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)

WP3 Worked Examples of Good Practice Guide

Deliverable No D3.2

Date October 2020

VTI (Sweden)

BRRC (Belgium)

Arup (Ireland)

CEDR Call Safety 2016

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

Deliverable number 6: Worked Examples of Good Practice Guide

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

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Version: 4.0

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Glossary of Terms

AADT	Average annual daily traffic (measure of traffic volume).
CEDR	Conference of European Directors of Roads
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.
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 classed 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. However, of course, we must ensure that 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. Over the course of this project, we will review VRU standards across member states, analyse them and develop a "good practice guide" with focus on self-explaining systems for VRU in non-urban areas. It is worth noting that this work focuses on the development of guidance for design of cycle facilities to be used primarily by commuter and tourists rather than higher speed exercise/race biking.

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2 Project & WP 3 objectives

The objectives of this project are to identify improvements to existing standards and guidelines for the design of self-explaining road systems that promote 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.

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, 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.

This present Deliverable D3.1 draft "Worked Examples of Good Practice Guide" 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 is to test the applicability of the good practice identified on roads in different countries with different characteristics and constraints. It is intended that this exercise will inform the development of a more refined set of good practice.

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3 Methodology

The first step in Work Package 3 was to determine the road sections to be considered for inclusion in the worked examples. Using the collective knowledge of the project team and CEDR representatives in their respective countries, the following three road sections were determined as suitable candidates for the worked example.

- Worked Example 1: N4 – Castlebaldwin to Collooney (Ireland)
- Worked Example 2: N9 – Bruges to Ostend between the N307 and N34 (Belgium Flanders Region)
- Worked Example 3: Route 293 – Smedsbo to Stråtenbo (Sweden).

Of the sections selected, only Worked Example 1 does not currently have cycle facilities. Worked Example 2 in Flanders has cycle facilities, but these are considered to be substandard. Worked example 3 has what would be considered to be good facilities but has been reviewed to determine what could be done to improve the facility.

The designs have been prepared on the best background mapping available in each country. No mapping was available for Sweden and as such the review and suggested improvements are based on a combination of commentary and typical layout sketches.

In developing the worked examples, a number of options are considered but only one option is presented for each section. It is important to note that given the high level at which these designs are being undertaken, it is difficult to fully consider all constraints found along these road sections. The presented designs may therefore not be fully workable solutions. However, the designs do allow the good practice guide developed in Work Package 2 to be tested in real world scenarios and as well as allowing any issues in implementing the guide to be documented.

Following the development of the designs, the ease with which the good practice guide was implemented was reviewed and described. For the purpose of the Worked Examples the different design elements that were described in WP2 are also used in the Worked Examples, where applicable. At the end of each of the design elements a summary is given which of the recommendations were applied. It is intended that these findings will feed into the development of subsequent Work Packages.

4 Worked Example 1: N4 Castlebaldwin to Coolooney (Ireland)

4.1 Route Description and Context

Castlebaldwin to Coolooney is a 14km section of the N4 national primary route in the north-west of Ireland. The road is a single carriageway with a single 3.5m lane going in each direction and a speed limit of 100km/h. A 3km section starting at the roundabout south of Coolooney has a 2.5-3m hard shoulder on each side. The rest of the Castlebaldwin to Coolooney road has no hard shoulder with a grass verge/hedge located in close proximity to the road edge. There are a number of small settlements and junctions along the section of the N4 as well as a couple of narrow bridges and one roundabout. The extent of the route is presented in Figure 1. Figure 2 to Figure 4 illustrate the typical current layout at a number of locations along the route.

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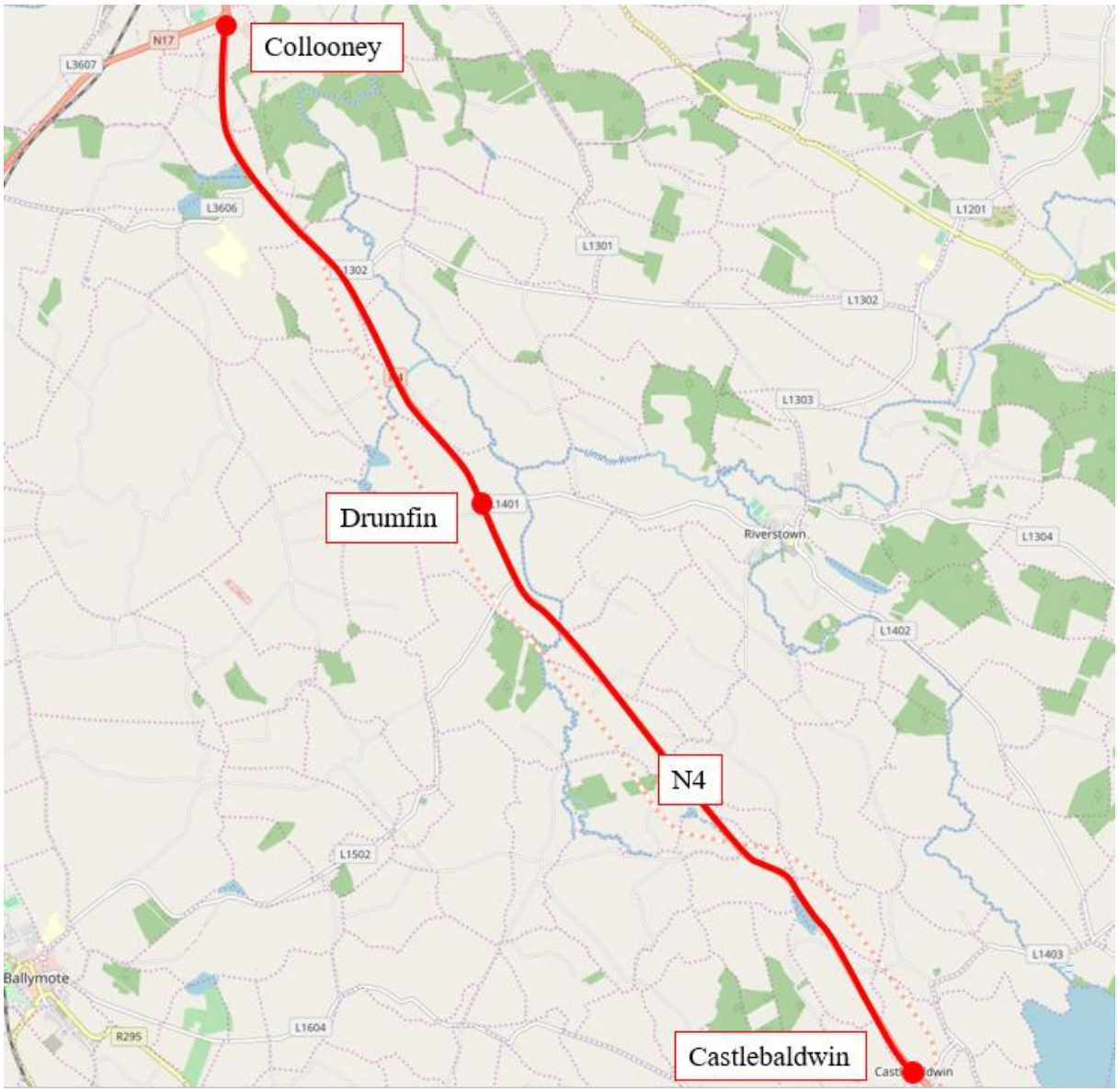

Figure 1: Worked Example 1 N4 Casltebaldwin to Collooney

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Figure 2: Typical cross-section (wide hard shoulders)

Figure 3: Typical cross-section (no hard shoulders)

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Figure 4: Typical cross-section (constrained by adjacent properties)

4.2 Concept Design Solutions Selected (including alternatives considered)

The first thing that had to be decided was which side of the road to put the cycle lane and whether to make it a 2-way on one side of the road or a 1-way on both sides of the road and if so, which side of the road. 2-way on each side of the road was also considered.

It was determined that a 2-way cycle track on the east side of the road was best option for this route. The primary reasons for providing a 2-way cycle track on one side of the road over the alternative was cost and logistics. Having it on just the east side minimised the number of land owners to deal with making the logistics, and cost of land acquisition easier. Other considerations were the number of side roads and entrances to private properties, which has an implication on traffic safety. There are also seven locations along the route were bridges need to be widened or a completely new cycling bridge needs to be constructed. If the cycle lane were to be on both side of the road, bridge widening, or a new bridge would need to be constructed on both sides which would increase costs. Having it on a single side means that the construction work would only need to be on the one side. There might be other considerations relating to propose a one-way cycle track on either side, like the expectations of the car driver: do they expect cyclists from the other side? However, in some cases where sight is good there could be a case for a two-way cycle track on one side.

Engineering issues/practicalities aside, the principle of positioning a two-way cycle track on one side of the road linking two towns would appear to offer more benefits than a single cycle

track on each side of the road. This is primarily as a result of the enhanced safety a two-way facility would bring largely due to the greater visual impact of a 3m wide two-way facility. With an added layer of assessment, providing the facility on a particular side of the road could be supported by traffic count data of side roads i.e. locate facility on the side of the road where there are side roads with lower traffic volumes and thus less risk of conflict. This principle is supported by the delivery practicalities noted above.

Once it was decided to position the facility on one side of the road, consideration was given to whether it would be located behind existing hedgerows or by removing/relocating hedgerows. It was considered that leaving the hedgerow in its current location with the shared cycle/pedestrian facility located behind this would introduce personal security concerns. Separated from the road, there would be no line of sight between motorists and users of the shared facility thereby removing any passive surveillance. This was considered to dilute the attractiveness of the facility and therefore it was decided to proceed with an option which relocated the hedgerow.

In addition to online upgrades, offline options are possible including greenway type facilities. These have not been explored by this study but would remain valid options for consideration in this situation.

It is estimated that the selected design solution would cost in the region of €4-5m to construct (excluding land costs).

4.2.1 Linear Alignment

For the purposes of this study, it is proposed that a 3 meters wide two-way shared pedestrian/ cycle track would be provided on the eastern side of the N4. This width is considered appropriate for low volumes of users. Where high volumes are expected wider facilities should be considered.

To enhance safety and provide some comfort to pedestrians/cyclists, a minimum of a 1-metre verge would separate the edge of the road carriageway from the pedestrian/cycle facility (preferably the verge should be wider). This verge could be a simple grassed verge, or a filter drain to facilitate drainage from both the pedestrian/cycle track and the roadway providing both a practical function as well as a safety buffer between vehicles and vulnerable road users. Consideration could be given to providing a vertical separation between the shared pedestrian/cycle facility and the road but doing so could require a kerb and thus might complicate drainage requirements. For this is important to know that drainage is dealt with differently per country. A typical cross-section proposed for this example is presented in Figure 5.

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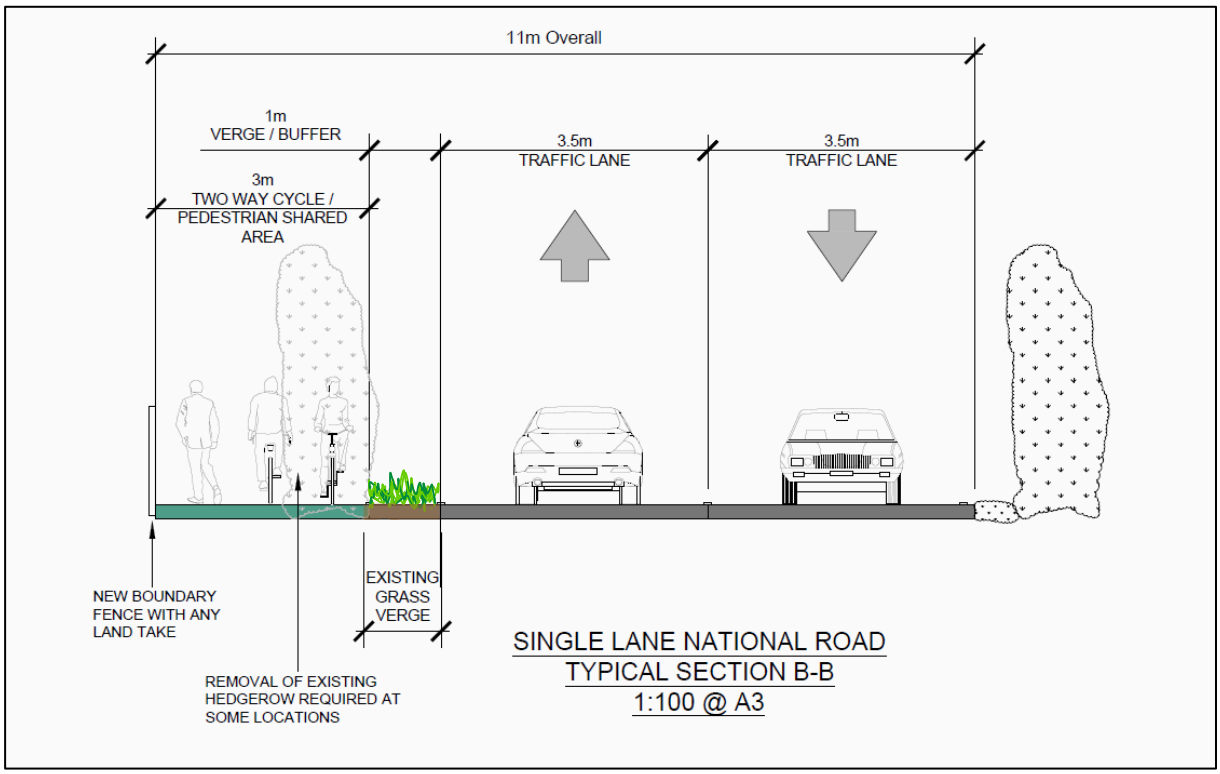

Figure 5: Worked Example 1 Typical Cross-section

Along the northern section of this route, there is a 2.5 – 3m hard shoulder present. Two options are available in this scenario. To maximise use of the existing road surface/infrastructure, the hard shoulder could be widened by 1 – 1.5m to enable a minimum 1m buffer and 3m shared surface (the desirable buffer depends on the maximum speed limit, the greater the speed limit the greater the distance)[1]. However, in doing so, the shared surface would effectively be an extension of the road. To provide some added visibility and safety for users of the shared facility, bollards could be installed at regular intervals (2-5m) in addition to the buffer being line marked with white hatching. Alternatively, the existing hard shoulder could be broken out and replaced with a grassed verge/filter drain. Both options are presented in the following figures.

[1] In the Netherlands the guidelines prescribe a minimum of 1.5m for 60km/h roads, 4.5 m for 80 km/h roads and 8m for 100 km/h roads.

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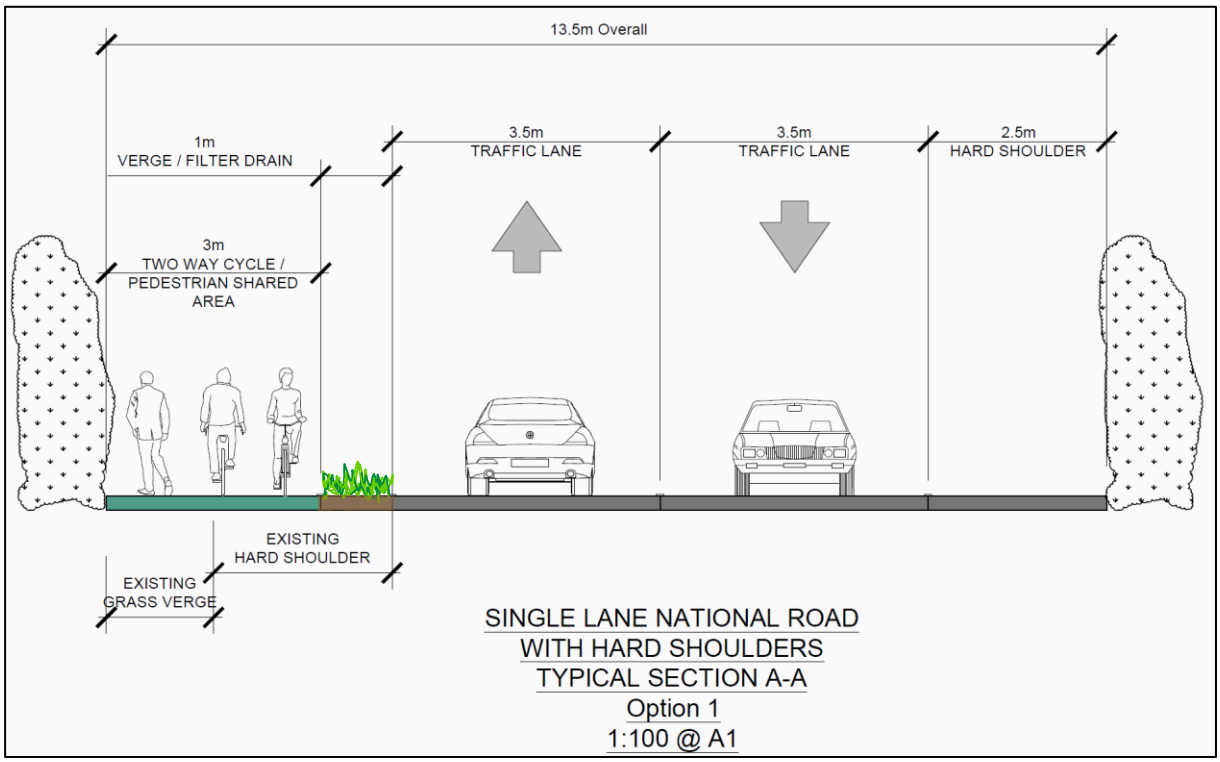

Figure 6: Option 1 for sections with hard shoulders (new grass verge/filter drain separating road from shared facility)

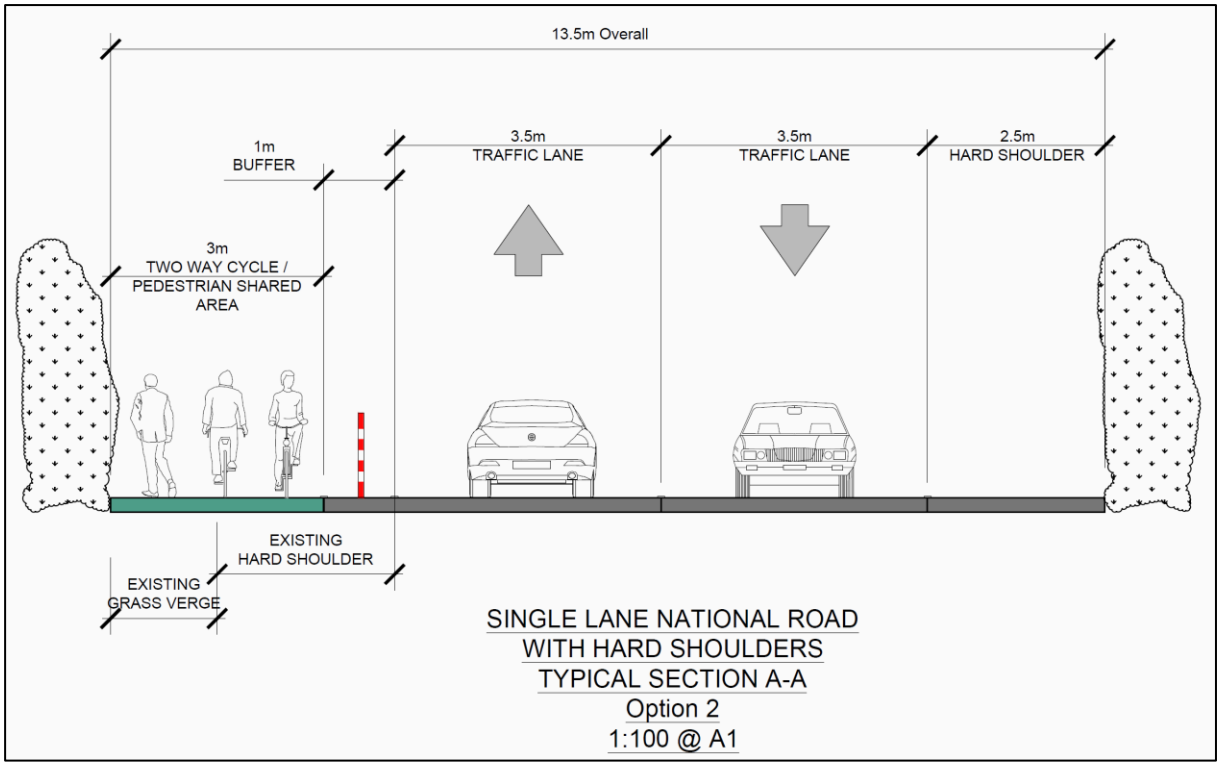

Figure 7: Option 2 for sections with hard shoulders (maximise use of existing infrastructure)

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Some other principles which informed the worked example design are listed below:

- All sections of the cycle lane will be visible from the road at all times in enhance passive security;
- Road markings and signage will be present on the cycle lane to distinguish the direction of travel for cyclists, particularly at junctions. These features serve to both inform VRUs as well as informing motorists who may misinterpret the facility as a small road.
- Warning signs will be in place along the road carriageway to warn that cyclist are present along the road, particularly where interactions with vehicles occur i.e. junctions.
- Warning signs will be present on the cycle lane and on the approach to junction crossings to inform the cyclist a crossing is approaching and that they should give way and exercise caution. This concept may vary from country to country and cyclist priority may be possible in countries where there is a greater culture of care given to cyclists. However, the safest arrangement for cyclists, albeit less convenient arrangement, is that they give way to vehicles.
- Lighting could be installed along the length of the cycle lane. Smart lighting could be used that is only illuminated when cyclists or pedestrians are detected in the shared facility. This would improve the visibility, and therefore safety, of the cyclist.

It is worth noting that the linear alignment requirements of this proposal would result in the direct impact on approximately 30 residential properties (requiring relocation of property boundary walls) and approximately 50 agricultural fields. There is also a requirement to widen a number of bridges. These are clear constraints and generally a restrictive barrier to the development of cycle facilities on the Irish legacy road network. While this can be overcome, it comes at a significant cost that cannot always be justified by the demand generated by the proposed facility. Some design refinement could lead to a reduction in the impact on land but would require derivations from the good practice such as the desired cross-section. For the purpose of this study, no such deviations were considered for this worked example (see section 5.2.1 for potential deviation considered for worked example 2).

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
Two-way cycle facility (min. 2.5m) on one side of the road.	Yes	Yes
Separation between cycle facility and carriageway (min. 0.5m, ideally in different material.	Yes	Yes
Differentiation between cycle/driving lane in colour if within carriageway.	No	No
The width of the cycle lane should be appropriate, given a speed limit of 50 km/h it should be a min. of 2.0m.	No	No

In situations where the road has speeds greater than 50-60km/h the cyclist should be separated from cars	Yes	Yes
Provide adequate carriageway widths that accommodate two-way traffic movements without the need for motorists to drive in cycle lanes.	No	No
Provide signs warning of potential for cyclists to be on the road.	No	No
Separate the cycle lane from the carriageway by a verge and in some locations by vegetation.	Yes	Yes
Consider winter road maintenance needs and give priority to VRU path over carriageway to reduce bring cyclist and pedestrian onto the winter carriageways.	No	No
A contra flow cycle lane maybe a viable way of providing for vulnerable road users in a rural area with restricted width and low AADT.	No	No
Contra-flow facilities should where possible, be provided with physical separation or MV meeting points (if in two-way traffic).	No	No

4.2.2 Junctions

There are ten locations where the cycle lane crosses side roads at junctions along this 14km section of the N4.

At each junction it is proposed that the crossing point is set back a minimum of 10 meter from the mainline road to allow for sufficient visibility and stopping time for vehicles turning off the main road who encounter a cyclist already crossing the road. It is also proposed to tighten radii at the junction to 6-8m will encourage lower vehicle movements turning into and out of the junction and thus improve safety for all road users. It is important that good visibility exists between motorists and cyclists so vegetation between both should be cleared at junctions.

It is proposed that pedestrians/cyclists yield to traffic at all junctions and as such no road markings or colour surfacing are provided across the road. While these markings can help draw a motorists' attention to the presence of a crossing, they can also give the impression

that cyclists have priority and as such they are not recommended. The same markings also might have a different meaning in different countries. It is proposed that yield markings and signage is provided for cyclists on approach to the crossing.

For this worked example, no central refuge is provided on the side roads as crossing widths are small (7 – 8m) and volumes on the side roads are low. Where the two-way volumes on the road during peak periods exceed 400-500 vehicles, consideration should be given to providing a central refuge of 2-3.5m, which is about the length of the longest bicycle (e.g. cargo bike).

A typical junction detail is presented in Figure 8.

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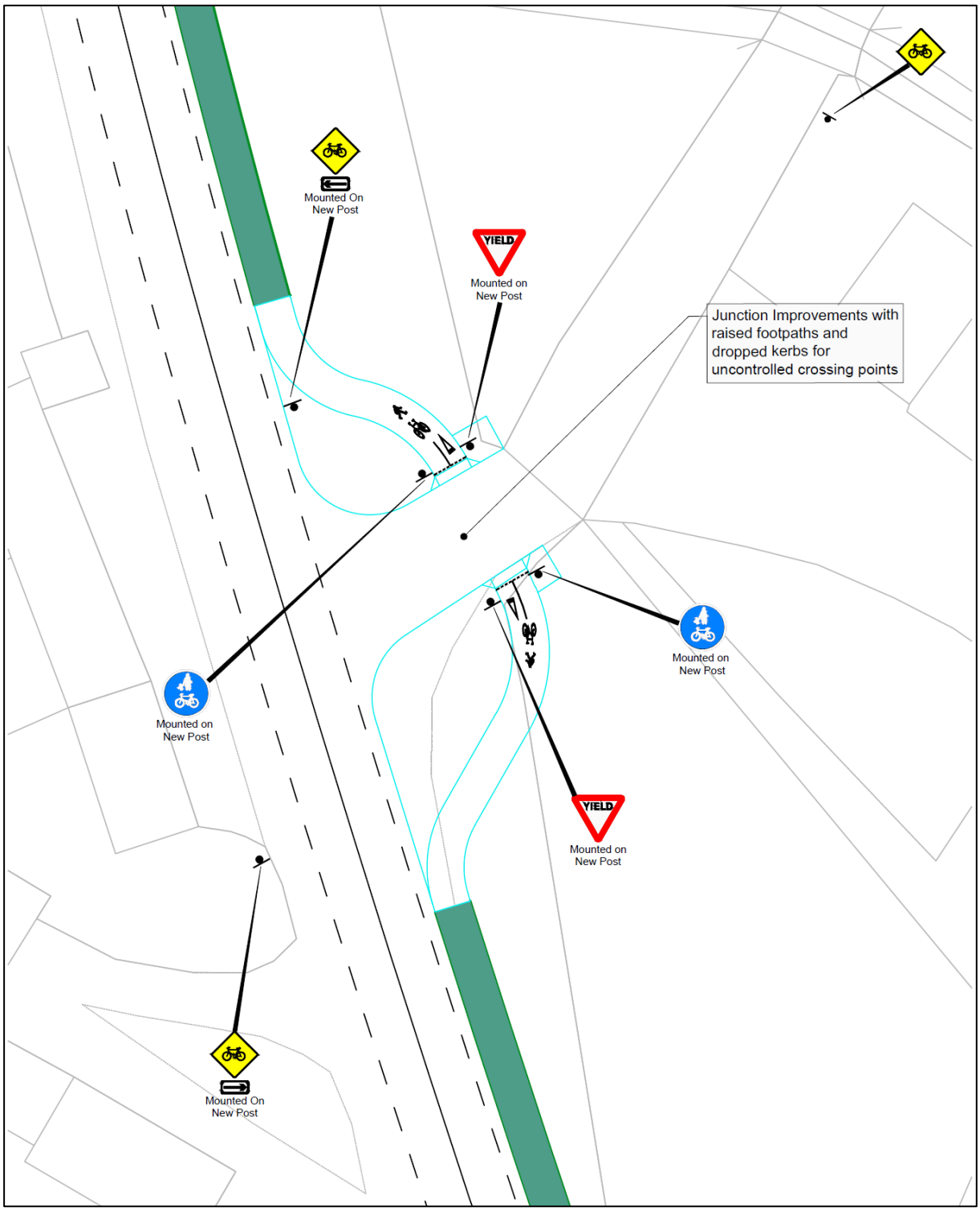

Figure 8: Typical Junction Layout

In addition to formal junctions with side roads, there are also a number of dwelling driveway entrances which the shared facility crosses. At these locations, it is not proposed to bend the cycle facility outwards, as is the case at junctions. In these cases, the alignment of the cycle facility will be continued along the general facility alignment (i.e. 1m back from the mainline) This is primarily due to the low volume of vehicles using driveways on a daily basis.

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However, to enhance visibility of the crossing, 'elephant footprint' type road markings are recommended, see Figure 9.

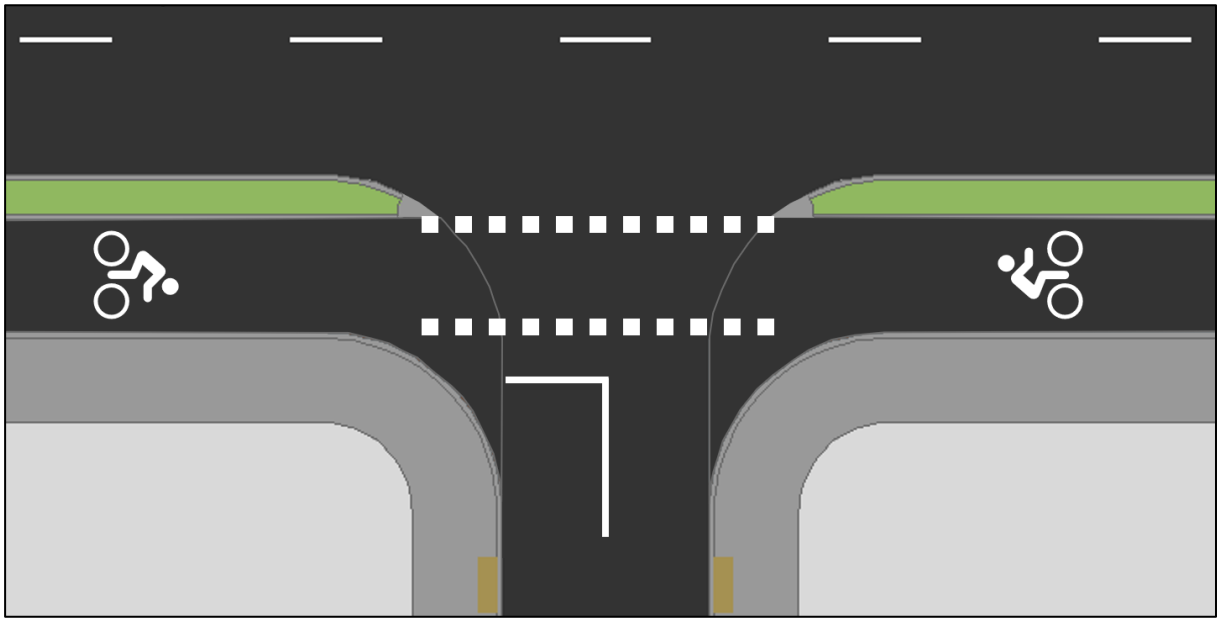

Figure 9: Example of Elephant Footprint Road Markings

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
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 (0.5 m) here as well between road and bicycle path.	No	No
The 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.	Yes	No
Arrows can be used to indicate that the cyclists can approach from either direction.	Yes	No
There is 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.	Yes	Yes

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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.	Yes	Yes
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.	No	No
Make sure that the priority for crossing in the junction is clear and sensible/logical. In nonurban areas (with speed > 50 km/h) would mean that cyclists always yield to MV traffic.	Yes	Yes
Use signage reinforcing message to yield.	Yes	Yes
Ensure adequate inter-visibility between motorists and cyclists at junction crossing points e.g. clear and maintain vegetation.	Yes	Yes
Provide clear signage for both motorists and cyclists such that the layout is self-explaining.	Yes	Yes
Avoid complex intersection for MV drivers with multiple crossing points, signalling and yielding rules.	No	No
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	Yes	Yes

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.	Yes	Yes

4.2.3 Crossings

No crossings across the mainline are deemed to be required as part of this worked example.

4.2.4 Linear Settlements

Castlebaldwin is the only linear settlement along this section of the N4, located at the most southerly point of the route. It is a small town with a number of businesses, shops, pubs and houses. There is currently a pedestrian footpath on both sides of the road with a small number of on-road parking spaces, but there are no cycling facilities at present in the town. The speed limit on the N4 reduces to 50km/h through the village. There are three side road that meet the N4 in the village, one from the west and two from the east.

In developing the worked example, it was proposed to continue the 3m shared cycle facility on the eastern side of the road though the town. A number of on-street car parking spaces would need to be removed to facilitate this.

The cycle lane would cross the two side roads that enter the town from the east. This worked example proposes that cyclists yield to traffic at these crossing points. While, priority could be afforded to cyclists in this more urban environment, it is felt that this may lead to confusion given the proposal that cyclists yield elsewhere along the route.

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
A maximum speed limit of exceeding 60km/h warrants a separate cycle path.	No	No
Smooth curves should be adopted on cycle lanes.	Yes	Yes
Provide buffer zones between bus stops and cycle lanes if they converge.	No	No
Cyclists should have a dedicated part of the shoulder that has been clearly marked when cycle traffic is within the carriageway.	No	No
Provide sufficient width on the shoulder relevant to the AADT and MV speeds.	Yes	Yes
The quality of the paving must be high and e.g. gravel and debris on the surface needs to	No	No

be removed regularly to avoid poor cycling conditions.		
Carriageways that are too wide, long and straight tend to lead to high MV speeds; traffic calming measures maybe be required to accommodate a safe environment for pedestrians and cyclists.	No	No
Shared rural carriageways that have been narrowed, e.g. 2-1 roads, should avoid blind bends which could prove potentially hazardous for car drivers driving in the centre lane if they encountered an on-coming car who is also driving in centre lane (as prescribed). In the same blind bend, as many drivers do, they driver could elect to use the hard shoulder. Unfortunately, the cyclist/pedestrian could also be there. Therefore the 2-1 design on rural road should be abandoned.	No	No
Unique road designs often require that the motor vehicle drivers behave in a certain manner. Information and instructions must be clear especially for the first-time user, particularly if there are no formal traffic rules for this unique/prototyped type of road segment.	No	No
Priority/right-of-way issues must be clearly stated and logical.	Yes	Yes

4.2.5 Roundabouts

There is one four-armed roundabout on this section of the N4, just south of Collooney. The speed limit at this location is 100km/h, despite the requirement for vehicles to slow through the junction. For the purposes of this worked example, the two-way cycle facility starts just north of the roundabout and continues on the eastern side of the roundabout. It is proposed that the crossing on the eastern approach to the roundabout is raised and signage in line with local standards. The cycle crossings will be set back by 6-8 meters to allow for a single vehicle to stop at the crossing without blocking traffic on the roundabout. This distance also gives time to motorists to acknowledge the presence of a cyclist and come to a stop.

North of the roundabout it is proposed to split the two-way cycle facility to a one-way facility on each side of the road. This is primarily due to the fact that there are destinations on each side of the road and there is therefore a potential for more crossing movements across the N4, something which is restricted by the presence of a median and two lanes in each

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direction through this section. In fact, space existing on both sides of the road to allow a two-way facility on each side which would better facilitate movement of cyclists in this area. As the speed limit is 100km/h on the N4 through the roundabout, it is proposed that the crossing on the northern approach is not raised and that again VRUs give way to traffic. Figure 10 presents the potential layout of the roundabout.

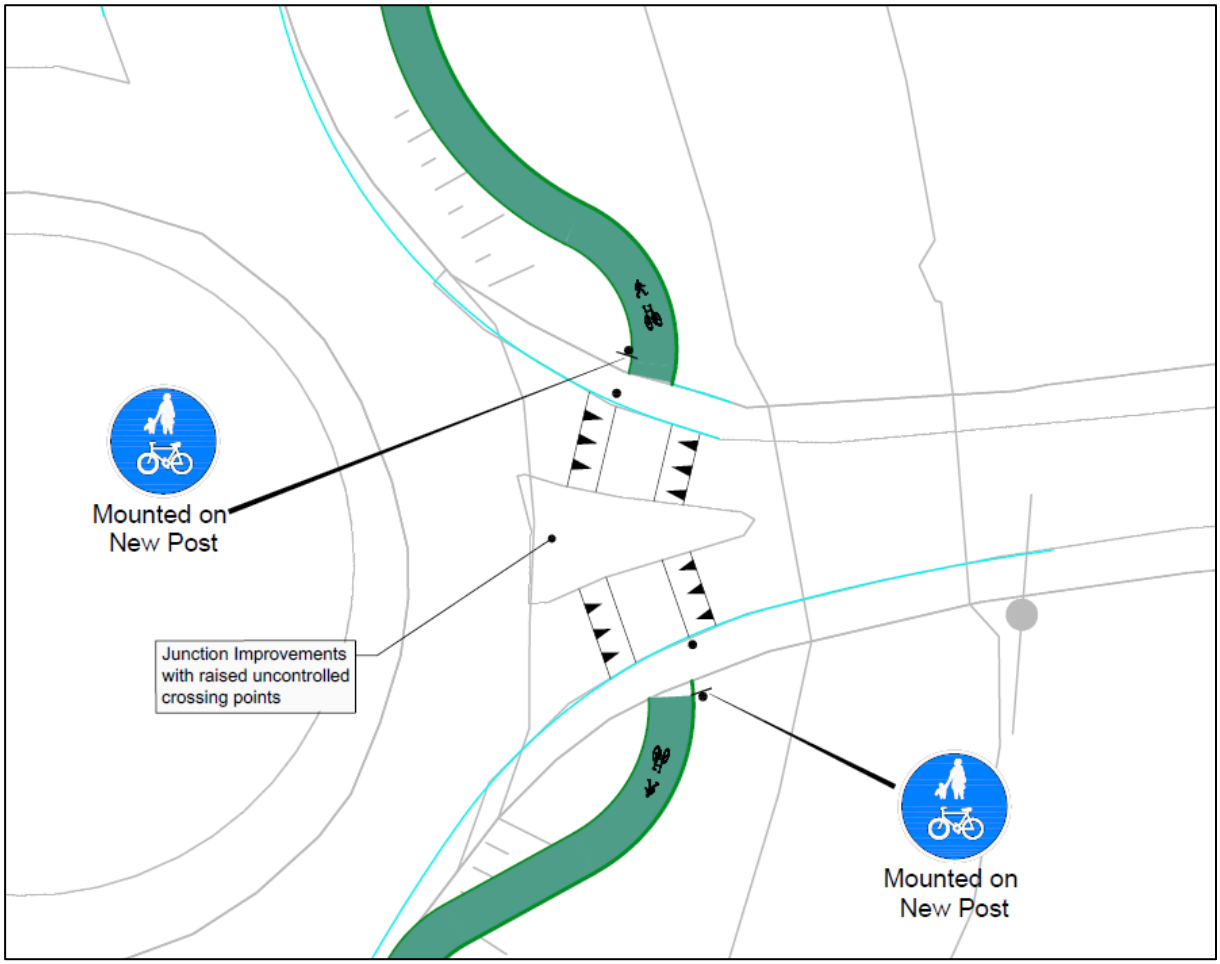

Figure 10: Roundabout Layout

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
Outside urban areas, cyclists and pedestrians should not have priority on non-signalised roundabout crossings due to higher MV speeds.	Yes	Yes
Split-level interchanges (e.g. 'crater' roundabouts) are advisable on high MV traffic volume areas, where possible.	No	No

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Dedicated facilities provided for cyclists are recommended.	Yes	No
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.	No	No
Use street lighting to make the VRU crossing points conspicuous.	Yes	Yes (at detailed design)
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).	Yes	Yes
Central traffic islands sufficiently wide in connection with stacking space for cyclists (minimum of 2.5m).	Yes	Yes
Use clear road markings and signs to alert MV drivers of the VRU crossing points.	Yes	Yes
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.	Yes	Yes
Ensure that foliage and shrubs do not restrict VRU visibility and MV driver sight-lines.	Yes	Yes (at detailed design)

4.3 Observations / Difficulties encountered applying Good Practice Guide

4.3.1 Physical Constraints

As can be seen in Figure 3 and Figure 4, the existing cross-section for much of this road section is severely constrained by private property (both residential and agricultural properties) on each side of the road in addition to hedgerows along the entire length of the route. This means that any improvement to provide dedicated pedestrian/cycle facility will result in significant land acquisition from adjacent landowners and potential environmental impacts through the removal of hedgerows. In many instances this would require

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encroachment into residential properties which would bring the building line almost immediately adjacent the proposed facility.

In reality, the scheme proposed in this worked example is almost certainly undeliverable, particularly in the local planning context and the context of the likely pedestrian/cyclist demand and the difficulties in justifying the land acquisition required. The existing cross-section on this road is typical of many legacy national roads around Ireland and highlights the difficulties in rolling out improvements to the legacy road network. While this calls into question the broader feasibility of such schemes in Ireland, if the desire, means and demand is there, the scheme could be delivered to the requirements of the emerging good practice guide.

4.3.2 Physical separation of facility

As the design was developed, consideration was given to how to separate the road and the cycle track. It was determined that the most suitable means of separation in this context was a filter drain which would both act as a buffer of different material between the road and the shared facility as well as facilitating drainage of both these surfaces. The width of this buffer should be maximised, but an absolute minimum separation of 1m is recommended. Marker posts/road studs could also be installed to define the road edge. In WP2 it was recommended to provide a buffer of at least 0.5m, which in this Worked Example was changed to 1m as it is considered to be more suitable for the local context.

The good practice guide WP2 suggests vertical separation of the shared facility by means of a kerb. This was considered but introduces complications particularly with how to deal with drainage – kerbing would require gullies or a kerb drainage system and potentially requiring a closed drainage system along the length of the scheme thus adding to cost. In addition, the kerb in a high-speed environment would have to be chamfered at a 45-degree angle and likely be less elevated (~70mm above the road level). This would reduce the effectiveness of the kerb as a traffic safety feature and provide little comfort to VRUs using the shared facility. This approach would seem most beneficial in areas where the speed limit is reduced (e.g. linear settlements) or in areas where the horizontal separation cannot be achieved due to space restriction

4.3.3 Provision for cyclists at roundabouts

Providing for cyclists at the roundabout on Worked Example 1 just south of Collooney was difficult, particularly in the context of the high speed on the mainline N4 (100kph speed limit). It is not uncommon in Ireland for high speed limits at roundabouts despite the need to slow down to navigate the roundabout. The cycle facility crosses a minor arm in this Worked Example, which is an access to a business park. It is proposed, unlike suggested in WP2, to provide raised crossings on this arm. Cycle traffic still has to yield, as was proposed in WP2, but speeds of motorized traffic is reduced and attention is drawn to the presence of cyclists with this measure.

Given the high speed of the road, the most practical way to facilitate a crossing of the mainline N4 is for cyclists to yield to traffic. However, given the high speed and the fact that the road is a dual carriageway at this location, this solution is far from ideal and in reality, speed limit reductions and associated traffic calming measures or grade separated solutions should be considered in these instances.

5 Worked Example 2: N9 Bruges to Ostend between the N307 and N34 (Belgium Flanders Region)

5.1 Route Description and Context

The N9 is a national road connecting Bruges to Oostende in the west of Belgium, near the North Sea. The section of the road selected for this study runs between the N9/N307 junction at Strooienhaan to the N9/N316 junction at Blauwe Sluis which is approximately 10km in length. The road is a single carriageway with a single 3.5m lane in each direction and a speed limit of 70km/h. However, given the straight alignment of the road, it is likely that speed limits are often exceeded on the road. A 2-3m hard shoulder is present along the length of the route on each side of the road, within which a cycle lane is provided. The existing cycle facility is considered to be substandard owing to the width of the facility, the high speed of vehicles on the adjacent road and the lack of adequate separation between vehicles. Those features make the current facility unsafe. The extent of the route is presented in Figure 11. Figure 12 to Figure 15 illustrate the typical current layout at a number of locations along the route.

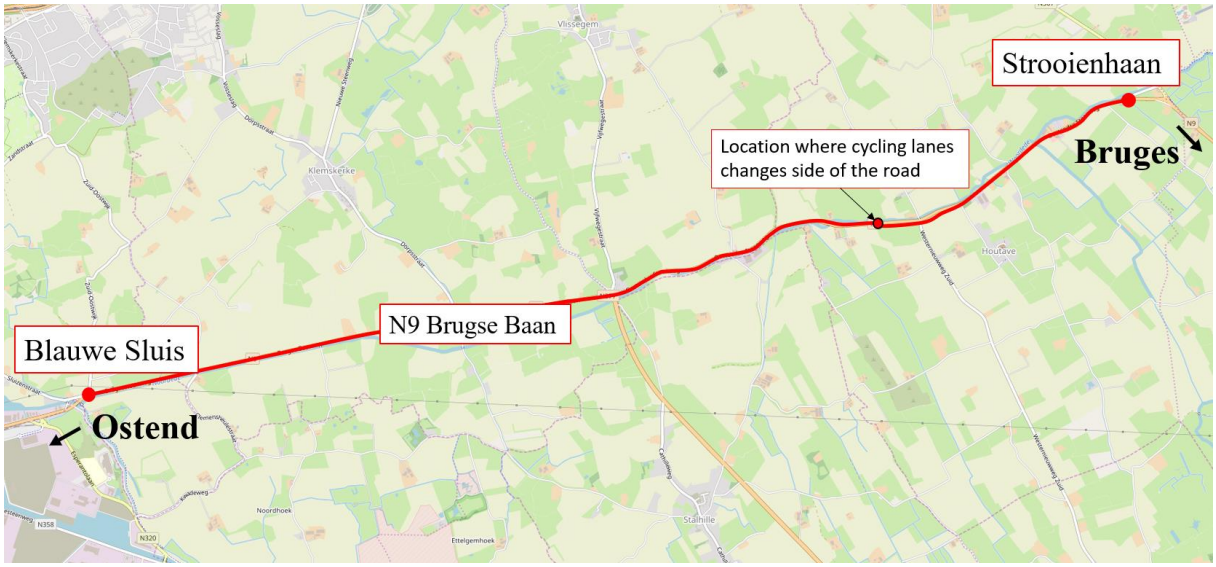

Figure 11: Worked Example 2 N9 Strooienhaan to Blauwe Sluis

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Figure 12: Typical cross-section (canal on southern side)

Figure 13: Typical cross-section (canal on northern side)

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Figure 14: Typical cross-section (adjacent dwellings and bus stop, coloured surfacing)

Figure 15: Typical cross-section (constrained width due to adjacent properties)

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5.2 Concept Design Solutions Selected (including alternatives considered)

A number of options were considered for this route, but a two-way shared facility on one side of the road was identified as the preferred option. Similar to worked example 1, the primary reason for this was cost and construction logistics. Specific to this route, adjacent land drains and a canal would make it difficult to deliver an improved cycle lane on each side of the road without significant cost and would impact on more landowners adding to the complexity and ultimately, the ability to deliver the scheme. In certain instances, road authorities might oppose a two way cycle facility due to the expectation of the car driver, which is why at junctions it is proposed that cyclists have to yield.

Given the proximity of the canal to the N9 which generally follows the alignment of the road, consideration was given to a greenway which would follow the canal. This is a viable option but there are some interactions which would need consideration to confirm the viability e.g. in places the canal runs through private property (between the entrance gate and the house). This option is likely to be feasible and an attractive alternative to an online upgrade but for the purposes of this study, an online proposal is presented.

It is estimated that the selected design solution would cost in the region of €3-4m to construct (excluding land costs).

5.2.1 Linear Alignment

For the purposes of this study, it is proposed that a 3 meters wide two-way shared pedestrian/ cycle track would be provided on one side of the road. This proposed width is considered appropriate for low volumes of users. Where high volumes are expected wider facilities should be considered.

Starting at the westernmost point, it is proposed to provide the cycling facility on the northern side of the N9. The reason for this, is that in places the canal runs very close to the road along the southern side of the road, making it difficult to accommodate the proposed shared facility between the canal and the road. At a point approximately 3km west of the N307 junction, it is proposed to switch the cycling facility from the northern side of the road to the southern side. This is due to the canal also switching sides, from the southern side to the northern side, opposite to the proposed cycle facility and creating a similar constraint as noted above. The location at which the cycle track and canal switches sides can be seen in Figure 16.

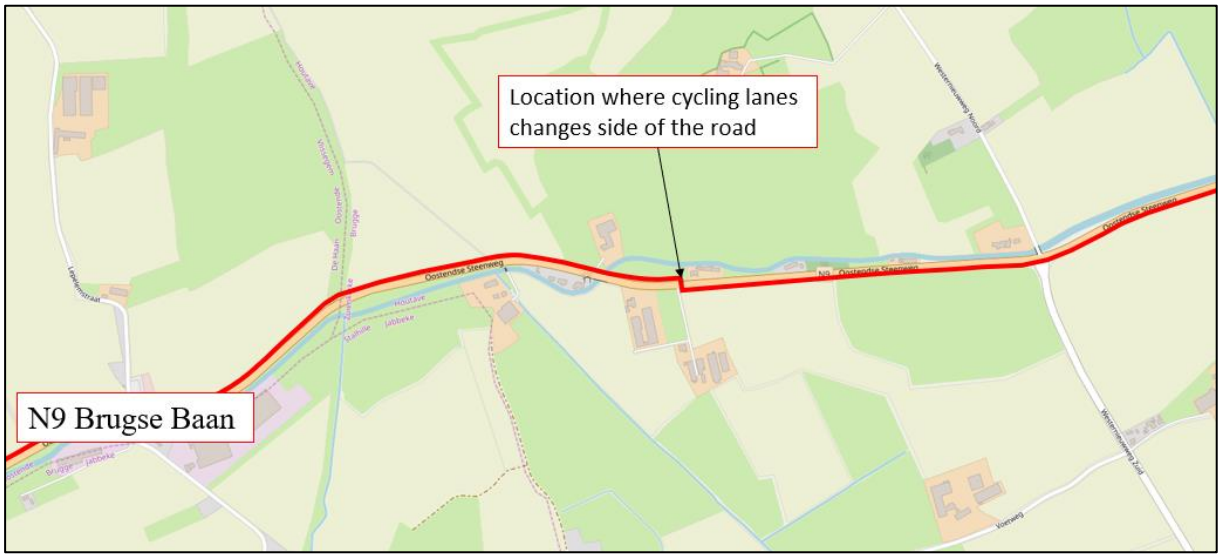

Figure 16: Proposed location of cycle crossing

There is also an option where the shared facility is provided on the northern side of the road for the entire way. The cycling facility would continue along the north side of the canal when the canal moves the northern side of the road. The cycling facility would then effectively become a greenway for the remainder of the route. However, as noted earlier, greenway options are not considered as part of this study.

Immediately adjacent the road for most of its length is an open land drain which is draining the adjacent field and/or the road. To enhance safety for pedestrian and cyclists, it is proposed that the drain is maintained in its current location and that cycle facility is located inside the drain. This effectively creates 6-7m of separation between the shared facility and the road edge. The alternative to this is to locate the shared facility in the location of the drain and rebuild the drain inside the cycle lane. This would move VRUs to within 3-4m of the carriageway but is still considered adequate. However, providing the drain between the cyclists and the carriageway offers more protection for cyclists and is therefore preferred. The cross-section assumed for this study is presented in Figure 17.

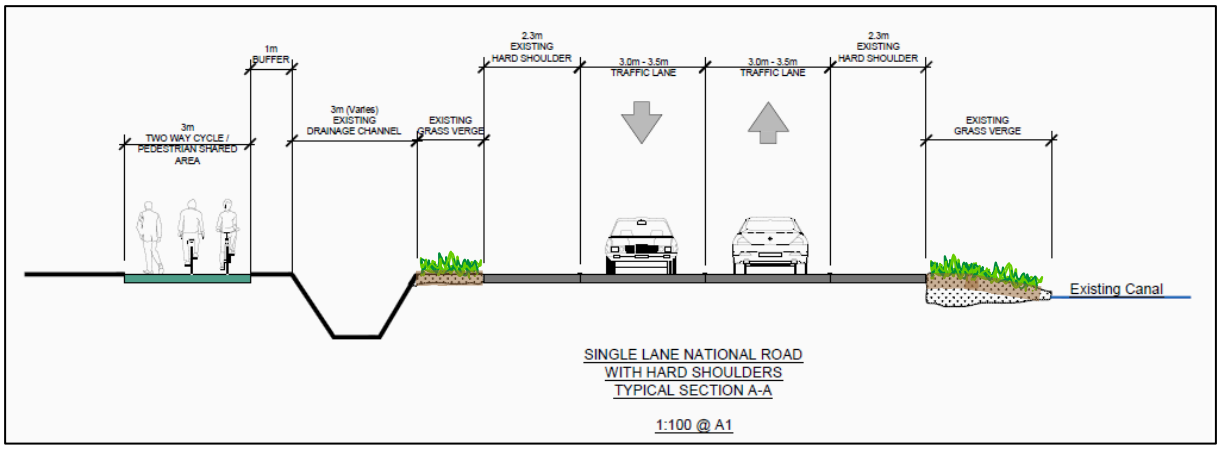

Figure 17: Worked Example 2 Typical Cross Section

There are a number of locations where properties are located close to the road edge limiting the available space (such as that presented in Figure 15). In these situations, three options are available. The safest, but more expensive option is to simply take the land required to continue the desired cross section as was assumed for Worked Example 1. Another suitable, albeit more expensive option, is to reroute the shared facility behind the property for a section. The alternative to provide a compromised design with some additional measures to enhance safety over these short sections. For the purpose of this study, the latter has been selected. The previous alternatives are all for rural environments. In a case where there is a more urban environment an option that could be considered is a local speed reduction (e.g. 50 km/h). Figure 18 shows a typical cross section for these scenarios which occur in a few areas over short distances (50-100m). Delineator bollards or similar physical barriers should be considered in these areas to enhance visibility of the extents of the facility for both motorists and VRUs. The bollards are not considered to be a safety measure, but merely a visibility measure and a disincentive for vehicle parking/driving in cycle facility given there is no other physical separation between the vehicular lanes and pedestrian/cycle facility at this location. An additional safety measure that could be considered to complement this proposal is a localised speed reduction, as mentioned above.

For clarity the existing hard shoulder is also shown in Figure 18, which clearly shows that repurposing of the hard shoulder was proposed in this Worked Example. Realignment the traffic lanes to make use of the existing hard shoulder on the opposite side of the road to create further horizontal separation between the vehicular traffic lanes and the pedestrian/cycle facility could be considered but the feasibility of such an arrangement would

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require more detailed engineering consideration of road cambers, crown positions, make-up of hard shoulder (is it suitable to carry traffic loads?) etc. For the purpose of this Worked Example this was not considered but it is acknowledged this could be a viable solution that improves the safety of the pedestrian/cycle facility.

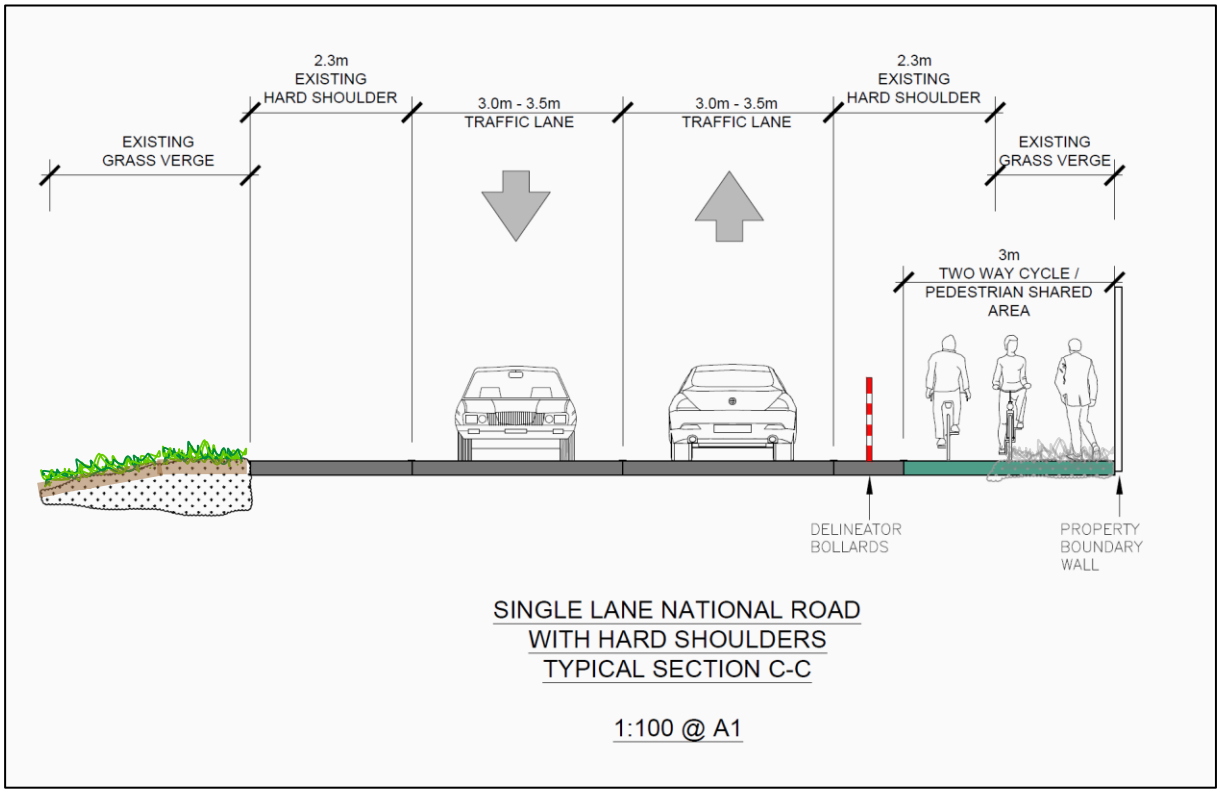

Figure 18: Worked Example 2 Typical Cross Section in constrained location

It is worth noting that the linear alignment requirements of this proposal would result in the direct impact on approximately 12 residential properties (requiring relocation of property boundary walls) and approximately 90 agricultural fields. There is also a requirement to construct bridges/culverts over drains at 29 locations along the route. Similar to Worked Example 1, these are clear constraints and generally a restrictive barrier to the development of cycle facilities on the legacy road network. However, it would appear that due to the lack of hedgerows along the road, the ability to deliver these schemes may be somewhat more straightforward than Worked Example 1.

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
Two-way cycle facility (min. 2.5m) on one side of the road.	Yes	Yes (with a switch of sides)
Separation between cycle facility and carriageway (min. 0.5m, ideally in different material.	Yes	Yes

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Differentiation between cycle/driving lane in colour if within carriageway.	No	No
The width of the cycle lane should be appropriate, given a speed limit of 50 km/h it should be a min. of 2.0m.	No	No
In situations where the road has speeds greater than 50-60km/h the cyclist should be separated from cars.	Yes	Yes
Provide adequate carriageway widths that accommodate two-way traffic movements without the need for motorists to drive in cycle lanes.	No	No
Provide signs warning of potential for cyclists to be on the road.	No	No
Separate the cycle lane from the carriageway by a verge and in some locations by vegetation.	Yes	Yes (but not always because of properties)
Consider winter road maintenance needs and give priority to VRU path over carriageway to reduce bring cyclist and pedestrian onto the winter carriageways.	No	No
A contra flow cycle lane maybe a viable way of providing for vulnerable road users in a rural area with restricted width and low AADT.	No	No
Contra-flow facilities should where possible, be provided with physical separation or MV meeting points (if in two-way traffic).	No	No

5.2.2 Junctions

There are eleven locations where the cycle lane crosses side roads at junctions along this 10km section of the N9.

At each junction it is proposed that the crossing point is set back a minimum of 10 meter from the mainline road to allow for sufficient visibility and stopping time for turning vehicles who

encounter a cyclist already crossing the road. It is also proposed to raise the shared facility from the road level at each junction. This, in combination, with tightening radii at the junction to 6-8m will encourage lower vehicle movements turning into and out of the junction and thus improve safety for all road users. It is important that good visibility exists between motorists and cyclists so vegetation between both should be cleared at junctions.

It is proposed that pedestrians/cyclists yield to traffic at all junctions and as such no road markings or colour surfacing are provided across the road. While these markings can help draw a motorists attention to the presence of a crossing, they can also give the impression that cyclists have priority and as such they are not recommended (yield markings and signage provided for cyclists on approach to the crossing). It is however acknowledged that local legislation may require that such facilities are coloured. In some countries where local conditions are that traffic is more aware of cyclists decisions can be made to reverse the priority.

For this worked example, a central refuge is provided on the side roads. Where the two-way volumes on the road during peak periods exceed 400-500 vehicles, consideration should be given to providing a central refuge like this with a width of 2-3.5m, which is about the length of the largest bicycle (i.e. a cargo bike).

A typical junction layout proposed on this worked example is presented in

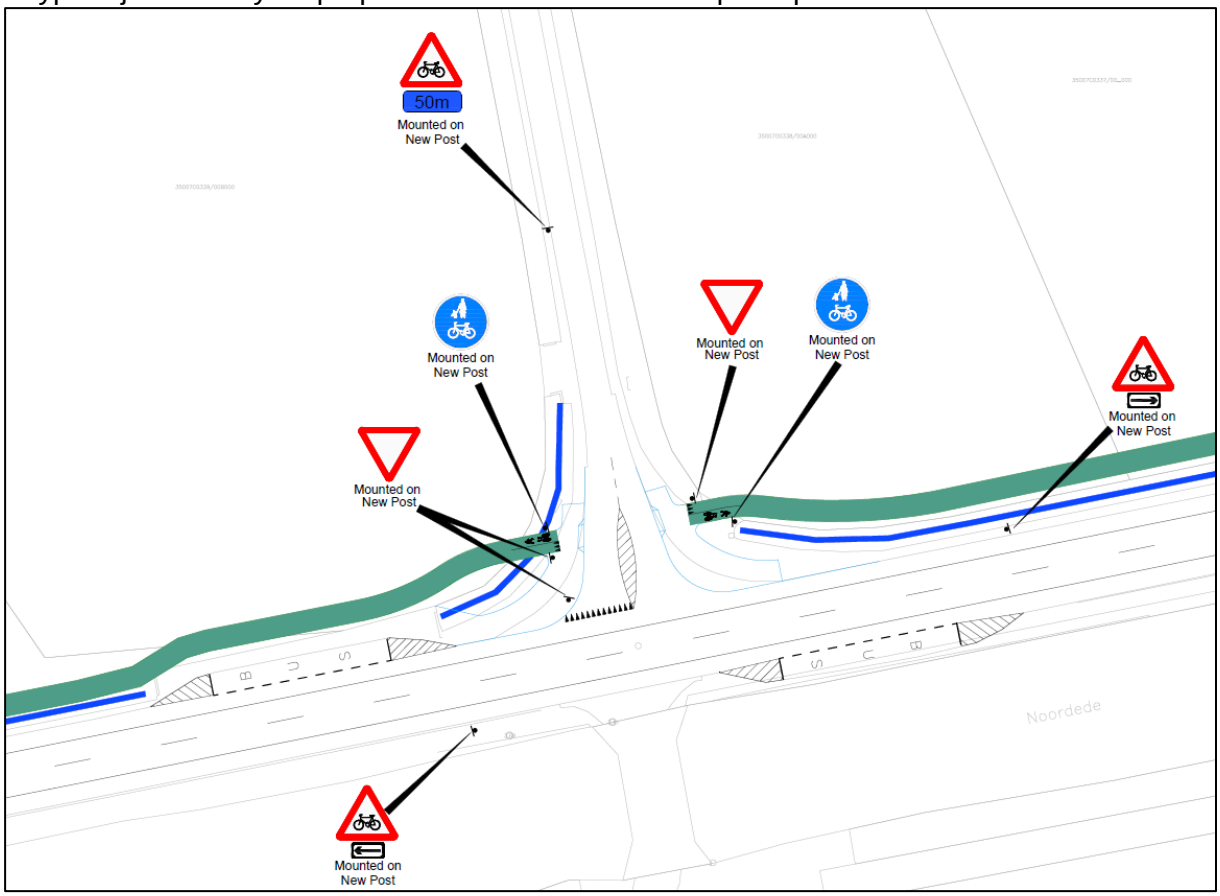

Figure 19.

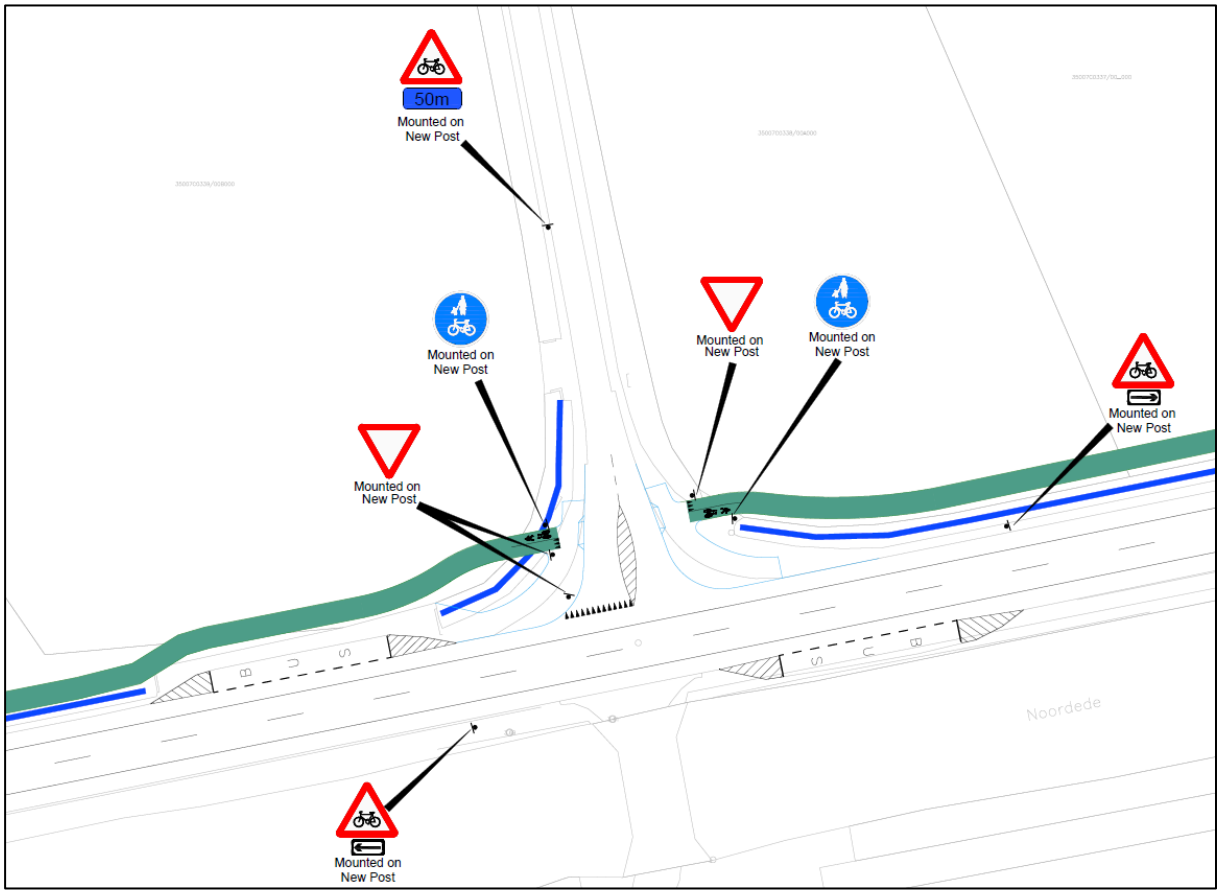

Figure 19: Typical junction layout

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
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 (0.5 m) here as well between road and bicycle path.	No	No
The colour can be used to indicate that there is a crossing point for cyclists to the MV	Yes	No

drivers but should be avoided because colours are irregularly used and have an ambiguous meaning in terms of priority.		
Arrows can be used to indicate that the cyclists can approach from either direction.	Yes	No
There is 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.	Yes	Yes
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.	Yes	Yes
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.	No	No
Make sure that the priority for crossing in the junction is clear and sensible/logical. In nonurban areas (with speed > 50 km/h) would mean that cyclists always yield to MV traffic.	Yes	Yes
Use signage reinforcing message to yield.	Yes	Yes
Ensure adequate inter-visibility between motorists and cyclists at junction crossing points e.g. clear and maintain vegetation.	Yes	Yes
Provide clear signage for both motorists and cyclists such that the layout is self-explaining.	Yes	Yes
Avoid complex intersection for MV drivers with multiple crossing points, signalling and yielding rules.	No	No
Use separate bicycle/pedestrian paths running parallel with a main road and at	Yes	Yes

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.	Yes	Yes

5.2.3 Crossings

As mentioned in section 5.2.1, there is one proposed crossing of the N9 in this worked example. This is located approximately 3km west of the N307 junction and is proposed as a means of overcoming constraints on the northern side of the road west of this point, and the southern side of the road east of this point. It is proposed that all VRUs would yield to traffic on the N9 and associated linemarking and signage would be provided to indicate this to VRUs.

The specific location of the crossing has been selected to ensure adequate forward visibility to the crossing (>300m). It is proposed to provide warning signage approximately 100m in advance to alert motorists to the potential for crossing cyclists or pedestrians. This signage could be equipped with a flashing beacon that is activated when a cyclist is detected on approach to the crossing.

Consideration should be given to targeting lighting at the crossing to clearly light the crossing during hours of darkness. Similar to the flashing signage, this lighting could be activated only when a cyclist is detected on the approach to the crossing.

A central median of 2-3.5m in width is proposed to allow VRUs to cross the road in two stages if needed. This is considered necessary to enhance safety due to the high speeds and traffic volumes on the road. Consideration could also be given to localised reduction in the speed limit and associated traffic calming measures to reduce traffic speeds at the crossing location.

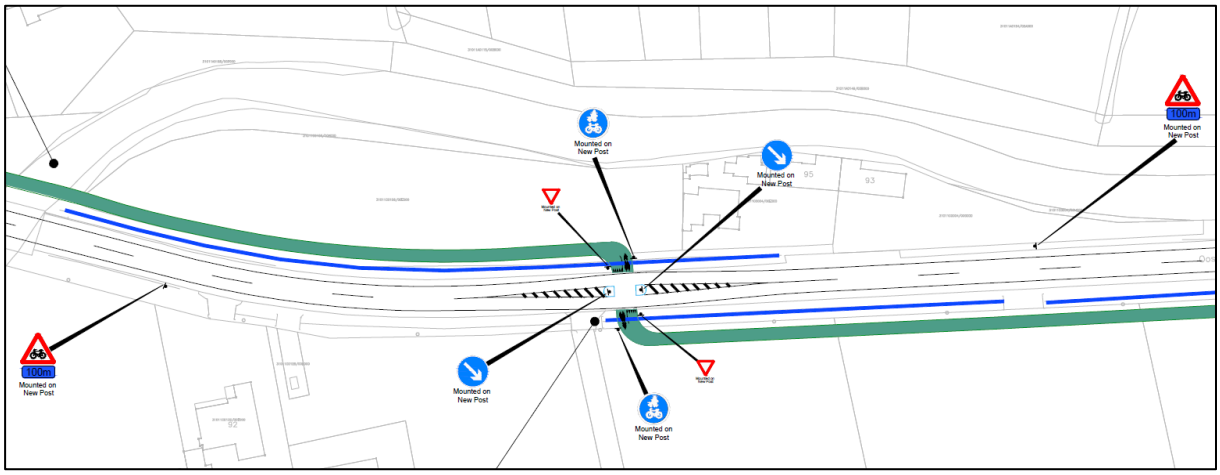

Figure 20: Suggested crossing layout

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
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. Staggered crossings for cyclist require more space for stopping, turning and stacking.	Yes	No (but median is provided)
Vertical deflections to increase visibility.	Yes	Yes
Lighting placed on the pole over the crossing.	Yes	No
Using a traffic island shortens crossing length.	Yes	Yes
Cyclists and pedestrians yield to MV traffic with clear signage and marking denoting this.	Yes	Yes (partly, should probably also be included on the centre island)
Clear signage on approach to the crossing warning motorists of presence of crossing.	Yes	Yes
Adequate radius (4m min) provided on bend to allow comfortable movement of cyclists.	Yes	Yes
The division between cyclists and pedestrians on the path should be clear and the cycle path has a generous width.	No	No
Pavement colour at the crossing is not recommended because it can easily be	Yes	Yes

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misconstrued as indicating a cyclist priority or have an ambiguous meaning; used inconsistently and lack universal deployment; and is often prone to lower carriageway friction when wet.		
Use clear right of way rules at the junction. For safety reasons, it is advisable to require VRU to yield.	Yes	Yes
Setting back the crossing point from the junction (or roundabout) reduces the complexity of the junction and reduces complexity and workload for MV drivers thus facilitating an increase in cyclist and pedestrian detection and the likelihood of MV giving way (if required).	No	No
Flashing speed limit sign grabs motorists' attention.	No	No
Multiple warnings (zig-zag edge line, horizontal stripes) help increase awareness of a crossing.	Yes	No
Visual and physical narrowing can help reduced MV speed (at the crossing).	No	No
Signalized traffic control maybe advisable if MV or VRU traffic flow is significant.	No	No
Grade separated crossing should be considered with high volumes.	No	No

5.2.4 Linear Settlements

While there are a number of residential properties located adjacent the roadway, there is no linear settlement/villages with multiple properties or retail offerings on this section of road.

5.2.5 Roundabouts

There are two roundabouts on this section of the N9, the first of which is at the junction with the N377. This junction is currently designed to facilitate a cycle lane in each direction on each side of the road and would therefore need to be redesigned to accommodate a two-way facility on one-side of the road. The existing layout is illustrated in Figure 21.

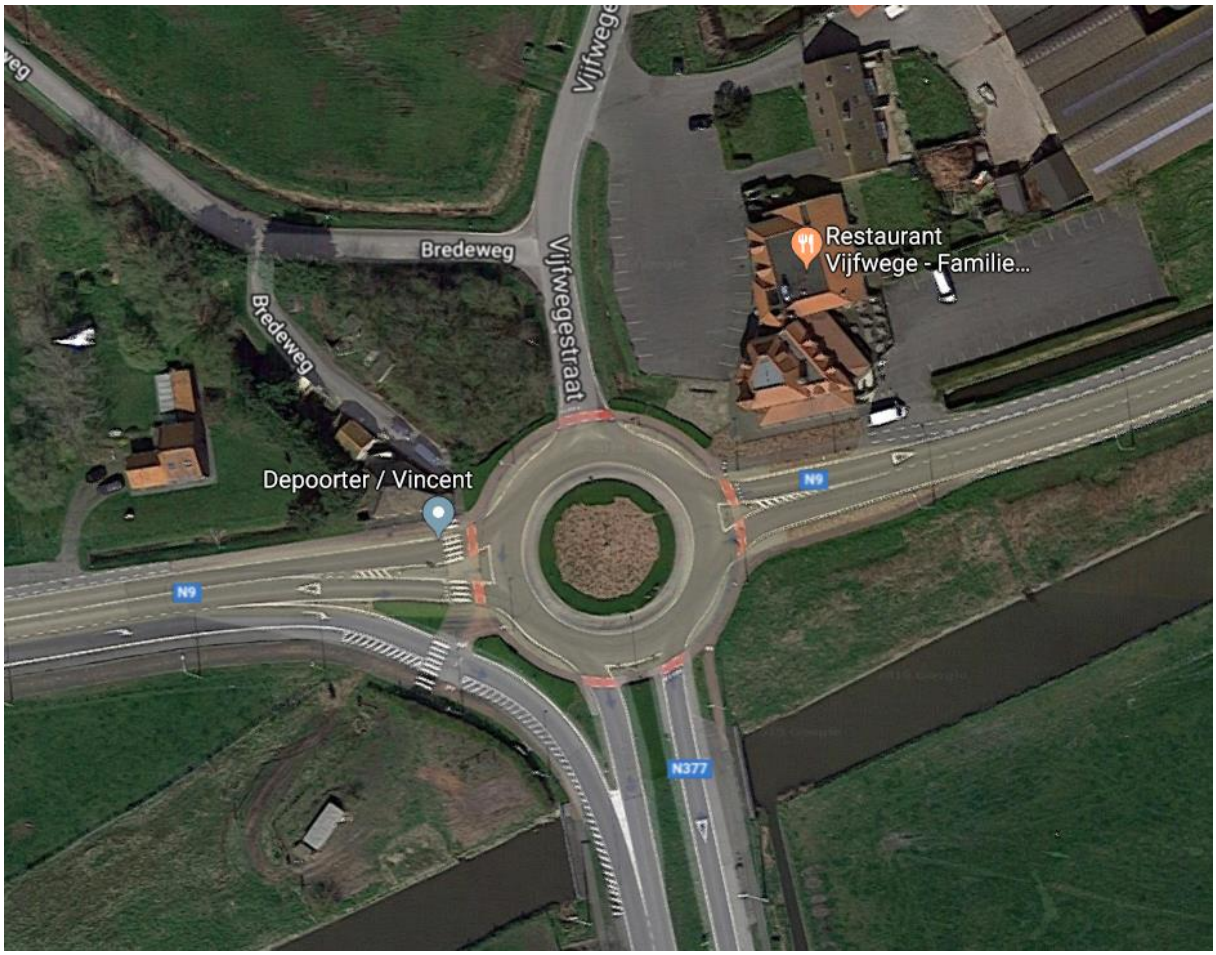

Figure 21: Existing N9/N377 Roundabout

At this location the proposed shared facility is on the northern side of the roundabout and as such the primary crossing point for the majority of cyclists will be across the northern approach to the roundabout which appears to be a local road (Vijfwegestraat). The concept scheme design proposes bending the crossing back onto this approach by 10-15m requiring acquisition of some land adjacent the roundabout and the removal of vegetation. The design proposes that cyclists give way to traffic at this, and all crossings on the roundabout. While local standards may dictate that traffic yields to cyclists, as is the case with the current arrangement, it is felt that to ensure a consistent approach to priority at all junction crossing points, that it is safer for cyclists to give way.

Figure shows the proposed layout.

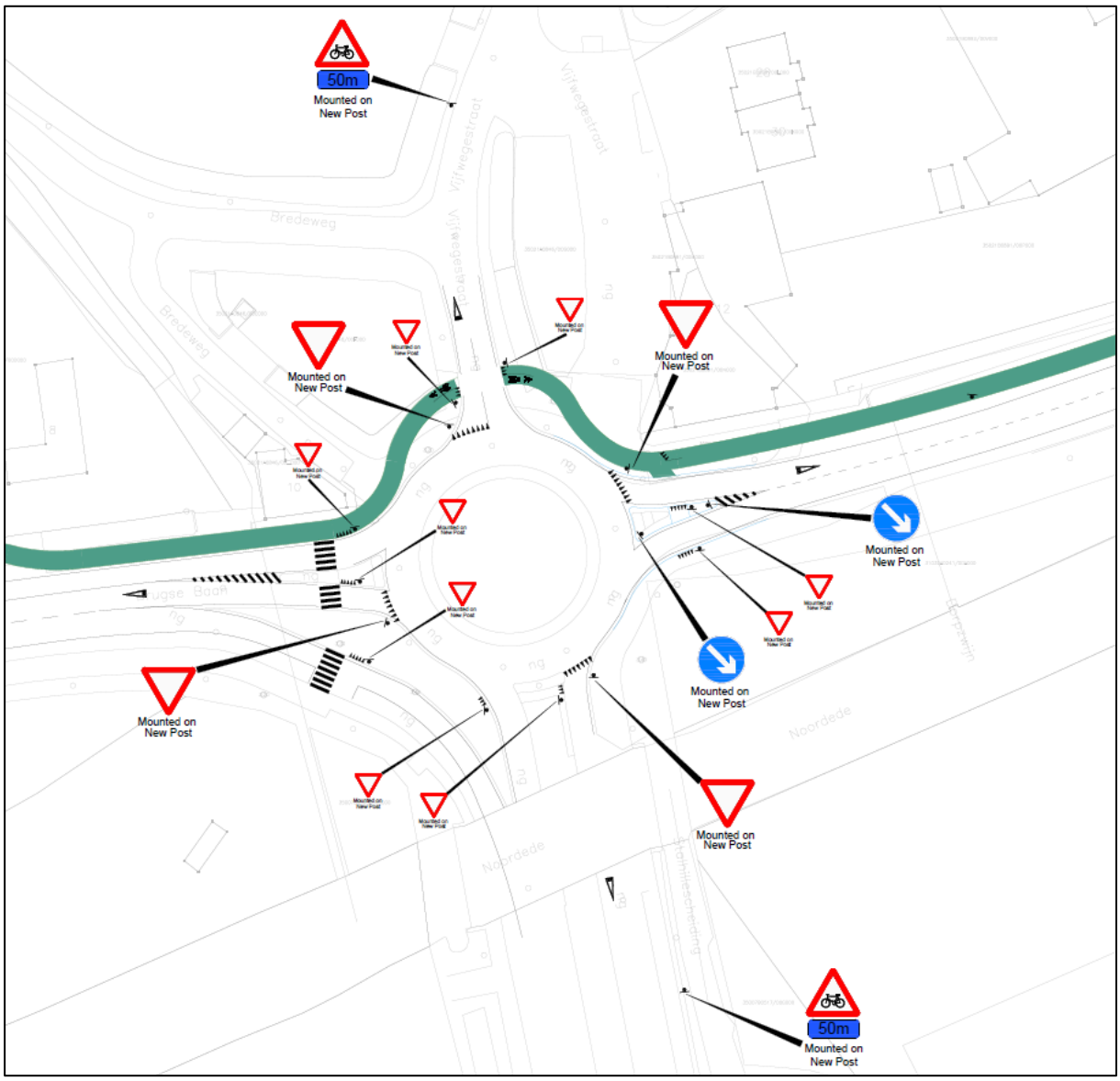

Figure 22: Proposed N9/N377 Roundabout Layout

The first roundabout on this section of the road is at the junction of the N9 and the N307 (Brugsesteenweg) at the end of the worked example section. On the N9 south of the roundabout, a reasonably new two-way shared pedestrian/cycle facility is provided on the eastern side of the road. At the roundabout, this facility splits to both the northern and southern side of the roundabout to tie into the one-way cycle facilities on each side of the N9 running towards Ostend. The existing layout is presented in Figure 23.

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Figure 23: Existing N9/N307 Roundabout

At this location the proposed shared pedestrian/cycle lane is on the southern side of the N9 when approaching from the west. The logical place for a crossing across the N9 to the existing two-way cycle facility on the southern approach to the roundabout is therefore on the southern approach. A similar arrangement is therefore proposed to the existing crossing at this location but with widening to accommodate a 3m shared facility. The use of road markings, could be considered to highlight the presence of the crossing but consideration should be given to local legislation and the meaning afforded to such road markings. The example shows a dashes line to highlight the presence of the crossing. Depending on the local context these marking could differ.

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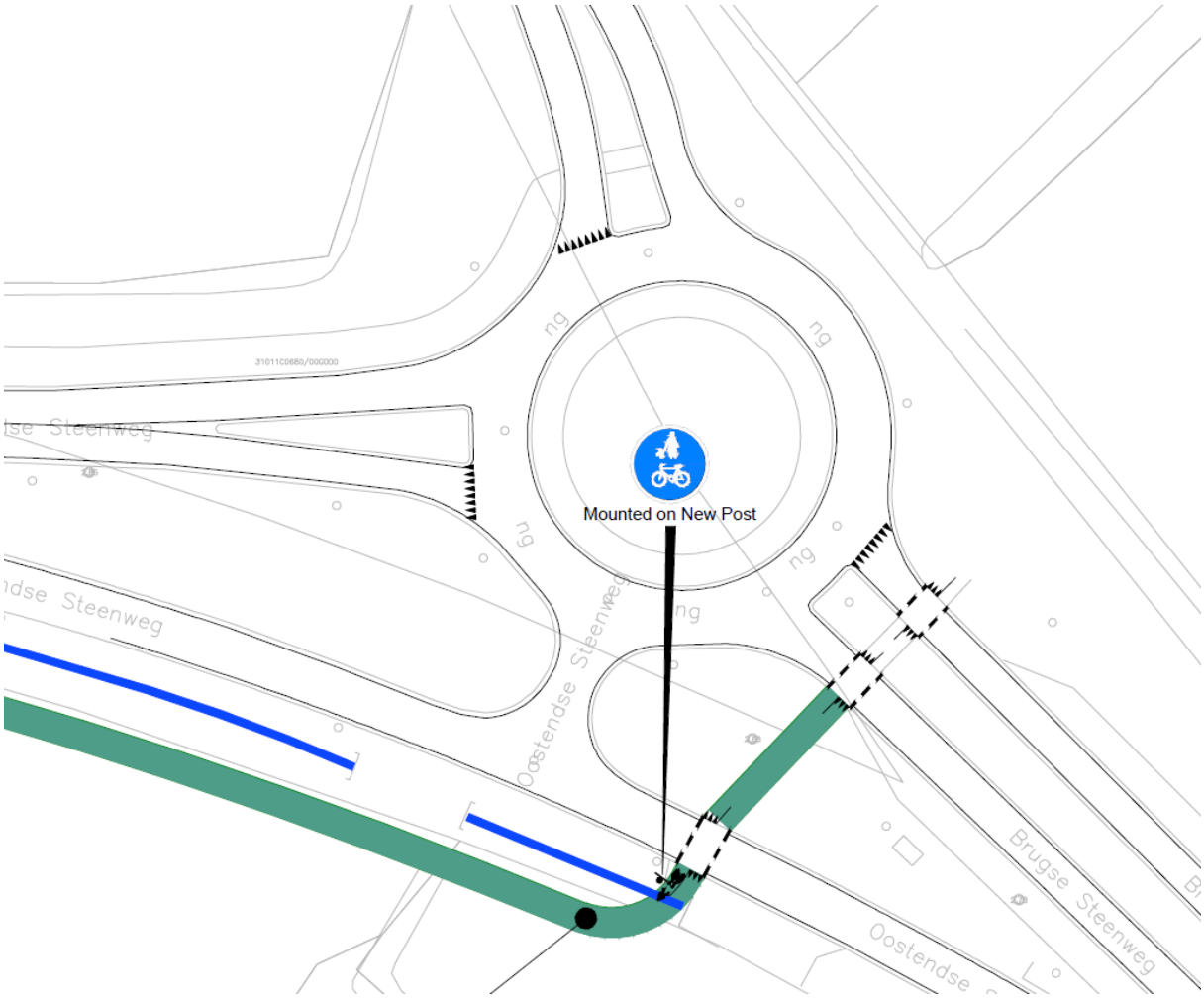

Figure 24: Proposed N9/N377 layout

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
Outside urban areas, cyclists and pedestrians should not have priority on non-signalised roundabout crossings due to higher MV speeds.	Yes	Yes
Split-level interchanges (e.g. 'crater' roundabouts) are advisable on high MV traffic volume areas, where possible.	Yes	No
Dedicated facilities provided for cyclists are recommended.	Yes	No (shared)
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	No	No

(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.	Yes	No
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).	Yes	Yes
Central traffic islands sufficiently wide in connection with stacking space for cyclists (minimum of 2.5m).	Yes	Yes
Use clear road markings and signs to alert MV drivers of the VRU crossing points.	Yes	No (not applied in the second example)
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.	Yes	Yes
Ensure that foliage and shrubs do not restrict VRU visibility and MV driver sight-lines.	No	No

5.3 Observations / Difficulties encountered applying Good Practice Guide

5.3.1 Physical Constraints

As with Worked Example 1, the main issue in applying the good practice guide was the availability of space and the physical constraints encountered along the route. Of particular note on this example was the presence of a canal in close proximity to the roadway which limited the option to continue the cycle route on a single side of the road. While land acquisition would be necessary from available properties, compared to Worked Example 1, this seems like it would be easier to achieve owing to the layout of the fields and the lack of hedgerows or physical barriers between the land and the roadway.

5.3.2 Physical separation of facility

An open drain is present along the length of the route between the road and the adjacent fields. While this could be considered a constraint, this also provides an opportunity to

provide protection for vulnerable road users using the facility which also serves to provide a generally more attractive facility. However, it is worth noting that this requires structures/culverts at locations where the cycle track crosses the drain such as at junctions.

Another consideration for further development of this layout would be how cyclists would cross from one side of the road to the other, for example to access a house on the other side, when the cycle track is separated by the drain.

In this Worked Example an addition to the recommendations in WP2 became apparent. In cases of high volumes on a side road it is recommended to include a centre island (like with the roundabouts) if grade separation is not feasible.

5.3.3 Provision for cyclists at roundabouts

The roundabout design for this option assumes that cyclists and pedestrians would give way to traffic on the roundabout. As can be seen in Figure 22, this would result in a large number of yield signs to fully sign all crossing points. However, as the speed limit is 70km/h in this location, there may be potential for pedestrian and cycle priority to be introduced but only with the inclusion of raised crossing which will both reinforce the presence of the crossing and slow vehicle speeds at the roundabout. Another alternative that should be considered in these type of locations is segregation.

6 Worked Example 3: Route 293 – Smedsbo to Falun (Sweden)

6.1 Route Description and Context

Route 239 is a primary county road linking the village of Smedsbo to the city of Falun in Central Sweden. The section of the road considered for this study is approximately 10km length. The road is a single carriageway with a single 3-3.5m lane in each direction and a general speed limit of 80km/h. The speed limit drops to 40km/h or 60km/h at some locations along the route where there are multiple residential properties. A 2.5m-3m shared pedestrian/cycle facility is present along the entire length of this section and runs on the northern side of the road. This facility is mostly separated from the carriageway by a verge which appears to also facilitate drainage from both the road and shared facility.

The extent of the route is presented in Figure 25. Figure 26 to Figure 28 illustrate the typical current layout at a number of locations along the route.

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Figure 25: Worked Example 3 Route 293 Smedsbo to Falun

Figure 26: Typical cross-section (general layout)

Figure 27: Typical cross-section (constrained by adjacent properties)

Figure 28: Typical cross-section (cycle route diverges offline behind constraints)

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6.2 Review of existing facility and suggested improvements

As noted in section 6.1, there is already cycle facility in this location and although it generally aligns with the Draft Good Practice Guide, there are a number of areas where improvements could be made. The following sections present a review of the existing facility and notes a number of measures that could be implemented to improve the safety of the facility. No CAD mapping was made available to allow improvements to be drawn up, but standard approaches to improvement elements have been included.

6.2.1 Linear Alignment

6.2.1.1 Existing Layout

The existing cycle facility can be summarised by the following features:

- A two-way separated cycle lane with a width of approximately 2.5-3 metres.
- A verge width generally varying from 0.5 metres to 4m separates the cycle lane from the road carriage way (Figure 26**)**.
    - Where no verge is provided due to adjacent constraints, a kerb has been provided for added protection for VRUs (Figure 27).
    - There are two locations where the cycle facility diverges away from the road and behind vegetation to avoid physical constraints such as residential properties or trees, removing the need for land acquisition. While there are practical reasons for doing this, this may introduce personal security/safety issues, albeit over short sections only (Figure 28).
    - In some locations the cycle track and the road are immediately adjacent one another, with no physical separation or markings to define the cycle lane for both cyclists or motorists, see Figure 29**.**

Figure 29: No clear definition of cycle facility (right hand side of image)

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- No road markings are provided on any part of the shared facility to denote that it is solely for use by VRUs. This could lead motorists to believe it is a narrow service road.
- Along the main road carriageway there are speed limit signs placed at regular intervals.
- The whole length of the cycle track has overhead lighting columns, allowing it to be lit up when it's dark.
- There would appear to be enough room in the verge that snow cleared from the road during winter road maintenance would not gather in the shared facility. It is interesting to note that winter maintenance includes clearance of snow from the cycle facility as evidenced in Figure 30.

Figure 30: Route 293 during winter with shared facility clear of snow

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
Two-way cycle facility (min. 2.5m) on one side of the road.	Yes	Yes
Separation between cycle facility and carriageway (min. 0.5m, ideally in different material.	Yes	Yes
Differentiation between cycle/driving lane in colour if within carriageway.	No	No
The width of the cycle lane should be appropriate, given a speed limit of 50 km/h it should be a min. of 2.0m.	No	No

In situations where the road has speeds greater than 50-60km/h the cyclist should be separated from cars.	Yes	Yes
Provide adequate carriageway widths that accommodate two-way traffic movements without the need for motorists to drive in cycle lanes.	No	No
Provide signs warning of potential for cyclists to be on the road.	No	No
Separate the cycle lane from the carriageway by a verge and in some locations by vegetation.	Yes	Yes (but not always in some cases)
Consider winter road maintenance needs and give priority to VRU path over carriageway to reduce bring cyclist and pedestrian onto the winter carriageways.	Yes	Yes
A contra flow cycle lane maybe a viable way of providing for vulnerable road users in a rural area with restricted width and low AADT.	No	No
Contra-flow facilities should where possible, be provided with physical separation or MV meeting points (if in two-way traffic).	No	No

6.2.1.2 Potential Improvements

The linear alignment of this implemented scheme is generally very good and adopts many of the principles promoted in the Good Practice Guide. Some suggested improvements include:

- Intermittent road markings and signage to identify the use as a shared pedestrian/cycle facility particularly at crossings where vehicles may identify the facility as a narrow parallel road; and
- Provision of kerb or delineator bollards at locations where the shared facility is immediately adjacent the carriageway (e.g. Figure 29).

6.2.2 Junctions

There are two types of junctions encountered along this section of Route 293 - major junctions with 2-way roads meeting Route 293 and direct accesses to residential accesses properties.

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6.2.2.1 Existing Layout

6.2.2.1.1 Major Junctions

The existing interaction of the shared facility with major junctions along the route can be summarised by the following features:

- All of the major junctions have a two-lane road meeting Route 293 and cyclist never have to cross a road greater than the width of two traffic lanes;
- It is not clear at any junction which user has priority, VRUs or motorists. No roadmarkings or signage is provided indicating priority (Figure 31,Figure 32 and Figure 33).
- There are no warning signs alerting motorists on Route 293 that if they turn off the road, there may be cyclists crossing.
- Generally, there is good inter-visibility between drivers and cyclists. However, in some instances it is not evident that there is a cycle facility when approaching from the side road (Figure 31);

Figure 31: Poor visibility of cycle facility from side road

- Most junctions are well lit with overhead street lighting (Figure 32**)**;

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Figure 32: Typical junction with road lighting

- Only one major junction has positioned the crossing 10-15m back from the mainline road (Figure 33). The proximity of the crossing to the roadway at other junctions (such as in Figure 32) introduces significant safety concerns;

Figure 33: Junction with crossing setback from Route 293

- Most of the major junctions have blue signs for pedestrian and cyclist defining the use of the surface, but not all;
- No coloured surfacing or line-markings have been used to highlight the crossing across side roads at the junctions. Given the lack of signage on approach warning of potential for VRUs to be crossing, this raises safety concerns;
- At all major junctions the side roads have stop signs and a stop line, to warn of conflicting traffic on Route 293.

6.2.2.1.2 Access to dwellings

- All access junctions are dwelling entrances with a single lane joining the main Route 293 (Figure 34);
- All access junctions have good visibility for both drivers and cyclists;
- No colours have been used to indicate the cycle lanes at dwelling access points.

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Figure 34: Typical dwelling access layout

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
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 (0.5 m) here as well between road and bicycle path.	No	No
The 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.	Yes	No
Arrows can be used to indicate that the cyclists can approach from either direction.	Yes	No
There is good visibility at the crossing, no objects or greenery is in the way of the	Yes	No (not in all cases – requires maintenance)

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bicycle path. That allows for the car driver to see the cyclists from a distance.		
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.	Yes	Yes
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.	No	No
Make sure that the priority for crossing in the junction is clear and sensible/logical. In nonurban areas (with speed > 50 km/h) would mean that cyclists always yield to MV traffic.	Yes	No
Use signage reinforcing message to yield.	Yes	Yes
Ensure adequate inter-visibility between motorists and cyclists at junction crossing points e.g. clear and maintain vegetation.	Yes	No (not in all cases)
Provide clear signage for both motorists and cyclists such that the layout is self-explaining.	Yes	Yes
Avoid complex intersection for MV drivers with multiple crossing points, signalling and yielding rules.	No	No
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.	Yes	No (not in all cases)

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.	Yes	Yes

6.2.2.2 Potential Improvements

6.2.2.2.1 Major Junctions

A number of improvements could be made to improve safety at junctions along the route as identified below:

- The implemented scheme fails to adequately cater for VRUs passing through junctions. The lack of signage and road markings to clearly identify to all road users who has priority, leads to an unsafe environment. The Good Practice Guide suggests that in rural situations, pedestrians and cyclists should always yield to traffic. Appropriate signs and line markings should be provided to ensure that the layout is legible for all road users. This should include (as illustrated in

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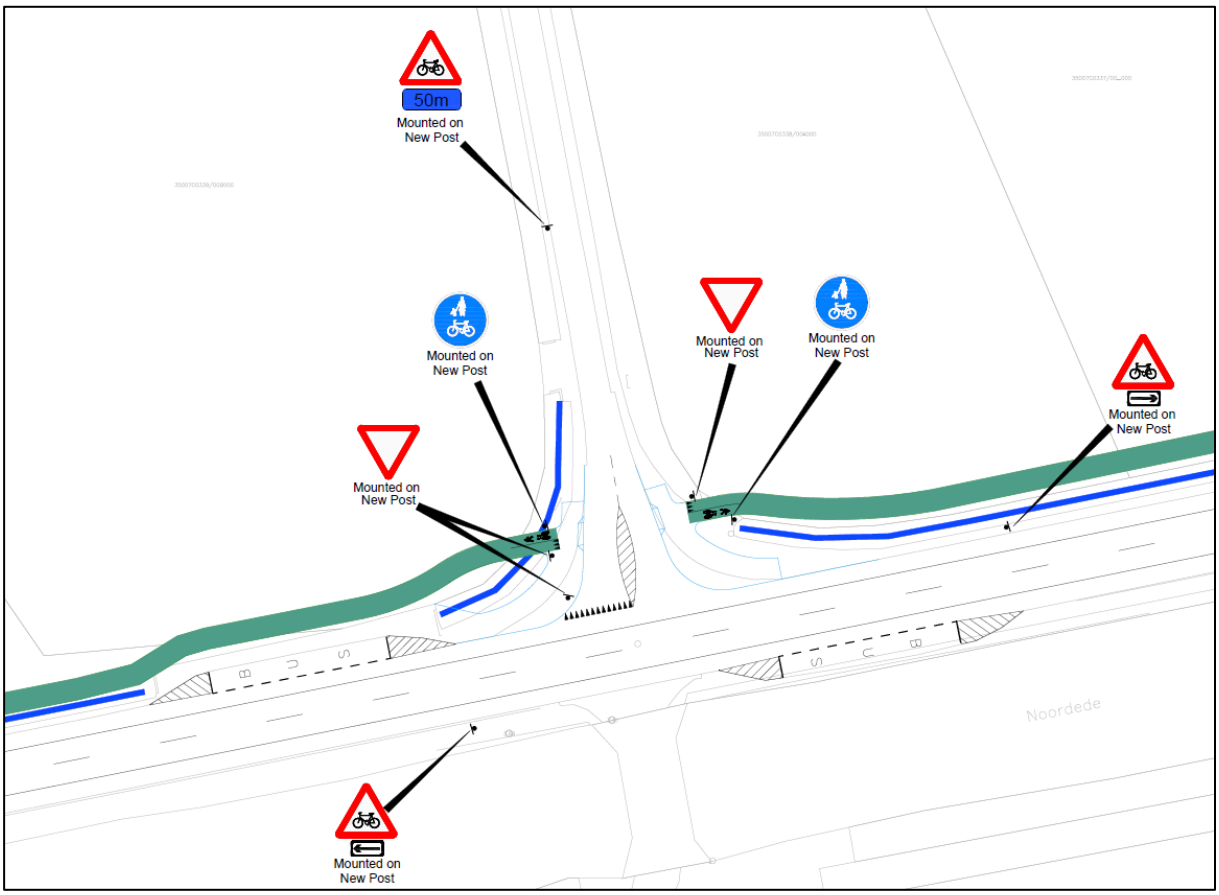

Figure 19 for Worked Example 2):

- Warning sign on the road carriageway (both side roads and Route 293) leading up to junctions should be installed to warn drivers of the possibility of cyclists crossing at the junction.
- Yield signs and road markings should be put in place to warn cyclists that they need to give way to traffic.
- Consideration given to road markings ('elephant footprints' etc) to identify presence of crossing.

- Cycle lane crossings at major junctions should be set back by 10-15m from the mainline roadway to allow space and time for motorists coming from the mainline to stop if a cyclist has already started to cross the road. Generally, there would appear to be room to facilitate this arrangement at most junctions without any great difficulty.

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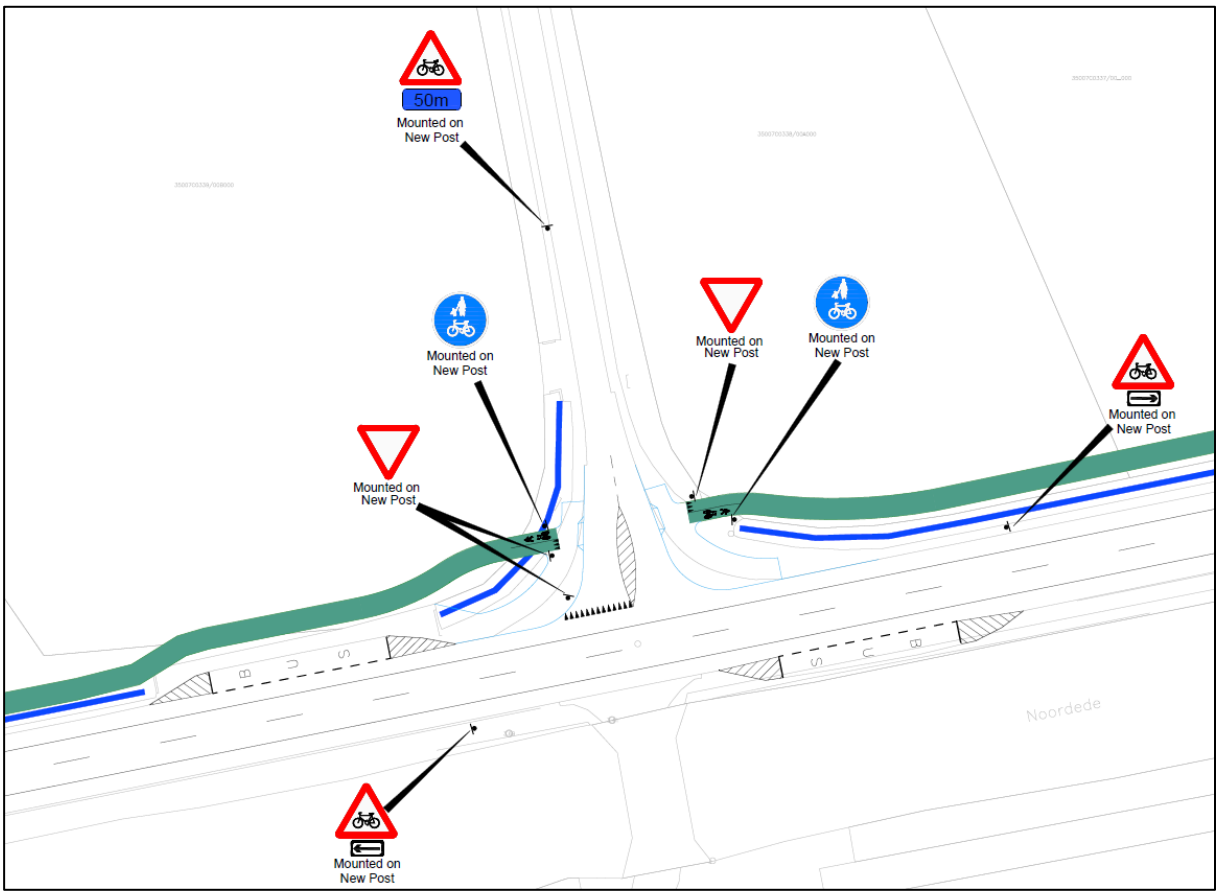

Figure 19 illustrates a potential layout for such an arrangement.

6.2.2.2.2 Access Junctions

- It's not considered necessary to step access junctions back as the traffic entering/exiting the access will likely be minimal and the motorists using the access will be regular users (i.e. residents) familiar with the layout;
- In this instance, priority would be given to VRUs.
- Warning signs can be installed along the cycle lanes to warn cyclists that they could be crossing an access junction and to exercise caution.
- Road markings ('elephant footprints' or similar) could be used to outline the cycle lanes when crossing these accesses.

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6.2.3 Linear Settlements

A number of small linear settlements with a small number of residential properties are located along Route 293. Figure 35 presents one such example.

6.2.3.1 Existing Layout

- Route 293 has a maximum speed limit of 80km/h and the cycle lane is separated from the road carriageway. Typically, at linear settlements along the route, the speed limit drops to 60km/h.
- The condition of the cycle lanes in small linear settlement areas are good with a high-quality surface, free of gravel and debris.
- Typically, the cycle lane in in linear settlements is separated by a kerb. A typical layout is presented in Figure 35

Figure 35: Typical Linear Settlement

- Where space isn't available between the adjacent properties and the carriageway, the cycle facility is diverted behind the residential properties.
- There are a number of bus stops located in small linear settlements, an example of which is shown in Figure 36, which has a small buffer zone between it and the cycle lane. There is no signage or road marking to define the use of the space.

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Figure 36: Typical Bus Stop Layout

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
A maximum speed limit of exceeding 60km/h warrants a separate cycle path.	Yes	Yes
Smooth curves should be adopted on cycle lanes.	Yes	Yes
Provide buffer zones between bus stops and cycle lanes if they converge.	Yes	Yes
Cyclists should have a dedicated part of the shoulder that has been clearly marked when cycle traffic is within the carriageway.	Yes	Yes
Provide sufficient width on the shoulder relevant to the AADT and MV speeds.	Yes	Yes
The quality of the paving must be high and e.g. gravel and debris on the surface needs to be removed regularly to avoid poor cycling conditions.	Yes	Yes
Carriageways that are too wide, long and straight tend to lead to high MV speeds; traffic calming measures maybe be required to accommodate a safe environment for pedestrians and cyclists.	No	No

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Shared rural carriageways that have been narrowed, e.g. 2-1 roads, should avoid blind bends which could prove potentially hazardous for car drivers driving in the centre lane if they encountered an on-coming car who is also driving in centre lane (as prescribed). In the same blind bend, as many drivers do, they driver could elect to use the hard shoulder. Unfortunately, the cyclist/pedestrian could also be there. Therefore the 2-1 design on rural road should be abandoned.		
Unique road designs often require that the motor vehicle drivers behave in a certain manner. Information and instructions must be clear especially for the first-time user, particularly if there are no formal traffic rules for this unique/prototyped type of road segment. Priority/right-of-way issues must be clearly stated and logical.	No	No

6.2.3.2 Potential Improvements

- Road signs on approach to settlements warning of potential hazards ahead should be located before a settlement area, these warning should that there is a potential for cyclist to be crossing the main road.
- Given the potential for more pedestrians in these areas, further road markings on the shared facility should be considered to reinforce the fact that it is being shared by both pedestrians and cyclists.
- Further signage/ road markings/ vertical elements should be given to the bus stops to better define the use of the space and in particular distinguish between the shared facility and the bus stop itself.

6.2.4 Crossings

6.2.4.1 Existing Layout

- There are a few crossings located on Route 293, two examples of which can be seen in Figure 37 and Figure 38.
- The first example, Figure 37, shows a traffic island being used to shorten the distance of crossing. Signage is provided to highlight to motorists the presence of the central island, but no signage identifies the presence of the crossing. This is the only crossing on Route 293 like this.
- There are a number of crossings along Route 293 like the one shown in Figure 38 with no markings or island to define the crossing.
- No specific lighting is provided at either crossing type.

Figure 37: Crossing Example 1

Figure 38: Crossing Example 2

The table below summarizes the recommendations from WP2, if the recommendations are applicable to this specific example and if the recommendation was applied.

Recommendation WP2	**Applicable?**	**Applied?**
Staggered pedestrian crossing, especially when unregulated, i.e., without traffic lights, supports pedestrian safety by	Yes	No (not in all cases)

nudging the pedestrian into looking in the direction of oncoming traffic. Staggered crossings for cyclist require more space for stopping, turning and stacking.		
Vertical deflections to increase visibility.	Yes	No (not in all cases)
Lighting placed on the pole over the crossing.	Yes	No
Using a traffic island shortens crossing length.	Yes	No (not in all cases)
Cyclists and pedestrians yield to MV traffic with clear signage and marking denoting this.	Yes	No (not clearly marked)
Clear signage on approach to the crossing warning motorists of presence of crossing.	Yes	No
Adequate radius (4m min) provided on bend to allow comfortable movement of cyclists.	Yes	Yes
The division between cyclists and pedestrians on the path should be clear and the cycle path has a generous width.	No	No
Pavement colour at the crossing is not recommended because it can easily be misconstrued as indicating a cyclist priority or have an ambiguous meaning; used inconsistently and lack universal deployment; and is often prone to lower carriageway friction when wet.	Yes	Yes
Use clear right of way rules at the junction. For safety reasons, it is advisable to require VRU to yield.	Yes	Unclear
Setting back the crossing point from the junction (or roundabout) reduces the complexity of the junction and reduces complexity and workload for MV drivers thus facilitating an increase in cyclist and pedestrian detection and the likelihood of MV giving way (if required).	No	No
Flashing speed limit sign grabs motorists' attention.	No	No
Multiple warnings (zig-zag edge line, horizontal stripes) help increase awareness of a crossing.	Yes	No

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Visual and physical narrowing can help reduced MV speed (at the crossing).	No	No
Signalized traffic control maybe advisable if MV or VRU traffic flow is significant.	No	No
Grade separated crossing should be considered with high volumes.	No	No

6.2.4.2 Potential Improvements

- Traffic islands (with a width of at least the length of a bike) should be considered at all crossings but in particular those which are more than 7m wide (i.e. two traffic lanes).
- Consideration should be given to providing a raised crossing to enhance the visibility of the crossing, to reduce traffic speeds and generally provide a safer environment for pedestrians. Raised treatment should only be considered where the speed limit is reduced to below 60km/h.
- 'Elephant footprint' road markings or other markings could be used to mark the edge of the crossing, particularly if not raised.
- Advance warning signage should be provided for motorists to identify that they are approaching a crossing point. As noted in section 5.2.3, this signage could include a flashing beacon which is activated if a cyclist is detected in the shared facility;
- Consideration should be given to providing targeted lighting at cross points to highlight the crossing point during hours of darkness. Similar to the above, this lighting could be activated if a cyclist is detected in the facility.
- On cycle lanes, a 4-meter radius bend should be used to bring cyclists perpendicular to road they are crossing.
- At the crossing there should be yield sign and road marking on the cycle lane to inform cyclist that need to yield.
- Figure 20 presents a potential layout for a crossing across Route 293.

6.3 Observations / Difficulties encountered applying Good Practice Guide

Generally speaking, the cycle route as constructed, aligns with many of the principles of the Good Practice Guide. What was really lacking from this example was any definition of use and definition of priority at junctions which could lead to confusion and thus increase potential for collisions. Applying the Good Practice Guide principles to this built scheme would be generally straightforward and would only require new signage or linemarkings.

7 Summary of Findings

The Worked Examples have all shown that applying the Good Practice Guide leads to certain challenges. The most apparent challenge that the Worked Examples have illustrated is that the local context in terms of physical constraints is a determining factor for how well the Good Practice Guide can be applied. E.g. in linear settlements there might be a house in the way of the cycle facility, which will lead to a decision: compromise, find an alternative (possibly longer) route, or take land. These decisions are often subject to the local political context and availability of funds.

Another important finding from the Worked Examples is that there are geographic differences per country. Legislation and the rules of the road are different from country to country.

Applying generic road markings for instance, might legally mean different things in different countries. Geographic differences are also apparent in the use of the bicycle and the awareness of it with motorists. For countries where these levels are higher different decisions could be made in terms of priority.

A last finding that should be pointed out is the provision of cycle/pedestrian infrastructure around roundabouts. This is a challenging aspect, especially because of high speeds of motorists. On the minor arms at crossings raised tables could be considered, as these provide a safer crossing for cyclists and pedestrians.

8 Next steps

The next step of the SANA-4U project will start with WP4 the Preparation of Guidelines for Selection of Design of VRU Infrastructure. This will draw on the information gathered and developed in all prior work packages to develop a set of draft guidelines for the design of VRU facilities.

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