CEDR Transnational Road Research Programme

Call (Safety 2016)

Funded by Belgium-Flanders, Ireland, Netherlands, Slovenia, Sweden, United Kingdom

Safety in Non-Urban Areas for VRU (SANA-4U)

WP5 Guideline for Selection of VRU Infrastructure Design

Deliverable No D5.1

Date October 2020

VTI (Sweden)

BRRC (Belgium)

Arup (Ireland)

CEDR Call Safety 2016

Safety in Non-Urban Areas for VRU (SANA-4U)

Deliverable 5.1: Final report – Guidelines for Selection of VRU Infrastructure Design in Non-Urban Areas

Start date of project: 2017-09-01 End date of project: 2020-11-01

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Version: 2.0

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Glossary of Terms

AADT	Average annual daily traffic (measure of traffic volume).
CEDR	Conference of European Directors of Roads
CPiJ	Crossing Points in Junctions (referring to the Junction section). Usually in conjunction with a pedestrian/bicycle path running parallel with a main road and the crossing point (of interest) occurs when a secondary road intersects with the main road. The point of crossing is (generally) the secondary road.
HF	Human factors (HF) is the application of psychological and physiological principles to the design of products, processes, and systems. The goal of human factors is to reduce human error, increase productivity, and enhance safety and comfort with a specific focus on the interaction between the human and the thing of interest (from Wickens et al., 2004).
MV	Motorised vehicles
NMU	Non-motorised users
NRA	National road authority
NUA	Non-urban areas: Specifies a transition zone which can comprise a road length which is designed between the rural and urban areas.
pcu/h	Passenger car unit per hour (measure of traffic volume).
Pelican crossing	A pelican (originally *pelicon* sic.) crossing is a type of pedestrian crossing derived from pedestrian light controlled crossing.
VRU	Vulnerable Road User: The road user groups defined as vulnerable road users in this project comprises pedestrians and cyclists. Electric bicycles are classes as bicycles if the effect does not exceed 0.250 kW (and speed restricted to 25 km/h). Motorised wheelchairs are included. Electric bicycles with an engine effect > 0.25 kW are classed as mopeds (class 1 or 2 depending on power) or motorcycles if they exceed 4 kW. Neither of these types are included in the projects definition of VRU. Equestrian transport or hackneys are not included in this project's definition of VRU.

1 Introduction

The promotion of active transport (cycling and walking) for everyday physical activity is a win-win approach; it not only promotes health but can also lead to positive environmental effects, especially if cycling and walking replace car trips. Cycling and walking can also be more readily integrated into people's busy schedules than, for example, leisure-time exercise. We must however, ensure that even these activities by cyclists and other vulnerable road users (VRU) can be done in a safe environment.

Promoting safety for VRU is an item that comes back in several initiatives, on national and European levels. Many European road authorities focus their design standards on VRU's. However, those standards have been developed to be implemented in new road projects and are unfortunately not always implemented on the existing road network outside urban areas, often due to the difficulty in achieving standards due to constraints of the adjacent road.

Over the course of this project, we have reviewed VRU standards across member states, analysed them and developed a "good practice guide" based on the good examples used by the CEDR members, with focus on VRU provision on existing roads in non-urban areas. The rationale of this method is to lend good CEDR member ideas and practices and compile them for the collective benefit of all the CEDR members. In regard to cycling, it is worth noting that this work focuses on the development of guidance for design of bicycle facilities to be used primarily for leisure, commuting and tourism rather than high speed exercise/bicycle racing. The last step in the project is the consolidation of the guidelines found in this deliverable.

The authors of this report, unless otherwise indicated, regard much of the bicycle infrastructure suggested in this report, such as bicycle paths, as having a multi-purpose use and therefore used by other VRU groups such as pedestrians (if specific pedestrian infrastructure is missing), roller skiers (common in Nordic countries) or in-line skaters. Zebra/pedestrian and bicycle crossings are obvious exceptions to the multi-purpose ethos, even if they are often found in close proximity.

2 Project objectives

The objectives of this project are to identify and collect good examples or improvements to existing standards and guidelines for the design of a road systems that promotes safety for vulnerable road users (VRU) especially in non-urban areas. The non-urban areas of main interest comprise existing legacy road networks in CEDR member states. A summary of the work compiled over the course of this project is presented below.

- **Work package 1 (WP1)** reviewed available VRU Standards across CEDR member states and these were summarised in *D1.1 "Review of Standards and Practices for VRU on non-urban roads"*.
- **Work package 2 (WP2)** collected and presented a number of examples, both good and bad (or rather less good), for implemented cycle and pedestrian schemes in non-urban areas. The examples collected were done through road authority contacts made during WP 1 as well as through internet searches for relevant examples.

  Examples for various elements of non-urban VRU design were collected and presented in the WP2 report, *D2.3 Final version of the Good Practice Guide*. The report reviewed the following cycle and pedestrian design elements:
  - Crossing points;
  - Junctions (which have good visibility and poor visibility);
  - Continuous road segments, including curves (which have good visibility and poor visibility);
  - School Zones;
  - Small linear settlements, small numbers of houses/buildings alongside the road which are not indicated/characterised as a city or town, but does result in VRU's walking and cycling along or across the road;
  - Roundabouts (rural roundabouts).

  For each of the design elements reviewed, a list of good practice principles was established.
- **Work package 3 (WP3)** focused on 3 worked examples. This WP 3 led to Deliverable D3.1: "Report on three Worked Examples of Good Practice" and presents sample concept designs, based on existing standards across Europe collected during Work Package 1, and the good practice principles identified in Work Package 2. The purpose of the worked examples was to test the applicability of the good practice identified on roads in different countries with different characteristics and constraints.

- **Work package 4 (WP4)** was a draft set of guidelines that were referred to the CEDR members. The objective of WP 4 was to come to well-founded guidelines concerning VRU's which can be implemented on the existing legacy road network, in particular in non-urban areas. The suggested guidelines are the result of the good practices, prepared in WP 2 (which had a somewhat more theoretical approach), combined with findings and recommendations after analysing the "worked examples" (which had a more practical approach) which were carried out in WP 3, refined in WP4 and subsequently finalised in WP5.

The objective of work package 5 (WP5) is to harmonise the reports prepared during work package 1 to 4, and compile a usable set of good-practice guidelines which will assist NRAs in member states in developing standards within their individual administrative region.

3 Guidelines Structure and Methodology

3.1 General Structure

The structure of these guidelines has been developed to provide a clear set of design principles for all elements of the design of a complete VRU facility. To assist the presentation of the information in a clear manner, the guidelines in this document has been subdivided into the following topics covering the main design elements:

- Crossing points;
- Junctions;
- Continuous road segments, including curves (which have good visibility and poor visibility);
- School Zones;
- Small linear settlements, small numbers of houses/buildings alongside the road which are not indicated/characterised as a city or town, but does result in VRU's walking and cycling along or across the road;
- Roundabouts (rural roundabouts).

3.2 Design Elements Presentation and Methodology

Within each of the subsections noted above, the guidelines are presented in a consistent manner using a similar methodology:

- Design Element Guiding Principles
- Design Recommendations
- Design Recommendation Selection (Decision Tree)

The presentation structure, as well as any specific considerations in terms of methodology, are presented in the following sections.

3.2.1 Design Element Guidelines

The first section within each design element presents a suite of guiding principles, including both things to consider for inclusion and things to avoid. These guidelines have been supplemented with images of examples where appropriate.

The guidelines have been broken down into recommendations for three speed zone categories ≥70 km/h, 50-69 km/h and <50 km/h. These speed zones categories have been selected as it is considered that these represent the thresholds at which different design solutions could be considered. While it is noted that <50 km/h zones do not typically arise on national roads in non-urban areas, these may occur in some member states, in particular in locations such as small linear settlements or school zones.

To assist in the presentation of clear recommendations, traffic light icons using the red-amber-green colours have been used to indicate appropriateness or level of the good practice-recommendations. The green hue being the most recommended and the red hue being the least appropriate (or used as a cautionary note). The amber hue could be advisable in certain circumstances given contextual considerations such as AADT.

The distinction between crossing points in junctions referred to in the Junction section and crossing points per se, is explained below. In this report, crossing points in junctions will usually occur in conjunction with a pedestrian/bicycle path running parallel with a main road and the crossing point (of interest) occurs when a secondary road intersects with the main road.

The point of crossing is (generally) the secondary road. *Crossing points* per se, refers to elements where a main road is crossed by VRU on links/continuous road segments.

Table 1: Legend - Traffic light metaphor

	Items indicated with a green traffic light are recommended as a good practice guideline. This should be the starting point for all design and should only be deviated for good reasons.
	Sometimes, the ideal situation cannot be achieved or there are contextual considerations which make implementation difficult. Those recommendations – indicated with an amber traffic light- could also be effective, but sometimes have limitations, that need to be taken into account.
	Short-term adjustments, but which must be thoroughly adjusted in the case of redesigns, are indicated with a red traffic light. Those solutions cannot be recommended in the long term. The red light may also be used as a cautionary note.

3.2.2 Design Recommendations

Having presented the broad guiding principles that should be considered for the design element, more detailed information is presented regarding specifics of the design element including geometric recommendations (widths etc.), requirements for segregation etc. For each infrastructure type, a number of solutions may be presented. This is intended to provide flexibility in the design decision process, and in particular facilitate the balance of the need to provide safe VRU facilities, with the reality of implementing solutions on the legacy road network which may have significant constraints. The specifics described for each solution is based on the information gathered throughout the study.

Different levels of design interventions are presented which align with different contexts such as speed, AADT, cycle volumes etc.

3.2.3 Design Recommendation Selection (Decision Tree)

To assist with determining the most appropriate infrastructure solution, a decision tree has been prepared for each design element which takes the primary drivers for selection into consideration, to arrive at a recommended design solution for a variety of scenarios. While this is not intended to provide a definitive methodology for selecting infrastructure solutions, it will provide NRA authorities with a framework to work with when developing their own standards.

The thresholds used to determine particular design solutions are described in the following sections.

Speed Limit

Speed is a key consideration when determining the most appropriate design solution. In all decision trees, this forms the first item for selection. As with the presentation of the guiding principles, three speed zone categories (≥70 km/h, 50-69 km/h and <50 km/h) are used. These speed zones categories have been selected as it is considered that these represent reasonable thresholds at which different design solutions could be considered. Again, while it is noted that <50 km/h zones do not typically arise on national roads in non-urban areas, these may occur in some member states, in particular in locations such as small linear settlements or school zones.

Annual Average Daily Traffic (motor vehicles)

In order to put a general framework around the selection of recommended infrastructure solutions, indicative thresholds for daily traffic and cycle volumes have been suggested. The thresholds presented in this document are based on Dutch guidelines, combined with common practice in other member states. Dutch guidelines state that for all roads with higher volumes than 3,000 AADT a cycle track should be considered, regardless of the maximum speed. From our research and professional judgement, we believe that this threshold is a reasonable starting point from which NRAs can establish their own thresholds in developing local standards relevant to their jurisdiction and local context. It is noted that where AADTs are presented in this document, these refer to the main road rather than roads which join the main road.

Heavy Goods Vehicle (HGV) Percentage

The presence of HGVs along a route have to potential to create a less safe environment for VRUs. This is therefore considered to be a driver in determining the appropriate infrastructure provision. Within the decision trees presented in this document, roads with <5 % are considered to carry low volumes of HGVs and may therefore require lower level of infrastructure provision (depending on combination with other criteria being considered). Roads with >5 % HGVs is considered to carry high volumes of HGVs and therefore may require a higher level of infrastructure provision. It is noted that where the percentage of HGVs are presented in this document, these refer to the main road rather than roads which join the main road.

Number of Potential Cyclists

Using the suggested AADT thresholds alone would imply that a cycle track should be considered on most rural roads, which is not a realistic prospect. Therefore, an extra element is introduced, which again is based on the Dutch guidelines. The Dutch guidelines state that if there are 500 cyclists per day or more a cycle track should be considered. This criterion has been applied to a second bracket of AADT whereby the AADT is between 3,000 and 6,000 and there are 500 daily cyclists or more a cycle track should be considered. Again, based on our professional judgement, we believe that a threshold of 500 cyclists per day (approximately 60-80 in the peak hour) reflects a reasonable threshold beyond which more physical infrastructure is warranted. It is noted that while the guidelines present the above thresholds, these should be viewed as a guide only and NRAs should consider their local needs and context when developing local standards. It is noted that where number of potential cyclists are presented in this document, these refer to the main road rather than roads which join the main road.

4 Crossing points

Making a clear distinction between crossing points and junctions may be difficult, since several consulted documents take them together as one concept. The distinction becomes more and more difficult to make especially with bicycle infrastructure, since bicycle infrastructure can also be a “cycle street”, the ‘crossing point’ with a (car) street looks more like a junction than a ‘crossing point’. For the purposes of this study, crossing point shall refer to the point of crossing of a main road by VRU on a link (i.e. mid-block crossing).

As a general principle, one can state that the higher the permitted speed on the road to be crossed, the ‘more secure’ the safety of the crossing must be (but with restrictions on the number of (pedestrian) crossings).With reduced motor vehicle speeds and a lower road category (e.g. secondary or local roads), a greater number of crossings could be required, but should have less extensive facilities.

4.1 Guidelines for Crossing Points

Table 2: Crossing points - higher speeds

High speed (≥ 70km/h)

Split-level crossing (pedestrian/cycle tunnel or bridge), since allowed speed on the road to cross is too high to be able to cross safely.

Bridge: A safe way to cross a major road, a gentle slope is necessary.

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Figure 1: A high speed crossing point alternative - Bridge

Tunnel:

Figure 2: A high speed crossing point alternative - Tunnel

High speed (≥ 70km/h)

Reduce the speed locally at the height of the crossing (+ see guidelines below, for 50km/h).

Be sure that traffic cannot stop or overtake in the immediate area of the crossing, this preserves forward visibility for approaching drivers so they can see people who are about to cross, or who are crossing.

Use traffic lights to protect and regulate traffic flow in the crossing (pelican style crossing).

Figure 3: A high speed crossing point alternative – Staggered crossing with a traffic island and lights

Table 3: Crossing points - lower speeds

Speed limits 50 km/h – 69 km/h:

Ensure **good visibility** in the crossing by:

Using vertical elements to emphasize the crossing (and ensure recognisability with vertical elements and street lighting).

Figure 4: Example of increased visibility for the crossing.

Lighting placed on the pole over the crossing.

Speed limits 50 km/h – 69 km/h:

Clear signage on approach to the crossing warning motorists of presence of crossing, but also vice versa: cyclists and pedestrians yield to MV traffic with clear signage and marking denoting this.

Flashing speed limit sign may help grab motorists' attention and aid them to maintain (or adjust to) the correct speed limit prior to entering the crossing area.

Multiple warnings (zig-zag edge line, horizontal stripes) help increase awareness of a crossing.

Be sure that traffic cannot stop or overtake in the immediate area of the crossing, this preserves forward visibility for approaching drivers so they can see people who are about to cross, or who are crossing.

Ensure **good readability** on the crossing, by:

Indicate right of way situation in an unambiguous way.

If pedestrians/cyclists have priority, provide an adequate radius (4m min) on bend to allow comfortable movement of cyclists

If pedestrians/cyclists do not have priority, this must be visible in the design and markings/signs

Reduce the crossing length, by:

Using a traffic island: the provision of a traffic (refuge) island allows the user to cross the road in two halves, thus only requiring concentration on one direction of traffic flow at a time. Furthermore, the introduction of a traffic island can lead to reduced pedestrians and cyclist delays, thus improving convenience. It constitute the cheapest form of crossing facility.

Good dimensions of traffic islands are important!

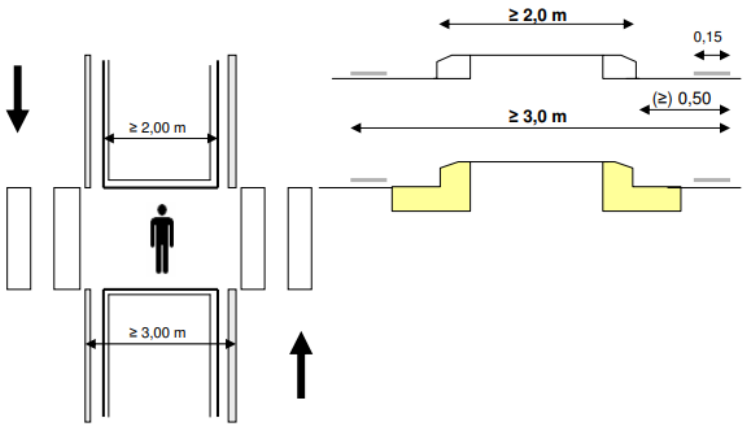


Figure 5: Reduced crossing lengths – pedestrians

Speed limits 50 km/h – 69 km/h:

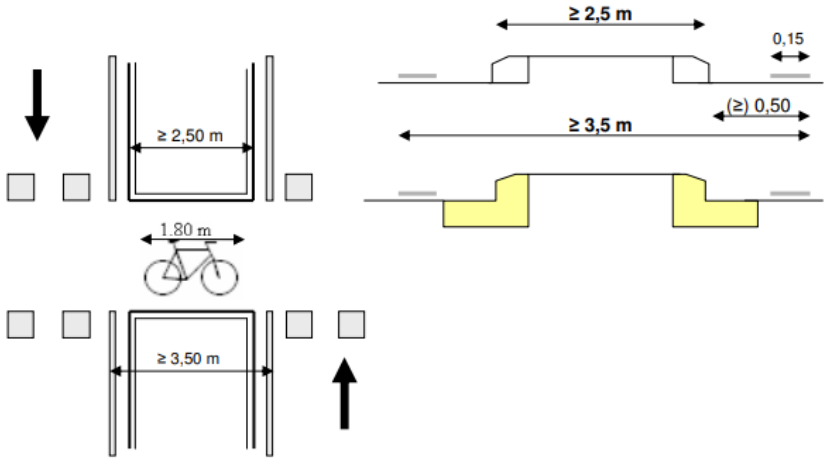


Figure 6: Reduced crossing lengths – cyclists

Reduce the number of lanes at the height of the crossing to a maximum of one lane per driving direction.

Visual and physical narrowing can help reduced MV speed (at the crossing)

Use of high-friction surfacing at sites where speeding is an issue.

Nudge the pedestrian/cyclist by obliging **them to look in the right direction**:

Staggered pedestrian crossing, especially when unregulated, i.e., without traffic lights, supports pedestrian safety by nudging the pedestrian into looking in the direction of oncoming traffic.

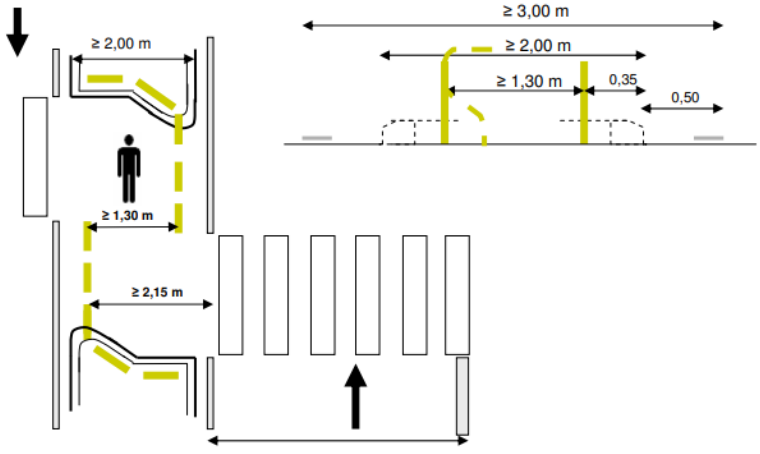


Figure 7: Nudging pedestrians/cyclists

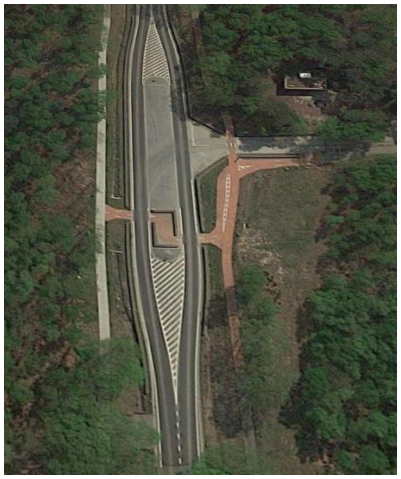
	Speed limits 50 km/h – 69 km/h:
	Staggered crossings for cyclist require more space for stopping, turning and stacking.  Figure 8: Staggered crossings for cyclist

Table 4: Crossing points - low speeds (exceptional circumstances)

Low speed (< 50km/h)
Low speed 30 and 40 km/h zones are not commonly used outside urban area. However, if they are, it is important that the infrastructure complies with the maximum speed permitted. It should be visually clear from the infrastructure's design that e.g. 30 km/h is the maximum speed limit (self-explanatory). Road surface texture (e.g. with cobble-stones) can also be used to signal a low speed zone.

4.2 Design Recommendations for Crossing Points

Based on the guiding principles for crossing points presented in Section 4.1, the level of infrastructure provision can be distilled into 3 main categories:

- CP1 High segregation/control
- CP2 Medium segregation/control
- CP3 Low segregation/control

On roads outside urban area, the number of pedestrians / cycle crossings will generally be very limited.

A pedestrian crossing is therefore only warranted where there are a considerable number of pedestrians/cyclists who wants to cross. However, it is important that this number of pedestrians/cyclists is considered in combination with the number of cars on the road.

On primary roads with higher speeds, there will generally also be fewer pedestrian/cycle crossing. In these cases, there would be more of an inclination to opt for a more limited number of well-equipped crossings.

If such crossings are justified or not, depends on the number of pedestrians crossing, related to the number of cars. Details of recommended thresholds and associated infrastructure provision are presented further on.

4.2.1 Detailed description of CP1: High Segregation/control (max speed > or =70 km/h)

Table 5: Detailed description of CP1 High Segregation/control (max speed > or =70 km/h)

Aspect	Recommendation	Possible next best solution
Type	Split level interchange (underpass or overpass). Primarily used for speed limits >90km/h	Traffic lights with vertical elements and flashing lights on approach
Orientation of priority	N/A	Staggered Signalised crossing with central median
Visibility	N/A	Road markings, Traffic lights Clear forward visibility to crossing Road/street lighting
Direction	Two-way possible	Two-way possible
Width	4-5m clear width on structure	4m crossing width desirable 3m central island/refuge desirable
Other	Ensure adequate gradient on rises/falls to segregated facility (no greater than 5%)	Flashing lights on approach to crossing (when pedestrian / cyclist detected) to alert motorist to potential use of crossing point

4.2.2 Detailed description of CP2: Medium Segregation/control (max speed between 50 and 69 km/h)

Table 6: Detailed description of CP2 Medium Segregation/control (max speed between 50 and 69 km/h)

Aspect	Recommendation	Possible next best solution
Type	Traffic lights with vertical elements and flashing lights on approach	Zebra crossing
Orientation of priority	Staggered Signalised crossing with central median	Pedestrian priority
Visibility	Road markings, Traffic lights Clear forward visibility to crossing Road/street lighting	Road markings, Clear forward visibility to crossing Road/street lighting
Direction	Two-way possible	Two-way possible
Width	4m crossing width desirable 3m central island/refuge desirable	4m crossing width desirable
Other	Flashing lights on approach to crossing (when cyclist detected) to alert motorist to potential use of crossing point Crossing distance to be restricted to one-lane at a time where possible	Flashing lights on approach to crossing (when pedestrian / cyclist detected) to alert motorist to potential use of crossing point Crossing distance to be restricted to one-lane at a time where possible

4.2.3 Detailed description of CP3: Low Segregation/control (max speed between 50 and 69 km/h)

Table 7: Detailed description of CP3 Low Segregation/control max speed between 50 and 69 km/h)

Aspect	Recommendation	Possible next best solution
Type	Zebra crossing	No controlled crossing point needed. Dropped kerb with tactile paving to assist crossing activity
Orientation of priority	Pedestrian priority	Vehicle priority
Visibility	Road markings, Clear forward visibility to crossing Road/street lighting	Clear forward visibility to crossing Road/street lighting
Direction	Two-way possible	
Width	4m crossing width desirable	
Other	Flashing lights on approach to crossing (when cyclist detected) to alert motorist to potential use of crossing point Crossing point to be reduced to one-lane where possible	

4.3 Design Recommendation Selection (Decision tree)

To assist with the selection of the most appropriate design solution for a route with specific conditions, a decision tree has been prepared which considers the main criteria outlined in section 3. The recommended solution identified in Figure 9 directly relates to the design recommendations presented in Section 4.2.

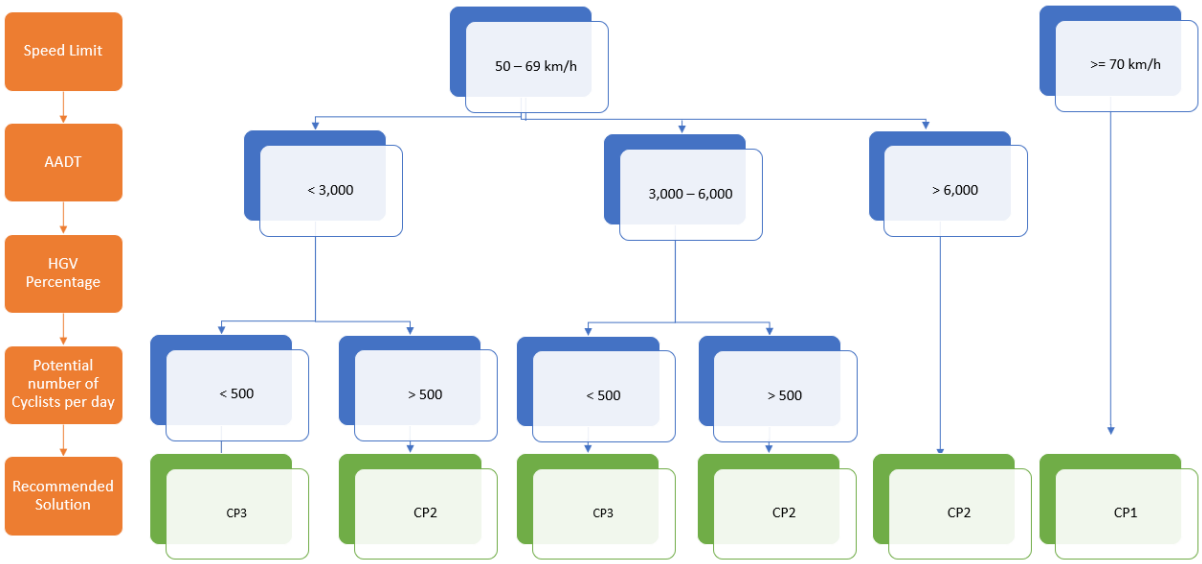


Figure 9 Decision-tree – Crossing Points

5 Junctions

The type of road crossing (primary/secondary) described in this section cover crossing points in junctions (CPiJ). Usually in conjunction with a pedestrian/bicycle path running parallel with a main road and the crossing point (of interest) occurs when a secondary road intersects with the main road. The point of crossing is generally the secondary road.

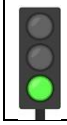
Traffic volume thresholds, expressed as average annual daily traffic (AADT), are an area for discussion and should not be seen as a prescriptive. Moreover, the bicycle AADT is often an elusive measure. Acquiring accurate/representative bicycle data for particular roads/paths may be difficult. The bicycle AADT can in practice be viewed as high or low levels of bicycle traffic if reliable data is not available. Note that bicycle traffic is often affected by e.g. weather or school holidays etc., in a way that motor vehicle traffic is not.

Signposted speed limits of ≤ 30 km/h are not included in the scope of this chapter where these speed zones are predominately found in urban areas and not in non-urban areas.

5.1 Guidelines for junctions

Table 8: General summary of good practice design elements for junctions

	All Speeds
	Good visibility at the crossing, no objects or greenery is in the way of the bicycle path. That allows for the car driver to see the cyclists from a distance.
	Colour can be used to indicate that there is a crossing point for cyclists to the MV drivers but should be avoided because colours are irregularly used and have an ambiguous meaning in terms of priority. [This may not work well in e.g. Nordic countries due to the winter climate.]
	Arrows can be used to indicate that the cyclists can approach from either direction.
	Ensure adequate inter-visibility between motorists and cyclists at junction crossing points e.g. clear and maintain vegetation.
	Provide sufficient space for a car between the bicycle crossing and the perpendicular road. This allows sufficient time for motorists to react and slow to allow a cyclist which has already started to cross the road.
	Avoid wide crossing (e.g. crossing 2 or more lanes) which exposes cyclists for a substantial length; separate with traffic islands (with an adequate mid-way area) where possible, e.g. if width to be crossed is greater than 8 à 9 m.

	All Speeds
	Make sure that the priority for crossing in the junction is clear and sensible/logical. In non-urban areas (with speed > 50 km/h) would mean that cyclists always yield to MV traffic.
	Use signage reinforcing message to yield.
	Provide clear signage for both motorists and cyclists such that the layout is self-explaining.
	Avoid complex intersection for MV drivers with multiple crossing points, signalling and yielding rules.
	Use separate bicycle/pedestrian paths running parallel with a main road and at junctions/crossing points, set them back, e.g. ≥ 10 m (a car length) from the main road intersection. This will facilitate space and time for the MV driver to complete their turning manoeuvre when turning off the main road or alternatively when entering the main road. Providing space and time to observe VRUs before having to prepare for the main road manoeuvre. This road design will reduce goal-conflict for MV drivers and increase safety for VRU.
	Good *communication* in the road design can provide clarity on what may be expected and what the expectations are on the road user in any given part of the road infrastructure.

The general summary of design elements also requires a context before more specificity can attributed a choice of design. The following decision tree charts are intended to assist in the decision process. The decision tree charts are divided into two general MV speed zones, viz. ≥ 70 km/h and 50 - 69 km/h and refers to the sign posted speed limit. The next decision step is relative level of MV traffic volume expressed in AADT. Because we are designing for VRU, the percentage of heavy goods vehicles (HGV) will also have baring on the overall design-choice. The next step in the decision process is to consider the level of bicycle traffic (expressed in bicycle units per day) being planned for. Larger bicycle traffic volumes will need to be considered. Conceivable routes going to and from nearby schools, colleges and universities or other facilities (e.g. sports fields) should also be factored in and accommodate improved safety.

5.2 Design recommendations for junctions

Based on the guiding principles for junctions presented in Section 5.1, the level of infrastructure provision can be distilled into 5 main categories:

- No. 1. CPiJ High Speed, High Traffic volume (1. Signalised crossing, 2. MV-priority, 3. Bend-out design).

- No. 2. CPiJ High Speed (1. MV-priority, 2. Bend-out design).
- No. 3. CPiJ Medium Speed, or Multiple lanes (1. Signalised crossing OR MV-priority, 2. Bend-out design + traffic islands).
- No. 4. CPiJ Medium Speed (1. Bend-out design with VGU-priority, OR 2. Adjacent (running parallel with main carriageway) crossing point with MV-priority).
- No. 5. CPiJ Low speed, low traffic volume. (In carriageway bicycle path/track. Not for pedestrians or other VRU-groups).

5.2.1 Detailed description of No. 1. CPiJ High Speed, High Traffic volume.

Table 9: Detailed description of No. 1. CPiJ High Speed, High Traffic volume

Design specification	Solution	Possible next best solution
Geometric considerations	Bend-out design. Crossing point min. 10 m from main carriageway.	
Orientation of priority	Signalised crossing	MV priority
Visibility	Road markings, Traffic lights Clear sightlines Road/street lighting	
Direction	Two-way possible	
Width	Minimum 2.5 meters	

Remarks: Highlights to consider for junctions:

- Lower speeds at junctions reduce risk of injuries.
- Cycle lane crossing/across side roads should be a minimum of 2 m wide.
- Designers should ensure good visibility between cyclists/pedestrians on a side road crossing.
- The priority of the respective road user groups in the junction should always be overt (e.g. signposted) and be perceivable as logical and also be reasonably viable, especially for the MV-drivers that might be required to give priority to VRUs in the junction.

5.2.1.1 Bend-out design

Note that the figure below is drawn from a left-hand driving perspective. In countries driving on the right-hand side, the road markings etc. should be mirrored.

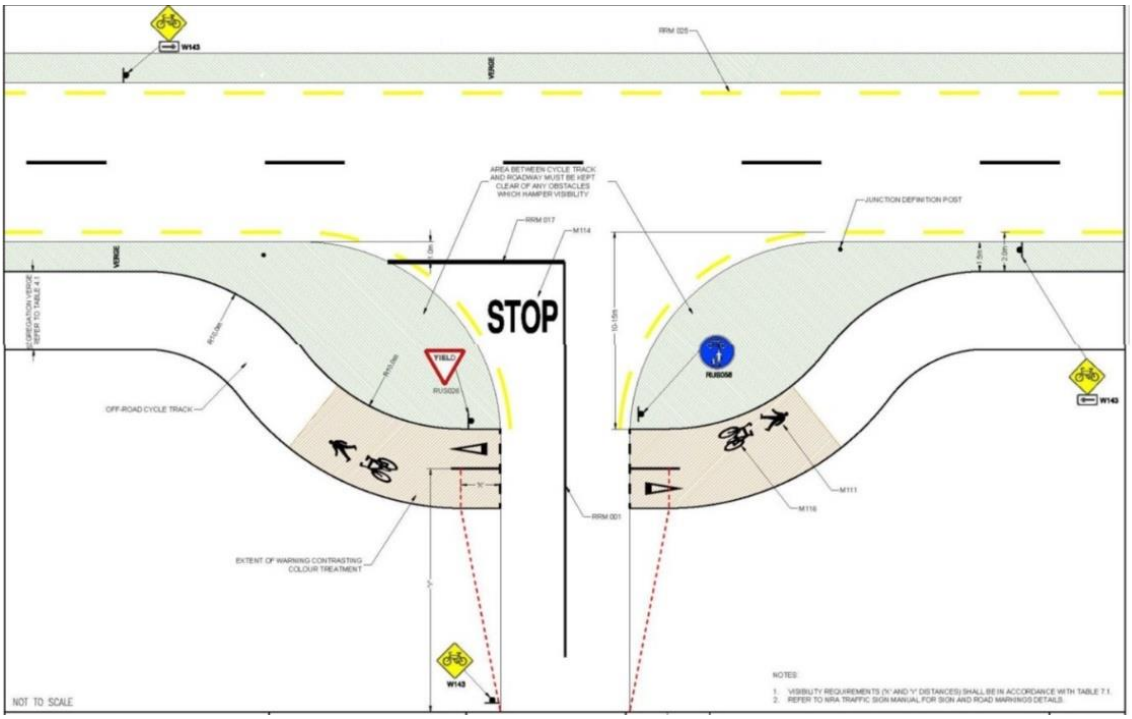


Figure 10: Bend-out design

- Bicycle and pedestrian (on a separate path parallel with a main road) crossings a secondary road that joins the main road and that is set back ≥ 10 m (a car length) from the main road intersection. Thus, facilitating the MV driver space and time to complete their turning manoeuvre when turning off the main road or alternatively when entering the main road, there is space and time to observe VRUs before having to prepare for the main road manoeuvre; thus, using road design to reduce goal-conflict for MV drivers.
- Signage on all approaches to the crossing warning motorists of presence of crossing.
- Adequate radius (4m min) provided on bend to allow comfortable movement of cyclists.

Source: Infrastructure Ireland standard, (2014). National Roads Authority Design Manual for Roads and Bridges. Rural Cycle Scheme Design (including Amendment No. 1) DN-GEO-03047.

5.2.2 Detailed description of No. 2. CPiJ High Speed.

Table 10: Detailed description of No. 2 CPiJ High Speed

Design specification	Solution	Possible next best solution
Geometric considerations	Bend-out design. Crossing point min. 10 m from main carriageway.	
Orientation of priority	MV priority	
Visibility	Strongly recommended solutions to improve visibility: Use clear road markings Use traffic lights Maintain clear sightlines for MV drivers as well as for VRU Use road/street lighting	
Direction	Two-way possible	
Width	Minimum 2.5 meters	

Remarks: Highlights to consider for junctions:

- Lower speeds at junctions reduce risk of injuries
- Cycle lane crossing/across side roads should be a minimum of 2 m wide
- Designers should ensure good visibility between cyclists/pedestrians on a side road crossing

5.2.2.1 Bend-out design

See section 5.2.1.1 for details.

5.2.3 Detailed description of No. 3. CPiJ Medium Speed, or Multiple lanes.

Table 11: Detailed description of No. 3 CPiJ Medium Speed or multiple lanes

Design specification	Solution	Possible next best solution
Geometric considerations	Bend-out design. Crossing point min. 10 m from main carriageway.	Traffic islands for multiple lane-crossings
Orientation of priority	Signalised crossing	MV priority
Visibility	Recommended solutions to improve visibility: Use clear road markings Use traffic lights Maintain clear sightlines for MV drivers as well as for VRU Use road/street lighting	
Direction	Two-way possible	
Width	Minimum 2.5 meters	

Remarks: Highlights to consider for junctions:

- Lower speeds at junctions reduce risk of injuries
- Cycle lane crossing/across side roads should be a minimum of 2 m wide
- Designers should ensure good visibility between cyclists/pedestrians on a side road crossing

5.2.3.1 Bend-out design

See section 5.2.1.1 for details.

5.2.4 Detailed description of No. 4. CPiJ Medium Speed.

Table 12: Detailed description of No. 4 CPiJ Medium Speed

Design specification	Solution	Possible next best solution
Geometric considerations	Bend-out design. Crossing point min. 10 m from main carriageway.	Adjacent crossing point (running parallel with main carriageway) crossing point with MV-priority
Orientation of priority	MV priority	VRU priority (when speed and AADT is low)
Visibility	Recommended solutions to improve visibility: Use clear road markings Maintain clear sightlines for MV drivers as well as for VRU Use road/street lighting	
Direction	Two-way possible	One-way crossing (with VRU priority)
Width	Minimum 2.5 meters	

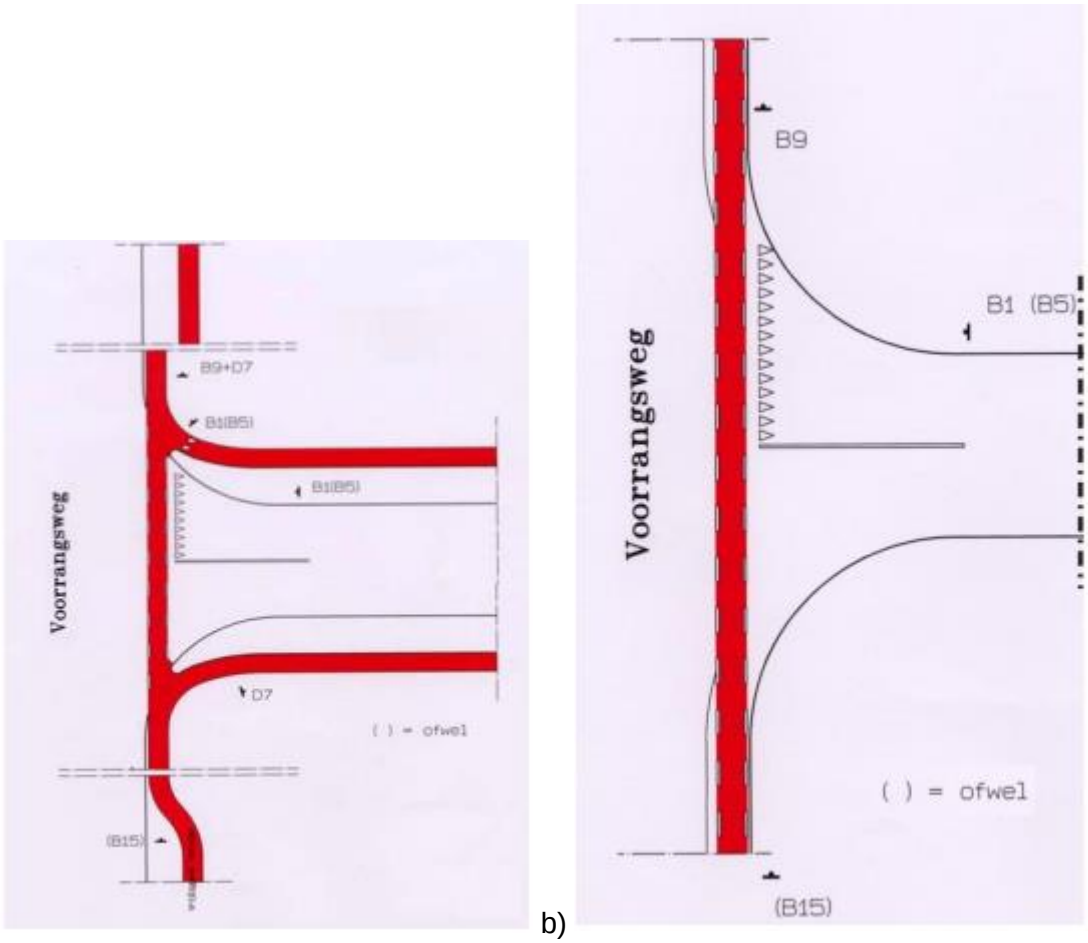
Remarks: Highlights to consider for junctions:

- Lower speeds at junctions reduce risk of injuries
- Cycle lane crossing/across side roads should be a minimum of 2 m wide
- Designers should ensure good visibility between cyclists/pedestrians on a side road crossing

5.2.4.1 Bend-out design

See section 5.2.1.1 for details.

5.2.5 Adjacent crossing point design



a) b)

Figure 11: Adjacent crossing point design

If the bicycle path on the priority road is separated from the main road (often occurring in traffic areas) it preferably bends inwards (abutting). As a rule, this happens from about 30 meters for the connection. It is recommended to maintain a narrow safety zone here as well between road and bicycle path.

Source: https://www.mobielvlaanderen.be/pdf/vademecum/hfdst4.pdf

& https://www.mobielvlaanderen.be/vademecums/fiets-praktijkvoorbeelden.pdf

5.2.6 Detailed description of No. 5. CPiJ Lower Speed. (Not for pedestrians).

Table 13: Detailed description of No. 5 CPiJ Lower Speeds (not for pedestrians)

Design specification	Solution	Possible next best solution
Geometric considerations	Crossing point in junction for in-carriageway bicycle path/track.	
Orientation of priority	Shared priority (conflict may occur when right-turning vehicles intersect with cyclist going straight-on). Signalised crossing	VRU priority (when speed and AADT is low)
Visibility	Recommended solutions to improve visibility: Protruding bicycle lane Road markings, Clear sightlines Road/street lighting	
Direction	One-way only	
Width	Minimum 2.5 meters	

Remarks: Highlights to consider for junctions:

- Lower speeds at junctions reduce risk of injuries
- Cycle lane crossing/across side roads should be a minimum of 2 m wide
- Designers should ensure good visibility between cyclists/pedestrians on a side road crossing

5.2.7 In-carriageway crossing point design (cyclists only)

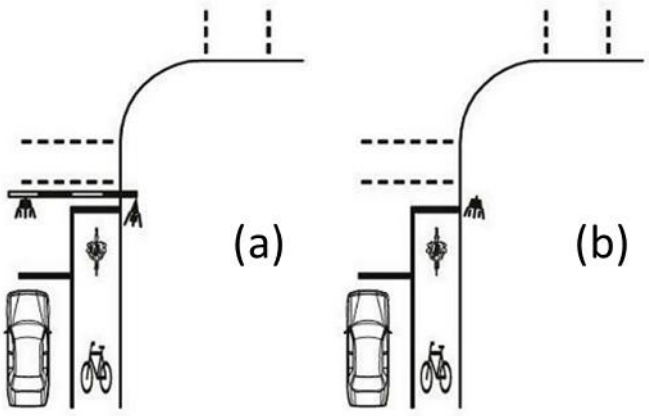


Figure 12: In-carriageway crossing point design (cyclists only)

Protruding bicycle lane found in the figure above (in-carriageway crossing point in junction) provide an early start for cyclists in a signalised junction. This design alternative is mostly applicable in urban areas and partially falls out of the study's scope.

- Improving visibility (safety) of cyclists on shared carriageways.
- Early start in such a way that cyclists arrive at the conflict point before the right-turning motorised traffic arrives there.
- Early start not too long, as cyclists wanting to turn left will otherwise come into conflict with quickly accelerating motor vehicles from the opposite direction.
- Type a: Bicycle direction given green light before light for other traffic.
- Type b: Early start by moving stop line, simultaneous green light for cyclists and other traffic.
- Critical analysis of green light and clearance times are necessary.

Source: http://kennisbank.crow.nl/zoeken/search

5.3 Design Recommendation Selection (Decision tree)

5.3.1 Decision-tree – Crossing Points in Junctions (CPiJ) ≥ 70 km/h

A decision tree chart to assist in the selection of design element for crossing points in junctions where the speed limit on the main road is ≥ 70 km/h. The design elements suggested in the decision tree chart are specified in the tables below.

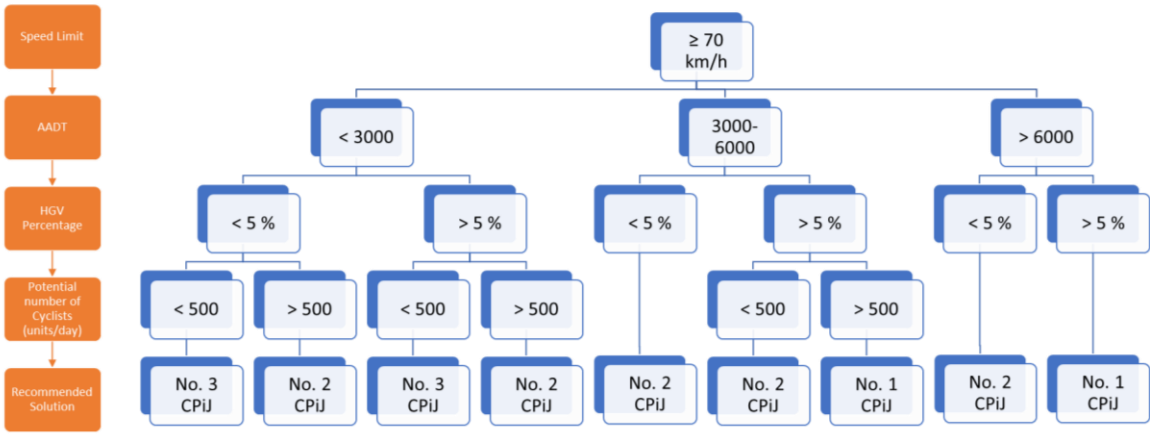


Figure 13: Decision-tree – Crossing Points in Junctions (CPiJ) ≥ 70 km/h

5.3.2 Decision-tree – Crossing Points in Junctions (CPiJ) 50 – 69 km/h

A decision tree chart to assist in the selection of design element for crossing points in junctions where the speed limit on the main road is 50 – 69 km/h. The design elements suggested in the decision tree chart are specified in the tables below.

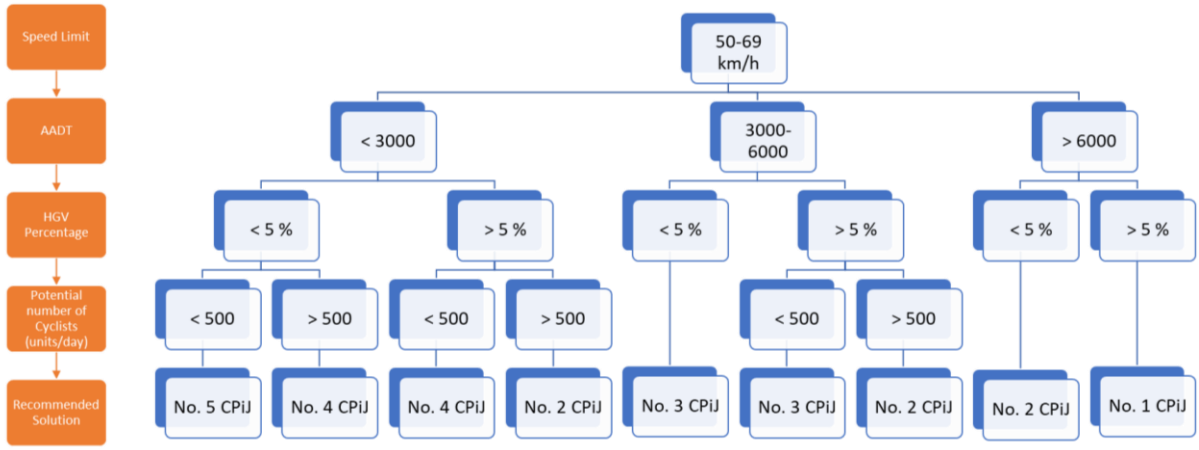


Figure 14: Decision-tree – Crossing Points in Junctions (CPiJ) 50-69 km/h

Description of *Recommended Crossing Points in Junctions* (CPiJ) that are alluded to in the decision tree charts above (Figure 13 and Figure 14). The suggested components found below are intended as combinations of measures unless otherwise stated. Traffic volumes (AADT) in the decision chart mainly refer to the main roads and not the smaller side roads. Common sense should apply if local circumstances require alternative measures.

6 Continuous road segments

6.1 Guidelines for Continuous Road Segments

Continuous road segments, or links, form the most significant length of any rural VRU scheme. The main considerations for continuous road segments is the level of segregation to be provided which is directly related to the conditions of the road (e.g. speed, traffic volumes).

The following sections present the guiding principles to be considered when developing designs for Continuous Road Segments as well as a suite of more specific design options for a variety of design scenarios.

Table 14: Guidelines for Continuous Road Segments (all speeds)

	All speeds:
	Ensure adequate maintenance, clearing loose gravel, and de-icing during winter periods. Ensure that vegetation is maintained so it does not encroach on the cycle path or obstruct visibility.
	Provide adequate connection points for the bicycle lane to a road of lower speed and lower volume.
	Provide adequate signage indicating the presence of vulnerable users.
	Ensure connection points are provided and that cycle paths do not end abruptly resulting in an unsafe environment for VRU's.  Figure 15: A cycle path ending with an abrupt end

Table 15: Guidelines for Continuous Road Segments (higher speeds)

Higher speeds (≥ 70 km/h):

For speeds greater than 70km/h, separation should be made between cyclists and vehicles.

Figure 16: Separate track example 1

The preferred cycle facility for non-urban areas are one-way cycle facilities on each side of the road. The cycle facility should be wide enough to accommodate the volume of cyclists (minimum 2.5m).

Figure 17: Separate track example 2

Provide adequate connection points for the bicycle lane to a road of lower speed and lower volume.

Figure 18: Separate track example 3

Higher speeds (≥ 70 km/h):

Adequate separation between carriageway and bicycle lane should be provided (2m minimum where there is no vertical separation). Separation should ideally be a different material to carriageway (i.e. grassed verge). Care should be taken to ensure secluded sections pose no safety/security risks. The below example shows no horizontal separation, but (limited) vertical separation is provided. Generally, kerbs should only be considered at the lower end of this speed bracket (i.e. 70kph) or in speed zones less than 70kph..

Figure 19: Separate track example 4

Vertical separation (120mm kerb) should be considered particularly where separation between the carriageway and cycle/shared facility is not feasible. Minimum of 0.5m horizontal separation is recommended.

Table 16: Guidelines for Continuous Road Segments (lower speeds)

Speeds 50 – 69 km/h:

Ensure there is good protection, visibility and awareness of cyclists on road.

Using signage to warn of the potential for cyclists to be on the road.

Speeds 50 – 69 km/h:

Ensure adequate width of the bicycle lane. There are different specifications depending on the number of vehicles, speed limits etc. A single bicycle lane within the carriageway should be ≥2.0 m give a speed limit of 50 km/h, and for higher speeds more segregation is desirable.

Figure 20: Separate track lower speed example

Provide differentiation between the driving lane and the cycle lane, using bright colours for the cycle lanes if they are within the carriageway. The example below illustrates a 2-1 arrangement which is only suitable on roads with low traffic volumes. Shared rural carriageways such as this should avoid blind bends which could prove potentially hazardous. Moreover, the ambiguity of this design element for MV drivers is a threat to VRU safety.

Figure 21: Two-minus-one track example for lower speeds

Provide adequate carriageway widths to accommodate two-way traffic movements without the need for motorists to drive in cycle lanes (if provided on carriageway).

Table 17: Guidelines for Continuous Road Segments (low speeds)

Low speeds (< 50 km/h):
Low speed zones in this range will not be commonly used outside urban areas. But if so, vulnerable users should be provided for with good protection, visibility and awareness from other road users. It is advised that urban design guidance is applied in these scenarios.

6.2 Design Recommendations for Continuous Road Segments

Based on the guiding principles for continuous road segments presented in Section 6.1, the level of infrastructure provision can be distilled into 3 main categories:

- Track: A dedicated facility for VRUs segregated from the road either by a vertical (e.g. kerb, drain) or horizontal (e.g. verge) feature
- Mandatory Lane: A dedicated facility for VRUs which is provided on the carriageway, possibly with some horizontal or vertical separation (visually demarcated by white line, bollards etc.)
- Advisory lane: A demarcated facility for VRUs which is provided on the carriageway but can be driven on by vehicles if needed to pass an oncoming vehicle.

The specifics for each of these facility types is presented in the following section.

6.2.1 Continuous road segments decisions, TRACK

Table 18 presents 3 options for the provision of a track for VRUs. The Recommendation column presents the ideal facility features with the remaining columns presenting alternatives which could be considered fit within the constraints identified on any particular route.

Table 18: Continuous road segments decisions, TRACK

Aspect	**Recommendation**	**Possible next best solution (1)**	**Possible next best solution (2)**
Segregation	Required	Required	Required
Type and width	One way either side	Two way one side	Two way one side
	Minimum 2.5 meters	Minimum 3.0 meters	Minimum 3.0 meters
Vertical separation and horizontal segregation	Ditch / open drain	No vertical separation	Minimum 120 mm kerb
	Minimum 3 meters	Minimum 2 meters	Minimum 0.5 meter
Signage	Indicate cycle track	Indicate cycle track	Indicate cycle track

6.2.2 Continuous road segments decisions, MANDATORY LANES

Table 19 presents a single option for the provision of an on carriageway mandatory lane for VRUs.

Table 19: Continuous road segments decisions, MANDATORY LANES

Aspect	Recommendation
Segregation	Preferred; not required[1]
Type and width	One way either side mandatory
	Minimum 2.0 meters
Vertical separation and horizontal segregation	Solid line markings
	Not required
Signage	Warning traffic that cyclists are on road

[1] if provided, go to Track table for requirements

6.2.3 Continuous road segments decisions, ADVISORY LANES

Table 20 presents a two options for the provision of an on carriageway advisory lanes for VRUs.

Table 20: Continuous road segments decisions, ADVISORY LANES

Aspect	Recommendation	Possible next best solution
Segregation	Not required	Shared Street
Type and width	One way either side advisory	
	Minimum 1.0 meters	
Vertical separation and horizontal segregation	Dashed line markings	
	Not required	
Signage	Advanced warning signage	Cycle symbols on road Shared street signage

6.3 Design Recommendation Selection (Decision Tree)

To assist with the selection of the most appropriate design solution for a route with specific conditions, a decision tree has been prepared which considers the main criteria outlined in section 3. The recommended solution identified in Figure 22 directly relates to the design recommendations presented in Section 6.2.

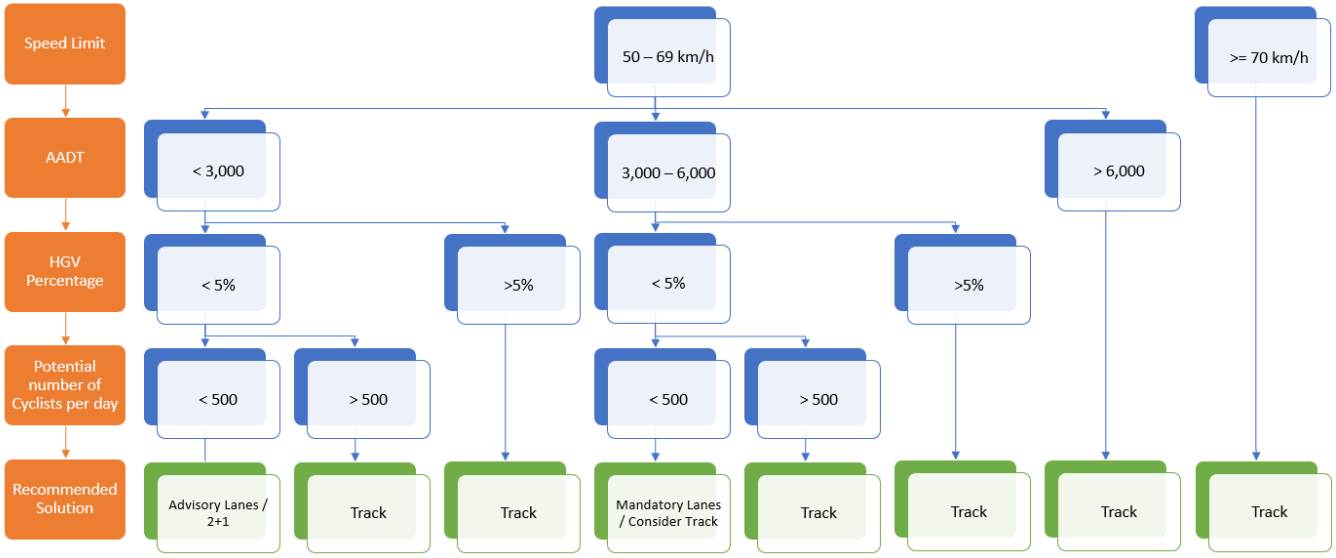


Figure 22: Continuous road segments decision chart

7 School zones

7.1 Guidelines for School Zones

School zones are places where we can expect many children/young people. Those places have to be safe for them. Safe means adapted speed and safe infrastructure.

As a starting point one can state that having a school zone “outside urban area” is maybe not the best location, since roads outside urban area are roads where traffic flow is important.

School zones must be relocated to areas where the residential function prevails (not an easy/cheap solution), as for instance could be the case in small linear settlements.

Alternatively, adequate barriers must be put in place to protect VRU (specifically children) in school zones.

Table 21: School zones (high speed)

	High speed (≥ 70 km/h):
	School zones and 70 km/h speed limit zones are not compatible with each other.
	School zones must be relocated to areas where the residential function prevails (not an easy/cheap solution) or completely segregated VRU-infrastructure constructed.
	If the school cannot be relocated, maybe the main school entrance can be relocated. E.g. the main entrance can be moved to an access from a side street, where less traffic passes and the maximum allowed speed can be reduced
	If the school cannot be relocated, there must be a gradual decrease in speed, first to 50 km/h and then to 30 km/h in the school zone.
	Use high visibility signage (including variable message signs) to make MV users aware of the possible presence of school children.  Figure 23: High visibility speed sign
	If a carriageway needs to be crossed, provide a median. Provide zebra or pelican crossings where appropriate. (see also guidelines for Crossing Points)

Table 22: School zones (between 50 – 69 km/h)

Speed between 50 and 69 km/h:
In a 50 km/h zone, the speed must be reduced until 30km/h in the school environment.
Use a low, maximum speed limit (30 km/h) during school hours (e.g. Monday to Friday, 08-15 hrs.) = variable speed display
The speed limit of 30 km/h should be supported by infrastructural measures, e.g. chicanes, adaptive speed humps (programmable and variable.
Consider the provision of adequate and safe drop-off areas for school buses and parents' cars, but not too close to the school entrance to avoid chaos at the school gate
Use high visibility signage (including variable message signs) to make MV users aware of the possible presence of school children.
 Figure 24: High visibility barriers and signage
Crossing could be raised to reduce vehicle speeds.
Good street lighting including at pedestrian crossing is necessary.

Table 23: School zones (low speed)

	**Low speed (≤ 50 km/h) :**
	The speed limit of 30 km/h should be supported by infrastructural measures, e.g. chicanes, adaptive speed humps (programmable and variable).
	Crossing could be raised to reduce vehicle speeds.

7.2 Design Recommendations for School Zones

Safe infrastructure:

Safe infrastructure provision (sidewalks, safe crossings, traffic calming measures, speed bumps, etc.) should be a priority for protecting children on the school journey. The built environment in schools and densely populated neighbourhoods should be designed or reconfigured to prioritize pedestrians and cyclists as part of policies to promote child health.

Infrastructure for traffic calming, when linked to speed enforcement, can create effective low-speed zones around schools.

Benefits:

- School zones and crossing supervisors can reduce pedestrian risk.
- School zones help to moderate traffic speeds which can reduce injury severity.
- It has been shown that school zones can reduce crashes involving bicyclists.
- School crossing supervisors can help to control pedestrian crossing movements.
- School crossing supervisors provide a safe place to cross.

Implementation issues:

- Traffic signs and road markings must make it clear to motorists that they have entered a school zone.
- Consider incorporating flashing beacons to compliment the school zone signs and markings.
- Operating times and any speeds limit changes must be clearly signed and understood.
- Through traffic must be able to see pedestrian crossing points in time to stop for them.
- Advanced warning signs should be located on approaches with adequate forward visibility.
- Parking provision should be carefully considered within school zones with adequate sight distances at pedestrian crossings.

Source: http://toolkit.irap.org/default.asp?page=treatment&id=59

7.3 Design Recommendation Selection (Decision Tree)

There is no decision tree chart for school zones because these areas can also include crossing points, junctions, school zones or roundabouts. Please refer to the other sections for the appropriate chart.

8 Small linear settlements

8.1 Guidelines for Small Linear Settlements

Small linear settlements are in rural settings with the presence of VRU's and possibly high speeds. For a safer environment, the higher the speed, the more separation should be made between vehicles and VRU's.

In general, the guidance set out in other sections of this report will apply when designing facilities for vulnerable road users in small linear settlements e.g. continuous road segments in high speed linear settlements should be segregated vertically and horizontally. As such, flow charts for each individual design element should be followed in small linear settlements. In addition, the following table presents some considerations that are particular to small linear settlements.

Table 24: Good practice summary for small linear settlements

	All speeds:
	Small linear settlements may contain bus stops serving local or regional bus services. The interface between bus stops and facilities for VRUs will require consideration in order to safely accommodate bus users and VRUs using the shared facility. The specific arrangement will depend on the type of facility provided on that particular road section (dependent on speed and flow conditions). It is recommended that urban design guidance for treatment at bus stops is utilised at these locations. Provide buffer zones between bus stops and cycle lanes if they converge. Examples such as the below may be suitable depending on cycle volumes and bus passenger volumes. Where high volumes are anticipated, it is recommended that cycle track runs behind the bus shelter.  Figure 25: Use of buffer zones between bus stops and cycle lane
	There is likely to be more of a desire for crossing activity in small linear settlements, particularly if bus stops are present or there are amenities located within the village (shops, restaurants, churches etc.). Crossings which align with anticipated desire lines should therefore be considered in small linear settlements.

All speeds:

Small linear settlements may contain community facilities such as shops, restaurants, and churches which may have car parking located on the road edge. Similar to bus stops, the treatment of the interface between car parking and facilities for VRUs will be dependent on the type of facility provided on the road on approach to the car parking. It is recommended that urban design guidance for treatment at car parking is utilised at these locations.

Linear settlements tend to generate more pedestrian and cycle activity along rural roads. In order to promote a safer environment for VRUs in linear settlements, it is recommended that lower speed limits (50 km/h or less) are introduced at these locations. Reduced speed limits may need to be complemented with traffic calming measures to self-regulate speed restrictions.

Figure 26: Traffic calming example

Ensure adequate maintenance, clearing loose gravel, and de-icing during winter periods. Ensure that vegetation is maintained so it does not encroach on the cycle path or obstruct visibility.

8.2 Design Recommendation Selection (Decision Tree)

There is no decision tree chart for small linear settlements because these areas can also include crossing points, junctions, school zones or roundabouts. Please refer to the other sections for the appropriate chart.

9 Roundabouts (rural roundabouts)

Roundabouts in a rural setting are often higher speed environments whereas inter-urban settings tend to have lower speeds but high motor vehicle and bicycle traffic volumes. For a safer environment, the higher the speed, the more separation should be made between vehicles and VRU's.

There are some general good practice measures which important for roundabouts, regardless of the speed and dependent on the speed. Moreover, roundabouts are generally very beneficial for reducing serious and fatal injuries in motor vehicle accidents despite their relative user-complexity. The practitioner should bear in mind that introducing more complexity by layering the circulars of motor vehicles and cyclists, will diminish some benefits. This may be mitigated however, by following some of the relevant steps outlined below.

9.1 Guidelines for Roundabouts (rural)

Table 25: Good practice summary for roundabouts

	All Speeds
	Split-level interchanges (e.g. 'crater' roundabouts) are advisable on high MV traffic volume areas, where possible.
	Outside urban areas, cyclists and pedestrians should not have priority on non-signalised roundabout crossings due to higher MV speeds.
	Dedicated facilities provided for cyclists are recommended.
	Consider use of signalised crossing points for cyclists and pedestrians if VRU and traffic volumes are high. If MV speeds are high, use traffic islands (with an adequate streaming area mid-way) where possible to shorten the crossing time for VRU.
	Use street lighting to make the VRU crossing points conspicuous.
	Avoid placing the crossing located too close to the gyratory at the roundabout exits. At least 6-8 m (one car length) is advisable (also avoid placing crossing too far away from the roundabout, or else it would be used).
	Central traffic islands sufficiently wide in connection with stacking space for cyclists (minimum of 2.5 m).

All Speeds

Use clear road markings and signs to alert MV drivers of the VRU crossing points.

Consider that motorists arriving at the roundabouts may be burdened by navigating or orientation tasks; therefore, avoid mixing route guidance signs with (VRU) awareness or warning signs.

Ensure that foliage and shrubs do not restrict VRU visibility and MV driver sight-lines.

Suburban setting with lower MV speeds (≤ 50 km/h) could employ characteristics that:

Shared cycle/pedestrian facility around entire roundabout. Could be better if separated facility provided although facility appears wide and speeds are low (if in rural areas the pedestrian/cyclist volumes are be small, shared facility could even though be a solution).

Dedicated raised pedestrian / cycle crossings with priority given to pedestrians and cyclists.

The crossing points, for safety reasons, need to be moved away from the complexity of the inner section of the roundabout to accommodate at least one car length (≥ 6-8 m).

Consider MV and VRU AADT when dimensioning the crossing/roundabout design.

The following decision tree charts are intended to assist in the decision process. The decision tree charts are divided into two general MV speed zones, viz. ≥ 70 km/h and 50-69 km/h and refers to the sign posted speed limit. The next decision step is relative level of MV traffic volume expressed in AADT. Because we are designing for VRU, the percentage of heavy goods vehicles (HGV) will also have baring on the overall design-choice. The next step in the decision process is to consider the level of bicycle traffic (expressed in bicycle units per day) being planned for, however, for rural roundabouts this was generally not decisive; local exceptions may occur. Conceivable routes going to and from nearby schools, colleges and universities or other facilities (e.g. sports fields) should also be factored in and accommodate improved safety.

9.2 Design recommendations for roundabouts

Based on the guiding principles for roundabouts presented in Section 9.1, the level of infrastructure provision can be distilled into 4 main categories:

- No. 1. Roundabout with high speed, high traffic volume (1. Crater style design (split-level interchange, 2. Complete segregation).
- No. 2. Roundabout with high speed, medium traffic volume (1. Separate cycle track (segregation) 2. MV-priority in crossing points, 3. Use VGU traffic islands for with multiple lane crossings 4. Bend-out crossing principles).
- No. 3. Roundabout with medium speed, medium traffic volume (1. Separate ring outside of MV carriageway 2. MV-priority, 3. VRU priority at crossing point if speed ≤ 50 km/h, 4. Bend-out crossing principles).
- No. 4. Roundabout with low speed, low MV & bicycle traffic volume (1. Mixed traffic, single carriageway roundabout).

9.2.1 Detailed description of No. 1. Roundabout with high speed, high traffic volume.

Table 26: Detailed description of No. 1. Roundabout with high speed, high traffic volume

Design specification	Solution	Possible next best solution
Geometric considerations	Crater style design (split-level interchange)	
Orientation of priority	Complete segregation (i.e. no priority)	
Visibility	Orientation signage important Road/street lighting	
Direction	Two-way only	
Width	Minimum 4 meters (cyclists & pedestrians)	

Remarks: Highlights to consider for junctions:

- Cycle lane crossing/across side roads should be a minimum of 2.5 m wide
- Designers should ensure good visibility between cyclists/pedestrians
- Consider possible conflict points (and remove/mitigate)

9.2.1.1 Crater style design

Figure 27: Crater style rural roundabout design

- Outside urban area
- Safe for cyclists & pedestrians
- Split level interchange

Source:
https://www.google.com/maps/@51.2884199,4.8547974,3a,60y,56.55h,81.12t/data=!3m6!1e1!3m4!1s-2vqteRgVrY-a-PV6dSyww!2e0!7i13312!8i6656

9.2.2 Detailed description of No. 2. Roundabout with high speed, medium traffic volume.

Table 27: Detailed description of No. 2. Roundabout with high speed, medium traffic volume

Design specification	Solution	Possible next best solution
Geometric considerations	Separate cycle track (segregation) Use VGU traffic islands for with multiple lane crossings Bend-out crossing principles	
Orientation of priority	MV-priority in crossing points with VRU	If the bicycle AADT has periodic peaks, from e.g. nearby schools, consider signalised crossings. Evaluation of affected routes necessary.
Visibility	Orientation signage important Road/street lighting Bend-out crossing design for increased visibility Use VGU traffic islands for with multiple lane crossings	
Direction	Two-way possible	
Width	Minimum 4 meters (cyclists & pedestrians)	

Remarks: Highlights to consider for junctions:

- Cycle lane crossing/across side roads should be a minimum of 2.5 m wide (single)
- Designers should ensure good visibility between cyclists/pedestrians
- Consider possible conflict points (and remove/mitigate)

9.2.2.1 Separate cycle track

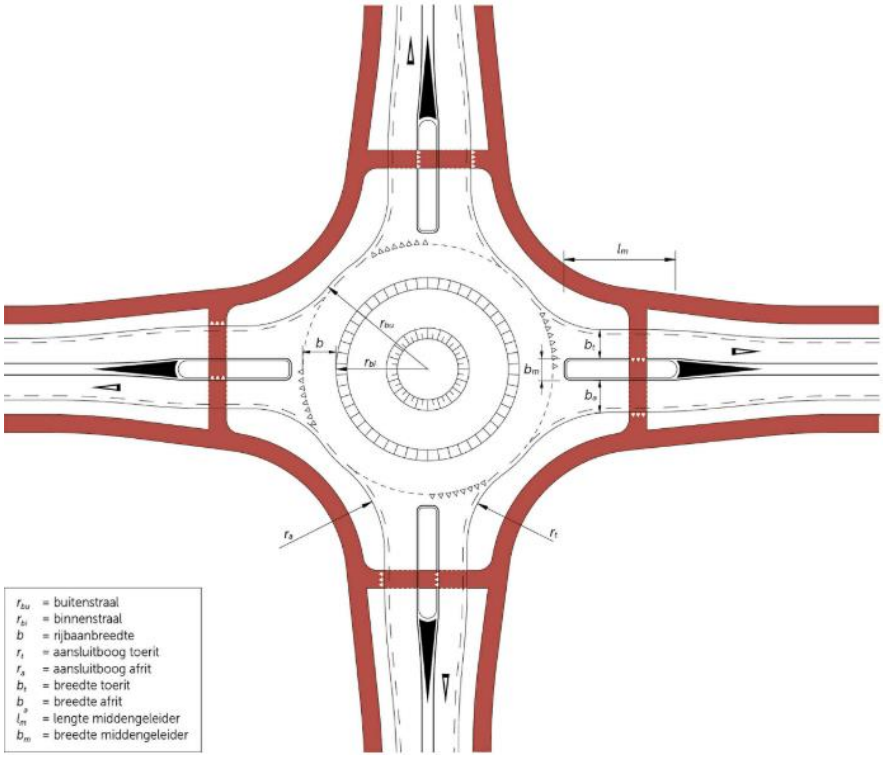


Figure 28: An example of some of the specifications of the No. 2 Roundabout

An example of some of the specifications from the Netherlands for No. 2 Roundabout are found below.

- Outside urban area, cyclists have to give priority on roundabouts.
- Implementation:
- No block marking at the cycle crossing location
- No continuous pavement on cycle track
- Central traffic islands sufficiently wide in connection with stacking space for cyclists
- Equal right of way regime for cyclists and pedestrians
- Vertical elements on elevated central traffic island
- Guarantee recognisability by means of public lighting
- Dimensions:
- R1 = 12,50 to 20 m
- R2 = 6,50 to 15 m
- ra = 12 m, with central traffic island
- = 8 m, without central traffic island
- rb = 15 m, with central traffic island
- = 12 m, without central traffic island
- B = 5 to 6 m (depending on R1 and R2)
- b1 = 1,50 (1,00) m
- b2 = 2 to 2,50 m
- b3 = as large as possible

- L = 5 m
- C = 2 m
- Length of central traffic island (b1) > = 6 m
- Stacking space on cycle track (b2) 2,10 to 3 m
- Width of central traffic island (b3) 2,50 to 3 m (2,10 m)

Source: http://kennisbank.crow.nl/zoeken/search

9.2.3 Detailed description of No. 3. Roundabout with medium speed, medium traffic volume.

Table 28: Detailed description of No. 3. Roundabout with medium speed, medium traffic volume

Design specification	Solution	Possible next best solution
Geometric considerations	Separate cycle track (segregation) outside of MV carriageway Use VGU traffic islands for with multiple lane crossings	
Orientation of priority	MV-priority in crossing points	VRU priority at crossing point if speed is ≤ 50 km/h
Visibility	Orientation signage important Road/street lighting Bend-out crossing design for increased visibility	
Direction	Two-way possible	
Width	Minimum 4 meters (cyclists & pedestrians)	

Remarks: Highlights to consider for junctions:

- Cycle lane crossing/across side roads should be a minimum of 2.5 m wide
- Designers should ensure good visibility between cyclists/pedestrians
- Consider possible conflict points (and remove/mitigate)

9.2.3.1 Separate cycle track

Figure 29: Example of a Separate cycle track No. 3. Roundabout

- Outside urban area
- Cyclists have no priority on roundabouts.
- Flexible application possibilities (for local needs)

Source: https://www.mobielvlaanderen.be/pdf/vademecum/hfdst4.pdf

9.2.4 Detailed description of No. 4. Roundabout with low speed, low MV & bicycle traffic volume (1. Mixed traffic, single carriageway roundabout).

Table 29: Detailed description of No. 4. Roundabout with low speed, low MV & bicycle traffic volume

Design specification	Solution	Possible next best solution
Geometric considerations	Mixed use, low speed, single-lane design.	
Orientation of priority	MV-priority in crossing points	
Visibility	Orientation signage important Road/street lighting	
Direction	Two-way possible	
Width	Minimum 4 meters (cyclists & pedestrians)	

Remarks: Highlights to consider for junctions:

- Designers should ensure good visibility between cyclists/pedestrians
- Consider possible conflict points (and remove/mitigate)

9.2.4.1 Low speed mixed traffic single-lane roundabout

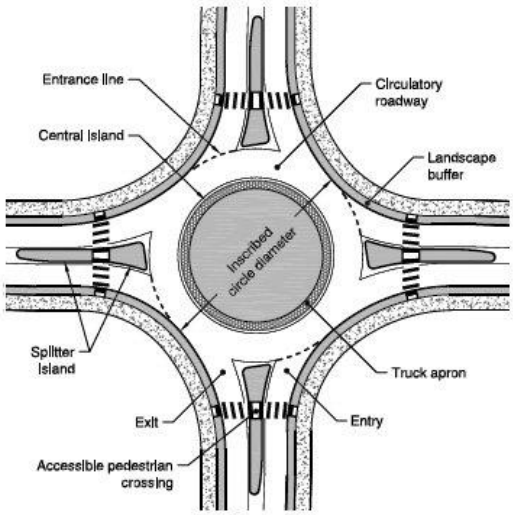


Figure 30: Detailed description of No. 4. Roundabout with low speed, low MV & bicycle traffic volume

Source: https://safety.fhwa.dot.gov/intersection/innovative/roundabouts/fhwasa10006/ & https://www.google.se/maps/@59.9221817,16.588482,3a,75y,208.5h,83.49t/data=!3m6!1e1!3m4!1sIKVDDXNGzJEFATc4eTYvGQ!2e0!7i16384!8i8192

9.3 Design recommendation selection (Decision tree)

9.3.1 Decision-tree chart – Roundabouts ≥ 70 km/h

A decision tree chart to assist in the selection of design element for rural roundabouts where the speed limit on the main road is ≥ 70 km/h. The design elements suggested in the decision tree chart are specified in the tables below.

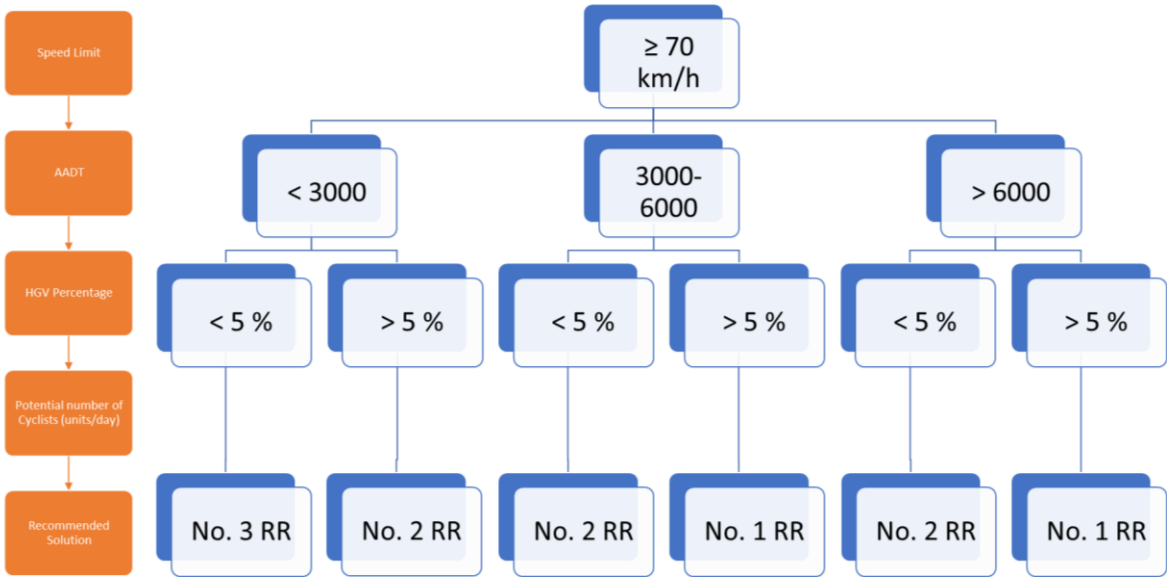


Figure 31: Decision-tree chart – Roundabouts ≥ 70 km/h

The AADT refers to the maximum value found in any of the roundabout arms. If the traffic flow through the roundabout arms are very asymmetric and do not traverse VRU routes, lower thresholds can be considered. The descriptions of the type of rural roundabouts (RR) are found below.

9.3.2 Decision-tree chart – Roundabouts 50 – 69 km/h

A decision tree chart to assist in the selection of design element for rural roundabouts where the speed limit on the main road is 50 – 69 km/h. The design elements suggested in the decision tree chart are specified in the tables below.

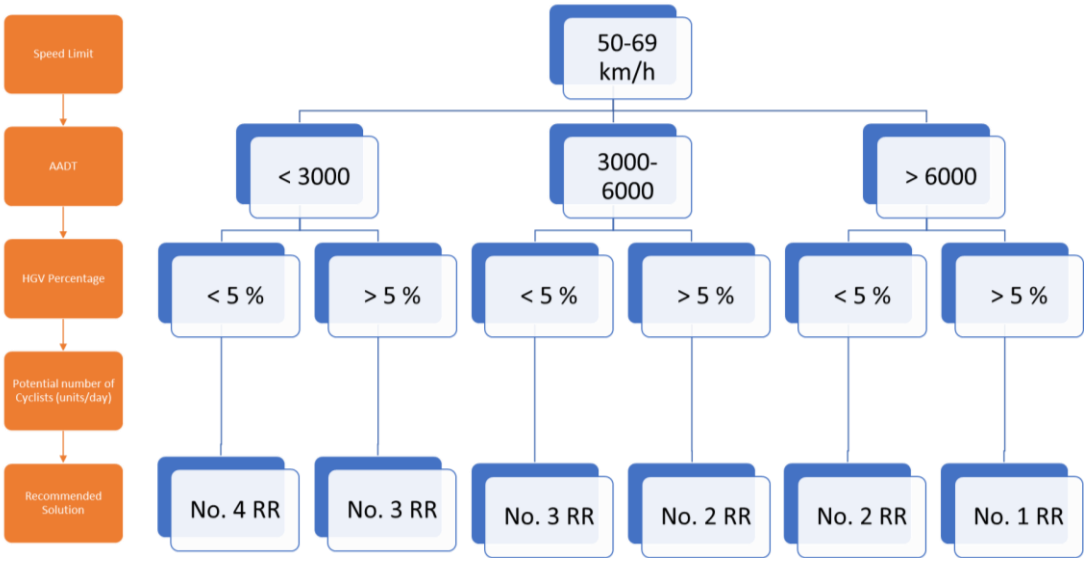


Figure 32: Decision-tree chart – Roundabouts 50 – 69 km/h

The AADT refers to the maximum value found in any of the roundabout arms. If the traffic flow through the roundabout arms are very asymmetric and do not traverse VRU routes, lower thresholds can be considered.

10 Conclusion

The good practice guidelines recommended in this CEDR report have been based on a detailed study of the developed standards already in place in member states, and an investigation of good road designs and practices implemented within the CEDR member countries. This document is intended to provide initial guidance to NRAs about the design of VRUs on legacy road networks and should be supplemented with local context to tailor individual NRA requirements that respond to varying needs and constraints in different CEDR members

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