Technical Note 188

Geometric Design of Innovative Intersections “Displaced Right Turn”

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1 Purpose and scope

This technical note provides advice on the geometric design methodology for Displaced Right Turn (DRT) Intersection treatments on the Queensland State Controlled road network. The scope of this advice focuses on the geometric characteristics for the DRT aligned with Transport and Main Roads' *Road Safety Policy*.

Guidelines from the United States Federal Highway Administration (FHWA, 2014) https://www.fhwa.dot.gov/ have been used as a general basis to produce this technical note. Any design criteria specified in this technical note, however, takes precedence over equivalent design criteria in documents from the USA and other countries.

Whilst this technical note provides guidance on the specific geometric characteristics for the DRT, Designers, Engineers and Planners must also consider the traffic operational performance, driver expectation, public transport, road lighting, egress, environmental and future land use impacts with any proposal for including the DRT as a solution. Furthermore, the accessibility and safety to vulnerable road users must also be considered.

Comments and suggestions for improvements to this document based on experience with its use should be forwarded to the Director (Road Design) so that any adjustments can be considered and implemented where appropriate in subsequent revisions.

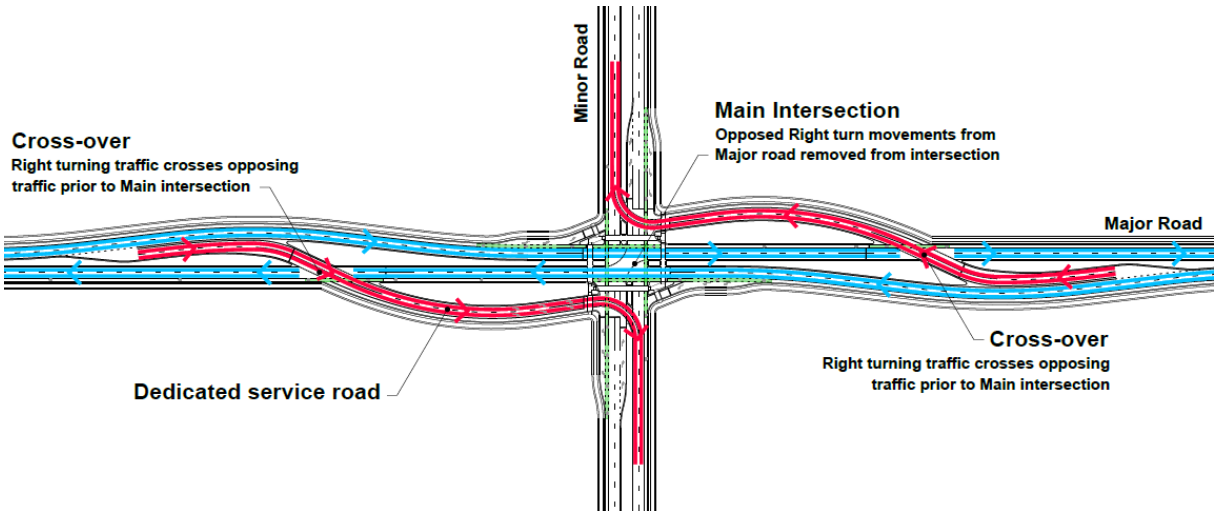
This technical note is intended to be incorporated into Transport and Main Roads’ *Road Planning and Design Manual* (RPDM) in due course.

2 Benefits of a Displaced Right Turn (DRT) intersection

The (DRT) intersection treatment also known as Continuous Flow Intersection (CFI) represents new and innovative design thinking for road infrastructure within Australia. The principles of the DRT have been leveraged from the USA, having implemented these types of design solutions for several years, delivering positive economic outcomes, improving traffic reliability and safety at challenging locations of the road network.

A diagram showing the characteristics of a DRT is provided in Figure 2.

Figure 2 - Characteristics of the DRT



The primary advantage to the DRT is the reduction of the number of traffic signal phases and conflict points to the main intersection consequently resulting in improvements to the movement of traffic through the intersection. It has the potential to improve intersection performance, reliability and safety which could postpone or eliminate future grade separated solutions.

Industry and Transport and Main Roads' practitioners are encouraged to consider this type of treatment at appropriate locations as an acceptable design solution. It may be possible for the DRT to be applied to one side of an intersection or even be applicable to ‘Tee’ intersections.

3 Application

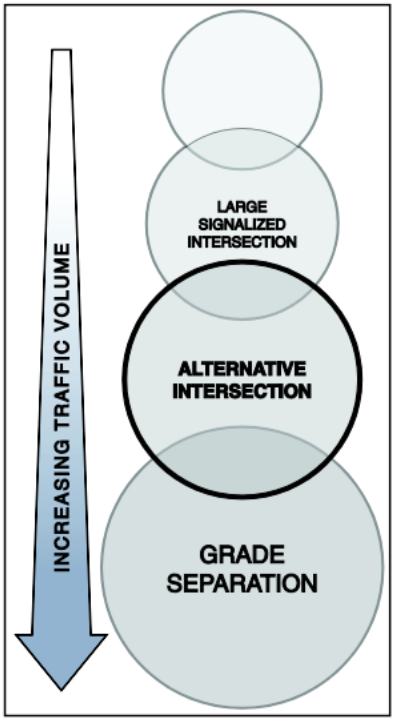
It is recognised that congestion particularly at urban locations continues to impact motorists, pedestrians and cyclists through delays and creates a heighted risk of exposure. This increase to traffic volume and requirement to meet the travel demands can lead to safety challenges that can be difficult to address through conventional intersection layouts.

Figure 3 extracted from FHWA (2014) demonstrates the relationship between increasing traffic volumes, conventional intersection treatments, alternative treatments such as a DRT and grade separation. The diagram shows that the most useful application of the DRT (alternative intersection) is when traffic volumes are too high for a conventional signalised intersection and grade separations cannot be justified.

The DRT treatment is particularly effective where there are very high volumes of right turning traffic, reprioritising the signal phasing to the main intersection by relocating the right turning traffic upstream of the intersection.

The DRT as an alternative treatment is **not** considered appropriate for rural sites.

Figure 3 - Relationship between increasing traffic and intersection treatments



Source – FHWA (2014)

4 Design philosophy

The fundamentals when developing a geometric layout to an intersection requires careful consideration of the physical and functional characteristics of the site, safety, operational requirements including vulnerable road users (pedestrians and cyclists). Designers require an understanding of the potential ‘trade-offs’ of the physical, environmental and right of way constraints for any proposed DRT may have existing conditions that preclude the optimum DRT intersection layout. Undesirable geometry should not be mitigated simply by the application of additional signage, pavement markings and or overhead gantries.

A critical aspect to the DRT is to provide a geometric solution that channelises right-turning motorists into the service road, the approach should be to provide an alignment (geometry) that is ‘self-navigating’ that can be enhanced with signage and pavement markings.

As previously mentioned a primary benefit to the DRT is the reduction in the number of traffic signal phases at the main intersection. This is can be achieved by locating right turning traffic further upstream of the main intersection to cross the opposing traffic at the ‘cross-over’ and travel along a new median divided service road. Traffic signals at the crossover and main intersection should be coordinated so vehicles do not stop multiple times in the intersection area.

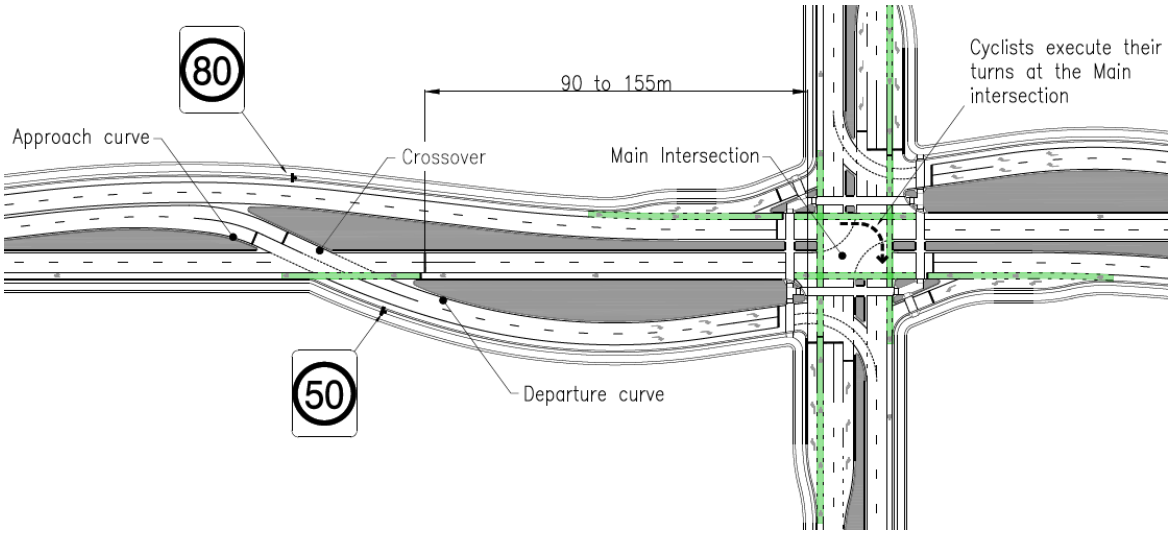
The design methodology of the DRT must be consistent with current Queensland practice for road infrastructure with respect to *“Greenfield and/or Brownfield”* sites i.e. RPDM and *Guidelines for Road Design on Brownfields Sites*.

5 Geometric design

5.1 Positioning of the crossover

FHWA (2014) recommends the spacing between the main intersection and the crossover ranges from 300 to 500 feet (90 to approximately 155 metres). A function of the DRT is to coordinate the signals at the crossover and the main intersection, thus the spacing between these two intersections will have an impact on the signal phasing strategy to achieve the optimal performance for the network. Local site constraints and other factors may also need to be factored in considering the spacing of the crossover and the main intersection.

Figure 5.1 - DRT intersection spacing



5.2 Speed

It is possible for the posted speed to an arterial road throughout Transport and Main Road’s network can be up to 80 km/h. The DRT should be designed to encourage right turning vehicles to slow down at the crossover, with a maximum posted speed through the Service Road of 60 km/h.

Designers must consider the appropriate deceleration length (typically to the back of any stationary vehicle or queue) and should consider treatments such as a ‘buffer’ to act as a separation between the through traffic and traffic entering the DRT to mitigate the effects of the potential speed differential that may be created.

5.3 Provision for on-road cyclists

On-road cyclists wishing to undertake right turns at the main intersection should be catered for at the main intersection consistent with current practice e.g. hook turn. Encouraging on-road cyclists through the displaced right turn geometry is not recommended.

5.4 Crossover angle

The desirable crossover angle between the right turning traffic and the opposing through traffic ranges between 19 to 25 degrees as shown in Figure 5.4(a) below. Crossover angles less than 19 degrees lead to undesirable geometry that increase the potential ‘exposure length’ of vehicles through the crossover including the potential increased risk of motorists taking an unacceptable travelled path into the opposing traffic causing serious injury.

Other key elements to the geometric design at the crossover include:

- A minimum length of straight of 0.7V between the approach curve and the departure curve.
- The tangent point at the end of the approach curve to be set-back a minimum distance of 5.0 m from the opposing carriageway edge line or shoulder. This ensures the approach geometry can be set to clearly guide motorists through the crossover into the service road away from the opposing traffic stream.
- The design speed of the approach curve must not exceed the limiting curve speed.

Figure 5.4(a) - Desirable DRT crossover geometry

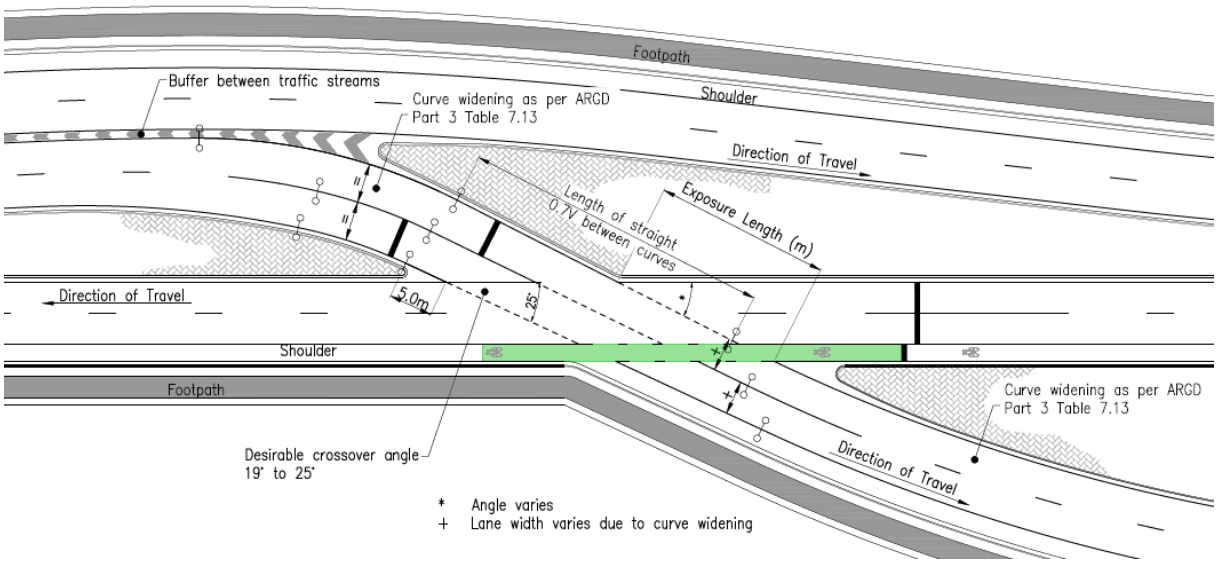
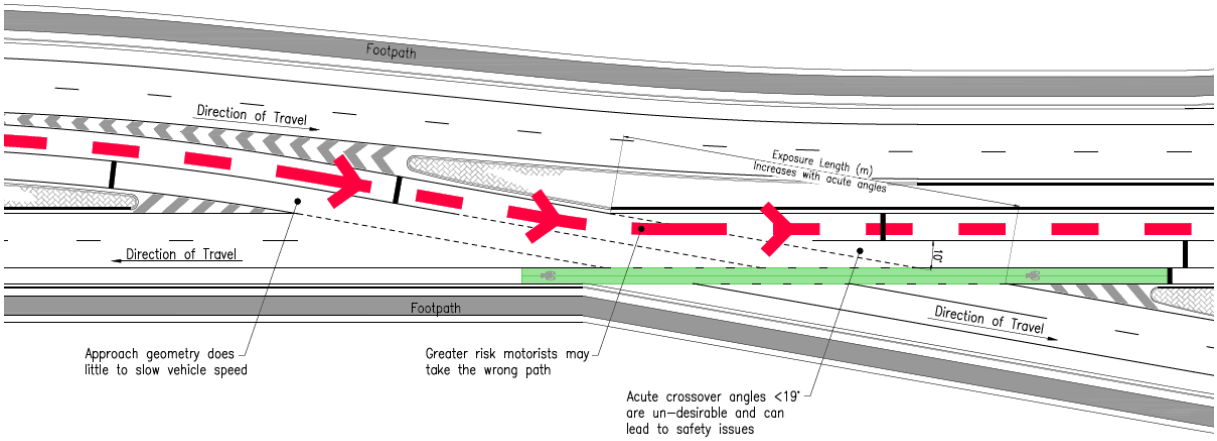


Figure 5.4(b) - Undesirable crossover geometry



5.5 Cross fall / superelevation

The desirable minimum cross fall through the DRT is 3% with an absolute minimum of 2.5%. However cross fall should not exceed 5% on the approach and through the DRT.

Transport and Main Road's preference is for superelevation to be applied to all horizontal curves. Horizontal curves should be designed using the desirable side friction demand values for both cars and trucks as per the department's *Road Planning Design Manual* and Austroads.

It is recognised that the use of adverse cross fall may be required in some cases for example on the departure curve of the DRT. This may be required for reasons of constructability, property access, comfort and efficient drainage to the finished road surface.

Adverse cross fall should not exceed -3%. As referenced in Part 3 of *Austroads Guide to Geometric Design (Austroads 2016a)* adverse cross fall should be avoided in the following areas:

- on the approach to intersections or other braking areas
- locations subject to aquaplaning, ponding of water, and
- where longitudinal grades exceed 4%.

Horizontal curves that use adverse cross fall shall be designed based on 2/3rds of the recommended side friction values for trucks published within Austroads (2016a).

5.6 Cross section

Lane widths through the DRT shall be as per the *Road Planning and Design Manual*, Edition 2 Volume 3, *Supplement to Austroads Guide to Road Design, Part 3 Geometric Design* (TMR, 2018b), based on the designated design vehicle. Curve widening shall be applied as per Austroads (2016a). However, lane widths should not exceed 4.6 m. Where lane widths exceed 4.6 m based on the curve widening or using turn-path templates, Designers should consider changing the proposed alignment. Shoulder widths are to be a minimum of 0.5 m.

5.7 Sight distance

All aspects of sight distance, approach sight distance, safe intersection sight distance, sight distance to property access shall be in accordance with the current guidelines outlined within TMR (2018b) and Austroads (2016a, 2016b and 2016c) as relevant.

5.8 Main intersection

Figure 5.8(a) below shows an example layout of the main intersection that accommodates high volume right turning movements of the DRT. It is desirable for the ‘Stop Line’ on the Minor Road to be positioned before the intersection with the ‘DRT Service Road’ primarily to avoid any minor road traffic queuing across the turning path of the traffic exiting the DRT service road.

Depending on the site conditions and traffic performance there may be instances where the ‘Stop Line’ on the minor road needs to be placed in a conventional position at the main intersection (refer Figure 5.8(b)). The figure also shows the recommended pavement marking treatment to mitigate motorists to keep clear the turning path for vehicles exiting the DRT.

Figure 5.8(a) - Desirable treatment at the main intersection

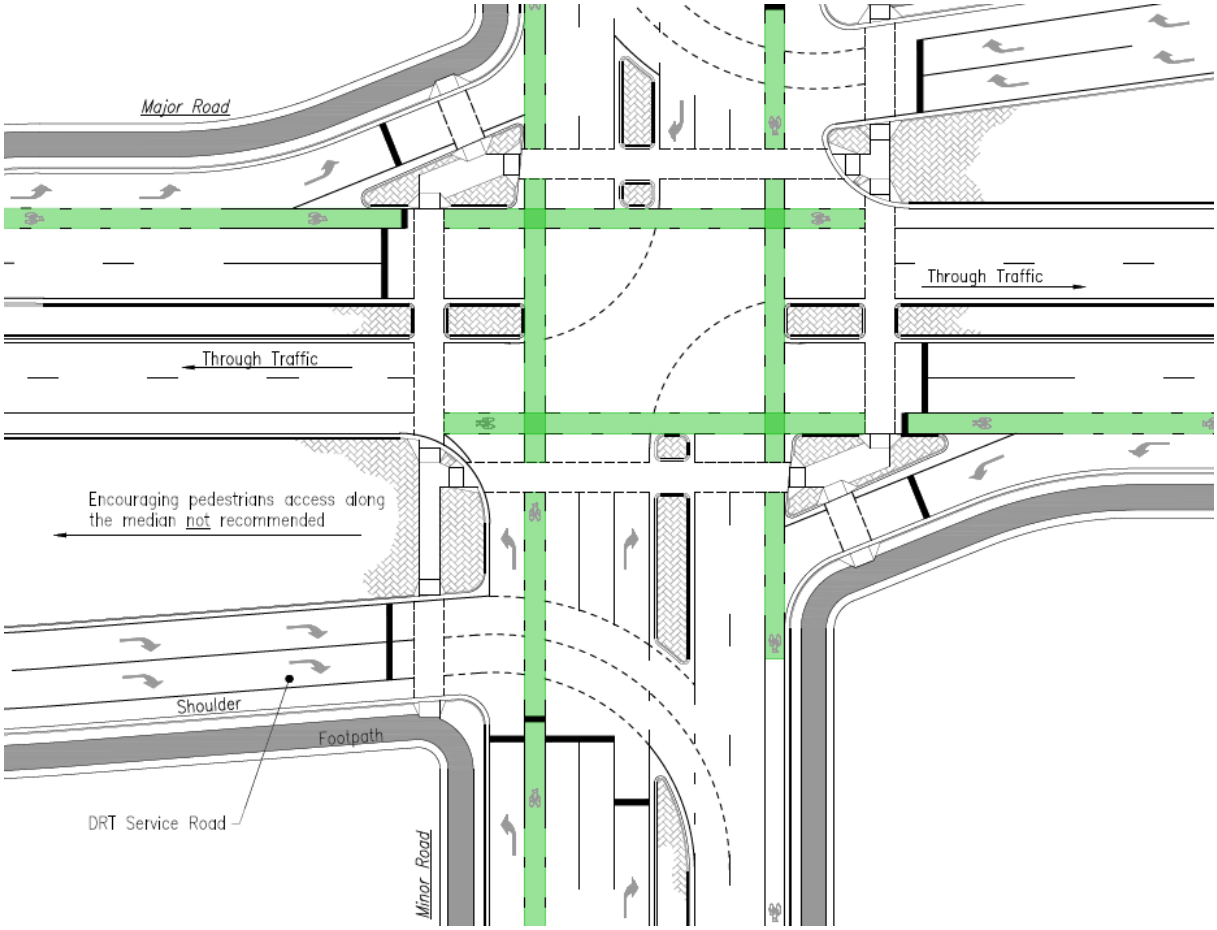
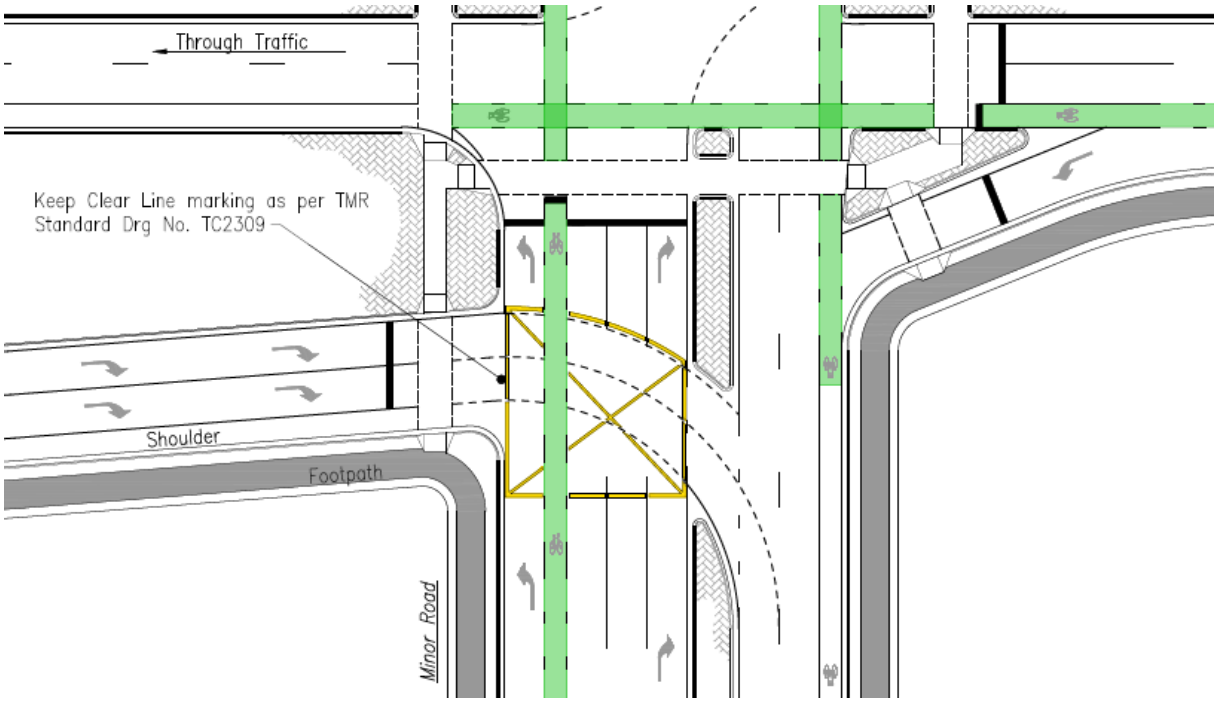


Figure 5.8(b) - Alternative treatment at the main intersection



6 References

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