Traffic Signs Manual

CHAPTER 6

Traffic Control

2019

Traffic Signs Manual

Chapter 6

Traffic Control

Department for Transport

Department for Infrastructure (Northern Ireland)

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Traffic Signs Manual

Contents of Chapters 1–8

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1 INTRODUCTION

1.1 Overview

1.1.1. The Traffic Signs Manual (the Manual) offers advice to traffic authorities and their contractors, designers and managing agents in the United Kingdom, on the correct use of traffic signs and road markings on the highway network. Mandatory requirements are set out in the Traffic Signs Regulations and General Directions 2016 (as amended) (TSRGD). In Northern Ireland the relevant legislation is the Traffic Signs Regulations (Northern Ireland) 1997 (as amended). Whilst the Manual can assist with complying with the mandatory requirements, it cannot provide a definitive legal interpretation, nor can it override them. This remains the prerogative of the courts or parking adjudicators in relation to the appearance and use of specific traffic signs, road markings etc. at specific locations.

1.1.2. The advice is given to assist authorities in the discharge of their duties under section 122 of the Road Traffic Regulation Act 1984 and Part 2 of the Traffic Management Act 2004 in England and under Part 1 of the Roads (Scotland) Act 1984. Subject to compliance with the Directions, which are mandatory (see **1.4.2** and **1.4.3**), it is for traffic authorities to determine what signing is necessary to meet those duties.

1.1.3. The Manual applies to the United Kingdom. References to “the national authority” should therefore be interpreted as referring to the Secretary of State for Transport, the Department for Infrastructure (Northern Ireland), the Scottish Government or the Welsh Government as appropriate. Any reference to the “Department” is a reference to the Department for Transport or the appropriate national authority for Northern Ireland, Scotland or Wales as described above.

1.1.4. This chapter of the Manual contains advice recommended for those designing traffic signal junctions and crossings on roads with a speed limit of 40 mph and under, particularly in urban areas. It also provides advice on the design of wig-wag signals, tram signals and lane control signals. For junctions on roads with speed limits above 40 mph, the advice given in Highways England’s Design Manual for Roads and Bridges (DMRB) may be more appropriate.

1.1.5. The following documents are superseded by the advice in this chapter:

a) Traffic Advisory Leaflet 2/03 ‘Signal-control at Junctions on High speed Roads’, in respect of the advice on Speed Assessment and Speed Discrimination
b) Traffic Advisory Leaflet 3/03 ‘Equestrian Crossings’
c) Traffic Advisory Leaflet 5/05 ‘Pedestrian Facilities at Signal-controlled Junctions’
d) Traffic Advisory Leaflet 1/06 ‘General Principles of Traffic Control by Light Signals’
e) Traffic Advisory Leaflet 1/08 ‘Wig-wag signals’
f) Traffic Advisory Leaflet 1/13 ‘Reducing Sign Clutter’
g) Local Transport Note 1/95 ‘The Assessment of Pedestrian Crossings’
h) Local Transport Note 2/95 ‘The Design of Pedestrian Crossings’
i) Local Transport Note 1/98 ‘The installation of traffic signals and associated equipment’

1.1.6. Engineers who design and maintain the road network must be able to offer consistent standards that can satisfy road users’ needs. Traffic authorities depend on signing and signalling for the efficient control and movement of traffic, for enforcement of traffic regulations and, most importantly, as an aid to road safety. It is therefore recommended that all major traffic signalling work should have been designed or checked by someone with an appropriate qualification.

1.1.7. An example qualification would be the Institute of Highway Engineers' Professional Certificate in Traffic Signal Control that allows applicants to demonstrate their experience and produce work to the required standard. For more information please see:

www.theihe.org/professional-certificates

1.2 Legal

1.2.1. Traffic signs are placed by the traffic authority, through the powers provided by the Road Traffic Regulation Act 1984, to provide warnings, information and details of restrictions to road users. The police and certain other public bodies and statutory authorities also have the right to place traffic signs, but only in the limited circumstances provided for by the relevant legislation. All traffic signs (which include traffic signals and road markings) placed on a highway or on a road to which the public has access (right of passage in Scotland), as defined in section 142 of the Road Traffic Regulation Act 1984 and amended by the New Roads and Street Works Act 1991, must be either prescribed by Regulations or authorised by the Secretary of State for Transport (for installations in England), the Department for Infrastructure (Northern Ireland), the Scottish Government or the Welsh Government as appropriate.

1.2.2. Care should be taken to ensure that traffic signs are used only as prescribed in the Regulations, and in accordance with any relevant directions, and that no non-prescribed sign or signal is used unless it has been formally authorised in writing. Failure to do so may leave an authority open to litigation, or make a traffic regulation order or traffic control measures unenforceable.

1.2.3. There could be circumstances where it might be appropriate to use prescribed signs or signals in a manner that is not strictly in accordance with the General Directions or the Schedule-specific Directions. In such cases, a special direction (not an authorisation), given in writing, should be sought from the Department. Except in the case of certain signs to indicate temporary obstructions or placed by the police in an emergency, signs may be placed only by, or with the permission of, the traffic authority.

1.2.4. Occasionally a sign, signal or marking that is not prescribed by the Regulations may be authorised by the national authority for placing on a public highway.

1.3 Definitions

1.3.1. In the Manual, the word "must" is used to indicate a legal requirement of the Traffic Signs Regulations and General Directions (or other legislation) that must be complied with. The word "should" indicates a course of action that is recommended and represents good practice. The word "may" generally indicates a permissible action, or an option that requires consideration depending on the circumstances.

1.3.2. Section 64 of the Road Traffic Regulation Act 1984 defines a traffic sign as "any object or device (whether fixed or portable) for conveying to traffic on roads or any specified class of traffic, warnings, information, requirements, restrictions or prohibitions of any description … and any line or mark on the road for so conveying such warnings, information, requirements, restrictions or prohibitions" and stipulates that these signs be "specified by regulations made by the national authority, or authorised by the national authority". The types of signs and their appropriate use are prescribed in TSRGD.

1.3.3. "Signing" includes not only traffic signs mounted on supports (and other structures such as gantries, bridges, railings, etc.) but also carriageway markings, beacons, studs, bollards, traffic signals, matrix signals and other devices prescribed in TSRGD.

1.3.4. A glossary of commonly used technical terms, and a table of commonly used drawing symbols is at Appendix A. Designers are advised to familiarise themselves with both.

1.4 References

1.4.1. Any reference to the "Regulations" or the "Directions" is a reference to the Traffic Signs Regulations and General Directions 2016 (as amended), applicable to England, Scotland and Wales. Reference to a diagram number or to a Schedule is a reference to a diagram or Schedule in those Regulations.

1.4.2. In Northern Ireland, the relevant legislation is the Traffic Signs Regulations (Northern Ireland) 1997 as amended, and the Zebra, Pelican and Puffin Pedestrian Crossing Regulations (Northern Ireland) 2006. Diagram numbering occasionally differs in these Regulations and references to Schedules do not apply to Northern Ireland. The design of road markings, meanings and permitted variants are generally similar but can vary; where the two Northern Ireland Regulations apply, the designer is advised to read them in conjunction with the Manual.

1.4.3. Not all road markings referred to in the text are included in the two Northern Ireland Regulations. References to directions are not applicable in Northern Ireland; where these are referred to, advice should be sought from the Department for Infrastructure's Roads Service Headquarters.

1.5 Format

1.5.1. Any reference to a "Chapter" is a reference to a Chapter of the Traffic Signs Manual, and any reference to a "section", unless otherwise stated, is a reference to a section within a chapter of the Manual. Reference is also made to Requirements and Advice documents in the Design Manual for Roads and Bridges (DMRB), published by TSO and available at:

www.standards-for-highways.co.uk/dmrb

1.5.2. Note that DMRB is being revised at the time of writing, and designers should check the status of individual documents before use.

1.5.3. References to Schedules, Parts, items and paragraphs within TSRGD are shown in an abbreviated format. In this system, "Schedule" is shortened to "S" and "Part" is indicated by the second number without a prefix. The final element, variously "item" or "paragraph" is also denoted by a number without a prefix. This is illustrated in the following examples:

"Schedule 9, Part 6, item 25" becomes "S9-6-25"

"Schedule 11, Part 6, paragraph 3" becomes "S11-6-3"

"Schedule 12, Part 2" becomes "S12-2"

1.5.4. The numbering system contained in the Manual utilises three levels comprising sections, sub-headings and numbered paragraphs. Internal references are in **bold blue.**

1.6 Working drawings

1.6.1. Dimensions on the figures are in millimetres unless stated otherwise. Many signs are fully dimensioned in the Regulations. Detailed working drawings of the more complex ones are available at:

www.gov.uk/government/collections/traffic-signs-signals-and-road-markings

1.6.2. Working drawings for Welsh and English bilingual signs are available at

https://gov.wales/traffic-signs-and-road-markings

1.7 Use of traffic signals

1.7.1. Traffic signals are a key tool in managing traffic. They are provided for a number of reasons – to manage flows and delays between main and side roads, to provide safe crossing places, and to reduce conflicts.

1.7.2. They achieve this by separating conflicting traffic in time, and sometimes space, safely, efficiently and effectively. Note that the term “traffic” includes all road users: pedestrians, pedal cycles (which are vehicles), equestrians, public service vehicles, and motor vehicles.

1.7.3. In the past the design philosophy for traffic signals has tended to prioritise the movement of motor traffic, with other road users and consideration of the wider street environment taking second place. In places this has led to junctions that are over-engineered for the location and which provide a lower level of service for pedestrians and cyclists.

1.7.4. There has been considerable shift in street design in recent years, with an increasing focus on ‘place’ over ‘movement’, particularly in urban areas. The advice in this chapter takes its lead from the Manual for Streets and Manual for Streets 2, which include a hierarchy of provision putting pedestrians at the top and motor traffic at the bottom. While recognising that the primary function of traffic signals is to control vehicular traffic, this type of approach is likely to be more suitable for dense urban areas (see **Figure 1-1**).

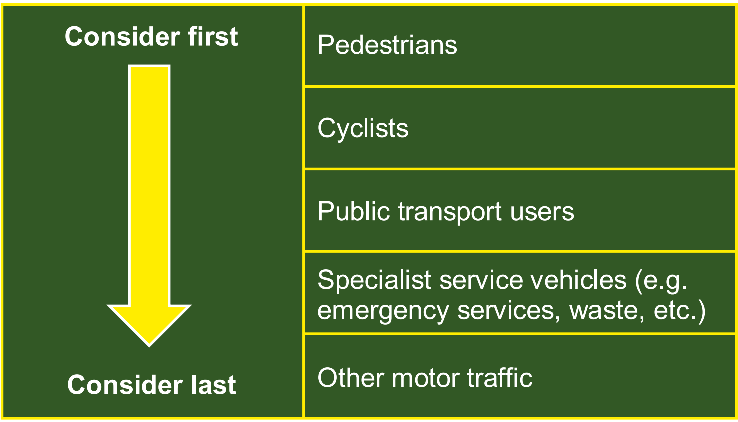


Figure 1-1 Hierarchy of provision

1.7.5. Where signals are justified, the aim is to maximise capacity, reduce delays to traffic as much as possible (accepting that there will be some) and to reduce the risk of accidents. Traffic flows, available road space, layout and stage sequences all affect how well the installation achieves this.

1.8 Justification

1.8.1. Signal control at a road junction may be justified if a site has a poor accident record, there is a need to provide better facilities for pedestrians and cyclists, or there is a dominant flow on one road leading to congestion.

1.8.2. Traffic authorities should develop policies and criteria to enable them to objectively assess the need for traffic signals at sites, taking into account these and any other local relevant factors.

1.8.3. Any assessment process should demonstrate that other types of junction control have been considered, and explain why they are not suitable.

1.8.4. Consideration of the costs of installation and maintenance should also form part of the assessment process. In order to work effectively, a signal control installation will require regular maintenance, not just for the equipment but for the associated road markings and signs. Traffic authorities should ensure that maintenance contracts will cover any proposed installations, particularly those put in place as part of new developments that they may be required to adopt in future. Advice on installation is given in section **27**.

1.8.5. The Department does not produce or advocate numerical flow criteria for junction assessments, as decisions on when to signalise a junction depend on many factors that will vary from site to site and cannot easily be quantified. Flow data will be part of the assessment process but has to be considered in context. There is a range of factors which will form part of an assessment, such as road layout, accident records, traffic speeds and vehicle counts.

1.8.6. Much of the above also applies to stand-alone crossings. In addition, suggested assessment criteria are set out in section **13**.

1.9 Consultation and publicity

1.9.1. There are no legal consultation requirements for a traffic signal junction. If the design incorporates banned movements or other restrictions, then these will require Traffic Regulation Orders (TROs) which must be made following the procedures set out in the relevant regulations.

1.9.2. Section 23 of the Road Traffic Regulation Act 1984 requires authorities establishing, altering or removing Zebra or Puffin crossings to consult with the local chief of police, and give public notice of the proposals. Notification to the Secretary of State is no longer required following the Deregulation Act 2015.

1.9.3. There are no set procedures for “giving public notice”, and authorities should consider what approach will ensure local residents, businesses and accessibility groups are properly informed and able to comment.

1.9.4. In addition to statutory requirements (where applicable), the Department strongly recommends that authorities engage with local residents and others affected by proposed works. It is particularly important to involve groups representing disabled people at an early stage, as a change from one type of facility to another can be disorientating. Any concerns raised should be considered and addressed as far as possible.

1.9.5. There are no statutory consultation requirements for equestrian, Parallel or Toucan crossings, or stand-alone signal-controlled pedestrian facilities (Pedex), but as above it is strongly recommended that engagement is carried out with those likely to be affected.

1.9.6. The Equality Act 2010 places a duty on public sector authorities to comply with the Public Sector Equality Duty in carrying out their functions. This includes making reasonable adjustments to the existing built environment to ensure infrastructure is accessible to all.

1.10 Control equipment

1.10.1. The Regulations removed the requirement for traffic control equipment to be of a type approved by the Secretary of State. Recognising that the removal of type approval meant there was a need for a body to maintain standards, the Department has worked with traffic authorities, as purchasers of this equipment, and representatives of the industry to set up TOPAS – Traffic Open Products and Specifications. TOPAS maintains a product register and the suite of TR technical specifications previously maintained by the Highways Agency (now Highways England). To be included on the register of TOPAS products, manufacturers self-certify that their equipment meets the relevant specification and has passed the relevant tests. This enables purchasers to check that equipment they are buying meets national good practice.

1.10.2. Although a voluntary process, the Department and the devolved administrations endorse the use of TOPAS-registered products and encourage all traffic authorities to specify TOPAS registration in the procurement process. Standard text for inclusion in tender documents is available from the TOPAS website at:

www.topasgroup.org.uk

1.10.3. To ensure safety standards are maintained, the 2016 Regulations also include safety-critical requirements that all traffic signal control equipment must comply with. S14-6-46 sets out that equipment used in connection with signals (including the content of all instructions stored in, or executable by, that equipment) may only be placed if it complies with the relevant requirements of BS EN 12675:2001 and BS EN 50556:2011. These relate to safety-critical matters such as failure modes and signal states dangerous to traffic.

1.11 Post-installation

1.11.1. At installation, any signal design provides a base that will need validating on site. Once a site has been installed and is operating, any assumptions made during the design phase should be validated by on-site observations. For example, timings may need adjusting in the light of real-world experience.

1.11.2. Signal installations should be reviewed on a regular basis, and adjusted or upgraded where necessary. This may include adjusting timings to take account of changes in traffic patterns and flows. Other post-installation modifications may include providing selective vehicle detection to support priority for bus services, changing the control strategy, or removal of redundant facilities. If the installation no longer meets the criteria under which it was put in, consideration should be given to removal.

Section I
Signal-Controlled Junctions

2 LAYOUT REQUIREMENTS

2.1 General

2.1.1. This section provides general guidance on the layout of traffic signal-controlled junctions on roads with a speed limit of 40 mph or below. For junctions on roads with speed limits above 40 mph, the advice given in DMRB may be more appropriate.

2.1.2. In the context of this document, at a signal-controlled junction: an arm is one road forming part of the junction; an approach is that part of the arm which carries traffic towards the junction and a traffic stream consists of vehicles in one or more lane, on the same approach, which, when they have right of way, will move in the same direction.

2.1.3. The IHE Guidance Note 'Traffic Control and Information Systems' recommends and makes reference to good practice to be adopted for all traffic control systems. It covers all stages of the life cycle, from design and installation, through to maintenance and operation, to decommissioning. It updates and replaces 'TA84: Code of Practice for Traffic Control and Information Systems'.

2.1.4. The primary considerations for traffic signal design and placement are visibility and clarity. Road users approaching a junction should be clear what is required of them, with sufficient time to act on the information. The designer should ensure that drivers:

a) Have sufficient advance visibility to know what route to take at the junction;
b) On multi-lane approaches, are then guided into the intended lane or lanes by road markings and signs;
c) Have a clear view of the signals at the junction;
d) Have a clear view of any crossing facilities;
e) Have adequate intervisibility within the junction (see **2.2**).

2.1.5. Recommended visibility distances to the junction are shown in **Table 2-1**. Those for speeds up to 35 mph have been calculated based on the research carried out in the development of the Manual for Streets. The value for 40 mph is taken from 'TD 9/93: Highway Link Design'. For speeds above 40 mph, designers should consult DMRB.

Table 2-1 Recommended visibility distances

85th percentile speed (mph)	20	25	30	35	40
Recommended Stopping Sight Distance (m)	22	31	40	51	80

2.1.6. Signal-controlled junctions are not recommended where the 85th percentile approach speed exceeds 65 mph.

2.2 Junction intervisibility zone

2.2.1. The junction intervisibility zone is the area within which drivers and pedestrians should be able to see each other, at the stop lines and while waiting to cross (see **Figure 2-1**).

2.2.2. It is defined as the area measured from 2.5 m behind each stop line extending across the full carriageway width. Where advanced stop lines (ASLs) are provided for cyclists (see **12.14**), the intervisibility zone should ideally be measured from behind the first stop line. If the intervisibility envelope cannot be maintained from the first stop line then it should be measured from the second stop line. This recognises the fact that drivers may need to encroach on the ASL if the signals have failed.

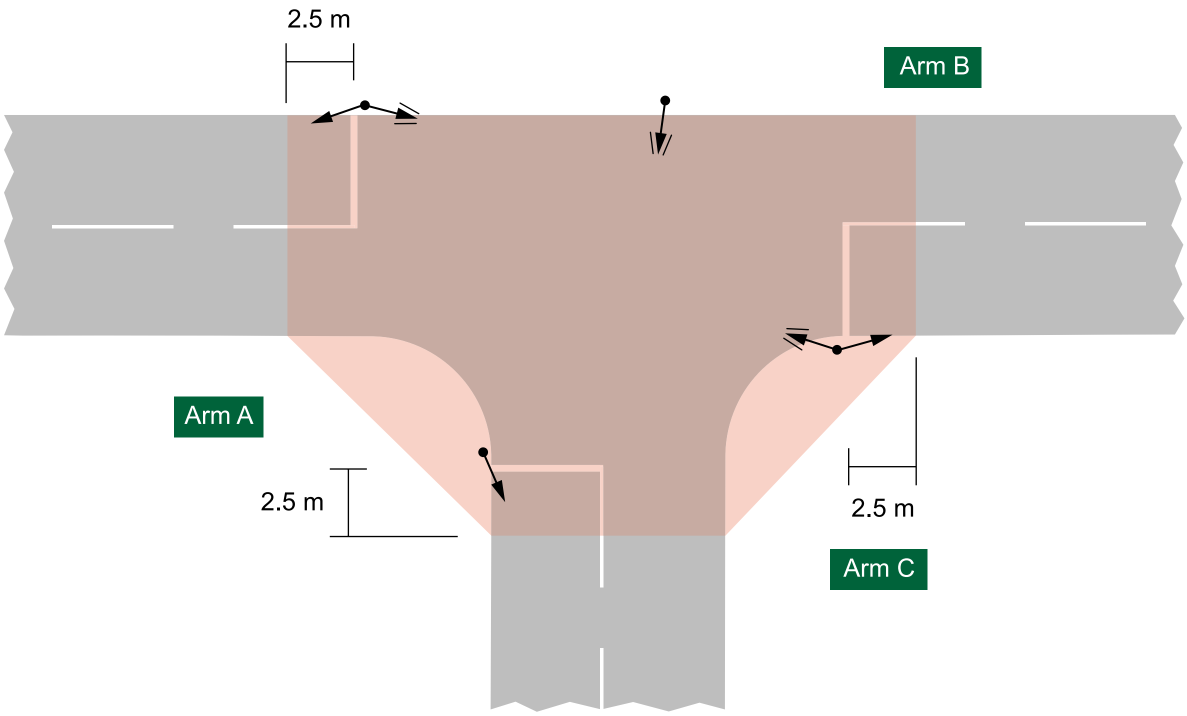


Figure 2-1 Diagram showing a Junction Intervisibility Zone (without crossings) in relation to the road layout

2.2.3. The zone should include the full width of tactile paving provided for crossing facilities (see **Figure 2-2**).

2.2.4. Visibility requirements at signal-controlled junctions are less onerous than for give-way junctions, due to the control provided by the signals. The junction intervisibility zone should enable drivers to complete their manoeuvre through the junction safely once they have entered it.

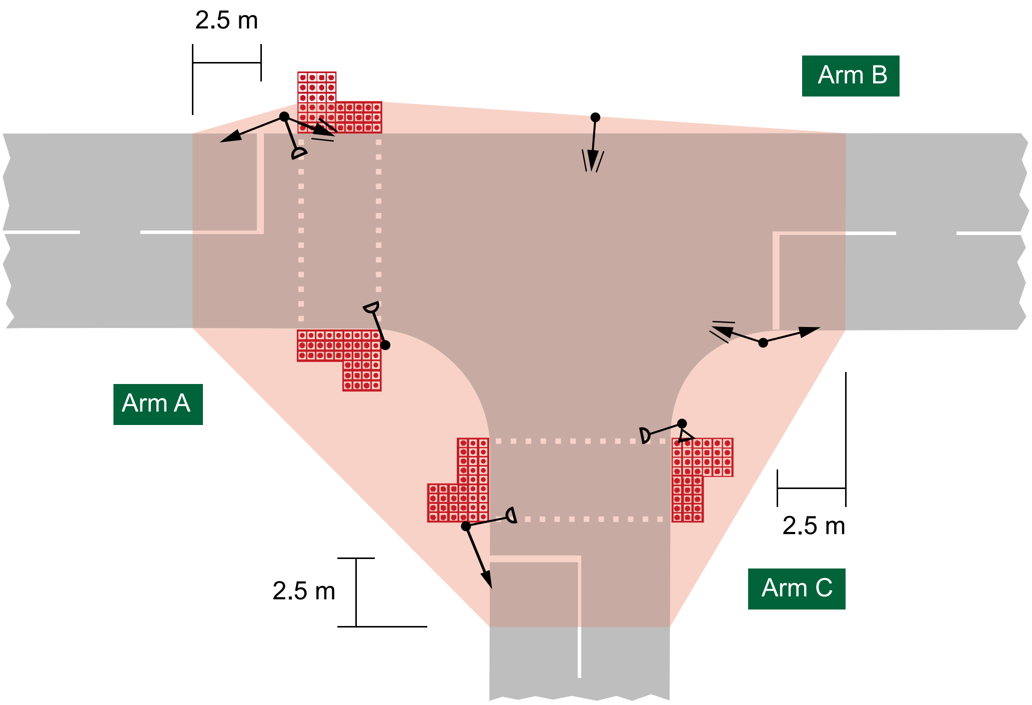


Figure 2-2 Diagram showing a Junction Intervisibility Zone (with crossings) in relation to the road layout

2.3 Obstructions

2.3.1. Adequate intervisibility helps ensure the safety of road users at junctions, and the aim should be to provide the greatest level possible for both drivers and other users. However, in urban areas, existing building lines and other features may reduce the visibility possible below that set out above.

2.3.2. Minor obstructions to visibility can be reduced by ensuring signs, street furniture, planting, and other features are placed to minimise any impact. This will also help improve the environment for pedestrians.

2.3.3. The use of guardrailing should be minimised as far as possible. See **15.11** for detailed advice.

2.4 Corner radii

2.4.1. As set out in 'Manual for Streets 2: Wider Application of the Principles', in dense urban areas, where both approach speed and the proportion of heavy traffic is low, tighter radii than the traditional 6 m have been shown to work well. They are better for pedestrians and cyclists as they reduce the distance pedestrians have to walk, and reduce the speed of turning traffic. Tighter radii can also improve junction intervisibility where existing building lines create an obstruction, by allowing the stop line to be brought forward. This may reduce saturation flow, which will need to be taken into account in capacity assessments.

2.4.2. Larger vehicles are still able to negotiate junctions where minimal radii are used, depending on the available carriageway width (see **Figure 2-3**). Where the numbers of large vehicles are low, in many cases it will be better to use slightly wider carriageways at the junction and keep the radii lower, and to accept that large vehicles may need to occasionally cross into the opposing lane.

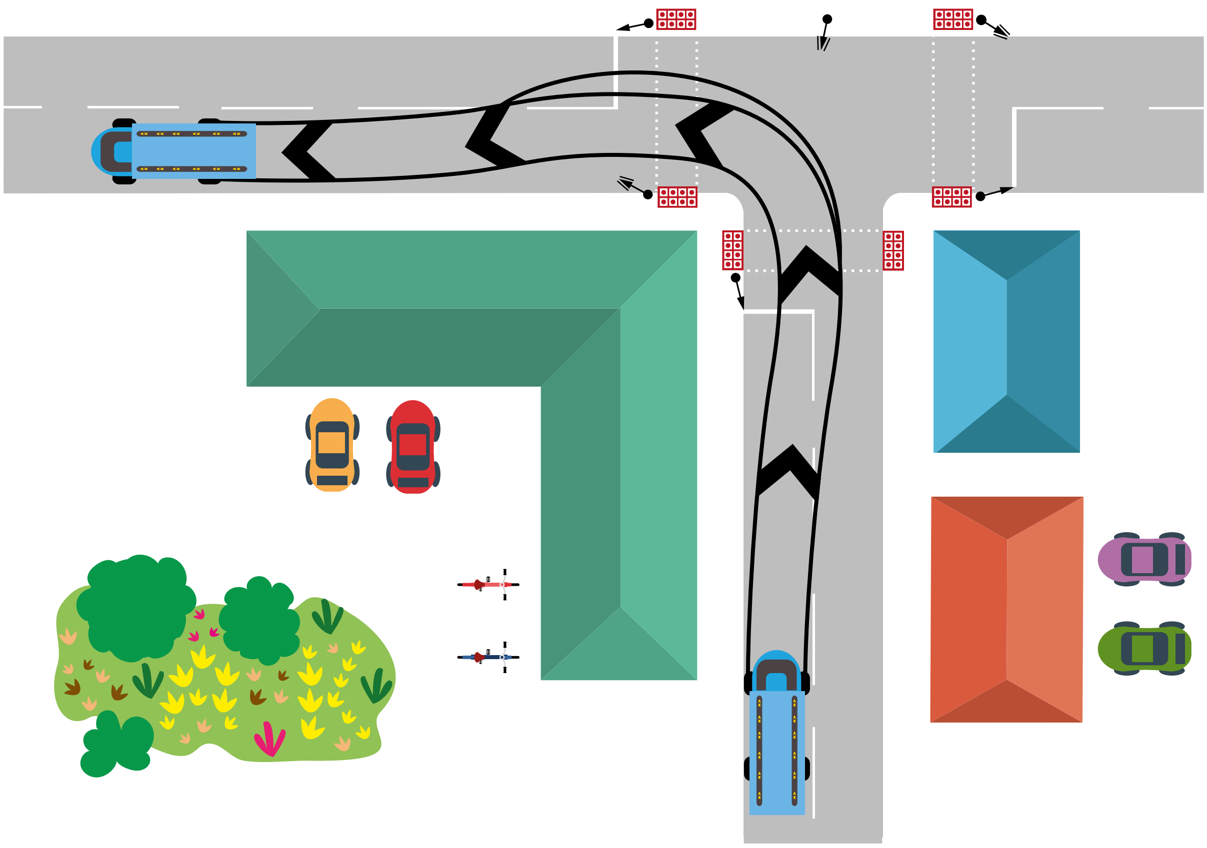


Figure 2-3 Despite the small corner radius, with sufficient carriageway width a long vehicle can still negotiate a junction

2.4.3. Vehicle tracking software should be used to test the swept path requirements for possible layouts, rather than relying on accepted standards.

2.4.4. Where there is a large proportion of Heavy Goods Vehicles (HGVs), the stop line can be set back to enable them to negotiate the junction. However, the impact on pedestrians should be considered - any associated crossing facilities should not be moved with the stop line if possible, to avoid taking pedestrians off their desire line (see **11.14.4**).

2.5 Lane widths

2.5.1. While the design lane width has traditionally been 3.65 m in the UK, narrower lanes may be appropriate in many circumstances, particularly built-up areas where space is constrained.

2.5.2. Where an existing junction is being signalised, lane widths will be constrained by the available carriageway. Where traffic speeds, HGV and bus numbers are low, lane widths at the stop line may be as low as 2 - 2.5 m. For new junctions, the appearance and 'place' functions of the surrounding environment should be considered and lane widths chosen as appropriate to ensure the junction design fits with the overall aim of the scheme.

2.5.3. Where large numbers of HGVs and buses are expected wider lanes may be more appropriate. It should be borne in mind that lane widths between 3.2 m and 4 m can be unsatisfactory where cyclists and motor traffic are expected to move together, as this range leaves insufficient room for drivers to pass cyclists safely.

2.6 Left turn slip lanes

2.6.1. Left turn slip lanes, whether give way or signal-controlled, should not be provided unless there is a significant proportion of left turning traffic, including HGVs. Segregated left turn slip lanes may increase capacity but they can also make pedestrian and cyclist movements more difficult, by adding extra distance to travel and making the crossing time longer. They require more signal heads and space within the junction, adding to clutter.

2.6.2. Where a left turn slip lane is justified, a separation island should be provided between the slip lane and other traffic lanes.

2.6.3. A give way left turn slip lane must be indicated with Give Way markings to diagram 1003A, the warning triangle to diagram 1023A and the upright sign to diagram 602. If visibility is such that a stop line would be justified, or where the give way and stop lines are so close as to risk confusing drivers, the left turn should be brought under signal control.

2.7 Separation islands

2.7.1. Separation islands may be used to separate two independently controlled lanes of traffic on the same entry, and are recommended where two movements share a stop line that has an associated pedestrian facility. Separation islands can also act as a refuge to help provide crossing places for pedestrians – if there is a substantial pedestrian movement, the islands should be designed to cater for this, following the advice in section **11** on pedestrian facilities.

3 LOCATION OF SIGNALS

3.1 General

3.1.1. The Regulations state that there must be a minimum of two signal heads visible per approach, at least one of which must be a primary signal (S14-6), unless the approach is for traffic consisting only of pedal cycles, in which case a minimum of one signal head is permitted. This is to allow drivers to see one signal head while approaching the junction, and one while waiting at the stop line. It also allows for a degree of redundancy if one signal head fails, which is particularly important in the event of red lamp failures.

3.1.2. The primary signal is placed beyond the stop line, or second stop line if an advanced stop line is provided, normally on the near side, and in front of any crossing studs. It should be at least 1.5 m from the stop line, although 2.5 m is preferable. 1.2 m may be appropriate where ASLs are provided. Where the approach controls pedal cycle traffic only, the distance may be further reduced, particularly where low level cycle signals are used.

3.1.3. The second required signal may be of any of 3 other types. **Figure 3-1** shows a primary signal plus secondary signal usually placed on the far side of the junction, for example on a small island. This must show the same information as the primary signal, but may include additional information if this does not conflict with the primary head.

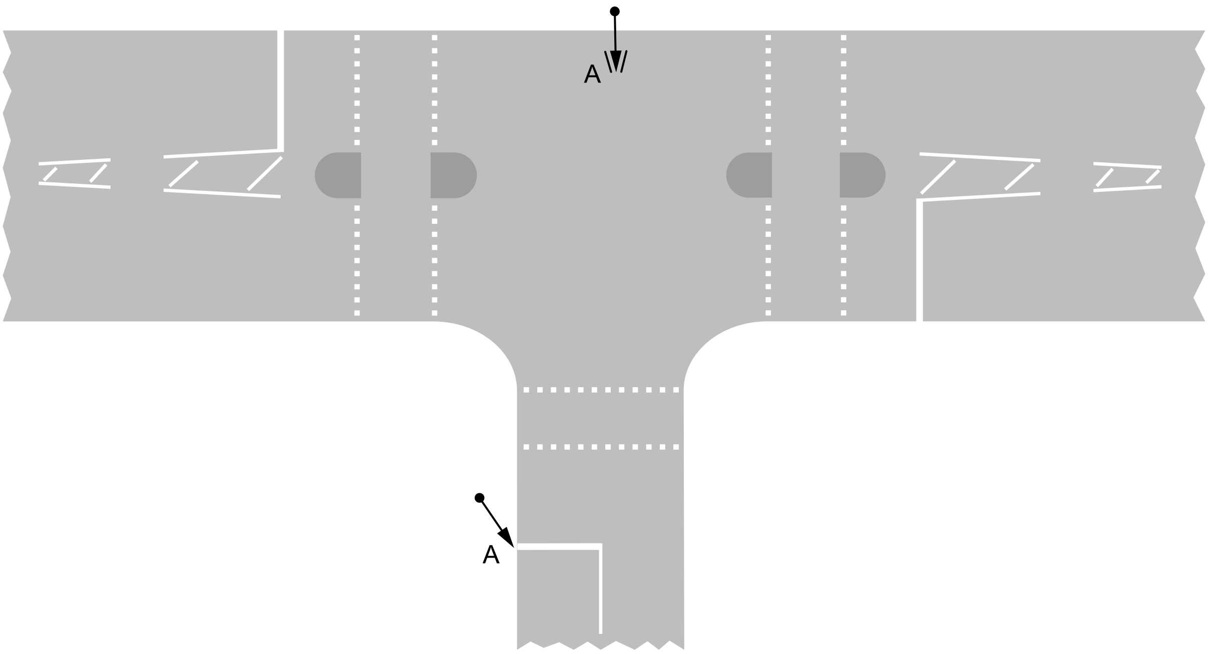


Figure 3-1 Layout diagram showing the positions of a primary signal head, plus a secondary signal head placed on the far side of the junction

3.1.4. **Figure 3-2** shows a primary signal plus a double or duplicate primary: a further primary head placed on the entry side of the junction, on the off-side and sometimes on a small 'splitter' island.

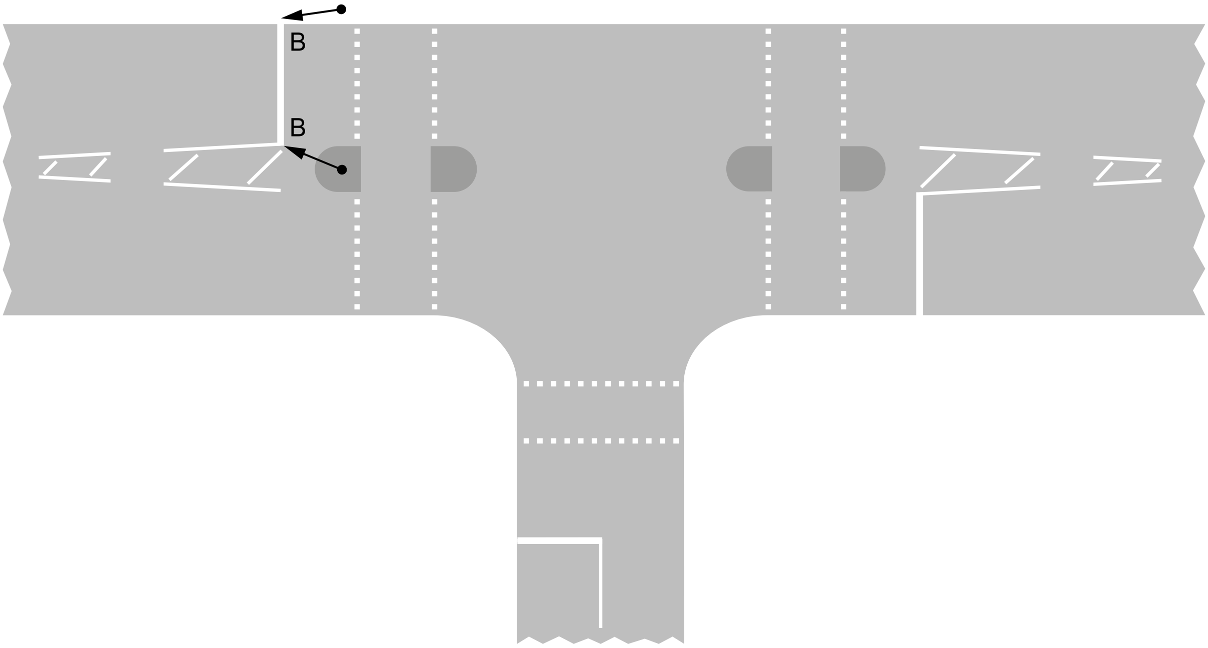


Figure 3-2 Layout diagram showing the positions of a primary signal head, plus a double or duplicate primary signal head

3.1.5. **Figure 3-3** shows a primary signal plus a closely associated secondary signal head placed on the entry side of the junction, beyond the primary signal but preferably on the off-side, and visible from the stop line. Otherwise, this is the same as a standard secondary head.

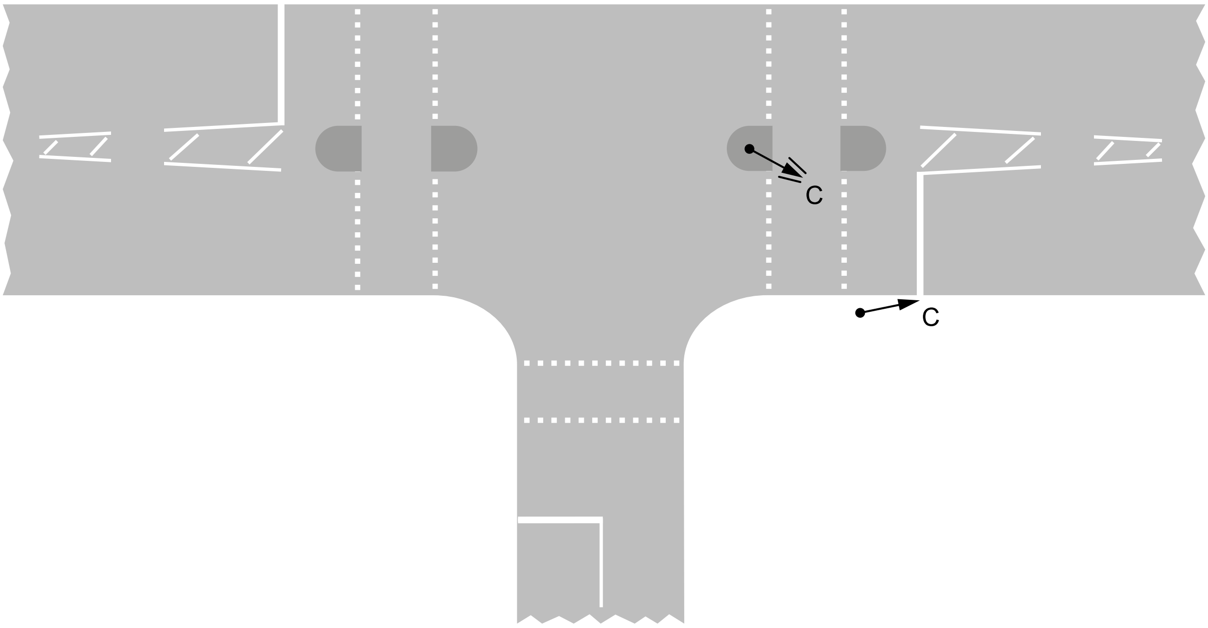


Figure 3-3 Layout diagram showing the positions of a primary signal head plus a closely associated secondary signal head

3.1.6. As far as possible, secondary signals should be placed within the direct line of sight of the driver. If this cannot be achieved it should be within 30° of the driver's line of sight (see **Figure 3-4**). Secondary signals should not be more than 50 m from their associated stop line.

3.1.7. A secondary signal should not be positioned on the far side of a junction approach if the opposite approach includes a right turn indicative arrow running within an early cut-off sequence. In this case, the change to red could be interpreted as applying to both approaches, endangering a right turning vehicle. Closely associated secondary signals should be used in these circumstances (see **8.3.5**).

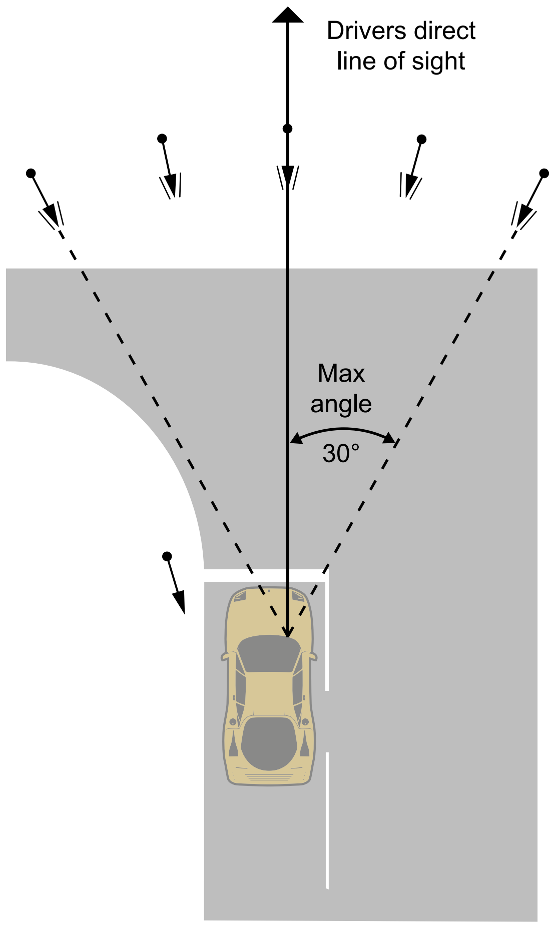


Figure 3-4 Layout diagram showing the recommended angle of position of secondary signal heads relative to a car positioned at the stop line

3.2 Signal heads

3.2.1. The full range of permitted traffic signal heads is set out in S14-2. This covers pedestrian, cyclist, equestrian and vehicle signals, and includes associated signs and road markings that may be combined with signals to create junctions and crossings.

3.2.2. Vehicle signal heads must be "ES Compliant", that is, they must comply with BS EN 12368:2015. The relevant clauses are set out in S14-1-3.

3.2.3. S14-3 prescribes green arrows, tram signals and cycle symbols which may be combined or included within signal heads to allow for different control scenarios.

3.2.4. Individual elements in a signal head are known as "aspects". Signal heads may be provided with a black backing board, referred to in BS EN 12368 as a background screen, which enhances the conspicuousness of the signal, especially if there are background distractions such as advertisements, street lighting, or general visual 'noise'.

3.2.5. A white border may also be placed around the backing board to highlight it further, or placed on the signal head itself. A white border or backing board can help to enhance the definition of the signal head, which may be important if the signals are not working for any reason. The white border may also be retroreflective, which may be particularly helpful in the case of a local power failure, or in areas with no street lighting. Backing boards will increase the overall width of the signal head, which should be borne in mind.

3.3 Signal head alignment

3.3.1. This advice does not apply to approaches used only by cycle traffic, which are covered in section **12**. Where the 85th percentile approach speed is 35 mph or less, the primary signals should be directed at a point approximately 1.5 m above the half of the carriageway involved, at a distance of 50 m from the stop line.

3.3.2. On roads with an 85th percentile approach speed greater than 35 mph, the aiming distance should be increased to 200 m. If the visibility distance at a particular site is less than 200 m then the primary signal aiming distance should be the actual maximum visibility distance.

3.3.3. Signal heads should have a horizontal clearance of not less than 450 mm from vertically above the kerb edge to the nearest part of the assembly. This is to minimise the likelihood of damage to the signal heads from passing vehicles, especially vehicles with long overhanging mirrors or loads. On high speed roads, or where the road has a steep camber, the clearance may be increased to a minimum of 600 mm. Offset traffic signal head mounting brackets or cranked poles may be used to ensure that the horizontal clearance is maintained. Low level cycle signal heads to diagram 3000.2A may be used with a horizontal clearance of 250 mm if they are mounted on a separation island.

3.3.4. The height to the centre of the amber aspect for vehicle signals is prescribed in diagrams 3000 (S14-2-1) and 3000.2 (S14-2-3). A minimum clearance of 2.1 m between the lower edge of the signal assembly and the footway should be maintained, but the possibility of the later addition of regulatory box signs or additional green aspects below the existing traffic signal assembly should be considered.

3.3.5. An increased clearance of 2.3 m is recommended wherever cyclists may be present, and particularly for cycle signals to diagram 3000.2 (S14-2-3). Pedestrian, cyclist or equestrian signals to diagrams 4002.1 (S14-2-9), 4003.2 (S14-2-15), or 4003.5 (S14-2-19) should be erected with a clearance of 2.1 m - 2.6 m to the lower edge of the assembly.

3.4 Signal posts

3.4.1. A standard signal head is normally mounted on a post, within the height limits set out in diagram 3000 (see **Figure 3-5**). Signal heads may be mounted on lighting columns where the columns are in the right positions, which may help reduce street clutter. A structural assessment of the column may be required to ensure it is able to take the additional loading. Electrical connections should always be kept separate and be on the same electrical phase, to prevent a voltage difference of more than 240 V being present in the column.

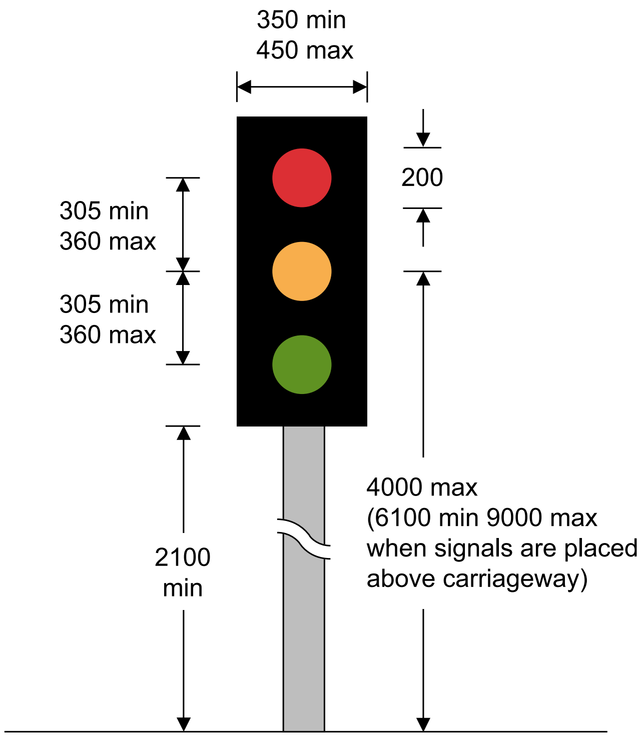


Figure 3-5 Diagram 3000 (S14-2-1) Permanent traffic signal head

3.4.2. Traffic signals by their nature are more visible than static signs. In most cases, a primary signal on the left-hand side of the road, and a secondary signal on the right-hand side will be sufficient to ensure visibility, particularly at stand-alone crossings.

3.4.3. There will always be circumstances where extra signal heads are required, such as on multi-lane approaches or where large numbers of heavy goods vehicles or buses are present, but their use should be carefully considered at the design stage. The aim should be to provide the minimum number of signal heads necessary for the installation to function safely.

3.4.4. Extra signal heads may be needed where visibility is compromised by factors such as poor sight lines caused by the road layout. In these cases, use of a taller post may be considered, to allow the signal head to be mounted above the standard height of 4 m to the centre of the amber aspect, up to a maximum of 6.1 m. Alternatively, an additional signal head may be added to a taller post above a signal head mounted at the standard height, or a signal head mounted above the carriageway by installing a post with a mast arm.

3.4.5. Mast arms and taller posts can present additional maintenance liabilities, and associated increased costs. Maintenance activities will impact on traffic flow, as lane or road closures will be required. In urban areas, due to the presence of buried services it may be difficult to find enough room within the footway to install the necessary foundations. Designers should check that the posts to be used are structurally approved for the specific design.

3.4.6. The use of signal heads beyond the minimum number required by the Regulations at stand-alone crossings has become almost a matter of course in some places. They are often unnecessary, create extra clutter and should be avoided except where necessary to address a particular safety problem.

3.4.7. To minimise the risk of driver confusion and distraction caused by too many signs on the signal posts, the types of additional signs that may be mounted on signal posts are prescribed in the Schedule 14 General Directions (S14-6-5).

3.4.8. Retention sockets and fully ducted systems are now widely used at traffic signal sites. Retention sockets consist of a foundation and socket set flush with the ground, into which the signal post is securely installed, and associated ducting. The socket system enables posts to be removed more easily, as they are not set directly into the ground. Damaged posts can be quickly replaced, and posts can be removed as a planned measure to enable abnormal loads to pass, or for special events.

3.5 Green arrows

3.5.1. A green arrow signifies that drivers may proceed only in the direction of the arrow (assuming no other green signal is shown) and continue through the junction in that direction. Exception plates cannot be used with green arrows as they apply to all traffic.

3.5.2. A green arrow may be fitted in place of the full green in a three aspect signal head. This is known as a “substitute green arrow” (see **Figure 3-6**). It may indicate any movement through 180° above the horizontal. A green arrow in this position must always be preceded by a red/amber signal, and terminated by an amber aspect.

3.5.3. Additional green arrows may be fitted in any of the positions indicated in S14-3 (see **Figure 3-6**). There are two main types:

a) **Filter arrow**: a green arrow displayed on its own, with an associated red signal. Not preceded by a red/amber signal, and followed by a full green signal. Commonly used to filter left turning traffic in advance of the main traffic movement, or to filter straight ahead movements at T-junctions.
b) **Indicative arrow**: additional green arrow displayed with a full green aspect, usually only on the secondary signal head. Preceded by a red/amber signal or a full green, and followed by an amber signal. The most common use is in early cut-off sequences to allow right turning traffic to clear (see **8.3**).

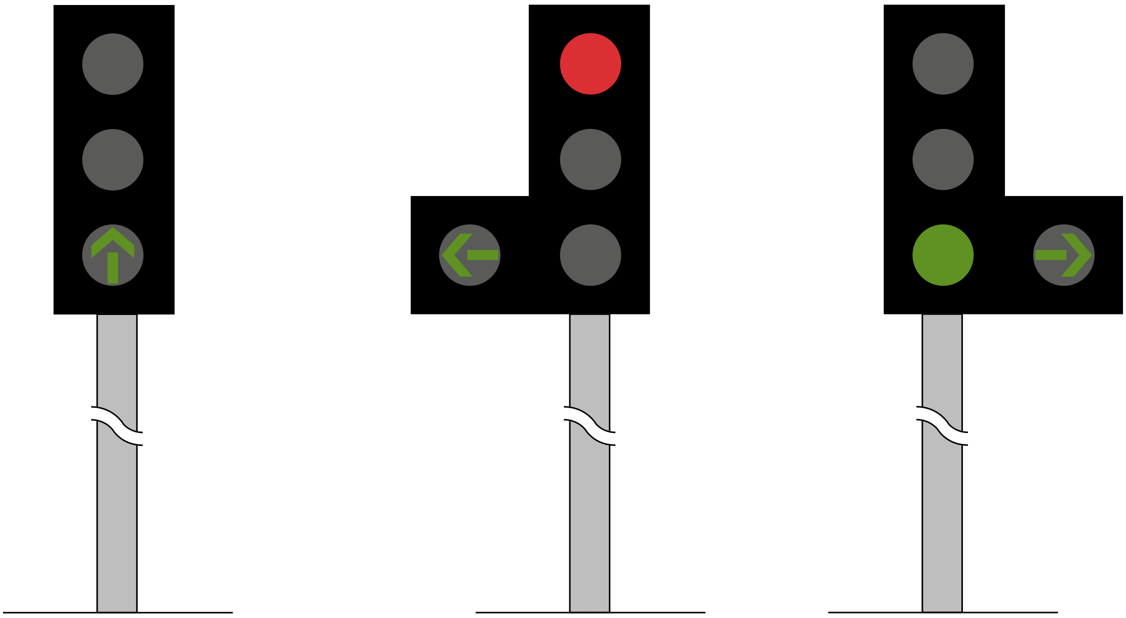


Figure 3-6 Diagrams showing alternative signal head arrangements incorporating, from left to right, a substitute green arrow, a left turn filter arrow, and a right turn indicative green arrow.

3.5.4. When green arrows are used drivers will expect an exclusive right of way. When filter and substitute green arrows are displayed there should therefore be no conflicting movements. Where right turn indicative arrows are used they should not be displayed until the conflicting movements are presented with a red signal. When used with an early cut off (see **8.3**), the indicative arrow follows a period when right turning traffic gives way to conflicting movements (under a full green signal). The arrow which then supplements the full green is indicative to right turning traffic that they have or are about to have right of way. Care should be taken in selecting an appropriate intergreen to precede the indicative arrow, as driver behaviour can vary, with some motorists assuming right of way immediately and others waiting for the last vehicles to clear the conflict point. In some cases, an intergreen of 3 s may be considered adequate, while in others a longer intergreen may be deemed necessary.

4 ROAD MARKINGS

4.1 General

4.1.1. Effective marking of the approaches to signal-controlled junctions is essential if the signals are to operate at their maximum efficiency. To achieve this:

a) the Stop line to diagram 1001 should be sited as near as practicable to the intersection.
b) lane lines should be arranged to secure the maximum use of available carriageway space consistent with adequate lane width; and
c) where lanes are dedicated to a particular turning movement, the appropriate lane destination arrows should be provided at the start of the lane, and repeated as necessary.

4.1.2. **Figure 4-1** shows a standard layout of the Stop lines, signals and pedestrian crossings at a signal-controlled crossroad junction.

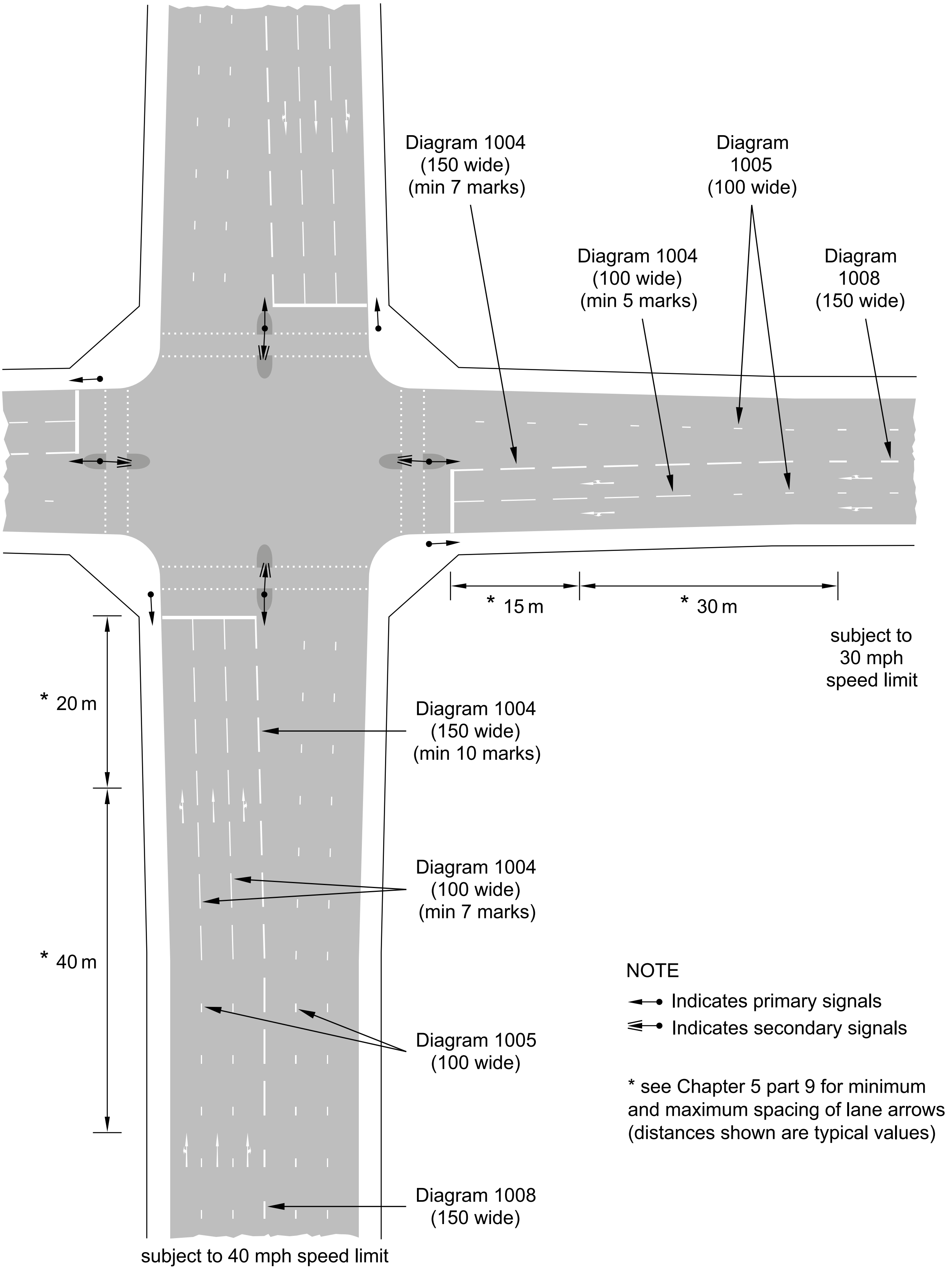


Figure 4-1 Layout of urban signal junction

4.2 Stop lines

4.2.1. The Stop line marking to diagram 1001 (S14-2-46) consists of a single continuous line 200 mm or 300 mm in width, and indicates the position beyond which a driver must not proceed when required to stop by the signals. The 200 mm width is generally for use in urban areas. The 300 mm width should be used in rural areas, or where the 85th percentile speed exceeds 35 mph. The greater width may also be used in urban areas at difficult locations, or where heavy traffic results in rapid erosion of the marking.

4.2.2. The Stop line will normally be at right angles to the centre line of the road to which it applies, even at skew junctions. It should be at least 1.5 m in advance of the near side primary signal, although 2.5 m is preferable. Site conditions may necessitate a greater distance.

4.2.3. It may be necessary to set back the Stop line to allow for positioning of the primary traffic signal and any pedestrian crossing facility (see **2.4.4**). At some junctions, Stop lines and near side primary signals need to be located sufficiently far back from the junction to enable long vehicles to turn into that road without being blocked by vehicles waiting at the Stop line. In setting back the Stop line, the requirement for crossing studs to diagram 1055.1 to be no more than 10 m from their associated traffic signals should be borne in mind.

4.2.4. Guidance on the use of advanced stop lines for cyclists is given in **12.14**.

4.3 Longitudinal markings

4.3.1. On the immediate approach to the signals, the normal lane marking to diagram 1005 (S11-4-4) or 1005.1 (S11-4-5) and the centre of carriageway marking to diagram 1008 (S11-4-6) or 1008.1 (S11-4-7) should change to the warning line versions to diagram 1004 (S11-4-2) or 1004.1(S11-4-3). Chapter 5 Table 2-3 gives details of the size and minimum number of marks recommended.

4.3.2. Lane markings may be laid within the junction where some guidance for drivers would be helpful, although care should be taken that the meaning is clear to drivers on all approaches. There should be no risk of giving the impression of a Stop or Give Way line to transverse movements. The arrow to diagram 1038.1 (S11-4-21) may be used to indicate a route through a junction.

4.3.3. **Figure 4-2** shows the use of a pair of arrows to diagram 1038.1 at a signal-controlled junction. Where a signal phase permits opposing right turns but no ahead movements from the right turn lanes, and there are no opposing dedicated lanes, use of the arrows to indicate that vehicles should pass near side to near side (non-hooking) may help prevent conflict. If the number of right turning vehicles is high, it may be of benefit to provide a dedicated right turn lane even if a separate signal stage is not provided.

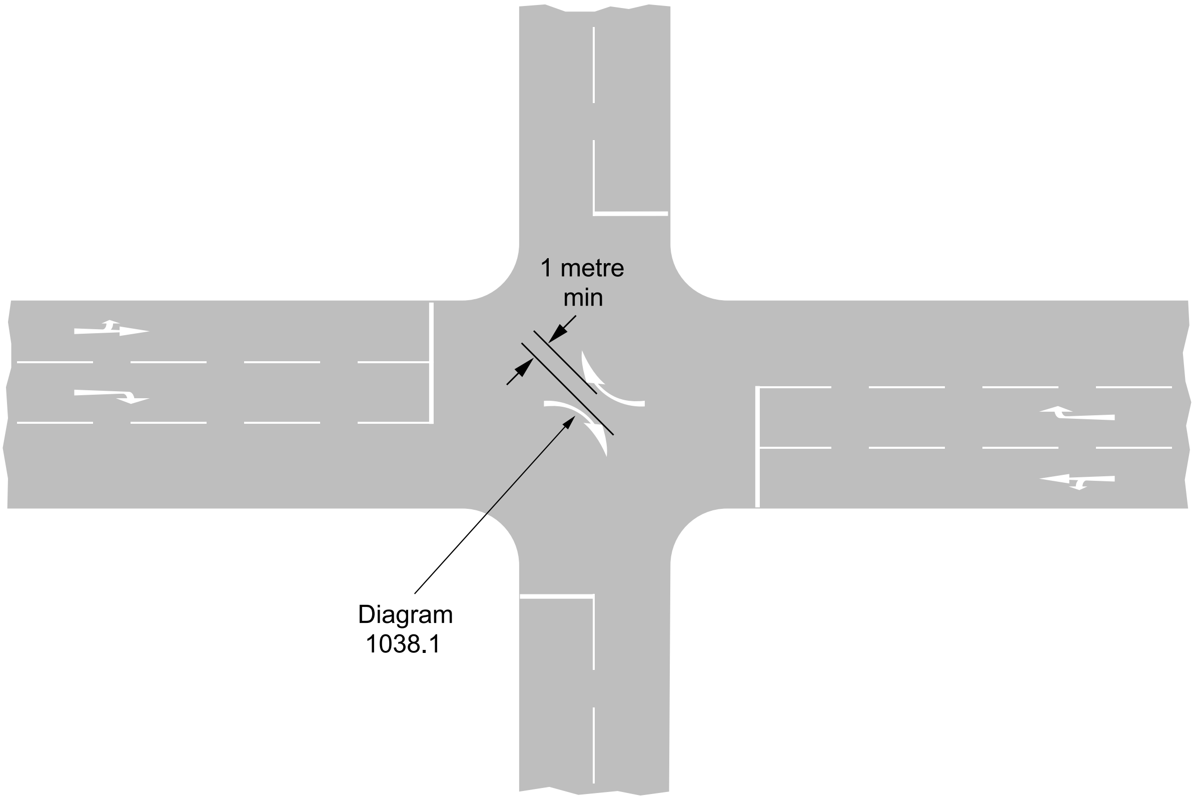


Figure 4-2 Layout of guidance arrows at a signal-controlled junction

4.4 Lane destination markings

4.4.1. It is essential that drivers are made aware in good time of the correct lane to use at signal-controlled junctions. Where lanes are indicated for left or right turn movements only, it is particularly important that early notice is given by the use of the appropriate lane arrow, repeated as necessary. If this is neglected, drivers may become trapped in the wrong lane. At some junctions it might also be helpful to provide lane destination markings to diagram 1035 (S11-4-19). A lane arrow should be used at the start of a newly formed lane, and at heavily trafficked junctions the lane markings, supplemented by upright signs as appropriate (e.g. to diagram 877 (S11-2-22)), should be extended sufficiently far upstream to cope with peak flows. The use of lane arrows and lane destination markings is further described in Chapter 5 section 9.

4.4.2. In all cases, the lane and centre line markings should meet the Stop line.

4.4.3. The number of lanes on the exit side of the junction should match the number of ahead lanes at the Stop line. If localised widening of an exit is necessary to achieve this, the subsequent reduction in the number of lanes should be carried out beyond the junction over a distance of at least 100 m for a single lane reduction. Deflection arrows to diagram 1014 may be used to warn of the impending lane loss (see Chapter 5 Table 2-6 for length and position of arrows). Normally, it should be the right-hand lane that is lost, so that slower vehicles are not required to merge with faster moving accelerating traffic. Upright signs to diagram 516 (S2-2-13), diagram 517 (S2-2-14), or diagram 872.1 (S11-2-15) are not normally appropriate where the lane loss occurs immediately after the junction. In order to maintain capacity at signalled junctions, it is important to keep the exits as well as the approaches clear of parked vehicles.

5 SIGNING

5.1 General

5.1.1. Signs on the approach to, and at the junction are an important part of the overall design. Regulatory, warning and informatory signs may be needed depending on the site circumstances. When considering additional signing that may be needed at a junction, the potential for clutter should be considered. Any existing signing should be audited and every opportunity taken to remove any redundant signs.

5.2 Regulatory signs

5.2.1. Signals on their own may not be able to convey all the information required to allow the junction to function in the most efficient, safe way. The signs to diagram 606 (S14-2-42), 612 (S14-2-42) and 613 (S14-2-43) with a diameter of 300 mm may be mounted on the primary and secondary signals. They must be internally illuminated at all times except when the light signals to which they are fixed are being maintained or repaired. Unlike at uncontrolled junctions it is not appropriate to use a sign to diagram 609 ("turn left/right ahead") at the junction itself. If appropriate, a sign to diagram 609 may be erected on the approach to the junction.

5.2.2. "Turn left" and "turn right" signs to diagram 606 should be mounted on the left or the right of the signal head respectively. Diagram 606 varied to show "ahead only" should be mounted immediately below the green aspect. "No left turn" and "no right turn" signs should be mounted on the left or the right of the green aspect respectively. Alternatively the signs may be mounted immediately below the green aspect.

5.2.3. Where only one manoeuvre is permitted, the signal head should include a substitute green arrow in place of a full green lens, to indicate the direction in which vehicles must proceed. Where both left and right turns are prohibited, a sign to diagram 606 pointing upwards should be used rather than both signs to diagrams 612 and 613. As at priority junctions, the signs at signal-controlled junctions may be supplemented by road markings to diagram 1036.1 (S9-6-19), diagram 1036.2 (S9-6-20), diagram 1037.1 (S9-6-21) or diagram 1038 (S11-4-20). For more detail on the use of these markings see Chapter 5.

5.2.4. Where appropriate, a sign to diagram 818.4 (S12-28-22), varied to a legend matching the restriction in place at the junction, or a map-type sign incorporating regulatory roundels may be used on the approach to the junction.

5.2.5. Where there is a left turn filter slip road immediately in advance of traffic signals but not controlled by them, any "no left turn" sign relating to the signals should not be sited with the primary signal head unless this is at least 10 m beyond the dividing nose. Where the distance is less, the sign should be mounted only on the secondary signal head.

5.2.6. "No entry" signs to diagram 616 (S14-2-44) may be placed on signal heads, but should only be used on the back of signal heads to indicate a one-way road exiting the junction. S14-2-44 prescribes a 300 mm diameter version for use in these circumstances.

5.2.7. Banned or required movements must have an associated TRO, including those indicated by a sign to diagram 606, as set out in S14-6-28. If a substitute green arrow is used to show a specific movement there is no requirement to include a box sign to diagram 606, but it may be useful in the event of signal failure, as it will still provide a visible indication of a banned and possibly dangerous movement. Where a sign to diagram 606 is used with an exemption, a green arrow cannot be used as this would mean those exempt from the requirement of diagram 606 would be unable to comply with the green arrow. In these cases, a full green aspect is required. **Figure 5-1** shows some commonly used signal head layouts that incorporate regulatory box signs – note that not all possible combinations are shown and the designer will need to consider which arrangement will be suitable for particular circumstances.

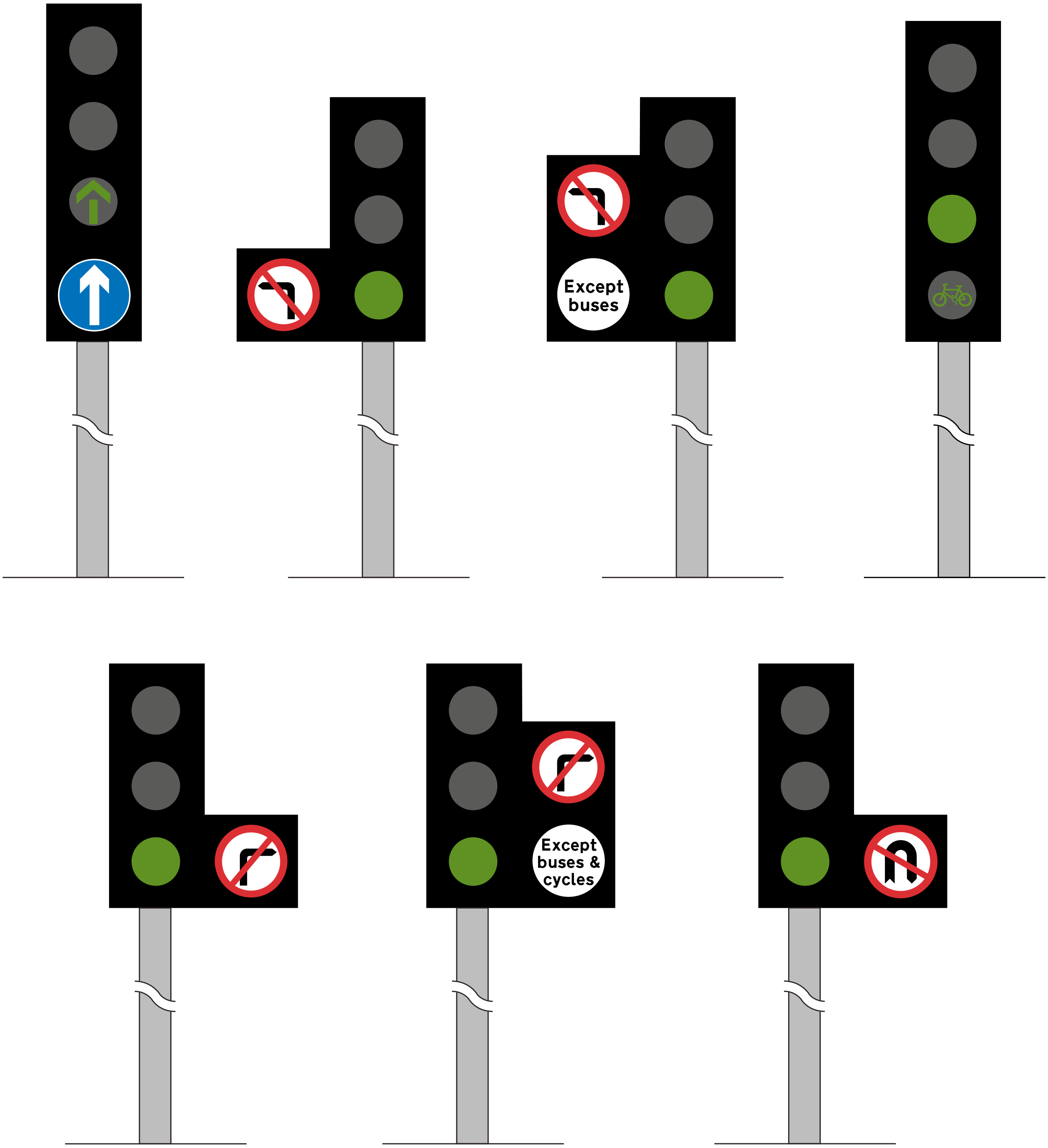


Figure 5-1 Alternative signal head layouts showing common regulatory box sign arrangements and exception plates

5.3 Supplementary exception plates

5.3.1. A TRO restricting the movement of vehicles through a junction may provide exceptions for buses, cycles and taxis. In such cases the signs to diagrams 606, 612 and 613 may be used with a supplementary plate excepting buses, local buses, cycles and taxis as appropriate. Exception plates to diagrams 954.5, 954.6 and 954.7 (S14-2-45) are circular with a diameter of 300 mm for use with signs mounted on traffic signal heads and must be internally illuminated at all times except when the light signals to which they are fixed are being maintained or repaired.

5.4 Warning signs

5.4.1. The ‘traffic signals ahead’ warning sign is shown in diagram 543 (S14-2-28, see **Figure 5-2**). A plate to diagram 572, varied to include an arrow, is used where the signals are located along another road. When used on a dual carriageway road with two lanes or more in each direction, the signs may be duplicated on the central reservation.

5.4.2. The “Part time signals” plate to diagram 543.1 (S14-2-29, see **Figure 5-3**) should always be used where the signals are in use for a period of less than 24 hours. The “Peak hour” variant may be used where appropriate. The plate should be used on each signal post, and in combination with diagram 543 on the approaches to the junction.

Figure 5-2 Diagram 543 (S14-2-28)
Traffic signals ahead

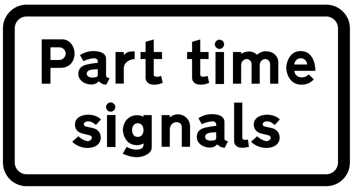


Figure 5-3 Diagram 543.1 (S14-2-29)
Part-time signals

5.4.3. Diagram 543 may be used with all three-aspect type traffic signals, including signal-controlled crossings. It is not for use with wig-wag signals to diagram 3014 (S14-2-5, see **Figure 24-1**), where diagram 563.1 (S14-2-7) or 773 (S14-2-6) should be used with the appropriate warning sign. Diagram 543.1 (S14-2-29) may be varied to create a distance plate.

5.4.4. The sign should not be placed routinely. Only where specific circumstances require it, such as where a bend obscures the site, or at sites where the speed limit is over 50 mph, should it be considered. Nor should it normally be used where visibility is impaired only by parked vehicles, when the imposition of waiting and loading restrictions should be considered.

5.4.5. Diagram 543 should generally be used only where the visibility distance of the signals is less than that specified in **Table 5-1**. A distance plate should not be necessary. Where distance plates are used, these must be in yards to the nearest 10 yards.

Table 5-1 Visibility distance criteria

85th percentile speed (mph)	Visibility distance of signals (m)
Up to 30	65
31 to 35	80
36 to 40	100

5.4.6. Where map-type advance direction signs are provided on the approach to a signal-controlled roundabout, diagram 543 (with the appropriate plate) should be installed, as drivers might not otherwise expect the signals.

5.4.7. The use of diagram 7014 indicating "NEW TRAFFIC SIGNALS AHEAD" should be avoided if at all possible. The sign has little benefit - drivers who are new to the area will know no different, and regular drivers will have seen the works taking place and will be aware of the changes already. Variants of diagram 7014 (S13-6-37, see **Figure 5-4**) indicating "SIGNAL PRIORITIES CHANGED" or "SIGNAL TIMINGS CHANGED" may be useful where the appearance of the junction remains unchanged and drivers may not necessarily know that a change to the method of control has taken place.

5.4.8. Diagram 7014 and its variants must have a "remove by" date on the back corresponding to the date of installation. The signs must be removed from display no later than 3 months after the completion of the works to which they relate. Where used, it may be preferable to place the signs on a temporary support such as an 'A' frame, so that they can be easily removed.

5.4.9. When maintenance work is being carried out on traffic signals, a temporary sign to S13-9-8 with the legend "TRAFFIC SIGNAL MAINTENANCE" may be used. If the traffic signals are not operating, signs to diagram 7019 (S14-2-61, see **Figure 5-5**) may be erected on the signal post. These must be reflectorised if not internally or externally illuminated.

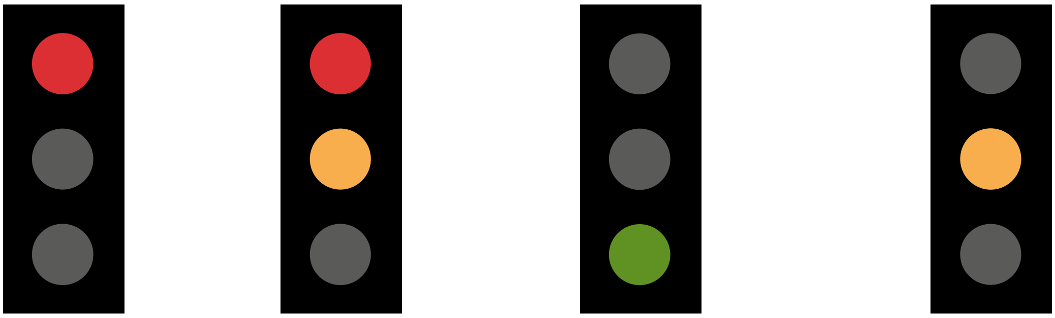
Figure 5-4 Diagram 7014 (S13-6-7)
Signal timings changed

Figure 5-5 Diagram 7019 (S14-2-61)
Traffic light signals not in use

6 BASIC PRINCIPLES

6.1 General

6.1.1. The signal sequence at junctions is prescribed in S14-1-4 and is shown in **Figure 6-1**.



RED means STOP. Wait behind the stop line on the carriageway until GREEN shows

RED and AMBER also means STOP. Do not pass the stop line until GREEN shows

GREEN means go IF THE WAY IS CLEAR. Take extra care if you intend to turn left or right, and give way to pedestrians who are crossing

AMBER means STOP. You may go on only if the amber appears after you have crossed the stop line or are so close to it that to pull up might cause an accident

Figure 6-1 Vehicular traffic signal sequence

6.1.2. The period during which an amber signal is displayed is fixed at 3 seconds (s) and the red/amber signal at 2 s, with a tolerance of 0.25 s either way. This is prescribed in S14-1-4. No variations to these values are permitted. There are no other fixed time periods within the signal sequence.

6.1.3. The controller allocates time intervals during which separate demands for each arm of the junction can make use of the available road space. How each arm of the junction is divided into separately signalled movements will depend on design traffic flows, site geometry and conditions and local driver behaviour. The duration of the red and green periods for each approach to a junction will vary from site to site and depend on a number of factors. These may include road geometry, traffic volumes and speed, time of day, day of week, numbers of pedestrians.

6.1.4. Responsive control systems use detection systems to monitor traffic flow through a junction. The controller uses this information to adjust the operation of the junction to reduce queues and delays as far as possible. Junctions should be designed to optimise operation as far as possible through responsive control systems.

6.2 Cycle

6.2.1. Traffic signal installations operate a cycle time made up of stages. An amount of green time is allocated to each approach, to allow traffic to pass through the junction. The cycle time will vary from site to site depending on circumstances, and should be matched to actual demand. Relatively short cycle times are generally better for traffic management. At junctions, cycle times greater than 120 s are not recommended.

6.3 Phase

6.3.1. A phase can be thought of as a unique electrical circuit from the controller to one or more signal heads. As it is on the same circuit, all signal heads for that phase will change at the same time. The number of phases will depend on the number of approaches, the amount of turning traffic, the number of signalised pedestrian movements and any vehicle-specific movements. Two or more phases may overlap in time. Vehicular phases include cycle-specific and green arrow movements.

6.3.2. A consistent approach to labelling phases should be adopted. Phases are usually labelled alphabetically, with full vehicular phases on all arms allocated first, followed by any supplementary phases such as green arrows. The lettering is often organised so that the phases appear in alphabetical order in a typical stage sequence. After the full vehicular phases and arrows have been labelled, any pedestrian or cycle-specific phases take the next letters and any special phases, such as dummy phases, are labelled thereafter. **Figure 6-2** shows phase and stage labelling for a typical crossroads junction.

6.4 Stage

6.4.1. Phases are assigned to stages. A stage can be defined as a period of time when one or more non-conflicting phases are given a green signal at the same time. Stages usually run in a specific, pre-determined order within the cycle. They can be demand-dependent, only running if called, and can be omitted if not required.

6.4.2. A stage may be considered as starting at the point at which all phases that will have right of way during the stage have been set to green, and all phases terminating have been set to red. The stage ends at the point at which the first phase loses right-of-way. Stages are separated by a period made up from the safety margins that separate the various conflicts, known as the interstage period.

6.4.3. The convention should always be to number stages in the most likely order of stage sequence, with stage 0 being reserved for an all-red stage. Stage 1 contains the phases designated as the “main road”, and should then be followed by any early cut-off stages, the side road, and so on. Stage 1 should always contain the main road phases, as it is almost universally adopted as the start-up stage when the controller is switched on or restarted for any reason.

6.4.4. The duration of the green signal for any one approach or stage will depend on the method of control.

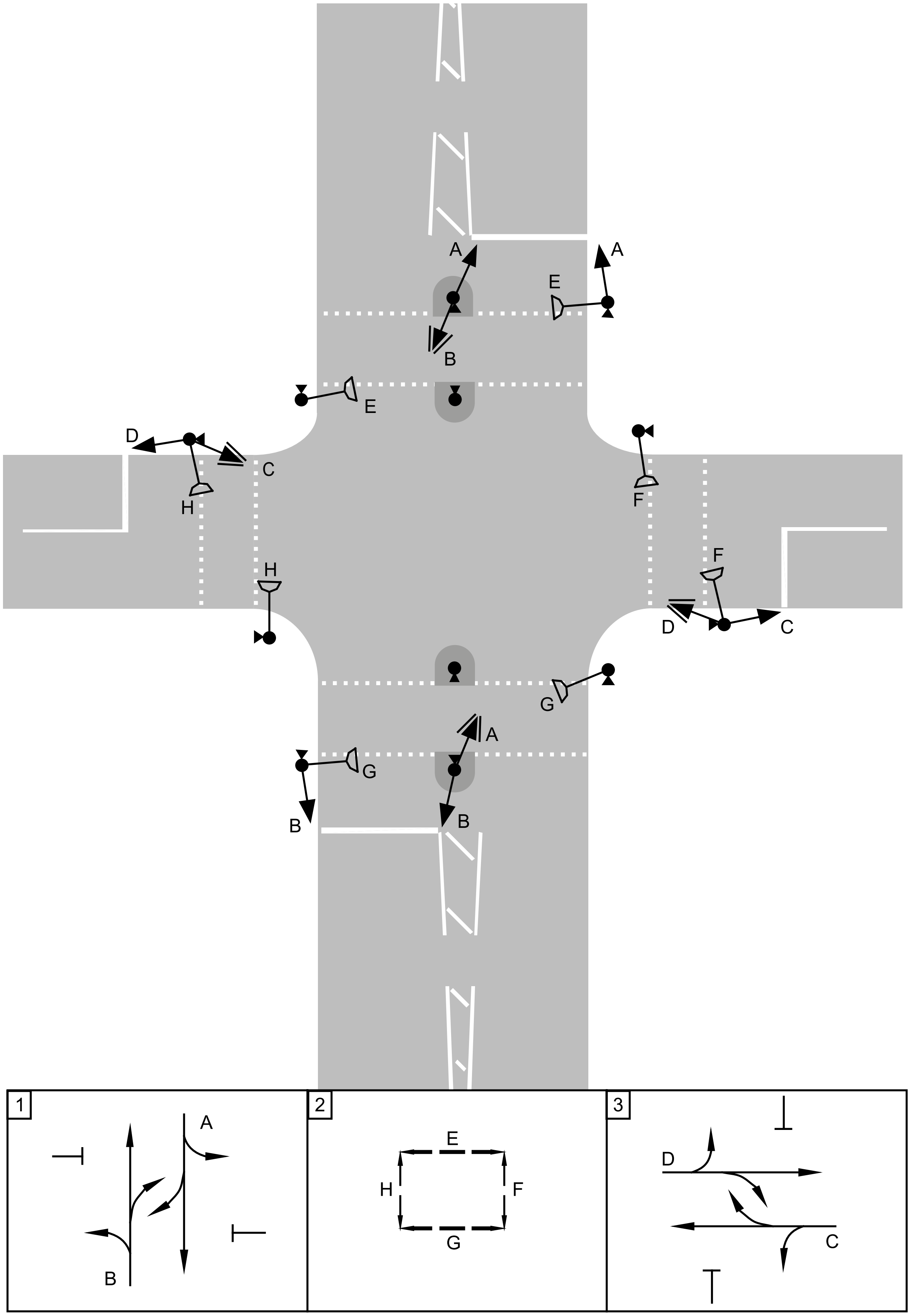


Figure 6-2 Layout diagram showing phases and stages for a crossroads junction with a full pedestrian stage

6.5 Intergreen period

6.5.1. The intergreen is the period between the end of the green signal giving right of way for one phase, and the beginning of the green signal giving right of way for the next conflicting phase. It can be thought of as the 'safety margin' to allow traffic to clear the junction safely. It can be extended by external factors, but never shortened.

6.5.2. Intergreen values for an individual junction are calculated based on the site geometry and pedestrian walking speed and will vary from site to site. The minimum duration is generally 5 s, made up of 3 s stopping amber after one green and 2 s starting red/amber before the next. Intergreens may be extended by adding an additional all-red period if required, to take account of local factors.

6.5.3. It is possible for an intergreen to be shorter than 5 s. Examples of this include:

a) an intergreen preceding a right turn indicative arrow in an early cut-off sequence as described in **8.3**. In this case the intergreen may be as low as 3 s.
b) intergreens preceding and following dummy phases where there is no actual conflict between traffic, but there is a need to provide an intergreen.

6.5.4. Intergreens can be made variable, for example because of a high speed detection requirement (see **9.3.8** and **10.4**)

6.5.5. Intergreens can also be extended by detection, for example through use of an all-red facility to allow right turning traffic to clear, or at signal-controlled roundabouts to keep sections of the roundabout clear. Extendable intergreens can also be provided with pedestrian facilities. It is important that such sites are remotely monitored as a faulty detector will mean that the intergreen will default to extending up to the maximum value, which over time will encourage drivers to disregard the red signal.

6.5.6. A short intergreen period is potentially dangerous but equally a period that is too long leads to delay, frustration and disobedience, again potentially encouraging drivers to ignore the red signal.

6.6 Determination of intergreen times

6.6.1. Computer modelling programmes now include the ability to calculate intergreen times automatically, but it is helpful to understand the theory behind this to ensure the values obtained are accurate.

6.6.2. The intergreen period for conflicts between two traffic phases is measured by identifying the probable collision points, measuring the distance that traffic has to travel from the stop lines to reach the collision points and then calculating the path differences. In all cases the path difference is considered as the distance travelled to the conflict point by the traffic losing right of way minus the distance travelled to the same conflict point by the traffic gaining right of way. This means that when calculating path differences the calculations will result in some negative values. When determining which path difference is critical between conflicting phases, all the relevant path differences should be measured and the highest value should always be taken as the 'x' distance. These path differences are then used in conjunction with a table to determine an appropriate intergreen time in seconds.

6.6.3. The process is described in the following paragraphs, and with reference to **Figure 6-3**. This illustrates a crossroads with four traffic phases and two pedestrian phases configured to operate in 3 stages. The swept paths are illustrated, along with the probable collision points identified by red dots and for reference some of the collision points have been identified by a bracketed lower case letter. The starting points for measurements are identified by blue dots and bracketed letters. To simplify the example, the right turn movements from the north and south are shown as prohibited.

6.6.4. For the purposes of this calculation, it is assumed that vehicles enter the junction at a constant speed and that the probable collision points are at the intersection of the centre lines of the swept paths. In practice, of course, there will be collision areas rather than collision points, since vehicles have width and length. Drivers will also take action by swerving, or braking/accelerating to avoid a collision. To take account of all these and other factors would be impracticable. The method set out here has been found to give a good basis for the initial settings, but on-site observation once the installation is in operation is essential, and adjustments should be made if necessary.

6.6.5. On a stage transition from stage 2 to 3 phases A and E lose right of way and phases C, D and F gain right of way and therefore a total of five intergreens are required:

a) A to F,
b) A to C,
c) A to D,
d) E to C, and
e) E to D.

6.6.6. To determine the intergreen between A to C, measure the distances from the stop lines controlled by phase A and phase C to the 6 relevant collision points: (q), (r), (s), (t), (u) and (v). Determine the path length differences by subtracting the distance from the stop line controlled by phase C (which is the phase gaining right of way) to each collision point from the distance from the stop line controlled by phase A (which is the phase losing right of way) to the same collision point. The greatest path difference is the x distance. In this example, the paths which give the greatest path difference are (a) - (u) = (21 m) and (f) - (u) = (20 m). This gives an ‘x’ distance of 1 m. **Table 6-1** then suggests an intergreen of 5 s is appropriate. The process should be repeated for the A to D intergreen.

6.6.7. To determine the A to F intergreen, it is necessary to allow enough time for the last vehicles travelling from the stop line controlled by phase A to clear the pedestrian crossing controlled by phase F, before phase F gains right of way. Therefore measure the distances between the stop line controlled by phase A and the furthest line of pedestrian studs - (a) - (o) and (b) - (p). Since the paths are parallel and in a straight line the distances will be the same. The distance measured is the x distance. In this example the distances are 6 m, for which **Table 6-1** suggests an intergreen of 5 s is appropriate.

6.6.8. The determination of the intergreen from the pedestrian phase E to the traffic phases is described in **6.7**.

6.6.9. On a stage transition from stage 3 to stage 1, intergreens will be required for

a) C to A,
b) C to B,
c) D to A,
d) D to B, and
e) F to A.

6.6.10. In the case of the intergreen between C and A, the collision points and associated distances will be the same as those considered for the intergreen between A and C, but when calculating the path differences it is important to always subtract the path distance related to the phase gaining right of way from the distance associated with the phase losing right of way. This can result in a significant difference between the A to C and a C to A intergreen.

6.6.11. On a stage transition from stage 1 to stage 2, phase B loses right of way and phase E gains right of way. To determine the B to E intergreen measure the distances between the stop line controlled by phase B and the furthest line of pedestrian studs - distances (e) - (g) and (d) - (h). Since the paths are parallel and in a straight line the distances will be the same. The distance measured is the 'x' distance. In this example if the distances are 26 m, **Table 6-1** suggests an intergreen of 7 s is appropriate.

6.6.12. The process of calculating 'x' distances and determining intergreens should be undertaken between all conflicting phases, and the intergreen determined for each phase losing right of way to each phase gaining right of way in each pair. When determining which phases conflict, the stage sequence should not be taken into account - it is safer to assume that all stage to stage transitions are possible, to future proof the intergreen matrix.

6.6.13. It should also be recognised that where right turning traffic may legitimately give way to traffic controlled by the phase opposite, an intergreen between the opposite phases will not be required (if intergreens were added it would not be possible to run the opposite phases in the same stage).

6.6.14. The intergreens suggested in **Table 6-1** take no account of factors such as vehicle speeds, the vehicular mix of traffic or site conditions such as gradients. It may therefore be necessary to make adjustments to the intergreen once the site is operational. Factors which influence this include:

a) Traffic speeds on the phase losing right of way are substantially less than on the phase gaining right of way because of a steep gradient,
b) Right turning traffic may be slow to clear the collision points if giving way to other traffic,
c) There may be a predominance of slow-moving vehicles or cyclists.

6.6.15. Advice on suitable intergreen periods for cycle traffic is given in **12.2**.

6.6.16. Intergreen values should be validated on site once the installation is in operation, to ensure they are appropriate.

Table 6-1 Intergreen values

Distance 'x' (m)	≤ 9	10-18	19-27	28-37	38-46	47-55	56-64	65-73
Intergreen (s)	5	6	7	8	9	10	11	12

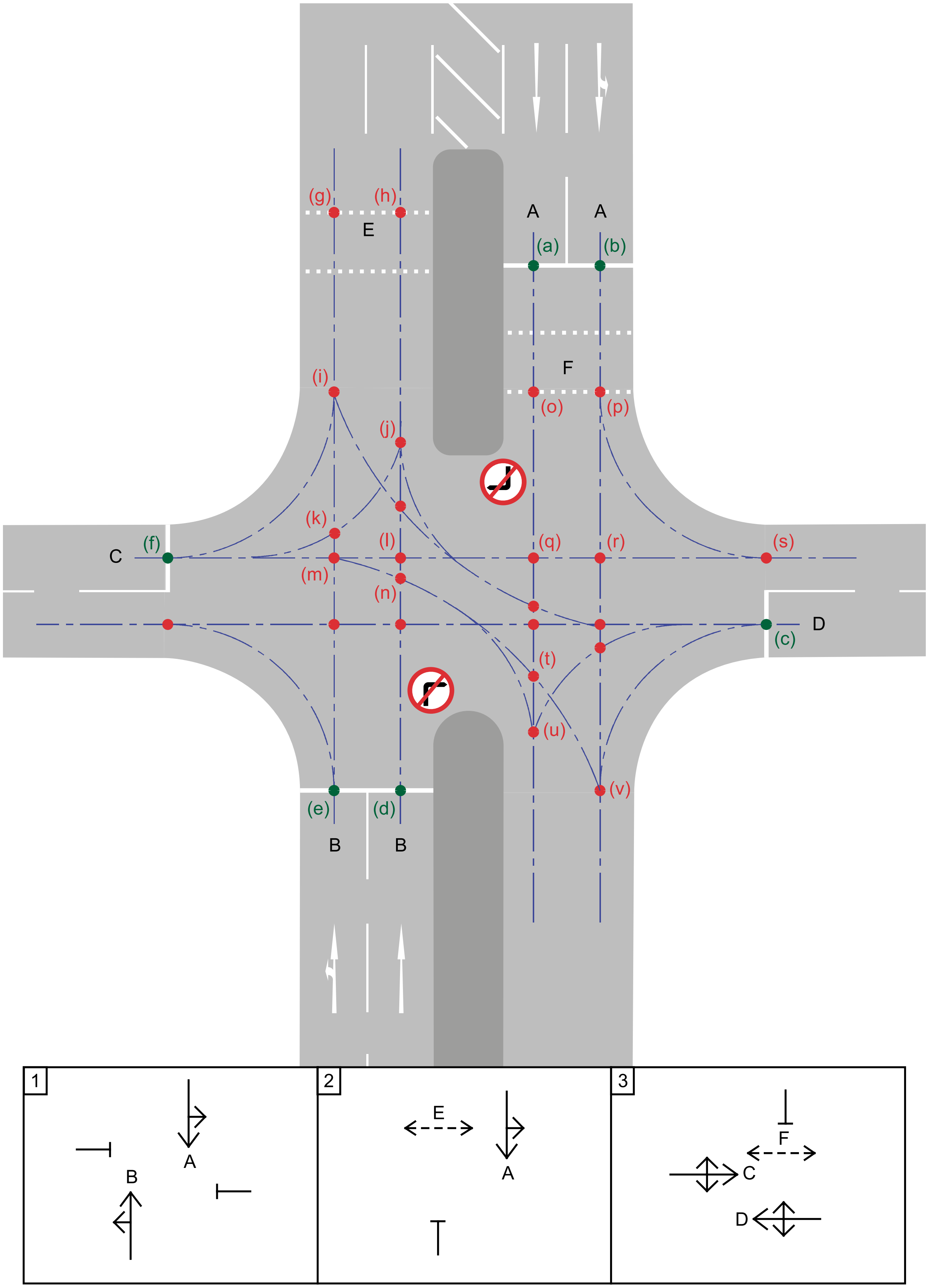


Figure 6-3 Layout diagram showing probable collision points for movements at a typical crossroad junction

6.7 Pedestrian-to-traffic intergreens

6.7.1. Intergreen periods are also required between pedestrian phases losing right of way and traffic phases gaining right of way.

6.7.2. The intergreen period between pedestrian and traffic phases should allow any pedestrians on the crossing to clear it before the vehicle phase gaining right of way receives a green signal. Rather than an 'x' distance, this intergreen period is based on the length of the crossing from kerb to kerb, and the pedestrian walking speed. This length of crossing should be divided by the chosen walking speed (1.0 m/s or 1.2 m/s, see **11.7.2**) to give the required crossing time. An additional 2 s should be added as a safety buffer, rounding up to the nearest whole second if the result is not a whole number.

6.7.3. Where a pedestrian phase is used to control more than one crossing point, the crossing distances for all the crossings should be measured and the intergreen period based on the longest distance.

6.7.4. Where on-crossing detection is used, intergreen periods following pedestrian phases may be extendable (see **11.7.2**).

6.8 Interstage period

6.8.1. The interstage period is the period between the end of one stage and the start of the next stage. The principle is illustrated in **Figure 6-4**.

6.8.2. Design of interstage periods is important in achieving an efficient junction design. In assessing an interstage period's efficiency, the key issue is the period of time between the end and start of critical traffic phases terminating and starting in that period. The period separating a critical terminating phase and a critical starting phase should equal the intergreen between the two phases wherever possible. Where necessary, phase delays can be used to structure the interstage period so as to ensure that the period between critical phases controlling the most saturated traffic movements is minimised.

6.8.3. **Figure 6-4** shows an interstage diagram for an early cut off junction which includes a right turn indicative arrow and a filter. The stage sequence is stage 1 followed by stage 2 followed by stage 4. Note that in this stage sequence stage 3 (which is demand dependent) does not run and therefore phases G and J do not appear.

6.8.4. Phases A, B, H and I run in stage 1, and phases A, C, E and I run in stage 2. The interstage between stage 1 and stage 2 has a duration of 8 s and is determined by the H to C intergreen. Note that the right turn indicative arrow starts in the interstage 3 s after the termination of Phase B.

6.8.5. A phase losing delay of 2 seconds has been applied to phase B on a stage 1 to stage 2 transition, to minimise the time between traffic phases B and C.

6.8.6. A phase gaining delay of 1 s (relative) has also been applied to phase B on a stage 4 to stage 1 transition. This ensures that phases A and B start at the same time, and may be applied to prevent an early start. The phase delay is described as 'relative' as it is relative (or additional) to the existing intergreen.

Typical Stage sequence for an Early Cut Off including a Right Turn Indicative arrow, a Filter and Parallel Pedestrian Phases (note Phases G and J do not run in this particular sequence).

The Interstages would result from the Intergreen Table and any Phase Delays that are added. Phase Delays have been specified by the designer and do not occur automatically, they are typically used to improve efficiency and junction safety.

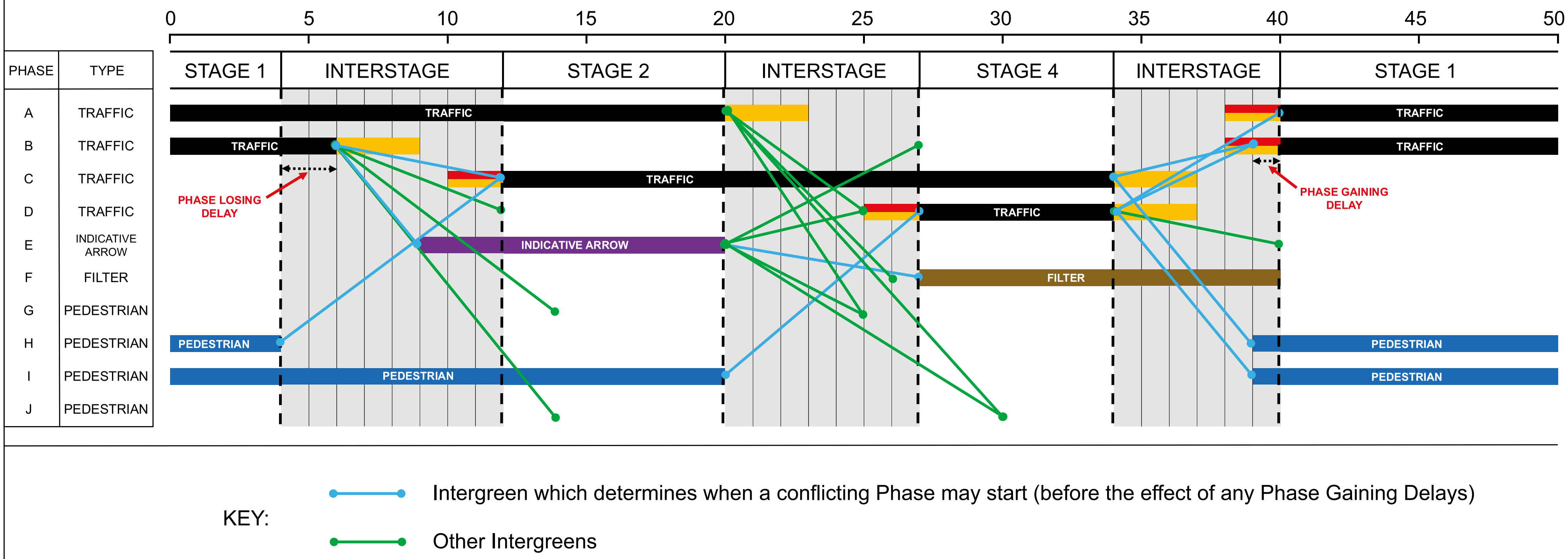


Figure 6-4 Interstage diagram for a junction utilising an early cut off sequence

6.9 Parallel stage stream

6.9.1. Under parallel stage streaming, two or more separate stage streams run in parallel within one controller. In effect, the controller is running two or more smaller controllers within it. It can be very useful, but requires careful design, both in terms of location of equipment and how it operates. For safety reasons, phases in different parallel streams should be physically unable to be in conflict with one another.

6.10 Dummy phases

6.10.1. A dummy phase is a software device within the controller. It can be allocated to a stage and have timings, but what distinguishes it from a live traffic phase is that it is not connected to any signals and does not control traffic. Typical uses include:

a) Where there is a requirement to give a stage priority. A dummy phase can be used as the priority phase, and a demand inserted when priority is required,
b) A stage may include a phase which runs in both that stage and the following one, which may result in the minimum time for the second stage defaulting to zero. This may cause problems - for example, under Urban Traffic Control (UTC) a zero-length stage will not be detected and an error will be reported. This can be prevented by allocating a dummy phase to the stage with a minimum duration of 1 s,
c) A pedestrian phase runs parallel to a traffic phase within the same stage, but only when called by a push button. A dummy phase can be used as the alternative when a call is not present. If the stage initially starts without the pedestrian signal but a demand is received during the stage the dummy phase is terminated and replaced by the pedestrian phase. This saves the pedestrian waiting another cycle for a green signal,
d) To vary an intergreen period to allow for slower vehicles, or certain types of traffic, for example because of a steep incline on one approach. A dummy phase can be introduced either by detectors, or by time of day or day of week,
e) A dummy phase may be allocated to an all-red stage to give longer extension periods. A dummy phase can also allow the junction to revert to the all-red period at quiet times. The controller can be programmed to revert to all-red after a pre-set period when no demands or extensions are recorded. The signals may then be set to change to red/amber on the appropriate phase immediately a demand is received.

6.11 Minimum phase green times

6.11.1. The minimum green time allows drivers in front of the detector to clear the junction, or to allow the moving queue to reach the minimum speed for detection.

6.11.2. Without a minimum green time, a vehicle could become trapped in front of the stop line with no means of registering a demand for another green period. The minimum also gives the signals credibility by not changing too quickly and by allowing a vehicle just outside the detection zone to register an extension. The minimum green time is fixed for that phase within the controller, starting at the beginning of the green signal. It cannot be overridden by demands from vehicles, manual control devices, central computers, or linked controllers.

6.11.3. The shortest minimum green period normally used for traffic phases is 7 s, except for filter phases which may be shorter, and indicative arrow phases used in early cut-off and late start stages, where the minimum may be as low as 3 s (see **6.5.3**). At sites with very low flows, a minimum of 5 s may be used with caution.

6.11.4. Site conditions may require a longer period, for example where large numbers of heavy vehicles have difficulty in starting away from the stop line or the approach is on a steep gradient.

6.11.5. Where pedestrians and traffic share the same stage, the stage minimum green time will be determined by a combination of phase minima, overlaps, and phase delays.

6.12 Maximum phase green times

6.12.1. The maximum green time is calculated using a combination of layout and traffic flow parameters. It may also be set by the designer for a given cycle if site circumstances require it. Under Vehicle Actuation, the maximum green normally starts on the receipt of a demand for an opposing stage.

6.13 Extension times

6.13.1. Where vehicle actuation is used, a vehicle detected on the approach during the display of a green signal will, within certain limits, extend the time the green signal is displayed. The purpose of extensions is to permit the vehicle to pass the stop line safely before expiry of the green period. Detectors should respond to all vehicles, including pedal cycles. Recommended extension periods are given in TOPAS 2500: Specification for Traffic Signal Controller. Designers should ensure they use the latest version.

7 ASSESSMENT AND MODELLING

7.1 General

7.1.1. The overall capacity of a junction is the amount of traffic that can pass through it from each approach in a given time. It is dependent on various factors including the available green time, traffic flows, and site layout. When designing a junction, these factors are considered as part of the assessment of the design.

7.2 Saturation flow

7.2.1. At the start of the green period, vehicles queuing at the stop line will take some time to move off and to accelerate to a normal running speed. After a few seconds, any remaining queuing traffic will discharge at a more or less constant rate known as the saturation flow. This is the flow which would be obtained if there was a continuous flow of vehicles and they were given a constant green signal.

7.2.2. In order to compare flows consisting of different vehicle types, saturation flows are usually expressed in passenger car units (PCUs) per hour. Each type of vehicle is equivalent to a number of cars in respect of how much space it requires on the road. Common vehicle types are assigned a conversion factor, applied to classified vehicle data to generate a PCU value. Typical values are shown in **Table 7-1**.

Table 7-1 Typical PCU values for various vehicle types

Vehicle Type	PCU Value
Pedal Cycle	0.2
Motor Cycle	0.4
Passenger Car	1.0
Light Goods Vehicle (LGV)	1.0
Medium Goods Vehicle (MGV)	1.5
Buses & Coaches	2.0
Heavy Goods Vehicle (HGV)	2.3

7.2.3. The saturation flow depends on a number of factors, including the width of lanes, the numbers of turning vehicles, the radii of turns and the mix of vehicle types. Local factors such as driver behaviour can also have a significant effect. Saturation flow can often be measured by survey and where it is practicable to do so it should be measured. Saturation flow may also be calculated using empirically derived formulae. In the case of concept designs for new sites, it may need to be estimated.

7.3 Degree of Saturation

7.3.1. This is the ratio of the actual flows to the maximum possible flows on the approaches to a junction, and will give a good indication of whether a junction will function well or be subject to delays. It is usually expressed as a percentage and is given by the following:

Degree of saturation = (demand x cycle time) / (saturation flow x effective green time)

Although degrees of saturation below 100% are within theoretical capacity (i.e. demand flow does not exceed capacity), random traffic arrivals throughout time may result in shorter time periods where the degree of saturation exceeds 100%. Therefore, an arm is generally considered to be over capacity once the degree of saturation exceeds 90%.

7.4 Lost time and effective green time

7.4.1. In any traffic signal cycle, a certain amount of time is lost during the interstages. This is primarily due to the intergreen periods, but other factors such as traffic continuing to travel through part of the leaving amber period (end displacement), and traffic taking time to start moving at the start of a green signal (start displacement) will also have an effect. The total lost time, L, is often taken as:

L = total of the intergreen periods between the phases controlling the critical movements, minus 1 s for each of those intergreens.

1 s is used to represent the ‘effective green’ time, that is, the duration of the leaving amber (3 s) – the starting amber (2 s)

7.5 Preliminary assessment

7.5.1. Although proposed schemes will usually be modelled using computer software, an initial assessment using the manual methods described below can identify staging arrangements which can be tested by more detailed analysis, give a general indication of whether the junction would operate comfortably or close to its capacity limit, and may help eliminate options which are not practical.

7.5.2. The first step is to consider whether the main vehicular flows exceed the overall junction capacity available. This is based on the assessment of the critical y value in the cycle, where y = the ratio of demand to saturation flow, or the proportion of the cycle time a signal has to be green to allow the demand flow to pass. A flow of 1000 PCU/h crossing a stop line with a capacity of 2000 PCU/h needs a signal which is effectively green for at least 50% of the cycle time, a y value of 0.5.

7.5.3. The critical y values are identified by considering the stage sequence and assessing which y values need to be combined in the sequence to satisfy the demand flow. The total of these critical y values is the Y value.

7.5.4. If Y is greater than the proportion of the cycle time left after taking the lost time into consideration, then the junction has insufficient capacity. But in practice the Y value should not exceed the Ypractical (Yprac, defined as 90% of Y). If Y exceeds Yprac, whatever timings are applied the junction is likely to suffer from delays during peak periods.

7.5.5. The practical reserve capacity is the difference between the actual capacity of a junction and the practical capacity. It can be used to give an idea of the life expectancy of a junction, and is usually expressed as a percentage.

7.5.6. Where $Y < Y_{pract}$: Practical reserve capacity = $100\ (Y_{pract} – Y)Y$

7.5.7. Where $Y > Y_{pract}$: Practical reserve capacity = $100(Y_{pract} – Y)Y_{pract}$

7.6 Modelling

7.6.1. Analysis of a proposed traffic signal scheme through computer modelling is a key part of the design process. Modelling can provide details of optimum timings and predicted performance in terms of capacity, delays and queues. There are many specialist software packages available and it is for the designer to determine which is most suitable for their needs, depending on what size of network is being modelled.

7.6.2. Different approaches will be required for isolated junctions, a town centre network, or a strategic model covering a wide metropolitan area. The advice in this section is generally aimed at modelling of isolated junctions and town centre road networks, rather than strategic area-wide modelling. Traffic modelling is a complex discipline and models should be checked by an experienced practitioner.

7.6.3. Modelling is used to identify design options for further consideration, and to rule out those that will not work or will cause unacceptable delays. Accurate modelling will enable effective decisions to be made and help ensure a scheme's viability. For example, a model may be used to support a business case to secure funding for a scheme. It may also be helpful in demonstrating the practical impacts of a scheme as part of public consultations.

7.6.4. The starting point is generally to create a base model of existing conditions, without any proposed changes, which should be validated as accurate through on-street observations. This model will take data from many different sources, including the site layout, traffic flows, traffic composition and speeds, and road user behaviours.

7.6.5. The base model can then be used to create models of various proposed options, which may involve:

a) altering site layouts, for example to include new pedestrian facilities,
b) altering timings, for example to model a proposed change in staging arrangements,
c) altering traffic flows to predicted future levels to assess the impact on junction capacity, or
d) altering the composition of traffic, for example if a rise in the number of cyclists is expected.

7.6.6. The results of these proposed models can be compared with the base model to assess the potential impacts of each. Decisions can then be made as to which one is most suitable to take forward, or further options considered.

7.6.7. The results from the chosen option will form part of the detailed design process. It may be used to generate the signal timings required for input into the controller, and to give an indication of exactly how the installation will operate on-street.

7.6.8. If a model is to be used to create timing plans for co-ordinated control, it should be validated through on-street observations, to ensure that it accurately represents how the installation performs.

7.6.9. A model is only as accurate as the data used to create it. Site data should therefore be collected at a time representative of typical network operation. For example, school holidays, planned events and street works should be avoided.

7.6.10. If existing drawings or online mapping are used to develop the model, these should be checked first to ensure they are accurate. Typical time periods for data collection should be identified.

7.6.11. Accurate traffic flow data will be needed. This can be obtained through various methods, including manual counts, fully classified turning counts and origin-destination surveys. The choice will depend on site circumstances and the specific modelling software being used. Traffic counts should cover the morning and evening peaks and inter-peak periods on weekdays. They should also cover peak times at weekends, especially at places that may generate significant weekend traffic, such as shopping centres.

7.6.12. Measurements such as journey time, saturation flow and queue length surveys should ideally be conducted while traffic counts are taking place. Many factors, such as traffic management, weather and incidents may have a bearing on survey results and these should be identified as part of the process.

7.6.13. There are many site-specific parameters to be considered. These may include:

a) Junction layout,
b) Link lengths, lane widths and pedestrian crossing distances,
c) Road markings and how these are used,
d) Saturation flows,
e) Give way behaviour,
f) Right turn storage and blocking effects,
g) Exit blocking,
h) Waiting and loading restrictions,
i) Speed limits,
j) Bus lanes and bus stops,
k) Roadworks and other incidents, and their impact.

7.6.14. As well as site-specific parameters, more general observations of road user behaviour may be useful, for example where traffic does not use road markings as intended.

8 STAGING ARRANGEMENTS

8.1 General

8.1.1. The staging arrangement, or method of control, used at a junction will depend on many factors. The aim should be to balance the need to provide facilities for different groups of road users, with reducing delays, and maintaining capacity and safety.

8.1.2. It is most efficient to adopt staging arrangements and techniques that allow one or more arms to run at the same time to keep traffic moving safely.

8.1.3. Staging arrangements can reduce delay and improve capacity by:

a) using the fewest conflicting phases and practicable stages in a cycle,
b) ensuring interstage periods are designed as efficiently as possible, and
c) allocating time to each phase/stage and user groups, including pedestrians and cyclists, appropriate to the actual traffic flow.

8.1.4. The advice in **8.2** to **8.7** uses a four-arm junction of the type shown in **Figure 4-1** to illustrate common approaches to designing staging arrangements.

8.1.5. The level of right turning traffic is often the critical factor in determining a staging arrangement for a junction, as they have to wait for gaps in opposing traffic and can therefore block traffic moving straight ahead or to the left from moving through the junction.

8.1.6. A four-arm crossroads junction may have space for two or three vehicles beyond the stop line, allowing drivers to move forward on a green signal and wait in the middle of the junction for a gap in which to complete the turn. If this is not possible they complete the turn in the intergreen period.

8.1.7. If the number of right turning movements exceeds the number that can clear the junction in gaps, or during the intergreen, the staging will need to make special provision for this. If right turning traffic is left in front of the stop line after a change to another stage, the driver may be left in a vulnerable position, and the presence of vehicles may obstruct pedestrians.

8.1.8. There are various ways of accommodating right turn flows, three of which are discussed in **8.3**, **8.4**, and **8.5**.

8.2 Two vehicular stages

8.2.1. At its most basic, two stage operation gives vehicles on opposite approaches a green signal, whilst those on the other two approaches have a red signal. Where an all-round pedestrian stage is provided as well, all vehicle movements are stopped.

8.2.2. Right turning traffic is not separately signalled but waits within the junction to complete the turn. This may reduce the capacity of the junction due to the road space occupied by traffic waiting to turn right, and by the time required for this movement in the cycle. Where there is a relatively minor right turn flow this may be acceptable.

8.2.3. Where right turning flows are more substantial, and cannot be accommodated within the existing capacity of the junction, alternative staging arrangements may need to be considered. Two stage operation with right turn manoeuvres prohibited will reduce delay and improve capacity, but will require drivers to make a detour. For example, they may be required to turn left before the junction and make two right-turns to appear at the junction on the left-hand arm. Any such diversion routes should be adequately signed in advance so that drivers are clear what is expected of them. If the diversion routes are residential the additional through traffic may be unacceptable, particularly if this includes large numbers of HGVs or buses.

8.2.4. Where right turn movements are prohibited, signal heads to diagram 3000 (S14-2-1) should be used with a regulatory box sign to diagram 612 (S14-2-43). This staging can be used at a single lane approach.

8.2.5. A further alternative is to use two stage operation with both the left and right turns prohibited. This gives exclusive ‘ahead only’ movements using signal heads to diagram 3000 (S14-2-1) with substitute green arrow aspects to diagram 3001.2 or 3001.3 (S14-3-1). If both opposing arms operate this way, walk with traffic pedestrian phases may be incorporated. This staging will improve capacity but alternative routes for turning traffic will need to be found, which may have capacity implications elsewhere on the network.

8.3 Early cut-off

8.3.1. The staging arrangements discussed in 8.2 improve the junction capacity, but at the expense of turning traffic which is required to make a detour. There are alternatives that allow for more efficient control, such as including an early cut-off stage. This is a common method of dealing with significant right turning traffic on one approach which allows opposing arms to run together on the first stage but only one arm to continue on to the next. A right turn indicative green arrow to diagram 3001.2 or 3001.3 (S14-3-1) may be provided on the secondary signal head, illuminated during stage 2 (see **Figure 8-1**). This is indicative to right turning traffic that they have or are about to have right of way and that they may complete their turn without conflict. It allows other vehicles travelling straight ahead which may have been delayed by the right turn traffic to clear.

8.3.2. As an early cut-off runs in two stages, one straight ahead movement has more green time than the opposing straight ahead movement. If this is roughly equivalent to the balance of straight ahead flows then this arrangement is likely to be efficient. If the arm has only a single lane approach, this method may not be suitable depending on the level of traffic.

8.3.3. The length of the early cut-off period can be varied by detectors, and the indicative arrow can be demand dependent. It can also be stopped from appearing by time of day if not required.

8.3.4. **Figure 8-1** represents a simple crossroads. It should be noted that the intergreen between phases C and D does not have a red/amber component. With early cut off operation, it is common to have a 3 s intergreen between the phase controlling the opposing traffic in stage 1 (phase C in **Figure 8-1**) and the right turn indicative arrow in stage 2 (phase D in **Figure 8-1**), but the start of phase D can be held off by additional red time to give a longer intergreen. The relatively short intergreen (3 s) takes account of the fact that drivers are beyond the stop line, and are already giving way to opposing traffic. The green arrow is indicative of the opposing traffic losing right of way.

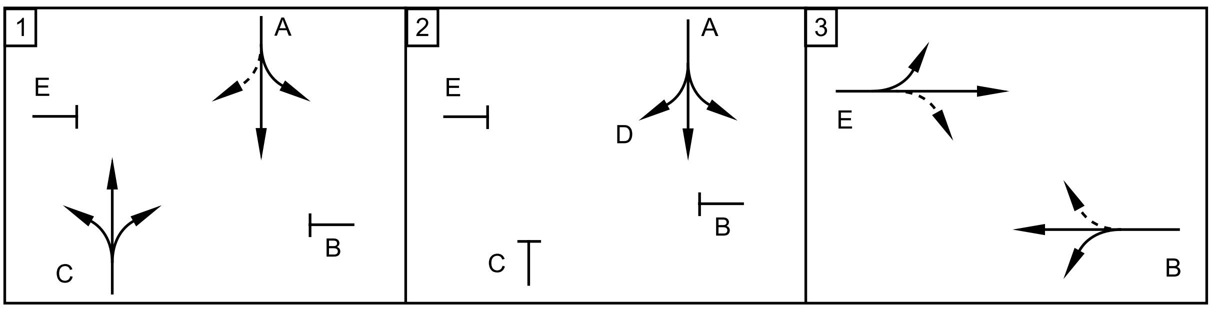


Figure 8-1 Staging diagram showing an early cut-off sequence

8.3.5. The signals on the arm that loses right of way at the end of the first stage should be sited with care. The secondary signal should always be “closely associated”, that is, on the same side of the junction as the primary signal (see **Figure 3-3**). Far side secondary signals in this situation are potentially dangerous and should not be used, as drivers turning right on phase C may assume they can continue, bringing them into conflict with the traffic controlled by phase D. The only exception is at a junction where there is no right turn from the approach losing right-of-way. If this movement is banned, there is no conflict between phase C and right turning traffic from phase D. This also applies to T-junctions where phase C would refer to the movement across the top of the T.

8.3.6. Phase A will have a standard three-aspect primary signal, with the secondary signal always placed beyond the junction. The secondary signal will have an additional right turn indicative arrow illuminated during stage 2. If the right turn from phase C is still thought to be a problem a TRO may be considered to ban the movement.

8.3.7. Stage 2, the right turn indicative green arrow labelled phase D, will usually terminate when its associated phase A loses right of way. This means that unless a late start is deployed (see **8.5**) the controller should not be permitted to move from stage 2 to stage 1 unless via another stage.

8.3.8. If traffic demand is sufficient, and there is room to provide a segregated lane, it is possible to allow left turn traffic on the side roads to run in stage 2 under a left turn green filter arrow. The advice in **3.5.3** should be followed and care taken to avoid danger to pedestrians from the left turn traffic. A filter phase may only terminate when the associated full green traffic phase gains right of way. Note that if a left turn filter is operating at the same time as the indicative green arrow, care will be needed to ensure that there is an exit from that stage if there are no other demands.

8.4 Separately signalled right turns

8.4.1. Separately signalled right turns should be considered in circumstances where opposed right turns may be unsafe, for example on roads where the 85th percentile speed is above 45 mph on the relevant approaches. They may also be considered if it is necessary to separate control between right turning traffic and adjacent ahead movements, for example, when trying to accommodate parallel pedestrians or when both right turns from opposite arms are heavy.

8.4.2. In this method of control, typically the right turns are held on a red signal while the straight ahead and left turn traffic proceeds on green. All traffic is then stopped and the right turning traffic on both approaches is then released simultaneously. The right turning traffic should be separated into exclusive lanes with separate signal displays for each approach. Alternatively, the opposing arms may be run in separate stages. The staging is shown in **Figure 8-2**.

8.4.3. Both options may have serious implications for capacity. They should only be considered where other means, such as providing an early cut off stage, have been ruled out.

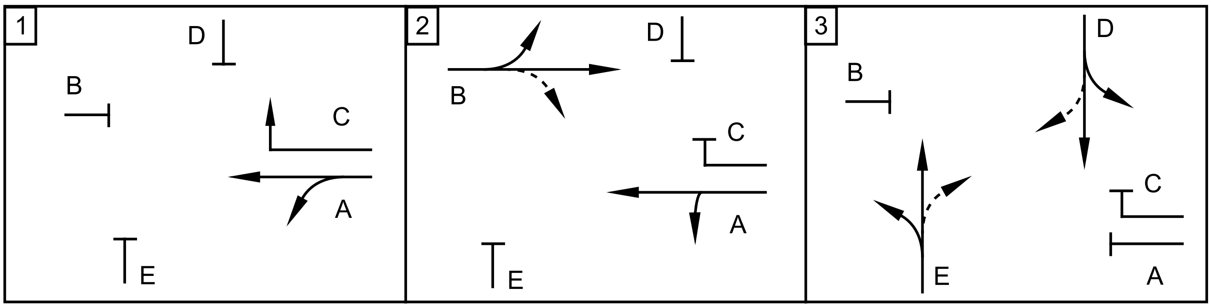


Figure 8-2 Staging diagram showing a separately signalled right turn sequence

8.5 Late start

8.5.1. Late start describes a staging arrangement in which one or more traffic streams are permitted to move before the release of other traffic streams. These are then permitted to run with them during the subsequent stage. In practice, this usually means allowing the right turners to move first, before then giving the conflicting straight ahead movement a green signal. The staging is shown in **Figure 8-3**.

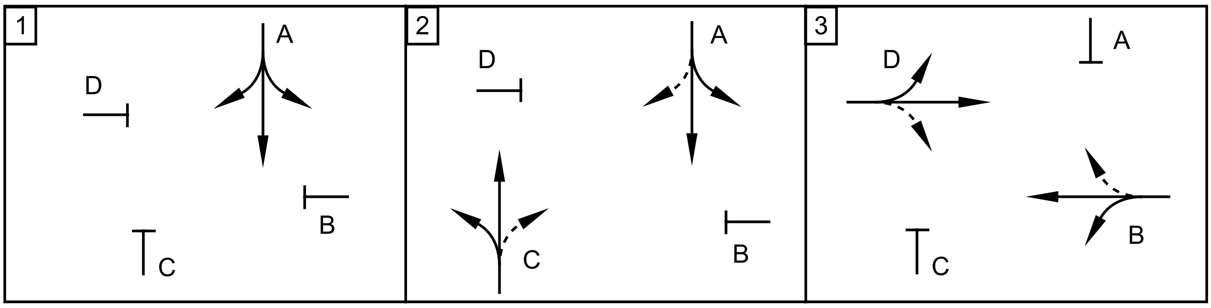


Figure 8-3 Staging diagram showing a late start sequence

8.5.2. Although used in a few regions, late start is not recommended for two reasons. Once a dominant flow has been established, those drivers that initially received a green arrow assume this will continue unopposed, and are not expecting the conflicting straight ahead traffic. It is also difficult for the right turning driver on the opposing flow to complete the turn. Both scenarios may lead drivers to take unnecessary risks.

8.5.3. The exception to this is where the movement receiving the green first is not permitted or able to turn right, in which case the safety concerns are not realised.

8.6 Part-time operation

8.6.1. While part-time operation is possible, it is generally not recommended for signal junctions for a number of reasons. Part-time operation can have implications for safety and accessibility, particularly for disabled people who may rely on facilities provided at traffic signals to provide a safe and easily navigable place to cross the road. Part-time operation effectively removes these while in operation.

8.6.2. Part-time control may also lead to a greater accident risk, as drivers may get confused about who has right of way when the signals are off. If the junction is working efficiently on responsive control during off-peak periods, part-time operation should be unnecessary.

8.6.3. The most common use of part-time control is at signal-controlled roundabouts, where an alternative priority control is available at other times. This reduces the risk of drivers becoming confused about what is expected of them. If part-time operation is used, it should be activated by time of day as well as by level of vehicular traffic flow, to help ensure a consistent experience for road users. Advice on designing signal-controlled roundabouts, including on part-time operation, is given in ‘Local Transport Note 1/09: Signal-controlled roundabouts’. Advice on traffic signing for part-time control is given in **5.4**.

8.7 Hurry calls

8.7.1. A hurry call is used to request the controller to move immediately to a specific stage. It is most often used to give emergency vehicles priority by putting in a demand for a certain stage at the nearest junction. It can be triggered remotely by selective vehicle detection, or is sometimes used with a manual switch to provide priority exit for vehicles from emergency services premises (see **24**). Hurry calls can also be used as a bus or tram priority measure. They may also be used as a form of queue detection, especially on signal-controlled roundabouts, and to protect against excess queuing from one junction backing up to another junction.

8.7.2. Hurry calls are useful for certain circumstances, but their unpredictability of demand means there is potential for them to reduce the overall capacity of the junction, depending on how often they are called. The misuse of a hurry call can be prevented by the provision of an override timer, which prevents repeated demands being made within a specified timeframe.

9 CONTROL STRATEGIES

9.1 General

9.1.1. The stage sequence, start of green period and length of green period can be varied to match prevailing traffic conditions by one or more of the following methods.

9.1.2. Fixed-time is the most basic control strategy, in which the timings and stages are fixed and the controller is unable to vary them.

9.1.3. Permanent fixed-time operation is inflexible and rarely satisfactory, and should only be used as a fall-back method. The delays are usually unacceptable and the resulting frustration may encourage drivers to disobey the signals. In the short term, the controller is unable to adjust to take account of changes in traffic flow, for example during peak hours. In the longer term, as traffic flows and patterns change over time, the initial settings will become out-of-date as they are only accurate at the moment they are inputted. Initial settings require time-consuming manual updates on a regular basis to remain efficient.

9.2 Responsive control strategies

9.2.1. For these reasons, responsive control strategies are recommended in preference to fixed-time operation. All responsive control uses detectors to monitor how traffic moves through a junction, feeding this information back to the controller to allow it to alter timings as required.

9.2.2. The control is usually varied by:

a) vehicle responsive instructions, known as vehicle actuation, for example MOVA,
b) instructions from a cableless linking facility (CLF),
c) instructions from an associated junction controller (cable-linked),
d) instructions from a central computer (Urban Traffic Control (UTC), including adaptive control), or
e) an integral time switch.

9.2.3. Responsive control may broadly be of two types, isolated or co-ordinated. Isolated means that the installation's operation is not connected to any other site; it does not necessarily mean that the site is physically isolated. Co-ordinated control refers to systems in which neighbouring installations are linked together, either between a few sites, or by central computer across a wider network.

9.2.4. Installations may be capable of operating either isolated or co-ordinated control strategies at different times. For example, a site may operate as part of a UTC system during the peak periods to reduce delays, but may switch to operating an isolated control strategy overnight when traffic is light.

9.3 Isolated control strategies

9.3.1. Vehicle Actuation (VA) provides considerable benefits compared with fixed-time operation and is widely used.

9.3.2. Vehicles approaching a red signal insert a demand for a green signal for that movement. This demand is stored in the controller, which will serve stages in cyclic order omitting any stages for which no demand has been received. Where it is essential that one stage always follows another, the appearance of the first stage can automatically insert a demand for the second. When a stage loses right of way having reached the maximum green time, a demand can be inserted by the controller for a reversion to that stage after other demands have been met.

9.3.3. Once a green signal is displayed, the duration may be extended by vehicles detected moving towards the signal. On expiry of the last extension and with no more vehicles detected, the controller will answer a demand for another stage, either at the end of the minimum green period, or immediately if this has already expired. If vehicles continue to extend the green period and a demand exists for another stage, the green signal will be terminated on expiry of a pre-set maximum period after the demand has been received. If there are no demands for another stage the signals will normally not change.

9.3.4. In the absence of demands, the controller should either remain on the last stage called, revert to all-red, or revert to the main road, to reduce delays especially at quiet times of day.

9.3.5. When traffic signals change away from green, drivers have to decide whether they can safely stop, at an acceptable deceleration rate, or continue and clear the stop line before the start of red. On high speed roads (those where the 85th percentile approach speeds at a junction are 35 mph or above) the decision becomes more difficult with increasing vehicle speeds.

9.3.6. Close to, and far from, the junction, the decision is relatively easy. The probability of an accident happening is highest for drivers making a decision between these points. The length over which decisions are deemed to be difficult is termed the “dilemma zone” and has been defined as being between the following boundaries:

a) The distance at which 10% of drivers stop when the signals change to amber, and
b) The distance at which 90% of drivers stop when the signals change to amber

9.3.7. If the 85th percentile approach speed to the junction is above 35 mph, standard VA operation such as System D should be supplemented with Speed Assessment (SA) or Speed Discrimination (SD) equipment. These systems provide green extensions to enable drivers to clear the dilemma zone safely (see **10.4**).

9.3.8. Isolated adaptive control systems build on the VA philosophy by adjusting signal timings and operation in real time in response to traffic conditions. These systems offer benefits over standard VA and can reduce delays at off-peak times. For high speed roads, adaptive control of this type offers advantages over SA or SD as separate equipment is not needed.

9.3.9. MOVA (Microprocessor Optimised Vehicle Actuation) is one such system, developed by TRL (www.trl.co.uk). MOVA is capable of rapidly responding to all conditions and to varying traffic patterns, particularly rapidly changing traffic flows. It is particularly well suited to sites with high traffic flow, particularly where these are seasonal or intermittent, such as diversion routes or holiday routes.

9.3.10. It should be noted that SA and SD are not compatible with MOVA. The convention is to extend the calculated intergreens by 1 – 2 s on high speed MOVA sites.

9.4 Co-ordinated control strategies: linked systems

9.4.1. Co-ordinated control allows delays to be reduced across a network and helps avoid situations such as queues from one junction blocking another. A linked system usually requires each controller to be functioning on the same or multiples of the cycle times of the key intersection, with the co-ordination determining the start or finish of certain stages.

9.4.2. Linking across a small number of sites such as neighbouring junctions in close proximity is usually achieved in one of two ways. With a cableless linking facility (CLF) two or more installations are linked by synchronisation with the mains supply frequency. Different combinations of stage timings, cycle times and stage off-set periods between junctions can be selected according to the time of day and day of week to cater for variations in overall traffic flows. CLF may also be used as a fall-back mode at UTC controlled sites and signal-controlled roundabouts and may also benefit isolated sites during particular times of day or during specific events.

9.4.3. Demand dependent stages can be incorporated, which can be selected by a vehicle demand, or a pedestrian demand. If such a stage is not demanded then the time is added to the preceding or subsequent stage, an alternative stage, or a combination thereof.

9.4.4. Correctly set and synchronised CLF offers reduced delays to road users by co-ordinating the operation of neighbouring signal junctions. As timing plans are fixed, apart from the use of demand dependent stages, it assumes that the variation in traffic flow over a particular period is small.

9.4.5. Two or more junctions may also be linked by the use of MOVA control.

9.5 Co-ordinated control strategies: Urban Traffic Control (UTC)

9.5.1. In a UTC system signal-controlled junctions and crossings across a network are connected to a central computer system. UTC is generally used in an urban situation to control a group of two or more junctions which are closely linked, normally less than 200 m apart.

9.5.2. Fixed-Time UTC uses fixed timing plans as a base, which are input to the central computer and are usually based on timings derived from a traffic model. Plans can be changed via the UTC computer automatically by time of day or manually by UTC operators. Fixed-time UTC has fixed cycle times, but is capable of using demand dependent stages, such as pedestrian stages, and can also utilise information from detection systems.

9.5.3. Changes to traffic patterns within towns and cities are often rapid, meaning fixed-time UTC systems require regular surveys to remain operationally accurate. Not only do general patterns change, but day-to-day flows can alter considerably, due to road works, broken down vehicles, accidents, and so on. Such surveys are time consuming and periods between surveys may become very long, leading to a UTC system that does not operate as efficiently as possible. This can particularly affect co-ordination between closely spaced junctions.

9.5.4. Adaptive UTC systems, such as SCOOT, deal with many of these issues by responding automatically to changes in traffic flow, based on input from detectors at every signal installation within a network. Adaptive UTC systems model the real time traffic patterns throughout the network, and attempt to minimise the overall delay in the network by constantly changing the phase and cycle timings at each junction, and modifying offset times between adjacent signal installations. Adaptive control allows the system to automatically adjust to take account of time of day variations, roadworks, poor air quality and so on. Compared with a fixed-time system, it is more efficient and can reduce unnecessary delays to road users.

9.5.5. The SCOOT (Split, Cycle and Offset Optimisation Technique) system is the major adaptive control programme in use in the UK. Further information is available in Traffic Advisory Leaflets 7/99 and 7/00.

9.6 Urban Traffic Management and Control (UTMC)

9.6.1. UTMC takes the concept of adaptive control a stage further. UTMC-compliant equipment enables different types of traffic management systems to be linked together into one network, enabling greater benefits to be realised. For example, a UTMC system may incorporate SCOOT-UTC, car park occupancy data, variable message signs, and air quality monitoring systems. More information is available from https://utmc.eu/.

9.7 Master time clock switch

9.7.1. The master time clock switch is based on a precision real time clock and calendar from which timing information is derived. It provides the facilities necessary for the controller to be integrated into a cableless linked system or to allow the controller to be operated in a fall-back mode of operation in a UTC scheme.

9.7.2. It may additionally be used to deliver time-controlled switch facilities, such as alternative timing plans, or method of control, or the control of regulatory box signs only shown at certain times. It is also used to change to and from British Summer Time.

10.1 General

10.1.1. Effective detection is key to the efficient operation of a junction as it allows the controller to adjust timings based on the information it receives. Detectors come in many types but the basic choice is between ones buried in the road surface (such as inductive loop or magnetometer) or mounted above ground, usually on top of the signal post (such as microwave, radar or infra-red). Both types have advantages, and some are more suited to certain applications, but the choice is for the traffic authority to make. Maintenance costs should be considered as part of the decision-making process.

10.2 Below ground detection

10.2.1. When in place securely, below ground detection can provide accurate and reliable information. It is not susceptible to vandalism or accidental adjustment, e.g. from high winds, but often fails due to damage caused by contractors working in the road who may not realise they are present. They can be difficult to maintain as they require a road or lane closure to enable access. Examples of below ground detection are loop detectors and magnetometers.

10.3 Above ground detection

10.3.1. The most common type of above ground detection is microwave vehicle detectors (MVDs). Infra-red detectors are commonly used for pedestrian, cyclist and equestrian detection. Trials have been carried out with newer types such as video or image-based processing, particularly for pedestrian detection. Above ground detectors are easily replaced and maintained as access does not generally require a lane or road closure. However, they can be susceptible to vandalism or accidental damage. Secure fixings and regular checks are essential.

10.4 System D, Speed Assessment and Speed Discrimination

10.4.1. Used for VA control, there are normally three loop detectors in system D, although fewer can be used (see **Figure 10-1**). The 'Z' loop at 12 m from the stop line is typically used to demand and extend the phase. The 'Y' and 'Z' loops, at 25 m and 39 m from the stop line respectively, are used to extend the phase. The furthest, at 39 m from the stop line is normally nominated as 'X'. Traditionally the system demands the green if the signals are on red or extends a green phase already running. The 'Y' and 'Z' loops traditionally only extend the green but can also place demands. There may be good reasons for specifying this - for example, there may be a minor side road or a bus stop less than 40 m from the junction. In both cases, at quiet times with no other traffic, anyone turning out of the side road, or the bus pulling away after the signals have turned to red will not be detected.

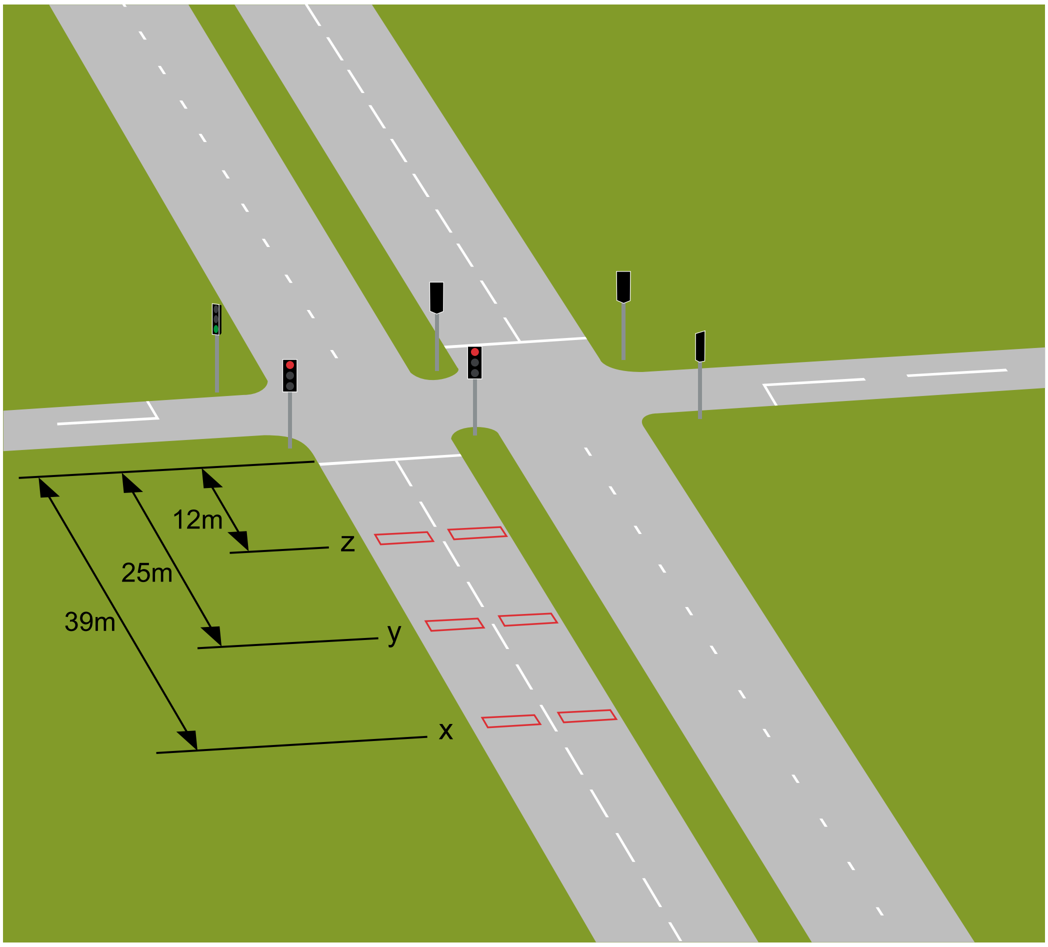


Figure 10-1 Layout of X, Y and Z detector loops for System D

10.4.2. Layout details can be found in drawing G23 in the G series of Volume 3 of the Manual of Contract Documents for Highway Construction Works, published by Highways England.

10.4.3. At advanced stop lines (see **12.14**) drivers must stop at the first stop line if the signals are on red, with the normal proviso for the amber signal. If they pass the first line while the signals are on green, but do not reach the second before the signals turn red, they must stop between the stop lines. Consequently detector positions should be measured from the second stop line to be reached.

10.4.4. System D can be supplemented with either Speed Assessment (SA) or Speed Discrimination (SD) systems at high speed sites (see **9.3.8** - **9.3.10**). Both SA and SD use sub-surface inductive loop detectors. Two loops per lane are installed at each detection site to provide for speed measurement. Guidance on loop detector configuration and spacing for System D, SA and SD can be found in specification MCE0108C.

10.4.5. SA gives a speed related period during which the signals can change, followed by a 5 s fixed extension which, at a constant speed, enables the driver to reach the System D detection area. If the inputs from detectors indicate a speed of 28 mph or more, the phase green is extended by a fixed period of 5 s, following a delay period given by the formula:

$$\text{Delay} = (140 - 5v) / v$$

where v is the measured vehicle speed in m/s. Above 62 mph, where this formula gives negative results, the delay should be set to zero.

10.4.6. SD is simpler, giving a fixed extension period if a vehicle is travelling above a minimum speed. There are two types – “double” for 85th percentile speeds between 35 and 45 mph, giving a 3 s extension, and “triple” for 85th percentile speeds over 45 mph, giving a 3.5 s extension at both additional detection points. Once the vehicle reaches the System D area the extensions run in parallel.

10.4.7. The green period can terminate:

a) at the end of the minimum green,
b) after the last extension period (a gap change), or
c) at the maximum green (a max change).

10.4.8. On a max change, the controller will extend the all-red period by 2 s.

11 PEDESTRIAN FACILITIES AT SIGNAL-CONTROLLED JUNCTIONS

11.1 General

11.1.1. The design issues at signal-controlled junctions may be vehicular movement, delay and congestion problems, but crossing places at junctions are a key part of the network, providing a safe and reliable place to cross. The initial justification for signal control may still be a vehicular one but the needs of all road users should be taken into account in the final design. In recent years there has been an emphasis on encouraging walking and cycling, improving accessibility, and creating streets with a better sense of ‘place’ that encourages footfall. The provision of better crossing facilities is an essential part of this.

11.1.2. Pedestrian demand should be assessed as part of any traffic signal design process, both for new junctions and for upgrades, and specific measures included in the design, unless site circumstances justify their exclusion.

11.1.3. When considering crossing types it is important to establish the level of pedestrian demand and any existing desire lines as this will influence the eventual choice. Vehicle speed and flow, impact on capacity and the layout of the site will also need to be considered when assessing what option to provide.

11.1.4. Pedestrians are more likely to ignore the red signal if they consider the time they have to wait is unreasonable. While waiting at a junction in bad weather, a driver may be frustrated but is generally warm and dry. A frustrated, cold and wet pedestrian is more likely to take risks. A crossing that requires them to deviate off their desire line further than they consider acceptable is also unlikely to be used.

11.1.5. As with all facilities, it is important to consult local accessibility groups and road safety officers. Much of the advice in section 18 on stand-alone crossings is relevant to providing crossing facilities at junctions, and should be considered.

11.1.6. Although footbridges and underpasses remove conflict between pedestrians and vehicles, and are therefore technically the safest options, they have proved to be generally unpopular and many have been removed. They are expensive to install and maintain, are often seen as unpleasant, inaccessible and unsafe, and are not generally suitable for cyclists or mobility impaired people. They may make journeys longer as they force people to divert off the desire line. As a result, people often do not use them, putting themselves at risk by continuing to cross at street level as it provides a more direct route.

11.1.7. Unless it is possible to provide a well-designed, accessible installation that is accepted by all groups, particularly those representing disabled people, other options to footbridges and underpasses should be considered.

11.2 Signal heads, push buttons and pedestrian demand units

11.2.1. Pedestrian facilities may be described as “farside”, if the pedestrian signal head is viewed by the pedestrian from across the road, or “nearside”, if the pedestrian signal is incorporated into the push button unit on the same side of the road as the pedestrian waiting to cross.

11.2.2. Both nearside and farside crossing facilities are prescribed in the Regulations. It is for the local authority to consider which type of crossing to provide, both in individual circumstances and as an area-wide policy. Consistency and safety are key factors in these decisions. Authorities should consider adopting a policy setting out which types of crossings are to be provided in what circumstances, and why. It is important that local policy is applied consistently so that road users are clear what is expected of them.

11.2.3. Farside pedestrian signal heads are prescribed in diagram 4002.1 (S14-2-9, see **Figure 11-1**) and push buttons in diagrams 4003 (S14-2-11, see **Figure 11-1**) and 4003.8 (S14-2-12, see **Figure 11-3**). Diagram 4003.8 shows the compact push button unit consisting of only the push button and legend “push button; wait for signal”, omitting the ‘WAIT’ legend. This may be used as an alternative to the full-size push button to diagram 4003. Use of these can reduce visual intrusion and cut down costs, but the need to provide consistency for road users across surrounding sites should be borne in mind. It should be provided with a rotating tactile cone in the same way as a full-size push button unit.

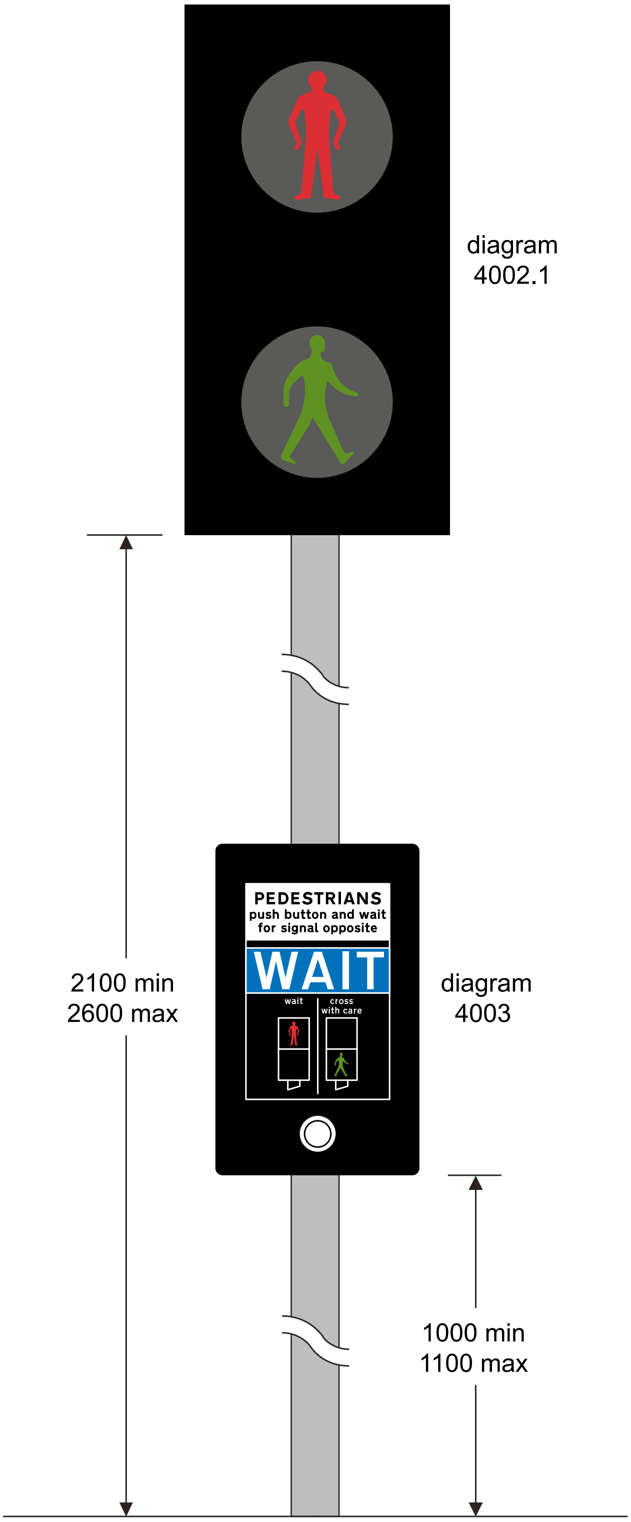
11.2.4. Nearside pedestrian demand units are prescribed in diagram 4003.1 (S14-2-13, see **Figure 11-2**). High-level repeater signals, for use at sites where large numbers of pedestrians may obscure the demand unit, are prescribed in diagram 4003.1A (S14-2-14). These should be mounted with a minimum of 1700 mm clearance to the underside of the unit.

11.2.5. The position of the push button or demand unit and the general waiting area governs intervisibility (see **2.1.6**). Indecision caused by a poor line of sight will increase the chance of an accident. Good intervisibility allows an informed choice.

11.2.6. Visually impaired people are taught to look for a push button to their right, placed within easy reach of the edge of the tactile paving. A distance of 0.5 m from the stud markings and edge of the tactile paving is recommended. This push button unit should always be provided with a tactile signal. Additional push button units should be provided on wider crossings, especially when nearside signals and pedestrian detectors are in use.

11.2.7. On refuges and on one-way streets, a push button unit should be provided on each side, as sighted pedestrians need a push button to the left to encourage them to face oncoming vehicles. Additional push button units should also be provided on central refuges where pedestrians may be trapped at the end of the pedestrian stage.

11.2.8. Where additional nearside pedestrian demand units to diagram 4003.1 are provided on central refuges, it is important that these show a blackout between the green and red symbols, to reduce the risk of pedestrians stopping on the carriageway if they see a red symbol. The unit should display a red signal if a pedestrian pushes the button during the blackout period.



Mounting arrangement for pedestrian signal head to diag 4002 and push button to diag 4003. Similar arrangements should be used for farside toucan crossings. Diag 4003.8 may be used instead of diag 4003; the same height is recommended.

Figure 11-1 Diagram 4002.1 (S14-2-9) and Diagram 4003 (S14-2-11)

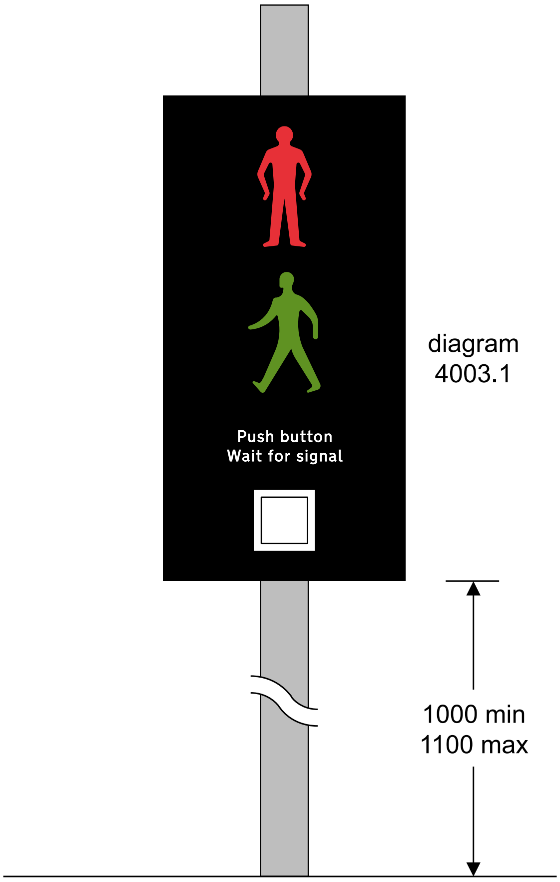


Figure 11-2 Pedestrian demand unit to diagram 4003.1 (S14-2-13)

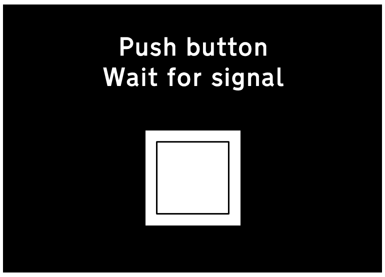


Figure 11-3 Compact push button unit to diagram 4003.8 (S14-2-12)

11.3 Geometric layout

11.3.1. Pedestrians can be disoriented by complex layouts. For example, at a contraflow lane or on a one-way street the direction of vehicular flow may not be obvious to pedestrians. If there is any possibility of confusion, appropriate signs and road markings should be used to remind drivers and pedestrians, for example signs to diagram 810 (S11-2-2), diagram 963 (S11-2-40), and diagram 1029 (S11-4-18).

11.4 Stop lines

11.4.1. The Regulations do not specify a minimum distance between stud markings, stop line and primary signal post, but a minimum distance of 3 m from stop line to crossing studs (2.5 m from stop line to primary signal post, which will usually have the pedestrian push button mounted on it) is recommended to give good intervisibility between driver and pedestrian. 1.2 m may be appropriate where ASLs are provided (see **3.1.2**). This is particularly important where vehicles sharing the same stop line move at different times. The actual distance will depend on the site and local experience of driver behaviour – it may be appropriate to provide a larger gap. Drivers will generally show greater respect for stop lines and other white lining that is in good condition, and regular renewal can be a low cost but effective safety measure.

11.4.2. At some installations the stop line may need to be moved back from the primary signal post to accommodate large turning vehicles. It is not normally necessary to move the crossing studs in such circumstances but the impact on intervisibility should be considered (see **4.2.3**). Where crossing stud markings to diagram 1055.1 are provided but without dedicated pedestrian signals, as described in **11.14.4**, they may be placed up to 10 m from their associated signals, which should be taken into account when positioning the signals and markings.

11.5 Crossing studs and tactile paving layouts

11.5.1. Pedestrian crossing stud markings are prescribed in diagram 1055.1 (S14-2-55). The minimum prescribed width between the studs is 2.4 m but the actual width used will be dependent on site conditions. Crossings between 2.4 m and 5 m are typical, but the width may be increased up to a maximum of 10 m. This may be beneficial where there are large numbers of pedestrians.

11.5.2. Tactile paving should always be provided at all crossing points, to the layouts and colours recommended in the 'Guidance on the Use of Tactile Paving Surfaces'. The edges of tactile paving areas should line up with the crossing stud markings to diagram 1055.1. A gap of 0.5 m between the edge of the tactile surface and the crossing studs, and the push button or pedestrian demand unit is recommended to allow visually impaired people to locate the push button and orientate themselves at the kerb edge. Dropped kerbs should always be provided across the full width of the crossing point.

11.5.3. Where pedestrian refuges are provided, the full width of the crossing should be maintained as a dropped kerb or flush with the carriageway through the refuge.

11.5.4. Coloured surfacing between the studs may help highlight the crossing, but the risk of pedestrians becoming confused as to who has priority should be considered. There should be a contrast between the footway and the carriageway.

11.6 Pedestrian crossing sequences and timings

11.6.1. The pedestrian crossing sequence at a signal junction is shown in **Table 11-1** and consists of two parts. The first is known as the "invitation to cross", and is the period in which the green pedestrian symbol shows. This is followed by the clearance period, which should be long enough to cross the carriageway for someone stepping off the kerb at the end of the invitation to cross. The clearance period is configured differently depending on whether farside or nearside signalling is used. At farside signals a black-out is shown, and neither the red nor the green pedestrian symbol is illuminated. This is followed by an all-red period. At nearside pedestrian facilities, the invitation to cross is followed by an all-red period.

11.7 Design walking speed

11.7.1. A walking speed of 1.2 m/s is conventionally used to calculate timings for crossings. This results in timings that are suitable for the majority of crossings. The clearance period is key, as this is what allows people to clear the crossing if they step off the kerb as the green symbol goes out. If this is properly calculated, it will ensure there is sufficient crossing time.

11.7.2. A lower design speed of 1.0 m/s may be used, either on a site-by-site basis or as an area-wide policy. Where there is a large number of slower pedestrians, this may be beneficial. The use of on-crossing detection may also help, by automatically extending crossing times where needed.

11.7.3. The duration of the invitation to cross period will depend on how many people are waiting, time of day, and distance to cross. Generally, it should be long enough to allow people to clear the footway, establish themselves on the crossing and avoid turning back when the all-red or blackout period begins.

11.7.4. The invitation to cross should never be shown until the red signal has been shown for sufficient time for turning vehicles to clear all pedestrian crossing facilities. This should be considered as part of the calculation of intergreen times (see **6.5**).

11.7.5. At walk with traffic pedestrian facilities, the duration of periods 4-6 inclusive (see **Table 11-1**) should be safeguarded as the minimum.

11.7.6. Where the junction is included in a UTC scheme, no centrally-controlled timing plan should be used unless the requirements in **11.7.4** and **11.7.5** for the pedestrian stages are fully met.

Table 11-1 Sequences and timings for farside pedestrian facilities at signal-controlled junctions

Period P	Farside pedestrian signal	Vehicle signal	period duration (seconds)
1	Red	Green	Dependent upon cycle time.
2	Red	Amber	3
3	Red	Red	Minimum to clear traffic in the junction.
4	Green (invitation to cross)	Red	6-12, depending upon carriageway width and pedestrian density.
5	Black-out (clearance)	Red	3-15, may be extendable where on-crossing detection is used Where pedestrian countdown is used, this period is fixed and cannot be extended.
6	Red	Red	1-3
7	Red	Red + Amber	2

Table 11-2 Sequences and timings for nearside pedestrian facilities at signal-controlled junctions

Period P	Nearside pedestrian signal	Vehicle signal	period duration (seconds)
1	Red	Green	Dependent upon cycle time.
2	Red	Amber	3
3	Red	Red	Minimum to clear traffic in the junction.
4	Green	Red	4-9
5	Red	Red	1-5
6	Red	Red	0-30 (pedestrian extendable period)
7	Red	Red + Amber	2

11.8 Clearance period

11.8.1. The clearance period allows people to clear the crossing if they step off the kerb as the green symbol goes out. This should always be calculated to ensure there is sufficient crossing time whichever type of facility is provided.

11.8.2. The following worked examples show calculations for clearance periods for both farside and nearside facilities, using a typical site with one lane in each direction 3.5 m wide. Two calculations are shown, for design walking speeds of 1.0 m/s and 1.2 m/s. Results should always be rounded up to the nearest whole number.

11.9 Worked example: farside facilities

11.9.1. The clearance period is given by the formula:

P5 + P6 = L/s

Where L = lane width in metres and s = design walking speed. P5 and P6 are periods 5 and 6 from **Table 11-1**.

L = 3.5 x 2 = 7 m

For a design walking speed of 1.0 m/s:

P5 + P6 = 7/1 = 7 s

For a design walking speed of 1.2 m/s:

P5 + P6 = 7/1.2 = 5.8 s, rounded up to 6 s.

Note that where an extendable blackout is to be used, this result is the minimum length of the blackout period.

11.10 Worked example: nearside facilities

11.10.1. For nearside signals, the clearance period may be calculated in two ways depending on whether the controller is configured to operate in a consecutive or concurrent mode. In consecutive mode, the variable extension P6 starts at the end of the minimum extension period P5. In concurrent mode, P6 starts at the same time as P5.

11.10.2. For consecutive mode the clearance period is given by:

P6 = (L/s + Pc) - P5

Where L = the width of the carriageway in metres, s = design walking speed and Pc = pedestrian comfort factor, taken as 3 s. P5 is the fixed minimum extension period following immediately after the invitation to cross period (P4). The base setting for this is 3 s.

For a design walking speed of 1.0 m/s:

P6 = [(7/1.0 + 3] – 3 = 7 s

For a design walking speed of 1.2 m/s:

P6 = [(7/1.2) + 3] – 3 = 5.8 s (rounded to 6 s)

11.10.3. Pc should be chosen to reflect the characteristics of the pedestrians using the crossing, for example if there are significant numbers of children or older people, and the width of the crossing. 3 s is a reasonable value, and may be fine-tuned on site if necessary.

11.10.4. For concurrent mode the clearance period is given by:

P6 = (L/s) + Pc

For a design walking speed of 1.0 m/s:

P6 = (7/1.0) + 3 = 10 s

For a design walking speed of 1.2 m/s:

P6 = (7/1.2) + 3 = 5.8 + 3 = 8.8 s (rounded to 9 s)

11.11 Kerbside and on-crossing detection

11.11.1. Crossings may employ two forms of detection in addition to push buttons:

a) kerbside call/cancel detectors, which cancel pedestrian demands that are no longer required. They may also be used to adjust crossing timings to take account of pedestrian flows, and
b) on-crossing detectors, which extend the all-red time.

11.11.2. Developed originally for Puffin crossings, both types of detection may now be used at all signal-controlled facilities. Whether or not to do so will depend on local policies and on-site circumstances. For example, on-crossing detection cannot be used with pedestrian countdown as this requires a fixed blackout period.

11.11.3. Kerbside detection can improve the efficiency of a crossing by cancelling unwanted demands and allowing timings to be adjusted to take account of pedestrian flows. It may now be used on both farside and nearside facilities. At sites with high pedestrian demand, kerbside detection may be of limited value as demand is likely to be present for the majority of the time.

11.11.4. Kerbside detection may need adjusting where narrow footways mean passing pedestrians may trigger the detection unnecessarily.

11.11.5. Where kerbside call/cancel detection is used, the delay time, after which the call is cancelled if the kerbside detector does not detect anyone waiting, should be set to a value between 2 s and 4 s depending on site conditions.

11.11.6. On-crossing detection should be properly installed, aligned and maintained in accordance with the manufacturer's guidelines. This can be particularly relevant at nearside facilities, as pedestrians cannot see a demand unit once they are established on the crossing. At crossings over 4 m in width, two sets of parallel detectors will generally be required to ensure full coverage of the crossing.

11.11.7. On-crossing detection can be used with farside facilities, and can give similar benefits to nearside facilities as well as improving efficiency of operation. The exception is where pedestrian countdown is to be used, as on-crossing detection is incompatible with this (see **11.12**).

11.11.8. The clearance period can be extended by on-crossing detection. A fault monitor algorithm in the controller checks for outputs from the on-crossing detector during the pedestrian and vehicular traffic stage, to ensure it is operating correctly. The operation of the on-crossing detector is checked between the end of one pedestrian clearance period to the start of the next. In normal operation, vehicles passing the detector would trigger operation. If nothing is detected, indicating a possible fault, the following pedestrian clearance period would be extended to a maximum pre-set value stored in the controller. This process is repeated each cycle.

11.12 Pedestrian countdown signals

11.12.1. Pedestrian countdown signals are prescribed in diagram 4002.1A (S14-2-10, see **Figure 11-4**). The diagram shows them in combination with the farside Toucan signal head but the cycle aspect is omitted when used at pedestrian-only sites. Countdown signals indicate the amount of time remaining in which people can finish crossing the road. They are not prescribed to indicate any other part of the signal sequence.

11.12.2. Countdown must only be used with either farside pedestrian or Toucan facilities. At pedestrian facilities it may be mounted to the left or right of the green symbol, but must not be mounted in any other position. At Toucan facilities it must be mounted on the opposite side of the green pedestrian symbol to the cycle symbol, with the signal head making an inverted 'T' shape. The countdown unit is designed to retrofit to existing signal heads and to learn the existing timings. No timing changes are required to fit countdown, but it may be useful to review what is currently in use if countdown is being considered.

11.12.3. If countdown is to be used, on-crossing detection will not be possible as the blackout period must be fixed.

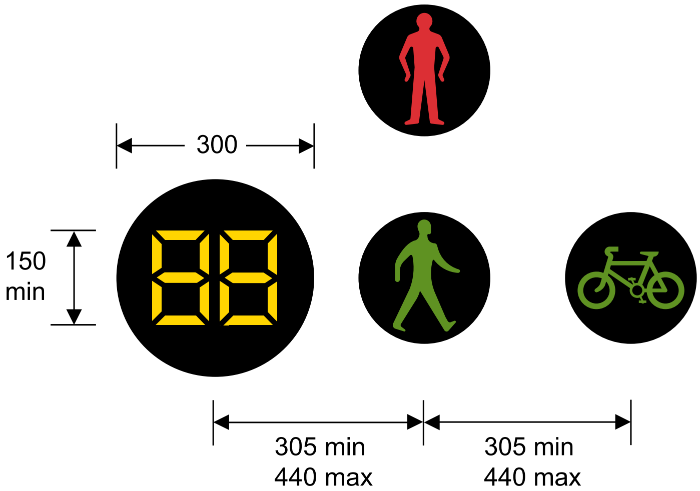


Figure 11-4 Diagram 4002.1A (S14-2-10) Pedestrian countdown unit, shown in combination with the diagram 4003.5 (S14-2-19)

11.13 Tactile and audible signals

11.13.1. S14-1-9 permits tactile and audible signals to be used in conjunction with the green pedestrian symbol, or invitation to cross period, to convey the same meaning. Both are intended primarily for the benefit of visually impaired people, but are also helpful to others. Tactile and audible signals are covered by relevant TOPAS specifications.

11.13.2. Tactile signals should be provided at crossing facilities as a default. They can be used at times and in places where audible signals are not suitable, for example where an audible signal is switched off overnight, or cannot be used because the junction does not operate a full pedestrian stage. Designs are available that offer improved detection for people with loss of sensation in the fingers, and authorities should be aware of the different design options when specifying tactile signals. Advice on installing tactile signals is given in 11.2.

11.13.3. Audible signals are in the form of an intermittent tone. In residential areas, those living nearby may object to the noise levels of audible signals, particularly at night. The site should be checked after installation to see if any adjustments are needed. A time switch can be used to reduce the sound levels, or, if appropriate, switch them off overnight.

11.13.4. The standard audible signal can be heard at some distance and it can be hard to pinpoint its origin. For this reason, at junctions where the audible signal at one crossing could be heard and mistaken for that at another, audible signals should only be used where a full pedestrian stage is used.

11.13.5. Tactile and audible signals should always start at the same time as their associated green pedestrian signal, and should be activated only whilst this is illuminated. Tactile and audible signals should not be activated until all pedestrian phases within a full pedestrian stage have started. They should never continue past the end of the first green pedestrian signal to finish. Invitation to cross periods may need adjusting to ensure those relying on tactile and audible signals are given sufficient time to establish themselves on the crossing.

11.13.6. As part of the design process a risk assessment should be carried out to assess possible misinterpretation of the tactile and audible signals. The staging, phasing and layout may need adjusting to ensure safe and unambiguous operation.

11.14 No pedestrian facilities

11.14.1. Providing no signalised pedestrian facilities at all at a junction should be seen as the exception. A lack of formal facilities requires pedestrians to judge for themselves when to cross while traffic is held, which can be intimidating for those not familiar with the junction, and especially for visually impaired people and mobility impaired people. Generally, this is only acceptable where levels of pedestrian demand are very low and the width to be crossed is narrow. Examples of where it may be justified are at sites where there are no footways, at tunnel control sites or at bus gates, particularly where part of the site is not signal-controlled.

11.14.2. Without a pedestrian phase, most pedestrians will try to cross during the intergreen period and it is important to check that these have been correctly calculated. Extending the intergreen to give pedestrians more time is generally not recommended. It lacks the clarity provided by pedestrian signals, and can increase delays to vehicles and driver disobedience.

11.14.3. Where demand is low and a more formal crossing is not justified, pedestrian refuges can be helpful by breaking up the crossing task into two parts. The refuge should be large enough to accommodate the expected number of people and to allow those with pushchairs or wheelchair users to wait safely. They may be an absolute minimum of 1.2 m wide, but to cater for wheelchair users they should be at least 1.5 m and preferably 2.0 m.

11.14.4. Crossing studs to diagram 1055.1 (S14-2-55) can be used, whether refuges are installed or not, which may be helpful to visually impaired people but on their own they generally offer little help to pedestrians. Where used to provide an unsignalled facility, crossing studs must be placed within 10 m of their associated signal.

11.14.5. Shared stop lines may create particular problems if no signalled pedestrian facility is provided, as pedestrians may assume that once the first lane has stopped all others sharing the same stop line will follow. In a similar way, where staging includes a right turn indicative arrow, and one arm of a previous two-arm flow has stopped, pedestrians may cross in front of the approach still having a green signal assuming that both approaches will stop together. There may be added confusion if the right turn arrow only appears at peak times and a pedestrian may have previously crossed in the off-peak. Where this type of staging is unavoidable, pedestrians should be provided with dedicated signals to reduce possible confusion.

11.15 Full pedestrian stage

11.15.1. A full pedestrian stage, in which all pedestrian phases run at the same time while traffic is held on a red signal, is simple and easily understood and provides a good level of service for pedestrians. It may require a longer cycle time, and a pedestrian arriving after the end of the green pedestrian signal may have a long wait. Providing two pedestrian stages per cycle can ease this but this will have a greater effect on junction capacity. **Figure 6-2** shows a typical layout and staging arrangement.

11.15.2. Normally, the facility should only be called by push button demand. This encourages pedestrians to use push button facilities and in the case of nearside signals, look towards oncoming vehicles. The use of permanent demands may be considered where there is a large and continuous pedestrian demand, for example outside a station or in a busy high street. Permanent demands can be introduced by time-of-day, which may help where demand varies. Push buttons should be provided at all points where pedestrians may cross. Note that visually impaired people are generally taught to look for a push button on the right hand side – on one-way streets push buttons may be required on both sides to accommodate this.

11.15.3. On wider approaches, refuges may be provided but should not be staggered. Nearside signals may help reduce any uncertainty for pedestrians following the green pedestrian phase.

11.15.4. Diagonal crossings should only be used with a full pedestrian stage. They can be helpful if they enable people to follow a desire line, or relieve pressure on crowded junctions, but they may not be appropriate for some groups, particularly visually impaired people. Conventional orthogonal crossing places should always be provided with flush dropped kerbs, tactile paving and tactile and audible signals. Flush dropped kerbs, tactile paving, and audible and tactile signals should not be provided on the diagonal crossing part. If a lowered kerb is provided, there should be a minimum upstand (after possible re-surfacing) of at least 25 mm. Crossing times should cater for the longest crossing distance, likely to be the diagonal.

11.15.5. The controller should be configured to ensure that, on termination of the pedestrian stage, the right of way would revert to a nominated stage in the absence of other demands. If there is no obvious default stage, this could be an all-red so that the response to the next demand will be with minimum delay.

11.15.6. When an early cut-off stage is provided, the pedestrian stage should never immediately follow if a left turn filter is permitted to run on the side road at the same time as the early cut-off stage (see **8.3.8**). If stage skipping is used as part of an adaptive control system, the operation of this should consider the possible impacts on pedestrian facilities.

11.15.7. If one approach of a junction is more difficult for pedestrians to cross than others, the pedestrian stage should generally follow the end of the vehicle stage on this approach.

11.16 'Walk with traffic' pedestrian facility

11.16.1. Providing facilities that run at the same time as other vehicle movements can reduce pedestrian delay and ambiguity caused by long red pedestrian periods. It can also reduce the impact on junction capacity by making the junction operate more efficiently. This option may work well at larger, more complex junctions where there are limited possibilities for a full pedestrian stage. This is often referred to as a 'walk with traffic' facility.

11.16.2. On one-way roads, or where the straight-ahead movement runs in a different stage to the turning movement, this can work well. On two-way roads, it will require some turning movements to be banned to enable pedestrian and vehicle stages to run together, and therefore it will only be suitable in certain locations. **Figure 11-5** shows a typical layout and staging.

11.16.3. Advance signs to diagram 612 or 613 may be needed to ensure drivers are informed of the restriction and to reduce the risk of them turning illegally – see Chapter 3. Regulatory box signs to diagram 606, 612 or 613 (as appropriate) should be provided within the signal head at the junction (see **5.2**). 300 mm diameter versions of these signs for use in signal heads are prescribed in S14-2-42 & S14-2-43. Any banned movements will require a supporting TRO.

11.16.4. The risk of drivers ignoring the banned movement and therefore turning into the crossing while it is being used should be carefully considered as persistent problems will create an increased safety risk. This may be a particular issue as drivers become familiar with a new layout that includes a banned movement previously permitted. Kerb radii may need to be adjusted to reduce this risk, by making it physically harder for drivers to make the turn.

11.16.5. Where space permits, walk with traffic pedestrian facilities can be accommodated by designing appropriate splitter islands. The left and right turning movements from the side road pass either side of the island and pedestrians can cross safely from the island across the main road between the segregated flows when the side road traffic has the right of way.

11.16.6. Where pedestrians are given a green signal at the same time as moving vehicles on other approaches, signal heads will need to be carefully positioned to ensure that drivers or pedestrians are not misled. Louvres on green farside pedestrian aspects may be considered to avoid potential 'see through' problems, but should never be used on red pedestrian signal aspects.

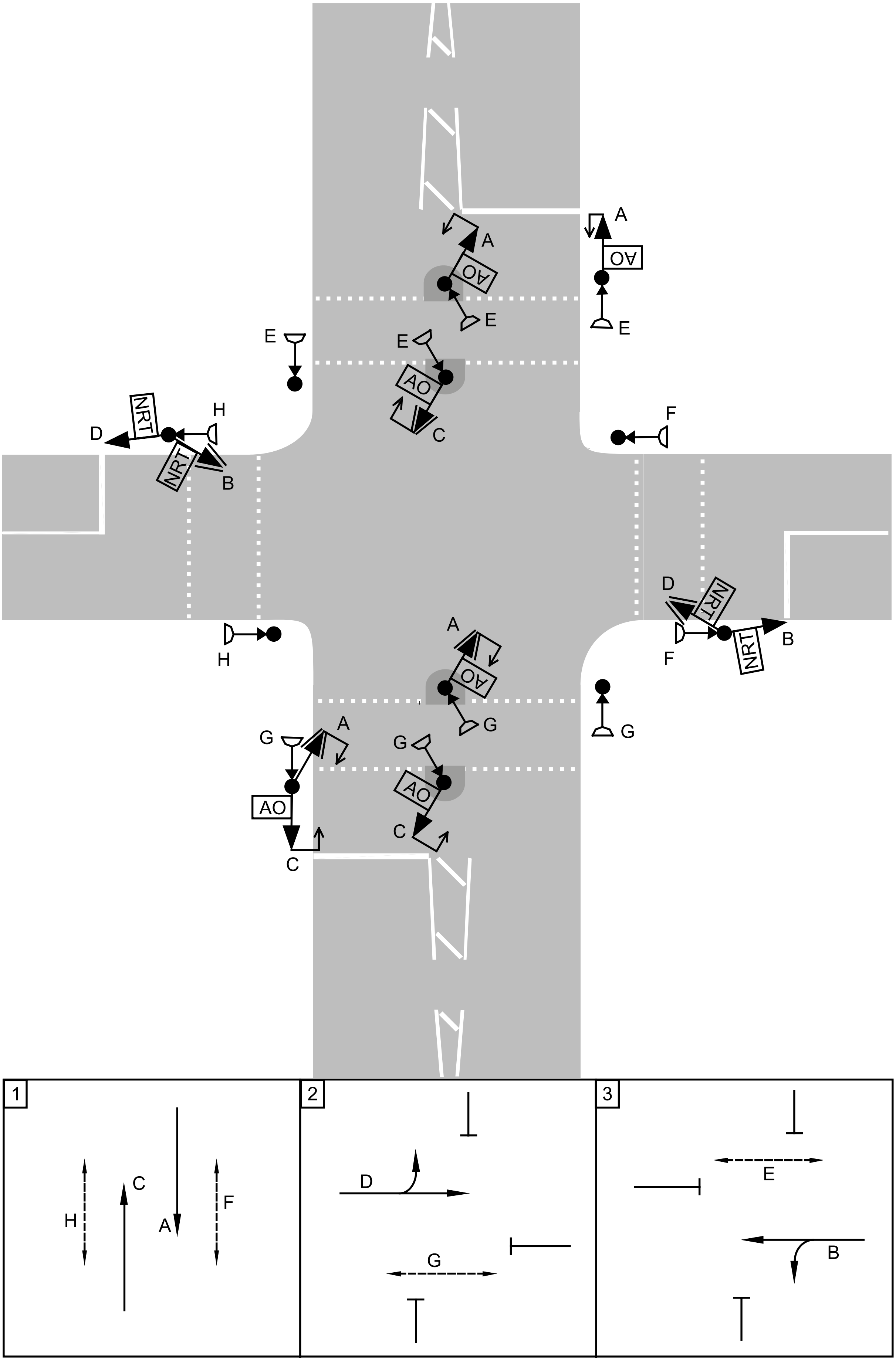


Figure 11-5 Walk with traffic pedestrian facility

11.17 Staggered or two-stage pedestrian facility

11.17.1. On wider approaches, pedestrian refuges can be used to enable the pedestrian movement to operate in two stages. This helps reduce cycle time by allowing the pedestrian movement to be better integrated with vehicle movements, thus reducing the amount of time pedestrians have to wait for a green signal. The disadvantage is that pedestrians have to cross in two movements and it may be difficult to locate the crossing on the desire line. Staggered facilities should be designed to meet the desire line as closely as possible.

11.17.2. The size of the refuge should cater for the expected numbers using the crossing and their routes. The type of user should also be considered – for example, people with mobility scooters may need extra space. There should be a minimum clear refuge width of 2 m, which will allow two wheelchair users to pass each other. At staggered refuges, a 3 m width allows for guardrailing to be installed and a clear waiting area of 2 m provided. Where guardrailing is not provided, it may be possible to reduce the width to 2.5 m.

11.17.3. A minimum of 3 m between crossing limits will generally allow space for pedestrians to wait and to pass each other between the crossings, and reduces the risk of 'see-through'. Where either or both crossings are on an angle this risk is reduced and the gap between crossings can be reduced. This may also apply where nearside facilities are used. **Figure 11-6** shows an indicative layout and staging.

11.17.4. In some places staggered crossings have been replaced with refuges wide enough to allow the two movements to operate in line, but in two stages. This relies on the refuge being wide enough so that pedestrians do not mistake the green signal on the second stage for that on the first. Nearside operation will reduce this risk but experience has shown that a refuge width of between 5 - 7 m can work. Rather than providing a full stagger, offsetting the crossings slightly from each other, or placing one at a slightly different alignment to the other, may also help pedestrian understanding. The location of the crossings should meet the pedestrian desire lines as far as possible.

11.17.5. Some advantages and disadvantages of right/left or left/right staggered crossings are set out in **Table 11-3**.

Table 11-3 Advantages and disadvantages of right/left or left/right staggered crossings

Stagger	Advantages	Disadvantages
Left / right	• Consistent with stand-alone crossings. • Encourages pedestrians to face oncoming vehicles. • Pedestrians on the exit of a junction are nearer to the junction, improving intervisibility.	• Moves stop line and queue further from junction. • May increase intergreens and therefore lost time if crossing points, on all approaches, are not the same. • If a stop line were needed for the crossing on the exit it would be very close to the junction. • Reduces available stacking space within the junction, where an internal stop line is used.
Right / left	• Brings the stop line nearer to the junction. • Moves the exit crossing away from the "side road" and allows drivers of turning vehicles longer to assess possible dangers. • Allows possible stop line for exit crossing to be a reasonable distance from junction.	• Not consistent with stand-alone crossings. • Pedestrians not encouraged to face oncoming vehicles whilst walking between crossings. • May cause problems with intervisibility between "side road" and pedestrians, unless an internal stop line is used.

11.17.6. If the two crossings are dividing two flows of vehicles travelling in the same direction, markings to diagram 1029 (S11-4-18, LOOK LEFT or LOOK RIGHT) should be provided.

Signs to diagram 963 (S11-2-40) and 810 (S11-2-2) may be considered, depending on site circumstances. Push button or demand units should always be provided on central islands.

11.17.7. In the layout shown in **Figure 11-6**, two-stage staggered facilities allow pedestrians to cross one half of the carriageway at the entry stop line when traffic on that approach is held on red (phases E and G). The other pedestrian phase may either run in the full pedestrian stage (phase I) or is controlled through separate signals and a parallel stage stream (phase K). The parallel stage stream requires separate signals to avoid the risk of traffic from the side road turning through the crossing. This can work well if the route follows a natural pedestrian desire line, and can be made demand dependent through the use of push-buttons.

11.17.8. This arrangement will need to consider the reservoir length and the observed speed of turning vehicles. The alignment of the vehicle signal heads should be checked to avoid possible problems with pedestrians seeing through the signals and misinterpreting them.

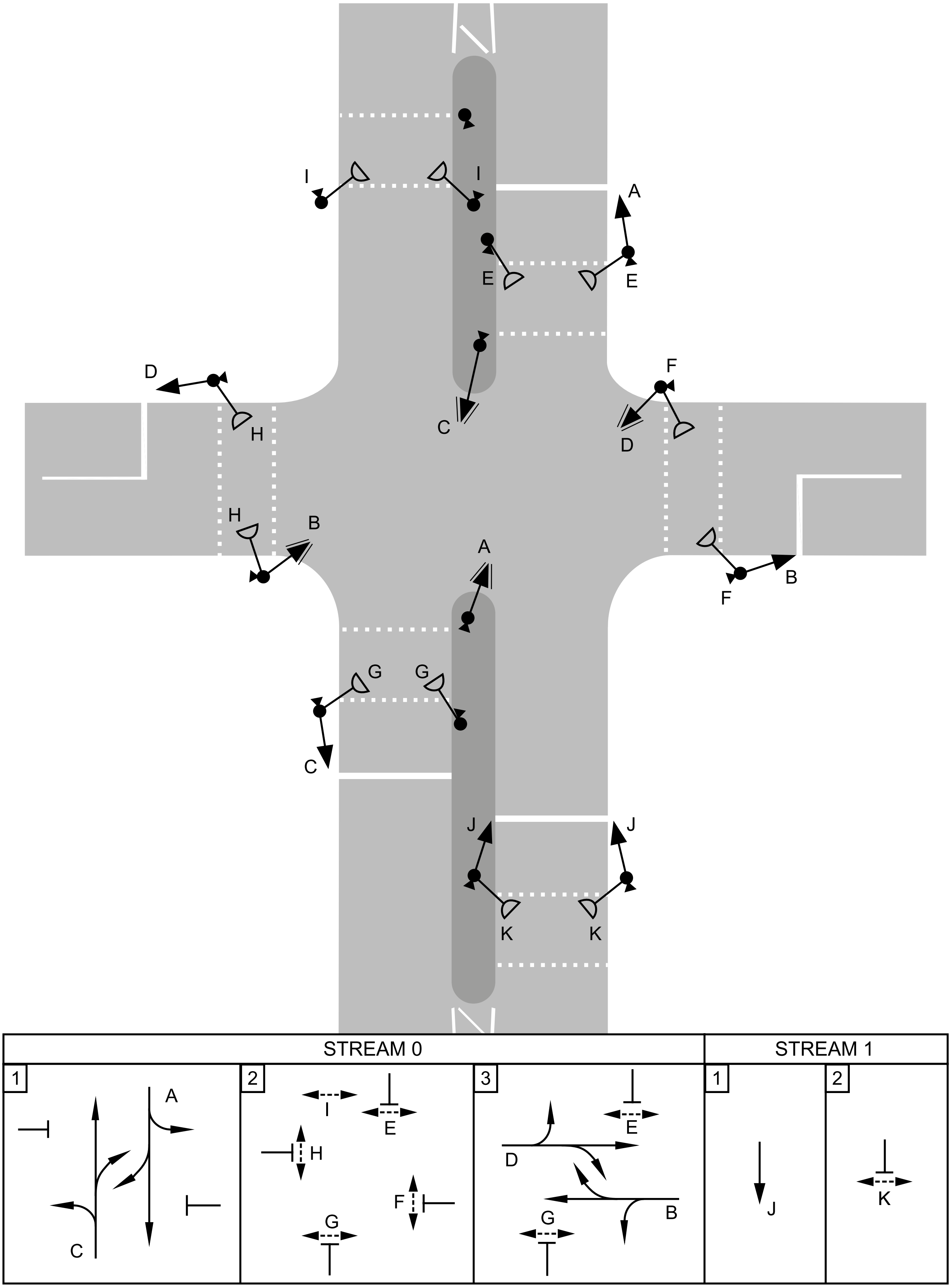


Figure 11-6 Diagram showing indicative layout of a staggered pedestrian facility

11.18 Displaced pedestrian facility

11.18.1. A displaced facility can be used where there is little pedestrian demand at a junction but there is a need close to it, or perhaps where it is not practical to have the crossing on one arm of the junction (see **Figure 11-7**). It may also have capacity advantages, which in turn will mean a shorter waiting time for pedestrians on the arm in question. The displaced facility should be as close as possible to the desire line, as if it is inconvenient for pedestrians it is less likely to be used. Displaced facilities should be no more than 50 m from the junction. The conditioning for the parallel stage stream controlling the pedestrian facility should be specified so that queuing traffic at the crossing does not block the junction. Louvres may be needed on the green traffic aspects on the approach to the crossing from the exit of the junction, to reduce the risk of see-through issues for approaching drivers.

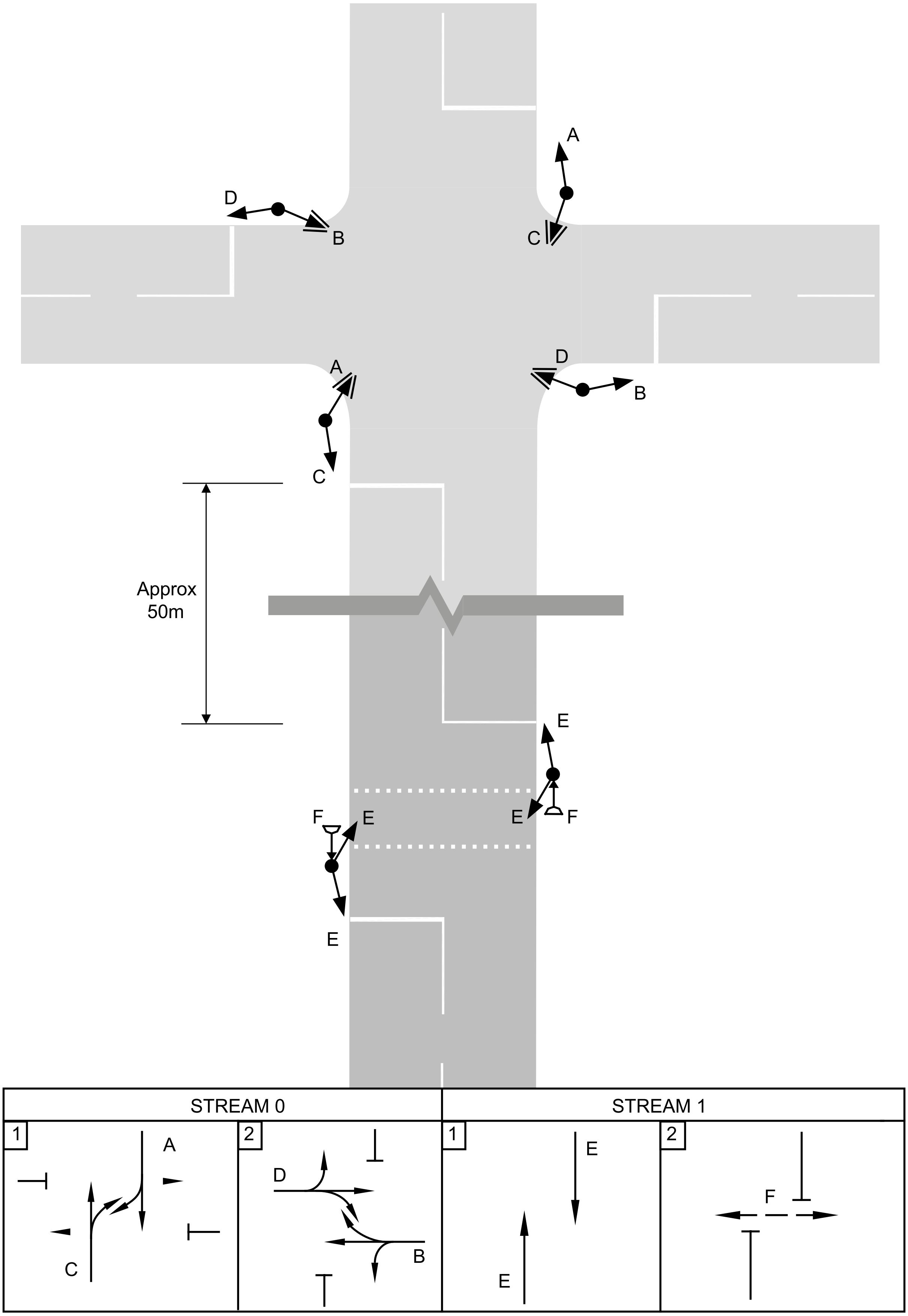


Figure 11-7 Diagram showing indicative layout and staging for a displaced pedestrian facility

12 FACILITIES FOR PEDAL CYCLE TRAFFIC

12.1 General

12.1.1. This section covers facilities for cyclists at traffic signal junctions, and should be read in conjunction with the Department's latest advice on designing cycling infrastructure.

12.2 Signal timings for cyclists

12.2.1. At junctions where no specific facilities for cyclists are provided, adjustments to signal timings for cyclists may nevertheless be beneficial, particularly at larger junctions, or where a junction arm has an uphill gradient. At all junctions where cyclists are present, timings should be validated on site to ensure the available clearance time for cyclists is correct.

12.2.2. Cycle phases at junctions should have a minimum green duration of 7 s, but longer green times may be necessary where cycle flows are high. Intergreens for cyclists are calculated using the same theory as those for general traffic (see **6.6**), but the different parameters of acceleration and speed that apply to cyclists mean that these intergreens may be a few seconds longer. Cyclists' speeds and their ability to move off are also greatly affected by gradients. Extensions can be demand dependent and triggered by detection where necessary.

12.2.3. Design parameters for cycles at traffic signals are shown in **Table 12-1**. These have been used to calculate the intergreen times in **Table 12-2**, taking into account cyclists' slower speed.

Table 12-1 Design parameters for cyclists

Parameter	Value	Notes
Acceleration	0.5 m/s^2	< 3% uphill gradient
	0.4 m/s^2	≥ 3% uphill gradient
Design speed	20 kph	< 3% uphill gradient
	15 kph	≥ 3% uphill gradient
Length of cycle	2.8 m	This length encompasses a wide range of different cycle types, thus ensuring the facility is accessible to all.

12.2.4. The minimum duration of a cycle stage (green period plus clearance time) should be sufficient to enable a cyclist to clear the junction when setting off from rest.

12.2.5. Cyclists crossing the stop line in the final second of the phase losing right of way may be travelling more slowly than motor traffic and have the potential to conflict with traffic starting to move in the phase gaining right of way.

12.2.6. For signal crossings the distance to the conflict point should be measured to the far side of the crossing.

Table 12-2 Calculation of intergreen timings to accommodate cyclists

Difference in distance to conflict point from closing cycle phase and opening traffic phase (AB minus BC on Figure 12-1)	Uphill gradient of 3% or more	Flat, downhill or uphill gradient of less than 3%
1-3	5	5
4	6	5
5-9	6	6
10-14	8	7
15	8	8
16-18	9	8
19-21	10	9
22-23	11	9
24-27	11	10
28-33	13	11
34-36	14	12

12.2.7. Figure 12-1 shows the difference in distance to the conflict point (B) from the phase losing right of way (A), and the traffic phase gaining right of way (C).

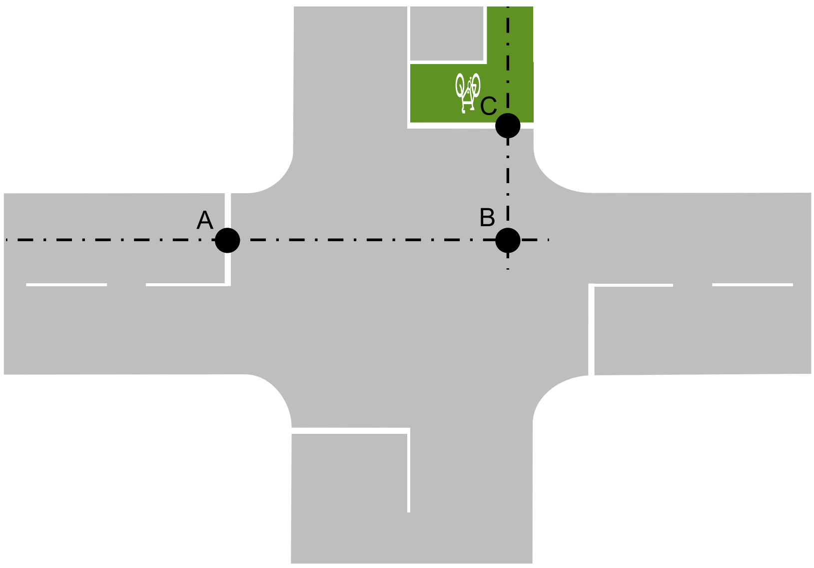


Figure 12-1 Diagram illustrating distances to potential conflict point

12.3 Detection for cyclists

12.3.1. Well positioned detector equipment with suitable sensitivity settings will enable cyclists to be detected at most signal controlled junctions.

12.3.2. Detection for cyclists needs careful consideration. Above ground infra-red or radar detectors may be easier to configure for cyclists than loop detectors, which need accurate positioning and calibrating to ensure they reliably detect cycle traffic. Loops for general traffic may not pick up cyclists, who tend to ride across the extremity of the loop, and where a large cycle flow is expected the position of the loop in the lane relative to the path of the cycle traffic should be considered. Similar considerations will be needed for loop detectors within cycle lanes and Advanced Stop Lines (ASLs).

12.4 Signal heads for cyclists

12.4.1. The Regulations prescribe two types of signal heads to control traffic consisting solely of pedal cycles. Those to diagram 3000.2 have 200 mm diameter aspects, with the amber and green aspects being cycle symbols (see **Figure 12-2**). They may incorporate either a full red aspect or a red cycle symbol aspect. Where compliance with the red signal is an issue, the red cycle aspect may help reinforce the message to cyclists. It also allows other traffic to recognise the phase as applying only to cycles. Signals to diagram 3000.2 must be ES compliant to BS EN 12368:2015.

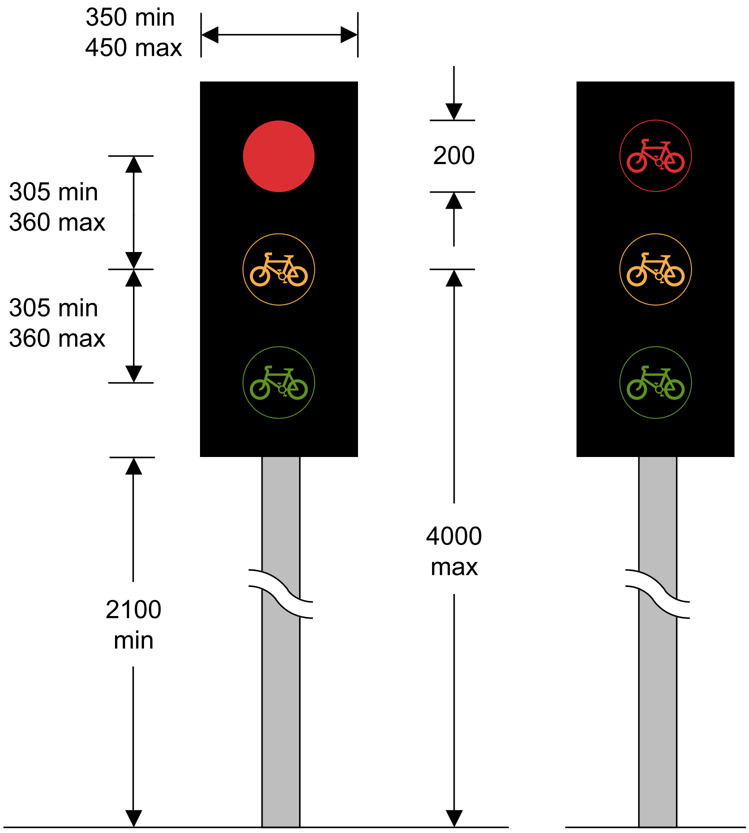


Figure 12-2 Diagram 3000.2 (S14-2-3), alternative types

12.4.2. Low level cycle signals (LLCS) are prescribed in diagram 3000.2A (see **Figure 12-3**), in two different variations, both with 100 mm diameter aspects. The signal heads must be ES compliant to BS EN 12368:2015, with the relevant performance requirements set out in S14-1-3. These differ from those specified for full-size signal heads.

12.4.3. The Regulations allow considerable flexibility in how LLCS are used:

a) on their own to signal segregated cycle movements,
b) as repeater signals mounted on the same post as traffic signals to diagram 3000 (S14-2-1),
c) as repeater signals mounted on the same post as full size cycle signals to diagram 3000.2 (S14-2-3), or
d) as an early release function mounted on the same post as full-size signals to diagram 3000 (S14-2-3).

12.4.4. Unlike standard signals to diagram 3000, the minimum requirement is for one cycle signal per approach. This may be full size to diagram 3000.2, or low level to diagram 3000.2A, but low level is likely to be more visible in the cyclist's eye-line. Signalling arrangements should be designed according to the site specific requirements, with full size and/or low level signals specified as appropriate.

12.4.5. Diagrams 612 and 613 (S14-2-43) and diagram 606 (S14-2-42) may all be varied to between 95 and 110 mm in diameter for use as regulatory box signs with LLCS. Where used, the restriction should apply to all traffic, including cycles. If the movement is “except cycles” the signals to diagram 3000 (S14-2-1) should have standard box signs with exception plates. This is not required for the associated LLCS as the movement is permitted to cyclists.

12.4.6. Where the use of LLCS is proposed, any existing signal equipment will need to be checked to ensure it is using Extra Low Voltage (ELV) and that the signal aspects are LEDs. Older installations may require equipment upgrades to enable the installation of LLCS.

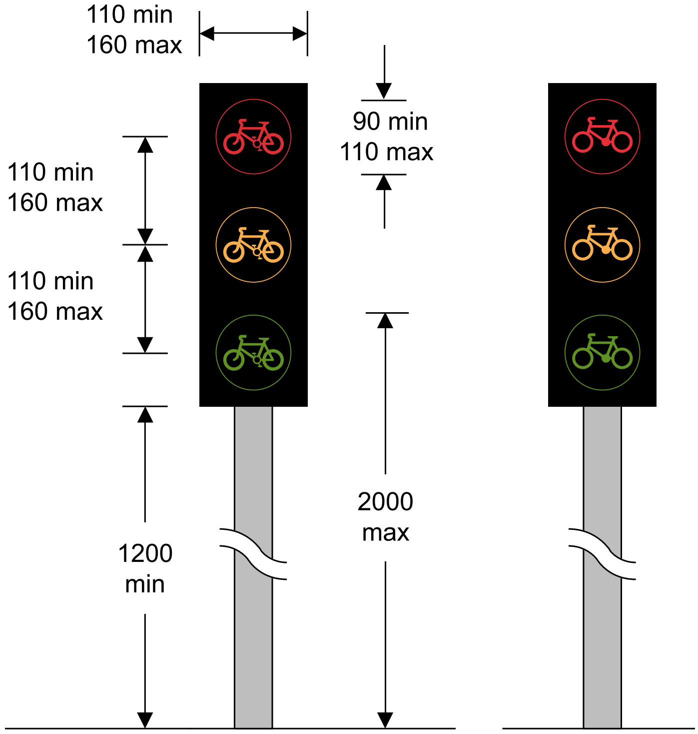


Figure 12-3 Diagram 3000.2A (S14-2-4): alternative types

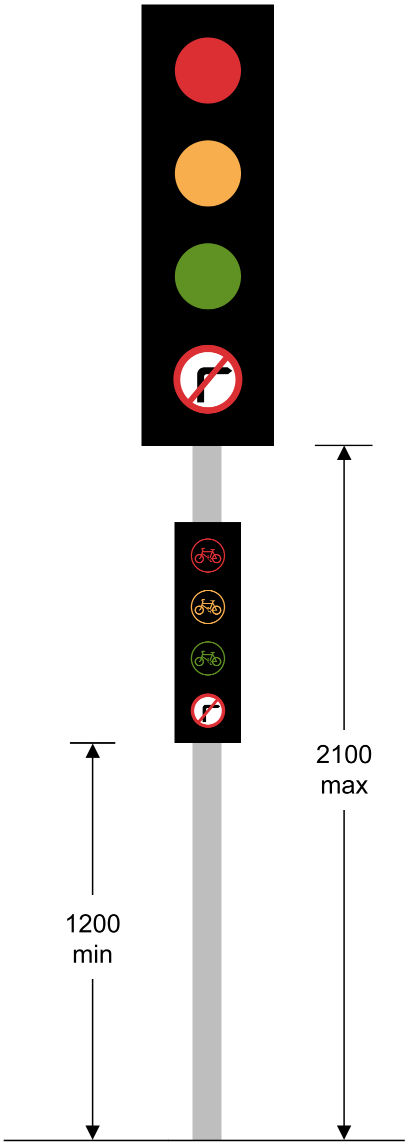


Figure 12-4 Diagram 3000 (S14-2-1) shown in combination with low-level cycle signals and an optional regulatory box sign

12.4.7. When mounted on the same post as standard vehicle signals (see **Figure 12-4**), LLCS may operate with the same timings, providing a reminder to cyclists in their eyeline of what the signal condition is. This gives no priority in time to cyclists but when used with an ASL provides more information at the point at which they are making decisions, which can be helpful.

12.4.8. LLCS used to provide an early release are programmed to turn green a few seconds before the main traffic phase. This enables cyclists to establish themselves within the junction ahead of the release of general traffic, in order to reduce the risk of potential conflicts between cyclists and turning traffic. LLCS are generally used with an ASL, allowing cyclists to position themselves in front of the traffic queue and gain maximum advantage.

12.4.9. The early release phase should be long enough to allow cyclists to travel beyond the left turn conflict point before other vehicles reach that point. Experience so far suggests an early start phase of 4 s gives cyclists good priority without unduly delaying traffic. Designers may start with this as a default value, but should confirm this is suitable through on-site observations once installed, and adjust if necessary. An early start phase of less than 3 s is not recommended.

12.5 Signal-controlled junction layouts

12.5.1. Introducing more complex layouts or methods of control to accommodate cycling may increase overall delays, particularly during off-peak periods, compared to give way junctions and roundabouts. The needs of all users, including pedestrians, will need to be considered when making any such changes.

12.5.2. There is a range of facilities available to cater for cyclists at traffic signals, discussed below. Note that some may require traffic signs authorisation from the appropriate national authority.

12.6 Cycle bypasses

12.6.1. Cycle lanes that bypass the main signals can reduce delays. This arrangement is used to allow cyclists to turn left, or to continue straight ahead across the head of a T-junction. A dedicated left turn cycle lane using a separate phase or green signal will enable cyclists to clear the junction ahead of other traffic. Short bypasses with their own signal head can cater for other movements, for example to enable cyclists to continue straight ahead where other traffic has to turn left. If it is appropriate, the bypass can be left unsignalled, using give way markings instead. Any such proposals need careful design, as it is essential that the needs of pedestrians, and particularly disabled people, are taken into account.

12.6.2. If there is insufficient room in the carriageway for a bypass, it can be created by converting part of the footway to a cycle track using powers under the Highways Act 1980. For example, cyclists going straight ahead may use the track to bypass the signals at a T-junction. Cyclists may be returned to the carriageway by placing the end of the cycle track on a buildout and parallel to the main flow. Such an arrangement minimises the potential for conflict when cyclists rejoin the carriageway, and should allow them to do so without stopping.

12.7 Dedicated cycle phase for cycle-only movements

12.7.1. Where a cycle track or cycle-only on-road provision, such as a contraflow lane, enters a signal-controlled junction, cyclists can be provided with a dedicated phase. The signal aspect to diagram 3000.2 (S14-2-3, **Figure 12-2**) or 3000.2A (S14-2-4, **Figure 12-3**) can be used, or a combination of both.

12.7.2. The Regulations require a minimum of one primary signal head to diagram 3000.2 or 3000.2A. LLCS are unsuitable for use as a secondary signal in these circumstances as they are too small to be seen effectively. A secondary signal could be provided by using a full size signal to diagram 3000.2, either mounted on the same post as the primary LLCS, or on the far side of the junction. They must be placed with an associated stop line to diagram 1001. The 200 mm variant is likely to be suitable in most circumstances.

12.7.3. Markings to diagram 1055.3 (S14-2-57, **Figure 12-5**) may be used to mark a cycle route through a signalled junction. The markings must be between 250 mm and 400 mm square. Where the marking size is varied, the space between two markings in a line must be varied similarly to maintain proportionality.

12.7.4. Diagram 1055.3 also allows for the markings to be placed up to 5 m apart. They may be used to indicate either a one-way or two-way route. Note that this marking is not prescribed for use at uncontrolled or priority junctions.

12.7.5. The cycle symbol to diagram 1057 (S11-4-28) may be placed within the markings at appropriate intervals.

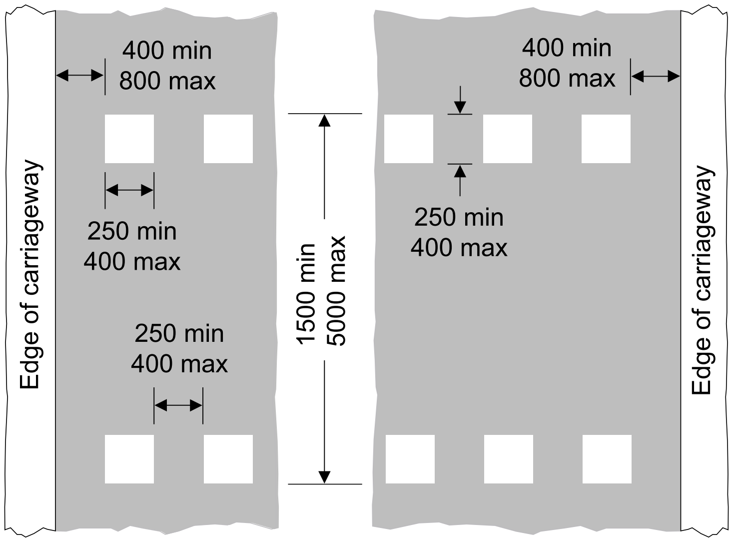


Figure 12-5 Diagram 1055.3 (S14-2-57)

12.7.6. A push button unit for cyclists to diagram 4003.6 may be provided, to call the cycle phase if required. Care should be taken to ensure push buttons can be reached by cyclists who cannot dismount, including from a recumbent position.

12.8 Toucan facilities

12.8.1. Toucan facilities can be provided at signal junctions, either in a walk with traffic configuration, or as a full toucan stage. However, to accommodate this it is necessary to provide shared use facilities around the junction and therefore it is unlikely such an arrangement would be suitable where pedestrian and cyclist flows are high. If a full toucan stage, with associated shared use, is being considered it is essential that local accessibility groups are involved at an early stage. Any shared use areas should be indicated with tactile paving to the recommended layouts and colours set out in 'Guidance on the Use of Tactile Paving Surfaces'.

12.8.2. Toucan facilities may use nearside signals to diagram 4003.7 (S14-2-21, **Figure 20-1**), or farside aspects to diagram 4003.5 (S14-2-19) with a push button to diagram 4003.6 (see **Figure 12-6**) or 4003.8 (S14-2-12, **Figure 11-3**) Farside and nearside signals must not be combined in the same installation. Nearside signal aspects can be obscured by those waiting, and supplementary signals to diagram 4003.7A (S14-2-22, **Figure 20-2**) may be useful at busy sites. These should be mounted with a minimum of 1700 mm clearance to the underside of the unit.

12.8.3. Staggered or split crossings are not generally recommended for cyclists as they can cause delay to people crossing and give rise to potential conflict between cyclists and pedestrians, but in some locations they may be the only practicable design solution. Refuges at staggered crossings should be able to accommodate a design cycle 1.2 m wide by 2.8 m long.

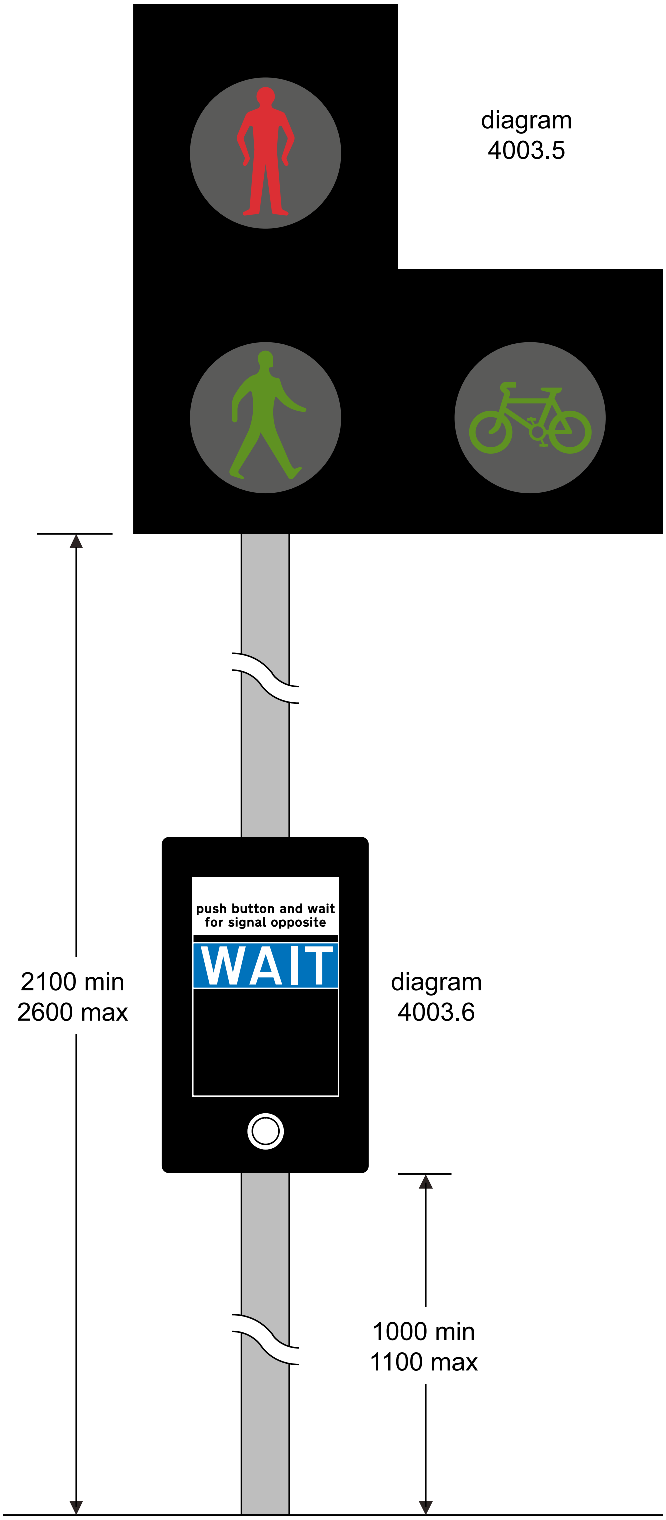


Figure 12-6 Diagram 4003.5 (S14-2-19) and Diagram 4003.6 (S14-2-20)

12.9 Signal-controlled cycle facility

12.9.1. A signal-controlled cycle facility may be provided where a cycle track is connected across a road or an arm of a junction. The crossing may be for cyclists only, but can be provided adjacent to a pedestrian crossing facility which may be useful where separate but parallel routes exist with relatively high cycle and pedestrian flow. The pedestrian and cycle crossings do not have to operate with the same signal timings.

12.9.2. The pedestrian crossing is signalled in the usual way, and the cycle facility is indicated using signals to diagrams 3000.2 (see **Figure 12-2**) or 3000.2A (see **Figure 12-3**) and markings to diagram 1055.3 (see **Figure 12-5**). Cyclists generally travel faster than pedestrians and the cycle crossing should preferably operate as a single stage, without the need for cyclists to wait on refuges in the middle of the carriageway. This can be achieved by setting the cycle crossing outside any pedestrian crossing refuges (see **Figure 12-7**). On two-stage crossings a straight or angled alignment at the refuge should be provided for cyclists even if the pedestrian crossing is staggered.

12.9.3. The footway and cycle track on the approach to the crossing should be paved in contrasting materials and preferably at different levels, separated by a kerb.

12.9.4. When provided as part of a junction, or as a stand-alone facility, a signal-controlled cycle facility must not be marked with a controlled area indicated by zig-zag markings to diagram 1001.3.

12.9.5. However, a stand-alone pedestrian crossing (Puffin or Pedex) provided alongside a signal-controlled cycle facility will require a controlled area in the usual way. Sufficient space will need to be provided between the crossing and the cycle facility to accommodate this, noting the flexibility in the number of zig-zag marks that may be provided. Where this is not possible, the national authority may consider authorising a controlled area to be placed in a layout that encompasses both facilities.

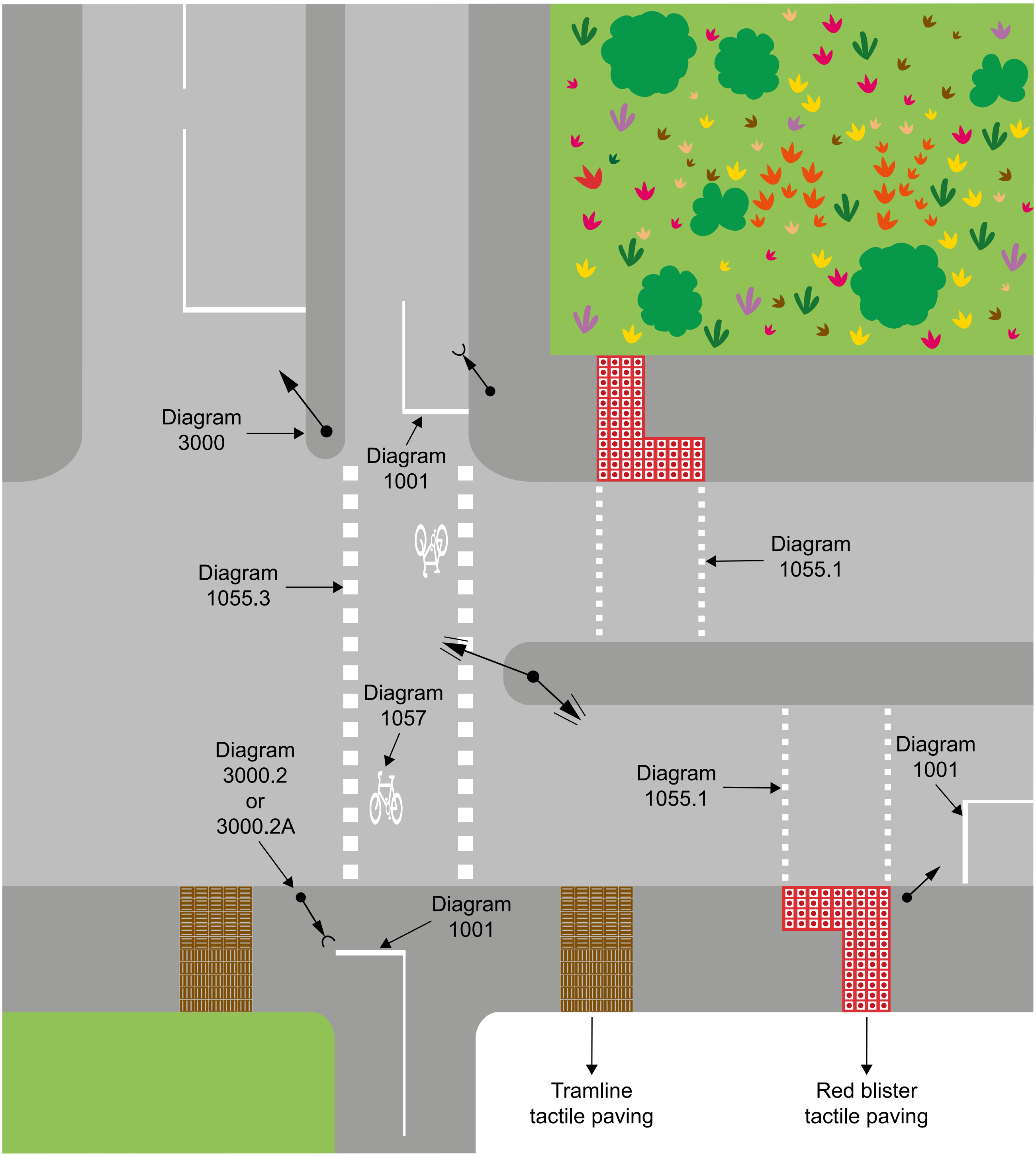


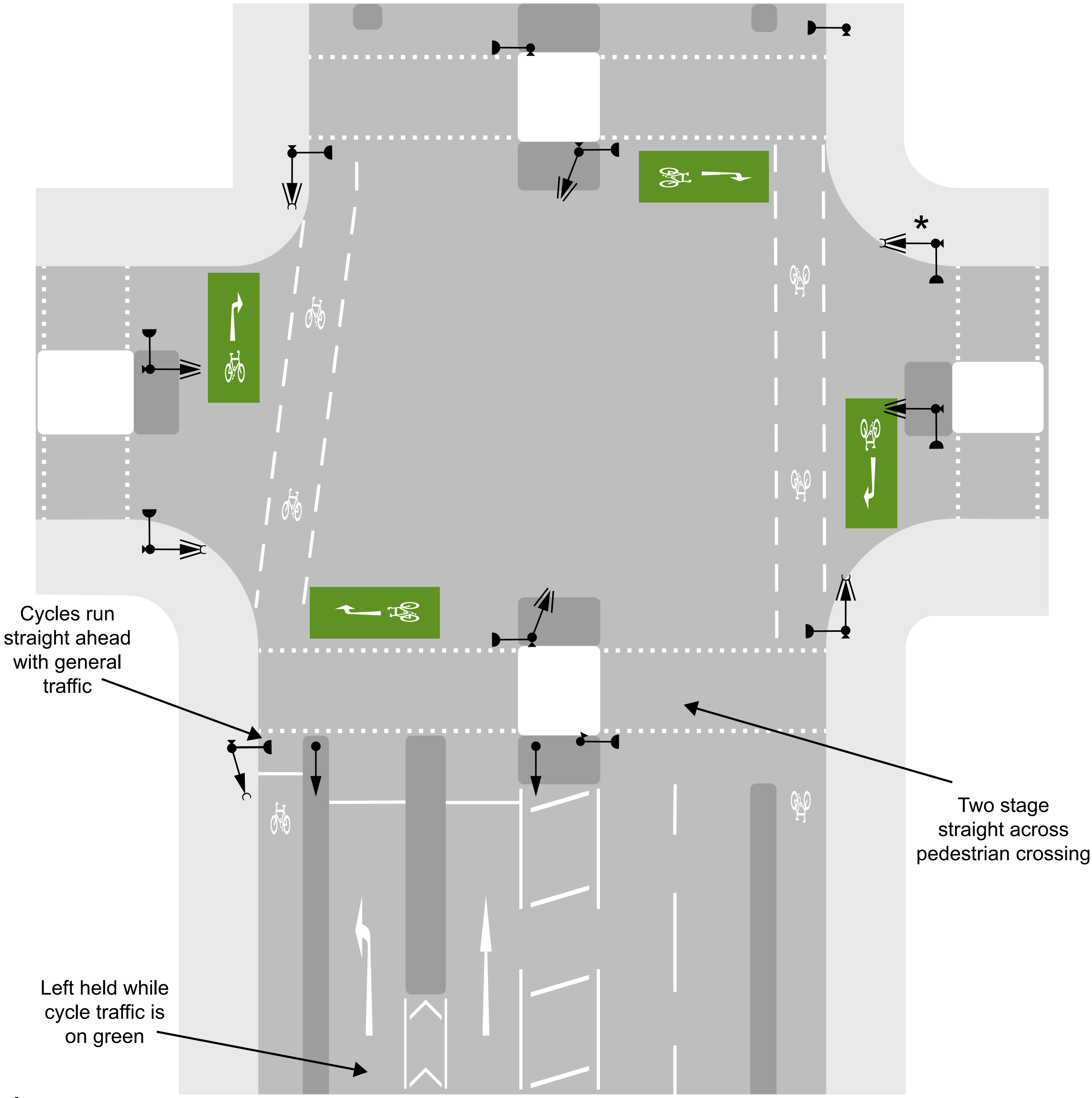
Figure 12-7 Signalised separate pedestrian and cyclist facility at a junction

12.10 'Hold the left turn'

12.10.1. In this arrangement, a near side cycle track is given a dedicated green signal while conflicting general traffic turning across the cycle track – typically the left turn but also any opposing right turn – is held on a red signal. The turning motor traffic only receives a green signal when cyclists are held on a red signal. This removes potential for 'left and right hook' conflicts between cyclists and motor traffic. The layout is shown in **Figure 12-8**.

12.10.2. Depending on the geometry of the original site, this design may require additional space for splitter islands between the various movements and to mount the required signal heads and so may be difficult to fit into some locations. It also makes the method of control more complex, which may reduce junction capacity, although this can be mitigated by banning some turns.

12.10.3. If a right turn for cyclists is permitted at the junction, a two-stage right turn facility as described below should normally be provided, to avoid having to run the separate cycle approach in its own stage.



* Secondary cycle signal to green at the same time as the low-level cycle signal for early release for cyclists waiting behind the stop line; the green cycle aspect must then terminate once the associated traffic phase gains right of way. Secondary cycle signal must always be far-sighted even if motor traffic secondary signal is near-sighted.

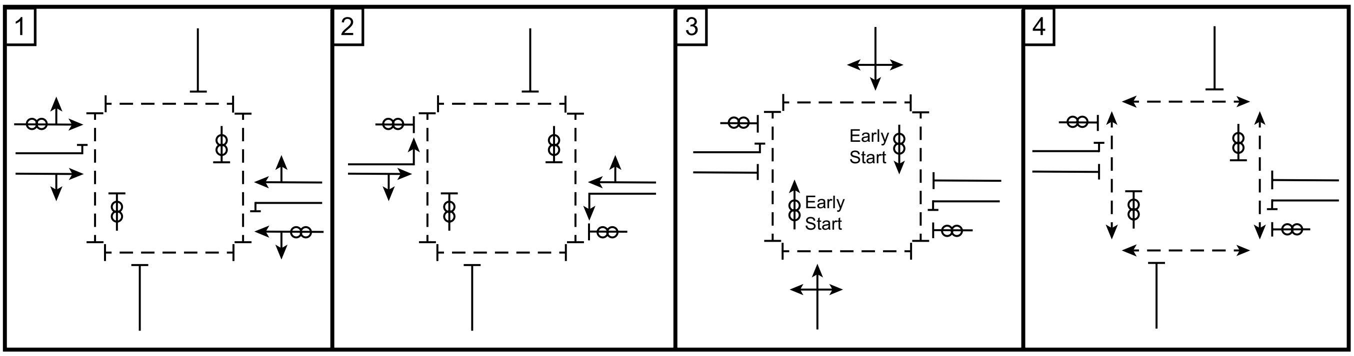


Figure 12-8 Diagram showing indicative layout and staging for a ‘hold the left turn’ arrangement at a signal junction

12.11 Two-stage right turns

12.11.1. The two stage turn arrangement enables cyclists to turn right without having to move to the centre of the carriageway. It can be of benefit on a multi-lane approach where the speed and volume of motor traffic makes a conventional right turn manoeuvre difficult for cyclists, even with an advanced stop line. The layout is shown in **Figure 12-9**.

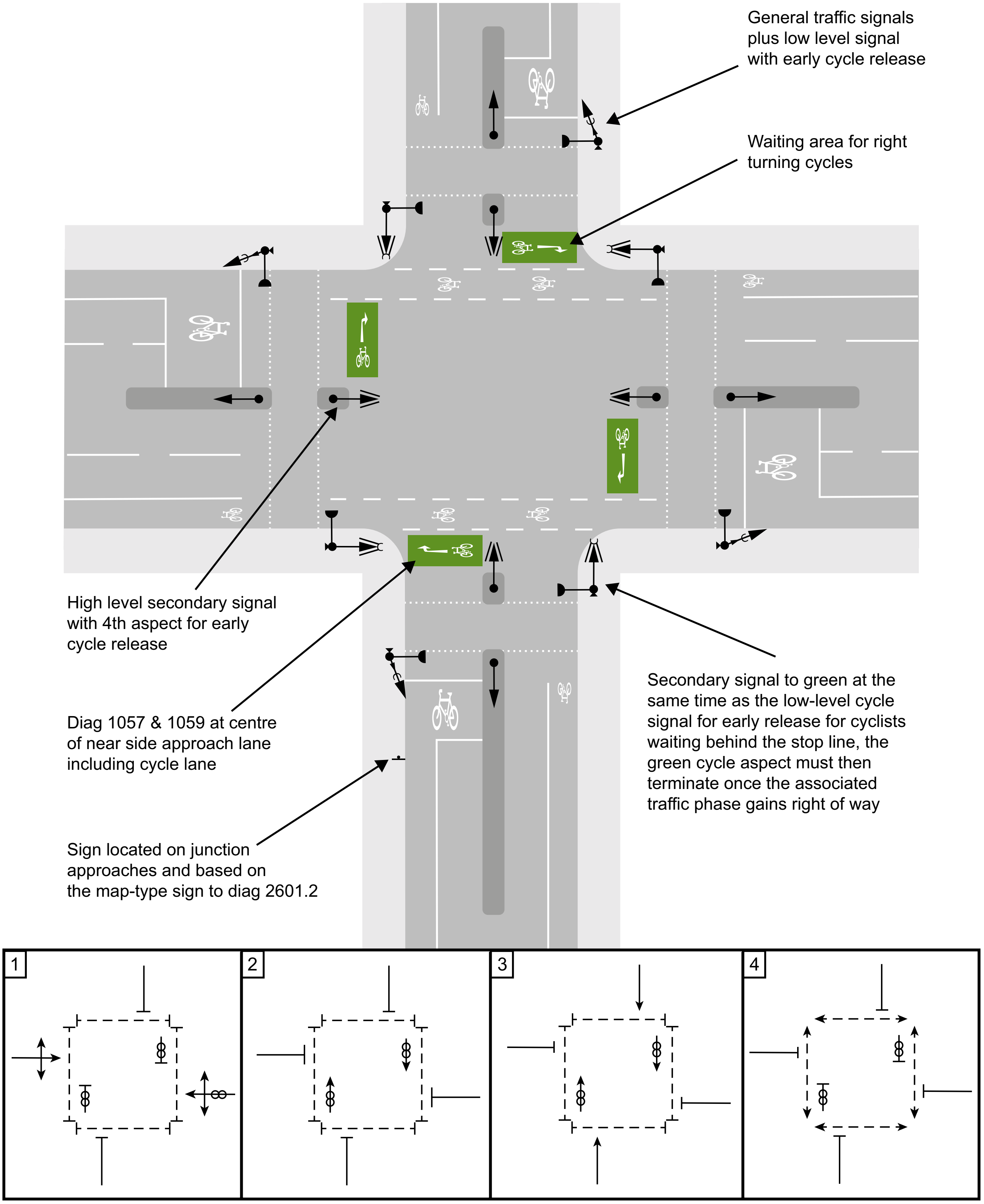


Figure 12-9 Diagram showing indicative layout and staging for a two-stage right turn arrangement at a signal junction

12.11.2. Provision is made for cyclists to pull in to an area of the carriageway in advance of the stop line and pedestrian crossing (where present) on their left, and to wait there until that junction approach has a green signal. At that point, cyclists make a straight across movement to complete their right turn. The waiting area is indicated by cycle symbols to diagram 1057 and a right turn arrow to diagram 1059.

12.11.3. The length of intergreen periods should take into account cyclists moving off to complete their turn. The size of the area provided for cyclists to wait to complete the turn should be capable of accommodating a design cycle 1.2 m long by 2.8 m wide and the total number of cyclists that are expected to make the turn at peak times.

12.11.4. Two traffic signs to support a two-stage turn layout have been designed. One informs cyclists to make a right turn in two stages. If the right turn is otherwise banned to cyclists (i.e. they must not turn in the conventional manner) an 'except in two stages' box sign may be placed on traffic signals to accompany a sign to diagram 613. These signs require authorisation and designers wishing to use them should contact the relevant national authority in sufficient time to ensure this is obtained before the scheme is installed.

12.11.5. Cyclists waiting to complete the right turn in advance of the stop line have to be able to see a secondary signal on the far side of the junction in order to know when it is safe to proceed. This may include a cycle priority signal to diagram 3001.4 to give an early release to cycle traffic waiting to complete the turn, thus reducing conflict from left turning motor traffic.

12.11.6. Two stage turn arrangements are usually provided with hold the left layouts and can also be used to enable cyclists to turn right and left from two-way tracks.

12.12 Cycle gates

12.12.1. A cycle gate provides a reservoir area with separately controlled entry points for cyclists and motor traffic. Cyclists and motor vehicles are held in the reservoir at a second set of signals, at different stages in the signal cycle.

12.12.2. Unlike an advanced stop line, the controlled access to the reservoir means that cyclists do not have to travel through the junction at the same time as motor vehicles. It also eliminates the conflict that can occur when cyclists reach an ASL just as the signals change to green. They can provide time and space to move away from a junction ahead of motorised vehicles.

12.12.3. Cycle gates require a substantial amount of space in terms of road width and depth of reservoir. Although they may help at sites where there is a large amount of left turning motor traffic, they can be confusing if the design or operation leads cyclists to assume the first green light gives permission to proceed into the junction itself, instead of to the second stop line.

12.12.4. The reservoir should not be marked in such a way as to make it appear like an ASL – for example, it should not have coloured surfacing or be marked with cycle symbols. To avoid potential problems with see-through, the recommended minimum separation between the two general traffic stop lines is 18 m (see **Figure 12-10**). This ensures signals can be clearly associated with each stop line.

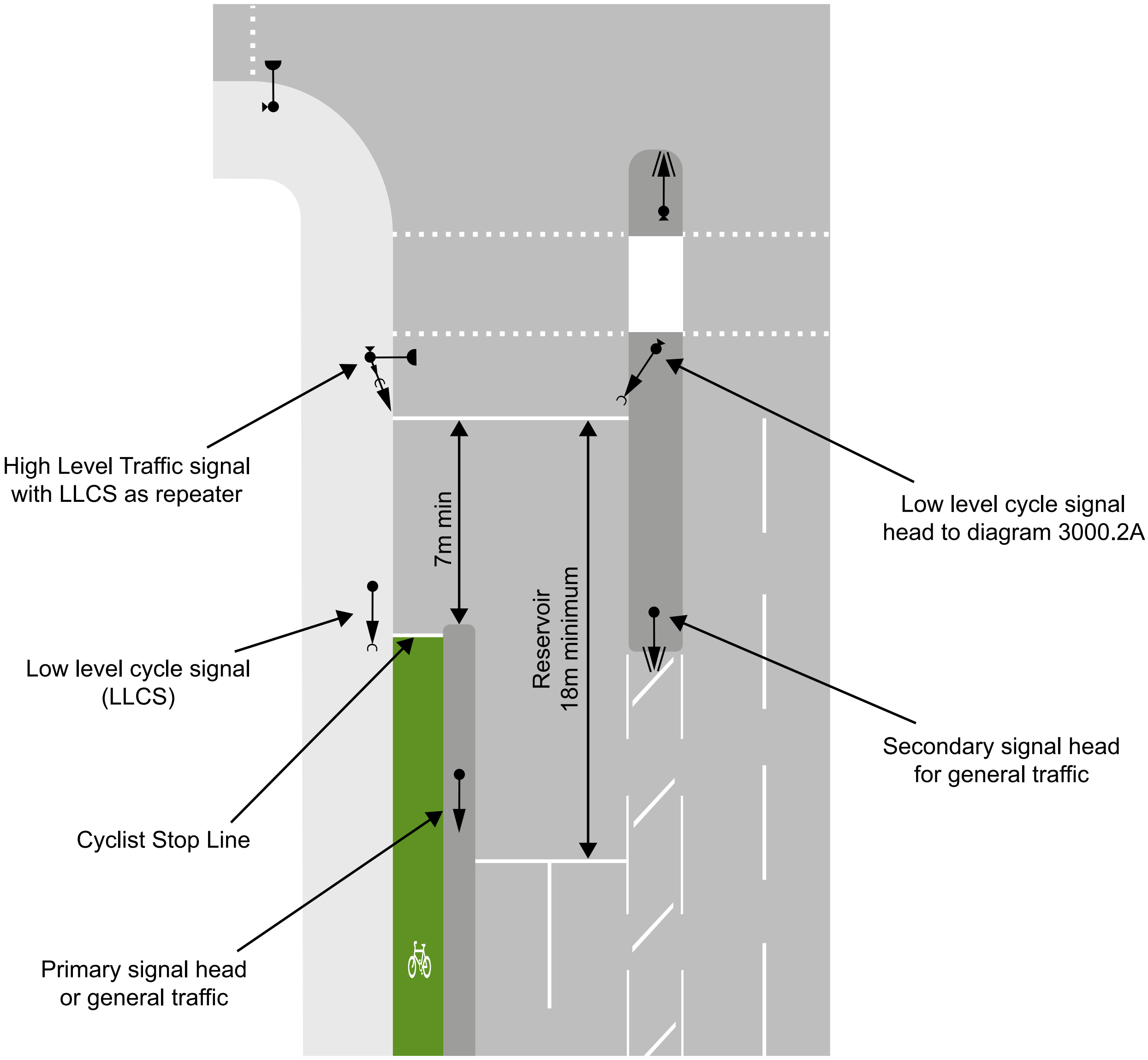
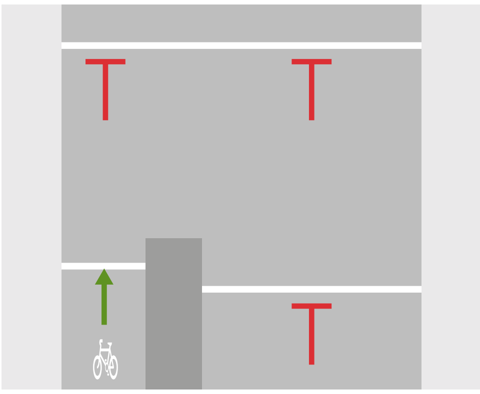


Figure 12-10 Diagram showing indicative layout of cycle gate road markings and position of signal heads

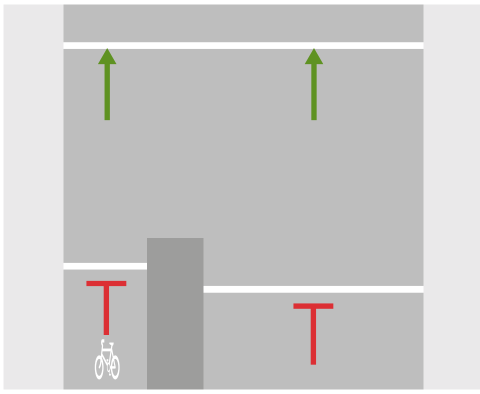
12.12.5. The operational sequence is shown in **Figure 12-11** and is such that:

a) The reservoir is clear when the cycle signals go green so that cyclists can move to the front of the area, and

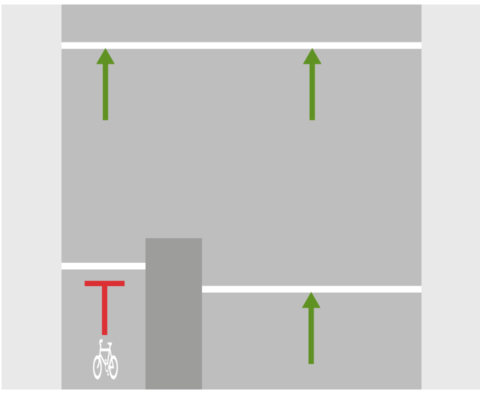
b) The signals controlling the exit from the reservoir go green in advance of those on the general traffic entry, to give cyclists in the reservoir a head start. LLCS can be used at this stop line to give an additional early release.



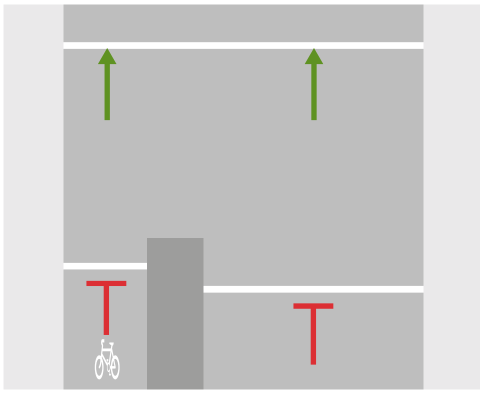
Stage 1 - cyclists enter reservoir



Stage 2 - cyclists (and any trapped vehicles) enter junction from reservoir



Stage 3 - general traffic enters reservoir and all vehicles continue to enter junction from reservoir



Stage 4 - traffic clears reservoir

Figure 12-11 Diagram showing operational sequence for a cycle gate facility

12.13 Priority using green cycle aspects

12.13.1. The green cycle aspect prescribed in diagram 3001.4 (S14-3-8, see **Figure 12-12**) can be used, either together with LLCS or as an alternative, to provide priority through an early release for cyclists. This works in a similar way to a green arrow filter, giving cyclists a few seconds head start before the main traffic flow. The aspect can be mounted below the full green, to the left or to the right.

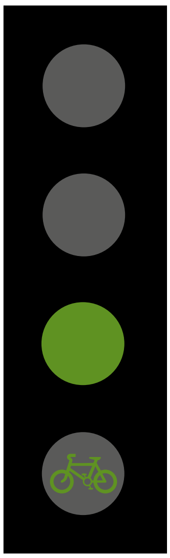


Figure 12-12 Diagram 3001.4: green cycle aspect as an additional aspect to vehicle signals to diagram 3000

12.13.2. The 4-in-line arrangement is generally used, as placing the aspect to the left or right may result in cyclists assuming they can only move in those directions. Green aspects should be combined with an ASL to allow cyclists to position themselves in front of traffic to gain maximum benefit from the priority stage.

12.13.3. Unlike LLCS, the green cycle aspect has no red or amber phase associated with it, hence users' reaction times will be longer and the length of the early release phase will need to be adjusted accordingly. Typically an extra 2 s are required where cycle filters are used instead of LLCS. Timings should be confirmed as suitable through on-site observations once installed, and adjusted if necessary.

12.14 Advanced stop lines (ASLs) for cyclists

12.14.1. **Figure 12-13**, **Figure 12-14** and **Figure 12-15** show typical layouts for an ASL for cyclists at signalled junctions. They may be used at standalone crossings but are not permitted at level crossings. See **3.1.2** for advice on placing ASLs in relation to other markings such as crossing studs to diagram 1055.1 (S14-2-55).

12.14.2. Three types of ASL are prescribed, in diagrams 1001.2 (S14-2-48, see **Figure 12-13**), 1001.2A (S14-2-50, see **Figure 12-14**) and 1001.2B (S14-2-49, see **Figure 12-15**). Diagram 1001.2 incorporates an advisory or mandatory cycle lane, preferably a minimum of 1.5 m wide, provided to enable cyclists to enter the reservoir. The mandatory lane must be indicated by the marking to diagram 1049B (S9-6-7, see **Figure 12-16**). Where the lane operates only at certain times, the sign to diagram 959.1 (S9-4-9, see **Figure 12-17**) is required to indicate the hours of operation. This type of approach lane can be used only on the near side of the carriageway.

12.14.3. Diagram 1001.2A (S14-2-50) replaces the mandatory or advisory lane with a diagonal "gate" marking. Diagram 1001.2B (S14-2-49) has neither approach lane nor gate, but consists of two stop lines placed parallel to each other.

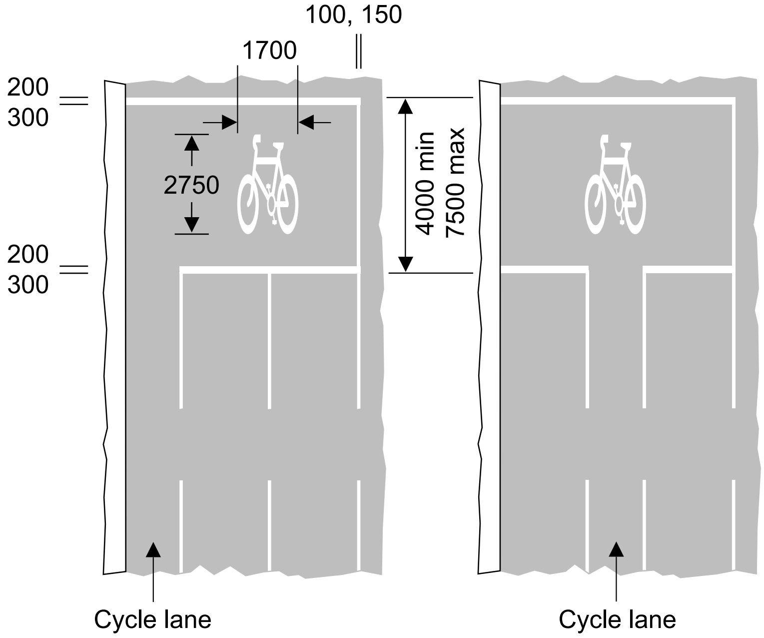


Figure 12-13 Diagram 1001.2 (S14-2-48): ASL with near side or central approach lane

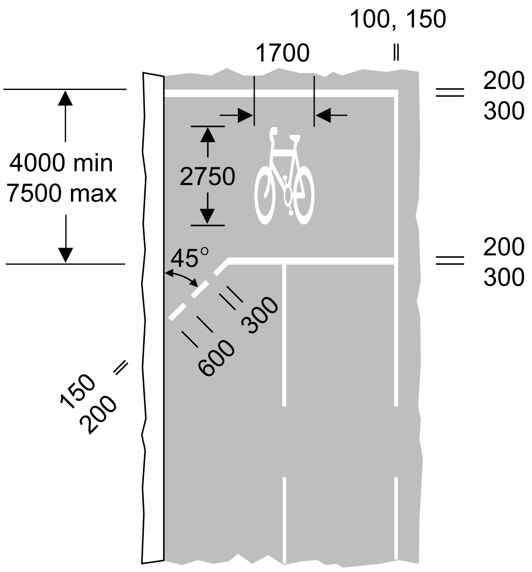


Figure 12-14 Diagram 1001.2A (S14-2-50) ASL with approach lane replaced with a diagonal "gate" marking

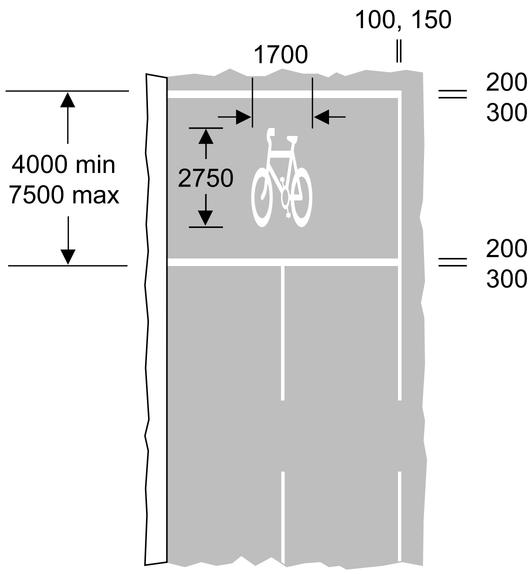


Figure 12-15 Diagram 1001.2B (S14-2-29) ASL without approach lane or gate

Figure 12-16 Diagram 1049B (S9-6-7): boundary of a designated lane, used to indicate a mandatory cycle lane

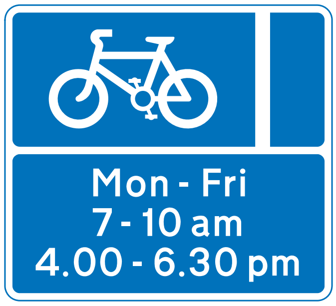


Figure 12-17 Diagram 959.1 (S9-4-9): upright sign used to indicate a mandatory cycle lane, with hours of operation where the lane does not operate at all times

12.14.4. Vehicles other than pedal cycles must stop at the first Stop line when signalled to do so. Cyclists may cross the first Stop line at any point, whether or not an approach lane or gate is provided, but must stop at the second. ASLs to diagram 1001.2B may not be accessible to all, for example, 3 and 4 wheeled cycles and child cyclists may not be willing or able to overtake, especially when vehicles are already queuing.

12.14.5. The two Stop lines must be between 4 and 7.5 m apart; the area between them across the full width of the approach is available for cyclists to wait at the red light. This area, and the cycle approach lane if used, may be highlighted using coloured surfacing. The Stop lines should be 200 mm or 300 mm wide. The longitudinal boundary line should be the same width as the centre line of the road – this line may be omitted where it is adjacent to a kerb, for example in a one-way street or where there is a central traffic island.

12.14.6. A central cycle approach lane bounded by a line to diagram 1049B is not a prescribed variant of diagram 1001.2. S11-4 permits an advisory cycle lane on the approach to an advanced stop line to be indicated by the cycle symbol to diagram 1057 (S11-4-28) without an upright sign, although a sign to diagram 967 (S11-2-44) could be used for a near side lane, especially if this has a long approach. Where a central advisory cycle approach lane is provided an upright sign is not used, but the marking to diagram 1057 should be provided within the lane. A central lane might be appropriate where there are significant numbers of left turning motor vehicles with cyclists going ahead or right, but they are generally unattractive to less confident cyclists. Where provided they should be at least 2.0 m wide.

12.15 Cycle safety mirrors

12.15.1. S14-1-27 prescribes a cycle safety mirror for use with traffic signals. This is a circular convex mirror measuring between 300 and 500 mm in diameter, used to alert drivers of large vehicles to the presence of cyclists entering their blind spot at signal junctions. This will most commonly occur on the near side.

12.15.2. The mirror may only be placed in combination with light signals to diagram 3000; in practice this will involve co-locating a mirror on the same signal post either immediately below, or to the side of, the signal head.

12.15.3. A risk assessment should be made if their use is being considered. They are likely to be of most assistance at junctions with both ahead and left turn movements, and where there are high cyclist and HGV flows.

12.15.4. To achieve the optimum position, and reduce the risk of tampering and vandalism, mirrors will usually be mounted on the near side primary signal pole, with 2.4 to 2.5 m clearance to the footway.

Section II
Crossings

13.1 General

13.1.1. This section sets out suggested criteria for use when assessing the provision of stand-alone crossings. “Stand-alone” means that vehicular traffic stops solely for those wishing to cross the carriageway, and where the crossing is not part of a signalised junction.

13.1.2. The criteria can be applied to all crossings and are recommended to all those involved in designing and implementing crossings. Although aimed at new crossings, they may be useful when considering replacement of an existing crossing with a different type.

13.1.3. The general references to pedestrians in this section can be read to include equestrians and cyclists, but it should be remembered that only pedestrians may use Zebra or Puffin crossings, or stand-alone signal-controlled pedestrian facilities (referred to as Pedex crossings within this Chapter).

13.1.4. The three main objectives of any crossing should be safety, convenience and accessibility. A crossing that does not improve on all three to some degree is unlikely to be satisfactory, and consideration of these criteria will form an important part of the assessment process.

13.1.5. All three objectives overlap and impact on each other – a crossing that provides dropped kerbs and tactile paving improves its accessibility, which in turn can make it more convenient. Similarly, a crossing that feels unsafe, despite a good safety record in practice, will not be used and may put vulnerable users off, which will impact on the accessibility and convenience.

13.1.6. Pedestrians are free to cross the road where they like and, where there are sufficient gaps in traffic and speed is reasonably low, many people are able to cross without needing a specific crossing point. However, as vehicle flow and speed increase pedestrians, particularly more vulnerable people, may find it harder to establish themselves on the carriageway and are likely to need a dedicated facility in order to feel secure enough to cross. Crossings are also an important part of the street-scene, and well-connected networks are likely to have a positive impact on the street’s ‘place’ function as well as on levels of walking and cycling.

13.1.7. There are three main types of crossing facility:

a) Uncontrolled or informal crossings; for example a pedestrian refuge or dropped kerb,
b) Zebra and Parallel crossings; which give pedestrians and cyclists (as appropriate) a right of way over vehicles when on the crossing, and at which drivers must give way, and
c) Signal-controlled crossings; which require drivers to stop at red lights, and which give users a push button to register the demand for a green signal.

13.1.8. Each type of crossing facility has advantages and disadvantages. The type chosen should be appropriate to the circumstances of the site and road users’ needs.

13.1.9. The provision of crossings should be targeted at groups who experience most difficulty, but the provision of a crossing alone will not necessarily lead to an improvement in safety. Any crossing has to be seen within the wider context of the street in which it sits.

13.1.10. A site assessment should be carried out by an experienced practitioner, taking into account criteria such as geometry, layout, pedestrian and traffic flows, costs and accident data.

An assessment will enable the designer to make an informed decision about whether a crossing is needed and if so, what type it should be. Records of decisions and the reasoning behind them should be kept for future reference. Decisions can be challenged, and records can help explain decisions made some years ago, since when those involved may have moved on.

13.1.11. While parts of the assessment may be carried out through a desktop study, site visits will provide more information about the site and any constraints, in particular pedestrian and traffic behaviour. The site should be visited at night if possible, to check if the street lighting is adequate.

13.1.12. A site assessment may consist of:

a) a site survey,
b) a pedestrian survey,
c) a traffic survey, and
d) other relevant factors including crossing difficulty, crossing times and speeds, and road accident data.

13.2 Site Survey

13.2.1. A site survey should include the proposed site and a length of road approximately 50 m either side. It may include the following:

a) A site plan to an appropriate scale showing the site layout and its major features. Photographs and on-line mapping tools may also provide useful information,
b) Carriageway width and number of lanes in each direction,
c) Effective footway width,
d) Features that could obscure visibility, or cause obstructions, particularly for mobility or visually impaired people. These may include trees, street furniture and lamp columns,
e) Existing traffic management measures such as waiting and loading restrictions and positions of bus stops,
f) Nearby facilities or buildings likely to generate significant pedestrian and vehicle movements for example schools, shops, bus stops, rail stations, hospitals, seaside facilities, day-care centres or sheltered housing,
g) Details of the driver's view at various points on the approach and of the pedestrian's view of approaching traffic at the crossing point, and
h) For Toucan and equestrian crossings, information about the relevant route (bridleway or cycle route) to establish if a crossing is required. Additionally, information about road layout to establish if the waiting area can be accommodated.

13.2.2. In the case of roads not yet built, or where future development is likely, some information may have to be based on estimates and where this is the case it should be noted.

13.3 Pedestrian survey

13.3.1. A pedestrian survey should record both numbers and type. The numbers of people with characteristics that may make it more difficult for them to cross should be recorded, as these groups are particularly significant when assessing the difficulty of crossing at a site. These may include:

a) Visually impaired people,
b) Mobility impaired people,

c) Children,
d) Older people, and
e) People with pushchairs.

13.3.2. A low number of people crossing the road, particularly vulnerable road users, may not indicate low demand. The low numbers may be due to latent demand as people experience difficulty in crossing. Where a Parallel or Toucan crossing is being considered the number of cyclists should be recorded separately.

13.3.3. The type of surroundings will determine the profile of pedestrian movements and the most representative day of the week to carry out a count – for example, taking account of school start and finish times. The time of year may also have an impact. For example, coastal towns may experience large seasonal differences in pedestrian flows.

13.3.4. The length of a count will vary from site to site but should be chosen to be long enough to enable the peak periods to be identified.

13.4 Traffic survey

13.4.1. The numbers and type of vehicle flows should be surveyed, particularly during peak periods. A classified count may be useful to give an accurate breakdown of the proportion of particular classes of vehicles, such as cyclists, HGVs and passenger service vehicles.

13.4.2. Where proposals for crossings form part of a wider public realm scheme, some assumptions will need to be made and recorded about the impact of the scheme on traffic speeds and flows.

13.4.3. Vehicle speeds should be recorded at peak and off-peak periods. The measured speed of vehicles in each direction, taken roughly 50 m before the crossing site, should be recorded and the highest 85th percentile speed used in the assessment. The speed limit should also be noted.

13.5 Crossing difficulty

13.5.1. Crossing difficulty may be assessed by considering the number of gaps in the traffic flow which are acceptable to pedestrians, and the delay to pedestrians caused by having to wait for an acceptable gap.

13.5.2. An acceptable gap from kerb to kerb, or kerb to refuge, varies from person to person. A gap of 4 - 6 s may be acceptable at normal urban traffic speeds, and shorter gaps where traffic is slower. Other groups may require larger gaps, of 10 - 12 s or longer. The waiting times for various gap durations should be established for all types of users, particularly vulnerable groups.

13.6 Average crossing time and speed

13.6.1. Measuring the average crossing speed for pedestrians may reveal whether there is a large number of people who may be slower, and therefore need extra time to cross. Where a signal-controlled crossing is installed, the timings may need adjusting based on these crossing speeds.

13.7 Road accidents

13.7.1. Existing accident records for the proposed location, including a length of road either side, should be investigated to identify any patterns. If a crossing is being considered because of a high number of accidents a separate investigation may help to establish the cause and identify any other remedial measures that may be necessary. It may be that other measures are needed, such as traffic calming or improved visibility, either instead of or in conjunction with a formal crossing.

14 OPTION ASSESSMENT

14.1 General

14.1.1. The results of the site assessment will enable the different options to be assessed to determine which crossing type is most suitable. The final decision as to whether and what type of crossing to install will depend on a combination of factors including the number of accidents, delays, local representations, local interest groups, cost and relative priority with other sites.

14.1.2. A formal cost benefit methodology is not appropriate for the assessment of individual crossings. The costs of delays to road users are generally not reduced by the introduction of a pedestrian crossing. It should not be assumed that provision of a crossing will necessarily lead to a reduction in road accidents. The effect of delays on vehicles should be considered but should not normally overrule the provision of a crossing where there is a clear difficulty for pedestrians.

14.1.3. The following factors are most likely to have a bearing on the choice of pedestrian crossing type:

a) difficulty in crossing,
b) vehicle delays during peak periods,
c) carriageway capacity,
d) local representations,
e) cost (including maintenance), and
f) vehicle speeds.

14.1.4. Difficulty in crossing is related to the average time that a person normally has to wait at the site for an acceptable gap before crossing (see **13.5**).

14.1.5. Vehicle delay is assessed by estimating the number of stops each minute and the average duration of each stop which the crossing flow levels would produce for each of the options. For example, if a Zebra or Parallel crossing is installed and crossing flows are very high the number of stops and their duration will be far higher than with a signalled crossing.

14.1.6. In addition to delays at the crossing the reduction of carriageway capacity may have an effect on the local network. If problems are expected this should be noted.

14.1.7. The source of a request and any supporting correspondence should be recorded. This is not only to enable the correspondents to be informed of the decision but incoming correspondence may often give detailed local knowledge of problems.

14.1.8. The total cost of installation of the crossing should be estimated including all civil, electrical and specialist contractors' work. The annual cost of maintenance of the crossing, including increases in the maintenance costs of any associated facilities, should be estimated and included for consideration.

14.2 Crossing options

14.2.1. If an assessment concludes that the existing situation is performing well for pedestrians then making no change to the provision of crossings may be acceptable, in which case the reasoning behind the decision should be recorded.

14.2.2. As part of a wider public realm scheme, or where changes to the streetscape to reduce vehicle flows and speeds are being planned, an assessment may conclude that a less formal crossing place is suitable, or that one crossing type could be replaced with another. The impact on accessibility should be considered as any change can be disorientating for some groups. It is essential that local accessibility groups are involved from the outset.

14.2.3. It may be possible to create more crossing opportunities by other means, such as installing traffic calming measures to slow traffic speed, or narrowing the carriageway to reduce the crossing time. These may form part of a wider streetscape or public realm scheme, which may give opportunities to shift the balance from vehicles to pedestrians. For example, narrowing the carriageway may have the advantage of allowing the footway to be widened, enhancing visibility past permanent obstructions such as trees and street furniture. Vehicle speed and the percentage of heavy vehicles and buses will influence how acceptable these are to local residents.

14.2.4. Where the assessment shows that a formal crossing is justified the different options should be considered relative to the existing situation, to enable an informed judgement to be made. Advice on the choice of farside or nearside crossing types is given in **11.2**.

15 CROSSING DESIGN REQUIREMENTS

15.1 General

15.1.1. This section gives advice on planning, designing and installing stand-alone crossings for pedestrians, cyclists and equestrians. For advice on designing crossing facilities at signal-controlled junctions see section **11**.

15.1.2. The term 'controlled crossing' refers to Zebra, Parallel, Puffin, Pedex, Toucan and equestrian crossings as defined in the Regulations, at which vehicles must give way or stop to allow pedestrians, cyclists or equestrians to cross. Note that a Zebra crossing is considered to be a controlled crossing, as the design is prescribed in the Regulations, and drivers must give way to anyone on the crossing.

15.1.3. The term 'uncontrolled crossing', sometimes called an informal crossing, refers to facilities such as refuge islands, provided to assist people to cross, but where no legal priority over traffic is given.

15.2 Accessibility

15.2.1. Crossings are important for all road users but they are a key part of enabling some groups, particularly mobility and visually impaired people, to navigate independently. The Equality Act 2010 places a duty on public sector authorities to comply with the Public Sector Equality Duty in carrying out their functions. This includes making reasonable adjustments to the existing built environment to ensure infrastructure is accessible to all.

15.2.2. The needs of disabled people accordingly should always be considered at an early stage when designing the layout of crossings. If a crossing is well-designed, good quality and accessible then everyone benefits. Effective engagement with local accessibility groups is particularly important to fully understand any concerns they may have and address those as far as possible. A change from one type of crossing to another can be disorientating and it is important that the changes are explained clearly.

15.2.3. Accessibility features that should be provided as standard are dropped kerbs and tactile paving. Tactile signals and audible signals (where appropriate) should be provided for signal-controlled crossings.

15.2.4. Flush dropped kerbs should always be provided across the crossing width to provide easy access for mobility impaired people. The section of footway between the lowered kerb line and the adjacent footway should be ramped with a slope having a recommended gradient of 1 in 20 but no steeper than 1 in 12. Blister tactile paving should be installed across the dropped kerb to the layouts and colours recommended in 'Guidance on the Use of Tactile Paving Surfaces'. 'Inclusive Mobility: A Guide to Best Practice on Access to Pedestrian and Transport Infrastructure' should be referred to for advice on designing accessible pedestrian environments, including recommended minimum footway widths.

15.3 Uncontrolled or informal crossings

15.3.1. In the right circumstances informal crossings such as refuge islands can be a simple and inexpensive way of improving facilities for pedestrians. Although they give no priority in law, where vehicle speeds and flows are low they can work well.

15.3.2. A refuge should be large enough to accommodate the expected number of people and to allow those with pushchairs or wheelchairs to wait safely. They may be an absolute minimum of 1.2 m wide, but to cater for wheelchair users they should be at least 1.5 m and preferably 2.0 m wide. Where space allows, a refuge or median can help improve the performance of the crossing by encouraging drivers to give way. Refuges and medians may help pedestrians by breaking up the crossing task into two parts.

15.3.3. The carriageway width past a refuge should be wide enough to prevent vehicles passing too close to the refuge or the footway as this can be intimidating for pedestrians.

15.3.4. The carriageway width will also have an impact on cyclists – it should either be enough to allow vehicles to overtake cyclists safely, or narrow enough to discourage overtaking altogether. Gaps between 3.2 m and 3.9 m should be avoided and a minimum gap of 4 m is recommended. If the refuge island is not on a straight stretch of carriageway the width either side of the refuge may need to be greater.

15.3.5. Refuges commonly consist of two 'D'-shaped islands with a gap between them to facilitate crossing. The width of this gap should be maintained across the full carriageway. Dropped kerbs should always be provided and should always come in pairs – in other words, on both sides of the carriageway. Under no circumstances should people be encouraged to cross from a dropped kerb on one footway only to find it missing on the other side. Tactile paving should always be provided to the layouts set out in the 'Guidance on the Use of Tactile Paving Surfaces'.

15.3.6. As well as, or instead of, a refuge, informal crossings can be indicated with any or all of the following: coloured surfacing, raised carriageways, or patterned materials. The design should be carefully considered to ensure that it does not lead people to assume a priority over traffic that they do not have. Any pattern or coloured surfacing should not mimic the stripes of a Zebra crossing as this is likely to be misleading.

15.3.7. Vehicles parking adjacent to the refuge may reduce intervisibility or block the free flow of vehicular traffic. Waiting and loading restrictions may be needed, which will require a TRO.

15.3.8. If a refuge is on the approach to a junction the existence and extent of the average vehicle queue should be recorded as this may affect the position of the refuge. Queuing vehicles can block access to a refuge resulting in people having the choice of either crossing through the queue or away from the refuge. Where the junction will be regularly used by HGVs, swept path analysis may help ensure the position of the island does not cause problems for HGVs turning into the side road from the main road.

15.4 Location

15.4.1. Any crossing should be located as near as possible to the desire line – that is, the route pedestrians actually want to, and do, take, which is not always the same as where a designer may wish to place it. Providing a crossing on the desire line will reduce the risk of pedestrians crossing near or in the "shadow" of the crossing, which may be dangerous. If there is a local strategic network of pedestrian routes, for example as set out in an authority's Local Cycling and Walking Infrastructure Plan, this should be referred to before final decisions are made.

15.5 Visibility

15.5.1. Minimum distances for visibility of crossings for approaching traffic are set out in **Table 15-1**. For more detail see **2.1.5.**

Table 15-1 Recommended visibility distances for pedestrian crossings

85th percentile speed (mph)	20	25	30	35	40
Recommended Stopping Sight Distance (m)	22	31	40	51	80

15.5.2. Pedestrians should be able to see and be seen by approaching traffic. Different groups will have different requirements – for example, wheelchair users and children may be harder for a driver to see as they are lower in the landscape.

15.5.3. Visibility should not be obscured or restricted by factors such as parked vehicles, trees or street furniture. Obstacles should be moved or removed wherever possible, especially if doing so enables a crossing to remain on the desire line. If the carriageway is wide enough, it may be worth building out the footway to provide enhanced sight lines. Street furniture such as controller cabinets should be placed in a position that does not obstruct intervisibility between pedestrians and approaching vehicles.

15.5.4. The controlled area is an important part of maintaining good visibility at controlled crossings. By banning parking and overtaking, the zig-zags enable the approach to a controlled crossing to be kept clear. The Regulations allow for the number of zig-zag marks to be reduced to a minimum of two where the local authority is satisfied that the layout or character of the road makes it impractical to provide eight. However, reducing the number of zig-zag marks in this way may impact on visibility, which should be borne in mind if considering this. Detailed advice on placing zig-zag markings is given in **15.8**.

15.5.5. Footways on the approach to a crossing should be well-maintained and kept clear of obstructions. If poorly placed and maintained, trees and street furniture can be a hazard for pedestrians, especially disabled people.

15.5.6. Where there is an alignment problem vehicles queuing back from a crossing can be a hazard. The expected queue length should be estimated so that an adequate safety distance can be achieved in the design.

15.6 Width

15.6.1. The minimum widths of the different controlled crossing types are prescribed in S14-2. This allows for the crossing width to be increased up to a maximum of 10 m at the discretion of the designer. This can be useful at sites with high pedestrian flows, for example in town centres or outside stations.

15.6.2. Wide crossings may also help prevent overcrowding where the footway is narrow. Crossings over 10 m will not be considered for authorisation as wider crossings can lead drivers to have difficulty seeing the other side, or being unaware they are still on a crossing once they have passed the stop line.

15.6.3. The width of any refuge provided should be the same as the crossing. This is particularly important for visually impaired people who may otherwise find it difficult to navigate the crossing.

15.7 Road markings and controlled areas

15.7.1. Markings for all controlled crossing types are prescribed in Schedule 14. The area of carriageway bounded by zig-zag markings, known as the “controlled area”, is defined in Schedule 1 and in Schedule 14 part 1.

15.7.2. Controlled areas are required at all stand-alone Zebra, Parallel, Puffin, Toucan, Pedex and equestrian crossings. Signal-controlled facilities of any type provided as part of a junction must not be provided with controlled areas.

15.7.3. It may be helpful to consider whether traffic would need signalling to control vehicle conflicts if the pedestrian crossing were removed. If the answer is no, then it could be considered a stand-alone crossing and must be provided with a controlled area. This is not an absolute rule – for example, crossings on or near the exit arm of a junction could be considered stand-alone, but as they are controlled by the junction controller should not be provided with controlled areas.

15.7.4. Where a crossing is placed across a cycle track the zig-zag marks may be omitted. If the crossing then continues across general traffic lanes, these lanes must be provided with zig-zag markings in the usual way, see **Figure 15-1**.

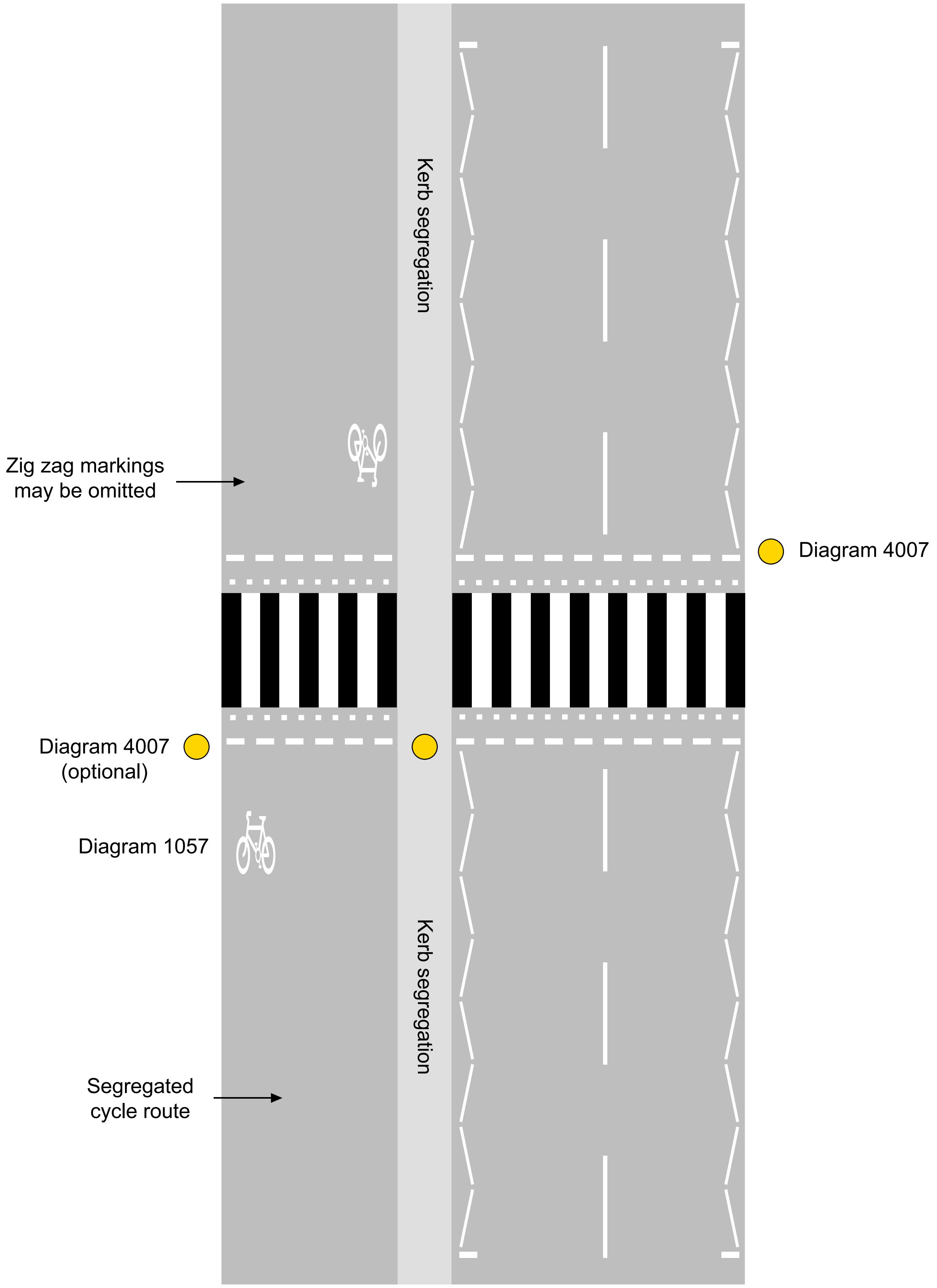


Figure 15-1 Diagram showing road marking layout for a Zebra crossing across both general traffic lanes and a cycle track

15.7.5. The width of a pedestrian crossing is determined by the pedestrian flow. An extra 0.5 m should be added to the minimum width of 2.4 m for each 125 pedestrians per hour above 600 averaged over the four peak hours, up to the statutory maximum width of 10 m.

15.7.6. Both stopping (other than when the crossing is in use) and overtaking are prohibited within the controlled area. Where there is more than one lane on the approach, and the crossing is in use, vehicles may overtake the stationary vehicles in the other lanes, but not any vehicle that has stopped adjacent to the crossing.

15.7.7. The definition of a controlled area in Schedule 1 permits only signs or markings to diagrams 610, 611, 612, 613, 616, 810, 1029, 1057 or 1062, and those indicating the crossing (including hatched or chevron markings in the centre of the road), to be placed within a controlled area. No other signs or markings must be placed within the controlled area. For example, cycle and bus lane markings must be discontinued, although coloured surfacing may be used.

15.7.8. Crossings should normally be positioned at right angles to the carriageway edge. Where this is impracticable the Give Way or Stop line should as far as possible be at a right angle to the kerb, even if it is then not parallel to the edge of the crossing. This ensures that drivers do not violate the overtaking prohibition when stopping at the line alongside other vehicles.

15.8 Zig-zag and terminal lines

15.8.1. The zig-zag markings used at all stand-alone controlled crossings have a standard pattern comprising eight 2 m marks. The controlled area over which the Regulations apply extends from the limit of the crossing up to and including the terminal line. The length between the Give Way or Stop line and the terminal line is marked with zig-zags. The standard distance from the edge of the carriageway is 250 mm but this may be increased to a maximum of 2 m to allow cyclists to ride between the kerb and the zig-zag markings, see **Figure 15-2**. The marking to diagram 1057 may be placed behind the zig-zags in such circumstances, see **15.8.17**.

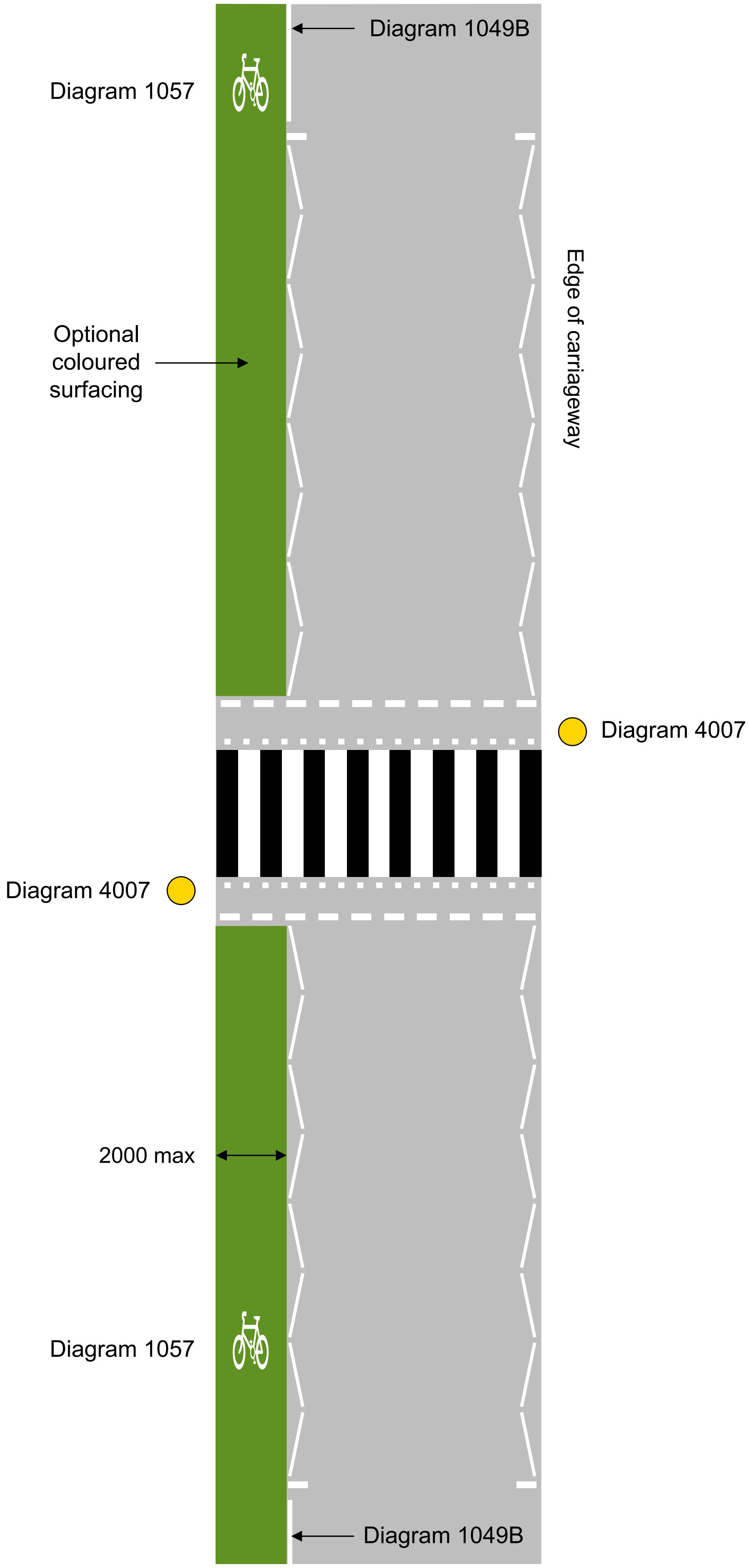


Figure 15-2 Road marking layout showing zig-zag markings offset from the edge of the carriageway at a Zebra crossing, permitting cyclists to ride behind them

15.8.2. Where there is an area of carriageway adjacent to the main carriageway, such as a lay by, this forms part of the controlled area. The zig-zag markings must be laid, therefore, along the back edge of this area and not along the edge of the main carriageway. Where there is a build out for pedestrians at the crossing point, this should be tapered back to the existing edge of the carriageway; it is not appropriate to use hatched markings to diagram 1040.4.

15.8.3. In addition to the zig-zag lines on each side of the carriageway, another zig-zag line may be laid in the centre of the carriageway. This central line may be reversed. On carriageways up to 6 m in width, the latter may be replaced with a warning line to diagram 1004. On carriageways more than 6 m wide, a zig-zag line is always used as the centre line. On multi-lane approaches, the lane lines should also be replaced with zig-zag markings. Where there is a pedestrian refuge, a double row of zig-zag markings should be used in the centre.

15.8.4. The Regulations permit the use of central hatched or chevron markings within the controlled area of crossings. Such markings may be used between a central double row of zig-zags, but only in the following circumstances:

a) diagram 1040 may be used on the approach to a central reservation (including pedestrian refuge) of a single crossing in a two-way road, and diagram 1041 in a one-way road, and
b) diagram 1040.2 must be used on the approach to a staggered crossing.

15.8.5. The zig-zag marks are angled between two guide lines 500 mm apart (see **Figure 15-3**). In standard and all longer patterns, the unit length of each zig-zag mark should be 2 m. They may be set out using a stencil positioned between the guide lines.

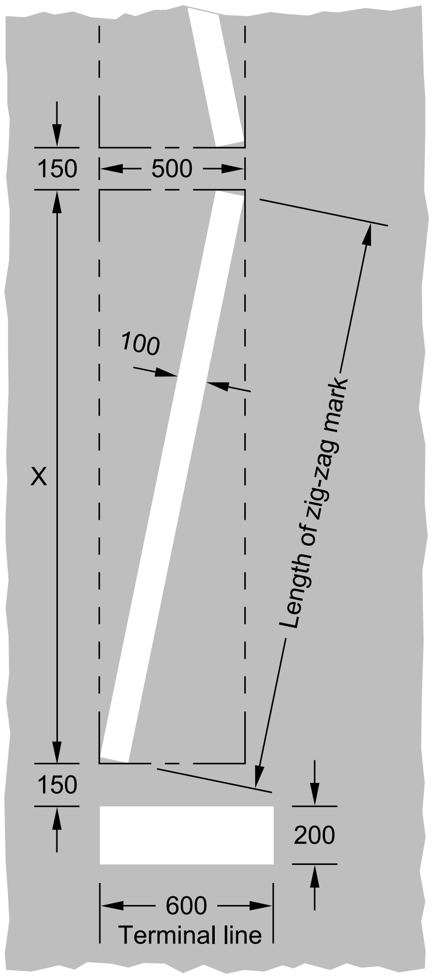


Figure 15-3 Dimensions of zig-zag line

15.8.6. The length of the section of controlled area from the Give Way or Stop line to the terminal line inclusive (the marked controlled area, L in **15.8.10**) is given by the formula:

L = NX + (N+1)150 + Y + Z,

15.8.7. where N = the number of zig-zag lines, X = the longitudinal limit of each mark (see **Figure 15-3**), Y = the width of the Give Way or Stop line and Z = the width of the terminal line (all dimensions in millimetres).

15.8.8. For a 2 m mark, X = 1.979 m, and the length L for eight 2 m marks is 17.585 m. Where a longer approach marking is required, e.g. where visibility is poor or the speed of traffic is high, the number of marks may be increased up to a maximum of 18.

15.8.9. The aim should be to lay at least the standard pattern of eight 2 m marks on both sides of the crossing. Where site constraints prevent this, the length of the zig-zag marks may be varied to a minimum of 1 m and the number of marks reduced to a minimum of two. Zig-zag marks shorter than 2 m should be used only to indicate a controlled area of fewer than eight marks. Even then marks as near as possible to the maximum 2 m length should be provided, using a smaller number if necessary; each mark in each zig-zag line must be substantially the same length as the other marks in the same line.

15.8.10. For controlled area lengths between 2.750 m and 17.585 m, the appropriate number of zig-zag marks should be determined from **Table 15-2**. The longitudinal limit of each mark (X in **Figure 15-3**) is obtained from the formula:

X = (L – 350 – Y – 150N)/N

where L = the overall length available for marking, Y = the width of the Give Way or Stop line and N = the number of marks required from table 15-2 (all dimensions in millimetres).

Table 15-2 Numbers of zig-zags

Length available for the marked controlled area (m)	Recommended number of equal length zig-zag marks
2.750 – 4.500	2
4.500 – 6.500	3
6.500 – 9.000	4
9.000 – 11.000	5
11.000 – 13.000	6
13.000 – 15.500	7
15.500 – 17.585	8

NOTE 1: The length in column 1 consists of the controlled area, excluding the distance between the Stop or Give Way line and the limit of the crossing.

NOTE 2: Crossings must not be laid with fewer than two zig-zag marks.

NOTE 3: Where a length in the first column is common to two recommended numbers of marks, the lower number should be adopted.

15.8.11. The controlled area for crossings on major roads may extend across the mouth of a side road but it should never stop between the two projected kerb lines of the minor road. If this would otherwise occur, the zig-zag lines should be extended to the projection of the far kerb line of the side road.

15.8.12. Crossings on minor roads close to junctions will tend to restrict the layout of the controlled area markings. To preserve the effectiveness of a junction Give Way or Stop line, the terminal line of the zig-zag markings should not normally be less than 1 m from it. This distance may be reduced to 500 mm if necessary to enable the minimum pattern of markings to be laid. The controlled area should never extend beyond the nearer kerb line of the major road. It should be the aim to provide room for at least one vehicle turning into the minor road to wait at the crossing without obstructing traffic on the major road. More vehicles should be accommodated if there are large numbers turning.

15.8.13. Normally all zig-zag lines in a pattern should comprise the same number of marks. However, the Regulations allow for an exception to this rule to provide maximum coverage of the controlled area where the distance available for the marks on each side of the carriageway is unequal.

15.8.14. On dual carriageway roads and one-way streets, at least the standard pattern of eight 2 m marks should be laid on both sides of the crossing wherever possible.

15.8.15. Where a crossing is situated close to a roundabout, the markings should never be extended into the circulatory area, and they should be subject to the restrictions described in **15.8.13**.

15.8.16. Markings to diagrams 1029 (S11-4-18) and 1062 (S11-4-33) may be used at or near a crossing. The use of diagram 1062 is described in Chapter 5.

15.8.17. No other marking may be used within the controlled area, except hatched and chevron markings in the circumstances described in **15.8.4** and the cycle symbol to diagram 1057 where the zig-zags are off-set from the kerb to allow cycling.

15.8.18. **Figure 15-4**, **Figure 15-5**, **Figure 15-6**, and **Figure 15-7** show suggested layouts for controlled areas for two-way and one-way streets. It is not possible to cover all possibilities here and designers will need to make individual decisions to suit their site circumstances, within the flexibilities of the Regulations and the spirit of the examples given. The figures are based on signal-controlled crossings but apply to Parallel and Zebra crossings as well.

15.8.19. Where an Advanced Stop Line to diagram 1001.2B is provided at a stand-alone signal-controlled crossing, the controlled area should begin at the first stop line, as shown in **Figure 15-8**.

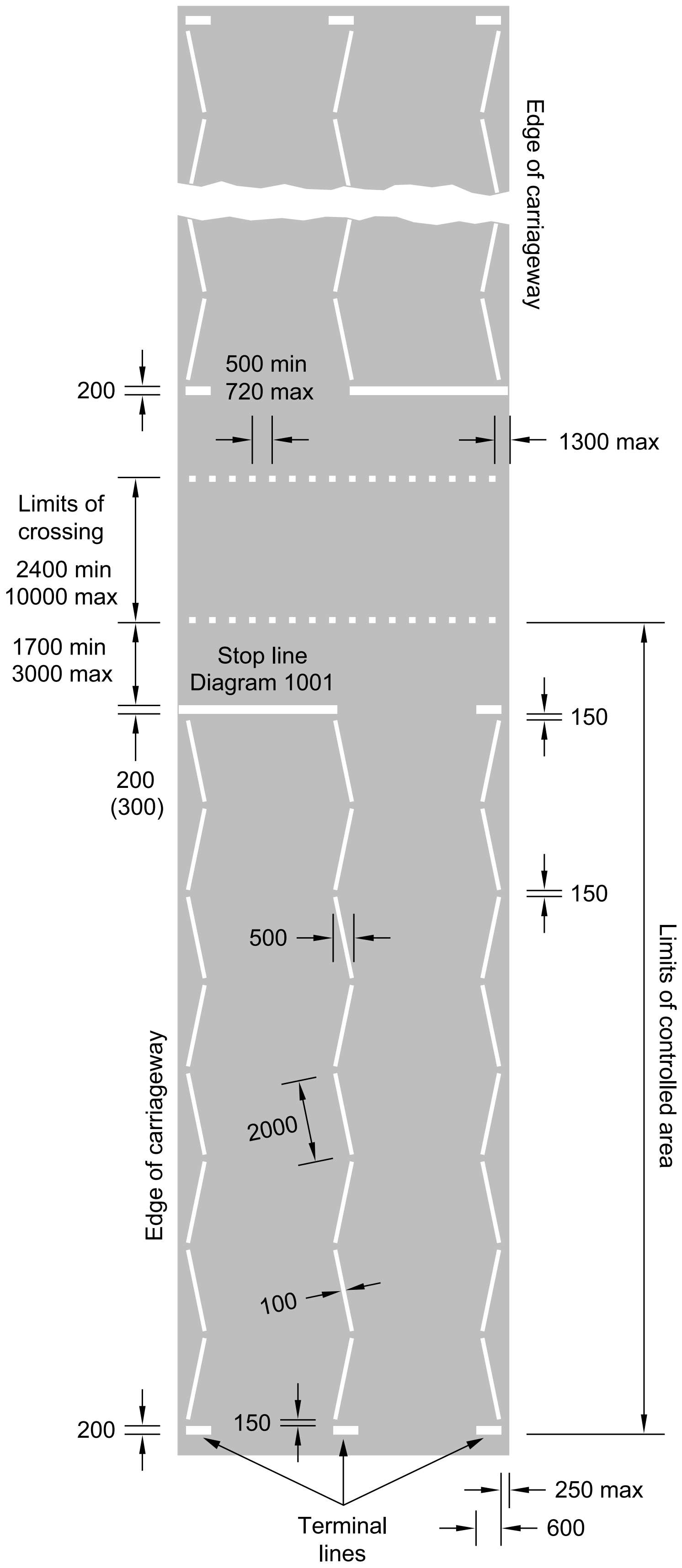


Figure 15-4 Zig-zag layout for a crossing on a two-way street. The central zig-zag line may be reversed

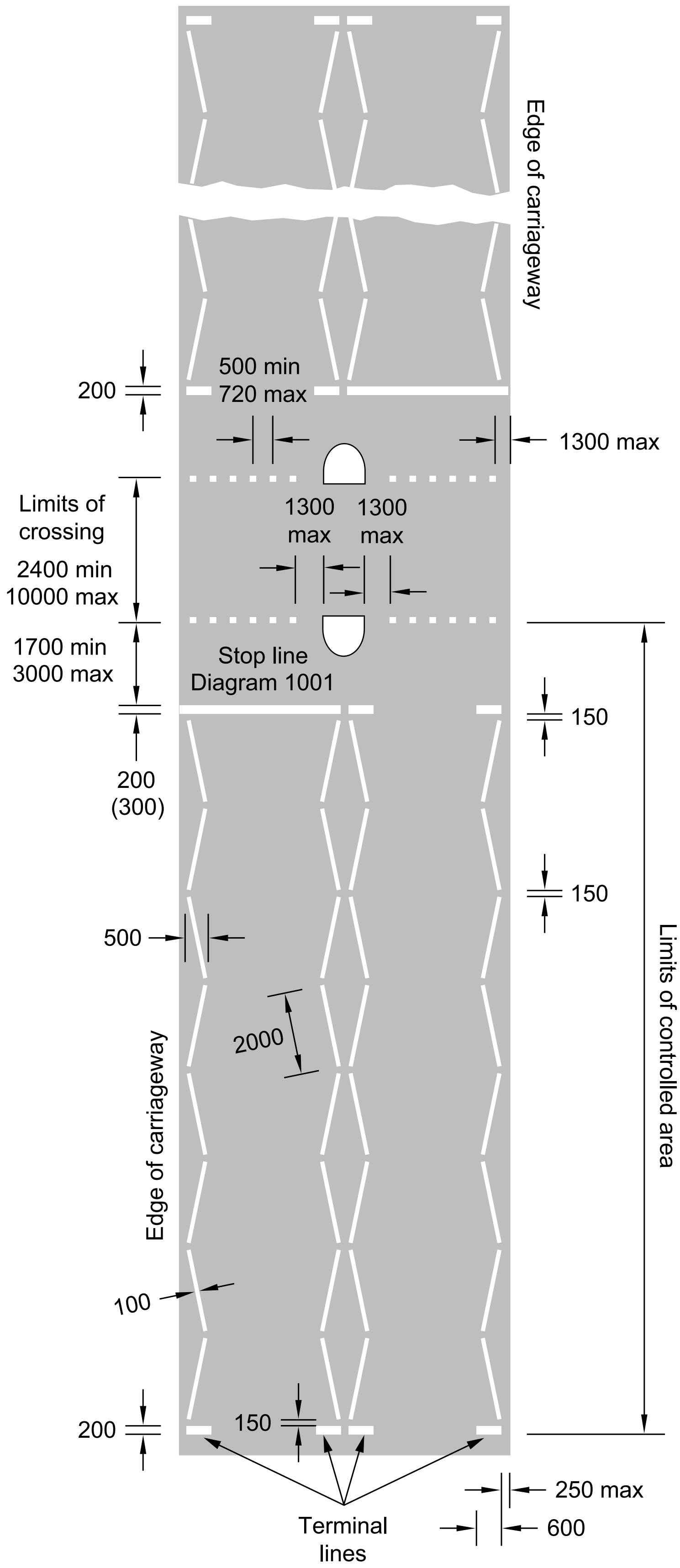


Figure 15-5 Zig-zag layout for a crossing on a two-way street with a central refuge island

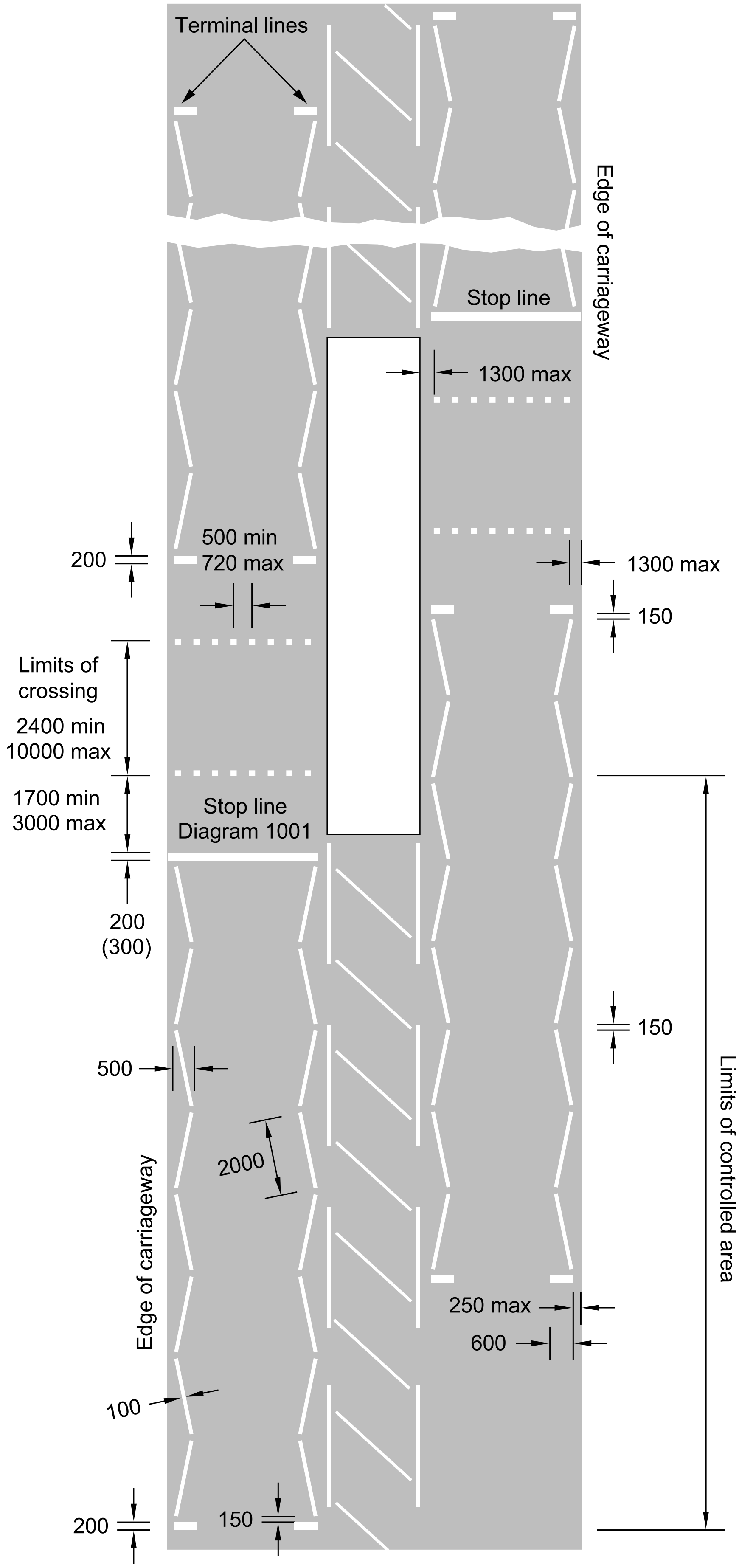


Figure 15-6 Zig-zag layout for a staggered crossing with a central refuge, incorporating markings to diagram 1040

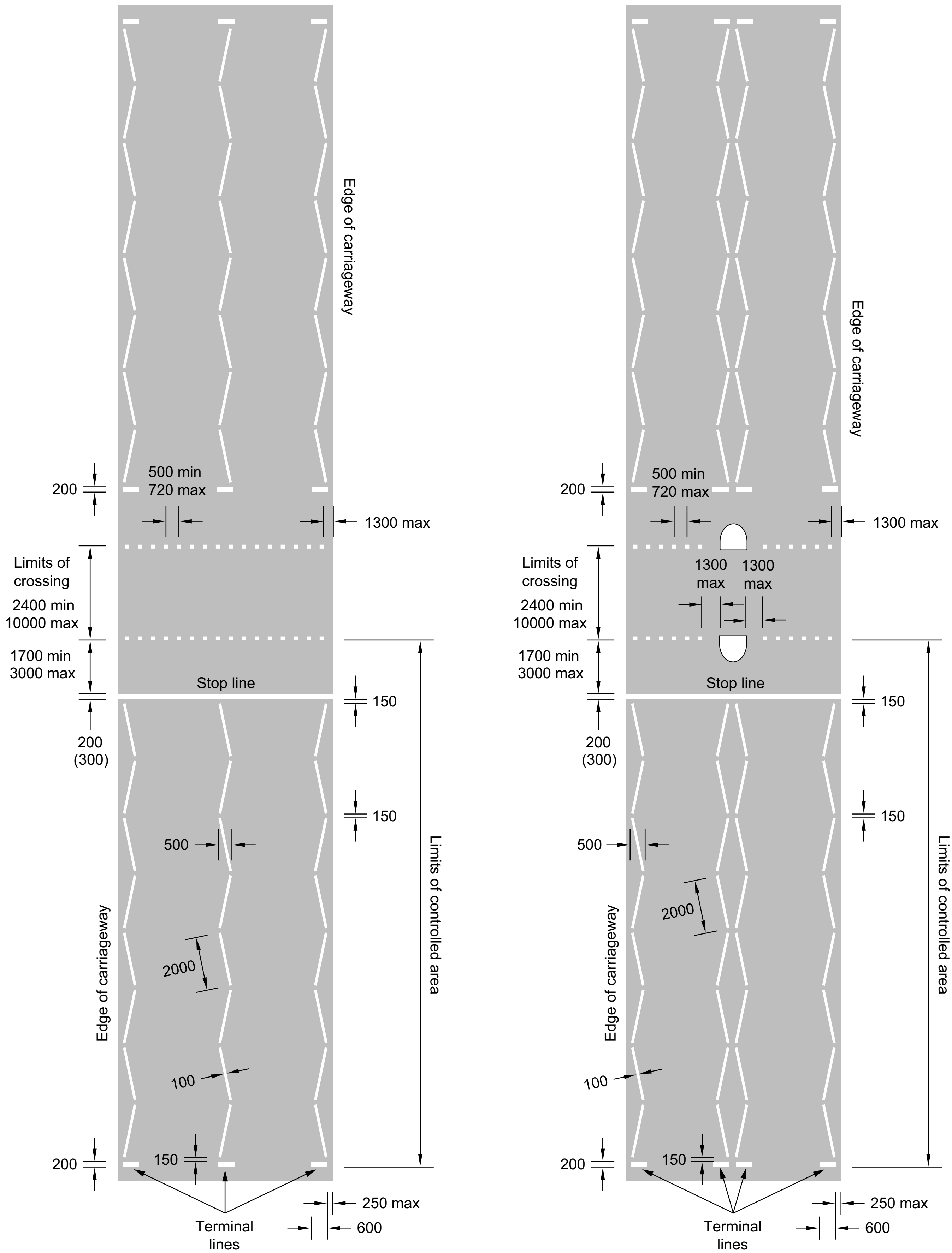
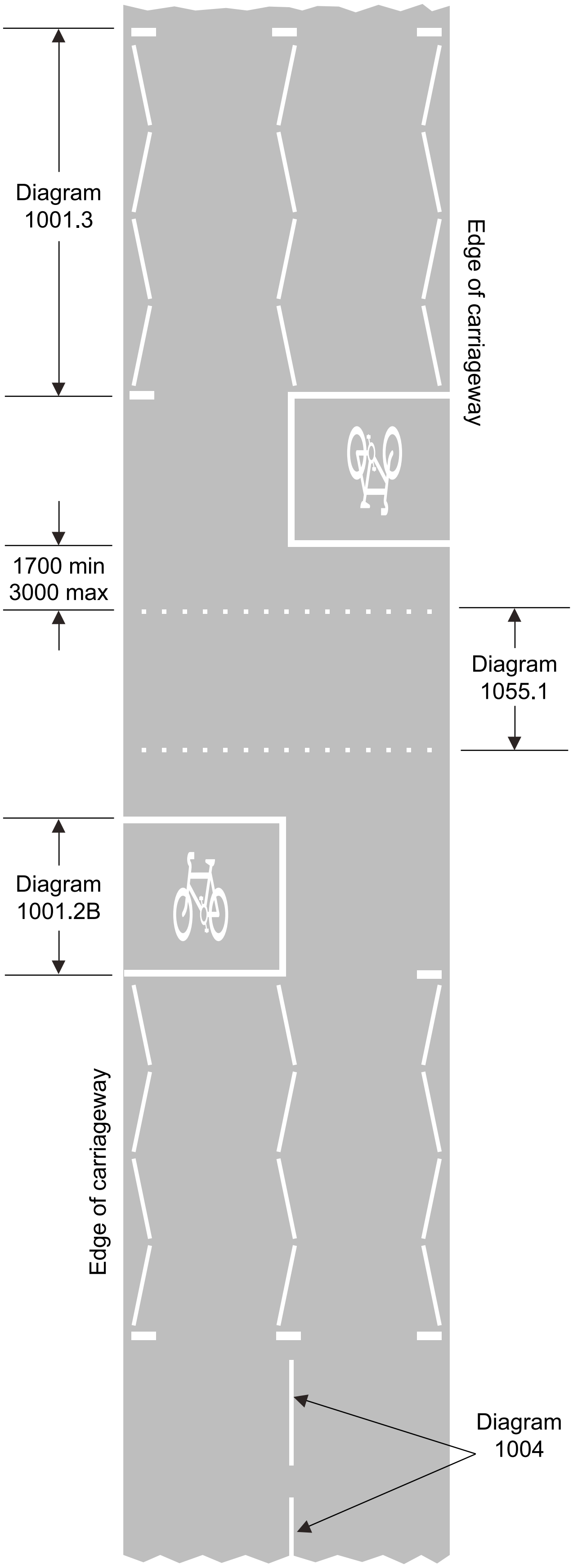


Figure 15-7 Zig-zag layout for signal-controlled crossings on one-way streets, with and without a central refuge island



Road marking layout for signal-controlled crossing with ASLs

Figure 15-8 Road marking layout for a signal-controlled crossing incorporating an Advanced Stop Line to diagram 1001.2B

15.9 Road studs

15.9.1. Road studs to diagram 1055.1 are arranged in two lines across the carriageway. They delineate the limits of the crossing, except at Zebra crossings where studs are optional and the limits are indicated by the stripes. At Parallel crossings, road studs are not required and the limits of the crossing are indicated by the black and white stripes and markings to diagram 1055.3. At equestrian crossings, road studs to diagram 1055.2 are used to indicate two crossing points where a parallel pedestrian or Toucan facility is provided.

15.9.2. When provided, studs must comply with the following requirements:

a) they must be white, silver or light grey in colour and may be laid in road marking material or be conventional non reflective road studs (i.e. without reflective lenses or an intermittent light source), in which case they must not project above the carriageway by more than 20 mm at their highest point nor more than 6 mm at their edges,
b) they must be either square or circular in shape. The sides of square or the diameter of circular studs must be not less than 95 mm nor more than 110 mm,
c) road marking material may be reflectorised, but retroreflecting or illuminated road studs must not be used,
d) centres of studs in the same line must not be less than 250 mm apart nor more than 720. The centre of the nearest stud must be no more than 1300 mm from the edge of the carriageway, and
e) the two lines of studs need not be at right angles to the edge of the carriageway, but they must form straight lines and, as far as practicable, be parallel to each other.

15.9.3. Although the Regulations permit the use of stainless steel, aluminium, thermoplastic or paint products, some types of metal studs can be slippery when wet, and the potential risk to two-wheeled traffic should be borne in mind. The use of intelligent road studs capable of showing different colours is not permitted at crossings.

15.10 Surfacing

15.10.1. Crossings should be installed so that adjacent drainage collects surface water from the crossing area. Care should be taken to ensure that dropped kerbs are installed in such a way that excess water does not collect at the crossing point.

15.10.2. Both the carriageway and footway should be free of surface obstructions such as cable drawpits, access covers to underground services, gratings and gullies. Street furniture should not be placed within the tactile paving area. As far as possible items such as supply pillars should be sited in an area not used by pedestrians.

15.10.3. High skid resistance surfaces should be considered on the carriageway approaches to pedestrian crossings. The approach speed and accident record should be considered when determining the length over which high skid resistance surfacing should be applied. The colour contrast should also be considered, as some colours can blend with road markings, making them less visible.

15.11 Guardrailing

15.11.1. The aim of guardrailing is to restrict the movement of vulnerable road users and channel them to a designated crossing place. However, experience has shown that where it creates a detour, people will still take the shortest route (for example by walking on the wrong side of the guardrailing) even if this puts them at greater risk.

15.11.2. Research carried out for the Department by the University of Southampton showed that guardrailing had no statistically significant effect on road safety. There is some evidence that it can increase traffic speeds and present an increased risk to cyclists, who can be crushed against it. It can be unsightly and creates a maintenance burden.

15.11.3. Guardrailing should not be installed as a matter of course, and should only be considered where there is a clearly identified safety risk. 'Local Transport Note 2/09: Pedestrian Guardrailing' sets out an assessment procedure to establish the need for guardrailing. It advises that alternative measures should be considered before deciding to install guardrailing. These may include:

a) Reducing traffic speeds,
b) Relocating or installing a new pedestrian crossing to better match pedestrian desire lines,
c) Footway improvements and widening if possible,
d) Providing direct crossings rather than staggered, and
e) Using other means of directing pedestrians if this is necessary.

15.11.4. Where guardrailing is used it should be limited to the minimum amount necessary. Where a site is being upgraded or refurbished, the opportunity should be taken to consider if any guardrailing is necessary and remove whatever is redundant. The assumption should not be to replace guardrailing "like for like".

15.12 Proximity to priority junctions

15.12.1. Where a crossing is to be placed near a side-road junction on a major road, the desire line may conflict with visibility requirements for drivers exiting the side road. Crossings may need to be moved off the desire line in order to give drivers enough time to see a crossing and brake safely, but deviations from the desire line should be minimised as far as possible. The exact distance will depend on the geometry of the junction and type of side road.

15.12.2. Where a crossing is on a minor road, drivers of vehicles turning into that road need time to judge the situation and space in which to stop. Crossings on a minor road should be sited far enough from a give way or stop line to allow at least one car to stop before the crossing. Generally the nearer the crossing is to the major road the greater will be the distance to be crossed.

15.12.3. The exact distance between a crossing and the junction will depend on the volume of turning vehicles and the pedestrian desire lines, but there should be sufficient distance between the crossing and the priority marking for at least one waiting vehicle. For signal-controlled crossings, it is important to make sure signal heads are aligned so that drivers cannot mistake a vehicular green signal on the signal-controlled crossing as a priority signal over traffic on the major road.

15.13 Approach to a roundabout

15.13.1. When crossings are needed on the approaches to a roundabout extra care is needed in the siting. There is no set minimum distance for a crossing from a roundabout but the considerations are similar to those in **15.12**. The use of different types of crossing at the same site is not recommended as this could lead to confusion. A Zebra crossing is preferred as it avoids any ambiguity as to priority that a signal-controlled crossing can create for the driver approaching or exiting the roundabout.

15.13.2. If a signal-controlled crossing is provided, it should preferably be staggered to avoid excessive delays at the exit points, blocking circulation. The pedestrian desire line, vehicle speeds, visibility, pedestrian/vehicle flows, size of roundabout, and length of crossing/road width should be considered when deciding the optimum location. Crossings away from flared entries are preferable as the carriageway is narrower and vehicular traffic movements are simpler.

15.13.3. It may be harder to place a crossing on the desire line on the approach to a roundabout. Guardrailing or other means of directing pedestrians to the crossing may need to be considered where pedestrian flows are high, but in doing so, the advice in **15.11** should be borne in mind.

15.13.4. The impact on driver behaviour of a crossing on the exit arm of a roundabout should be considered. Drivers concentrating on negotiating the roundabout may not be expecting to see pedestrians crossing.

15.14 Junctions with a yellow box marking

15.14.1. Where a pedestrian crossing is provided near to a junction with a yellow box marking, the crossing should be placed so that the zig-zag markings do not overlap the yellow box markings. The Regulations allow the overall length of the zig-zag markings to be varied, and it may be necessary to reduce the numbers of marks in these cases (see **15.8.8**).

15.15 Traffic signal-controlled junction

15.15.1. Where a crossing is required close to a traffic signal junction, a signal-controlled crossing may be the best option. Zebra crossings or refuges are generally less suitable as there is a conflict of control methods, which can lead to traffic blocking back. Even with a signal-controlled crossing care should be taken to ensure that queues do not build back from one installation to block the other. In these instances, linking the operation of the junction and the crossing may be appropriate.

15.16 School crossing patrols

15.16.1. If an existing school crossing patrol operates within 100 m of the crossing site, then a mutually convenient site should be found to accommodate both the patrol and other pedestrians.

15.16.2. A patrol may be operating on an existing desire line. The crossing should be placed on this desire line if possible. In these circumstances it may be helpful to provide manual control for signal-controlled crossings for the patrol warden, with suitable training and equipment.

15.17 Tactile and audible signals

15.17.1. S14-1-9 permits tactile and audible signals to be used in conjunction with the green pedestrian symbol, or invitation to cross period, to convey the same meaning. Both are intended primarily for the benefit of visually impaired people, but are also helpful to others. Tactile and audible signals are covered by relevant TOPAS specifications.

15.17.2. Tactile signals should be provided at crossing facilities as a default. They can be used at times and in places where audible signals are not suitable, for example where an audible signal is switched off overnight, or cannot be used because the junction does not operate a full pedestrian stage. Designs are available that offer improved detection for people with loss of sensation in the fingers, and authorities should be aware of the different design options when specifying tactile signals. Advice on installing tactile signals is given in **11.2**.

15.17.3. Audible signals are in the form of an intermittent tone. In residential areas, those living nearby may object to the noise levels of audible signals, particularly at night. The site should be checked after installation to see if any adjustments are needed. A time switch can be used to reduce the sound levels, or, if appropriate, switch them off overnight.

15.17.4. Staggered crossings can present problems with audible signals. The proximity of the two crossings can create a risk that the audible signal at one crossing may be heard and mistaken for the other. The standard audible signal should not be used and alternatives considered. Tactile signals should always be provided.

15.18 Lighting

15.18.1. A crossing and those using it need to be easily seen against the background of other lights and signs at night. At night drivers may not be able to see pedestrians waiting to cross unless good street lighting is provided. Supplementary lighting can be used to illuminate the crossing. If the crossing is within an area in which street lighting is switched off for part of the hours of darkness the lighting for the crossing should be operational during those times.

15.18.2. Good street lighting will reduce the majority of the problems related to extraneous light sources. Advice from a competent lighting engineer should be sought to ensure that street lighting to ‘BS 5489-1:2013: Code of practice for the design of road lighting’ is used at all pedestrian crossing sites. The Institution of Lighting Professionals also publishes guidance in Technical Report No. 12 ‘Lighting of Pedestrian Crossings’.

15.18.3. If supplementary lighting is used it should be designed to prevent glare to drivers which could hide or “veil” pedestrians standing behind it, thus defeating the objective of its installation. The pedestrian approach, particularly the area covered by tactile paving, and the carriageway crossing area should be illuminated to a uniform level.

15.18.4. Supplementary lighting units may be susceptible to vandalism and should be checked regularly to see that they are aligned and operating correctly. It is essential that all units are operating correctly to ensure that uniform lighting of the crossing is achieved.

15.19 Provision for bus stops

15.19.1. In urban areas, bus stops and crossings are often sited close together. In these circumstances, a bus stop is better positioned on the exit side of a crossing, and there is an exemption in the regulations for buses to stop on the zig-zags on the exit side, which should be borne in mind when considering layouts. It may be preferable to keep the standard eight zig-zag marks rather than shorten them to provide a bus stop bay – a flag and shelter can still be provided, and the zig-zags prevent other users parking there. Bus operators should be involved in agreeing the position of the bus stop as part of the planning process to ensure that buses at the stop do not obscure the vision of pedestrians or drivers.

15.20 Crossings placed on road humps

15.20.1. The Highways (Road Humps) Regulations 1999 (The Road Humps (Scotland) Regulations 1998 in Scotland) permit a Zebra or Puffin crossing to be placed on a road hump, though not in the controlled area, provided that the crossing is centred on the road hump. A humped crossing can give advantages, as vehicle speed will be slower on the approach, and pedestrians can cross the carriageway at the same level as the footway. Toucan, equestrian, Parallel and stand-alone signal-controlled pedestrian facilities (Pedex) may be placed on humps subject to obtaining authorisation from the relevant national authority. Within Greater London, Transport for London, the City of London Corporation and the London Boroughs may place these crossings on humps provided they follow the procedures set out in section 90CA of the Highways Act 1980.

16 ZEBRA CROSSINGS

16.1 General

16.1.1. Where there is a need for a crossing, pedestrian numbers and vehicle flows are moderate, and the 85th percentile traffic speed does not exceed 35 mph, then a Zebra crossing may be suitable.

16.1.2. Pedestrians establish precedence by stepping onto the crossing and so delays to them are minimal. Vehicle delays are typically 5 s for a single person crossing but may increase where irregular streams of people cross over extended periods.

16.1.3. The potential impact of installing a Zebra crossing may be tested by checking the availability of sufficient gaps in the traffic flow. Where either pedestrian or traffic flows are relatively high a Zebra crossing may not be suitable. Higher traffic flows result in few gaps meaning pedestrian waiting times may be long because people feel nervous about establishing precedence. Higher pedestrian flows may cause delay to vehicles.

16.1.4. Where traffic speeds are higher than 30 mph, people will require longer gaps in the traffic flow or be exposed to the risk of more serious injury if they cannot establish themselves on the crossing. Zebra crossings should not be installed on roads with an 85th percentile speed of 35 mph or above without speed reducing measures to slow traffic.

16.1.5. At unusual sites such as contraflow bus lanes and one-way streets, care will be needed as these layouts can cause uncertainty. A signal-controlled crossing may be more suitable.

16.2 Layout considerations

16.2.1. The minimum width for a Zebra crossing is 2.4 m. The width used at individual sites will vary according to the site circumstances, but where pedestrian flows are over 600 per hour a wider crossing may be helpful (see **15.7.5**).

16.2.2. Yellow globes are prescribed in diagram 4007 (S14-2-27, see **Figure 16-1**) to indicate the presence of a Zebra crossing. S14-2-13(3) sets out the requirements for the post on which the globe is mounted, including permitting the post to be internally illuminated.

16.2.3. The Regulations state that one yellow globe must be provided at each end of the crossing. There are no set locations and they are normally placed on the near side closest to approaching traffic. The guiding principle should be to make sure vehicles can see them in time to react. Where a Zebra crossing is on a one-way street, it may be more appropriate to place both globes on the approach side, rather than one on the approach and one on the exit. However, the decision will depend on site circumstances. Where a crossing has a refuge it may be helpful to place an extra globe on the refuge island. Globes may be omitted where a crossing is placed across a cycle track.

16.2.4. While the Regulations allow for a globe to be fitted with a device to enhance its conspicuousness, any such device should be in addition to a globe as depicted in S14-2-27 – that is, with a yellow surface that would appear uniform if the additional device was not present.

16.2.5. The Regulations also permit a shroud to be fitted to the globe to reduce the amount of light entering neighbouring properties where this is an issue.

16.2.6. BS 8442:2006 covers performance requirements for yellow globes. While compliance with this is not a requirement of the Regulations, equipment that meets this is likely to perform to an appropriate standard.

16.2.7. The markings used to indicate a Zebra crossing and its controlled areas are shown in **Figure 16-2** and consist of:

a) alternate black and white stripes,
b) Give Way lines to diagram 1001.5,
c) zig-zag lines to diagram 1001.3, including terminal lines, and
d) road studs (optional).

16.2.8. Black and white stripes, between 2.4 m and 10 m long, in the direction of travel are laid across the full width of the carriageway. Road studs at Zebra crossings are optional. Where used, they are placed not more than 155 mm from each end of the stripes. Advanced Stop Lines are not prescribed for use at Zebra crossings.

16.2.9. The stripes immediately adjacent to the edge of the carriageway must be black and be not more than 1.3 m wide. All other stripes, both black and white, must be of equal width and not less than 500 mm nor more than 715 mm wide. The Regulations permit the minimum to be reduced to 380 mm and the maximum increased to 840 mm where an authority considers it necessary having regard to the road layout. For example, the stripes may be narrowed where a Zebra crossing is provided across a cycle track, or widened to reduce the number on a wide carriageway.

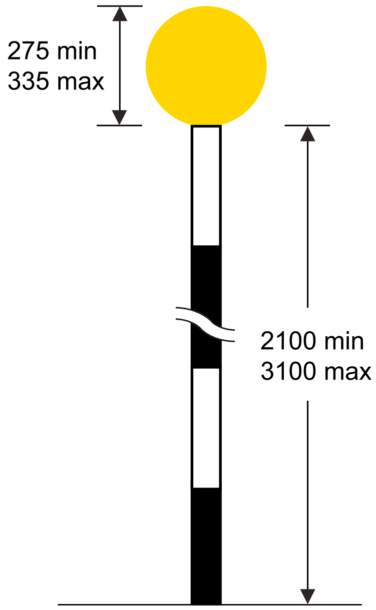


Figure 16-1 Diagram 4007 (S14-2-27)

16.2.10. The white stripes may be illuminated with retroreflecting material. The carriageway surface may be used to represent the black stripes if it provides a reasonable contrast with the white.

16.2.11. The Give Way line consists of a single broken line comprising 500 mm marks and 500 mm gaps, and is 200 mm wide. It is normally sited between 1.1 m and 3 m from the edge of the stripes on the crossing, whether or not studs are used, and must extend across the full width of the carriageway. This 3 m limit may be increased up to 10 m if necessary.

16.2.12. Where a crossing is placed across a segregated cycle track the Regulations allow for the omission of the controlled area and the yellow globes (see **Figure 15-1**). It may be necessary to reduce the dimensions of the black and white stripes to the minimum to retain proportionality. Give Way lines should always be provided, to enforce the requirement for cyclists to give way to pedestrians. Where the crossing then continues over the main carriageway, zig-zags and yellow globes must be provided for this area (see **Figure 15-1**). If the segregation between the cycle track and the main carriageway does not give enough space to place globes it may be more appropriate to place them on the kerb.

16.2.13. Zebra crossings may be provided with a central refuge which can help break up the crossing task on wide roads. The refuge should be large enough to accommodate the expected number of people and to allow those with pushchairs or wheelchairs to wait safely. The exact size will depend on the particular site but an absolute minimum of 1.2 m width is recommended. Tactile paving should be provided on the refuge to the layout and colour recommended in ‘Guidance on the Use of Tactile Paving Surfaces’.

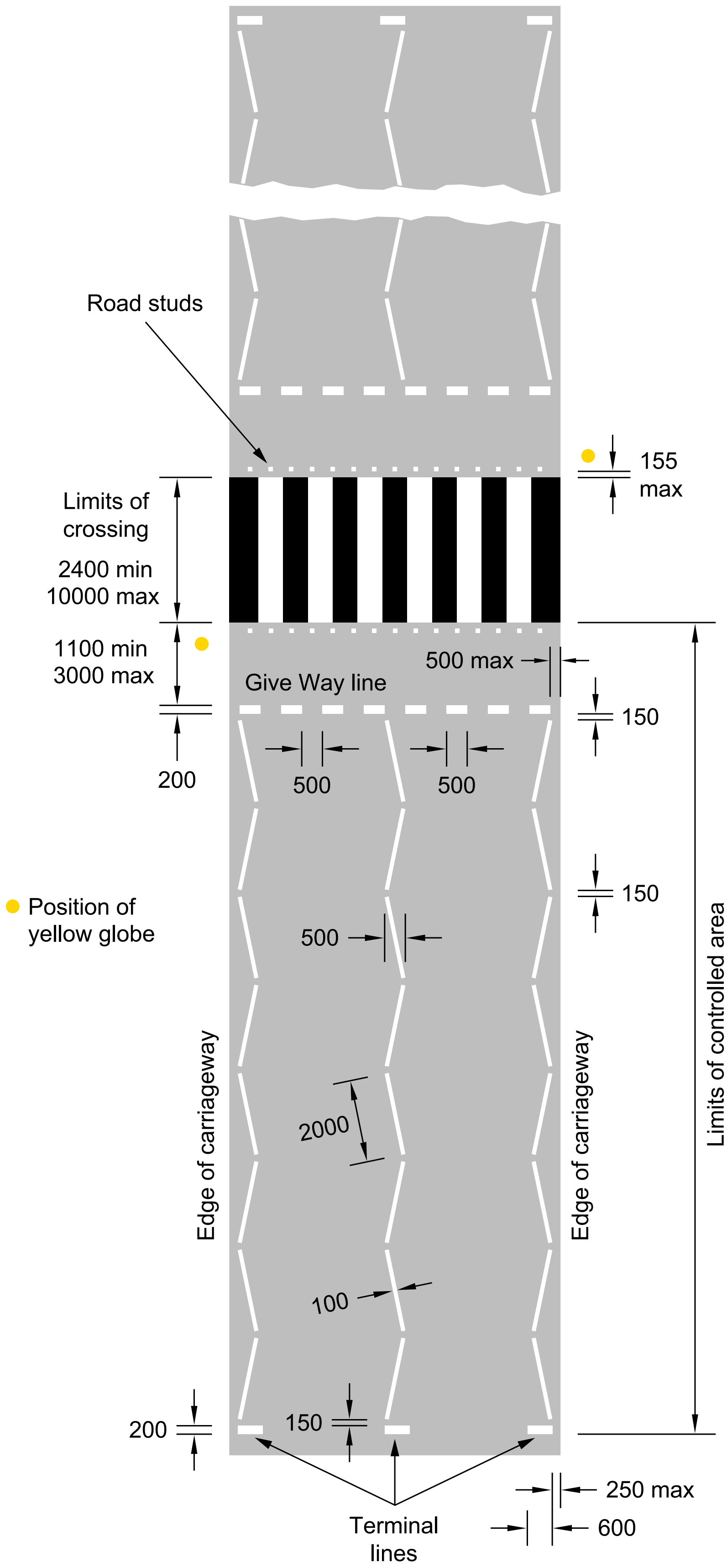


Figure 16-2 Diagram 1001.4 (S14-2-52): Road markings indicating a Zebra crossing

17 PARALLEL CROSSINGS

17.1 General

17.1.1. Where there is a need for cyclists to cross the road as well as pedestrians but a Toucan crossing is not justified, a Parallel crossing may be suitable. This consists of black and white stripes for pedestrians, as at a Zebra crossing, with a parallel route for cyclists indicated by markings to diagram 1055.3. Vehicles must give way to any pedestrian or cyclist on the crossing, and pedestrians and cyclists establish precedence on the crossing in the same way as at a Zebra.

17.1.2. The same considerations of vehicle speed and flow apply as for Zebra crossings, and a Parallel crossing should not be placed on roads with an 85th percentile speed of 35mph or above without speed reducing measures. Cyclists travel faster than pedestrians, and as a Parallel crossing does not require them to stop and wait for a green signal as a Toucan does, good visibility is essential to ensure traffic can see cyclists in time to stop. Cyclists should also be able to see oncoming traffic in time to react, as they have no priority over other traffic until they are on the crossing.

17.1.3. If the pedestrian and cyclist desire lines do not coincide a Parallel crossing is unlikely to be suitable. The number and speed of cyclists will be a key factor in determining if a Parallel crossing is suitable. If there are very large flows of cyclists, but few pedestrians, a Parallel crossing may not be the best solution and a signal-controlled facility using cycle only signals may be more suitable. A Parallel crossing may also be unsuitable if significant numbers of cyclists are expected to turn right from the main road onto the cycle route at this point.

17.2 Layout considerations

17.2.1. The markings used to indicate a Parallel crossing and its controlled areas are:

a) alternate black and white stripes
b) white markings to diagram 1055.3 (S14-2-57)
c) Give Way lines to diagram 1001.5 (S14-2-54), and
d) zig-zag lines to diagram 1003.5 (S14-2-53), including terminal lines.

17.2.2. The layout is shown in diagram 1003.5 (S14-2-53, see **Figure 17-1**). A give way line, controlled area and yellow globes are required, as for Zebra crossings. Stud markings to diagram 1055.1 (S14-2-55) are not prescribed for use at Parallel crossings. Advanced Stop Lines are not prescribed for use at Parallel crossings.

17.2.3. S14-1-21 requires drivers to give way to any pedestrian or cyclist on the black and white stripes, or within the markings to 1055.3 respectively. Priority is established in the same way as at a Zebra crossing.

17.2.4. Diagram 1055.3 consists of white squares that may be varied to between 250 mm and 400 mm on a side. The gaps between them may be similarly varied, but must remain in proportion with the markings. The first marking in the line may be between 400 mm and 800 mm from the edge of the carriageway. The cycle symbol to diagram 1057 may be omitted or reversed as required. Coloured surfacing may also be used to highlight the cycle route. The gap between diagram 1055.3 and the Give Way line must be between 1.1 m and 3 m.

17.2.5. As for a Zebra crossing, the minimum requirement is for one yellow globe at each end of the crossing. To highlight the crossing for drivers extra globes may be required but it is for the designer to consider the most appropriate position. Globes may be placed between the pedestrian and cycle sections, and on central refuges where used.

17.2.6. The minimum width of a Parallel crossing is 2.4 m for the pedestrian section, as for a Zebra crossing, and 1.5 m for the cycle route. A minimum width of 2 m is recommended for cycle lanes on busy roads, but 1.5 m may be generally acceptable for a one-way cycle route at a Parallel crossing. Where the cycle route is two-way the minimum width should be 3 m. The black and white stripes should be marked as for a Zebra crossing, following the advice in **16.2.8**. The maximum width for the cycle route is 5 m.

17.2.7. Cyclists generally travel faster than pedestrians. On the approach to a Parallel crossing, if the cycle route joins the crossing at or near a right angle to the main road, this may lead to cyclists entering the crossing at an inappropriate speed, which could endanger themselves and intimidate pedestrians.

17.2.8. To ensure cyclists have sufficient time to assess whether there is a large enough gap in which to cross, and to allow drivers to see cyclists approaching and be ready to give way, the designer should consider how the cycle route layout can be varied to ensure cyclists do not enter the crossing too fast, for example, by deflecting the cycle route on approach. Pedestrian guardrailing for this purpose should only be used as a last resort and positioned with great care, as it can create conflict between cyclists and pedestrians, see **15.11**.

17.2.9. The pedestrian section of the crossing should be provided with tactile paving, as for a standard Zebra crossing, to the layouts and colours recommended in 'Guidance on the Use of Tactile Paving Surfaces'.

17.2.10. Although the waiting areas for pedestrians and cyclists are separate at a Parallel crossing, this area should be treated as shared-use, similar to the approach to a Toucan crossing. Ladder/tramline and corduroy tactile paving layouts should be considered. This will give reassurance to visually impaired people about the environment they are entering, particularly if they are entering from the cycle route side of the crossing.

17.2.11. A plate to diagram 547.8 (S14-2-31) with the legend "Parallel crossing" has been prescribed for use with the Zebra crossing warning sign to diagram 544 (S14-2-30). This sign may be useful when a crossing is newly installed to help alert drivers to the possibility of cyclists crossing ahead. As road users become familiar with the layout the need for the sign should be reviewed and it should be removed if possible, to reduce clutter.

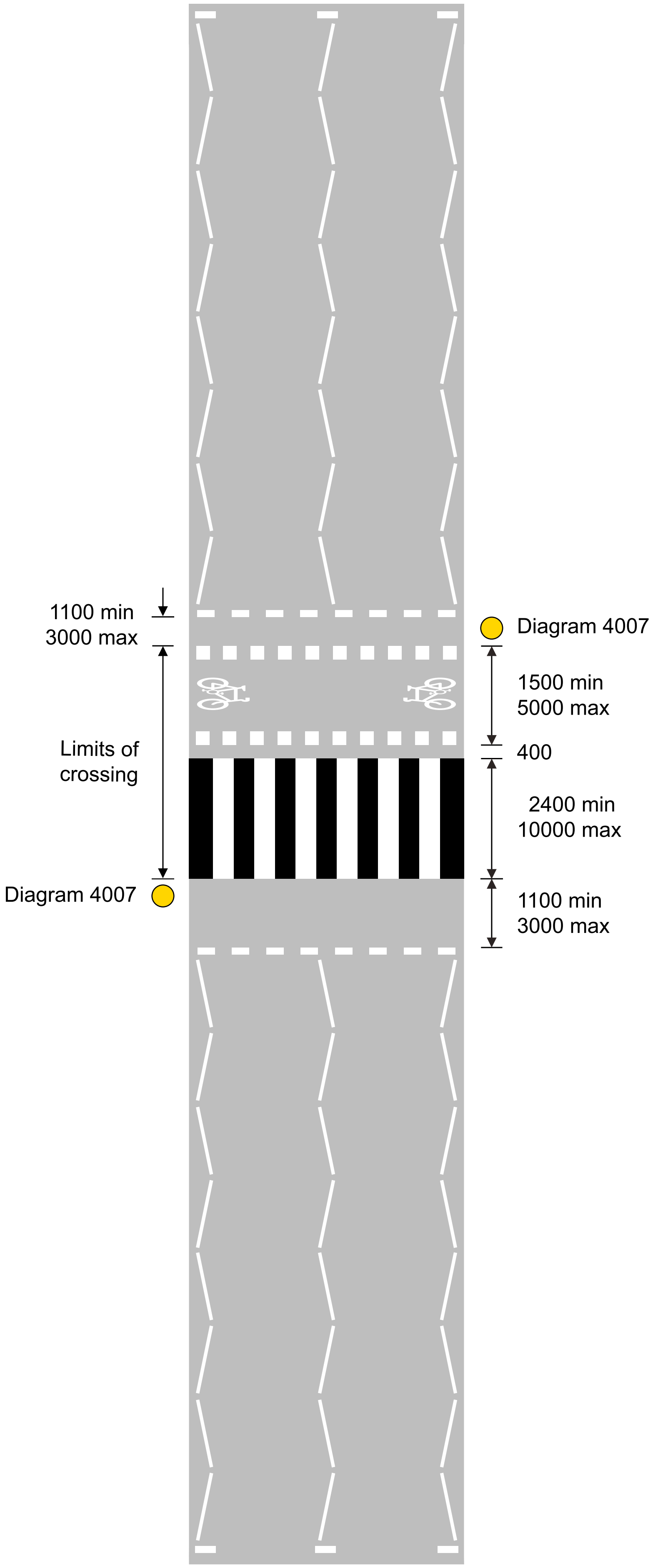


Figure 17-1 Diagram 1001.5 (S14-2-53): Road markings indicating a Parallel crossing

18 SIGNAL-CONTROLLED CROSSINGS

18.1 General

18.1.1. This section provides general advice common to Puffin, Toucan and equestrian crossings, and signal-controlled pedestrian facilities (Pedex). More detailed advice on each crossing type is given in the following sections.

18.1.2. Signal-controlled crossings may operate with either farside or nearside signals, see **11.2**. Consistency and safety are key factors when considering what type of crossing facilities to provide. It is important that users encounter a consistent experience within an area.

18.1.3. Signal-controlled crossings are used where:

a) vehicle speeds are high and other options are unsuitable,
b) there is normally a greater than average proportion of older or disabled people,
c) vehicle flows are very high and pedestrians have difficulty in asserting precedence,
d) other traffic management measures could create uncertainty for pedestrians, such as a contraflow bus lane,
e) there is a need to link the operation with adjacent traffic signal junctions or crossings,
f) pedestrian flows are high, resulting in substantial delays to vehicular traffic.

18.1.4. The carriageway markings used to indicate the presence of signal-controlled crossings and their controlled areas are:

a) Stop lines to diagram 1001 (S14-2-46),
b) Advanced Stop Line to diagram 1001.2B (S14-2-49) (optional),
c) zig-zag lines to diagram 1001.3 (S14-2-51) including terminal lines, and
d) Studs to diagram 1055.1 (S14-2-55) or 1055.2 (S14-2-56).

18.1.5. The Stop line to diagram 1001 indicates the position where traffic must stop when signalled to do so. Diagram 1001.3 states that the Stop line must be placed a minimum of 1.7 m and normally not more than 3 m from the studs, but the advice for signal junctions to place the stop line 3 m and the primary signal post 2.5 m from the studs, is applicable here as well. The 3 m distance may be extended to a maximum of 10 m if necessary. On two-way roads the Stop line extends from the edge to the centre line, and on one-way roads across the full width. The controlled area should be laid following the advice in **15.8**.

18.2 Layout considerations

18.2.1. The minimum requirements for positioning of signals at a controlled crossing are prescribed in S14-6. The restrictions on the mounting height for signals are prescribed in S14-2.

18.2.2. The minimum requirement is for two signal heads per approach to ensure drivers have a clear view of at least one signal head on approach and one while waiting at the stop line. Extra signal heads may be considered where the driver's view of the signals is reduced by the vertical or horizontal alignment of the road, or other situations such as masking of signals in heavy traffic conditions.

18.2.3. Building out the kerb line may be an alternative if the carriageway width is sufficient. Mast arm signals mounted over the carriageway can be used to enhance visibility but are generally difficult to maintain and costly, as well as creating street clutter and other means of enhancing visibility should be considered first.

18.2.4. S14-6-5 allows signal posts to be fitted with a white or yellow band to help visually impaired people navigate the crossing.

18.2.5. Pedestrian push button or demand units should be close enough to the tactile paving to allow anyone who could reasonably be expected to use the crossing to reach them easily. This is particularly important for crossings with kerbside detectors. 0.5 m is recommended (see **19.1.3**).

18.2.6. Refuges at a non-staggered crossing should not be provided unless sufficient space is available (see **15.3.2**). A refuge may help mobility impaired people by enabling them to break the crossing task into two parts. Refuges should be provided with push buttons and signals as required.

18.3 Staggered and two-stage crossings

18.3.1. Staggered crossings generally offer more benefits for traffic than pedestrians as they allow two streams of traffic to be controlled in separate stages, but they will generally make crossing distances longer for pedestrians. A typical layout is shown in **Figure 15-6**.

18.3.2. In town centres reassessing crossing provision can help pedestrians move around more easily and increase a sense of ‘place’ over ‘movement’. For example, where crossings are planned to be installed or revised as part of a wider public realm scheme, there may be opportunities to build out the footway to reduce the distance people have to cross, or to replace staggered crossings with straight-ahead crossings.

18.3.3. A staggered layout may be beneficial where the road is very wide and pedestrians have to cross a number of traffic lanes but alternatives can be considered. Nearside operation can accommodate longer crossing distances, allowing people to cross in one movement and avoid delay. Where farside signals are used, pedestrian countdown signals can reassure pedestrians and enable longer single-stage crossings to work.

18.3.4. In some places staggered crossings have been replaced with refuges wide enough to allow the two movements to operate in line but in two stages, see **Figure 18-1**. This relies on the refuge being wide enough that pedestrians do not mistake the green signal on the second stage for that on the first. Nearside operation will reduce this risk but experience has shown that a refuge width of between 5-7 m can work. Rather than providing a full stagger, offsetting the crossings slightly from each other may also help pedestrian understanding.

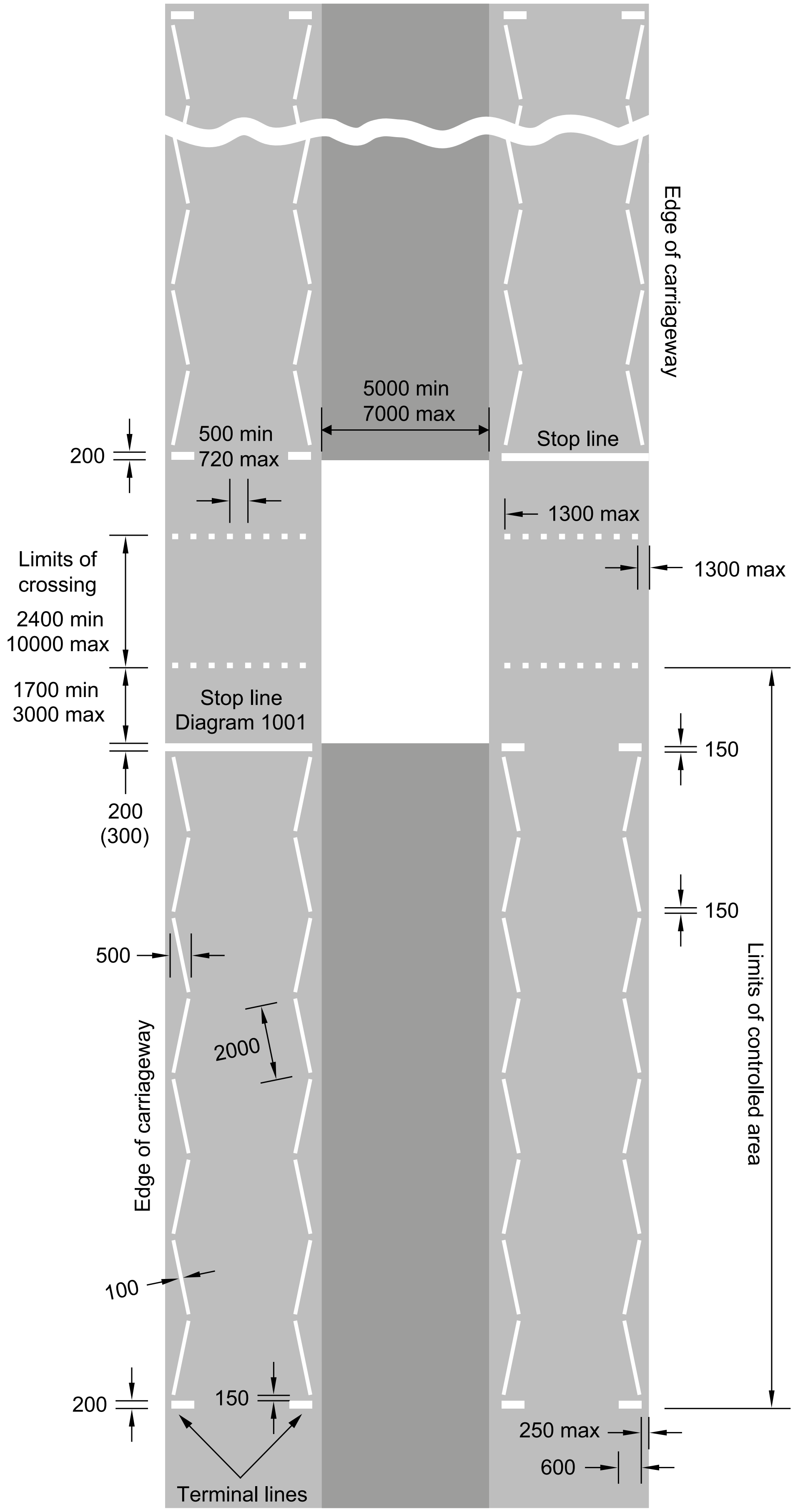


Figure 18-1 Diagram showing suggested layout for an in-line crossing operating in two stages

18.3.5. Staggered crossings generally have a left-handed stagger so that pedestrians on the central refuge are guided to face approaching traffic, but a right-handed stagger may be appropriate depending on site circumstances. Where this is the case, careful alignment to limit the field of view may be needed to avoid the risk of waiting pedestrians "seeing through" a red signal to a green signal at the opposite crossing.

18.3.6. Staggered signal-controlled crossings are not recommended for one-way roads. If unavoidable, such as within a town centre gyratory system, road markings should be provided in order to deter drivers from weaving when approaching the crossings. Consideration should be given to providing informatory signs to help avoid confusion for pedestrians.

18.3.7. Where used, a central refuge for a staggered crossing should be long enough to indicate the segregation of the crossings. A minimum of 3 m between crossing limits is recommended as wide enough to allow pedestrians to pass each other between the crossings.

18.3.8. The use of guardrailing at central refuges can be unsightly and create a maintenance burden, and can prevent people following the desire line, see **15.11**. In town centres, where vehicle speeds are low and movement of pedestrians is prioritised, use of kerbs to define the central refuge area can be more attractive and give protection to users, while allowing those who wish, to cross where they prefer.

18.3.9. Where guardrailing is considered necessary, such as at crossings across high speed roads, a recommended minimum width for the central refuge of 3 m will give 2 m between obstructions, providing enough room for pedestrians waiting to cross.

18.3.10. Staggered crossings are considered as two separate crossings and for electrical safety during maintenance, a post on the central refuge should only have equipment for one crossing mounted on it. Accessibility for maintenance of crossings should be considered at the design stage.

18.3.11. Push buttons should always be provided on the central island. The controller may be configured such that a demand for one half of a staggered or two-stage crossing automatically inserts a demand for the other half, with an appropriate delay.

18.3.12. Pedestrian waiting areas should be large enough to cater both for people waiting and passers-by.

18.3.13. At Toucan crossings, the waiting area should be large enough to accommodate pedal cycles. Where there is a large number of pedestrians, designers should consider widening the footway if possible, or providing a wider crossing to accommodate the numbers waiting. Refuges at staggered crossings should be able to accommodate a design cycle 1.2 m wide by 2.8 m long.

18.4 Signal operation

18.4.1. As with signal-controlled junctions, responsive control is the normal method of operation for crossings. The recommended options are described in **Table 18-1**. The approach speed should be taken to mean the 85th percentile speed under free flow conditions. Detectors are covered by relevant TOPAS specifications.

18.4.2. On roads subject to a speed limit of 30 mph and where the 85th percentile approach speeds do not exceed 35 mph, fixed time operation may be an option. A pedestrian demand initiates the cycle, and the vehicle precedence period will terminate when a pre-set time has expired. The pre-set time is normally set low, typically 20 s to 30 s, but can be extended during peak periods if required.

18.4.3. Microwave vehicle detection may be used on roads with speed limits higher than 30 mph but signal settings will need to be adjusted to ensure safe clearance periods are introduced.

18.4.4. On roads with speed limits above 30 mph, or an 85th percentile approach speed above 35 mph, if vehicle actuation is used it should always be supplemented with Speed Assessment or Speed Discrimination equipment (see **10.4**). Isolated adaptive control such as MOVA may be used as an alternative.

Table 18-1 Recommendations for Vehicle Detection for signal-controlled crossings

Speed limit (mph)	85th percentile approach speed (mph)	Recommended Operation
Up to and including 30	Up to and including 35	a) Fixed time operation, or b) Microwave vehicle detection (MVD) or c) With a single loop sited 39 m from the stop line with a 4.0 second extension time for vehicles, or d) With a multi-loop configuration such as System D
Above 30	Up to and including 35 Greater than 35 and up to and including 45	a) Vehicle actuation or isolated adaptive control b) Vehicle actuation as above. In addition, Speed Discrimination loops spaced at 79 m from the stop line (vehicles travelling in excess of 30 mph being granted 3.0 second extensions) should be used

18.5 Co-ordinated control

18.5.1. Where a crossing is proposed close to a signal junction (within about 100 m), consideration should be given to linking the operation of the crossing to that of the junction, either locally or within a UTC system.

18.5.2. Crossings within UTC or locally linked system may be:

a) omitted from the UTC scheme and remain on isolated control when coordination is not justified, for example at quiet times of day,

b) operated as part of an adjacent controlled junction, or

c) controlled directly by the system.

18.5.3. If controlled directly, the normal method is to control the change to the start of the pedestrian stage. It is either allowed or inhibited by use of software commands within the controller. Where kerbside detection is used, improved control may also be achieved by modelling the crossing as a junction with the pedestrian stage entered as a stage with a call/ cancel facility. This method will also allow for the variable all-red.

18.5.4. The vehicle precedence time of the crossing should be matched to the timings of the adjacent installations. It may be necessary, and desirable, for a complete crossing sequence to operate more than once within the area cycle time to avoid long pedestrian waiting times.

18.5.5. Under UTC it may be possible to insert artificial pedestrian demands. This could present drivers with an unexpected loss of right of way and should be avoided.

18.5.6. When calculating timings, the crossing length used is the maximum distance between footway kerbs. At staggered, off-set or in-line two-stage crossings, each carriageway should be treated as a separate crossing.

18.6 Design walking speed

18.6.1. A design speed of 1.2 m/s is conventionally used to calculate timings for crossings. This results in timings that are suitable for the vast majority of crossings. The clearance period is key as this is what allows people to clear the crossing if they step off the kerb as the green symbol goes out. If this is properly calculated it will ensure there is sufficient crossing time.

18.6.2. A lower design speed of 1.0 m/s may be used, either on a site-by-site basis or as an area-wide policy. Where there is a large number of slower pedestrians this may be beneficial. The use of on-crossing detection will also help by automatically extending crossing times where needed.

18.6.3. The invitation to cross period for all crossings will depend on how many people are waiting, time of day, and distance to cross. Generally, it should be long enough to allow people to clear the footway, establish themselves on the crossing and avoid turning back when the all-red or blackout period begins.

18.6.4. The invitation to cross period may need increasing if:

a) there are heavy pedestrian flows,
b) the crossing is very wide,
c) a central refuge area is provided,
d) space in the pedestrian waiting area is limited,
e) at crossings on high speed roads, or
f) if there are high proportions of disabled, older or slower moving pedestrians or schools nearby.

18.6.5. At nearside crossings, pedestrians cannot see the green signal once they enter the crossing. There is therefore little benefit to increasing the invitation to cross unnecessarily.

18.7 Detection

18.7.1. Crossings may utilise two forms of detection in addition to push buttons:

a) kerbside call/cancel detectors, which cancel pedestrian demands that are no longer required. They may also be used to adjust crossing timings to take account of pedestrian flows, and
b) on-crossing detectors, which extend the all-red time.

18.7.2. Developed originally for Puffin crossings, both types of detection may now be used at all signal-controlled facilities. Whether or not to do so will depend on local policies and site circumstances. For example, on-crossing detection cannot be used with pedestrian countdown as this requires a fixed blackout period.

18.7.3. Kerbside detection can improve the efficiency of a crossing by cancelling unwanted demands and allowing timings to be adjusted to take account of pedestrian flows. It may now be used on both farside and nearside facilities. At sites with high pedestrian demand, kerbside detection may be of limited value as demand is likely to be present for the majority of the time. Kerbside detection may need adjusting where narrow footways mean passing pedestrians may trigger the detection unnecessarily.

18.7.4. On-crossing detection should be properly installed, aligned and maintained in accordance with the manufacturer's guidelines. This can be particularly relevant at nearside facilities, as pedestrians cannot see a demand unit once they are established on the crossing.

At crossings over 4 m in width, two sets of parallel detectors will be required to ensure full coverage of the crossing.

18.7.5. On-crossing detection can be used with farside facilities, and can give similar benefits to nearside facilities as well as improving efficiency of operation. The exception is where pedestrian countdown is to be used, as on-crossing detection is incompatible with this (see **11.11**).

18.7.6. Where kerbside call/cancel detection is used the delay time, after which the call is cancelled if the kerbside detector does not detect anyone waiting, should be set to a value between 2 and 4 s depending on site conditions.

18.8 Operational cycles and timings

18.8.1. The operational cycles and recommended timings for all crossing types are given in the following tables.

Table 18-2 Operational cycle and timings for nearside crossings

Period	Crossing signal	Vehicle signal	Duration in s	Comments
1	Red	Green	6-15 min 60 max	**Traffic green**: minimum is typically 7 s but may exceptionally be set in the range 6-15 s if necessary. Can be set up to a maximum of 60 s according to traffic flow, but maximum timings over 30 s should be avoided to minimise pedestrian delay.
2	Red	Amber	3	Mandatory stopping amber signal to traffic. No variation permitted.
3	Red	Red	1-3	**All-red following traffic**: allows traffic to clear before pedestrians are given right of way. a) 1 s after a gap change or 1-3 s after a force change on low speed roads; b) 3 s when the 85th percentile speed is greater than 35 mph
4	Green	Red	4-9	**Invitation to Cross**: 4-5 s when pedestrian flows are light to moderate. See **18.6.4**
5*	Red	Red	1-5	**Fixed All Red**: ensures that pedestrians who enter the crossing at the end of Period 4 are established on the crossing. Can be set in the range 1-5 s. 3 s is recommended as the base setting, but 2 s has been successfully used at a number of sites. The fixed all red period will always appear whether or not pedestrians are present on the crossing, therefore this timing should not be unnecessarily long. May vary according to the type of detection used.
6*	Red	Red	0-30 (Puffin) 0-22 (Toucan)	**Variable All Red**: holds traffic on red whilst pedestrians clear the crossing. The maximum value is based on road width and the pedestrian ‘comfort factor’ (Pc) Will have a 0 s duration if there are no pedestrians on the crossing but will run to a maximum if there are pedestrians present, or gap out between the minimum and maximum when pedestrians leave the crossing. Minimum value is dependent on the width of the crossing
7	Red	Red / amber	2	Mandatory starting red/amber signal to traffic. No variation permitted

*advice on calculating periods 5 and 6 is given in **11.10**

Table 18-3 Operational cycle and timings for farside crossings without countdown

Period	Crossing signal	Vehicle signal	Duration	Comments
I	Red	Green	7-20	Min and max for use with vehicle actuation. May vary according to traffic volumes
II	Red	Amber	3	Mandatory stopping amber signal to traffic. No variation permitted
III	Red	Red	1-3	Allows traffic to clear before pedestrians are given right of way. a) 2 s after a gap, max, fixed time or UTC change b) 3 s when the 85th percentile speed is greater than 35 mph
IV	Green (invitation to cross)	Red	6-12	dependent upon carriageway width and pedestrian/cyclist density, user type, presence of central refuge.
V	Fixed Blackout	Red	3	Fixed minimum blackout to comply with TOPAS 2500A
VI	Extendable blackout	Red	0-22	Minimum value dependent on width of crossing and type of detection. A further 3 s blackout should be added if period VI reaches max.
VII	Red	Red	1	Further clearance period
VIII	Red	Red/ amber	2	Mandatory starting red/amber signal to traffic. No variation permitted

Table 18-4 Operational cycle and timings for farside crossings with countdown

Period	Crossing signal	Vehicle signal	Duration	Comments
A	Red	Green	7-20	Min and max for use with vehicle actuation. May vary according to traffic volumes.
B	Red	Amber	3	Mandatory stopping amber signal to traffic. No variation permitted.
C	Red	Red	1-3	Allows traffic to clear before pedestrians are given right of way. a) 2 s after a gap, max, fixed time or UTC change b) 3 s when the 85th percentile speed is greater than 35 mph
D	Green (invitation to cross)	Red	6-12	Dependent upon carriageway width and pedestrian density, user type, presence of central refuge
E	Blackout	Red	Dependent on width of crossing	L/s, where L = width of crossing in m, and s = chosen design walking speed, either 1.0 m/s or 1.2 m/s.
F	Red	Red	3	Fixed all-red period to allow pedestrians to clear the crossing before traffic is given right of way.
G	Red	Red/ amber	2	Mandatory starting red/amber signal to traffic. No variation permitted.

19 PUFFIN CROSSINGS

19.1 General

19.1.1. The minimum width of a Puffin crossing is 2.4 m, as set out in diagram 1055.1 (S14-2-55). Puffin crossings use nearside pedestrian demand units to diagram 4003.1 (see **Figure 11-2**), and additional push buttons to diagram 4003.8 (see **Figure 11-3**). Pedestrian demand units include pedestrian red and green displays, plus a push button either in combined or separate units.

19.1.2. The prescribed road markings are set out in **18.1.4**.

19.1.3. Pedestrian demand units should be sited between waiting pedestrians and the nearest approaching traffic as this encourages pedestrians to look towards the approaching vehicles. If a pedestrian demand unit is not located to the right, when viewed looking into the crossing, a push button should be provided as visually impaired people are used to seeking a push button on the right.

19.1.4. Pedestrian demand units and push buttons should be installed 0.5 m from the line of crossing studs. This enables pedestrians standing on the tactile paving, particularly those with sight problems, to reach the demand unit. The demand unit should be positioned so that people using mobility scooters or wheelchairs can reach it easily, as they may have more difficulty depending on the site layout.

19.1.5. Pedestrian demand units and push buttons should be mounted at a height of between 1.0 m and 1.1 m from the footway to the button, and be inclined at 25° to 30° to the kerb face pointing into the footway, except on islands where they should be at right angles.

19.1.6. In some circumstances, for example where buried services create siting issues, it may be necessary to site poles more than 0.5 m from the kerb face to avoid existing services. In such cases, the angle of the pedestrian demand unit may have to be reduced to ensure that pedestrians do not stand too far from the kerb edge.

19.1.7. Extra push button units can be placed on the other side of the crossing if needed and may be helpful where the crossing is wider than standard, or on one-way streets. These can be placed on short posts or on other signal posts if they are in the correct location.

19.1.8. Where pedestrian flows are high standard height pedestrian demand units can be masked by waiting pedestrians. High-level repeaters to diagram 4003.1A (see S14-2-14) can be installed with a minimum 1.70 m clearance to the underside of the unit.

20.1 General

20.1.1. Toucan crossings allow both pedestrians and cyclists to cross at the same time. They may use nearside signals to diagram 4003.7 (S14-2-21, see **Figure 20-1**), or farside signals to diagram 4003.5 (S14-2-19) with a push button to diagram 4003.6 (S14-2-20) (see **Figure 12-6**) or 4003.8 (S14-2-12, see **Figure 11-3**). Farside and nearside signals must not be combined in the same installation.

20.1.2. The prescribed road markings are set out in **18.1.4**.

20.1.3. If the footway and cycle track on the approach are segregated, segregation should stop short of the waiting area, which should be provided with tactile paving to the recommended layouts and colours in 'Guidance on the Use of Tactile Paving Surfaces'. Nearside signal aspects can be obscured by waiting pedestrians at busy sites, and high-level repeater signals to diagram 4003.7A (S14-2-22, see **Figure 20-2**) may be useful.

Figure 20-1 Diagram 4003.7 (S14-2-21)

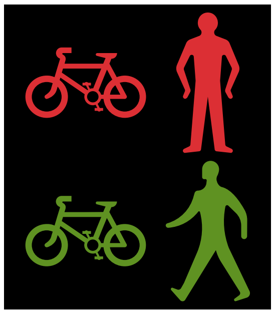


Figure 20-2 Diagram 4003.7A (S14-2-22)

20.1.4. 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, but in some locations they may be the only practicable design solution. Refuges at staggered crossings should be able to accommodate a design cycle 1.2 m wide by 2.8 m long.

20.1.5. The minimum permitted width of a Toucan crossing is 3 m, as set out in diagram 1055.1, but 4 m is recommended as a more effective width. General layout requirements are the same as for Puffin crossings, but one push button should be placed on either side of the crossing. Pedestrian countdown may be provided with a Toucan crossing (see **21.2**). Timings are given in **Table 18-2**, **Table 18-3** and **Table 18-4**.

21 SIGNAL-CONTROLLED PEDESTRIAN FACILITIES (PEDEX)

21.1 General

21.1.1. Whilst crossings with nearside operation have become the main form of crossing in many places, it is recognised that there are places where they are unsuitable. Accordingly, although it is no longer possible to install Pelican crossings in England, Scotland and Wales, a crossing using farside signals is prescribed in the Regulations. Note that Pelican crossings are still prescribed in Northern Ireland. Existing Pelican crossings elsewhere may remain in place until the equipment reaches the end of its life.

21.1.2. A Pedex crossing is a junction pedestrian facility installed as a stand-alone crossing. It is defined in Schedule 1 of the Regulations as a "signal-controlled pedestrian facility" and uses farside signals to diagram 4002.1 (S14-2-9) with push buttons to diagram 4003 (S14-2-11), or 4003.8 (S14-2-12). The sequence is the same as at a signal-controlled junction, with a steady amber period for traffic, and a green pedestrian symbol followed by a blackout period.

21.1.3. The prescribed road markings are set out in **18.1.4**. Timings are given in **Table 18-3**.

21.2 Pedestrian countdown

21.2.1. Pedestrian countdown signals are prescribed in diagram 4002.1A (S14-2-10, see **Figure 11-6**). The diagram shows them in combination with the farside Toucan signal head but this is not a requirement; the cycle aspect may be omitted. Countdown signals indicate the length of the blackout period and therefore the amount of time remaining in which people can finish crossing the road. They are not prescribed to indicate any other part of the signal sequence.

21.2.2. Countdown can be used with either Pedex or farside Toucan crossings. At Pedex crossings it may be mounted to the left or right of the green symbol, but must not be mounted in any other position. At Toucan crossings it must be mounted on the opposite side of the green pedestrian symbol to the cycle symbol, with the signal head making an inverted 'T' shape. The countdown unit is designed to retrofit to existing signal heads and to learn the existing timings. No timing changes are required to fit countdown but it may be useful to review what is currently in use if countdown is being considered.

21.2.3. If countdown is to be used on-crossing detection will not be possible as the blackout period must be fixed. Kerbside call/cancel detection may be used. Timings are given in **Table 18-4**.

22 EQUESTRIAN CROSSINGS

22.1 General

22.1.1. Equestrian crossings allow horses and their riders to cross the carriageway. They may help reduce the risk of accidents involving ridden horses, which can be very serious. Advice on the needs of equestrians is given in 'TA 57: Roadside Features', much of which is applicable for local roads.

22.1.2. Where a bridleway crosses a road where the visibility is adequate and the vehicular flows and 85th percentile speeds are reasonable, leaving a crossing place uncontrolled may be suitable, particularly if the bridleway has a good surface and there is space for all users to wait in safety. Low-key improvements could be considered such as providing a holding area or an improved surface.

22.1.3. Equestrian crossings are prescribed for use by a horse and rider and are not suitable for horse-drawn vehicles.

22.2 Signal heads, push buttons and pedestrian demand units.

22.2.1. These are prescribed in both farside and nearside forms, in diagram 4003.2 (S14-2-15), diagram 4003.3 (S14-2-16) and diagram 4003.4 (S14-2-17). Supplementary high-level repeater signals are prescribed in diagram 4003.4A (S14-2-18). Nearside and farside signals must not be combined in the same installation.

22.2.2. The prescribed road markings are set out in **18.1.4**. Stud markings to diagram 1055.2 may be used instead of those to diagram 1055.1 where a parallel pedestrian or Toucan facility is provided (see **22.5**).

22.2.3. On a two-way road the push button or demand unit should be positioned to the right of the rider, to encourage them to look first towards the nearest approaching vehicles.

22.2.4. On a one-way street, or at staggered crossings, the push button or demand unit should be located at the side of the crossing from which traffic is approaching. A horse rider may typically be 1.8 m from the front of the horse, and the push button or demand unit should be sited sufficiently far back from the carriageway to accommodate this. 2 m is a recommended minimum but the exact distance will depend on site circumstances. The push button should be mounted a minimum of 1.5 m from ground level to enable riders to press it without dismounting.

22.3 Holding area

22.3.1. A holding area for horses and their riders should be provided. If there is a footway the holding area should be behind it. Guidance on a suitable layout and materials for holding areas is given in TA 57. If possible, the arrangement should result in the rider being in line with the crossing rather than parallel with the kerb. Some form of barrier or guardrailing should be provided as a minimum to define the limits of the holding area as horses can behave unpredictably.

22.3.2. A grassed surface may be satisfactory within the holding area but for heavily used crossings, and on cohesive soils, a hardened surface should be considered. If hardened surfaces are used a nearby salt/grit bin may be useful. The British Horse Society document 'Advice on Surfaces for Horses' provides guidance on suitable surfaces. Inspection covers should where practicable be kept away from the route used by horses, especially on non-hardened approaches. Controllers should also be sited away from the holding area, as maintenance vehicles and personnel in hi-visibility jackets may worry horses.

22.3.3. Lowered kerbs should be provided with a minimum of 25 mm upstand, to ensure that visually impaired people do not mistake it for a pedestrian crossing. Tactile paving should not be used at the equestrian crossing point.

22.4 Timings

22.4.1. Recommended timings are shown in **Table 18-2** and **Table 18-3**. The crossing time may need to be longer than that provided for pedestrians or cyclists. Horses may be used to travelling in groups, and if the group is split, especially if one horse is isolated from others, those separated may become more difficult to control. The same may apply to horses kept standing by busy carriageways. Both the holding area and timings should address these points, especially if there is a refuge or central reserve.

22.4.2. If push buttons are installed more than 2 m from the kerb edge the timings will need to take account of this. A demand from a push button 20 m away may mean that the horse has less time to wait at the kerb edge. However, if a demand has already registered from another push button and the change to green occurs whilst the horse is still some way from the carriageway, the invitation to cross period needs to be long enough to allow for this. A second push button position may be required nearer to the 2 m minimum. Red lamp monitoring will be required.

22.5 Parallel pedestrian and Toucan facilities

22.5.1. Bridleways and footpaths often follow the same or similar routes, and where a demand exists for an equestrian crossing, it is likely that cyclists and pedestrians will need to cross as well. The Regulations allow for a segregated, but parallel, Toucan or pedestrian and equestrian crossing using stud markings to diagram 1055.2 (S14-2-56). An indicative layout is shown in **Figure 22-1**. The crossing is segregated as horses can behave unpredictably and sharing a crossing with pedestrians or cyclists may create an accident risk. Equally, horses may be worried or startled by other users if the crossing is shared.

22.5.2. Diagram 1055.2 requires a minimum of 3 m between the two parts of the crossing. The maximum separation is 5 m to dissuade drivers from stopping between crossings.

22.5.3. The advice in this section on pedestrian and Toucan facilities should be followed for the signal heads, push buttons and demand units. Accessibility features should be provided as described in **15.2**. The level of the audible signal should be adjusted so that it is adequate for pedestrians and cyclists but has the minimum impact at the equestrian crossing. Tactile signals can be provided at the equestrian crossing, if there is a local need. **Figure 22-1** shows a suggested layout for a parallel equestrian and pedestrian or Toucan facility using farside signals.

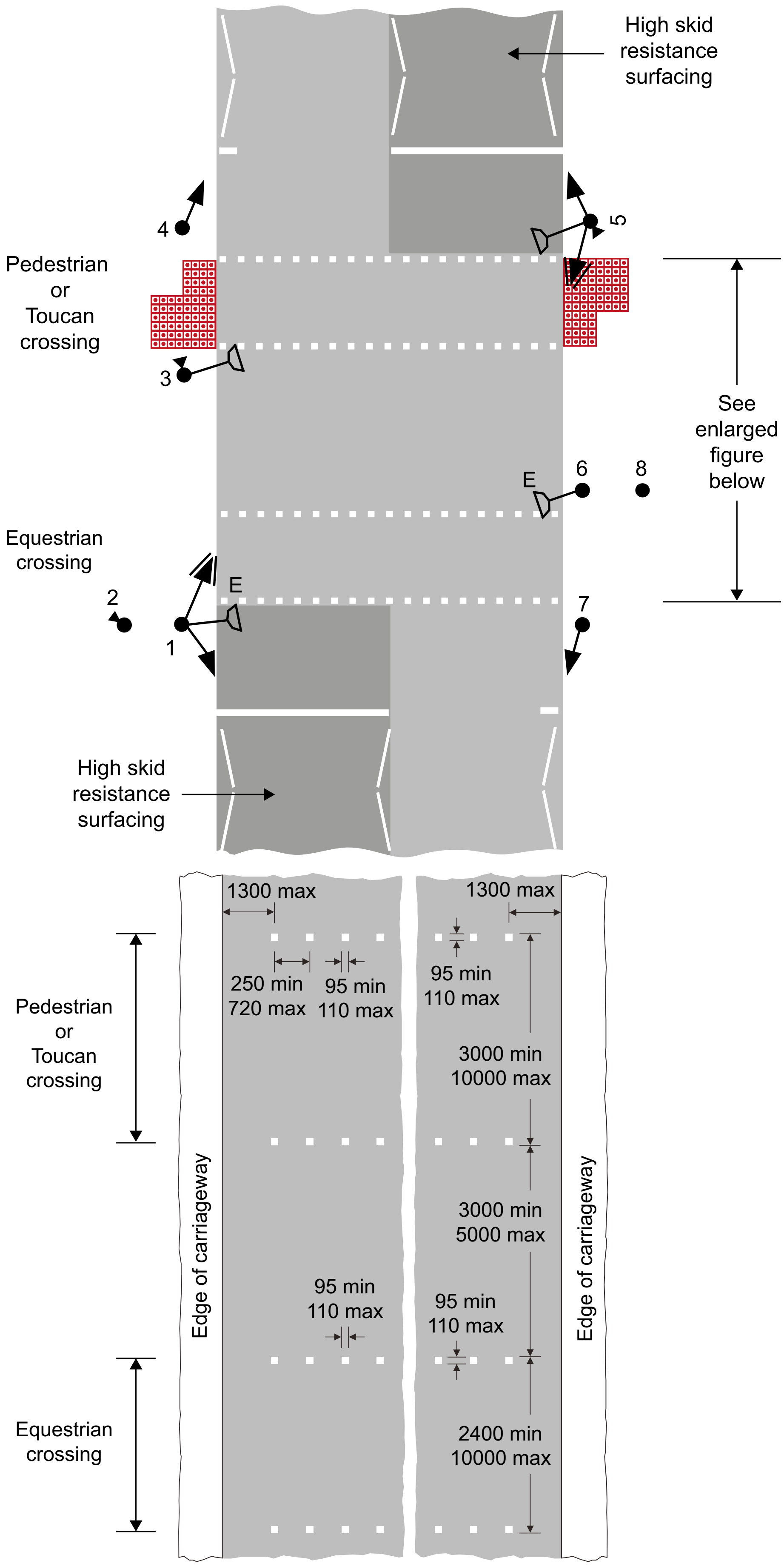


Figure 22-1 Layout of a parallel equestrian and pedestrian or Toucan facility

Section III
Other Signals

23.1 General

23.1.1. Where a tram route uses the road network, tram signals are used to separately signal road and tram traffic. Tram signals are prescribed in diagram 3013 (S14-3-2, see **Figure 23-1**) and consist of a single aspect capable of showing up to 5 different signals through different combinations of white dots. S14-3 sets out the permitted positions of tram signals within a signal head in relation to the standard aspects.

23.1.2. The Office of Rail and Road should be involved from the early stages of development of any tram system project. Facilities for pedestrians crossing at signal-controlled junctions and elsewhere will need particular consideration.

23.1.3. Other tram signals used on the system, such as point indicators used by tram drivers, are not necessarily seen by road users. However, if they are they will need authorisation, as they are not prescribed in the Regulations.

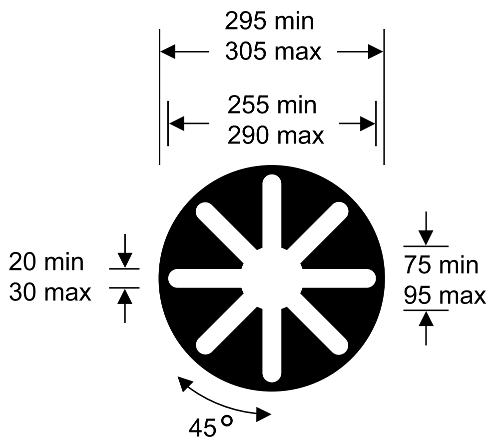


Figure 23-1 Diagram 3013 (S14-3-2) Light signal for control of tramcars

24 WIG-WAG SIGNALS

24.1 General

24.1.1. The wig-wag signal to diagram 3014 (S14-2-5, see **Figure 24-1**) is used where the need for a vehicle to stop is paramount for safety reasons, but unpredictable and sometimes infrequent. This requires a different type of signal to those used at junctions.

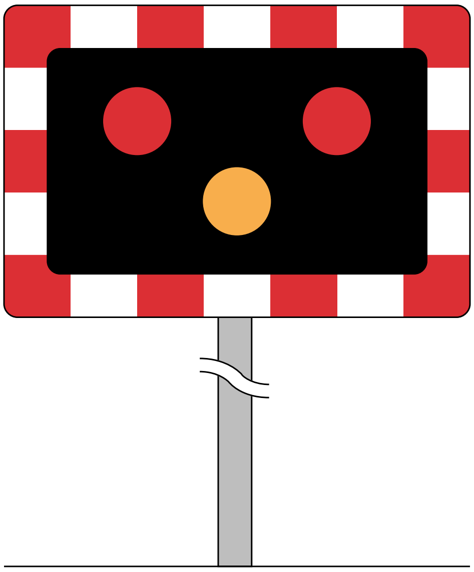


Figure 24-1 Diagram 3014 (S14-2-5) Wig-wag signal

24.1.2. Wig-wag signals are used at level crossings, swing or lifting bridges, airfields or in the vicinity of premises used regularly by fire, police or ambulance service vehicles. Tunnel entries must be controlled by standard traffic signals to diagram 3000. Tunnel sites with existing wig-wag installations may remain in place until the equipment reaches the end of its life.

24.1.3. This section does not provide advice on the use of wig-wag signals at level crossings as these are the responsibility of Network Rail. The Office of Rail and Road gives guidance on the design of these sites in 'Railway Safety Publication 7 Level Crossings: A guide for managers, designers and operators'.

24.1.4. Although specified vehicles may pass a standard red signal as shown in diagram 3000 in certain circumstances, there are no exceptions for traffic to pass the flashing red signals as shown in diagram 3014. Wig-wag signals generally indicate a situation in which a driver passing them on red may be heading into immediate danger, for example if a moveable bridge is in the lifted position and the road does not continue.

24.1.5. The advice in this section should be read in conjunction with the advice on the use of warning signs for wig-wag installations given in Chapter 4.

24.2 Signal heads

24.2.1. Wig-wag signal heads must be ES compliant to BS EN 12368:2015 as set out in S14-1-3. The signal sequence and flashing rate for the red signals is defined in S14-1-8. The amber period is also defined in S14-1-8 as 5 s, with a tolerance of 0.25 s either way. S14-6-5 requires a minimum of two signal heads per approach.

24.2.2. The positioning of the posts and heads will vary from site to site, but for most applications both signals are placed on the approach side of the hazard. As with standard traffic signals, drivers must be able to see one signal on approach and one while waiting. Stop lines to diagram 1001 (S14-2-46) must be provided at a distance from the signal head to allow drivers to see the signal while waiting. There is no set minimum distance, but as with a traffic signal junction, 2.5 m is likely to provide adequate visibility.

24.2.3. There are situations where the standard signal to S14-2-5 cannot be used because of a lack of space. A narrower version is available but requires the relevant national authority's authorisation. This has the same layout as the standard signal but with smaller gaps between the aspects and a reduced width backing board. Designers wishing to use this should contact the relevant national authority for the approved drawing.

24.3 Control equipment

24.3.1. Control equipment for wig-wag signals must comply with the requirements of S14-6-46, which sets out that equipment used in connection with signals (including the content of all instructions stored in, or executable by, that equipment) may only be placed if it complies with the relevant requirements of BS EN 12675:2001 and BS EN 50556:2011. These relate to safety-critical matters such as failure modes and signal states dangerous to traffic.

24.3.2. Control equipment is covered by a TOPAS procurement specification, TOPAS2513, and it is recommended that local authorities install TOPAS-registered equipment.

24.3.3. Unlike signal control at junctions, or at stand-alone crossings, there may be a need to have an operator control panel off-site, for example in a fire station or bridge control room. Remote monitoring is essential and should be considered at an early stage. Many wig-wag sites are in isolated locations and do not operate regularly. By the nature of the sites, any accident could be serious. The correct operation, full display of aspects and a swift response to any faults is essential to minimise risk.

24.4 Swinging or lifting (moveable) bridges

24.4.1. The equipment at moveable bridges is normally maintained by the organisation involved, for example the Canal and River Trust. Traffic authorities should be aware of the ownership and maintenance arrangements. British Waterways can provide information on responsibilities.

24.4.2. Lifting barriers are provided, either full-width or double half-barriers. The type selected will depend on the site conditions and the method of control is different for each case. Both single and double barriers, when lowered, should cover the whole of the carriageway and footways.

24.4.3. The operator initiates the sequence. Traffic is stopped by the standard wig-wag signal sequence, and after a set clearance period, the barriers lower automatically. At double barrier layouts, the near side barriers on each approach are lowered first. When the bridge is seen to be clear of all traffic the operator will lower the off side barriers. When the bridge is back in the normal position the barriers will start to rise.

24.4.4. Red warning lamps are provided on each barrier boom, which should illuminate when the boom is in any position except vertical. Audible signals for pedestrians are provided, which start at the same time as the flashing amber and continue until the barrier or barriers are fully lowered. The audible signal starts again before the barriers start to rise. The signal should sound like a single stroke bell so that it cannot be mistaken for other audible warnings.

24.5 Airfields

24.5.1. The equipment at airfields or airports is normally maintained by the airport operator, or the Ministry of Defence for military facilities. Whilst the controller is likely to be sited at the roadside, the control panel is more likely to be off-site in a control room. Traffic authorities should be aware of the relevant ownership and maintenance arrangements. The Airport Operators' Association also keeps details.

24.5.2. Wig-wags may be used where there is a need to interrupt traffic flow due to hazards such as sudden noise or to allow aircraft to move around the site. The need for barriers will depend on the reason for stopping the vehicular traffic. If it is being stopped because of sudden noise from low-flying aircraft barriers would not normally be required. However, if the hazard is at the same level, for example an aircraft being towed across the road, then barriers would be used to give added protection. As for other sites with barriers they should extend across both carriageway and footways. Depending on pedestrian flows, consideration should be given to providing an audible warning signal, as at moveable bridges.

24.6 Premises used by the emergency services

24.6.1. The installation of wig-wags should be considered where there is a special need to provide breaks in steady and fast streams of vehicular traffic outside a fire, ambulance or police station. This allows emergency vehicles answering a call to join the appropriate traffic stream with the minimum of delay. No barriers are provided.

24.6.2. If the emergency vehicles exit into a signal-controlled junction it may be more appropriate to provide a separate stage within the junction control with a hurry-call facility.

24.6.3. The positioning of the wig-wag signals and Stop lines should be determined by treating the access to the emergency premises as an approach to a standard signal junction. Yellow box markings to diagram 1043 (S9-6-25), or a Keep Clear marking to diagram 1026 (S11-4-26) may also be provided to keep the area outside the station free from queuing traffic.

24.6.4. If the wig-wag signals on the road cannot be seen from the premises, additional wig-wag signals may be installed to face exiting drivers. These should display the aspects in the same configuration as diagram 3014, but with blue or white aspects instead of red, with the amber signal remaining the same. These signals should never be visible to drivers on the public highway and ideally should be sited within the boundary of the premises.

24.6.5. A control panel may be situated inside the emergency vehicle building, with the button to activate the lights normally pushed by the last person to board the appliance. A miniature wig-wag signal is shown on the operator's panel mimicking the operation of the main signal. If the junction layout is complex it is helpful for the operator's panel to include a simple junction layout drawing.

24.6.6. Once a demand is received, the wig-wags should operate to the timings shown in **Table 24-1**.

Table 24-1 Operational sequence and timings for wig-wag signals at emergency premises

Period	Signals for general traffic	Signals for emergency vehicles	Duration (seconds)
A	Amber	Amber	5 (fixed)
B	Red flashing	Blue or white flashing	15-45
C	Blank	Blank	20 (fixed)
D	Blank	Blank	Await demand

24.6.7. Timings and operation may be varied depending on site circumstances. For example:

a) If the emergency vehicles are some distance from the exit on to the public highway, a delay in the appearance of the amber signal may be necessary. This would normally be in the range of 5 s to 35 s.
b) If the initiation of a demand is remote from the station, there can be an inbuilt delay to allow crews to reach the appliances.
c) If the station exits on to a dual carriageway it may not be necessary to stop the traffic flow on the approach furthest from the station if the appliance is turning left. Two separate push buttons should be provided, clearly labelled to avoid possible operator errors – a junction layout drawing and different coloured buttons may help. Safeguards should be in place against operator error, e.g. pressing the left turn-out button, followed immediately by a right turn-out button.

24.7 Warning lights: cattle crossing ahead

24.7.1. It should be noted that these do not provide priority or a dedicated crossing function. They provide a warning to drivers to be aware they may have to stop because of cattle in the road ahead. Advice on the use of the cattle crossing ahead warning sign to diagrams 548 and 548.1A is given in Chapter 4.

24.7.2. Cattle crossing warning lights must be ES compliant to BS EN 12368:2015 as set out in S14-1-2. S14-1-12 defines the flashing rate. The equipment should be programmed with an automatic time-out sequence of between 1 and 5 minutes, so that they are not left active unnecessarily, and an inhibit function to stop re-use within 5 minutes.

24.7.3. Although there is no requirement for warning lights on both sides of each approach, this should be considered.

25 SCHOOL CROSSING PATROL WIG-WAG SIGNALS

25.1 General

25.1.1. Warning lights to indicate a school crossing patrol is in operation must comply with diagram 4004. These must be placed with a sign to diagram 545 and a plate with any of the legends “School”, “Patrol” or “Disabled children” as appropriate, as shown in **Figure 25-1**. The advice in this section should be read in conjunction with the advice on siting the signs given in Chapter 4.

25.1.2. The wig-wag unit should be mounted below the sign to diagram 545 and its associated plate, separated from them by a minimum distance of 50 mm, see **Figure 25-1**. Wig-wags should not be mounted on backing boards. Lights should not be used near level crossings, traffic signals, Zebra, Parallel or signal-controlled crossings if this might cause confusion or distraction. They should never be used to warn of children crossing at Zebra, Parallel or signal-controlled crossings.

25.1.3. The base of the unit should be mounted not less than 2.1 m above the surrounding footway or verge (2.25 m in Scotland). This should be increased to 2.3 m where cyclists are present. This may be reduced to 1.8 m or less at sites where the authority is satisfied that the unit is unlikely to cause obstruction to pedestrians and that there is no risk of the indication to drivers being obstructed by pedestrians. The risk of vandalism and accidental damage should be borne in mind if a low mounting height is being considered.

25.1.4. The unit should be mounted upright and on the vertical axis of the sign. They may be programmed remotely to operate at specified times, and adjusted on site with mobile devices. They may also be operated by a key switch which should be mounted within convenient reach.

25.1.5. On single carriageway roads with a speed limit of 30 mph at a patrol site with flashing lights, the “School” supplementary plate may be substituted for the plate to diagram 545.1. This plate must be mounted in conjunction with flashing lights to diagram 4004, and may not be varied. It is unlikely to be effective on roads with speed limits greater than 30 mph, or on dual carriageways. For more information see section 8 of Chapter 4.

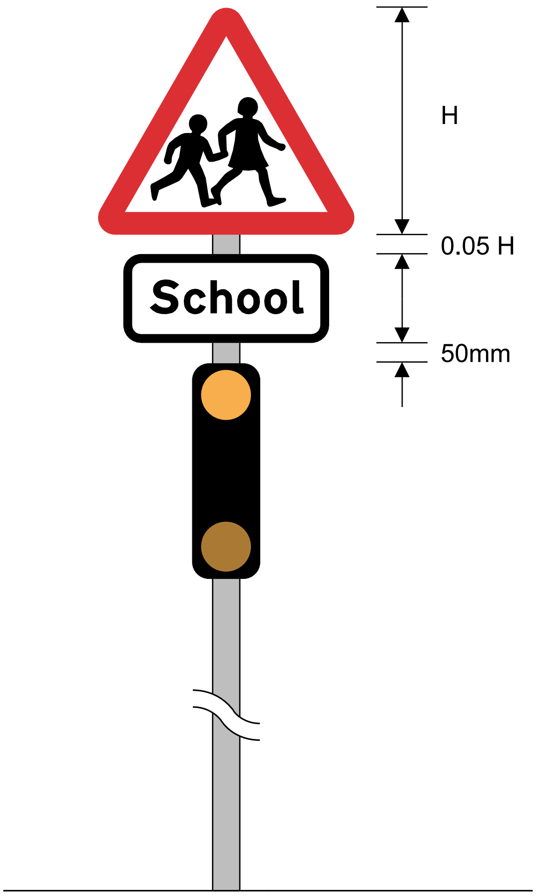


Figure 25-1 Diagram 545 (S2-2-25) and associated plate, shown in combination with diagram 4004 (S14-2-23)

26 SIGNALS FOR LANE CONTROL

26.1 General

26.1.1. The signals shown in S14-2-32 to 34 are used on single carriageway roads where a tidal-flow system is in operation, for example where a high proportion of the flow is in one direction during the morning peak hours, with the major flow in the reverse direction during the evening peak. This form of control permits the higher traffic flow to use a greater width of the carriageway by reversing the traffic flow in one or more central traffic lanes at different times of the day. The “red cross” signals shown in diagrams 5003 and 5003.1 (S14-2-33, see **Figure 26-2**) are also prescribed for use on actively-managed hard shoulders of motorways but this application is not considered here. Lane control signals may be used only to indicate the effect of a TRO.

26.1.2. A signal to diagram 5001.1 or 5001.2 (S14-2-32, see **Figure 26-1**) is placed above a traffic lane facing the direction of oncoming vehicles to indicate that traffic in the lane below the green arrow may proceed beneath or beyond that arrow.

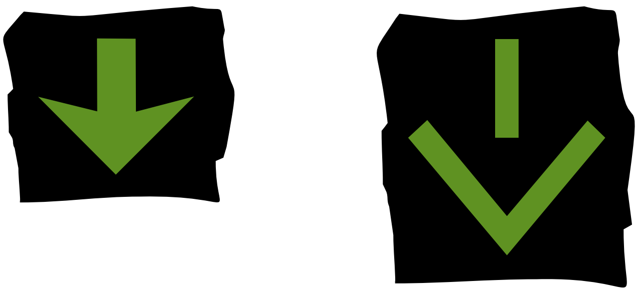


Figure 26-1 Diagrams 5001.1 and 5001.2 (S14-2-32) Lane open to vehicular traffic (Alternative types)

26.1.3. A signal to diagram 5003 or 5003.1 is placed above a traffic lane facing the direction of oncoming vehicles to indicate that traffic in the lane below the red cross must not proceed beneath or beyond that red cross.

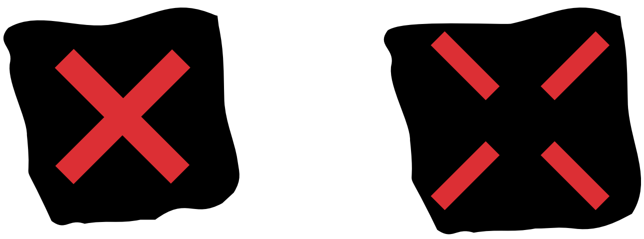


Figure 26-2 Diagrams 5003 and 5003.1 (S14-2-33) Lane closed to vehicular traffic (Alternative types)

26.1.4. **Figure 26-3** shows the basic arrangement for placing the signals above the carriageway. Schedule 14 requires that the height of the centre of each light signal from the surface of the carriageway in the immediate vicinity shall be not less than 5.5 m nor more than 9 m. Each signal is prescribed with maximum and minimum dimensions. Regulation 7(5), which requires the shape and proportions to remain the same when choosing dimensions for individual elements of a sign, does not apply in this case. This allows more flexibility when designing each signal. The overall size of each signal will depend on the speed of traffic, not just at peak times, but during free-flow conditions, as the signals are in use at all times. Although **Figure 26-3** shows five lanes tidal flow can be used in other situations, such as on a three-lane carriageway.

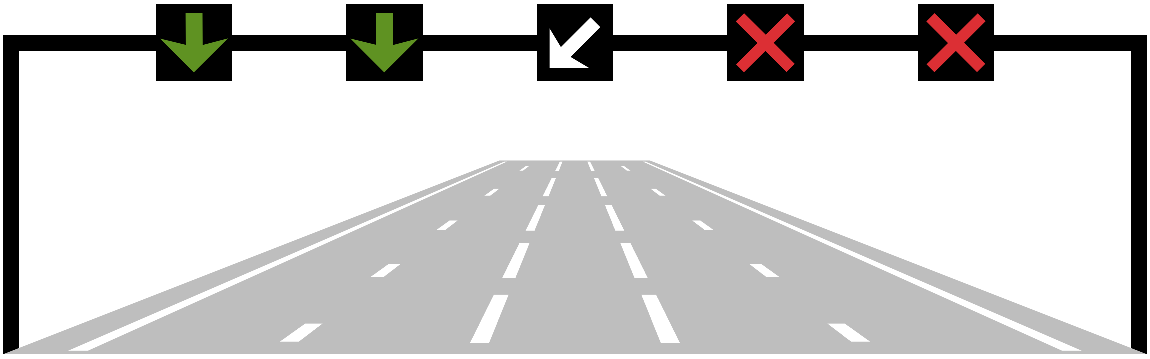


Figure 26-3 Example of lane control signals mounted above the carriageway for a tidal-flow system

26.1.5. A signal to diagram 5005 or 5005.1 (S14-2-34, see **Figure 26-4**) indicates that traffic should move to the next lane to the left as soon as it is safe to do so. It is normally used at the start of a tidal-flow system to direct traffic away from an opposing tidal-flow lane. The signal will also be needed when closing a tidal-flow lane, so that a green arrow first changes to a white arrow before changing to a red cross. However, depending on the road layout there might be situations where it is not required in one particular direction.

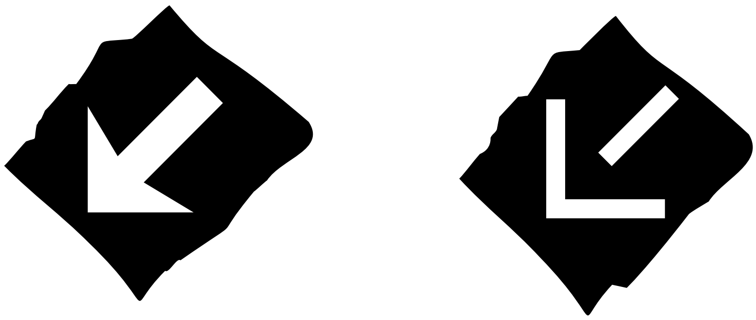


Figure 26-4 Diagrams 5005 and 5005.1 (S14-2-34) Lane closed ahead and vehicular traffic should move to the next lane on the left (Alternative types)

26.1.6. The signals should be mounted back to back centrally over a traffic lane to face both directions along the lane, so that whenever the green or white arrow facing traffic from one direction is showing, the red cross facing the opposite direction is also showing over the same traffic lane. When changing the direction of flow, the lane first needs to be closed with the red cross showing in both directions for a period long enough to ensure that the lane is clear of all traffic. For those lanes where the direction of flow is never changed the green arrow and red cross, as appropriate, will be permanently displayed. These signals must be internally illuminated and identical to those displayed above the tidal-flow lane.

26.1.7. The signs shown in S14-2-35 to 40 are used to inform drivers of a tidal-flow system ahead and to explain the meaning of the lane control signals. The x-height of these signs may be varied from 75 mm to 150 mm and depends on the speed of traffic.

26.1.8. A sign to diagram 5010 (S14-2-35, see **Figure 26-5**) is used on a road that leads directly into a tidal-flow system. It gives advance warning of lane control on the road ahead, and explains the meaning of the signals. The white arrow symbol and the legend “move to left” is omitted where the signal to diagram 5005 or 5005.1 is not used. The sign should be sited approximately 200 m before the first signal.

26.1.9. The sign to diagram 5011 (S14-2-36, see **Figure 26-6**) is similar to diagram 5010 (see **Figure 26-5**), and is used on a side road that joins a major road within a lane control section. The sign should be placed at least 50 m from the junction to enable drivers to assimilate the information on the sign before diverting their attention to the junction ahead. Where the side road is one-way (with two or more lanes) or a dual carriageway the sign should be provided on each side of the carriageway. A sign to diagram 5012 (S14-2-37, see **Figure 26-7**) should be sited between 50 m and 100 m before the first signal.

26.1.10. Where a side road joins a major road prior to the start of the lane control section, a sign to diagram 5011 should be provided if drivers would not pass a sign to diagram 5010 after turning into the major road. In this case, the sign should be supplemented by a sign to either diagram 5013 (S14-2-38, see **Figure 26-8**) or 5014 (S14-2-39, see **Figure 26-9**) located at the junction and with the arrow pointing in the appropriate direction. Signs to diagrams 5013 and 5014 may be used on their own where drivers, after turning into the major road, pass a sign to 5010 but not the sign to diagram 5014 without the arrow.

26.1.11. A sign to diagram 5014 (S14-2-39, see **Figure 26-9**), omitting the arrow, and varied to indicate the distance to the nearest ten yards, should be sited approximately 400 m before the first signal. Where the 85th percentile speed of traffic is above 30 mph an additional sign to diagram 5010 might be required. In this case it should be sited 400 m before the first signal, with the sign to diagram 5014 located approximately 800 m before the first signal. Where the road is one-way or a dual carriageway on the approach to the tidal-flow section, a sign to diagram 5010, 5012 or 5014, as appropriate, should be provided on each side of the carriageway at each location.

26.1.12. A sign to diagram 5015 (S14-2-40, see **Figure 26-10**) should be provided on each side of the road where the lane control signals end. Alternatively, the sign may be located above each lane that is available to traffic travelling away from the lane control section.

Figure 26-5 Diagram 5010 (S14-2-35)
Lane control light signals ahead

Figure 26-6 Diagram 5011 (S14-2-36)
Lane control light signals on a road extending from a junction ahead

Figure 26-7 Diagram 5012 (S14-2-37)
System of lane control light signals ahead

Figure 26-8 Diagram 5013 (S14-2-38)
Direction of a system of lane control light signals

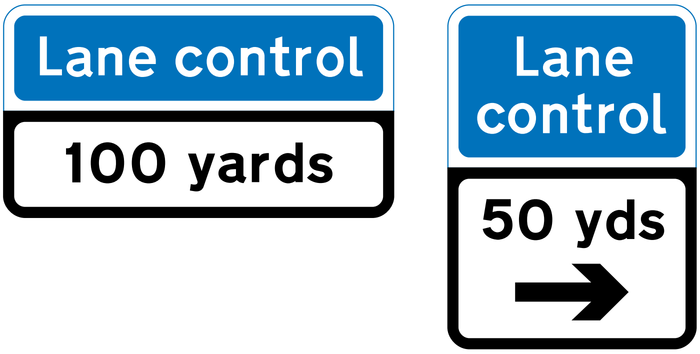


Figure 26-9 Diagram 5014 (S14-2-39)
Distance to and direction of a system of lane control light signals (Alternative types). The distance may be varied. The arrow may be reversed or omitted.

Figure 26-10 Diagram 5015 (S14-2-40)
End of a system of lane control light signals

Section IV
Installation

27.1 General

27.1.1. The detailed specification for construction of a traffic control scheme will be covered by the traffic authority's contract documents and procurement process. This section aims to give advice on the basic principles of installation of permanent signal-controlled and associated equipment, and for temporary traffic signals. Taking account of these during the construction process should result in a safe and easily maintainable installation. Designers should refer to the IHE Guidance Note on Traffic Control and Information Systems, which replaces TA84/06.

27.1.2. Organisations involved in the installation of equipment and cabling for traffic control systems should have an accredited registration for Quality Assurance to ISO 9001 with specific reference to the type of work involved. Specialist sub-contractors may be exempt from this requirement but should be adequately supervised by a Quality Assured organisation.

27.1.3. Installation work should be carried out with minimum disruption to pedestrian and vehicular traffic. Measures should be taken to ensure the safety of the contractor's staff and the public during the works. Adequate working space, warning signs, means of access and lighting will have to be provided. Precautions should be taken against the possible presence of gas in the controller cabinet, at the tops of signal poles, cable drawpits and ducts. If any gas is suspected anywhere in the ducting system, then the relevant gas utility company should be contacted immediately.

27.2 Relevant legislation

27.2.1. The Management of Health and Safety at Work Regulations 1999 make explicit what is required of employers by the Health and Safety at Work etc. Act 1974. There is a requirement on employers to assess the risks to health and safety of their employees and others who may be affected by the work activity. In the context of a traffic control system, this would also apply to maintenance procedures and the risks to health and safety which they bring to employees and members of the public. If a Health and Safety file is required for the project, any specific maintenance procedures that arise from the analysis of this Risk Assessment should be included in it.

27.2.2. 'The Construction (Design and Management) Regulations 2015' place duties on all those who can contribute to the health and safety of a construction project, particularly clients, designers and contractors. Reference should be made to the Health and Safety Executive best practice guidance document L153, Managing health and safety in construction. It describes the law that applies to the whole construction process on all construction projects, from concept to decommissioning, and what each duty holder must or should do to comply with the law to ensure projects are carried out in a way that secures health and safety.

27.2.3. 'Safety at Street Works and Road Works: A Code of Practice' (also known as the 'Red Book') provides guidance on how to carry out road and street works safely, including requirements for ensuring pedestrian safety. Under the New Roads and Street Works Act 1991, statutory undertakers and their contractors must have regard to this document in carrying out works.

27.2.4. 'The Electricity at Work Regulations 1989' require precautions to be taken against the risk of death or personal injury from electricity in work activities. They impose duties on those involved in the design, installation and maintenance of equipment.

27.2.5. The Health and Safety Executive document 'Avoiding Danger from Underground Services' is a practical guide applying to all situations where underground services may be found and where work is undertaken which involves penetrating the ground at or below the surface. It provides advice for those who have duties under the Health and Safety at Work etc. Act 1974 and other relevant legislation.

27.2.6. BS 7671:2008+A3:2015 'Requirements for Electrical Installations' (BS 7671), applies to the design, selection, erection, inspection and testing of electrical installations including traffic signals.

27.3 Preparation

27.3.1. A detailed site layout drawing of the signal installation should be produced prior to the start of the works, at an appropriate scale to ensure they are easily read, such as 1:200 or 1:500. This should include:

a) All cabling and ducting details,
b) Position of access chambers and retention sockets (where used),
c) Details of detector positions, and
d) Other relevant details such as existing inspection covers, trees, lighting columns, traffic signs.

27.3.2. The location of any buried services should be identified before work starts. Statutory undertakers may be able to provide details of locations of their services but site investigation and survey may be necessary. "British Standard PAS 128:2014 - Specification for underground utility detection, verification and location" provides a robust methodology for surveying and mapping buried services and its use is recommended.

27.4 Civil engineering works

27.4.1. Street Works UK's document 'Guidelines on the Positioning and Colour Coding of Underground Utilities' Apparatus' gives advice on duct laying and identification. For traffic signal equipment, all ducts and cables should be coloured orange and marked "Traffic Signals" at intervals along the length.

27.5 Electrical installation

27.5.1. Requirements for the supply and installation of safe electrical equipment are contained in BS 7671. The appropriate supply and earthing arrangements should be agreed with the electricity supplier, who may have their own requirements for circuits to be connected to their supply. The supply may be terminated within the controller cabinet, or in a separate power supply termination pillar, which avoids the supplier needing to gain access to the controller cabinet. It also provides a means of completely isolating the installation.

27.5.2. Multicore intersection and linking cables should be protected against accidental damage. All cables should be of adequate size and rating to meet the electrical current carrying requirements and electrical protection of the systems.

27.5.3. A mixture of extra low and low voltages should not share the same multicore cable, duct network or terminations.

27.6 Signal heads and posts

27.6.1. Retention sockets and fully ducted systems are widely used at traffic signal sites, which allow for all civil engineering works to be completed before the installation of cables, posts and signal heads. Retention sockets consist of a foundation and socket set flush with the ground, into which the signal post is securely installed, and associated ducting. The socket system enables posts to be removed as necessary, as they are not set directly into the ground. Damaged posts can be quickly replaced, and posts can be removed as a planned measure to enable abnormal loads to pass, or for special events. Cable apertures for signal heads, push button wiring and cable entry should be correctly aligned.

27.6.2. Where signal posts are erected on unmade ground consideration should be given to providing a concrete pad or paving slabs around the poles to provide a suitable base for a ladder for maintenance purposes.

27.7 Associated equipment

27.7.1. All signal equipment, including push buttons, which are not in use should be bagged over or clearly marked as out of use when they are installed to avoid confusion to pedestrian and vehicular traffic. Signs to diagram 7019 (S14-2-61) may be used to indicate vehicle signals are not working, and “crossing not in use” signs to Schedule 13 for crossings. Bags should be sufficiently opaque so that signal aspects do not show through when lit.

27.7.2. Tactile indicators should also be covered or removed when they are not in use so that visually impaired and deaf people are not misled, especially where tactile paving has been laid.

27.7.3. Where photocells are fitted to enable dimming of traffic signals at night they should not be overshadowed, for example by nearby trees, causing the signals to be permanently dimmed, or installed near street lighting, causing them to operate on full brightness during the hours of darkness.

27.7.4. Push button units to diagram 4003 (S14-2-11), diagram 4003.8 (S14-2-12), diagram 4003.3 (S14-2-16) or diagram 4003.6 (S14-2-20) should generally be mounted between 1.0 m and 1.1 m above the footway, at an angle of 45° to the kerb line.

27.7.5. Nearside signals to diagram 4003.1 (S14-2-13), diagram 4003.4 (S14-2-17) or diagram 4003.7 (S14-2-21) should generally be mounted between 1.0 m and 1.1 m above the footway, and inclined at 25° to 30° to the kerb line, except on central refuge islands.

27.7.6. All fixings should be concealed so far as possible to minimise the risk of vandalism.

27.8 Controller cabinet

27.8.1. The controller cabinet should be located so that when the access doors are open any obstruction to the footway is minimised. It should be possible to open the access doors fully. Consideration should be given to the safety of operatives during maintenance. If it is necessary to site the controller adjacent to the kerb then it should not be possible for the access doors to be opened over the carriageway and the controller should be sited at least 0.5 m from the kerb edge.

27.8.2. The controller cabinet should be positioned so that it does not obstruct the view of pedestrians waiting at a crossing, or drivers on their approach. This will generally mean siting it on the exit rather than the approach side of the crossing. It is also good practice to site controller cabinets so that the operation of the signals can be seen while standing at the front of the controller.

27.8.3. The controller should be installed on an appropriate foundation, as specified by the traffic authority. Controller bases should be sealed to prevent ingress of gas and moisture into the controller. Pre-formed cabinet bases are available which, together with retention sockets, can create a fully ducted system. These remove the need for a sand and base seal, help control vermin within the controller, and enable additional cables to be added at a future date.

27.8.4. Where a controller cabinet is mounted on unmade ground a concrete pad or paving slabs should be provided around the controller to enable access to the cabinet for maintenance purposes.

27.9 Temporary signals

27.9.1. Temporary signals are permanent signal heads mounted in a temporary fashion, as distinct from portable signals, which are prescribed in diagram 3000.1. Temporary signals use a standard signal controller, and therefore can provide much of the functionality of a permanent site. On complex projects such as site upgrades they allow traffic control and pedestrian facilities to be maintained while the work is carried out.

27.9.2. The contractor should agree the positioning and arrangement of temporary signals with the traffic authority, similar to the process used for approving portable signals. The contractor should provide a drawing showing the position of the temporary poles and signal heads for site approval.

27.9.3. Existing poles, and equipment not used during the temporary works, should be bagged over or otherwise covered, or removed from site by the contractor and stored for reinstatement on completion of the scheme.

27.9.4. The position of the support should be marked on the ground so that it can be replaced if it is moved for any reason.

27.9.5. The Regulations do not set any requirements for the design of the support, but S14-6-5 allows them to be painted in alternate red and white stripes.

27.9.6. Supports have traditionally been concrete-filled oil drums. Specialist systems are available that incorporate a temporary controller base, concrete support and metal shroud. While oil drum supports can still be used modern systems are likely to provide greater stability and better protection for the public from electrical cabling.

27.9.7. Signals should always be installed on the pole so that no part of the signal overhangs the side of the support in which they are mounted. It is recommended that the horizontal clearance from vertically above the kerb edge or traffic barrier to the nearest part of the assembly should not be less than 0.5 m.

27.9.8. The Regulations require temporary signal sites to be provided with road markings in the same way as a permanent signal site. This is particularly important where pedestrian facilities are provided. Where possible, tactile paving should be retained or provided to the appropriate layout and colour. If the temporary signals are positioned such that the normal stop line cannot be used a temporary stop line must be provided. The normal stop line should be removed or covered up.

27.9.9. Interconnecting cables and joint boxes should be waterproof and protected against accidental damage. Any cable left lying above ground should be positioned so that it cannot be damaged by plant using the area or create a hazard for other road users. Where temporary signals use surface laid cables, extra low voltage should be used.

27.9.10. When the temporary installation has been completed the contractor should ensure that all earthing conforms to the requirements in BS 7671. BS 7671 also requires an electrical installation completion certificate to be issued for temporary installations, which will require all aspects of the electrical installation to comply with the requirements of BS 7671.

27.10 Testing and certification

27.10.1. On completion of electrical installation and before commissioning, appropriate testing should be carried out by the contractor in accordance with BS 7671.

27.10.2. An electrical installation completion certificate, signed by a competent person in accordance with BS 7671, should be provided by the contractor.

27.10.3. Interconnecting cables should be tested in accordance with the Specification for Highway Works clause 1217.

27.10.4. Loops and loop feeder cables should be tested in accordance with the Specification for Highway Works clause 1218. For installations in Wales, the Welsh Government should be contacted for details of the appropriate testing.

27.11 Completion of works

27.11.1. All installations should be left suitable for use by all road users, particularly disabled people. Footways, including areas of tactile paving, should be even and free of any unnecessary obstructions and should be reinstated in accordance with the ‘Safety at Street Works and Road Works Code of Practice’.

27.12 Acceptance testing

27.12.1. Acceptance testing is an important step in the delivery of any new or modified traffic signal installation. Acceptance testing allows the designer to check that the site has been installed correctly to the design drawings and specifications; and that the controller and signal equipment has been programmed correctly and is operating as it should. Tests should be conducted to a previously prepared schedule.

27.12.2. The Factory Acceptance Test (FAT) takes place before the controller is installed on street, to test the controller hardware and that it has been configured correctly. Configuration testing may be carried out using a computer simulation package, and may then be followed up by a hardware test at the supplier’s facility. First, the controller hardware and data configuration are tested prior to installation on street. This is known as a ‘Factory Acceptance Test’.

27.12.3. A Site Acceptance Test (SAT) is carried out on completion of the installation to check that the site is operating as it should. Also referred to as commissioning, it takes place before the site is switched on to live traffic. It should always be carried out at new installations and a simplified version should be considered when changes are made to operation or safety related facilities on existing sites. All signal functions, including any UTC interface vehicle detection and signal dimming systems, should be tested to ensure that the system is working as specified in the contract.

27.12.4. Any signal equipment, including push buttons and tactile devices, installed and visible to road users and pedestrians prior to switch-on should be bagged over while such tests are in progress. Bags should be sufficiently opaque to ensure that signals are not visible to road users during tests. It may be necessary to uncover the heads for certain tests, and steps should be taken to ensure the safety of road users at these times. Minor defects or omissions, which do not prevent the installation from functioning properly, should be recorded.

27.13 Post completion works

27.13.1. Validation work is likely to be required after commissioning, to ensure that strategies such as MOVA and UTC/SCOOT are working as modelled, and that timings are appropriate, particularly intergreen periods.

27.14 Documentation

27.14.1. When the installation is complete the traffic authority should be supplied with all the documentation associated with the scheme including at least the following:

a) Controller test schedule
b) Loop test schedule
c) Earth test certificate
d) Electrical completion certificate and test results (prior to commissioning)
e) “As built” site layout drawing
f) Controller timings sheet
g) “As built” cable diagrams

APPENDIX A

A.1 Glossary of commonly used technical terms

Term	Definition
All-red	A condition of traffic signals where all movements receive a red signal
All-red period	Period during the change from one phase green to the next when all phases show red
Amber	The particular colour in the yellow part of the spectrum used in traffic signals. The same as the term “yellow” used in European specifications
Approach	That part of an arm which carries traffic towards the junction
Arm	One of the highways radiating from a junction
Arrow	A signal aspect with a symbol indicating a direction
Aspect (signal aspect)	A single unit, which, when illuminated, displays a single colour or symbol
Audible signal	A device producing a sound to indicate right of way to pedestrians
Backing board	A board mounted behind or around a signal head to increase contrast and improve visibility (referred to as “background screen” in BS EN 12368:2015)
Blackout	A period in a crossing sequence when neither the red nor the green pedestrian symbol is illuminated
Bracket	A device for mounting a signal head on to a signal pole
Cabling	The wiring installed on-street to connect a traffic signal controller with the signal aspects and other equipment
Call	The placing of a demand for a stage or phase
Call/cancel	The function of a detector which calls a stage or phase when occupied for a specified time but for which the demand is cancelled if it subsequently becomes unoccupied for a specified time before the demand matures. Can be used for vehicular, pedestrian, cyclist or other road user demands.
Capacity	The maximum flow that can proceed through a certain point in a given period of time
Carriageway	A way constituting or comprised in a highway, being a way (other than a cycle track) over which the public have a right of way for the passage of vehicles (Section 329, Highways Act 1980)
Central reserve	A central island separating the two halves of a dual carriageway
Classified count	A traffic count where flows for different classes of vehicle are recorded separately
CLF	Cableless Linking Facility. A system for co-ordinating the timings of signal equipment at adjacent signalled junctions by the use of clocks synchronised to mains supply frequency
Condition	The pattern of illumination of aspects of a signal head at a point in time
Conflict	Movements which cannot proceed at the same time safely are in conflict.
Conflicting phases	Phases which control movements which are in conflict
Controller	Apparatus that controls and switches traffic signals
Controller Cabinet	A box installed on-street to contain the traffic signal controller
Co-ordination	An arrangement which relates the timings of the signals at one installation with those at neighbouring installation(s)
Cycle	One complete sequence of the operation of traffic signals
Cycle time	The time taken to complete one cycle

Term	Definition
Cycle track	A way constituted or comprised in a highway being a way over which the public have right of way on pedal cycles only, with or without the right of way on foot (section 329, Highways Act 1980)
Demand	Request for right of way registered by traffic via a detector
Demand dependent	A stage in a signal cycle which is only selected when a demand for it is registered
Detector	Equipment detecting traffic that initiates a demand or extension. Different types are used to detect different road user types.
Detector loop	One or more turns of wire installed in the road surface forming part of a vehicle detector which relies on the electromagnetic changes caused by a vehicle
Detector unit	The part of the detector which is connected to a detector loop or transducer and produces an output when a vehicle is detected.
Dimming	The automatic reduction in brightness of signal aspects during hours of darkness to reduce glare to road users.
Ducting	The system of ducts carrying the cabling at a junction.
Duplicate primary signal	A second primary signal mounted on the right hand side of the carriageway. Also referred to as a ‘double primary’
Effective green	The effective time which drivers use to cross a signal-controlled stop line, used to derive the capacity of the installation. This is not necessarily the same as the actual green time. In the UK it is assumed that the effective green time is 1 second more than the actual green time.
Equestrian crossing	Crossing for ridden horses, which may use farside or nearside aspects. Defined in the Regulations as a place on the carriageway of a road— (a) at which provision is made for equestrian traffic to cross the carriageway; and (b) the presence of which is indicated by a combination of— (i) the traffic light signals provided for in S14-2-1, S14-2-3 or S14-2-4; (ii) the signals provided for at— (aa) in S14-2-15 and S14-2-16; or (bb) the signal provided for in S14-2-17 (whether or not placed with the signal provided for in S14-2-18); and (iii) the road marking provided for in S14-2-55 or S14-2-56
Exit	At a junction, the portion of an arm which carries traffic away from the junction.
Extension	Continuation of the signal that results from a request made by a vehicle or pedestrian that has right of way. May be used for black-out and all-red periods as well as green periods
Filter arrow	A green arrow which appears with a red (or red/amber) signal to give right of way to a specific movement
Fixed time	Traffic signal control strategy in which the duration of the red and green periods and the length of the cycle is fixed
Footpath	A way over which the public have a right of way on foot only, not being a footway (section 329, Highways Act 1980)
Footway	A way, comprised in a highway which also comprises a carriageway, over which the public has a right of way on foot only (Section 329, Highways Act 1980)
Green arrow	A green aspect consisting of an arrow symbol, to indicate permitted direction of movement
Guardrailing	Railing installed on footways and islands
Highways England	The traffic authority for the Strategic Road Network in England
High speed	For the purposes of traffic signal installations, a road where the 85th percentile motor traffic approach speeds at a junction are 35 mph or above

Term	Definition
Highway	Way over which the public has right to pass, maintainable at public expense, generally by the local authority. The right may be restricted to specific classes of vehicle.
Hood	A device mounted above a signal aspect to prevent incident light falling on the lens and reducing contrast and/or to prevent the aspect being seen by road users for whom it was not intended.
Indicative green arrow	A green arrow indicating that vehicles may proceed in the direction shown which is also covered by a full green signal.
Intergreen period	Period between the end of the green signal for one phase to the start of green of a conflicting phase.
Intergreen matrix	a matrix of intergreen timings between conflicting phases.
Interstage period	The period between the end of one stage and the start of the next stage.
Invitation to cross	The period of display of a steady green symbol to pedestrians, cyclists or equestrians at traffic signal junctions or crossings.
Island	Raised area on the highway, usually at a road junction, shaped and located so as to direct traffic movement.
Isolated control	Control of an installation where the timings are not related to neighbouring junctions.
Junction	The meeting point between two or more roads. (Note: no distinction is usually made between a junction being where roads meet, and an intersection being where roads cross). Defined in the Regulations as ‘a road junction’
Lamp	The light source in a signal aspect
Lane	A section of an approach marked for the use of a single file of vehicles
Lane control signals	Overhead signals to S14-2-32, S14-3-33, and S14-2-34 indicating the permitted direction of movement
Late start	A condition in which one or more traffic streams are permitted to move before the release of other traffic streams, which are then permitted to run with them during the subsequent stage.
Lens	The translucent face of a signal aspect which supplies the colour and symbol (if required) and which may control the light distribution of the aspect
Link	In a network, a connection between nodes. In traffic networks, links between junctions may be defined for particular directions, movements or vehicle types
Loop detector	A detector which operates by analysing the electromagnetic effects on a buried loop of wire caused by the presence or passage of a vehicle
Loop feeder	Cable connecting a detector loop to its detector unit
Mast arm	A pole being curved or having a cantilevered branch to allow a sign or signal to be mounted above a carriageway
Motorway	A special road which— (a) in England and Wales, can be used by traffic only of Class I or Class II as specified in Schedule 4 to the Highways Act 1980; (b) in Scotland, can be used by traffic only of Class I or Class II as specified in Schedule 3 to the Roads (Scotland) Act 1984 (c) in Northern Ireland, can be used by traffic only of Class I or Class II as specified in Schedule 1 to the Roads (Northern Ireland) Order 1993
MOVA	Microprocessor Optimised Vehicle Actuated: isolated adaptive control system based on minimising stops and delays which maximises capacity at a single controlled junction. Produced by TRL.
Movement	The traffic taking a specific route through a junction from a defined entry to a defined exit

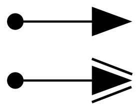
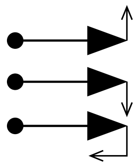
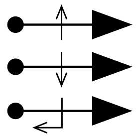
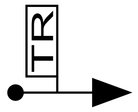
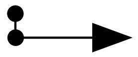
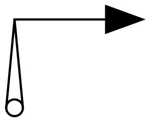
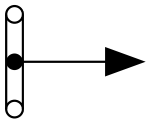
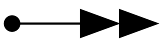
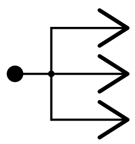
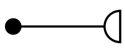
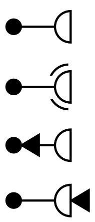
Term	Definition
National sequence	The sequence of indications of traffic signals which are prescribed by national legislation or regulation. Defined in S14-1-4.
Offset	The difference in time between a specific point in the cycle at a junction and a reference point
Overlap	Phases which run in successive stages (e.g. late start, early cut-off)
Parallel crossing	A controlled crossing allowing pedestrians and cyclists to cross. Defined in the Regulations as a place on the carriageway— (a) where provision is made for pedestrians and cyclists to cross the carriageway; (b) the presence of which is indicated by— (i) a yellow globe of the type provided for in S14-2-27 at each end of the crossing (except that globes need not be present at a crossing that only crosses a cycle track); (ii) in respect of the part of the crossing for pedestrians, the black and white stripes shown in the diagram in S14-2-53 and in respect of which provision is made in S14-1-18 (including provision for the black stripes to be a different colour); and (iii) in respect of the part of the crossing for cyclists, the markings provided for in S14-2-57 together with, where used, the cycle symbols shown in the diagram in S14-2-53; and (c) the limits of which are indicated— (i) in so far as they relate to the part for pedestrians, the stripes; and (ii) in so far as they relate to the part for cyclists, the marking in S14-2-57
Parallel stage streams	Two or more complete sequences of stages within the same controller which operate at the same time enabling two junctions or parts of a junction to be controlled with or without interaction between them
Passenger car unit (PCU)	The basic unit of traffic flow equal to the equivalent of a typical car plus headway to the adjacent car. Generally taken as 5.75 m.
Pedestrian demand unit	Signal to diagram 4003.1 used at nearside facilities and Puffin crossings.
Pedex	Alternative name for a stand-alone ‘signal-controlled pedestrian facility’, as defined in the Regulations: a place on the carriageway of a road— (a) which is not a Zebra or Puffin crossing; (b) where provision is made for pedestrians to cross the carriageway; and (c) the presence of which is indicated by a combination of— (i) the traffic light signals provided for in S14-2-1, S14-2-3, or S14-2-4; (ii) the sign provided for at— (aa) S14-2-9 (with or without S14-2-10) and either S14-2-11 or S14-2-12 (bb) S14-2-13 of the table (whether or not placed with S14-2-14); and (iii) the road marking provided for at S14-2-55 or S14-2-56
Pelican crossing	A pedestrian crossing using farside pedestrian indicators with a flashing amber/flashing green period during which vehicles are permitted to move subject to giving way to pedestrians. Under the Regulations, may no longer be installed in England, Scotland or Wales, although existing sites may remain until the end of their life. May still be installed in Northern Ireland.
Phase	“a set of conditions that fixes the pattern of movement and waiting for one or more traffic streams during the signalling cycle”. Can also be thought of as a unique electrical circuit from the controller to one or more signal heads.
Portable signal	A traffic signal to diagram 3000.1 (S14-2-2).
Primary signal	A signal head close to the stop line normally mounted on the left hand side of the carriageway

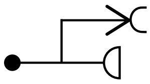
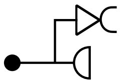
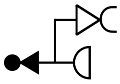
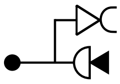
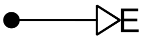
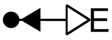
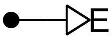
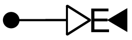
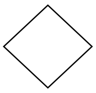
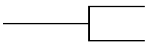
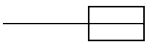
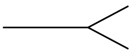
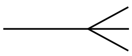
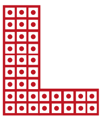
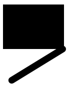
Term	Definition
Puffin crossing	A pedestrian crossing using nearside light signals, made under section 25 of the Road Traffic Regulation Act 1984, and defined in the Regulations as a place: (a) where provision is made for pedestrians to cross the carriageway; and (b) the presence of which is indicated by a combination of— (i) the traffic light signals provided for in S14-2-1, S14-2-3, or S14-2-4; (ii) the nearside light signals provided for in S14-2-13 (whether or not used with the supplementary nearside signals in S14-2-14); and (iii) the crossing marking provided for at S14-2 55
Push button	A button which may be pressed by pedestrians, cyclists or equestrians to register a demand
Push button unit	A housing containing a push button.
Queue	A stationary or slow-moving file of traffic where the progress of a vehicle is determined by that of the preceding vehicle.
Red lamp monitoring	Lamp monitoring of the functioning of some or all of the red lamps at a junction
Refuge	An island where pedestrians may wait
Regulatory sign	A sign indicating a traffic regulation (such as a prohibited movement)
Regulatory box sign	A regulatory sign to S14-2-42, S14-2-43, S14-2-44 or S14-2-45, designed to be mounted within a signal head housing
Remote monitoring	A system installed at a signal controller which checks for faults in operation and reports them automatically to a central point
Practical Reserve capacity (PRC)	The difference between the capacity of a junction and the current demand (usually expressed as a percentage).
Right of way (at traffic signals)	Right of priority attached to traffic moving in a particular direction, temporarily given to traffic by signals, signs, pedestrian crossings or other means.
Right of way (general)	Right of passage for the public or class of road user (such as footways or cycle tracks).
Risk Assessment	An analysis of the risks to health and safety involved in the construction, operation and maintenance of a scheme.
Road	Any highway, and any other road to which the public has access, including bridges over which a road passes. (In Scotland the definition of "road" includes any way over which the public have a right of passage). See "highway"
Road marking	A sign consisting of a line, mark or legend on a road
Run	A phase is said to be running when it is displaying a green signal. A stage is said to run a phase if that phase displays a green signal during that stage.
SA	Speed Assessment. A VA control strategy for high speed roads which affects the changing of the signals according to the speed of approaching vehicles.
Saturation flow	The maximum theoretical flow (usually expressed in pcu or vehicles per hour) obtainable over a stop line during green from a discharging queue.
SCOOT	Split, Cycle, Offset Optimisation Technique. A traffic control programme which uses real time traffic data to minimise stops and delays for UTC controlled areas.
SDE	Speed Discrimination Equipment. A VA control strategy for high speed roads which discriminates vehicles travelling above a given speed threshold.
Secondary signal	A signal beyond the stop line and the primary signal, which duplicates the display at the primary signal
Signal	A dynamic indication presented to road users
Signal display	The combination of illuminated aspects in a signal head which provides a control instruction to traffic

Term	Definition
Signal head	A combination of signal aspects which together provide all the signal displays required for the control of one or more traffic streams at the same stop line.
Signal post	Support provided at a traffic signal installation for one or more signal heads
Signal sequence	The sequence of displays shown by a signal head
Split	The division of available green time within a signal cycle between stages
Stage	The period within a traffic signalling cycle that gives right of way to one or more particular traffic movements. A stage starts when the last of its associated phases commences and ends when the first of its associated phases terminates.
Staging diagram	A diagram for a signalled controlled junction showing by means of arrows those movements permitted in each of the stages. Sometimes called 'method of control'
Stand-alone	Refers to a crossing facility provided away from a signal-controlled junction, where traffic is stopped only for the purpose of enabling pedestrians, cyclists or equestrians to cross the carriageway.
Start displacement	The time interval between the start of actual green and the start of effective green
Storage	Ability for vehicles (usually right turning) to wait within the junction
Stream (traffic stream)	Vehicles in one or more lanes on the same approach to the controlled area which, when they have the right-of-way, will move in the same direction
Tactile signal	A rotating cone which indicates the presence of a green signal for the benefit of visually impaired people
Tactile paving	A type of textured paving, the blister pattern of which can be identified by visually impaired people to indicate the location of a crossing facility
Temporary signal	A traffic signal using the same type of signal equipment as permanent signals but which is installed for a limited period of time, in a temporary support
Toucan crossing	a place on the carriageway of a road— (a) where provision is made for both pedestrians and pedal cyclists to cross the carriageway; and (b) the presence of which is indicated by a combination of— (i) the traffic light signals at S14-2-1, S14-2-3, or S14-2-4; (aa) the signals provided for at SA14-2-19 (with or without S14-2-10) and either S14-2-12 or S14-2-20; or (bb) the signal provided for at S14-2-21 -(whether or not placed with the signal provided for at S14-2-22); and (ii) the road marking provided for at S14-2-55 or S14-2-56
Traffic signs authorisation	The process of obtaining authorisation from the relevant national authority for the use of traffic signs (including traffic signals and road markings) which are not prescribed in the relevant regulations.
Tram signal	A signal which controls Light Rail Vehicles running on-street at signalled junctions
Urban Traffic Control System (UTC)	Urban Traffic Control. A method of controlling and managing a number of traffic signals from one computer system, within a defined area.
Variable message sign	A traffic sign capable of showing one or more traffic sign faces or legends or a blank face, as prescribed in the Regulations
Vehicle actuation	Traffic signalling strategy in which the duration of the red and green signals and the time of duration of the cycle vary in relation to the traffic flow into and through the controlled area. It is actuated by the traffic by means of vehicle detection
Walk with traffic	A method of control in which pedestrian phases run with non-conflicting vehicle phases
Wig-wag	A signal having two similar aspects which are illuminated alternately

Term	Definition
Y	The sum of the y values of the critical traffic stream of each stage for all the stages in the cycle
‘Y’ value	The ratio of demand and saturation flow for a traffic stream
Zebra crossing	a place on the carriageway— (a) where provision is made for pedestrians to cross the carriageway; (b) the presence of which is indicated by— (i) a yellow globe of the type provided for at S14-2-27 at each end of the crossing (except that globes need not be present at a crossing that only crosses a cycle track); (ii) the black and white stripes shown in the diagram at S14-2-52 and in respect of which provision is made at S14-1-18 (including provision for the black stripes to be a different colour); and (iii) where used, the marking provided for at S14-2-55 of that table; and (c) the limits of which are indicated by the stripes except that, where used, the limit is indicated by the marking at S14-2-55
85th percentile speed	the speed at or below which 85 percent of all vehicles are observed to travel under free-flowing conditions past a monitored point

A.2 Common drawing symbols

Symbol	Description
	3-aspect vehicle signal with primary visor 3-aspect signal with secondary visor
	3-aspect primary signals with substitute green arrow signals
	3-aspect primary signals with additional green arrow signals
	3-aspect primary signal with regulatory box sign: TL: Turn left (diagram 606) TR: Turn right (diagram 606) AO: Ahead only (diagram 606) NLT: No left turn (diagram 612) NRT: No right turn (diagram 613) NUT: No U-turn (diagram 614)
	3-aspect primary signal mounted on a bracket
	3-aspect primary signal mounted on a mast arm
	3-aspect primary signal mounted on a gantry
	Two 3-aspect signal heads, one at standard height, one at high level
	3- aspect primary cycle signal to diagram 3000.2
	3-aspect wig-wag signal to diagram 3014
	Tramcar signal to diagrams 3013 – 3013.5
	Push button to diagram 4003
	2-aspect farside pedestrian signal to diagram 4002.1
	Pedestrian demand unit without push button to diagram 4003.1 Pedestrian demand unit with restricted field of view to diagram 4003.1 Pedestrian demand unit to diagram 4003.1 Pedestrian demand unit with separate push button to diagram 4003.1

Symbol	Description
	farside Toucan signal to diagram 4003.5
  	nearside Toucan signal to diagram 4003.7 4003.7 without push button 4003.7 with combined push button 4003.7 with separate push button
	2-aspect farside equestrian signal to diagram 4003.2
  	2-aspect nearside equestrian signals to diagram 4003.4 4003.4 without push button 4003.4 with combined push button 4003.4 with separate push button
	Inductive loop vehicle detector
	Inductive loop vehicle detector (MOVA)
	Above ground vehicle detector
	Above ground stop line vehicle detector
	On-crossing detector
	Kerbside detector
	Photo-electric cell
	Tactile paving to indicate a controlled crossing point
	Guardrailing
	Controller or other equipment housing

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