Contents
This chapter of the Sustrans Design Manual should be read in conjunction with Chapter 1 “Principles and processes for cycle friendly design.” That chapter includes key guidance on core design principles, whether to integrate with or segregate from motor traffic, the space required by cyclists and other road users as well as geometrical considerations. Readers are also directed towards the “Handbook for cycle-friendly design” which contains a concise illustrated compendium of the technical guidance contained in the Design Manual. This chapter has initially been issued as a draft and it is intended that it be reviewed during 2015; feedback on the content is invited and should be made by 31 May 2015 to designandconstruction@sustrans.org.uk

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About Sustrans
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1. Key principles

- junctions and crossings for pedestrians and cyclists should provide convenient and comfortable connections with minimal delays

- junctions and crossings are an opportunity to provide accessibility and journey time advantages to cyclists and pedestrians compared to other road users. This can be achieved by giving priority to dominant cycle movements at priority junctions and minimising delays to cycle and pedestrian turning movements in traffic signal phasing. Cyclists should receive at least the level of priority afforded to motor vehicles

- cyclists should be exempt from banned manoeuvres unless there are overriding safety hazards

- design of any cycle facilities/markings should be legible for users, minimise complexity, and reflect how Bikeability training teaches cyclists to negotiate junctions/crossings

- ensure adequate intervisibility between cyclists/pedestrians and other traffic

- junctions should be designed for reduced traffic speeds, with tight geometry and entry treatments/raised tables as appropriate

- advanced stop lines or alternative suitable provision offering a higher level of service for cyclists should normally be provided at all signalised junctions, with feeder lanes where possible. Additional measures to assist cyclists, such as pre-signals and signal bypasses should be considered

- where a traffic free route intersects a road, the crossing should preferably be designed on a raised table with priority for the traffic free route

- flush dropped kerbs and appropriate aids for visually impaired pedestrians should be provided at all interfaces between cycle tracks and the carriageway
2. Introduction

2.1 Within most urban areas, the majority of cycling occurs on the highway. Delays at junctions and crossings are a major factor affecting cyclist journey times. Providing unrestricted, convenient movements for cyclists and pedestrians at junctions is key to creating permeable cycle and pedestrian networks that encourage mode shift to walking and cycling.

2.2 Road junctions and crossing points are, by definition, locations where conflicting movements between motor traffic, cyclists, pedestrians and mobility impaired users are concentrated. They are also locations where the complexity of the task of driving and riding is greatest. Approximately 70% of all cyclist casualties in the UK occur at junctions.

2.3 Large and complex junctions can present significant barriers and safety hazards for cycle users. On the strategic road network in urban and many rural areas, the primary design consideration at junctions is to maximise capacity and minimise delays for peak hour vehicle flows\(^1\). This frequently results in multi-lane approaches and large areas within the junction with opposing or weaving traffic movements. Rural junctions tend to be simpler and carry much lower vehicle flows, but traffic speeds and visibility can be problematic.

2.4 This chapter describes the variety of techniques that can be used to reduce delays and overcome safety issues for cyclists at junctions and crossings in urban and rural settings. It also considers locations where traffic free routes join the carriageway. The techniques that are appropriate will depend on the type of junction control (signalised or priority control); the vehicle, cycle and pedestrian turning movements and volumes; and the experience of the target user(s). Some of these techniques will require a revision of long-standing design practice in some authorities, but all have been trialled successfully in the UK. Crossings using bridges and underpasses are discussed in detail in Chapter 8.

3. General principles and guidance

3.1 The design or adaptation of junctions to facilitate and encourage cycling and walking should provide convenient, comfortable passage through the junction, catering for all possible manoeuvres and wherever possible matching desire lines.

3.2 Junctions, particularly large and complex intersections, are locations of inherent risk for cyclists due to the conflicting movements between cyclists, other vehicles and pedestrians. 70% of all casualties involving cyclist collisions with other vehicles in the UK occur at road junctions and cyclists are over-represented as a proportion of total casualties at intersections. Designs should mitigate these risks without introducing excessive detour or delay for cycle users.

\(^1\) Under the Traffic Management Act 2004 there is an onus on local authorities to ensure that traffic remains free flowing
3.3
Junctions are the locations in a highway network where capacity is most constrained and where delays are greatest for all traffic, particularly at peak periods. This is commonly the most significant constraint on enhancing provision for cyclists and pedestrians at junctions on the primary road network and at other congested locations. In some instances, high quality alternative routes can be found, but in most situations, provision for pedestrians and cyclists through major junctions is the only feasible option and traffic capacity may have to be compromised to deliver coherent cycling and walking networks.

3.4
Each junction on a cycle route should be assessed, both to establish those conflicts and movements that are difficult or uncomfortable for cyclists to make, and to assess the extent to which each proposed option addresses these issues. Transport for London (TfL) has developed a Junction Assessment Tool which can help with this process.

3.5
The five core principles for cycle infrastructure design, originally developed for the Dutch guidance, are applicable to individual junctions. Priority and quality of infrastructure should be equal to or exceed that provided for motor traffic. The five principles are:

- coherence
- directness
- safety
- comfort
- attractiveness

Key design considerations for each principle are outlined below.

3.6
**Coherence**

- junctions should provide for cycle and pedestrian movements between every pair of approach arms, including pedestrian and cycle-only routes. Routes should match desire lines where possible
- provision through junctions should be easy to understand and consistent with the ability and needs of the target users and provision on the approach roads. It should be easy to make on/off highway transitions
- clear destination signing should be provided on approaches to junctions to enable users to position themselves correctly. Road markings for cyclists need to be clear, simple and well maintained
- junction provision should allow for target growth in cycling and walking in urban areas and identify where future land-use developments fit into the designs
3.7 Directness

- routes should involve minimal detour and minimise delays
- priority and accessibility for cyclists and pedestrians should match or exceed provision for other traffic. Key techniques include:
  - designating priority to the dominant cycle movements at priority junctions
  - priority for traffic free routes at road crossings and at side roads
  - protected merges to minimise give way delays where cycle tracks re-join the carriageway
  - prioritising key cycle and pedestrian turning movements in traffic signal phasing to minimise delays. This can include use of late start/early cut off to vehicle movements opposing key cycle flows; double-cycling green phases for cycle movements and optimising precedence at multi-stage crossings for dominant cycle/pedestrian movements
  - single stage crossings of wide carriageways and single stage diagonal crossings at large junctions where there is an all-vehicle red
  - cycle detector loops on traffic free approaches and configure signals to respond instantly to cycle/pedestrian demand

3.8 Safety

- provision should manage or eliminate conflicting manoeuvres, minimise complexity, and moderate traffic speeds. Low vehicle speeds can be maintained through use of deflection, narrow widths and tight corner radii. Designs which incorporate ‘shared space’ design principles and remove formal priority can help moderate speeds
- designs should provide adequate widths and good intervisibility between pedestrians, cyclists and motor vehicles. Key features include:
  - advanced stop lines at all signal controlled junctions
  - protected space for cyclists to wait where there are significant right turning cycle movements
  - provision of offside cycle lanes where there is a significant left turning vehicle movement which conflicts with ahead cycle movements
  - designs should avoid low angle merge and diverges and minimise weaving movements
  - signage to raise driver and cyclist awareness may be appropriate in higher speed settings where cyclist numbers are low
3.9 Comfort

- designs should minimise the requirement to stop and avoid sharp changes in direction
- provision should be well-maintained with smooth surfaces and flush kerbs
- diverting cyclists to share limited space with pedestrians off the carriageway is rarely successful and can lead to animosity
- minimise guard railing and position other street furniture to maximise the effective width for users

3.10 Attractiveness

- routes should be well-maintained, with good lighting
- designs should avoid features that compromise personal security or restrict forward visibility, particularly where grade-separation is used
- junctions provide designers opportunities to create successful public realm that encourages place function/street activity as well as providing for movement function

3.11 Dutch guidance recommends the following for developing good quality solutions:

- reducing the number of potential conflict points to a minimum, even if this is at the expense of capacity for other vehicles
- cycle safety benefits from focussing movements rather than trying to separate them into complex/incomprehensible movements

Other considerations

3.12 Significant kerb line changes will have an impact upon existing drainage and utilities which can be very costly. Early engagement with statutory undertakers is necessary
4. Priority Junctions

Overview

4.1 At major/minor arm priority junctions, opposing turning flows give way according to defined priority rules, which are indicated through traffic signs and markings. Priority is normally given to the dominant traffic flow.

4.2 Some junctions are designed without defined priority, requiring road users to slow down and engage/negotiate with other road users. The application of these ‘shared space’ principles is becoming increasingly common in urban areas and has been demonstrated to be effective in terms of traffic capacity, delays and safety on four-arm intersections with peak period flows in excess of 2500 vehicles/hour. Examples include junctions in the centre of Coventry and in Bentley Heath in outer London.

4.3 Informal junctions can also use circular paving patterns to indicate roundabout-type priority without the use of road markings or signs.

4.4 In terms of cycling, this type of junction can work well as long as care is taken to ensure that the paths of motor vehicles through the junction are confined to one lane and speeds do not exceed 20mph, so that cyclists can adopt the primary position.

4.5 Manual for Streets 2 identifies seven styles of priority junction from the simplest “T” and “Y” shapes to multi armed squares, circuses and crescents that exhibit the greatest variety of traffic movements. Manual for Streets and Manual for Streets 2 guidance should be used in urban situations in preference to Design Manual for Roads and Bridges (DMRB).

4.6 The treatment at side roads of cycle lanes, hybrid cycle tracks and two-way cycle tracks are discussed in Chapter 4.

Benefits

4.7 Priority junctions offer a number of benefits for cycle users compared to signal controlled junctions. These are:

- lower construction costs
- less delay in off-peak traffic conditions, particularly where the dominant cycle flow has priority
- less visually intrusive infrastructure

4.8 Priority junctions are unlikely to cater adequately for cyclists, pedestrians or other road users where there are heavy and/or fast opposing traffic flows.

Design considerations

4.9 All priority junctions rely on users’ observations and judgement. Because cyclists and pedestrians tend to be less conspicuous than larger vehicles, they can be vulnerable to ‘failure to give way’ type collisions. Four over-riding principles underpin the design of priority
junctons that are safe and convenient for cycle users:

- low speeds - on approaches and through the junction
- good intervisibility
- single lane approaches
- designs that facilitate correct positioning and offer protection for right turns from the major arm

4.10
For pedestrians, the main design requirements are low speeds, siting uncontrolled or zebra crossings on the desire line (not set back from the junction), single lane entries with refuges if required, flush kerbs with blister tactile surfacing.

4.11
The following design details are recommended:

- change of priority to assist the major cycle flow and reduce traffic speeds. This is typically used on low-traffic streets where there is not a dominant traffic flow, and may need kerb deflection to support compliance. Changes in priority can signal a change in movement and place function and can support environmental enhancements
- kerb radii of 4.5m or less in residential areas or 7.5m/9.0m radii (depending on lane width) in areas that have significant flows of medium sized delivery vehicles (e.g. business/industrial parks). Vehicle tracking should be used to design appropriate radii where regular use by HGVs is intended (e.g. industrial/logistics parks). This is illustrated in figure 4.1
- narrow traffic lanes on junction approaches to reduce traffic speeds and reduce crossing distance for pedestrians. This can release space to accommodate cycle lanes or tracks, where needed
- provision of right turn lanes/ghost islands where cyclists are likely to have to wait for a gap in oncoming traffic to turn right
- provision of nearside cycle lanes across the minor arms at junctions. This can help to emphasise route continuity for cycle users and can increase awareness of cyclists to motorists turning across the cycle lane. However, care is needed in applying nearside cycle lanes as these can have a safety disbenefit in the following situations:
  - where there are significant left turning vehicle flows across the cycle lane - in this situation cycle users should be encouraged to cycle in the middle of the nearside lane to prevent ‘left hook’ collisions
  - where there are significant right-turning cycle movements but no right turn facility. A nearside lane within the junction can be problematic for right-turning cyclists who will need to wait outside the lane
  - where a cycle track alongside the carriageway crosses side roads, the cycle track should retain priority and follow the desire line wherever possible

Figure 4.1 Effect of corner radius on cyclists near turning vehicles

Small radius (eg. 1m)

Cycle and car speeds compatible

Large radius (eg. 7m)

Danger from fast turning vehicles cutting across cyclists

Source: Manual for Streets
Raised table junctions

4.12 Raised table junctions typically operate as a priority junction and create safer environments for all users by reducing the speed of vehicles negotiating the junction. Implementation of raised table junctions falls within the Highways Act, Section 90, which incorporated the Road Humps Regulations 1996.

4.13 Raised table junctions are generally accepted on roads with a speed limit of 30mph or less, with adequate street lighting provision, in two situations:

- urban/suburban residential areas; and
- in town centres as part of public realm improvements, where raised tables at key junctions provide informal crossing points for pedestrians

4.14 Raised table junctions included as part of wider traffic calming measures can discourage rat running, which should benefit cyclists and pedestrians. The impact of displaced traffic on alternative routes should be assessed, to ensure there are not negative impacts on walking and cycling movements on nearby parts of the network. Bus and emergency services will need to be consulted during the design process.

Benefits

4.15 Raised tables can emphasise the presence of a junction, encourage driver attention and lead to drivers giving informal priority to pedestrians. By reducing speeds, raised table junctions will commonly not require separate cycle facilities.

4.16 The speed reduction effect of raised tables can be used to mitigate reduced visibility at some low volume/low speed junctions.

4.17 Key Design Features

- the raised table should extend from kerb to kerb to benefit pedestrians crossing. This will require attention to drainage requirements to avoid standing water at the ramps
- approach ramps should be located sufficiently far from the junction mouth so that the changing level of the carriageway does not become problematic for cyclists when turning. Approach ramps with a sinusoidal profile will reduce discomfort for cyclists compared to a 1 in 15 ramp
- it may be necessary to install build outs, bollards or introduce parking restrictions as appropriate in order to prevent parking around the junction
- drainage covers / gully gratings set flush with the footway may become a hazard for pedestrians and cyclists. Grating covers should be changed to grids, and located away from main crossing points
Coloured surfacing can be used to highlight the raised plateau to motorists, but comes with added maintenance costs, Scunthorpe

A raised table junction included as part of town centre permeability works, with tighter junction radii, informal pedestrian crossings and central median strip. Narrowing of the minor arm entry has enabled on street cycle parking to be located on the carriageway, retaining the full footway width for pedestrians, Warwick

Traditional raised table approach. Diagram 1057 logo’s on the minor arm ensures that motorists entering the junction are aware of cyclists, South Bermondsey

Urban realm improvements around key buildings have delivered better junctions for pedestrian and cycle movements. The absence of formal priority markings requires motorists to moderate their speed to negotiate the junction, Stratford upon Avon
Changing junction geometry with kerb build-outs can assist pedestrians to cross, improving sight lines beyond parked cars and slowing vehicles on entry. Care is required when positioning cycle logos along the route, to avoid positioning them too close to the kerbline which may encourage cyclists to ride too close to parked vehicles, Bethnal Green (top) & Penarth (bottom).

**Modifying existing junction geometry**

4.18  
DMRB guidance TD 42/95: the Design of Major/Minor Priority Junctions is intended to accommodate traffic flows on primary routes. TD42/95, recommends a minimum radius of 6m for roads in urban areas, which will enable vehicles to maintain speed when turning left into side roads, thereby minimising the risk of rear end shunts on the major road.

4.19  
However, junction geometry designed to TD 42/95 standards can disadvantage cyclists and pedestrians and is not appropriate in many urban settings. 6m radii can result in inappropriate vehicle speeds and wide pedestrian crossing distances or crossings set back from the give way, off the desire line.

4.20  
For roads with speed limits of 30mph or less, Manual for Streets and Manual for Streets 2 recommend tightening the kerb radii on existing and new junctions to provide safer and more convenient spaces for pedestrians and cyclists (see Figure 4.1).

**Benefits**

4.21  
The benefits of reduced entry radii and reduced entry widths are:

- safety benefits resulting from lower vehicle speeds
- reduced pedestrian crossing distances, often retained on the desire line
- improved public realm
- leading to the informal acceptance of pedestrian priority over motorists
- to facilitate the transition from on-carriageway cycling to shared use paths

4.22  
**Key Design Features**

- kerbline radii of 4.5m or less in residential areas will slow vehicles, whilst remaining accessible to refuse/emergency services vehicles
- wider carriageways (5.0/5.5m) with tighter radii will allow large vehicles to manoeuvre by crossing both lanes of the minor arms at the junction. This is preferable to increasing the radii and retaining a narrower carriageway width, which would still enable vehicles to enter/exit at speed
- low cost changes to kerb radii can include painted treatments or use of contrasting materials. These visually change a junction layout and provide overrun areas for large vehicles, but are less effective than realigning the kerbs and do not reduce pedestrian crossing distances. Designers should consider the potential negative impacts of surfacing changes on cyclists
- changes to kerb radii should not be limited to residential roads or designated routes on a cycle network. Changes in any junction alignment should consider how the scheme can assist non-motorised users to pass through the revised layout
Build out used to accommodate a two way cycle track. The design should enable cyclists to join the cycle track from the carriageway and provide priority at the side road crossing wherever possible, Glasgow.

Changing geometry by creating over-run areas, either with white lining or contrasting materials, to visually change a junction. Designs should aim to reduce pedestrian crossing distances and avoid placing crossings off desire lines. In the top image the minor road crossing distance remains the same (although off the desire line) and build-outs reinforce the visual narrowing and reduce the crossing distance on the major arm (although dropped kerbs are not provided). In the bottom image the crossing is located some distance off the pedestrian desire line, Scunthorpe (top) & Dartford (above).

Public realm improvements to create a better entrance facility into Longford Park resulted in some considerable geometric changes in the junction layout, reducing the minor arm carriageway from three to two traffic lanes, Longford Park, Sale, Manchester.

This access road serves as a one way through route for service vehicles and residents. Constrained by property boundaries, a painted kerb-line, logo and coloured surfacing highlight the alignment for cyclists to access the shared use footway from the service road, Bedlington.
5. Signalised junctions

General considerations

5.1 This chapter discusses a range of interventions, some common place, others innovative, which have been implemented in the UK. It also highlights progress in developing new designs that draw on experience in other countries.

5.2 Improvements to cycle safety and comfort, and to the directness and coherence of cycle routes may be achieved through remodelling, removing or introducing signal control at junctions, particularly where signal timings can be changed to reallocate time between road users and generate time saving benefits for cyclists. Intervention types to consider are summarised in Table 5.1.

Safety

5.3 Signal-controlled junctions can provide safety benefits for pedestrians and cyclists by separating opposing traffic movements and reducing the need for weaving manoeuvres. Evidence indicates that signalised junctions are safer for cyclists than traditionally designed UK roundabouts with the same capacity.

5.4 Collisions involving cyclists which occur at signalised junctions are often related to drivers and cyclists running red lights, or due to conflict between left turning vehicles and straight ahead cycle movements.

Delays

5.5 Signalised junctions can reduce delays for cyclists and pedestrians during peak traffic periods and can manage and facilitate specific turning/crossing movements which may be difficult under priority control. This can give dominant cycle movements time advantage over other traffic.

5.6 However, signal controlled junctions commonly result in increased delays during off-peak conditions, compared to a priority junction.

5.7 Advanced stop lines or alternative suitable provision offering a higher level of service for cyclists should be provided at all signalised junctions to enable cyclists to bypass queues and to help cyclists position themselves correctly for their turning movement.

5.8 Cyclists do not like stopping because they lose momentum. Uninterrupted left turns for cycle users can be created by including cycle bypasses where space exists. In other situations, priority control may be preferable on cycle routes to minimise the need to stop and start.
### Table 5.1 Summary of options for cycle-friendly interventions at signal-controlled junctions

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signalisation to remove conflict</td>
<td>Complete separation at junctions involves signalling cyclists separately to remove all conflicting movements with others.</td>
</tr>
<tr>
<td>Managing conflict with turning vehicles</td>
<td>This may be done by giving cyclists an advantage in time or space, or by seeking to move the point of crossing conflict away from the junction itself (managing conflict).</td>
</tr>
<tr>
<td>Support for cycle right turn</td>
<td>As part of a segregated cycling system or a wider strategy on a route or a series of junctions to keep cyclists in a predictable position on the nearside, cyclists could be assisted with right turns by staying on the nearside and making the turn in two stages.</td>
</tr>
<tr>
<td>Cycle bypass of signals</td>
<td>In some instances, particularly through signalised T-junctions, cyclists making certain movements may be permitted a bypass of signal control.</td>
</tr>
<tr>
<td>Using ASLs and feeder lanes</td>
<td>Advanced stop lines (ASLs) can help cyclists position themselves in a safer, more advantageous position at a signal-controlled junction for the start of a phase and so, selectively can assist cycle movements through a junction.</td>
</tr>
<tr>
<td>Banning selected motorised vehicle movements</td>
<td>Generally in conjunction with other measures listed here, certain vehicle movements could be banned to improve cycle safety and directness. This should be done as part of a wider traffic management approach rather than on a case-by-case basis.</td>
</tr>
<tr>
<td>Convert to a priority junction</td>
<td>Signal removal can have some beneficial effects where the volume and mix of traffic and nature of conflicting movements does not necessarily justify the existence of a signal-controlled junction.</td>
</tr>
<tr>
<td>Remove all priority and de-clutter</td>
<td>As part of an integrated, area-wide approach, designers may explore the potential benefits of removing signal control and priority altogether in order to promote more consensual road user behaviour generally.</td>
</tr>
</tbody>
</table>

*Source: London Cycling Standards, 2014*
Designing for cyclists

5.9
The design of signalised junctions should consider all movements and how different user groups interact with each other. Many issues can be designed out, if cycle movements are considered early enough in the design process. Use of early start/late cut-off at signals can help cyclists making opposed right turns and providing designated space to wait for right turns is beneficial.

5.10
Most signalised junctions do not require significant changes to the existing timings in order to provide good quality solutions for cyclists. Traffic modelling can help determine whether minor timing changes will have a negative impact on network capacity.

5.11
Where cyclists share space with pedestrians, rationalisation of street furniture and single phase crossings will help reduce conflict. Parallel provision for cycles and pedestrians to cross junctions can further reduce conflict between these user groups. Puffin and Toucan crossing technology can be used to detect slow moving cyclists and pedestrians through a junction to delay the next signal phase until they are clear.

Advanced Stop Lines

5.12
An Advanced Stop Line (ASL) with a cycle feeder lane enables cyclists to pass queueing motor traffic on the approach and take up the appropriate position for their intended manoeuvre before the signals change to green. They are established practice in most highway authorities and some now have a presumption to install ASLs at all signalled junctions.

5.13
ASLs may not resolve all problems for cyclists at traffic signals, however and do not benefit cyclists when lights are green. Large complex traffic dominated junctions and those with high speeds will not be made cycle friendly by the provision of ASLs.

5.14
ASLs have little or no effect on capacity if the number of general traffic lanes remains unaltered.

5.15
Under TSRGD ASLs are not permitted at non-signalised junctions, or Toucan/Puffin crossings, but several authorities have installed them immediately adjacent to a standalone signalised crossing point and this will be permitted under the revised TSRGD in 2015.

5.16
Benefits

- feeder lanes allow cyclists to bypass waiting traffic, and get to the ASL ‘reservoir’ at the head of the queue. They can position themselves where they are visible and in the correct turning lane. This is particularly helpful for cyclists making right turns
- ASLs give a safe area for a cyclist to merge back into the carriageway from a cycle track
5.17 Key Design Features

- the design of ASLs must be site-specific. Consideration should be given to factors such as the turning traffic volumes and dominant cycle movements, signal staging, location and number of approach lanes, and vehicle swept paths.

- feeder lanes should be provided wherever possible. ASLs can operate without these but the benefit of the ASL is much reduced since fewer cyclists will reach the reservoir.

- once the revised TSRGD is available, cyclists will be permitted to cross the first stop line irrespective of whether a gap has been provided.

- the reservoir, or waiting area between the two stop lines, should be between 4m and 5m deep, but the revised TSRGD will permit 7.5m.

- feeder lanes are normally located on the nearside, with a minimum width of 1.2m being required (1.5m preferred). A wide advisory cycle lane, accepting that some vehicles may encroach, may be better than a narrow mandatory lane. The benefit of an ASL can be much reduced if no lead in lane is provided.

- centre and offside feeder lanes can be designed to help cyclists make specific movements (e.g. where there is a left-turning traffic movement which conflicts with a dominant ahead or right cycle movement, the feeder lane may be positioned between the left and ahead traffic lanes). Feeder lanes between traffic lanes need to be wider (a minimum width of 2.0m is recommended), and this is generally achievable by narrowing the traffic lanes. Continuity of cycle lanes feeding ASLs should be maintained, with traffic having to cross the cycle lane to access the left turn lane.

- on approaches to ASLs, it is important that detection loops are positioned so that they cover the approach cycle lanes as well as the general traffic lanes. Often this is not the case, resulting in approaching cyclists not being detected. Similar considerations apply to above ground detection.

- ASLs can be partial width, especially at junctions where vehicle movements are restricted. Coloured surfacing can also extend full or part width.

- where traffic lanes are separately signalled, there can be benefits in splitting the ASL on a two-lane approach to indicate to cyclists where to wait for the movement they will be making (see Bristol photo). However, this arrangement is not currently prescribed in the TSRGD. 

Left turn filter lanes are points of conflict with cyclists. The ASL feeder lane should extend back upstream of the merge, Shrewsbury.

Mandatory feeder lanes give cyclists added protection, but need a Traffic Regulation Order to implement, Southampton.

Split ASL where traffic lanes are separately signalled, Bristol.

DfT guidance changed in 2012 to permit ASLs without feeder lanes, but the first stop line needs to be broken, Nottingham.
Fig 5.1 *Cycle lanes and traffic signals*

- Parking/loading bay. Avoid echelon (nose in) parking
- Dividing strip 0.5m min (1m preferred)
- Cycle lane width retained where right turn lane provided. Reduce traffic lane width as necessary
- Cycle lane width min 1.5m (30mph limit) or 2m (40mph limit)

Central feeder lane to be min 2m width, with coloured surfacing, Shrewsbury

Central feeder lane to be min 2m width, with coloured surfacing, Shrewsbury

Cycle lane continued across junction with 0.5m increased width, London

Preferred length of feeder lane to be as long as normal peak period traffic queues

Hybrid cycle track to join carriageway as mandatory cycle lane on approach to signals

Hybrid cycle track (one way) with kerb segregation from both carriageway and footway, or ‘light segregation’. Preferred min 2m. For details see Streets and Roads 6, Brighton

Cycle lane should normally be mandatory (solid line). Advisory cycle lanes (broken lines) are required where vehicles may need to enter them

Reduced radius on corner, subject to tracking path for large vehicles, and possible side road entry treatment

Advisory cycle lane with 0.5m increased width and coloured surfacing across side road, London

Nearside ASL feeder lane min 1.5m width (absolute min. 1.2m)

Coloured surface in ASL box and up to 30m on approach to signals recommended

Advanced stop line (ASL) to assist cyclists. ASL box normally 5m deep, up to 7.5m with authorisation

Cycle track with separate stage at traffic signals

Radius at cycle track junction 2m minimum (4m preferred)

Hybrid cycle track returns cyclists to carriageway at side road, with tight corner radii and raised crossing, Brighton, or crosses side road as advisory cycle lane, York

Hybrid cycle track returns cyclists to carriageway at side road, with tight corner radii and raised crossing, Brighton, or crosses side road as advisory cycle lane, York

Not to scale
Bus lane widths
- 4.5m recommended
- 4m preferred minimum
- 3m absolute minimum
- 3.2m to 3.9m to be avoided

Advisory cycle lane provides continuity at break in bus lane, Brighton

Bus pre-signal with permanent green for cyclists (requires authorisation), Cambridge

Provision for cyclists in direction not served by bus lane

Presumption in favour of provision of feeder lane. However where width is limited feeder lane may be omitted

Car parking bay inset into widened footway, Stonehouse

Central margin strip and informal crossing point to assist pedestrians, Poynton

Exit taper 1:5 min
Parking/loading
Dividing strip 0.5m (1m preferred)
Entry taper 1:10 min

Road closure “except cycles”, Brighton

Cycle bypass at bus stop, Brighton

Cycle bypass at traffic signals, Brighton

Cycle lane through junction

Not to scale

Fig 5.2 Shared roads, buses and traffic signals

Provision for cyclists in direction not served by bus lane

Paved edge strip to narrow carriageway (see Streets and roads 2)

Bus lane widths
- 4.5m recommended
- 4m preferred minimum
- 3m absolute minimum
- 3.2m to 3.9m to be avoided

Central margin strip and informal crossing point to assist pedestrians, Poynton

Cycle bypass at traffic signals, Brighton

Cycle lane through junction

Not to scale
Exemption for cyclists from banned turns
5.18
There are many examples of cyclists being exempted from banned turns at signals. Where there is a bus-only movement it should normally be feasible and desirable also to include cyclists. However, there will also be situations where a cycle-only exemption is appropriate as a movement banned for all motor traffic may provide a valuable connection for cyclists.

Inter-greens for cyclists
5.19
Cyclists coming through a signal junction at the end of the green phase may be travelling rather slower than motor traffic; this may be affected by the gradient or the route they are taking through the junction. This need not alter the calculated inter-greens but can be addressed by including an all red extension when a cyclist is detected who has not cleared the junction, which prolongs the inter-green accordingly. This will improve the safety of cyclists using the signals.

Cycle signal phases
5.20
A separate signal phase for cyclists at a signalised junction can be the appropriate solution where a cycle track, or cycle-only on-road provision (e.g. contraflow facilities or cycle routes through road closures) enter a signalised junction.

5.21
Cycle-only phases can be useful, for example:
• where cyclists can undertake a manoeuvre not permitted for general traffic, and which cannot be shared with pedestrians, such as crossing between the carriageway and a cycle track on the other side of the junction
• where cyclists are separated from other traffic for safety reasons. Such an arrangement is being trialled at the Bow Roundabout in London

5.22
An on-demand cycle phase within the existing traffic light sequence is the most common option, but on busier cycle routes, fixed staging may be preferable.

Benefits
5.23
Improved accessibility: separate cycle phases can enable cyclists to undertake movements prohibited to other vehicles.

5.24
Safety: separate cycle phases can reduce or remove conflict with opposing traffic movements. This is particularly valuable at busy and complex junctions or where the target users are likely to be inexperienced (near schools, for example).
5.25 Key Design Features

- Waiting areas for cyclists should be suitable for holding the peak cycle demand. This may require reducing/reallocating carriageway space from other traffic.
- Flow capacity of the entry and exits and through the junction should be matched to avoid cyclists queueing at a bottleneck within the junction.
- Cyclists should not have to queue for more than one signal phase. I.e., the green time for cyclists should be sufficient to clear the peak cyclist demand in a single signal cycle. Generally, the green time for cycle phases can be set to the minimum allocated to motorists, unless the route is heavily used.
- The inter-green phase should be lengthened to allow cyclists to clear the junction safely before opposing traffic movements start. Technology used on Puffin/Toucan crossings, can be applied to signalised junctions to detect slower moving, or late starting, cyclists whilst they cross the junction, and extend the timings accordingly. Uphill gradients will reduce cycling speed through junctions. Green and inter-green timings for uphill movements may need to be extended to enable cyclists to clear the junction.
- Where a junction with a cycle stage is approached by a cycle track that only serves the crossing, detector loops or above ground detection on the cycle track approaches to the signals can be installed to call the cycle stage so that the lights change as the cyclist reaches the crossing, thereby reducing any delays and need for deceleration.
- Trials of low level signal heads are underway in the UK, but these are not currently permitted for wider use under current regulations.
- Areas physically segregated from vehicle traffic should remain accessible to mini road sweepers to enable efficient maintenance.

Cyclists permitted to make movements prohibited to motorists can be included into existing signal phasing with the addition/adaptation of signal heads, Norwich.

This traffic free route connects to a crossing with a separate cycle stage. Detector loops located as the track emerges from the park call the cycle stage before the cyclist arrives at the crossing, ensuring that the delay to cyclists is minimal, Leicester.

Low level cycle signal and red cycle aspect for cycle only stage on trial at Bow Roundabout, London.
Early start signal phase for cyclists

5.26
An ‘early start’ signal phase for cyclists enables cyclists to start ahead of other traffic and to clear locations of potential conflict with traffic on the same arm (e.g. overtaking and turning left) or opposing traffic streams.

Benefits

5.27
Early start signals for cyclists can improve safety and comfort for cyclists. It enables them to clear locations of potential conflict before motor traffic starts moving.

5.28
An ‘early start’ phase will tend to have a less negative impact on capacity than separating traffic stages. However, it only assists cyclists who are already at the traffic signals when the early start phase commences.

Key Design Features

- the early start phase typically starts 5 to 6 seconds before the traffic phase on the same arm, but traffic engineers will need to consider factors such as the number of cyclists, distance across the junction, nature of other road traffic, and gradient in determining the appropriate timing
- use of an early start phase without a separate bypass or waiting area for cyclists requires authorisation from DfT
- use of low level cycle signals are being trialled in London and offer more flexible signalling arrangements

5.30
In 1999 the Glasgow City Council opened the Colleges’ Cycle Route, a largely on road scheme which links the universities and further education colleges. A feature of this route is a separate cycle phase at the signals on Churchill Drive, giving cyclists a 6 second start over other traffic so as to protect them from left turning vehicles. It is constructed with a kerb separated lane which has limited capacity to accommodate queuing cyclists.

5.31
Early starts on routes in Brighton, York and, Cambridge incorporate ASLs but do not include kerb separated cycle tracks.

Permanent green cycle signal on bus gate

5.32
Increasingly traffic signals are being used at bus gates to provide queue relocation on the approach to a signalled junction. Several cities, including Cambridge, have incorporated a permanent green cycle aspect on the bus gate signal as there is no need to stop cyclists when other traffic has a green.
Diagonal cycle crossing stage during all red

5.33 Where there is a demand for cyclists to cross a four-arm signalised junction diagonally, providing a direct diagonal crossing may be preferable to directing them across one arm at a time. Diagonal crossings will increase the overall crossing distance that a pedestrian or cyclist is required to make in one movement – therefore increasing the length of the red stage for other traffic – but it allows users to replace a two stage crossing movement with a single stage, reducing their journey times.

5.34 At junctions where pedestrians cross on an all red stage, it may be feasible for a diagonal cycle crossing to be installed without increasing the duration of the vehicle all-red stage. Omagh, Cardiff and Birmingham all have signalled junctions which incorporate diagonal crossings for cyclists.

Cycle bypasses at traffic signals

5.35 Where space and level of pedestrian use allow, it is often possible to provide a slip off in advance of a signalised junction, leading to a short section of cycle track that enables the cyclist to bypass the red signal. This is commonly used in two situations:

- to turn left
- to continue straight ahead at the top of a T junction

5.36 Cycle bypasses can also be used as approach routes to cycle and pedestrian crossings in order to facilitate difficult manoeuvres (e.g. right turns) or to make manoeuvres which are prohibited to other traffic.
5.37
Care is needed to minimise cyclists conflicting with pedestrians (including pedestrians waiting at controlled crossings) and in designing how cyclists rejoin the carriageway - a protected entry is preferred.

Benefits
5.38
The provision of cycle bypasses at signals can:
- reduce delays to cyclists and offer time advantages compared to other traffic
- formalise (and legalise) common cyclist behaviour
- enable cyclists to maintain momentum, improving comfort
- increase permeability where it enables cycle users to make manoeuvres that are prohibited for other modes

5.39
Key Design Features
- bypasses should be built within the carriageway so as not to impede pedestrian flows, but where this is impractical the bypass can be merged into a cycle track at footway level
- the design should make it clear if the facility is to be used in one or two directions
- cycle bypasses may, or may not, have their own set of signals
- cycle bypasses should discharge into a cycle lane or track, or merge into general traffic; they should not end with a give-way line
- detection on the approaches will help improve the sequencing of the signals
- width of the bypass should be 2m, preferably 2.5m
- bypasses need to be designed to accommodate a variety of cycle types, and also be accessible to mini road sweepers. Poorly accessible facilities will collect litter / broken glass and become unusable
Uncontrolled cycle crossing at signalised junction

5.40
At some signalised junctions operational considerations may make it very difficult to justify a separately controlled crossing for cyclists. In such cases it may be appropriate to consider an uncontrolled cycle crossing of an arm of the junction, with the cycle track approaches marked as give way. This also has the advantage that cyclists are not faced with a full red signal at a time when it is quite safe for them to cross.

Guiding cyclists through signalised junctions

5.41
A cycle lane marked through a junction provides a visible indication of route continuity and can increase a driver’s awareness of key cycle movements. They are commonly used in two situations:

• to indicate route continuity and protect space for cyclist desire lines on important cycle routes

• to mark out cyclist turning manoeuvres which are different to or not permitted for general traffic movements

5.42
Route markings through junctions will be subject to high levels of wear and will require maintenance.

5.43
Benefits

• helps to guide cyclists

• raises the awareness of motorists that a junction forms part of a recognised cycle route

• encourage drivers to leave space for cyclists within the junction

• they are particularly beneficial for large and complex junctions
Wide and clearly marked cycle lanes, with elephant footprint markings, identify cycle movements that are prohibited to motorists, Liverpool (top), London (below).

Cycle routes through junctions which differ from and cross traffic streams. The cycle movements in both examples are controlled by separate cycle stages, Stoke (top), Cambridge (above).

In some situations adding more white line markings would confuse users. The use of large cycle logos backed with coloured surfacing indicates to cyclists the line to take, whilst reinforcing the message to motorists, Bethnal Green.

5.44

**Key design features**

- route markings may comprise broken white lines (diag 1004) or elephant footprint markings (WBM 294, which need DfT authorisation), with or without coloured surfacing
- width of cycle lane through junction to be at least 0.5m wider than the approach cycle lane: a minimum of 2m is recommended where movements are generally straight ahead, and traffic passes cyclists on the riders’ right
- minimum width lanes of 2.5m are necessary where traffic can be moving on both sides of the cyclist
- minimum width lanes of 2.5m are required where moving traffic may include large numbers of buses, HGVs, or the speed of the road is 40mph
- where cyclists have several crossing cutting desire lines through a junction, attempting to mark these is likely to be confusing and counter-productive

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2 Elephants Footprint road markings, 400mm x 400mm white squares, may be authorised for use at signalised junctions, although several local authorities have found them useful as a solution on a number of non-signalised junctions. They are to be included for use at signals in the revised TSRGD.
Blind spot mirrors

5.45 Blind spot road side mirrors are large convex mirrors installed at left turns on signalised junctions to enable drivers of large vehicles waiting at the stop line (buses and HGVs) to see down the nearside of their vehicles. These are intended to address the significant number of serious casualties caused by large vehicles turning left across cyclists on their nearside.

5.46 The DfT authorised their use on all 12 of the Cycle Super Highways in London, at key junctions, and blind spot mirrors are now widely used by the London Boroughs on other cycle routes. Manchester is the latest UK city to start to install these at key junctions across the city.

5.47 There is some debate as to whether these mirrors are effective once a vehicle is moving, and whether improvements to junctions needs to include removal or reduction of guard railing as well as mirrors to deliver maximum benefit.

Two stage right turn at traffic signals

5.48 Based on a standard feature at junctions in Denmark and the Netherlands, this design provides for cyclists needing to make a right turn at a signalised crossroads on a multi-lane approach where speed and volume of motor traffic makes a conventional right turn manoeuvre hazardous and unpleasant, even when an ASL is provided. Provision is made for cyclists to pull in to the road on their left and wait there until that road has a green signal, at which point cyclists can make a straight across movement to complete their right turn.

5.49 To date there is a single example of this design in the UK, which was fully implemented in late 2014 in Southampton. In addition to this on road trial, TRL is undertaking research for TfL on this.

Benefits

5.50 Cyclists able to make a safe right turn off a busy road without having to weave across traffic lanes

5.51 Key Design Features

- under existing regulations the waiting area can be marked with a cycle diagram and direction arrow, backed with coloured surfacing if needed. Designs in other European countries also include white stop lines, but these are not currently permitted in the UK
- the waiting area must be clear of any pedestrian crossing provision on the side road and sufficiently far back from ahead traffic on the main road for cyclists waiting there to feel safe. It should be clear of any cycle lane across the junction
- waiting area to be of sufficient size for the number of cyclists waiting
at present cyclists must rely on the secondary signal on the side road to know when they can make the second stage of the turn, so this must be located where cyclists can see it. Once low level cycle specific signals are available for use these can be provided to give cyclists making this movement their own signal.

5.52 Other considerations

- waiting area to be marked at centre of nearside approach lane
- detection of waiting cycles will be necessary if side road flow is insufficient to call the stage
- cyclists can choose to make a two stage right turn at junctions where such provision is not marked
- a cycle pre-signal can be used to reduce conflict with left turning general traffic
- this is an unfamiliar movement to most UK cyclists and a public information programme should be considered
- surface markings at junctions will be subject to high levels of wear and will require maintenance

Figure 5.3 Two stage right turn at traffic signals (e.g. Southampton)
Trials of innovative designs

5.50
At heavily trafficked and complex signalised junctions and those where traffic speeds are high an ASL may not be sufficient to enable cyclists to negotiate the junction safely for the full range of permitted movements. Previous sections have discussed a number of innovative measures that have recently been implemented on highway in the UK. In addition to these, further innovative designs are under development, some of which have been the subject of off road trials undertaken at TRL for TfL, drawing on experience in other countries.

5.53
Managing conflict with left turning traffic
Drivers turning left across cyclists moving ahead at junctions is one of the most hazardous collision types. Addressing the potential for this ‘left hook’ conflict is essential not just for cycle routes but for design of all highways that cyclists use. At signal controlled junctions with moderate to high left turning flows the ideal would be to ban that movement. Where that is impractical, methods of separately signalling cyclists and other traffic offer potential options for removing or at least reducing this conflict. There are a variety of ways that this has been achieved in other countries, but to date few of these have been trialled in the UK.

5.54
A recent literature review by TRL for TfL has highlighted a range of possible options, such as fully segregated signalised junctions and all green stages for cyclists, but coming up with designs that will work in the UK context will require further innovative development work.

5.55
Separately signalled left turn at traffic signals
TfL is planning to trial an arrangement that involves separately signalling cyclists and left turning motor traffic, based on the approach illustrated in Figure 5.4. This requires some segregation of lanes, including a dedicated left turning lane for general traffic, and provision for right turning cyclists. It has potential for locations where there is a moderate to high volume of left turning traffic and a large cycle flow ahead.
5.56
In addition to the road space requirements, the additional stages required at the signals can be expected to significantly reduce the junction capacity.

5.57
The design of such an arrangement must ensure that cyclists using the cycle track do not experience greater delay than those remaining on the carriageway.

Fully segregated signalised junction
5.58
This is a standard design in The Netherlands and TfL commissioned TRL to review the feasibility of such signalised junctions in the UK. Figure 5.5 shows a conceptual design of such an arrangement. Their report was published late 2014 and the conclusions state that “a greater understanding of pedestrian and bicycle interactions at this style of junction is required before this junction could be implemented on the highway.....The fully segregated signalised junction should not be viewed as a junction solution that is near implementation”.

Figure 5.5 Signalised junction with island segregation based on concept design by TRL
5.59
Key design aspects highlighted by this review that would need detailed consideration in taking forward a UK design are:

- interaction with pedestrians
- segregation
- corner islands and radius of turn
- stop line location
- road markings
- intervisibility between road users
- traffic signal timings

**All green for cyclists**

5.60
Dutch design guidance includes the option of an all green stage for cyclists, during which cyclists from all directions receive green simultaneously. This ‘scramble’ stage allows cyclists to make any movement, including right turns which can occur diagonally across the junction.

5.61
The implications of such an approach, including whether it could be implemented within current signal control arrangements, is included in the TRL research work.

**Green wave for cyclists**

5.62
Standard practice in the management of highway networks is to cater for a green wave that favours traffic travelling at a set speeds, generally 30mph. Some countries, notably The Netherlands and Denmark, provide a green wave on main cycle routes calculated for a lower traffic speed that matches the speed of cyclists, for example 20kph in Copenhagen.

5.63
At present there are no UK examples of such an approach, although Glasgow is in the process of developing such a scheme.
6. Roundabouts

Overview

6.1 Typical UK roundabouts, particularly roundabouts with two or more circulatory lanes, can present significant safety and inconvenience problems for cyclists and pedestrians. Cyclists are over-represented in casualty rates at roundabouts, and large roundabouts can be difficult and intimidating to negotiate even for experienced cycle users. Around half of collisions between cyclists and motor vehicles involve the cyclist circulating and the driver entering the roundabout (Layfield and Maycock, 1986).

6.2 Most of the problems result from drivers’ failure to notice or yield to cyclists in complex give way and lane weaving situations, particularly where the roundabout geometry enables high circulatory and exit speeds. The design features that cause these problems are:

- multiple entry lanes and flared entries – this can make correct positioning difficult for cyclists approaching the roundabout to turn right and leaves the circulating cyclist vulnerable to failure to give way collisions when crossing the wide entries
- large inscribed circle diameter (ICD) and wide and multi-lane circulatory carriageway – leads to higher circulating vehicle speeds and hazardous weaving movements
- low deflection on exits which encourages faster traffic speeds. This leads to collisions with circulating cyclists crossing the exit on the carriageway, and can make it difficult for pedestrians and cyclists using marginal cycle tracks to cross the exit
- left slip lanes, which do not give way to the circulatory carriageway, result in low angle / higher speed merges on the exit which are difficult for cyclists who are in the off-side lane leaving the roundabout
- use of guard rail and staggered crossings resulting in indirect routes and congestion where pedestrians and cyclists are corralled onto narrowed footways

6.3 All of the above features are designed to maximise vehicle capacity and regulate pedestrian movements, but act as barriers to encouraging cycling and walking.

6.4 In general there are two ways of dealing satisfactorily with cyclists at roundabouts:

- use of mini or compact roundabouts, where traffic volumes are relatively low and speeds are slow, and widths are narrow such that cyclists can safely share with single file traffic, in primary position
- where traffic volumes are higher and at larger roundabouts, provide a separate cycle track around the outside of the junction, preferably with cycle priority or signalled crossings of the entries and exits
Large conventional roundabouts pose problems for cyclists. Options to consider are:

1. Re-design to Compact/Continental design
2. Replace roundabout with traffic signals
3. Provide segregated cycle tracks with Toucan or Zebra crossings of busy arms, or cycle priority crossings/raised tables
4. Signal control of the roundabout
5. Shared space solution.

Note: cycle lanes on the circulatory carriageway should be avoided

Design to accommodate main pedestrian movements

Low profile over-run area

compact/continental Roundabout
- perpendicular approach and exit arms
- single lane approaches, 4m
- single lane exits, 4-5m
- external diameter (ICD) 25-35m
- island diameter (including overrun area) 16-25m
- circulatory carriageway 5-7m
- single circulatory lane
- roundabout capacity approx 25,000vpd, but consideration should be given to other options for cyclists where flows exceed 10,000vpd

Weymouth

On gradients where space is limited consider provision of a wider cycle lane in the uphill direction only, Bristol

Mini Roundabout:
Design for low speeds and single file traffic:
- single lane approaches
- domed central roundel
- deflection of traffic
- consider speed table
- consider deflector islands

Leicester

Cycle lane stops 20-30m before roundabout so cyclists mix with traffic on approach, Leighton Linslade

Re-design of roundabout to improve safety, Brighton

Before

After

Informal roundabout, London

Photos: Brighton and Hove Council
6.5
There are design solutions which can be applied to new roundabouts, or to adapt existing roundabouts, to make them significantly safer and more convenient for cyclists and pedestrians. This may reduce capacity in some cases. The principles are:

- controlling vehicle speeds
- reduce the amount of space
- raise driver awareness
- unobstructed passage for cyclists

6.6
Cycle lanes on the circulatory carriageway are not recommended, even on the Continental/Compact design of roundabout, as they place cyclists away from the field of vision of traffic entering and exiting the roundabout. They are no longer a recommended option in the Netherlands.

6.7
The following sections describe effective design features and features to be avoided for mini-roundabouts, continental (compact) roundabout design, conventional UK roundabout design and signalised roundabouts.

Mini-roundabouts

6.8
Mini-roundabouts, where the inscribed circle diameter\(^4\) is not greater than 15m, can improve safety and junction capacity compared to retaining an existing 3-arm or 4-arm priority junction. Because vehicles on every approach arm may need to give way, appropriately designed mini-roundabouts can reduce vehicle speeds, and can be included in traffic calming schemes.

6.9
Mini-roundabouts can be a compact and low cost intervention in situations where changing junction geometry or signalising is not an option. Mini roundabouts must only be used at existing junctions where the 85 percentile approach speeds on all approaches is less than 50 kph and space limitations preclude a normal roundabout\(^5\).

6.10
Four-arm mini-roundabouts with high traffic flows, mini-roundabouts with more than four arms and combinations of double mini-roundabouts tend to be problematic because the proximity and complexity of give way movements, combined with a lack of physical kerbs to regulate vehicle movements, can result in drivers failing to give way to cyclists.

6.11
Benefits
- single circulatory lane puts cyclist in driver's line of sight
- traffic calming, especially where mini-roundabouts are sited on raised tables
- improving traffic flows at priority junctions; in particular balancing priority between minor and major arms

\(^4\) Diameter of the carriageway outer margin

\(^5\) TA 23/81 Junctions and Accesses: Determination of size of roundabouts and major/minor junctions
single lane approaches mean that cyclists and motor traffic pass through the roundabout in a single stream
low-speed circulatory movements and priority to vehicles within the junction assist cyclists making right turns.

6.12
Mini-roundabouts are not normally recommended:
• at new junctions
• as direct accesses
• on steep gradients
• for busy four-arm junctions or junctions with more than four arms
• at a priority junction where vehicles on any arm are less than 500 per day (two-way average daily)
• on routes to schools unless included as part of an overall package to reduce vehicle speeds

6.13
Design considerations
• cycle lanes should stop 20-30m before roundabout to encourage cyclists to position themselves correctly
• the impact upon and the ability of pedestrians to cross the carriageway
• impact on long vehicles and some buses
• potential traffic diversion and impact on other cycle routes

<table>
<thead>
<tr>
<th>Table 6.1 Design features for mini-roundabouts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Feature</td>
</tr>
<tr>
<td>Approach arms</td>
</tr>
<tr>
<td>Entry width</td>
</tr>
<tr>
<td>Entry radius</td>
</tr>
<tr>
<td>Entry angle</td>
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<tr>
<td>Exit arms</td>
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<tr>
<td>Exit width</td>
</tr>
<tr>
<td>Exit radius</td>
</tr>
<tr>
<td>External diameter (ICD)</td>
</tr>
<tr>
<td>Central island diameter including over-run area</td>
</tr>
<tr>
<td>Circular carriageway</td>
</tr>
<tr>
<td>Speed limits</td>
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<tr>
<td>DMRB Document</td>
</tr>
</tbody>
</table>
Continental (compact) roundabout design

6.14 Continental style roundabouts (also similar to compact roundabouts described in TD 16/07) have tighter geometry with more deflection than typical UK roundabouts. As the geometry encourages lower speeds, cyclists generally pass through the roundabout with other traffic. Motorists are unlikely to attempt to overtake cyclist on the circulatory carriageway because of its limited width.

6.15 Continental style roundabouts have arms that are aligned in a radial pattern, with unflared, single lane, entries and exits, and a single lane circulatory carriageway. The design is widely used as a speed reducing feature in mainland Europe.

6.16 The principles applied in the geometric design of continental style roundabouts improve conditions for cyclists and can be applied to solutions in the UK.

6.17 Continental style roundabouts generally have lower capacity compared to a traditional UK style roundabout, however they are capable of accommodating vehicle entry flows of up to 25,000 vpd. For many cyclists, this is beyond the threshold at which cycle tracks with separate cycle provision at junctions becomes desirable, and consideration should be given to other options where flows exceed 10,000 vpd.

6.18 Benefits

- slower vehicle speeds at entry and exit and on the circulatory carriageway
- single lane entries and circulatory carriageway positions cyclists in drivers’ eyeline and minimises overtaking within the junction

Compact roundabout, Nottingham

Compact roundabout, Weymouth
Table 6.2 Design features for continental style roundabouts

<table>
<thead>
<tr>
<th>Design Feature</th>
<th>Continental (Compact) Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach arms</td>
<td>Perpendicular to roundabout</td>
</tr>
<tr>
<td>Entry width</td>
<td>Single lane, 4m wide</td>
</tr>
<tr>
<td>Entry radius</td>
<td>Not specified but generally 10m</td>
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<tr>
<td>Entry angle</td>
<td>Not specified but generally between 30-45 degrees</td>
</tr>
<tr>
<td>Exit arms</td>
<td>Perpendicular to roundabout, with deflection</td>
</tr>
<tr>
<td>Exit width</td>
<td>Single lane, 4-5m wide</td>
</tr>
<tr>
<td>Exit radius</td>
<td>10m or less</td>
</tr>
<tr>
<td>External diameter (ICD)</td>
<td>Min 25m, Max 35m</td>
</tr>
<tr>
<td>Central island diameter (including over-run area)</td>
<td>Min 16m, Max 25m</td>
</tr>
<tr>
<td>Circular carriageway</td>
<td>Single lane 5-7m wide</td>
</tr>
<tr>
<td>DMRB / Traffic Advisory Leaflet (TAL)</td>
<td>TD 16/07 Geometric Design of roundabouts.</td>
</tr>
<tr>
<td></td>
<td>TAL 6/97 Cyclists at Roundabouts: Continental design geometry</td>
</tr>
<tr>
<td>Vehicle flows</td>
<td>Up to 10,000 vpd (but see above)</td>
</tr>
</tbody>
</table>

Redesign of roundabout to improve safety, Brighton: Top, before. Bottom, after
Continental roundabout design with separate cycle track

6.19 Where traffic volumes are in excess of around 10,000 vpd a peripheral cycle track may be appropriate, in which case the aim should be to include cycle priority on each arm, whilst retaining the overall design approach to the roundabout itself. At present there are no UK examples of such a design although it is a standard approach in The Netherlands. However, off-road trials have been conducted for TfL by TRL, and an on road trial can be expected soon.

6.20 Figure 6.2 provides a concept design of this approach, utilising the parallel pedestrian and cycle crossing that is to be included in the revised TSRGD in 2015. Where such an arrangement is appropriate it can be expected that traffic volumes on most, if not all, of the approach arms will be such that segregated provision for cyclists will also be provided.
Informal roundabouts

6.21
Some authorities have installed junctions that are designed to encourage drivers to adopt circulatory priority, but they are in fact uncontrolled junctions, with no formal road markings or signs. Some informal junctions are designed with circular paving patterns to operate this way.

6.22
These have been found to work well in capacity and road safety terms at relatively high flows, of up to around 2500 vehicles per hour, though on cycle routes their use should be restricted to lower traffic volumes, preferably no more than 1000vph.

6.23
The use of circulatory patterns is appropriate where there is a high proportion of turning traffic, which would otherwise tend to give way to oncoming traffic in the centre of the unmarked space.

6.24
In terms of cycling, this type of junction can work well as long as care is taken to ensure that vehicles only circulate in one traffic stream and travel slowly, so that cyclists can adopt the primary position when passing through the junction, in a similar way to the Continental design of roundabout.

Conventional UK style roundabouts

6.25
Conventional UK designed roundabouts are focussed on minimising delays to vehicles whilst maintaining a clear and safe vehicular passage through the junction. In most locations there is an interaction with pedestrians and cyclists but it is given a low priority relative to other traffic.

6.26
Most collisions involving cyclists occur on the circulatory carriageway where they are hit by a car entering, and by retaining easy to negotiate geometry vehicles enter and travel around at a speed that is relatively high compared with that of cyclists.

6.27
Where a cycle route runs through a conventional roundabout options to consider are:

- redesign to Continental/Compact design
- replace roundabout with traffic signals
- provide segregated cycle tracks with Toucan, Zebra or raised table cycle priority crossings on each arm
- signal control of the roundabout, including advanced stop lines on the entries at stop lines on the circulatory carriageway
6.28
Where radical redesign of the roundabout is not currently acceptable and a peripheral cycle track does not afford adequate priority to cyclists, many cycle users will continue to use the circulatory carriageway. In such cases, as an interim measure, consideration should be given to measures to improve safety for those cyclists continuing to use the roundabout, such as:

- reduce the number of arms linking into the circulatory carriageway;
- reduce the carriageway width of entries and exits. This may be achieved by 1) widening the splitter islands (there is commonly unused carriageway space adjacent to the splitter islands) and / or 2) building out the nearside kerbs to reduce entry and exit radii. Measure 1) will provide a wider crossing refuge for pedestrians (or cyclists) on the splitter islands. Measure 2) will be more effective in increasing deflection and reducing speeds;
- provide raised tables on approaches;
- add over-run strips around the central island section effectively reducing the available circulatory carriageway width and increasing deflection.
- improve lane discipline for motorists with clearer, and maintained, lane markings on the circulatory carriageway.

6.29
Many of the above improvements deliver some aspects of Continental roundabout design.

6.30
A clear understanding of cycle desire lines and the movements required to access them is important. This can identify if, for example, there is a dominant right turn cycle movement that requires special provision.

6.31
Bedford Borough Council has recently re-engineered a conventional roundabout to a design drawing on the Dutch experience of turbo-roundabout designs, with improved lane discipline and lower speeds. The performance of this design for cyclists will be carefully monitored.

Crossing points should be clearly indicated to motorists. Tyne Dock, South Shields

Crossing points on approach arms may need to be signalised on roads that carry high traffic flows, Nantwich

Conventional roundabout redesigned to enforce lane discipline, Bedford
Cycle provision at signalised roundabouts

6.32
Large roundabouts are an obstacle for most cyclists. However, signalising them assists cyclists by introducing control of the main traffic movements. To accommodate cyclists using them, ASLs should normally be considered for each entry arm and if stacking space permits ASLs may also benefit cyclists on the circulatory carriageway.

6.33
Less experienced cyclists are likely to prefer an off carriageway route around the roundabout, with signal control across the busier entries and exits. Temple Quay in Bristol provides both options.

On and off carriageway provisions at signalised roundabout, Bristol

6.34
At large signalised roundabouts where there is a heavy cyclist demand for a right turn, it may be feasible to incorporate a short section of cycle track in the central island that is linked into the junction phasing to enable cyclists to make the right turn more directly. An example is for cyclists turning onto Lambeth Bridge in London.

Cycle track through roundabout, Lambeth
7. Crossings

General Principles and Guidance

7.1

The purpose of a crossing is to give pedestrians and cyclists, and sometimes equestrians, safe passage across the carriageway. The type of crossing chosen will need to be appropriate to the circumstances of the site and the behaviour/demands of the users. Crossings can range from a simple set of dropped kerbs through to signalised or grade separated crossings of major urban roads.

7.2

Local Transport Notes (LTNs) 1/95 “Assessment of Pedestrian Crossings” and 2/95 “Design of Pedestrian Crossings” should be used to determine the location and appropriate type of a new crossing point. The choice of crossing type is also related to the 85th percentile speed and the two way daily traffic flows. Reference should also be made to the Zebra, Pelican and Puffin Pedestrian Crossings Regulations and General Directions 1997; changes expected once the revised TSRGD is published.

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Fig 7.1 Crossing types (uncontrolled)

Not to scale

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6 Recent design experience has updated some of the design guidance in LTN 2/95, in particular relating to cycle use of single stage Toucan crossings and cycle use of Zebra crossings. This is highlighted later in this chapter.
7.3
Urban roads with traffic flows in excess of 8,000 vehicles per day and with 85th percentile speeds greater than 50mph are more suited to grade separated (bridges/subways) crossings. For rural roads grade separation may need to be considered where traffic volumes exceed 10,000 vpd and speeds 60mph.

7.4
Table 7.1 indicates appropriate treatments for a standalone crossing of a two-way carriageway for a range of speed and traffic flows. It is a guide only, and individual locations should be assessed on a case by case basis. In many situations reducing the speed of traffic using the carriageway will make possible additional and lower cost options for the crossing design that can offer greater priority for cycle users and pedestrians.

7.5
Crossings need to take account of the number of cycle and pedestrian users and the nature of the target cyclist, as well as the traffic speeds and volumes. For example; the benefits of a zebra crossing on a busy road in an area of very high pedestrian use would need to be balanced against the delays for vehicular traffic. Conversely a signalised toucan crossing in a quiet rural area may remain “green to motorists” for prolonged periods, resulting in drivers forgetting that the crossing exists.

<table>
<thead>
<tr>
<th>Table 7.1 Crossing types</th>
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<tbody>
<tr>
<td><strong>85th percentile speed</strong></td>
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<tr>
<td>&lt; 30 mph</td>
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<td>&lt; 30 mph</td>
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<tr>
<td>&gt; 50 mph</td>
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<tr>
<td>&gt; 60 mph</td>
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</tbody>
</table>
7.6 Although numbers of pedestrian and cycle users may be considerably lower in a rural environment, there may be seasonal variations that justify a crossing type appropriate for higher use areas.

7.7 Crossings should be sited on desire lines as closely as possible, and provide direct connections to traffic free routes, road closures and contraflow cycling facilities. All crossings should cater for cyclists joining and leaving the carriageway as well as those crossing the carriageway.

7.8 Crossings need to be wide enough to cater for maximum expected demand, and growth in usage. This should accommodate high concentrated demand around schools, public transport interchanges and workplaces. Once a new crossing is installed it will frequently be busier than originally expected. Catering for higher numbers at the design stage will avoid a route becoming compromised because dimensions on key crossings were set at the minimum required. Once installed it is difficult to justify further expense if a crossing needs widening.

7.9 Uncontrolled crossings should be at least the width of the approach paths, and never less than 2.7m wide (three dropped kerb widths). Therefore if the approach path is a cycle track, or shared use path 3.5m wide then the crossing should not narrow down and create pinch points but provide a facility at least 3.5m wide. Local widening of the cycle track at the crossing can be advantageous, to cater for the full range of cycle and pedestrian movements, including cyclists joining or leaving the carriageway. It will also help minimise conflicts where pedestrians and cyclists wait and then cross en masse in available gaps in traffic.

7.10 Conflicting movements for different user groups can be managed or eliminated by improving landing areas and approaches to crossings, and by providing dual use crossings that have plenty of width.

7.12 Central refuges at crossings should be capable of dealing with high user numbers, especially if a route links schools/colleges and popular family destinations. Pedestrians and cyclists should be able to wait safely and in comfort when there are high numbers of each user group.

7.13 Intervisibility between approaching drivers and cyclists is important for all types of crossing, but particularly for unsignalised crossings. Vegetation should be maintained at no more than 600mm high within the visibility splay.

7.14 Speed reduction for cyclists approaching the crossing should be achieved by cycle track geometry rather than by use of barriers. A bend with an internal radius of 4.0m will provide adequate speed reduction. Ensure that corners cannot be cut with vegetation planting or knee rail fencing. Staggered barriers and access gates or other access controls that require cyclists to dismount or slow unduly should be avoided.
7.15

All crossings should have flush kerbs, with adequate drainage. Crossing points should remain free from street furniture and other clutter.

7.16

Clear, coherent and well-maintained signing is important on traffic free routes, on the approaches to crossings and on the road network so that drivers become accustomed to routes.

Raised zebra crossing: cyclists may use them but do not have priority. Provide deflection on approaches (See Sustrans' Technical Information Note 17). Revised TSRGD will permit a parallel pedestrian/cycle priority crossing, see Figure 7.6

Toucan or other light-controlled crossing with cycle detection on approaches

Cycle track should cross a dual carriageway in a single stage

Provide for on road cyclists to access crossing to assist right turns

Signalled crossings to include cycle detection on approaches

Fig 7.2 Crossing types (controlled)
Cycle priority crossings

Overview

7.17 Where a cycle track crosses a relatively lightly trafficked street, the cycle track can be given priority over the road. The crossing should generally be sited on a flat-topped road hump to ensure low vehicle speeds. This treatment can be used at crossings of side roads where they join a larger road, or mid link.

7.18 The design in both situations should ensure that it is clear to motorists that they must give way, and that there is sufficient intervisibility between drivers and users approaching the road along the cycle track. This helps cyclists to maintain momentum as well as ensuring safety.

7.19 Coloured high skid resistant surfacing can be helpful to enhance/increase driver awareness, and adequate street lighting is essential.

Cycle priority at side road (raised) crossings

7.20 Cycle priority at side road (raised) crossings is appropriate where vehicle turning flows to and from the side road are low (two-way flows of <2000 vpd) and 85th percentile speeds are less than 30 mph – generally limited to urban situations. Treatment options with and without bending out the cycle track from the give way line are described in Chapter 4: Streets and Roads.

7.21 This treatment will help to maintain continuity and priority for cycle routes alongside main roads, which are commonly key cycle desire lines. Further guidance is contained in the Welsh Government Design Guidance: Design Element DE026.

Cycle priority crossings mid-link

7.22 This treatment is appropriate for low speed, low traffic situations (two-way flows of less than 4000 vpd and 85th percentile speeds less than 30 mph) and is generally restricted to urban areas or sensitive, low speed rural areas. Further guidance is contained in the Welsh Government Design Guidance: Design Element DE037.
**Fig 7.3 Cycle tracks alongside carriageway**

**Key design requirements:**
- minimise number of side road crossings
- provide for all movements at all junctions
- cycle track continuity to avoid crossing and recrossing road
- aim to provide cycle tracks on both sides of the road

**Lamp columns and other street furniture to be removed from cycle track**

**Crossing of side roads or busy private access set back 4m to 8m, cycle track has priority, on raised table**

**Bristol**

**Cycle track should not deflect through more than 45°**

**Min 0.5m margin separation from carriageway increasing to a min 1.5m where speed limit exceeds 40mph**

**Additional width for cycle track to be provided by reallocating carriageway space where practicable**

**Glasgow**

**Single stage Toucan 20m from give-way line at roundabout normally recommended (5m for a zebra)**

**London**

**Final approach of cycle track to crossing at right angles to carriageway to maximise visibility for cyclists**

**Side road or busy private access crossing not set back. On raised table, reduced entry radii. Priority to be determined from site conditions, visibility, speeds, flow**

**Uncontrolled crossing set back 5m (one car length) from give way line; consider use of raised table or zebra**

**Not to scale**

**Cycle tracks on both sides of road improve accessibility**

**Not to scale**

**Additional width may be required at bus stops, and visibility maintained**

**Reduced radii**

**Surface should be machine laid**

**Radius 2m min**

**Cycle Tracks**

Unsegregated shared use maximises the usable width. However local conditions may warrant segregation provided adequate width is available for each user group (see Traffic free routes 3)
Uncontrolled crossings – no refuge

7.23
On higher speed roads (85th percentile speeds above 30 mph), cyclists crossing will generally have to give way to motor traffic unless a controlled crossing is provided. However, cyclists will generally be able to cross conveniently in a single movement with traffic volumes up to around 6000 vpd.

7.24
A simple priority crossing is relatively cheap to install.

7.25
Farm tracks and lightly trafficked roads, in rural or semi-rural environments, and carrying up to 2000 vehicles per day, require little or no specific infrastructure. They are numerous and present very little difficulty to users. Intervisibility between users is important and may require management of vegetation within the visibility splay.

7.26
For crossings in urban or semi urban situations, greater use of signing, road markings and coloured surfacing and kerb-line modifications are often appropriate to increase driver awareness and reduce crossing distances, particularly where traffic flows are higher.

7.27
Road markings and coloured surfacing will need to remain in good condition and the designer will need to assess the benefits of these treatments against ongoing maintenance liability. Removal of a centre line may be an alternative speed reducing measure.

7.28
Buildouts can be effective in reducing vehicle speeds and improving intervisiblity, as well as reducing the crossing distance. However, this needs to be balanced against potential disbenefits to cycle users on the carriageway for whom the narrowed crossing may create a pinch point.
Semi-rural crossing, coloured surfacing highlights the approaches to a minor road, without the use of speed control/access barriers, Cornwall

Rural crossing: minimal but clear signing, Kenilworth

Encouraging permeability within new residential developments. Note the upstand on the carriageway is not recommended for cyclists, Bristol

Kerb lines changed and a poor condition refuge removed to enable pedestrians and cyclists to cross the narrowed carriageway in a single movement, Huyton

Mid-link cycle priority in new development, Derby
Uncontrolled crossing with refuge

7.29 Where cycle routes cross roads with speed limits greater than 30mph, or where vehicle flows are high, it can be difficult to find an adequate gap in the traffic to cross the carriageway in one movement. A central refuge allows a crossing to be undertaken in two easier movements, and can considerably reduce the time taken to cross a road. However, the arrangement needs to be carefully designed to avoid the refuge creating pinchpoints that can disadvantage cyclists using the carriageway.

7.30 Provision of a refuge for uncontrolled crossings becomes appropriate where two-way vehicle flows exceed 6,000 vehicles per day and 85th percentile speeds are greater than 35 mph7 as follows:

- urban: two-way traffic flows less than 8,000 vpd; 85th percentile speeds less than 50 mph
- rural: two-way traffic flows less than 10,000 vpd; 85th percentile speeds less than 60 mph

7.31 Key design features

- central refuges should be a minimum of 2.0m wide (between traffic lanes) and at least as long as the width of the approach tracks. Refuge dimensions should cater for peak flows in excess of current usage and allow for groups of cyclists (especially families) to wait together. Where a refuge of adequate width cannot be accommodated, a signalised crossing may be needed
- a straight line crossing is generally preferred
- designs should avoid refuges that retain a running lane width of between 3.1m and 3.9m. This range of dimensions causes difficulties for cyclists using the carriageway because drivers attempt to pass cyclists at the refuge where there is inadequate lane width. Where lane widths are 3.0m or less, drivers tend to wait behind cyclists at the refuge

Rural areas

7.32 On single two lane carriageways where the national speed limit of 60mph applies, the designs below should be considered. If necessary additional measures to reduce vehicle speeds should be implemented including one or more of contrasting colour, high skid resistant surfacing, rumble strips, visual narrowing. Consider use of detector loops in cycle track to activate additional warning signs for drivers.
SLOW markings or deflection (preferred) or staggered bollards on approach to reduce speeds

Fig 7.4 Rural major road crossing (flows < 6,000 vpd)

Central refuge, Berwick to Tynemouth

Cycles crossing xxx yards

Rumble strips

Bollards

Light coloured high friction surfacing laid over full width of carriageway for a distance of 50m in advance of and through the crossing

Diag 1012.1
(150mm line width)

Fig 7.5 Rural major road crossing with central refuge (flows < 10,000 vpd)

Note: additional signing, lining and surfacing details for Figure 7.4

Diag No 610. Mounted on reflective backing board where improved visibility is desirable

Cycles crossing xxx yards

Cycle Activated Traffic Signs at Crossings: detector loops can also trigger vehicle-activated signs to alert motor traffic of the presence of an infrequently used crossing only when there are cyclists or pedestrians present. In order to overcome limited visibility on the busy A453, derestricted road, in 2007 Leicestershire County Council installed the first CATS (Cycle Activated Traffic Sign) crossing in the world on a cycle route serving Nottingham East Midlands Airport.

The crossing uses pressure pads to activate a sign with flashing amber lights and a ‘SLOW DOWN’ message for traffic approaching on the A453. If a cyclist rides over the pad (or waits to cross) at the same time as an approaching car is detected by the sign’s radar, the sign is activated. The lights warn drivers so they slow down but the cyclist at the CATS crossing is unaware that a sign is being activated down the road and so proceeds with the same level of caution. Initial speed monitoring results show a 10% reduction in average approach vehicle speeds when the CATS are activated. This means most vehicles are travelling at just over 40 mph past the crossing.
Types of controlled crossing

7.33
There are five DfT approved forms of controlled crossing, which offer varying degrees of priority. These are in the table below;

Table 7.2 Types of Controlled crossing

<table>
<thead>
<tr>
<th>Type of crossing</th>
<th>Priority for</th>
<th>Min/Max crossing width</th>
<th>Recognised by</th>
<th>Vehicle flows /Speeds</th>
<th>Pedestrian /Cycle flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zebra</td>
<td>Pedestrians*</td>
<td>2.40m – 10.1m</td>
<td>Black / White stripes.</td>
<td>Moderate flows Speeds below 35mph</td>
<td>Low / Moderate flows</td>
</tr>
<tr>
<td>Pelican</td>
<td>Pedestrians</td>
<td>2.40m – 10m</td>
<td>Flashing orange / green man</td>
<td>Moderate flows Speeds below 50mph</td>
<td>Moderate</td>
</tr>
<tr>
<td>Puffin</td>
<td>Pedestrians</td>
<td>2.40m – 10m</td>
<td>Near side signal heads</td>
<td>Moderate / High Speeds below 50mph</td>
<td>Moderate/ High</td>
</tr>
<tr>
<td>Toucan**</td>
<td>Pedestrians and Cyclists</td>
<td>4.0m – 10m</td>
<td>Green bike symbol on signal heads</td>
<td>Moderate / High Speeds below 50mph</td>
<td>Moderate/ High</td>
</tr>
<tr>
<td>Pegasus</td>
<td>Horses</td>
<td>3.0m-5.0m</td>
<td>Green horse symbol, wide crossing point</td>
<td>Moderate flows Speeds below 50mph</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

*Cycle use of zebra crossings is not illegal, and informal use by cyclists continues to increase. See Sustrans Technical Information Note 17

**Toucan crossing control is now generally based on Puffin crossing technology for standalone crossings

7.34
The revised TSRGD is expected to include a new crossing design comprising a parallel crossing for pedestrians and cyclists (see Figure 7.6), based on the Zebra crossing design.

7.35
There is also increasing interest by some local highway authorities in providing parallel signalled crossings for pedestrians and cyclist, particularly on busier cycle routes. These may be provided under current regulations but the Toucan crossing was envisaged as a replacement for these.

Zebra crossings

7.36
Zebra crossings provide a recognised formal crossing point where pedestrians have priority over motorised vehicles. These crossing points can give equally valuable help to the cyclist, though the legal position on this is unclear. Advice from Transport for London is that it is not illegal for cyclists to use a Zebra crossing provided there is a cycle track each side, but they do not have priority over motorists. More detail is given in Sustrans Technical Information Note 17 Cyclists’ Use of Zebra Crossings.

Zebra crossing on a signed cycle route, Reading
7.37
DfT is committed to trialling some form of parallel crossing for pedestrians and cyclists and Figure 7.6 is based on the design included in the TSRGD consultation. However, it is unclear what restrictions may be placed on its use, pending publication of the revised TSRGD in 2015.

7.38
Key Design Features

- Zebra crossings can be located closer to junctions (5m minimum) than a signalised crossing (20m minimum), and therefore offer a greater chance of retaining pedestrian and cyclist desire lines

- cyclists should not be able to enter the crossing at speed, and creating deflection within the approach track alignment is recommended to reduce approach speeds. If deflection is not achievable, use of SLOW markings or staggered bollards should be considered

- widening crossings to cater for pedestrian and cycle provision starts to separate the various groups and reduces conflict. A 4m minimum width is recommended

- a variety of non-standard innovative solutions are installed and operate satisfactorily around the UK, with designs outside the current regulations. Some of these include parallel cycle crossings alongside zebra crossings

Figure 7.6 Parallel pedestrian/cyclist crossing (as included in draft TSRGD revision)

Wide mid-link Zebra on cycle route, Bristol

Zebra crossing with parallel cycle crossing, Canterbury
Signalised Crossings

7.39 Signalised crossings in urban areas are preferred where there is a greater pedestrian and cycle presence, as the “informal” arrangements of a Zebra crossing are not suited to areas of high demand. Where there was no previous provision, suppressed demand may be higher than anticipated, especially in residential areas.

7.40 Signalised crossings should not be used where 85th percentile speeds exceed 50mph.

7.41 Benefits

- signalised crossings can give priority to pedestrians and cyclists and can be set to respond to cycle and pedestrian demand with minimal delay
- signalised crossings can allow cyclists to re-join the carriageway ahead of traffic

Key design features

Minimising delay for cyclists at stand alone Toucans

7.42 Toucans that have a long delay time before giving a green to cyclists once a demand has been registered cause frustration and lead to frequent attempts to cross before the green light appears. On key cycle routes in some highway authorities, if a Toucan crossing has not registered a recent demand to cross, it will react immediately to a cyclist or pedestrian demand regardless of traffic flow. This is due to operating these crossings on a pre-timed maximum rather than vehicular activated mode, such that the controller starts to count down from its maximum value as soon as the traffic phase gains right of way.

7.43 Technology should be incorporated into new crossings so that they are more reactive to pedestrian and cycle movements. Microwave sensors are capable of detecting users waiting at kerbsides, as well as user movement on the crossing. Detector loops cut into approach paths can call the pedestrian/cycle signal stage so that the pedestrian/cycle signal is green when the user reaches the crossing.
Wide single stage Toucans

7.44
LTN 2/08 Cycle Infrastructure Design states that “staggered or split crossings are not generally recommended for cyclists, because they can cause delay to people crossing and give rise to potential conflict between cyclists and pedestrians”. LTN 2/95 recommends that if a road width is greater than 11m a staggered layout should be considered, and if it exceeds 15m a staggered crossing layout should be provided.

7.45
There are an increasing number of examples of single stage Toucan crossings over dual carriageways and other wide roads which operate satisfactorily, and give significant advantage to cyclists.

7.46
Where a Toucan crossing is required on a wide road, a single-stage crossing should generally be provided for widths below 15m. For widths over 15m, the option of a single-stage crossing should be fully considered in the light of existing examples.

7.47
Where a two-stage Toucan operates under SCOOT, delays for cyclists may be increased. However, it is possible to improve its performance for cyclists by considering it as a multi-node, in effect treating both halves as a single crossing.

7.48
Where staggered or multi-stage crossings are the only viable solution, designers should maximise space within the central waiting areas by realigning kerb lines or removing guard railing. Use of containment kerbs can be an effective means to avoid use of guard rail.

Wide crossings (4 or 5 lanes or greater) can have very positive impact on walking and cycling movements. Key corridors should aspire for high quality provision throughout. This crossing of 7 traffic lanes demonstrates cycling and walking is being prioritised, Liverpool.
Siting crossings on desire lines

7.49
Crossings should be located on desire lines, and provide direct connections to traffic free routes on either side of the road. Diagonal Toucan crossings can be appropriate where approach tracks to a crossing are not aligned, thereby avoiding an awkward dog leg on a shared use footway. A good example is on Fen Causeway in Cambridge, where the cycle routes on either side of the crossing are on opposite sides of a bridge over a stream; the crossing is at an angle diagonally across the bridge to avoid cyclists having to use the footway over the bridge.

7.50
Where a diagonal crossing is not feasible to connect approach facilities, linking crossings to connecting routes may require some road space reallocation to widen the shared footway on the road being crossed.

Providing good access to/from Toucans for all movements

7.43
In addition to providing a safe and convenient crossing for cyclists on traffic free routes, a Toucan crossing should also take account of cyclists wishing to join or leave the carriageway at the crossing. Whilst joining the carriageway can generally be accomplished during the crossing manoeuvre, cyclists leaving the carriageway to access the Toucan need a separate slip off the carriageway in advance of the crossing to avoid conflict with pedestrians or cyclists waiting to cross.

Parallel crossings

7.44
Separate parallel signalised pedestrian and cycle crossings on busy urban traffic free routes can be helpful to reduce potential conflict between user groups. This solution is only effective if the two user groups follow separate routes at each end of the crossing.
Use of high level nearside displays on Toucans
7.51
Where Puffin technology is used incorporating nearside displays at Toucans, the display can be masked by a group of cyclists / pedestrians. This can be addressed using the option of a second higher level signal.

Incorporating cyclists in UTC/SCOOT
7.52
Split Cycle Offset Optimisation Technique (SCOOT) has become an important tool for optimising the movement of traffic over the road network, although by doing so it may lead to additional delays for cyclists crossing at Toucans. However, whilst not often applied, there are ways in which SCOOT systems can be more cycle friendly, such as:

- switching SCOOT off when traffic flows are low, rather than just using a fixed timetable
- consider double cycling Toucan crossings under SCOOT operation
- using the gap-out option allowing a signal site (e.g. a Toucan) to operate partly on SCOOT and partly on local isolated mode

Signalised crossings in rural areas
7.53
Dedicated signalised crossings in rural areas are rare, but may be needed on heavily trafficked roads that have vehicle speeds close to 50mph, or where the nature of the traffic includes a high proportion of HGVs. In these situations, use of a refuge may be intimidating.

7.54
Key Design Features
- single carriageway two lane roads where the national speed limit (60mph) applies require designers to consider crossing points in relation to vehicle speed, crossing layout and inter-visibility between a fast moving vehicle and a cyclist on a traffic free route. Speed reduction measures are likely to be appropriate
- signalising crossings that are infrequently used by pedestrians and cyclists can be problematic. Drivers may fail to observe a red signal that is almost always green
- signalised crossings may need Traffic Regulation Orders (TROs) to reduce vehicle speeds to appropriate levels to aid installation
- use of detection systems that call the pedestrian/cycle signal stage before the users arrive at the crossing are beneficial to minimise waiting times on the side of busy or fast moving roads
- road markings should be used on the approaches to the crossing to warn motorists of the crossing ahead. Vehicle activated road signs activated by pedestrians and cyclists, are effective ways of warning motorists approaching the crossing point
- for high speed roads carrying in excess of 10,000 vehicles per day, a grade-separated crossing will usually be more appropriate
Grade separated crossings

7.55
Grade separated facilities will be appropriate when other crossing options cannot meet the design requirements of directness and safety, and a major obstacle has to be crossed such as a major road, river or railway. They are considerably more expensive and often less convenient to use than surface crossings and may require land take as well as special drainage arrangements so are rarely the preferred option where other alternatives exist.

7.56
Grade separated crossings for pedestrians and cyclists generally comprise shared use - either segregated or unsegregated - bridges (either converted from pedestrian only or new build), shared use alongside the carriageway on a road bridge, and existing subways adapted for cycle use. New subways are very costly and so are rarely constructed. They increase crossing distances and may require the use of ramps and stairs, so grade-separated crossings should be designed to be reasonably direct, with good sight lines throughout. These facilities should be light, open and well maintained. The relative isolation of some bridges and subways can give rise to personal security concerns.

7.57
Plans to convert existing subways, bridges and tunnels to shared use should not unduly inconvenience pedestrians. The crossing should ideally be as safe and attractive as the at grade equivalent, to help ensure it will be used. Sometimes existing canal, river or railway bridges and tunnels can provide opportunities to create attractive grade separated crossings. Conversion of existing structures may not meet the design criteria for new ones, in which case a risk assessment may need to be undertaken. These are discussed in detail in Chapter 8.

Pedestrian/cycle bridges

7.58
Bridges can provide very useful connections along footpath or cycle tracks away from the road, avoiding conflicts at major roads. Where the topography is favourable the need for approach ramps can be minimised and good natural surveillance improves personal security. New bridges can be designed as features along a route and may become attractors in their own right. New bridges are generally considerably cheaper than new subways.

Existing road bridges with footways converted to shared use

7.59
Road bridges can be adapted to meet the requirements of a shared use footway. Existing structures with narrow footways, restraining barriers or lower parapets should not be discounted, as it may be feasible to reduce the carriageway width. However, there are many locations across the UK that utilise existing structures for walking and cycling, but the quality of provision is poor. Often cited arguments are that shifting kerb lines and changing the dynamics of a structure is impractical, costly or that there are utilities affected.
**Subways/underpasses**

7.60 Subways/underpasses can provide very useful connections along footpaths or cycle tracks away from the road, avoiding conflicts at major roads. Where the topography is favourable the need for approach ramps can be minimised and good natural surveillance is essential for personal security. Generally this option will involve the conversion of an existing pedestrian subway or an underpass provided for private access.

**Wheeling Ramps**

7.61 Where cycle routes are introduced onto routes originally designed mainly for pedestrian use only, such as canal towpaths or railway footbridges, flights of steps are sometimes unavoidable. To assist cyclists, wheeling ramps may be added to one or both sides of the flights using steel sections or by forming them in concrete.

### 8. Interface with carriageway

**Overview**

8.1 The transition between a shared use footway, or cycle track, and the carriageway is a junction and therefore presents increased potential for conflict between cycles, vehicles and pedestrians. Designs should minimise both delays and hazards for cycle users and pedestrians.

8.2 A specific priority is to ensure that drivers and cyclists anticipate the junction, which may be less obvious in scale than road intersections. Less experienced cyclists, in particular, may not appreciate the change in cycling behaviour and attentiveness required when crossing or joining the carriageway. This section identifies four categories of transition and appropriate cycle provision. These are:

- low angle ‘diverge’ and ‘merge’ transitions where the transition is between on-carriageway provision and a parallel cycle track or shared used footway
- perpendicular (or high angle) junctions between a cycle track (or vehicle restricted route) and the carriageway. Design features include right turn facilities to assist cyclists leaving the carriageway, and facilities on traffic free routes on the approach to cycle/pedestrian crossings and cycle track junctions with the carriageway
- ‘jug handle’ approaches to a crossing from a cycle route parallel with the carriageway
- treatment at links between cul-de-sacs and at road closures

8.3 All transition designs should accommodate peak cycling demand (including potential growth), the range of target cyclists who are drawn to traffic free routes (including family groups, inexperienced and child cyclists) and the diverse variety of cycle designs including tandems, tricycles and trailers. Appropriate flush kerbs are a common requirement for all transition types and are also considered.
8.4 Key design considerations are:

- peak cyclist turning flows
- speed and volume of traffic
- intervisiblility between drivers and pedestrians/cyclists
- minimising cyclist delay and maintaining momentum
- minimising access controls
- preventing obstruction by parked vehicles
- impacts of level changes on drainage and buried services
- land ownership

**Low angle merge and diverge facilities**

8.5 ‘Merge’ transitions involve cyclists joining the carriageway from a parallel cycle track. At ‘diverge’ transitions, cyclists leave the carriageway to join a parallel cycle track.

8.6 Two common designs for the transition between the carriageway and parallel cycle tracks are shown in Figure 8.1. As well as providing transitions between on- and off-road facilities along links, these transitions can be used on the approaches to controlled crossings to enable cyclists to leave the carriageway to use a crossing without conflicting with other pedestrians and cycle users waiting at the crossing point.

**Fig 8.1 Leaving and joining the carriageway**

**Leaving carriageway (diverge)**

- Option 1: Raised white line
- Option 2: 1:10 taper

**Joining carriageway (merge)**

- Option 1: Raised white line, Verge separation
- Option 2: Build out, Carriageway kerb line
8.7
The designs should not introduce hazards for cycle users who remain on the carriageway and careful design of buildouts and carriageway narrows is required to achieve this. This is particularly relevant where there are side streets on the opposite side of the road which are accessed by cyclists remaining on the carriageway to turn right. Key design features for the diverge transitions are:

- to enable cyclists to leave the carriageway without decelerating sharply in the carriageway
- to provide adequate width and minimum deflection through the transition from carriageway to cycle track. A flush kerb length of at least 5m is desirable
- to avoid kerb upstands and access controls (including bollards) through the transition
- to ensure that any tactile surfacing and raised white lining is positioned away from locations where cyclists may be cornering (due to the potential skid hazard in wet conditions)
- to ensure that the facility is clearly marked as one-way to prevent cyclists riding on to the carriageway against the flow of traffic. This is particularly important where the transition joins a two-way cycle track

8.8
Key design features for the merge transitions are:

- wherever possible, provide kerb protection at the transition so that cyclists can merge alongside and not into the path of vehicles. This will enable cyclists to maintain their speed and ensure that cyclists do not need to look behind them while negotiating the merge (Figure 8.1, options 1 and 2)
- where kerb protection is not possible, designs should clearly indicate the need to give way and to include a higher angle approach to the merge. However, as cyclists have to give way here, this is not recommended
- mandatory cycle lanes at the merge help to maintain cycle and vehicle separation more effectively than advisory lanes and cycle lanes should be continued downstream of the merge where possible. A 0.5m wide strip of hatching can also be used to protect the merge
- merge transitions can lead directly into an advanced stop line reservoir. Where this is the case, right turning cyclists may need to wait for the red phase before entering the reservoir. There may need to be additional space on the cycle track to accommodate these right turners to avoid obstructing ahead or left turning cyclists who can proceed more easily while the signal is green
- for priority junctions, it can be beneficial to site the merge up to 50m upstream from the give way line to enable cyclists to select the correct lane for the junction
Perpendicular (or high angle) transitions

Overview

8.9
Figure 8.3 illustrates typical treatment where a cycle track joins a carriageway at or close to 90 degrees. On low traffic roads, the right turn cycle lane can be omitted. Designs should cater for all movements, including right turn movements from the cycle track and, where relevant, crossing movements to facilities on the opposite kerb.

Right turn lanes

8.10
A right turn ghost island (‘cycle pocket’) or kerb-protected right turn lane is recommended on busier roads to provide a safer waiting area for right turning cyclists leaving the carriageway. This can be used at junctions with cycle tracks and at side roads where right turns are prohibited for other vehicles. A cycle right turn lane should be a minimum of 1.5m wide. 2.0m is preferred on routes with higher traffic flows, high HGV or bus proportions and on bends.

Right turn boxes from major to minor road should ensure that there is sufficient space for cyclists to wait safely. On roads where HGV or bus traffic is expected kerb protection at the ends of the right turn lane should be considered, Upminster (above left), Norwich (above right).

Right turn pockets that include central refuges are more expensive to install than simple white lining solutions, but where turning movements are on a bend, or the road carries significant HGV traffic, the inclusion of kerbing and bollards enhances safety for right-turning cyclists. It can also enforce turning restrictions for motor vehicles, Chatelherault (top), Leicester (below).
8.11 Use of the road marking diag 1057 within the right turn lane can help to reinforce the turning restriction for motor traffic and contributes to route wayfinding. Use of coloured surfacing can be beneficial on busier routes.

8.12 Kerb protection of cycle-only right turn lanes is recommended on routes with high HGV or bus proportions, or where vehicle speeds exceed 40mph. The need for kerb protection increases where a 2m width for the right turn lane cannot be achieved. Potential disbenefits to other cycle users travelling ahead through the carriageway narrowing will need to be considered.

Kerb radii

8.13 Kerb radii where the cycle track meets the carriageway there should be a minimum radius of 4m (preferred) or an absolute minimum of 2m. It is important that radii and the width of the cycle track enable cyclists during peak cycling demand to enter the cycle track without decelerating sharply or bunching in the carriageway. Cycle track widening at the transition can be beneficial. This applies equally to the cycle gap at road closures.

Signing and speed reduction features

8.14 Give way markings (Diag 1003) and ‘SLOW’ markings (Diagram 1058.1) are recommended where a cycle track approaches a cycle crossing or a perpendicular junction with the carriageway, unless cyclists have priority there.

8.15 Speed reduction for cyclists on the cycle track approach to the junction should be achieved by cycle track geometry rather than by use of barriers. A bend with an internal radius of 4m will meet LTN 2/08 guidance. Staggered barriers and access gates or other access controls that require cyclists to dismount or slow unduly should be avoided. Staggered bollards can be used, but will reduce capacity and can be difficult to negotiate with a trailer or tandem. Where their use is essential, they should be set back at least 5m from the edge of the carriageway and cycle track widening provided to enable cyclists to pass in both directions simultaneously through the gaps.

8.16 Signing transitions where a cycle route leaves a shared path to join/cross the carriageway, signing should initially be kept to a minimum. If necessary, direction signing can subsequently be reinforced by:

- white lining
- arrow (1059) and cycle symbol (1057)
- Cyclists Rejoin Carriageway sign (966)

8.17 End of Route (966) and Cyclists Dismount (966) NOT recommended. Guidance on visibility splays is included in Chapter 3: Principles and Processes.
8.18 Figure 8.4 illustrates two options for the transition between a cycle track running parallel to the carriageway and a cycle crossing.

**Fig 8.4 Jug handle approaches to crossing**

**Option 1** (shared use with pedestrians)
- White lining positioned to encourage cyclists to approach at 90° to carriageway
- Tactile corduroy

**Option 2** (segregation from pedestrians)
- Centre line on two-way cycle track
- Jug handle to improve angle of approach

8.19 **Option 1** is a cycle track accommodated within the width of the footway. This arrangement can be problematic, particularly where cycle flows are significant, because of interactions in the confined space between cyclists travelling in different directions and pedestrians; there is also limited space for cyclists to position themselves perpendicular to the kerbline.

8.20 **Option 2** improves the angle of approach to the crossing and reduces the turning radius. A similar arrangement can be deployed for one way and two way cycle tracks. It requires greater land take than option 1.

8.18 Moving from shared use paths or cycle tracks onto or across main urban roads can be incorporated into Toucan crossings, where cyclists gain an advantage by being ahead of vehicles, Bermondsey.
Cul-de-sacs and road closures

8.21
Traffic free links through the closed end of a cul-de-sac or road closure are very valuable in providing accessibility and advantage to cycling compared to other modes. This ‘filtered permeability’ approach should be included as part of the initial planning in new developments to encourage walking and cycling journeys. Retrofitting such cycle links requires minimal infrastructure and can be used to link up routes on quiet roads.

8.22
Opening through access on roads that have previously been closed to cycle traffic will need community engagement to ensure proposals are accepted. Concerns about crime are common although research indicates that burglary rates are higher in a cul-de-sac than in locations with more pedestrian and cycle activity.

8.23
Cumbersome access controls in response to “perceived safety” are likely to reduce much of the benefits of the links and should not be included in the designs.

Flush Kerbs

8.24
All dropped kerbs for use by cyclists should be flush with a maximum upstand of +/- 6mm. This will also assist pedestrians and mobility impaired users. Greater kerb upstands cause discomfort and can be hazardous particularly where the kerb is crossed at a low angle, such as the merge and diverge transitions above.

8.25
A flush kerb can be achieved by use of a channel block or laying a bull nosed kerb upside down; bull nosed kerbs should not be laid in the conventional orientation.

8.26
Effective drainage can be achieved by using channel drainage or by correct positioning of gullies to suit the carriageway fall. Slotted channels prevent surface water encroachment onto footways. Gully grates should be orientated with slots perpendicular to the direction of cycle travel, or replaced by gully covers with small openings, to prevent cycle wheels from becoming stuck. Dished channels can define the carriageway margin where a formal kerbline has been removed but are not appropriate for use at cycle crossings.
8.27 The impact of tactile paving should also be considered. The use of excessive tactile paving can create discomfort for pedestrians, cycle users and individuals with some mobility impairments, and concerns about slip hazards particularly on steep gradients.

8.28 Provision of flush kerbs throughout a cycle network may merit a ‘mass action’ programme whereby all dropped kerbs with upstands along cycle routes are made flush.

Notes
1. All kerb transitions must be flush (±6mm)
2. Where cycle access may be obstructed by parking, consider use of a build-out, waiting restrictions, white line or ‘keep clear’ markings
3. Additional drainage likely to be required at transitions
9. References

Cardiff Council (2011) Cardiff Cycle Design Guide
Chartered Institution of Highways and Transportation (2010)
Manual for Streets 2
CTC (1993) Cyclists and Roundabouts
Department for Transport (2002) Inclusive Mobility: A Guide to Best Practice on Access to Pedestrian and Transport Infrastructure,
Department for Transport (2008) Cycling Infrastructure Design, LTN 2/08,
Department for Transport (2014) Traffic Signs Regulations and General Directions Consultation Draft
HA (1993) TD36/93 Subways for Pedestrians and Pedal Cyclists
HA (1995) TD42/95 Geometric Design of Major / Minor Priority Junctions
HA (2007) TD54/07 Design of Mini-roundabouts
HA (2007) TD16/07 Geometric Design of Roundabouts
Layfield and Maycock (1986) Pedal Cyclists at Roundabouts, Traffic Engineering and Control, June 1986
Sustrans Technical Information Note 17 Cyclists’ Use of Zebra Crossings.
Sustrans Technical Information Note 30 Parapet Heights on Cycle Routes
TfL (2014) London Cycling Design Standards
TfL (2014) International Cycling Infrastructure Best Practice Study
TRL (2014) Literature Review Looking at Dutch Style (Fully Segregated) Signalised Junctions, PPR716
TRL (2014) Fully segregated signalised junctions (Dutch Style), summary report
TRL (2014) Literature Review Concerning Ways for Cyclists to Turn Right at Signalised Junctions, PPR717

TRL (2014) Cyclists turning right at signalised junctions, summary report

TRL (2014) High Level Signals with Red Cycle Aspect: Track Trial Report, PPR715

TRL (2014) High Level Cycle Signals Trial, summary report