes to occur. Various methods can be used to help achieve safe operating speeds such as realigning the approaches to allow reverse curves or through horizontal deflection such as wombat crossing or speed humps.

*Source: ARRB.*

**Mini-roundabout**

A mini-roundabout is a small roundabout that typicall lacks the deflection on the approach legs and has a much smaller island – usually mountable – than a standard roundabout. This gives it a much more constrained footprint than a standard roundabout.

Mini-roundabouts can be provided with either just a painted, or raised but still mountable, island.

*Source: Austroads (2021).*

**Remove non-frangible hazards from within clear zone**

Due to the very nature of their design, roundabouts require vehicles to move laterally as they traverse the approach legs and central island. This can increase the likelihood of run-off-road incidents if drivers fail to adequately adjust their speed. Remvoing non-frangible hazards from the likely run-off-areas (clear zones) can help manage this risk.

## Roundabouts

**KSI Crash Reduction**

| Treatment | Crash Type: Pedestrian: | Rear-end | Run-off-road | Right Angle | Right Turn Thru | Other right turn crashes | Side Swipe | Other |
|---|---|---|---|---|---|---|---|---|
| Roundabout – Single Lane | 30% | −20% | | 78% | 85% | 85% | | |
| Roundabout – Two Lane | | −20% | | 78% | 85% | 85% | −20% | |
| Convert signalized intersection to a roundabout | | 50% | | 50% | 50% | | | 50% |
| Turbo Roundabout | | | | 70% | 70% | | | |
| Signalise a Roundabout | 30% | | | 30% | 30% | | | |
| Pavement bars between dual lane approaches at existing roundabout | 10% | 10% | | 10% | 10% | | | 10% |
| Modify roundabout approaches to achieve safe operating speeds | 30% | | | 30% | 30% | 30% | | |
| Mini-roundabout | 10% | | | 50% | 50% | | | |
| Raised mini-roundabout | 30% | | 40% | 60% | 60% | | | |
| Remove non-frangible hazards from within clear zone | | | 20% | | | | | |

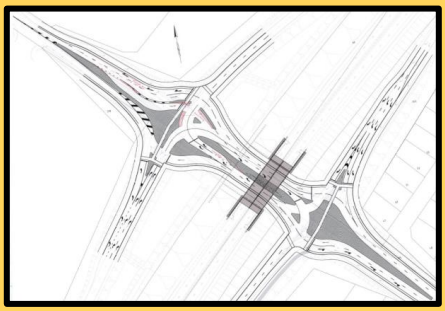
**Crash Map Spreadsheet Reference**

1-4, 5-9, 74 (Turbo Roundabout)

| **Roundabouts** |  |
|---|---|
| **Application** | Roundabouts are most effectively utilised where the traffic volumes are equal at each approach. Where there is a greater demand at a particular approach further design and analysis should be undertaken to determine the appropriateness of the treatment, or alternatively, signalised roundabouts could be considered.<br><br>Two lane roundabouts are generally implemented where traffic flows are required to be large than that which a standard single lane roundabout can manage.<br><br>Turbo roundabouts are generally applied to high traffic volumes and high speed intersections on higher order arterial roads (traffic of up to 35,000 vehicles a day). They should not be used where there is a high volume of cyclists. If required, specific cyclist lanes should be implemented to reduce risk to cyclists.<br><br>Signalisation can be applied to existing congested roundabouts where unbalanced traffic flow occurs. Generally, applied to high traffic volume intersections and higher order arterial roads. |
| **Issues** | High-speed environments ( > 80 km/h) require appropriate designs especially at entries, to reduce the speed of traffic to a safe operating speed while maintaining a steady flow.<br><br>Signalisation should not be installed where speeds exceed 80 km/h. In the instance where signals are deemed necessary, the speed limit should be decreased prior to the intersection approach.<br><br>Roundabouts can pose difficulties for cyclists unless provisions are made, such as on- or off-road cycle lanes. Pedestrian and cyclist facilities should be implemented in high traffic urban areas.<br><br>Eggabouts are more difficult to negotiate due to the difference in speeds along the axes. The speed difference makes it harder for entering vehicles to judge speeds and gap acceptability. This is particularly so for larger eggabouts.<br><br>Roundabouts, especially with two or more lanes, can pose difficulties for motorcycles. Larger service, emergency vehicles and buses may experience difficulties at small roundabouts unless the roundabout is made mountable. Similarly, roundabouts can be unsuitable for intersections with large volumes of larger vehicles.<br><br>Solid structures should not be placed in the central island due to the risk of impact should a vehicle lose control when entering the roundabout.<br><br>Visibility of both signals and the roundabout must be considered. This must include ensuring that signals are clear and positioned appropriately to prevent confusion with neighbouring signals. Additional signage may also be required to identify the combined use of signals and roundabout.<br><br>Signalisation may increase delay during off-peak times.<br><br>Partially signalised roundabouts are not supported (and have been removed) as they may create driver confusion, and require clear line marking for circulating vehicles, as well as careful consideration between signal greens for cyclists. |
| **Other Benefits** | Roundabouts can reduce the delay experienced by traffic at stop signs or traffic signals and improve the traffic flow.<br><br>Less space is required for a roundabout as opposed to a more complex, intersection interchange. Roundabouts require lower maintenance than other intersection treatments.<br><br>Signalisation also allows for the provision of pedestrian and cyclist facilities by including dedicated phasing.<br><br>Signalised roundabouts can maintain the benefits of a basic roundabout and traffic lights by prioritising different legs to create a more balanced flow and providing pedestrian crossing facilities. |
| **Cost** | Pavement bars between dual lane approaches and Remove non-frangible hazards: $ - Low<br><br>(Raised) Mini roundabout and Modify roundabout approaches to achieve safe operating speeds: $$ - Low to Medium<br><br>Roundabout 1 lane or Convert signalised intersection to roundabout: $$$$ - Medium to High<br><br>Roundabout 2 lanes and Turbo roundabout: $$$$$ - High |

| **Roundabouts** | |
|---|---|
| **Benefit Cost Ratio** |  |
| **Treatment Life** | Pavement bars between dual lane approaches, Remove non-frangible hazards and (Raised) Mini roundabout: 10 years<br>Roundabout (1 or 2 lanes), Convert signalised intersection to roundabout, Turbo rounabout and Modify roundabout approaches to achieve safe operating speeds: 30 years |
| **References/ Further Information** | Austroads 2012, *Effectiveness of Road Safety Engineering Treatments*, AP-R422-12, Austroads, Sydney, NSW.<br>Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW.<br>Austroads, 2015, *Guide to Road Design – Part 4B*, AGRD048-15 Austroads, Sydney, NSW.<br>Austroads 2021, *Guide to Road Design – Part 7* – AGRD07-21 Austroads, Sydney, NSW.<br>Makwasha, Tariro, and Blair Turner. (2017) *Road Safety Measures to Achieve Safe System Outcomes for Pedestrians*, ARRB Group LTD, July 2017<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.21 Grade Separation

| Grade Separation | |
|---|---|
| **Description** | Grade separated intersections physically separate at two major intersecting roads where the majority of traffic is through traffic. As most conflicts occur at intersections, this provides increased safety and lowers congestion. While traffic signals can provide separation, physical separation does not occur increasing the potential for serious injury.<br><br>Grade separation can be used to separate rail from roads. Similarly, grade separation can be in the form of an overpass.<br><br>Interchanges vary from simple arrangements with ramps and intersections at the minor road to complex and comprehensive layouts involving two or more freeways. |
| **Types** | **Dogbone** This is a grade separated intersection design that improves sight distances and utilises channelization to minimise the number of conflict points.<br><br>  <br><br>**Convert existing diamond to diverging diamond interchange** are usually built to replace diamond interchanges because DDIs serve high volumes of right turns particularly well.<br><br>The operational benefits and lower costs of retrofitting a conventional diamond with a DDI have contributed to increased use of the DDI.<br><br>  <br><br>The DDI has 18 conflict points (two crossing, eight merging, and eight diverging) whereas the conventional diamond interchange has 30 conflict points (10 crossing, 10 merging, and 10 diverging). Fewer conflict points across all conflict types reduce the exposure of traffic to crashes. Eight of 10 crossing conflict points are eliminated by the DDI design. (Crossing conflicts typically result in right-angle collisions that have a higher potential for injuries.)<br><br>Further information relating to DDI Benefits and Constraints can be found in HP Records Management D17#1025899<br><br>**Double Tennis Ball** An interchange which is similar to a signalised roundabout with 'cut throughs' for right-turning traffic. As with a roundabout, teh turning movements protected by the circular travel path which reduces travel speeds and impact angles.<br><br>  <br><br>This design provides signalised pedestrian crossing facilities which improves pedestrian safety. This treatment decreases the severity of potential impacts by reducing approach speeds and improving conflict angles. |

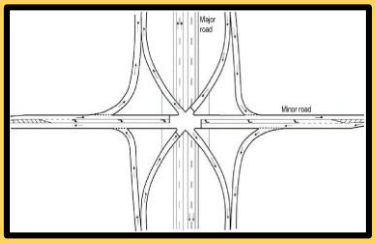
## Grade Separation

**Roundabout** This interchange removes all right angle conflicts (see Factsheet 8.20). As with other types of roundabouts, it can be partly or completely signalised.

**Single Point Interchange** (**SPI**)

This is a grade-separated interchange designed to move large volumes of traffic via limited amounts of space efficiently and safely.

The turning movements of the major road ramps and all the movements of the minor road occur in one central space that is placed either on the overpass or underpass.




**KSI Crash Reduction**

| | | Treatment | |
|---|---|---|---|
| | | Grade Separation | Convert Diamond Interchange to Diverging Diamond Interchange |
| Crash Type | Pedestrian | 70% | |
| | Rear-end | 73% | |
| | Right Angle | 50% | 40% |
| | Right turn thru | 50% | 40% |
| | Side Swipe | 38% | |
| | Other | 50% | 40% |

For ramp terminal treatments terminal arrangements, CRFs can be approximate from like intersection treatments. For instance, roundabout CRFs for a roundabout interchange or dogbone.

The above CRFs should be used as an approximation for all iterations of grade separation. The design of interchanges is highly complex and nuanced. Expert advice should be sought, and consideration of individual design context given.

**Crash Map Spreadsheet Reference**

73,75

| **Grade Separation** |  |
|---|---|
| **Application** | Grade separation is applicable where two major roads intersect and there is a need to maintain through flow along both major roads. Grade separation can also be provided at railway lines .<br><br>Similarly, where a minor and major road intersect, and a need for traffic exchange is not required, a fully grade separated overpass may be warranted. This would not require an interchange to be installed.<br><br>Grade separation for minor roads may be considered where topography and traffic volumes are suitable.<br><br>DDIs offer potential safety benefits and agencies should consider them strongly as replacements for conventional diamonds.<br><br>SPI's can be utilised in locations where grade separation is required. Due to the decreased number of signals, SPI's are efficient in high congestion sections of the network providing fewer consecutive signalised intersections.<br><br>Dogbone/Double Tennis Ball/Roundabout treatments should be utilised when grade separation is required and it is desired to decrease the number of conflict points and high angle crashes. |
| **Issues** | Often provision of an additional interchange on an existing freeway will significantly change the traffic flow patterns along it. Too frequent spacing of freeway ramps will add to the risk of high speed weaving and merging crashes, and may lead to unstable flow and congestion.<br><br>Grade separation requires a large degree of land availability.<br><br>Grade separation is often a very high cost treatment.<br><br>Grade separation of rail crossings may involve vertical realignment of substantial length of rail track in order to meet the low slope tolerances of trains. Such undertakings are usually major infrastructure projects and tend to be undertaken outside of annual road safety programs.<br><br>Anecdotally, DDIs have the potential to increase the risk of wrong-way crashes.<br><br>SPIs can result in a large area within the intersection that is uncontrolled. The following issues need to be carefully considered:<br>• Due to the large size of the intersection clearance times for cyclists and pedestrians are longer.<br>• The length and geometry of the vehicle path through the intersection can lead to confusion if adequate guidance is not provided, particularly where the intersecting road is on a curve.<br>• The potential relative speeds of the vehicles are increased.<br>• If the intersecting roadways are on a skew, the length of structures required may become excessive, clearance distances are increased and sight distance can be adversely affected.<br>• It is not possible to provide for the through movement from an exit ramp to an entry ramp.<br>• Higher-speed right-turns from ramps may be hazardous unless the design provides good sight distances and delineation of turning lanes.<br>• There is a possibility of wrong-way movements if no median is provided on the minor road. |

| **Grade Separation** | |
|---|---|
| **Other Benefits** | Improvement in traffic flow conditions.<br>SPIs can increase capacity and efficiency due to the use of a single set of traffic signals. The simplicity of a single signal set allows better integration with surrounding traffic signal phasing.<br>Other SPI benefits:<br>• Reduced delay through the intersection since there is only one set of traffic signals.<br>• The right-turns operate on larger radius curves and are therefore more efficient than at conventional intersections.<br>• The operational efficiencies result in an interchange with higher capacity than the conventional diamond. |
| **Cost** | $$$$$ - High |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | 30 years |
| **References/ Further Information** | Austroads 2012, *Effectiveness of Road Safety Engineering Treatments*, AP-R422-12.<br>Austroads 2020, *Guide to Traffic Management Part 6: Intersections Interchanges and Crossings*, AGTM06-20.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.22 Vehicle Activated Signs

## Vehicle Activated Signs

**Description**

Vehicle Activated Signs use sensors to detect the presence of a vehicle to set an appropriate warning or dynamic speed limit. They generally use the same technology as speed activated signs.

**Types**

**Side Road Activated Speeds (SRAS), previously RIAWS**

This treatment uses sensors to determine when a vehicle is approaching the intersection from the side road and triggers a warning to through traffic. The warning is a variable speed limit sign that displays a reduced speed.

This lowers the potential for collision and its likely severity.

**Side Road Activated Warning Sign (VAS)**

This treatment is nearly identical to RIAWS however features a warning sign only when a vehicle is approaching on the side road, without a reduced speed limit.

*Note: RIAWS shown*

**KSI Crash Reduction**

| | | Treatment | |
|---|---|---|---|
| | | Side Road Activated Sign | Side Road Activated Speeds (30 km/h temp. speed limit reduction) |
| Crash Type | Right Angle | 15% | 70% |
| | Right Turn Thru | 15% | 70% |

| | |
|---|---|
| **Crash Map Spreadsheet Reference** | 72 |
| **Application** | Vehicle activated signs are used on through roads at high speed highway intersections where there is an existing crash history, sight distance is poor or where the use of standard static warning signs has not been effective in altering driver behaviour. |
| **Issues** | Enforcement is needed to encourage compliance with speed reduction.<br>The posts present a hazard to errant vehicles and frangible posts should be used.<br>A power supply is required to operate the control, sensor and sign which is an issue in remote locations. Solar power is a viable option in such locations. |
| **Other Benefits** | |
| **Cost** | SRAS - $$ - Low to Medium<br>VAS - $ - Low |
| **Benefit Cost Ratio** | ✅✅✅ |
| **Treatment Life** | 10 years |

| Vehicle Activated Signs | |
|---|---|
| **References/ Further Information** | Austroads 2014, *Methods for Reducing Speeds on Rural Roads – Compendium of Good Practice*<br><br>Austroads 2016, *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice. AP-R514-16*<br><br>Thorne, R. & Mackie, H. (2020*). Intersection Speed Zones: Long-term operational and safety performance*. Prepared by Mackie Research for Waka Kotahi NZ Transport Agency, Auckland, New Zealand.<br><br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.23 Pedestrian Crossings

| Pedestrian Crossings | |
|---|---|
| **Description** | Pedestrian facilities aid in pedestrian's ability to safely cross the road. The appropriate facility should be selected based on the road environment and level of pedestrian demand. |
| **Types** | **Pedestrian Refuge**<br>A pedestrian refuge is a raised island in the middle of road. It provides an opportunity for pedestrians to stage their crossing which can greatly simplify the crossing manoeuvre.<br>  <br>*Source: ARRB.* |
| | **Pedestrian Cross (Zebra)**<br>A formalised pedestrian crossing point denoted by signage and painted road marking. These crossigns give pedestrians right-of-way over vehicles (upon entering the crossing) and highlight the presence of pedestrians in the area.<br>  <br>*Source: Makwasha and Turner (2017).* |
| | **Pedestrian Overpass**<br>A pedestrian overpass allows pedestrians to bypass the road entirely via an elevated walkway (underpasses are also used).<br>  <br>*Source: Makwasha and Turner (2017).* |
| | **Pedestrian Signals (midblock)**<br>Signalised pedestrians crossings aim to reduce vehicle-pedestrian conflicts by providing right-of-way to pedestrians during specific pedestrian green phases.<br>  <br>*Source: ARRB.* |

## Pedestrian Crossings

### Pelican Crossing

A pelican crossing is a type of signalised pedestrian crossing where vehicles are given an 'early release'. This early release is in the form of flashing yellow lines, which allows vehicles to proceed but they should yield to any pedestrians still on the crossing.

### Wombat Crossing

Also known as a raised crossing, a Wombat crossing is a standard pedestrian (zebra) crossing provided on a flat top road safety platform. The raised crossing highlights pedestrian priority and increases visibility by raising their height. It also slows vehicles to manage speeds at the potential points of conflict.

*Source: ARRB.*

### Kerb Extension to Edge of Parking Lane

This treatment can improve pedestrian Crossing Sight Distance by placing them infront of parked cars that would otherwise obscure sight lines as well as reduce crossing distance minimising the time pedestrians are exposed to potential conflicts with vehicles.

*Source: Makwasha and Turner (2017).*

**KSI Crash Reduction**

| Treatment | Crash Type: Pedestrian: | Crash Type: Rear-end |
|---|---|---|
| Pedestrian refuge | 30% | −10% |
| Pedestrian crossing (zebra) | 40% | |
| Pedestrian overpass / underpass | 90% | |
| Pedestrian signals (midblock) | 70% | −20% |
| Wombat crossing | 70% | |
| Kerb extension to edge of parking lane | 30% | |
| Pedestrian Refuge and/or kerbed buildouts | 30% | |

| **Pedestrian Crossings** | |
|---|---|
| **Crash Map Spreadsheet Reference** | 30 (provide pedestrian refuge and/or kerbed buildotus)<br>201-206 |
| **Application** | On busy multilane arterials with significant traffic volumes, mid-block pedestrian signals may be necessary to create a safe crossing opportunity. The level of pedestrian demand should be substantial to warrant the delay of the main road traffic. The proposed signals may be included in a coordinated signal system to reduce traffic delays. |
| **Issues** | **General**<br>To achieve maximum benefit, it is important that the pedestrian signals are placed on, or as close as possible, to the pedestrian desire line. In some cases pedestrian fencing may be needed to encourage pedestrians to use the crossing.<br>**Pedestrian Signalised Crossings (including Pelican crossings)**<br>Generally, when considering the use of pedestrian traffic signals at mid-block locations, it is desirable to ensure that they are provided only where sufficient demand exists.<br>Drivers who use the route regularly may tend to ignore the presence of the device if they rarely see it used. Similarly, pedestrians may ignore or misuse the signals if vehicle volumes are very low making the signals unnecessary on most occasions. In addition, frequent random interruptions to a dense traffic stream may create congestion and increase the likelihood of vehicle crashes. These factors highlight the need for care in applying the guidelines.<br>Additional clearance time should be provided at locations which have a substantial number of older or disabled pedestrians.<br>Pedestrian signals along selected routes may include bicycle signal displays. This enables cyclists to legally cross the road on a green signal without dismounting the bicycle.<br>Pelican crossings should be installed in lower speed environments (≤ 60 km/h)<br>**Overpasses**<br>If passive security (i.e. how visible the overpass is to the surrounding area) is poor this may reduce pedestrians' feelings of personal security and discourage crossing use. If necessary, ancillary treatments such as pedestrian fencing can be used to discourage crossing at grade.<br>Appropriate access for bicycles, prams and mobility impaired people should be considered.<br>**Wombat Crossings**<br>As with any raised feature consideration needs to be given as to impacts on drainage. The height and profile of the hump should also be appropriate for the context, and consider aspects such as traffic mix (heavy vehicle, motorcycles, bicycles, busses etc.) and speed environment. |
| **Other Benefits** | Some of the key benefits associated with these treatments include:<br>• substantially reducing vehicle/pedestrian crashes.<br>• higher level of service to pedestrians.<br>• providing improved access to the road network for pedestrians with disabilities.<br>• encouraging walking as a mode of transportation when pedestrian desire line is considered. |
| **Cost** | Pedestrian Crossing (Zebra): $ - Low<br>Pedestrian refuge and/or kerbed buildouts, Kerb extension to edge of parking lane, Pedestrian signals, Wombat crossing and Pelican Crossing: $$ - Low to Medium<br>Pelican crossing: $$$ - Medium<br>Pedestrian overpass / underpass: $$$$$ - High |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | Pedestrian Crossing (Zebra): 5 years |

| **Pedestrian Crossings** | |
|---|---|
| | Pedestrian refuge and/or kerbed buildouts, Kerb extension to edge of parking lane and Pelican Crossing: 10 years<br>Wombat crossing, Pedestrian signals and Pedestrian overpass / underpass: 20 years |
| **References/ Further Information** | Austroads 2012, *Effectiveness of Road Safety Engineering Treatments*, AP-R422-12, Austroads, Sydney, NSW.<br>Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW<br>Austroads 2016, *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice*, AP-R514-16, Austroads, Sydney, NSW.<br>Austroads 2020, *Guide to Traffic Management Part 8: Local Street Management*, Austroads, Sydney, NSW.<br>Makwasha, T, Turner, B, & Jurewicz, C 2017, *Road safety measures to achieve Safe System outcomes for pedestrians*, Transport Accident Commission.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]*<br>Website: https://austroads.com.au/network-operations/active-travel/pedestrian-facility-selection-tool |

# 8.24 Hazard Signs and Markers

<table>
<tr><th colspan="3">Hazard Signs and Markers</th></tr>
<tr><td>Description</td><td colspan="2">The provision of signage can delineate/draw attention to specific hazards. From a risk management perspective, signs are amongst the lowest form of control; however, they can be an effective measure to reduce crashes for little cost where more expensive interventions cannot be achieved.</td></tr>
<tr><td rowspan="3">Types</td><td>Static curve warning signs<br>Curve warning signs are placed in advance of curves to alert drivers/riders of an upcoming change in the road's horizontal alignment. These may be accompanied by advisory speeds (see below).</td><td rowspan="2"> 

Note: combination curve warning and advisory speed.<br>Source: Austroads (2014).</td></tr>
<tr><td>Advisory Speed Signs on Curves<br>Used in combination with curve warning signs (see above) advisory speed signs are supplementary signs that show the speed a driver/rider should take to comfortably navigate the curve. They are typically used in locations where the design speed of the curve is significantly lower than the speed limit.</td></tr>
<tr><td colspan="2">Vehicle activated curve warning signs (VAS)<br>Vehicle activated signs on the approach to curves are dynamic signs that are only activated in the presence of a vehicle, or — in some instances — a vehicle travelling above a threshold speed.<br> 

Source: Austroads (2016).</td></tr>
</table>

## Hazard Signs and Markers

**Chevron alignment markers (CAMs)**

Horizontal curves are among the most hazardous situations for drivers. Advance warning of alignment changes can be conveyed to the driver in numerous ways. can provide a better view of the curve on the approach.

As the driver traverses the curve, the delineation device provides a continuous reminder for positive guidance thereby assisting the driver to position the vehicle within the proper travel lane while negotiating the curve. This treatment tends to affect driver speeds on a horizontal curve, which is particularly important because excessive speed is a significant factor in crashes at horizontal curves. CAMs are used to supplement other standard signs

*Source: Austroads (2016).*

**Width marker**s are used to advise drivers of a feature close to the road such as may occur where culvert endwalls or bridge kerb is close to the carriageway.

**Variable Message Signs (VMS) to warn of adverse conditions, weather, congestion etc.**

Variable message signs can be provided in a variety of forms to provide a variety of different messages via text or image. This may include warning of specific hazards such as weather, roadworks or congestion.

## Hazard Signs and Markers

Source: Austroads (2020)

**Advanced Warning Flashing Signals (AWFS)** are flashing displays — usually provided in a pair that alternate their flashing (also known as wig-wag lights) — to draw attention to a particular hazard. They are commonly installed along traffic signs such as those used to highlight a school zone, low clearance, railway crossings etc.

**KSI Crash Reduction**

| Treatment | Crash Type: Run-off-road | Head-on | Right Angle | Right Turn Thru | Rear-end | Side Swipe | Other |
|---|---|---|---|---|---|---|---|
| Static curve warning signs | 25% | 25% | | | | | |
| Advisory speed signs on curves | 30% | 30% | | | | | |
| Vehicle activated curve warning signs (VAS) (from static curve warning signs) | 10% | 10% | | | | | |
| Chevron Alignment Markers (CAM) (on substandard curves if warranted AS1742.2) | 30% | 30% | | | | | |
| Width marker and associated signs and line marking at localised narrowing | 10% | | | | | | |
| Variable Message Signs (VMS) to warn of adverse conditions, weather, congestion etc. | 20% | | | | 20% | 20% | 20% |
| Advanced Warning Flashing Signals (AWFS) | | | 13% | 20% | 15% | | |

**Crash Map Spreadsheet Reference**

222-224 (curve related), 226(VAS), 303 (Width Marker), 305 (VMS)

**Application**

**Chevron alignment markers (CAMs)**

CAMs should be installed along the outside of a horizontal curve in line with and at right angles to approaching traffic. CAMs are to be spaced such that motorists will have at least two in view at all times until the roadway alignment no longer needs the signs.

**Width Markers**

Width markers should be erected in pairs where the clearance from the normal road width to the vertical obstruction is 1 m or less. Width markers are typically erected with their inner edge on the line of the vertical obstruction.

| Hazard Signs and Markers | |
|---|---|
| **Issues** | **Chevron alignment markers (CAMs)**<br>It is preferred that any treatment of curves be conducted as part of a mass-action scheme to ensure consistency of approach across the network. By ensuring the approach is consistent across the network, or at a minimum the route, greater benefits can be observed.<br>**Advanced Warning Flashing Signals (AWFS)**<br>The effectiveness of this treatment will diminish if they are overused, and as such should be used selectively, with approval from MRWA, where viable alternatives have been exhausted. |
| **Other Benefits** | |
| **Cost** | Width marker, Static curve warning signs, Advisory speed signs on curves, CAMs and Vehicle activated curve warning signs: $ - Low<br>VMS : $$$ - Medium |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | 5 years |
| **References/ Further Information** | Austroads 2014. *Methods for Reducing Speeds on Rural Roads – Compendium of Good Practice*, 2014.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]*<br>**Photo Sources:**<br>Austroads 2009. AP-T133/09 *Intelligent Transport Systems and Variable Message Signs for Road Safety Applications: Current Status and Future Prospects*. Austroads, Sydney, NSW:<br>Austroads 2014 *Methods for Reducing Speeds on Rural Roads – Compendium of Good Practice'* AGM06-20 Austroads, Sydney, NSW:<br>Austroads 2016. *AP-R519-16 Guidance on Median and Centreline Treatments to Reduce Head-on Casualties*. Austroads, Sydney, NSW:<br>Austroads 2020. *AGTM10-20 Guide to Traffic Management Part 10: Transport Control – Types of Devices. Austroads, Sydney, NSW:* |

# 8.25 Local Area Traffic Management

## Local Area Traffic Management

| | |
|---|---|
| **Description** | Selected measures that can be applied on local roads for the purposes of traffic calming. |
| **Type** | Local Area Traffic management incorporates a variety of traffic calming treatment types across a wide area. This includes **vertical features** (such as raised platforms and speed humps) and **horizontal features** (such as roundabouts, raised medians and slow points).<br>For guidance on the following treatments as applied to local roads refer to the relevant factsheet.<br>• Roundabouts (8.20)<br>• Closures (8.35)<br>• Raised Median (8.3)<br>  |
| | **Speed cushions** are similar to road humps, but occupy only part of the width of the roadway, rather than kerb-to-kerb. This means that they can be designed so as that larger axle vehicles such as busses and emergency vehicles, do not have to traverse them with their wheels (avoiding the vertical deflection). This does mean however that passenger vehicles can traverse them with one set of wheels only, reducing the impact of the vertical deflection and reducing their as a traffic calming device.<br>  |
| | **30–40 km/h speed limit strip shopping precinct with electronic signs in supporting road environmen**t are more of a unique case and have emerged from historic commercial shopping strips being located along busy arterial roads, creating a conflict between the road's movement and place functions. Reducing the speed limit can help improve safety outcomes for pedestrians and reduce the impact of conflicts between through traffic and parking/unparking vehicles without overly compromising the road's movement function.<br>  |

## Local Area Traffic Management

**Gateway Treatments** are used at a change in road environment, usually in rural locations as a high-speed rural road approaches a rural township or urban area with a lower speed limit. The treatments can take a variety of forms, but is typified by duplicated speed signage (usually on an enhanced backboard and larger than standard) and hatched median and lane narrowings to create a visual narrowing of the road.


*Source: ARRB.*

**KSI Crash Reduction**

| | | Crash Type | | |
|---|---|---|---|---|
| | | All | Pedestrian | Other |
| Treatment | Traffic Calming: Vertical Features (excl speed cushions) | 50% | | |
| | Speed Cushions | 30% | | |
| | Traffic Calming: Horizontal Features | 40% | | |
| | 30–40 km/h speed limit strip shopping precinct with electronic signs in supporting road environment | | 15% | 10% |
| | Gateway Treatment | 28% | | |

**Crash Map Spreadsheet Reference**

209 – 212, 314 (Gateway Treatment)

**Application**

Local area traffic management (LATM) can generally be considered as *the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter drive behaviour and improve conditions for non-motorised street users* (Transoprt Association of Canada, 1998 as appears in Austroads 2020),

Generally speaking, LATM involves the use of various traffic calming devices across an area and should be considered as a unified solution rather than individual treatments. The need for LATM usually arises from (Austroads 2020):

- an intent to reduce traffic-related problems
- orderly traffic planning and management
- a need to modify 'transport' behaviour
- a desire to improve the community space and sense of place
- a desire to improve environmental, economic and social outcomes
- traffic interventions associated with new development or the implementation of pedestrian and bicycle plans and other local policies

LATM can include both vertical and horizontal traffic calming features. As the names imply, they achieve their traffic calming effect through vertical and horizontal deflection of the vehicle path respectively. Vertical deflection devices may include road humps, platforms and cushions, including raised zebra crossings (wombat crossings) while as horizontal devices include lane narrowings and kerb extensions, slow points, centre blister islands, median treatments, roundabouts etc.

Regular placement of the devices, typically 80–120 m, is required to ensure ensure vehicles do not build up speed between devices.

| **Local Area Traffic Management**  | |
|---|---|
| **Issues** | Care needs to be taken when designing LATM treatments to ensure they achieve their traffic calming effect while still allowing the passage of larger design vehicles such as emergency vehicles, garbage trucks and busses. Speed cushions can be effective in this as wider axle vehicles can pass over them unimpeded, improve ride quality for bus passengers, for example. However they are typically less effective at reducing speeds of passenger vehicles.<br>The accommodation of cyclists at such facilities also need to be considered especially at horizontal deflection treatments which may create 'squeeze' points between motorised traffic and cyclists.<br>Further issues on specific LATM treatments can be found in Austroads (2020). |
| **Other Benefits** | LATM can have numerous other benefits such as improving residential amenity, encouraging active transport modes, reducing inappropriate through traffic (rat-running) etc.<br>These benefits are discussed in detail in Austroads (2020). |
| **Cost** | Speed cushions: $ - Low<br>30-40 speed limit precint: $$ - Low to Medium<br>Traffic calming vertical and horizontal features: $$$ - Medium |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | Speed cushions and 30-40km/h speed limit precint: 10 years<br>Traffic calming vertical and horizontal features: 20 years |
| **References/ Further Information** | Austroads 2016, *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice*, AP-R514-16, Austroads, Sydney, NSW.<br>Austroads 2020, *Guide to Traffic Management Part 8: Local Street Management*, Austroads, Sydney, NSW.<br>iRAP (2010), *Road safety toolkit*, iRAP, <www.toolkit.irap.org>.<br>Makwasha, T, Turner, B & Jurewicz, C 2017, *Road safety measures to achieve safe system outcomes for pedestrians'*. contract report PRS17017, ARRB Group, Vermont South, Vic.<br>Makwasha, T, and B Turner. *Evaluating the Use of Rural-Urban Gateway Treatments in New Zealand*. ARRB Group Ltd, 2013.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.26 Footpath Provision

## Footpath Provision

**Description**

Designated pedestrians rights-of-way on the roadside. In Western Australia footpaths can also be used by cyclists.

**Types**

**Widen path to better accommodate all users**

In Western Australia both cyclists and pedestrians can use the footpath legally. However, sufficient width is required for this to be successful (usually 3.0 m or more).

**Path provision from none previously**

Provision of a footpath adjacent to the road where there was not one before

**KSI Crash Reduction**

| Treatment | Crash Type: Pedestrian | Run-off-road | Head-on | Rear-end |
|---|---|---|---|---|
| Widen path to better accommodate all users (pedestrian and bicycle crashes only) | 80% | 80% | 80% | 80% |
| Path provision from none previously at Midblock (pedestrian and bicycle crashes only) | 90% | 90% | 90% | 90% |
| Path provision from none previously at Intersection (pedestrian and bicycle crashes only) | 30% | 10% | 10% | 10% |

**Crash Map Spreadsheet Reference**

61 (at intersection), 207-208

**Application**

Footpaths are provided alongside the carriageway to provide dedicated space for pedestrians and separate them from motorised traffic. Safety benefits increase with greater separation from the road including increased distance or physical separation such as barriers.

Cyclists are also permitted on the footpath in Western Australia. As such, all footpaths are effectively 'shared paths'. However, if the width is insufficient this may discourage use of the path by cyclists. Widening the footpath to better accommodate all road users — typically a minimum of 3.0 m is desirable — will help encourage better uptake and interaction between cyclists and pedestrians.

| **Footpath Provision** |  |
|---|---|
| **Issues** | Requires on-going maintenance. May be obstructed by utilities, footpath trading etc. unless this is suitably managed.<br>Consideration of pedestrian/cyclist interactions should be given. High pedestrian numbers and high-speed cycling may make the path uncomfortable for both road user groups. Consideration should also be given to the appropriateness of the path as cycling infrastructure. Frequent driveways and/or minor road crossings, sharp turns and other obstacles may discourage use by cyclists and/or make them unsafe to use. |
| **Other Benefits** | Encouraging walking and cycling can provide health, economic and environmental benefits.<br>Provision of footpaths can improve pedestrian accessibility.<br>Footpaths can be used for other public interest purposes such as footpath dining/trading; however, care should be taken to ensure it does not negatively impact pedestrian/cyclists movements. |
| **Cost** | $$ - Low to Medium |
| **Benefit Cost Ratio** | Path provision at midblock and Widen path:  <br>Path provision at intersection:  |
| **Treatment Life** | Widen path: 10 years<br>Footpath provision at midblock and intersections: 20 years |
| **References/ Further Information** | http://toolkit.irap.org/default.asp?page=treatment&id=20<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.27 Clearways & Parking Bans

## Clearways & Parking Bans

**Description**

Banning parking on a road on a permanent or timed basis

**Types**

**Clearway, parking bans (time specific) (left side)**

Clearway bans involve the banning of parked cars in a lane that could otherwise be used for through traffic, usually during peak periods.

**Clearway, parking bans (time specific) (right side on one way streets)**

Clearway bans involve the banning of parked cars in a lane that could otherwise be used for through traffic, usually during peak periods


**Ban parking adjacent to intersection**

On-road parking can cause localised 'pinch-points' and can complicate already complex traffic interactions in the vicinity of intersections. Banning parking in close proximity to the intersection can address this.

**KSI Crash Reduction**

| | | Crash Type | | | | |
|---|---|---|---|---|---|---|
| | | Pedestrian | Rear-end | Right Angle | Side Swipe | Parking Rleated |
| Treatment | Clearway, parking bans (time specific) (left side) | 30% | 35% | | | |
| | Clearway, parking bans (time specific) (right side on one way streets) | 30% | 35% | | | |
| | Ban parking adjacent to intersection | 30% | 20% | 10% | 20% | 50% |

**Crash Map Spreadsheet Reference**

50 (ban adjacent to intersection), 213-214

**Application**

Parked vehicles can obscure visibility between pedestrians trying to cross the road and through traffic. Further, vehicles parking and unparking can be hazard to both through traffic and pedestrians as well as cyclists.

Even when stationary, parked vehicles are an obstruction to through traffic that needs to be navigated around by through traffic. This presents the opportunity for conflicts to occur either by vehicles failing to navigate the parked vehicle (striking it) or when merging into adjacent traffic lanes. This is especially true around intersections, particularly downstream, due to the increased complexity of the environment.

| Clearways & Parking Bans | |
|---|---|
| **Issues** | On-street parking may be used by shoppers/patrons etc. to access adjacent land use and, as such, any reduction in parking supply may not be well received by local residents and business owners.<br>Parking can also have a traffic calming effect as the presence of parked cars effectively provides a localised road narrowing. As such, traffic speeds may increase once parking is removed. |
| **Other Benefits** | Banning parking may increase the capacity of a road/intersection and improve traffic flow. |
| **Cost** | $ - Low |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | Ban parking adjacent to intersection: 5 years<br>Clearway, parking bans (time specific, left and right): 10 years |
| **References/ Further Information** | Austroads. “Guide to Road Safety. Part 8, Treatment of Crash Locations.” Austroads, Sydney, Australia, 2015.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.28 Lighting

| **Lighting** | |
|---|---|
| **Description** | Example of flag lighting<br>  |
| **Types** | **Install pedestrian crossing lighting to AS1158 (night crashes only)**<br>Localised lighting of a pedestrian crossing |
| | **Road lighting to AS1158 V category where none previously (night crashes only)**<br>Lighting of the road to Australian Standard AS1158 – V, which is the vehicle standard for lighting. |
| | **Road lighting to AS1158 P category where none previously (night crashes only)**<br>Lighting of the road to Australian Standard AS1158 – V, which is the vehicle standard for lighting. |
| | **Upgrade existing road lighting to AS 1158 (night crashes only)**<br>Lighting that does not illuminate the road to the requirements of AS1158 may not be adequate, limiting its safety benefits. All provided lighting should meet the requirements of AS1158. |
| | **Flag lighting at remote intersections (night crashes only)** involves illuminating intersections in rural locations where general lighting of the roadway is typically not provided. |

## Lighting

**KSI Crash Reduction**

| Treatment | Crash Type: Pedestrian | Run-off-road | Right turn thru | Right angle | Head-on | Side Swipe | Rear-end | Other |
|---|---|---|---|---|---|---|---|---|
| Install pedestrian crossing lighting to AS1158 (night crashes only) | 60% | | | | | | | |
| Road lighting to AS1158 V category where none previously (night crashes only) | 10% | 30% | 30% | 30% | 30% | 30% | 30% | |
| Road lighting to AS1158 P category where none previously (night crashes only) | 30% | 10% | 10% | 10% | 10% | | 10% | |
| Upgrade existing substandard road lighting to AS 1158 (night crashes only) | 10% | 10% | 10% | 10% | 10% | 10% | 10% | |
| Flag lighting at remote intersections (night crashes only) | 10% | | 10% | 10% | | 10% | | 10% |

**Crash Map Spreadsheet Reference**

43-45 (intersections), 218-221 (road section)

**Application**

**General**

Street lighting can illuminate areas to allow drivers better visibility of the road environment at night, which would otherwise be limited by the range of their headlights. This can include road users who may not have their own source of lighting, such as pedestrians and cyclists, as well as road furniture. The spacing of lamp posts at regular intervals can also help to delineate the road alignment ahead.

**Flag Lighting**

The use of flag lighting at remote intersections can also help to highlight the presence of the intersection to drivers, heightening their awareness thereof.

**Issues**

Suitable transitions between lit and non-lit areas should be provided. Additionally, light pollution can be an issue.

On-going costs will be associated with the running and maintaining of street lighting, including the clearing of vegetation.

Street lighting can be a roadside hazard and suitable measures, such as slip bases, barriers or crash attenuators, should be provided to reduce this risk particularly in high-speed environments.

Lighting at pedestrian crossings should be of higher intensity, as per the requirements of AS 1158.

**Other Benefits**

Enhanced illumination can increase passive security and feelings of personal safety of road users.

**Cost**

Flag lighting at remote intersections and Install pedestrian lighting or Upgrade existing road lighting to AS1158: $$ - Low to Medium

Road lighting to AS1158 V or P where none previously: $$$ - Medium

| **Lighting**  | |
|---|---|
| **Benefit Cost Ratio** | Flag lighting at remote intersections and Upgrade existing road lighting to AS1158: ✓✓✓<br>Road lighting to AS1158 V or P where none previously: ✓✓<br>Install pedestrian lighting to AS1158: ✓✓✓✓ |
| **Treatment Life** | 20 years |
| **References/ Further Information** | AS/NZS 1158 Series: Lighting for roads and public spaces.<br>Austroads *2021 Guide to Road Design Part 6B:Roadside Environment* AGRD6B-15, Austroads, Sydney NSW.<br>Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW.<br>Austroads 2017 *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections,* Austroads, Sydney, NSW.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.29 Pavement Works

| Pavement Works | |
|---|---|
| **Description** | Paving of the road surface |
| **Types** | **Seal ≤ 5.5 m width gravel road**<br>As the name implies, this treatment involves sealing an unsealed road to a width of 5.5 m or less. Typically, these will be low volume roads as the width may be insufficient for two opposing vehicles to pass while remaining on the sealed surface.<br>  <br>**Design and seal gravel road > 5.5 m**<br>As the name implies, this treatment involves sealing an unsealed road to a width greater than 5.5 m. Widths greater than 5.5 m are generally sufficient to allow two opposing vehicles (passenger cars) to pass each other while remaining on the sealed surface. |
| | **Skid-resistant treatment (wet crashes only)**<br>Skid resistance treatments are speciality treatments applied to an existing pavement to enhance surface friction<br>  |
| | **Seal gravel terminating road flares at T-intersections with rural highway**<br>Unsealed roads are common within rural contexts. Where these roads intersect sealed rural highways, loose material from the unsealed road may spill onto the highway. Sealing the road flares (also referred to as the intersection bellmouth) helps address this issue and creates a more consistent surface at the intersection. |

## Pavement Works

**KSI Crash Reduction**

| Treatment | Crash Type | | | | | |
|---|---|---|---|---|---|---|
| | Pedestrian | Right Angle | Right Turn Thru | Head-on | Rear-End | Run-off-road |
| Seal < 5.5 m width gravel road | | | | | 10% | 15% |
| Design and seal gravel road > 5.5 m | | | | 40% | 15% | 40% |
| Skid resistant treatment (wet crashes only) | | | | | | 40% |
| Skid resistant treatment to through movement only (wet crashes only) | 30% | 5% | 5% | | 20% | |
| Skid resistant treatment to through and right movement only (wet crashes only) | 30% | 5% | 5% | | 20% | |
| Skid resistant treatment to through and left movement only (wet crashes only) | 30% | 5% | 5% | | 20% | |
| Skid resistant treatment to left turn movement only (dedicated left) (wet crashes only) | 30% | 5% | | | 20% | |
| Skid resistant treatment to whole approach (wet crashes only) | 30% | 5% | 5% | | 20% | |
| Seal gravel terminating road flares at T-intersections with rural highway | | 15% | | | 30% | |

**Crash Map Spreadsheet Reference**

25-29 (skid resistance treatments at intersections)

70 (seal gravel termining road flares at T-intersection)

228 (skid resistance treatment midblock)

257-258 (seal gravel road)

**Application**

**Sealing an Unsealed Road**

Sealing a road can remove inconsistencies in the surface, improve surface friction (allowing for shorter stopping distances) and reduce the likelihood of loss of control crashes.

**High Friction Surfacing**

High friction surfacing can enhance an existing pavements surface friction at a point in the road where surface friction is critical, such as on corners or intersection approaches.

| **Pavement Works** |  |
|---|---|
| **Issues** | **General**<br>The sealing of a road may encourage/allow drivers to adopt higher speeds. This can be particularly problematic as often the geometric design of unsealed roads is of a lower standard than sealed roads.<br>**Seal < 5.5 m width gravel road**<br>A sealed width of less than 5.5 m is generally insufficient for two vehicles to pass while remaining on the sealed surface. As such, this approach is usually only applied on roads where opposing traffic volumes are expected to be low. Because of the narrow width, drivers may take a driving position in the centre of the sealed formation. Care must then be taken on curves (both horizontal and vertical) where sight distance is limited to avoid potential head-on conflicts. Localised widening at such locations may be required.<br>**High Friction Surfacing**<br>High friction surface materials are usually applied with a specialty binder. This requires a uniform sound base to be applied and the design life of such treatments will likely be less than that of pavement underneath. |
| **Other Benefits** | The sealing of a road can enhance its durability and reduce ongoing maintenance requirements. |
| **Cost** | Skid resistant treatments and Seal gravel terminating road flares at T-intersections with rural highway: $$ - Low to medium<br>Seal gravel road: $$$$$ - High |
| **Benefit Cost Ratio** | Seal < 5.5 m width gravel road:  <br>Design and seal gravel road > 5.5 m:  <br>Skid resistant treatments and Seal gravel terminating road flares at T-intersections with rural highway:  |
| **Treatment Life** | Skid resistant treatments and Seal gravel terminating road flares at T-intersections with rural highway: 10 years<br>Seal gravel road: 20 years |
| **References/ Further Information** | Austroads 2012. *Effectiveness of Road Safety Engineering Treatments* Austroads, Sydney, NSW:2012.<br>Guide to Pavement Technology Part 4K: Selection and Design of Sprayed Seals<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.30 Property Access Treatments

## Property Access Treatments

**Description**

Treatments designed to manage access to adjacent properties

**Types**

**Right turn traffic island in medians for driveways**

A right turn provided within a median to provide a designated space for drivers to store while awaiting to turn right into a property access.

**Painted median right turn lanes for driveways**

Similar to the above, painted right turn lanes can provide designated space for vehicles to turn into a property access.

*Source: ARRB.*

**Controlled or restricted access to roadside development (access rationalisation/consolidation)**

Controlled access can be provided through a variety of ways. Commons include restricting direct access to a road at the planning stage, which may include requiring access to be from an alternative street frontage (such as at the rear of a block) or a service road.

**KSI Crash Reduction**

| Treatment | Crash Type: Driveway Related Crashes | Right Turn Related Vehicle | Head-on | Rear-End | Into driveway loss of control |
|---|---|---|---|---|---|
| Right turn traffic island in medians for driveways | | 30% | 20% | 33% | 15% |
| Painted median right turn lanes for driveways | | 20% | 15% | 35% | |
| Controlled or restricted access to roadside development (access rationalisation/consolidation) | 60% | | | | |

**Crash Map Spreadsheet Reference**

215-216

306 (control/restricted access to roadside development)

| **Property Access Treatments**  | |
|---|---|
| **Application** | Property accesses provide the opportunity for a number of conflicts to occur including rear-ends, right-angle crashes and sideswipes (as vehicles navigate around the stopped vehicle in the traffic stream).<br>Turn lanes can help to manage the conflicts associated with property accesses by giving vehicles designated places to store out of the general traffic stream. This reduces the potential for both rear-end and side swipe conflicts. Further, the designated space may reduce the pressure a driver feels to undertake a turn as soon as possible, leading to safer gap selection.<br>Restricted access prohibits vehicular access to a driveway/property access in a particular way. Often this involves the use of service or frontage roads which eliminates direc interaction between the accesses and the main carriageway. |
| **Issues** | Access restrictions may, or may be perceived to, negatively impact business/residents when applied retroactively. Accordingly, the preferences is to apply the restrictions when the road is constructed.<br>Consideration should also be given to the redistribution of traffic. If vehicles are unable to turn right into a site for instance, this may lead to increased demand to U-turn further up the road and it should be ensured that such provision is at a safe location. |
| **Other Benefits** | Removing right-turn movements from the traffic stream can improve traffic flow. |
| **Cost** | Painted median right turn lanes for driveways: $$ - Low to Medium<br>Right turn traffic island in medians for driveways: $$$ - Medium<br>Controlled or restricted access to roadside development (access rationalisation/consolidation): $$$$ - Medium to High |
| **Benefit Cost Ratio** | Painted median right turn lanes for driveways and Controlled or restricted access to roadside development (access rationalisation/consolidation):  <br>Right turn traffic island in medians for driveways:  |
| **Treatment Life** | Painted median right turn lanes for driveways: 5 years<br>Right turn traffic island in medians for driveways: 10 years<br>Controlled or restricted access to roadside development (access rationalisation/consolidation): 20 years |
| **References/ Further Information** | ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.31 Railway Crossing Treatments

<table>
<tr><th colspan="3">Railway Crossing Treatments</th></tr>
<tr><td>Description</td><td colspan="2">Treatments for the interaction of road and rail crossings</td></tr>
<tr><td rowspan="4">Types</td><td colspan="2">Signs (rail crossing)<br>Signage is the lowest level, and serves only to highlight the presence of the crossing.<br>  <br>Source: Austroads (2014).</td></tr>
<tr><td>Flashing lights (rail crossing)<br>Flashing lights highlight the presence of an approaching train. They are particular useful at remote crossings where trains can be infrequent, and drivers do not habitually look for them.</td><td rowspan="2">  <br>Note: Combination gate and flashing lights.<br>Source: ARRB.</td></tr>
<tr><td>Barriers/gates (rail crossing)<br>Barriers, often referred to boom gates, provide a physical deterrent for vehicles encroaching onto the railway line when a train is approaching.</td></tr>
<tr><td colspan="2">Grade separation (Rail crossing)<br>A grade separation physically separates the road from the railways crossing removing any direct interaction between road and rail traffic.<br>  <br>Source: Google Maps (2021), ‘Toorak Road, Hawthorn East, Victoria’, Google California, USA.</td></tr>
</table>

## Railway Crossing Treatments

**KSI Crash Reduction**

| Treatment | Struck Train Crashes |
|---|---|
| Signs (rail crossing) | 15% |
| Flashing lights (rail crossing) | 50% |
| Barriers/gates (rail crossing) | 80% |
| Grade separation (Rail crossing) | 100% |

| | |
|---|---|
| **Crash Map Spreadsheet Reference** | 310-313 |
| **Application** | The various level crossing treatments can be considered as a hierarchy of control levels, with signage being the lowest intervention level and grade separation being the highest. A review of the site context should be conducted to establish the appropriate control level.<br>It is noted that signage only will typically only be appropriate in very remote locations where both road and rail traffic is at a minimum. In urban contexts, it is generally expected that barriers/gates be installed at a minimum. |
| **Issues** | In very remote locations, trains may be infrequent. This may mean that drivers who frequent the crossing do not habitually look for a train as they do not expect to see one. This presents the opportunity for conflicts to occur and it is recommended that flashing lights at a minimum be installed at such locations. Consideration can also be given to realigning the approaches to improve sight lines.<br>Timing of the flashing lights/boom gates is important. Care should be taken to ensure they are not active for longer than necessary as frustrated drivers have been known to circumvent/ignore them if they are unable to see an approaching train.<br>Grade separations are very expensive, both in terms of cost and in land requirements, and may adversely impact adjacent land use. They may involve vertical realignment of substantial length of rail track in order to meet the low slope tolerances of trains. Such undertakings are usually major infrastructure projects and tend to be undertaken outside of annual road safety programs. |
| **Other Benefits** | Where trains are frequent, railway crossings may cause significant delays and place large restrictions on the capacity of the road. Grade separating the level crossing can therefore significantly improve traffic flow. |
| **Cost** | Signs (Rail crossing): $ - Low<br>Flashing lights and Barriers/gates (Rail crossing): $$ - Low to Medium<br>Grade separation (Rail crossing): $$$$$ - High |
| **Benefit Cost Ratio** | Signs, Flashing lights and Grade separation (Rail crossing): ✅✅✅<br>Barriers/gates (Rail crossing): ✅✅✅✅✅ |
| **Treatment Life** | Signs (Rail crossing): 5 years<br>Flashing lights and Barriers/gates (Rail crossing): 10 years<br>Grade separation (Rail crossing): 30 years |

| **Railway Crossing Treatments** | |
|---|---|
| **References/ Further Information** | http://toolkit.irap.org<br><br>Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW.<br><br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]*<br><br>**Photo Sources:**<br><br>Austroads 2014. *Methods for Reducing Speeds on Rural Roads – Compendium of Good Practice*, 2014.<br><br>Google Maps (2021), 'Toorak Road, Hawthorn East, Victoria', Google California, USA. Accessed 17 June 2021.<br><br>Standards Australia Limited. *Manual of Uniform Traffic Control Devices. Part 1: General Introduction and Index of Signs*. Homebush, NSW.: Standards Australia, 2014. |

# 8.32 Install Bus Embayment

<table>
<tr><th colspan="3">Install Bus Embayment</th></tr>
<tr><td>Description</td><td colspan="2">Indented area where busses can store while picking up/setting down passengers<br>  <br>Source: ARRB.</td></tr>
<tr><td>KSI Crash Reduction</td><td colspan="2"><table><tr><th colspan="2"></th><th>Treatment</th></tr><tr><th colspan="2"></th><th>Bus Embayment</th></tr><tr><th>Crash Type</th><th>Rear End</th><td>70%</td></tr></table></td></tr>
<tr><td>Crash Map Spreadsheet Reference</td><td colspan="2">217</td></tr>
<tr><td>Application</td><td colspan="2">Busses stopping in the traffic stream can present a hazard to through traffic which will be required to manoeuvre around them. Typically used on high speed, high volume environments, bus embayments reduce this risk by giving busses designated places to stop outside of the traffic stream, although some residual risk remains from busses slowing down to exit, and re-entering the traffic stream.<br><br>When provided in the vicinity of a signalised intersection it is generally preferable to provide the embayment on the downstream side. This allows busses to take advantage of gaps in traffic created by the signals to re-enter the traffic stream. Consideration needs to be given to passenger accessibility requirements and the potential for the arrival of numerous busses to spill back into the intersection.</td></tr>
<tr><td>Issues</td><td colspan="2">Bus companies have previously indicated difficulty in busses reentering the traffic stream from embayments. For this reason, it may be preferred to maintain the stopping position within the left hand lane.</td></tr>
<tr><td>Other Benefits</td><td colspan="2"></td></tr>
<tr><td>Cost</td><td colspan="2">$$ - Low to Medium</td></tr>
<tr><td>Benefit Cost Ratio</td><td colspan="2">✅✅✅✅</td></tr>
<tr><td>Treatment Life</td><td colspan="2">15 years</td></tr>
<tr><td>References/ Further Information</td><td colspan="2">ARRB 2021, CRF Review and Update (ROSMA & CARS) [D21#1302684]</td></tr>
</table>

# 8.33 Truck rest area on rural highway (not within 15 km of another rest area)

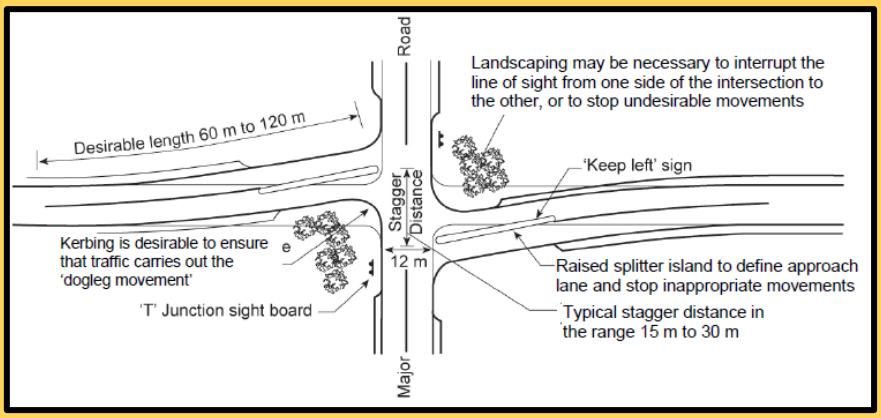
<table>
<tr><th colspan="2">Truck rest area on rural highway<br>(not within 15 km of another rest area)</th></tr>
<tr><td>Description</td><td>Designated space along a rural highway for heavy vehicles to pull over to allow drivers to rest. Can be equipped with various amenities such as tables and chairs, toilets, showers etc.<br>  <br>Source: Queensland Department of Transport and Main Roads (2014).</td></tr>
<tr><td>KSI Crash Reduction</td><td>
<table>
<tr><th colspan="2" rowspan="2"></th><th>Treatment</th></tr>
<tr><th>Truck rest area on rural highway</th></tr>
<tr><td rowspan="2">Crash Type</td><td>Run-off-road</td><td>10%</td></tr>
<tr><td>Head-on</td><td>10%</td></tr>
</table>
</td></tr>
<tr><td>Crash Map Spreadsheet Reference</td><td>307</td></tr>
<tr><td>Application</td><td>Fatigue is a significant contributor to the road toll in Western Australia. Rest areas help to combat fatigue by encouraging drivers to take time to rest when travelling long distances.<br><br>Regularly driving long distances, heavy vehicle drivers are particularly vulnerable to fatigue. The provision of regular rest areas can help road managers manage their drivers' fatigue levels by providing options for regular pre-planned stops within the drivers operating hours.<br><br>Heavy vehicle rest areas will typically also allow drivers to undertake purpose-based stops such as load checks and the like. Generally speaking, these types of facilities will cater for all vehicles; however, separation should be provided between heavy and smaller vehicles. Depending on the facility, overnight stays may also be permissible.</td></tr>
<tr><td>Issues</td><td>Consideration needs to be given to the type of vehicles the facility will cater for, as well as what amenities are required.<br><br>If overnight stays are permitted, additional capacity may be required to ensure the rest area can adequately cater for both overnight and short stay drivers.</td></tr>
<tr><td>Other Benefits</td><td>Regular rest areas can also improve the reliability of the freight fleet.</td></tr>
<tr><td>Cost</td><td>$$$$$ - High</td></tr>
<tr><td>Benefit Cost Ratio</td><td></td></tr>
<tr><td>Treatment Life</td><td>20 years</td></tr>
</table>

| **Truck rest area on rural highway (not within 15 km of another rest area)**  | |
|---|---|
| **References/ Further Information** | Austroads 2019. *Guidelines for the Provision of Heavy Vehicle Rest Area Facilities (Edition 1.1*) Austroads, Sydney, NSW<br><br>MRWA Policy and Guidelines for Rest Areas (https://www.mainroads.wa.gov.au/technical-commercial/technical-library/road-traffic-engineering/roadside-items/policy-and-guidelines-for-rest-areas/#mcetoc_1ebg0lgsd4i3)<br><br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]*<br><br>**Photo Source:**<br><br>Department of Transport and Main Roads 2014. *Rest Areas and Stopping Places – Location, Design and Facilities*. |

# 8.34 Fencing on open road (hit animal or swerve to avoid animal crashes only)

<table>
<tr><th colspan="2">Fencing on open road (hit animal<br>or swerve to avoid animal crashes only)</th></tr>
<tr><td>Description</td><td>The fencing of the roadside to prevent intrusion by animals (stock or wild).<br>  </td></tr>
<tr><td>KSI Crash Reduction</td><td>
<table>
<tr><th colspan="2" rowspan="2"></th><th>Treatment</th></tr>
<tr><th>Fencing on Open Road</th></tr>
<tr><td rowspan="2">Crash Type</td><td>Run-off-road (when swerving to avoid animal)</td><td>30%</td></tr>
<tr><td>Hit Animal</td><td>80%</td></tr>
</table>
</td></tr>
<tr><td>Crash Map Spreadsheet Reference</td><td>309</td></tr>
<tr><td>Application</td><td>Animals within the carriageway can present a significant hazard to vehicles both in terms of direct impacts and swerves to avoid crash that lead to secondary impacts.<br>Fencing the roadway can help to reduce this risk by discouraging intrusion by animals.</td></tr>
<tr><td>Issues</td><td>Ongoing maintenance of fences will be required.</td></tr>
<tr><td>Other Benefits</td><td></td></tr>
<tr><td>Cost</td><td>$$ - Low to Medium</td></tr>
<tr><td>Benefit Cost Ratio</td><td>✅✅✅✅✅</td></tr>
<tr><td>Treatment Life</td><td>10 years</td></tr>
<tr><td>References/ Further Information</td><td>ARRB 2021, CRF Review and Update (ROSMA & CARS) [D21#1302684]</td></tr>
</table>

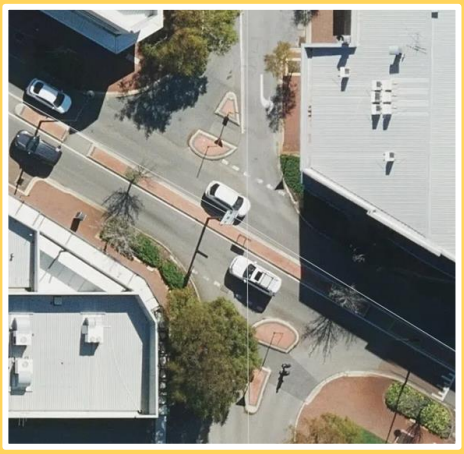
# 8.35 Intersection Geometry

| Intersection Geometry | |
|---|---|
| **Description** | Treatments relating to the geometry of unsignalised intersections, including changing the alignment of the intersection approaches. |
| **Types** | **Stagger cross intersection (right – left)**<br>Staggering a cross intersection involves changing the angle of the approach leg(s) to form two off-set T-intersections.<br>  <br><br>*Source: Austroads (2019).* |
| | **Street closure (one leg of cross)**<br>The closing of one leg of a cross intersection, creating a T intersection.<br>  <br> |
| | **Street closure (close stem of Tee)**<br>The closing of the minor leg approach of a T-intersection, effectively removing the intersection.<br>  <br> |

## Intersection Geometry

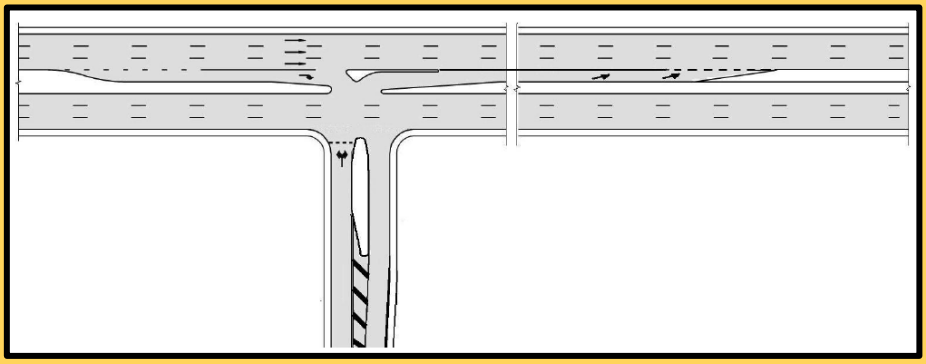
**Extend median through intersection (prevent right turns)**

Extending the median through a cross or T-intersection, effectively changing the intersection to left-in, left-out only.



**Seagull in median**

A seagull is a type of unsignalised T- intersection that includes the provision of both deceleration (usually) and acceleration lanes within the median to separate turning traffic from the general traffic stream



*Source: Austroads (2019).*

**Y-intersection to basic T-intersection**

Involves realigning the approach leg(s) of an intersection so as that the approaches are closer to right-angle.

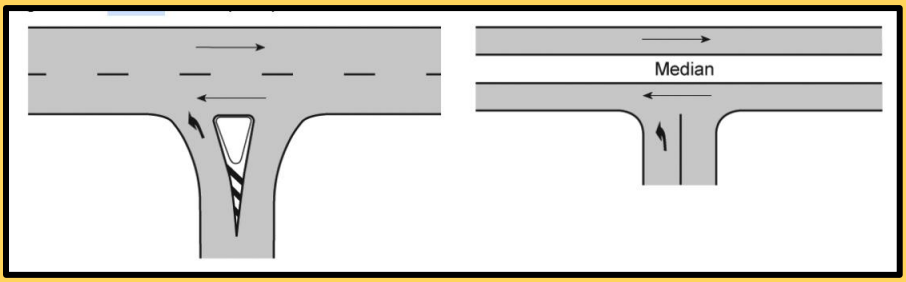
**KSI Crash Reduction**

| Treatment | Crash Type | | | | |
|---|---|---|---|---|---|
| | Pedestrian | Right Angle | Right Turn Thru | Rear-End | Side-swipe |
| Stagger cross intersection (right – left) | | 50% | 50% | 30% | −10% |
| Street closure (one leg of cross) | 50% | 50% | 50% | 50% | 50% |
| Street closure (close stem of Tee) | 50% | 90% | 90% | 75% | 75% |
| Extend median through intersection (prevent right turns) | 30% | 85% | 85% | 50% | 100% |
| Seagull in median | | 20% | 30% | | 40% |
| Y to Basic T-intersection | | 85% | 85% | | |

| **Intersection Geometry** |  |
|---|---|
| **Crash Map Spreadsheet Reference** | 30 (stagger)<br>34-35 (closures)<br>51 (extend median)<br>54 (seagull in median)<br>68 (Y to basic T) |
| **Application** | **Stagger cross intersection (right – left)**<br>Typically used in low volume, remote locations; a right-left stagger reduces the number of conflict points associated with the intersection (from 32 to 18) and can help to manage speeds of the minor (crossing) leg as well as reinforce the presence of the intersection to drivers on these approaches, mitigating oveshoot crashes.<br>Where volumes on the main road are higher, a left-right stagger may be preferred as it allows for drivers to select gaps in each direction independently. Left-right staggers typically require a greater offset between minor road legs to allow for storage of right-turning vehicles on the main leg.<br>**Street closures**<br>Where alternative routes are available, it may be possible to simply close a leg(s) of an intersection to remove conflicts associated with that approach, or removing the intersection entirely. Consideration will need to be given to access requirements and the broader network context to ensure alternative routes are feasible.<br>**Extend median through intersection (prevent right turns)**<br>Right turn movements are typically associated with the most severe crash types at intersections owing to the high differential speed of vehicles involved, high angles of impact and potentially complicated manoeuvres across multiple-traffic streams.<br>Extending the median through an intersection changes the minor leg approaches to 'left-in/left-out' only, significantly simplifying traffic movements and reducing potential angles of impact.<br>**Seagull in median**<br>Seagulls typically involve the provision of right-turn acceleration and deceleration lanes within a median of a T-intersection. They typically work well in situations where right-turning traffic from the minor leg would experience significant delays trying to access the main road due to a small number of suitable gaps. Roundabouts are generally preferred to seagulls where possible, and where the volume of right-turning traffic is small, a two-stage crossing may be more appropriate.<br>**Y to Basic T-intersection**<br>The alignment of a Y-intersection can create confusion as to right-of-way (where signage is obscured/not provided) and usually offers poor observation angles for the minor road to observe main road traffic.<br>Straightening the minor road approach to meet the main road at closer to right-angles improves observation angles for drivers and can reinforce the fact that they are on the minor approach and should yield to main road traffic. |

| **Intersection Geometry** |  |
|---|---|
| **Issues** | **Stagger cross intersection (right – left)**<br>The offsetting of one or both minor leg approaches may significant land acquisition and is likely to be costly.<br>Where traffic volumes on the main road are significant, right-turning traffic from the minor road (including minor road through traffic) may have difficulty entering the intersection due to a lack of suitable gaps and a left-right stagger could be considered to allow staging of the crossing movement.<br>**Street closures & Extending median through intersection**<br>Both of these treatment types include the prohibition of certain movements. It is important to consider the impacts this may have on access to adjacent land use as it may be detrimental.<br>When installing these treatments on safety grounds it is also necessary to consider the broader network implications. While preventing right-turn movements at an intersection may improve safety at that particular intersection, it is of little real benefit if the traffic is simply redistributed to an adjacent intersection that experiences similar problems. As such, these treatments should only be used where a safer alternative route exists.<br>Consideration should also be given to maintaining pedestrian and cyclists movements when proposing a street closure.<br>**Seagull in median**<br>Some seagull intersections are noted to experience high crash rates. Care should be taken in their use, noting roundabouts are generally preferred.<br>**Y to Basic T-intersection**<br>The realignment of the minor leg may require significant land acquisition and is likely to be costly. |
| **Other Benefits** | Seagulls can help improve traffic flows through the intersection. |
| **Cost** | Street closure, Extend median through intersection and Seagull in median: $$ - Low to Medium<br>Y to Basic T-intersection: $$$ - Medium<br>Stagger cross intersection: $$$$$ - High |
| **Benefit Cost Ratio** | Stagger cross intersection (right − left): ✓✓<br>Street closure (one leg of cross) and Seagull in median: ✓✓✓<br>Street closure (close stem of Tee), Extend median through intersection and Y to Basic T-intersection: ✓✓✓✓ |
| **Treatment Life** | Extend median through intersection and Seagull in median: 10 years<br>Street closure, Stagger cross intersection and Y to Basic T-intersection: 20 years |
| **References/ Further Information** | Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW.<br>Austroads 2019. *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings Management* Austroads, Sydney, NSW<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]*<br>**Photo Sources:**<br>Austroads 2019. *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings Management* Austroads, Sydney, NSW |

# 8.36 Turn Bans

<table>
<tr><th colspan="2">Turn Bans</th></tr>
<tr><td>Description</td><td>Turn bans involve the prohibiting of certain traffic movements through signage or physical means</td></tr>
<tr><td rowspan="4">Types</td><td colspan="2">Ban right turns left in / left out (physical barrier, e.g.. Islands) The banning of right turns into and out of a side road is also known as a ‘left-in/left-out intersection’. Usually this is done through physical means, such as a median through the intersection or a large splitter island on the side road.<br> 
<br>Source: Austroads (2019).</td></tr>
<tr><td>Ban right turns (at signalised and non-signalised intersections with signs)<br>Right turn crashes are often amongst the most severe due to the crashes occurring at close to right angles. Prohibiting right-turns with signage can reduce these incidents; however, compliance may be an issue.</td><td>  <br>Source: AS 1742.1.</td></tr>
<tr><td>Ban U-turns<br>U-turn crashes suffer from many of the same problems as right-turn traffic noting cashes can be close to right angle. However, it can also result in rear-ends both from drivers slowing down to undertake the U-turn and when they misjudge a suitable gap and are rear-ended by oncoming traffic as they try and enter the opposing traffic stream.</td><td>  <br>Source: AS 1742.1.</td></tr>
<tr><td>Ban left turns<br>Left turns are typically less likely to be associated with severe crashes however they may still involve crashes from vehicles slowing down to undertake the manoeuvre and side-swipes as they attempt to enter the adjacent traffic stream.</td><td>  <br>Source: AS 1742.1.</td></tr>
</table>

## Turn Bans

**KSI Crash Reduction**

| Treatment | Crash Type: Right Angle | Right Turn Thru | Rear-End | Side-swipe |
|---|---|---|---|---|
| Ban right turns left in / left out (physical barrier, e.g.. Islands) | 100% | 100% | 50% | 50% |
| Ban right turns (at signalised and non-signalised intersections with signs) | 50% | 50% | 25% | 25% |
| Ban U-turns | | 50% | 50% | |
| Ban left turns | | | 50% | 50% |

| | |
|---|---|
| **Crash Map Spreadsheet Reference** | 36-39 |
| **Application** | Turn bans are used when a particular movement is seen to be of high risk, or cannot be readily accommodated within the limited capacity of an intersection.<br>Turn bans should only be used where suitable alternative routes exist. |
| **Issues** | While preventing right-turn movements at an intersection may improve safety at that particular intersection, it is of little real benefit if the traffic is simply redistributed to an adjacent intersection that experiences similar problems. As such, the broader network context needs to be considered and these treatments should only be used where a safer alternative route exists.<br>Banning of particular movements can also cause undue delays to residents and businesses that use that route for access. Consideration of these access requirements should be given. |
| **Other Benefits** | Banning of particular movements — such as right turns — that may otherwise require a designated signal phase can improve the capacity of a signalised intersection. |
| **Cost** | Ban left turns, U-turn and right turns (at signalised and non-signalised intersections with signs): $ - Low<br>Ban right turns left in / left out (physical barrier, e.g.. Islands): $$ - Low to Medium |
| **Benefit Cost Ratio** | Ban left turns, U-turn and right turns (at signalised and non-signalised intersections with signs): ✅✅✅✅<br>Ban right turns left in / left out (physical barrier, e.g.. Islands): ✅✅✅✅✅ |
| **Treatment Life** | Ban left turns, U-turn and right turns (at signalised and non-signalised intersections with signs): 5 years<br>Ban right turns left in / left out (physical barrier, e.g.. Islands): 10 years |

| **Turn Bans** | |
|---|---|
| **References/ Further Information** | Austroads 2015, *Guide to Road Safety Part 8: Treatment of Crash Locations*, AGRS08-15, Austroads, Sydney, NSW.<br><br>Austroads 2019. *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings Management*, Austroads, Sydney, NSW.<br><br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]*<br><br>**Photo Sources:**<br><br>Standards Australia Limited. *AS1742 Manual of Uniform Traffic Control Devices. Part 1: General Introduction and Index of Signs*. Homebush, N.S.W.: Standards Australia, 2014.<br><br>Austroads 2019. *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings Management*, Austroads, Sydney, NSW. |

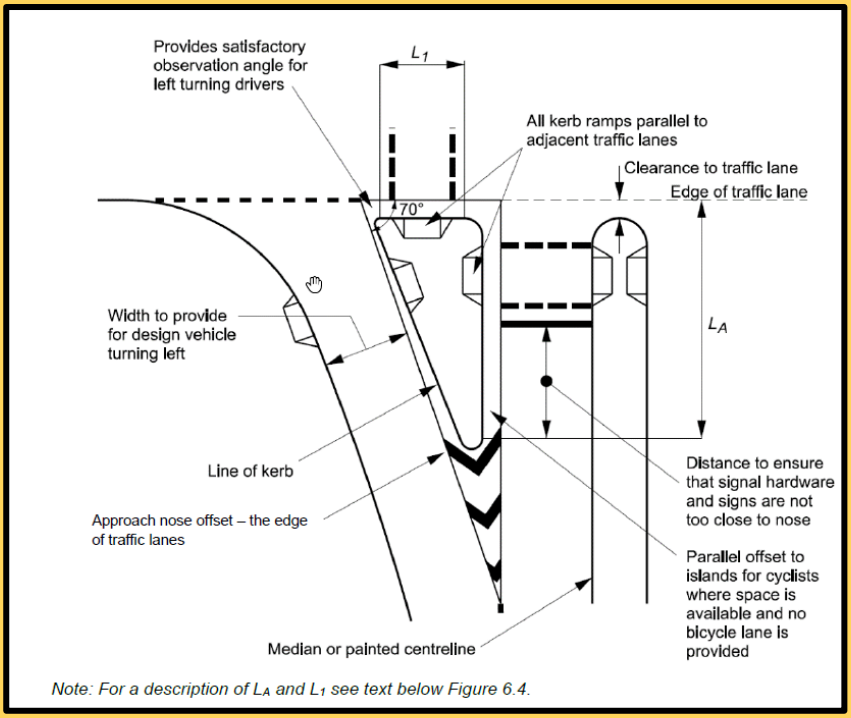
# 8.37 Turn Lane Treatments

| Turn Lane Treatments | |
|---|---|
| **Description** | Turn lanes, as the name implies, are dedicated traffic lanes for vehicles to turn. They separate turning traffic from the through traffic stream. |
| **Types** | **Extend right turn pocket to mitigate rear end crashes in through lane**<br>Lengthen of right turn lane so as that queues do not spill back into the through lane, where vehicles may be struck by through traffic. |
| | **Extend left turn pocket to mitigate rear end crashes in through lane**<br>Lengthen of left turn lane so as that queues do not spill back into the through lane, where vehicles may be struck by through traffic. |
| | **Reduce radius on left turn slip lane**<br>Large radius slip lanes can encourage high speed turning traffic. Reducing the radius can help control vehicle speeds. |
| | **Masking reduction: Protected left turn lane on through road (Channelised Left-turn (CHL))**<br>A channelised left-turn lane offsets left turning traffic further from the main carriageway, reducing potential sight line issues between minor road traffic and through traffic.<br>  <br>*Source: ARRB.* |

## Turn Lane Treatments

**Indented left turn slip (give way, stop or signal control) on terminating leg**

Indented left turn slip lanes separate left-turners from the rest of the traffic stream and allow left-turners to bypass the main traffic control for the intersection.



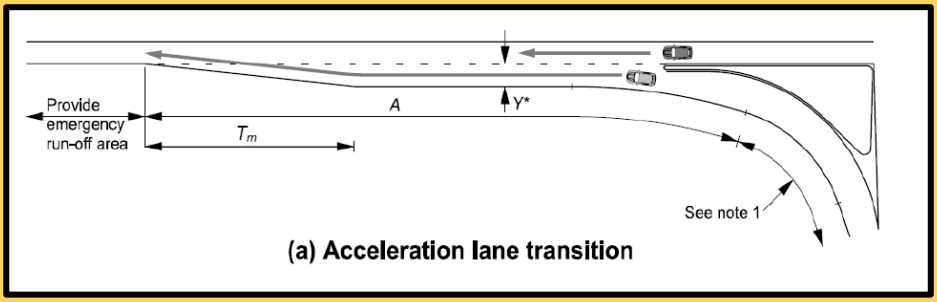

*Source: Austroads (2017).*

**Install left turn slip lane (no corner island)**

Indented left turn lanes separate left-turners from the rest of the traffic stream and allow left-turners to bypass the main traffic control for the intersection. Typically an island would separate left-turners from the other movements however this variant precludes this island.

**Left turn acceleration lane**

In high speed environments, left-turning traffic may have difficulty entering the traffic stream. An acceleration lane presents the opportunity to reach a comparable speed before merging.

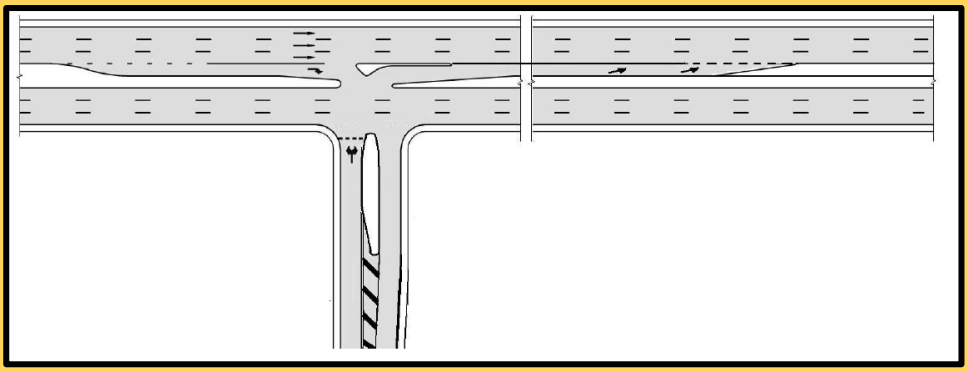



*Source: Austroads (2017).*

## Turn Lane Treatments

**Median acceleration lane (for right turn out)**

In high speed environments, right-turning traffic may have difficulty entering the traffic stream. An acceleration lane presents the opportunity to reach a comparable speed before merging.



*Note: Seagull Itnersection featuring right-turn acceleration lane.*

*Source: Austroads 2020.*

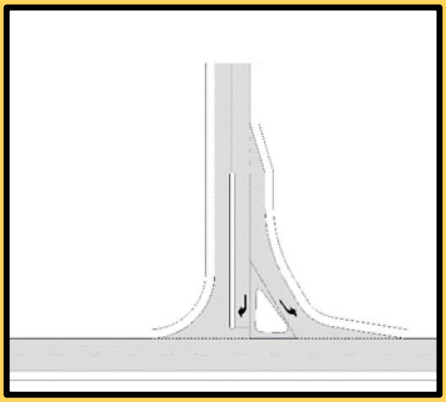
**Painted right turn lane**

Marking a specific area on the road for vehicles to turn right gives them dedicated space to store while waiting for a suitable gap in traffic.

*Source: iRAP toolkit.*

**Install fully separated channelised left turn (CHL)**

A CHL treatment involves separating the left turn traffic into a dedicated lane and can be used either on the minor or main road approach of an intersection.



*Source: Austroads (2020).*

**Line marking to improve lane definition between L slip & thru lane**

Clear definition of the turning movements to be undertaken from different lanes can help to prevent confusion and avoid sudden lane changes.

**Protected right turn lane (indented right turn island) (Channelised Right-turn (CHR))**

Similair to the CHL, a CHR is a dedicated right turn lane separate from general traffic. This case refers to the case of a CHR which is physically separated, such as through the use of an island or median.

## Turn Lane Treatments

**KSI Crash Reduction**

| Treatment | Crash Type | | | | | |
|---|---|---|---|---|---|---|
| | Pedestrian | Right Angle | Right Turn Thru | Rear-End | Side-swipe | Other |
| Extend right turn pocket to mitigate rear end crashes in through lane | | | 40% | 40% | | |
| Extend left turn pocket to mitigate rear end crashes in through lane | | | | 40% | | |
| Reduce radius on left turn slip lane | | 30% | | 50% | | |
| Masking reduction : Protected left turn lane on through road (Channelised Left-turn (CHL)) | | 30% | | 20% | | |
| Indented left turn slip (give way, stop or signal control) on terminating leg | | 30% | | 50% | | |
| Install left turn slip lane (no corner island) | | | 70% | 70% | | |
| Left turn acceleration lane | | 20% | | 30% | 30% | |
| Median acceleration lane (for right turn out) | | 20% | | | −10% | |
| Painted Right Turn Lane | | | 20% | 20% | | 20% |
| Install fully separated Channelised Left-turn (CHL) | −10% | | | 45% | 30% | |
| Line marking to improve lane definition between L slip & thru lane | | 5% | | | | |
| Protected right turn lane (indented right turn island) (Channelised Right-turn (CHR)) | | | 30% | 40% | | |

| **Turn Lane Treatments**  | |
|---|---|
| **Crash Map Spreadsheet Reference** | 23-24 (extend turn lanes)<br>33 (line marking to improve lane definition)<br>48-49 (new right turn lanes)<br>52 (reduce radius on left turn slip lane)<br>53 (masking reduction)<br>55, 56 (left turn slips)<br>57-58 (acceleration lanes)<br>67 (install fully separated chanellised left turn) |
| **Application** | The provision of turn lanes can offer a number of benefits depending on the configuration and type of intersection. As vehicles have to slow to undertake a turn, removing them from the traffic stream helps to reduce the potential for both rear end and side swipe crashes.<br>Slip lanes can allow for left-turning traffic to bypass the main traffic control of the intersection which may reduce delay for these vehicles. However, slip lanes also have the potential to allow high speeds for turning vehicles. Reducing the radius of the turn lane can help to constrain speeds, helping to reduce incidents of vehicles overshooting hold lane and/or failing to yield, and conflicts with pedestrians/cyclists crossing the slip lane.<br>Acceleration lanes form a similar function to other turn lanes. By providing dedicated space for vehicles to accelerate, they will be able gain speed before merging into the general traffic stream. This reduces the differential speed and helps to reduce rear-end and side swipe intersection in particular. |
| **Issues** | **Left turn lanes**<br>Vehicles in left turn lanes, particularly into minor roads at a T-intersection, have the potential to mask through traffic for those vehicles on the minor road approach. Consideration should be given to channelising of the left-turn lane in this instance. This allows the minor road leg to have a hold line in advance on the left turn lane, improving sight lines.<br>**Slip Lanes**<br>Slip lanes can be detrimental to pedestrians and cyclists attempting to cross them, especially when the radius is sufficient to allow high speeds.<br>If pedestrian volumes are significant, use of a wombat crossing or signalised pedestrian crossing should be considered to manage these conflicts or an alternative turn treatment should be considered.<br>Issues with storage capacity can also be a problem if pedestrian/cyclist volumes are high. As the slip lane is typically uncontrolled, and the main road crossing controlled, there is limit storage available on the island separating the slip lane from through traffic to accommodate pedestrians. Consideration may need to be given to priority pedestrian phasing in such instances. |
| **Other Benefits** | The separation of turning movements into dedicated lanes can significantly improve the capacity of an intersection, improving traffic flow. |
| **Cost** | Line marking to improve lane definition between L slip & thru lane: $ - Low<br>Extend left turn pocket to mitigate rear end crashes in through lane, Install fully separated Channelised Left-turn (CHL), Install left turn slip lane (no corner island), Masking reduction : Protected left turn lane on through road (Channelised Left-turn (CHL)), Painted right turn lane, Protected right turn lane (indented right turn island) (Channelised Right-turn (CHR)) and Reduce radius on left turn slip lane: $$ - Low to Medium<br>Extend right turn pocket to mitigate rear end crashes in through lane, Indented left turn slip (give way, stop or signal control) on terminating leg, Left turn acceleration lane and Median acceleration lane (for right turn out): $$$ - Medium |
| **Benefit Cost Ratio** | Indented left turn slip (give way, stop or signal control) on terminating leg and Median acceleration lane (for right turn out):  <br>Install left turn slip lane (no corner island):  |

| **Turn Lane Treatments** |  |
|---|---|
| | All other treatments:  |
| **Treatment Life** | Line marking to improve lane definition between L slip & thru lane: 5 years<br>Install fully separated Channelised Left-turn (CHL): 20 years<br>Indented left turn slip (give way, stop or signal control) on terminating leg: 30 yearsAll other treatments: 10 years |
| **References/ Further Information** | Austroads 2017 *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections*, Austroads, Sydney, NSW.<br>Austroads 2019. *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings Management*, Austroads, Sydney, NSWAustroads, Sydney, NSW.<br>iRAP Toolkit (http://toolkit.irap.org/default.asp?page=treatment&id=12)<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.38 Sight Distance Treatments

| Sight Distance Treatments | |
|---|---|
| **Description** | The provision of adequate sight distance is required so as that road users can make suitable decisions as to when to enter the traffic stream and so that vehicles have adequate time to stop in the event of a potential collision.<br>The following are various treatments to improve sight distance.<br>  |
| **Types** | **Clear all verges to ensure adequate Safe Intersection Sight Distance (SISD)**<br>Safe Intersection Sight Distance refers to, in the event of a worst-case scenario where a car attempts to enter the traffic stream and stalls, the vehicle on the through road would have sufficient stopping distance to avoid the incident. |
| | **Improve sight lines for opposing turns (e.g. clear median)**<br>Excessive foliage and other visual obstructions within the median can impede sight lines to approaching traffic. |
| | **Improve sight lines for rear-end crashes (e.g. remove crest or bend)**<br>A vertical crest or horizontal bend on the approach to intersections can obscure vehicles at the back of queue. Removing these curves can remedy this issue. |
| | **Achieve Crossing Sight Distance (CSD) for path users**<br>Pedestrians and cyclists require adequate sight distance to pick suitable gaps when attempting to cross a road. |
| | **Move stop or give-way lines forward using kerb extensions to improve Safe Intersection Sight Distance (SISD)**<br>Obstructions either on or close to the road-side can impede SISD. Moving the hold line forward can help drivers to see past such obstructions, such as moving it in line with the edge of adjacent parking bays to see past parked cars. |

## Sight Distance Treatments

**KSI Crash Reduction**

| Treatment | Crash Type: Pedestrian | Right Angle | Right Turn Thru | Rear-End | Side-swipe | Other |
|---|---|---|---|---|---|---|
| Clear all verges to ensure adequate Safe Intersection Sight Distance (SISD) | 30% | 30% | | 20% | | |
| Improve sight lines for opposing turns (e.g. clear median) | 30% | | 30% | 20% | | |
| Improve sight lines for rear-end crashes (e.g. remove crest or bend) | | | | 20% | | |
| Achieve Crossing Sight Distance (CSD) for path users | 15% | | | 5% | | |
| Move stop or give-way lines forward using kerb extensions to improve Safe Intersection Sight Distance (SISD) | 20% | 20% | | | | 20% |

| | |
|---|---|
| **Crash Map Spreadsheet Reference** | 40-42<br>60 (achieve crossing sight distance for path users)<br>69 (move stop ro give way lines forward) |
| **Application** | Sight distance should be provided as a matter of course and is particularly important at unsignalised intersections, or signalised intersection with filtered turn phases, where manual gap selection is required. |
| **Issues** | Where sight distance is obstructed by the road alignment, such as a bend or crest, improving sight distance may be very costly and other options such as reducing the speed limit or providing signage may be more appropriate. |
| **Other Benefits** | |
| **Cost** | Improve sight lines for rear end crashes (e.g. remove crest or bend): $$$$$ - High<br>All other treatments: $ - Low |
| **Benefit Cost Ratio** | Improve sight lines for rear end crashes (e.g. remove crest or bend): ✓<br>All other treatments: ✓✓✓ |
| **Treatment Life** | Move stop or give-way lines forward using kerb extensions to improve Safe Intersection Sight Distance (SISD): 20 years<br>All other treatments: 5 years |

| **Sight Distance Treatments** |  |
|---|---|
| **References/ Further Information** | Austroads 2015, Guide to Road Safety Part 8: Treatment of Crash Locations, AGRS08-15, Austroads, Sydney, NSW.<br>Austroads 2016 *Guide to Road Design Part 3: Geometric Design." Austroads Ltd.*, Austroads, Sydney, NSW.<br>Austroads 2017. *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections*, Austroads, Sydney, NSW.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]* |

# 8.39 Intersection Other

| Intersection Other | |
|---|---|
| **Description** | Various treatments for use at intersections, predominantly focussed on the retrofitting of existing intersections as opposed to new intersection geometry. |
| **Types** | **Install STOP sign at T-intersection (if warranted AS1742.2)**<br>Stop signs require vehicles to stop entirely before entering an intersection and are used at locations where the sight lines on the approaches are deficient.<br><br>**Install STOP sign at X-intersection (if warranted AS1742.2)**<br>Stop signs require vehicles to stop entirely before entering an intersection and are used at locations where the sight lines on the approaches are deficient. At intersections, signing can reinforce the presence of the intersection and clearly designate priority of the traffic movements.<br><br>  <br><br>*Source: AS 1742.1.*<br><br>**Install a GIVE WAY sign at T-intersection**<br>It is noted that give way at a T-intersection is required from the minor leg under the road rules, however specifically signing this can help reinforce the presence of the intersection to drivers and the need to give way.<br><br>**Install a GIVE WAY sign at X-intersection**<br>At intersections, signing can reinforce the presence of the intersection and clearly designate priority of the traffic movements.<br><br>  <br><br>*Source: AS 1742.1.*<br><br>**Raised intersection/ intersection approaches**<br>Raised intersections or intersection approaches are vertical traffic calming features akin to speed humps.<br><br>  <br><br>*Source: Blewden et al. (2020).* |

## Intersection Other

**Improve/reinforce priority signs (i.e. sign duplication)**

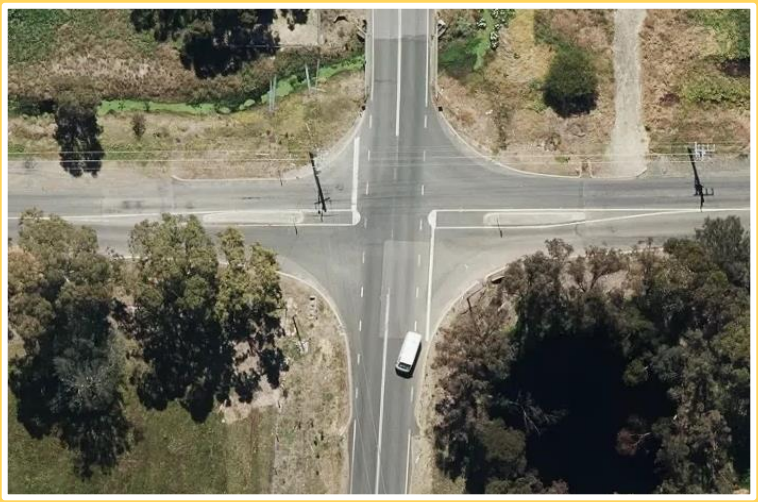
**P**riority signs, such as give-way and stop, clearly designate the priority rules of an intersection. Reinforcing this message through duplication of signage or early warning signs on approaches can help reinforce this message.

*Source: AS 1742.1.*

**Rumble strips on terminating intersection approaches (overshoot crashes)** involves the use of rumble strips on the stem of T-intersection to encourage vehicles to reduce speeds.

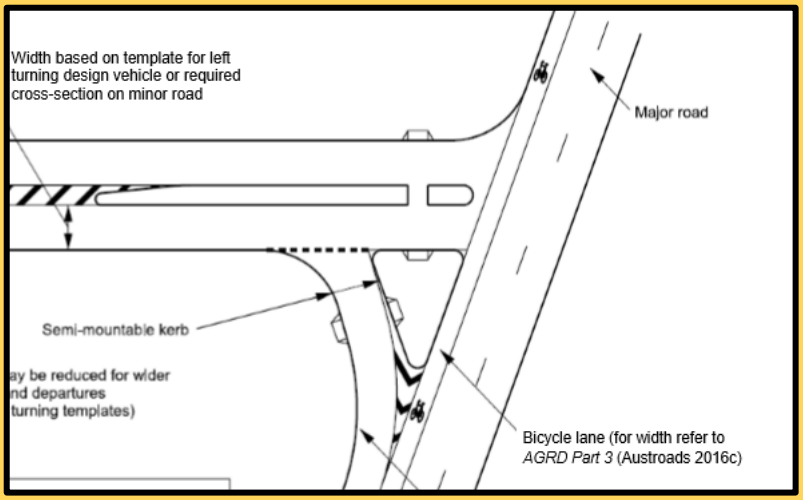
*Source: National Cooperative Highway Research Program et al. (2008).*

**Traffic median islands on approaches** are physical islands separating opposing traffic streams. These are typically provided on the minor road approaches of Give-way/Stop controlled intersections and can slow and direct traffic.



## Intersection Other

**Cycle lane through intersection (bicycle crashes only)** are marked cycle lanes that continue through the intersection




*Source: Excerpt from Austroads (2017).*

**KSI Crash Reduction**

| Treatment | Crash Type: Pedestrian | Right Angle | Right Turn Thru | Rear-End | Side-swipe | Other turning related crashes |
|---|---|---|---|---|---|---|
| Install STOP sign at T-intersection (if warranted AS 1742.2) | 10% | 20% | | | | |
| Install STOP sign at X-intersection (if warranted AS 1742.2) | 15% | 30% | 20% | | | |
| Install a GIVE WAY sign at T-intersection | 10% | 15% | | | | |
| Install a GIVE WAY sign at X-intersection | 15% | 20% | 15% | | | |
| Raised intersection/intersection approaches | 40% | 40% | 40% | -20% | 40% | 40% |
| Improve/reinforce priority signs (i.e. sign duplication) | | 8% | | | | |
| Rumble strips on terminating intersection approaches (overshoot crashes) | | 8% | | | | |
| Traffic median islands on approaches | 30% | 40% | 20% | 18% | 20% | |
| Cycle lane through intersection (bicycle crashes only) | | 10% | 10% | 10% | 10% | |

| **Intersection Other**  | |
|---|---|
| **Crash Map Spreadsheet Reference** | 31 (improve/reinforce priority signs)<br>32 (rumble strips on terminating intersection approaches (overshoot crashes))<br>47 (traffic median islandss on approaches)<br>62 (cycle lane through intersection)<br>63-66 (Stop/give-way signs)<br>76 (raised intersection/approaches) |
| **Application** | **Signage (stop and giveway)**<br>Signage can be used to reinforce road rules, assign priority to one approach or another, and/or to highlight the presence of an intersection to approaching drivers. Stop signs should be used over give ways when the sight distance on the minor road is restricted. Specific warrants are noted in AS 1742.2:2009.<br>Where visibility of signage is a problem, improvements to sign visibility and/or additional/supplementary signage may be appropriate to reinforce their presence. This can include changing the size of the sign, duplicating the sign on the right hand side of the road and/or installation of advanced warning signs further upstream of the intersection.<br>**Raised intersection/ intersection approaches**<br>Raised intersections and intersection approaches are used to reduce the speed of vehicles both on the approach to and through an intersection. A number of potentially severe conflicts exist at intersections, noting right-turn crashes in particular which can occur at conflict angles close to 90º, and by lowering vehicle speeds it's possible to reduce the potential speeds at which crashes occur to within tolerable thresholds.<br>**Rumble strips on terminating leg**<br>Rumble strips have a traffic calming effect and can help reduce vehicle speeds. By using them on the stem of a T-intersection, the approach speeds can be reduced, reducing incidents of vehicles overshooting the hold line.<br>**Traffic median islands on approaches**<br>Traffic median islands are used on intersection approaches to separate opposing traffic streams. By providing a physical offset between these streams the risk of such as sideswipe can be reduced. They can also be used by pedestrians to stage their crossing of the road in two movements.<br>**Cycle lane through intersection**<br>Cycle lanes help to highlight the presence of cyclists through an intersection, gives them designated space and improves lateral spacing between vehicles and cyclists. |
| **Issues** | **Signage**<br>Signage controlled intersections typically experience higher crash rates than roundabouts or signalised intersections as they place greater onus on drivers to pick appropriate gaps in traffic. They are amongst the lowest form of intersection control and should only be used on low volume roads where the provision of higher forms of intersection control cannot be practically provided.<br>**Raised intersection/intersection approaches**<br>As with any raised feature, drainage requirements will have to be considered in the provision of raised intersections and medians.<br>The raised features also need to consider all road users that use the road, and select appropriate ramp grades. Too steep a grade can be an issue for larger vehicles such as busses and heavy vehicles in particular while too shallower a grade can allow vehicles to traverse the ramp at speed. Placement of the ramp is also important and should typically not be placed within the likely turning path of vehicles as it can have a destabilising effect, particularly for motorcyclists.<br>**Rumble strips on terminating leg**<br>While rumble strips must cause enough vibration to capture the attention of the driver, rumble strips also create noise as the tyres cross over them. Therefore, rumble strips should not be installed in close proximity to residences. |

| **Intersection Other** |  |
|---|---|
| **Other Benefits** | |
| **Cost** | Install STOP or GIVE WAY sign at T or X-intersection, Improve/reinforce priority signs (i.e. sign duplication) and Rumble strips on terminating intersection approaches: $ - Low<br>Cycle lane through intersection, Traffic median islands on approaches or Raised intersection/intersection approaches: $$ - Low to Medium |
| **Benefit Cost Ratio** |  |
| **Treatment Life** | Install STOP or GIVE WAY sign at T or X-intersection, Improve/reinforce priority signs (i.e. sign duplication) and Rumble strips on terminating intersection approaches: 5 years<br>Traffic median islands on approaches and Cycle lane through intersection: 10 years<br>Raised intersection/intersection approaches: 20 years |
| **References/ Further Information** | AS 1742.2:2009, Manual of uniform traffic control devices: part 2: traffic control devices for general use.<br>Austroads 2016. *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice*, Austroads, Sydney, NSW.<br>ARRB 2021, *CRF Review and Update (ROSMA & CARS) [D21#1302684]*<br>**Photo Sources:**<br>Austroads 2016. *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice* Austroads, Sydney, NSW.<br>Austroads 2017. *Cycling Aspects of Austroads Guides*, Austroads, Sydney, NSW.<br>National Cooperative Highway Research Program, Transportation Research Board, and National Academies of Sciences, Engineering, and Medicine. *Guidelines for Selection of Speed Reduction Treatments at High-Speed Intersections: Supplement to NCHRP Report 613*. Washington, D.C.: Transportation Research Board, 2008. https://doi.org/10.17226/23095.<br>Standards Australia Limited. *Manual of Uniform Traffic Control Devices. Part 1: General Introduction and Index of Signs*. Homebush, N.S.W.: Standards Australia, 2014. |

# 9 References and Related Documents

| Document Number | Description |
|---|---|
| D15#676693 | Policy – Road Safety Management at Main Roads (ROSMA) |
| D15#686631 | Guideline – Road Trauma Treatments |
| D15#686631 | Guideline – Road Trauma Reduction |
| D15#686636 | Guideline – Road Safety Project Identification Strategy |
| D15#675339 | Guideline – Road Trauma Risk Analysis |
| D15#686638 | Guideline – Safety Treatments |
| D15#686647 | Continuous Improvement Plan |
| D15#686656 | Communication Plan |
| D15#686673 | Resource Plan |
| D21#1302684 | ARRB – CRF Review and Update (ROSMA & CARS) Report |
| D21#1302687 | Appendix B1 - ARRB – CRF Review and Update (ROSMA & CARS) Report |
| D21#1302691 | Appendix B2 - ARRB – CRF Review and Update (ROSMA & CARS) Report |
| D21#1302693 | Appendix E1 - ARRB – CRF Review and Update (ROSMA & CARS) Report |
| D21#1302696 | Appendix E2 - ARRB – CRF Review and Update (ROSMA & CARS) Report |
| D21#1302701 | Appendix F1 - ARRB – CRF Review and Update (ROSMA & CARS) Report |
| D21#1302706 | Appendix F2 - ARRB – CRF Review and Update (ROSMA & CARS) Report |
| D21#1302709 | Appendix G1 - ARRB – CRF Review and Update (ROSMA & CARS) Report |
| D21#1302712 | Appendix G2 - ARRB – CRF Review and Update (ROSMA & CARS) Report |
| | Bureau of Infrastructure, Transport and Regional Economics (BITRE), (2012), Evaluation of the national black spot program. Volume 1, BITRE Report 126, Canberra, Australian Capital Territory. |
| | Jensen, S (2013), Safety effects of converting intersections to roundabouts. Transportation Research Record 2389, 22–29. |

# Appendix A: Countermeasure Update/Comment Form

| **Insert name of new countermeasure here or**<br>**Enter the name of the countermeasure you which to comment on or update** | |
|---|---|
| **Description** | Either enter a description of new countermeasure or<br>Enter description of the amendment you want to make to an existing countermeasure |
| **Types** | Enter new text or modification to existing text as required. |
| | Enter new text or modification to existing text as required. |
| | Enter new text or modification to existing text as required. |
| | Enter new text or modification to existing text as required. |
| | Enter new text or modification to existing text as required. |
| | Enter new text or modification to existing text as required. |
| **KSI Crash Reduction** | Enter new text or modification to existing text as required. |
| **Application** | Enter new text or modification to existing text as required. |
| **Issues** | Enter new text or modification to existing text as required. |
| **Other Benefits** | Enter new text or modification to existing text as required. |
| **Cost** | Enter an estimated cost, e.g. $1000 per km |
| **Benefit Cost Ratio** | Enter new text or modification to existing text as required. |
| **Treatment Life** | Enter a treatment life, e.g. 3 years |
| **References/ Further Information** | Enter references to further information |

Please send completed form to roadsafety@mainroads.wa.gov.au