
VOLUME 6 ROAD GEOMETRY
SECTION 2 JUNCTIONS

PART 8

TA 86/03

**LAYOUT OF LARGE SIGNAL
CONTROLLED JUNCTIONS**

SUMMARY

This Advice Note gives recommendations for the procedures for designing and assessing the performance of large traffic signal junctions. It is intended to supplement and be used in conjunction with **TD 50 (DMRB 6.2.3)**. The Design Standard for The Geometric Layout of Signal Controlled Junctions and Signalised Roundabouts.

INSTRUCTIONS FOR USE

This is a new Advice Note to be incorporated in the Manual.

1. Insert TA 86/03 into Volume 6, Section 2, Part 8.
2. Please archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.



THE HIGHWAYS AGENCY



SCOTTISH EXECUTIVE DEVELOPMENT DEPARTMENT



Llywodraeth Cynulliad Cymru
Welsh Assembly Government

**WELSH ASSEMBLY GOVERNMENT
LLYWODRAETH CYNULLIAD CYMRU**



**THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND**

Layout of Large Signal Controlled Junctions

Summary: This Advice Note gives recommendations for the procedures for designing and assessing the performance of large traffic signal junctions. It is intended to supplement and be used in conjunction with **TD 50 (DMRB 6.2.3)**. The Design Standard for The Geometric Layout of Signal Controlled Junctions and Signalised Roundabouts.

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

VOLUME 6 ROAD GEOMETRY
SECTION 2 JUNCTIONS

PART 8

TA 86/03

**LAYOUT OF LARGE SIGNAL
CONTROLLED JUNCTIONS**

Contents

Chapter

1. Introduction
2. Design Procedure
3. Junction Types
4. Preliminary Design and Testing
5. References
6. Enquiries

Annexes

- Annex A Relative Junction Performance
- Annex B Traffic Flow Groups Used for Capacity Tests
- Annex C Compound Signal Controlled Junctions
- Annex D Definitions

1. INTRODUCTION

General

1.1 Standard **TD 50 (DMRB 6.2.3)** sets out the Overseeing Department's design standards, methodology and good design practice for the geometric layout of signal controlled junctions. The Standard highlights design considerations for the development of site specific final designs. Current Highway Design Standards and Technical Advice Notes in the Design Manual for Roads and Bridges shall be used in the design of large traffic signal controlled junctions. Standards cover the relevant safety aspects of Highway Design. Advice Notes give guidance on best practice an efficient and effective design which their use will ensure that safety issues are considered in the design.

1.2 The Highways Agency Code of Practice Consultancy (Dec 1997) or (Overseeing Organisation's equivalent) recommends and makes reference to good practice to be adopted for all traffic control or information systems from design and installation, through to the operation and de-commissioning of the system. The Code of Practice promotes safety and effectiveness through good practice and procedures and forms a central reference, guiding users to other relevant DETR publications that contain advice on the design, maintenance and operation of systems.

1.3 The purpose of this Advice Note is to supplement **TD 50 (DMRB 6.2.3)**, The Code of Practice and provide guidance to the Highway Engineer on the principles that steer the design of large signal controlled junctions on Trunk Roads. It gives examples of new types of signal control at junctions where additional capacity is required and shows in what circumstances they can be used. The analytical methods for assessing the operational characteristics of signalised junctions are described together with suggestions as to the different types of computer simulation software currently available.

1.4 Definitions of the principal technical terms used in this document in relation to signal controlled junction design can be found in Annex D and Annex 1 of **TD 50 (DMRB 6.2.3)**. Publications giving further detailed information on the subject are listed in Chapter 6.

1.5 As traffic densities increase, junctions are required to handle ever-growing volumes of vehicles. Economic and environmental constraints will often preclude the option of grade separating major traffic flows at junctions and in these situations, at-grade solutions with junctions designed specifically for traffic signal control can sometimes provide cost-effective options and maximise the capacity of the junctions.

1.6 In view of the cost of the highway works associated with a large signal controlled junction, proper design and assessment of the geometric options is essential to determine the most efficient layout for the particular traffic conditions.

Scope

1.7 This Advice Note considers the issues governing the design of large signal controlled junctions and includes the design of new junctions and existing junctions converted to signal control. It gives an overview of the types of large signal controlled junctions used in practice and comments on the circumstances in which these types of junction may work most successfully.

1.8 This document is intended to offer advice on the layout of large signal controlled junctions on trunk roads in urban and rural locations. Junctions in these locations will require different design considerations when taking into account the provision for non-motorised road users.

1.9 Large signal controlled junctions may vary in type from complex single node junctions where the design of the signal phase and stage structure will greatly influence capacity, to multi-node junctions where each node has a simple signal phase and stage structure and where the design of good signal co-ordination between nodes will be the more important issue. Although the principal concern of the evaluation of the type of junction to be considered may be to create additional capacity for vehicles, the needs of pedestrians and cyclists should not be suppressed. The resulting solution should aim to improve conditions for all road users.

1.10 Where example layouts of junctions are presented in this Advice Note, these are of a diagrammatic nature and are intended for guidance only.

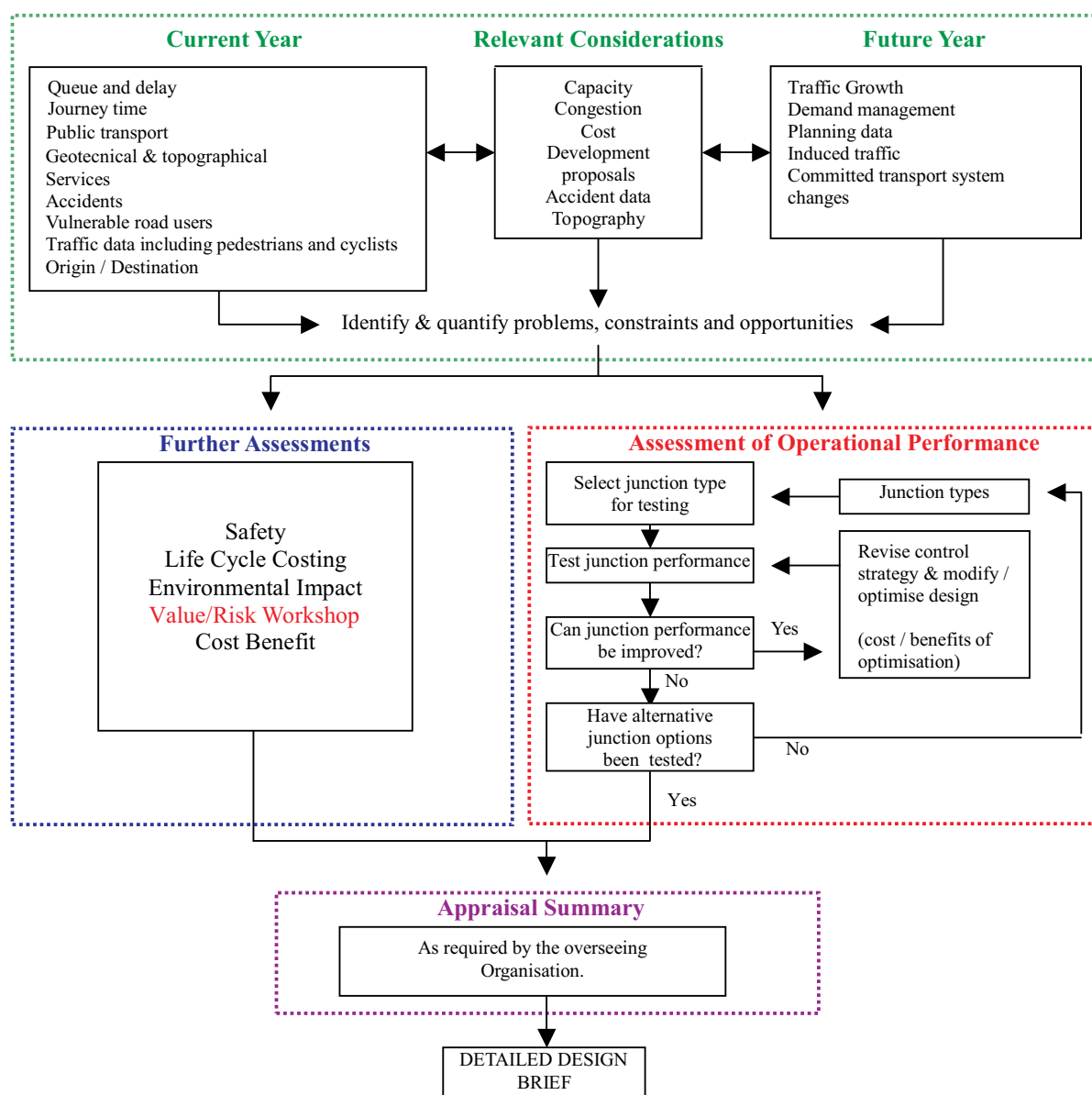
Implementation

1.11 This Advice Note should be used forthwith on all schemes for the management, improvement and maintenance of Trunk Roads currently being prepared provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. Design Organisations should confirm its application to particular schemes with the Overseeing Organisation.

2. DESIGN PROCEDURE

General

2.1 The geometric form of a large traffic signal junction will be determined by the nature of the individual circumstances. A recommended process by which the final solution may be achieved is described in Figure 2/1.



Note: A similar diagram is shown in the Highways Agency Code of Practice (Figure 2/9)

Figure 2/1: Typical Design Process

2.2 This process can be grouped into three stages (see Figure 2/1):

- the data gathering stage (Relevant Considerations, Current and Future year);
- the preliminary design and testing stage (Further Assessment, Assessment of the Operational Performance and Appraisal Summary);
- the detail design stage (Detailed Design Brief).

2.3 The detail design stage does not form part of this Advice Note. Matters relating to the detail design of junction and carriageway construction are addressed in the relevant Technical Standards and Advice Notes in the DMRB.

Data Gathering (see Figure 2/1)

2.4 This is the initial stage of the design process where information relevant to the design of the junction is gathered and collated.

2.5 From this information it will be possible to establish the basic constraints on the design of the junction and the traffic flows which are likely to use it in the design year.

2.6 Information is likely to be required in the following areas:

- existing traffic conditions (this should cover all vehicle types);
- pedestrian and cycle, movements and desire lines, and any local land uses which may require individual measures, eg school, hospital;
- current and future traffic flows;
- existing accident patterns;
- approved and potential development proposals within the design period;
- Local Plan policies relating to future land use;
- Local Transport Plan policies relating to pedestrian, cycle, equestrian, public transport and private transport routes;
- Land availability with an accurate survey of the proposed site at a scale of not less than 1:500.

2.7 This information will help to define the nature of the problem and how existing and future planning policies and proposals may influence traffic patterns.

2.8 Classified traffic flow data (including non-motorised users) will be an important element in the design process. In the case of an existing junction this will require both counts of actual traffic movements, including pedestrians, and an assessment of any future developments likely to affect the traffic movements through the junction.

Preliminary design and testing (see Figure 2/1)

2.9 During this stage the preliminary designs will be prepared, tested and optimised. It is likely that more than one design will fulfil the design criteria and some form of economic appraisal of the final options may be necessary.

2.10 Some basic junction configurations are considered in Chapter 3 and the relative performance of these configurations, together with a suggested selection process, is discussed in Annex A. This is intended as an aid in the initial selection of geometric options.

2.11 The process will comprise the formulation of efficient control strategies and the necessary highway geometry to enable the control strategies to be effectively implemented.

2.12 There will be an iterative process of design, testing and optimisation. The final design may well contain features from more than one junction configuration and ideally several options should be assessed to ensure the best solution is achieved. This exercise will form the majority of the work undertaken in developing a solution and is discussed more fully in Chapter 4 and Annex A.

2.13 The process will be aided by the use of computer software packages. These packages will either take the form of conventional modelling which use established equations to predict reserve capacity, delays and queues, or micro simulation. This technique has recently been used to predict the operation of junctions and networks on a microscopic level.

2.14 A micro simulation explicitly models the interaction of vehicles, junction geometry and signal control. It enables a number of design features such as blocking, flaring, merging and lane switching to be modelled more accurately than conventional computer models. However, whether these effects are critical in a

particular design depends on the junction type, geometric features, signal control and traffic flows.

2.15 A micro simulation model will usually require more resources and take longer to build and calibrate than a conventional model. For this reason a micro simulation model should only be considered where the accuracy of modelling could be improved by these extra resources; for example where a number of the design features mentioned above are likely to cause a problem. However, even when the need to build a micro simulation model is identified, a conventional model should still be used for preliminary design. This is to avoid the increased resources of simulation modelling at an early stage in a project and to identify areas of the design where greater detail will be required in the simulation.

3. JUNCTION TYPES

General Information and Advice

3.1 Large signal controlled junctions can be grouped into two broad categories:

- complex single node junctions, such as crossroads, where conflicts occur at a single point or node;
- multi-node junctions, such as roundabouts and gyratory systems, where conflicts are separated, and occur at a series of nodes arranged into a broadly circular pattern.

These are fundamental concepts that need to be considered at an early stage in the design process.

3.2 At a single node junction all conflicts occur at a single point. Where right turns are separately signalled, there are generally four vehicle conflict groups each requiring its own part of the signal cycle time.

3.3 In principle this is a simple method of junction control but the number of intergreen periods required to handle the various conflicts can result in a significant proportion of lost time during each cycle and the need for long cycle times.

3.4 The optimum capacity of single node junctions will be achieved with a layout and signal control system that enables as many non-conflicting traffic movements as possible to occur at the same time during the cycle. There may be several ways in which this can be accomplished and the traffic flows through the junction will be the prime indicator of which of the possible arrangements are likely to be the most efficient.

3.5 At multi-node junctions the aim is to improve on the single node described above with a series of nodes, each with two conflicting traffic movements. The reduction in conflicts will reduce the lost time associated with a single node. The performance of this type of junction is dependent on the co-ordination of the signal settings between the separate nodes. Considerable effort will be required to establish the best co-ordination.

Entry Arms and Circulatory Carriageways

3.6 Large signal controlled junctions are often innovative in design and provide at-grade solutions to problems associated with providing vehicular capacity in a restricted environment. The number of lanes provided on the approach to and within a circulatory carriageway is dependent on the volume of traffic, the exit distribution of traffic and space availability. The layout of the signalised nodes should conform to the requirements set out in **TD 50 (DMRB 6.2.3)**. In the case where a node is not signalised then the layout should conform to the appropriate standard.

3.7 Generally for layouts with four or fewer lanes at a stopline the design principles in **TD 50 (DMRB 6.2.3)** can be accomplished. Driver uncertainty can affect capacity, control and safe operation of the junction. Therefore layouts with five or more lanes at a stopline are not recommended, because of the problems caused by the complexity of design issues such as:

- visibility of signal heads;
- vertical signing;
- lane designation and marking; and
- provision for non-motorised users.

3.8 These elements and types of junction are described more fully below and their relative performance is discussed in Annex A.

Designated Lanes

3.9 Designated lanes are marked out on the approaches, exits and circulatory carriageway of junctions. They can be designated for use by:

- buses (see **TD 50 (DMRB 6.2.3)**);
- large goods vehicles (LGVs);
- taxis and high occupancy vehicles;
- cycles (see **TD 50 (DMRB 6.2.3)**).

3.10 Designated lanes are often generically referred to as 'bus lanes' although in practice other vehicle types, in addition to buses, could use the lanes.

3.11 Providing designated lanes at junctions can result in an overall reduction in junction capacity for vehicles but an increased capacity for the movement of people. It may be possible to modify an existing junction by incorporating traffic signal control that maintains the capacity for existing road users and can enhance the facilities for traffic using the designated lanes.

3.12 Further information on the provision of designated lanes can be found in the Institution of Highways and Transportation publications 'Transport In The Urban Environment' (1997) and 'Guidelines For Planning For Public Transport In Developments' (1999).

3.13 Improved facilities for traffic using the designated lanes can be provided in several ways:

- using traffic signal control to provide additional capacity to cater for all movements on a relatively short cycle time, then delays to prioritised traffic will be minimal;
- by providing specific lanes or segregated signals;
- in a passive way by detection to hurry call or hold specific signal stages;
- by providing a signal at a stop line in advance of the main junction that would be co-ordinated with the main stop line. These advance signals would allow the reservoir between the advance signals and the main stop line to be relatively clear of queuing traffic during the red phase, allowing prioritised traffic easy access into any lane;
- by introducing turning exemption or segregated bypass lanes, which allows prioritised traffic to make a movement that is prohibited to other traffic.

Bus Lanes

3.14 When assessing the need for facilities to aid public transport, bus priority should be considered where buses would be delayed by queuing traffic or where buses would have difficulty in making a particular movement, eg where lane switching is required. Bypassing queuing traffic is possible by the provision of a bus lane but complications arise at the

junction itself. If segregated bus signalling is to be avoided, then the bus lane will need to utilise the same signal phase as the other traffic. In order to cater for left turning traffic, the dedicated bus lane will have to be stopped short, to allow left turners into the nearside lane.

3.15 If additional stop line capacity is required, then the bus lane may need to be terminated further back from the stop line and the capacity of the approach calculated on the basis that the approach is 'flared'. To cater for buses that want to make a right turn and need to manoeuvre across normal traffic lanes a special bus phase could be provided, however, at some junctions this could restrict capacity and could affect other bus routes.

Guided Buses, Trams and Light Rapid Transport (LRT) Systems

3.16 A number of cities have introduced fixed track systems to enhance public transport. Most track systems will have a proportion of segregated track. Where there is an element of street running, signal priority measures are required to minimise delays and allow reliable journey times.

3.17 Vehicles running on fixed track systems require special consideration when incorporating them into large signalised junctions. Particular attention should be given to the swept vehicle path, stopping distances, the need for stops and frontage servicing.

Cycle Lanes/Cycle Tracks

3.18 The traffic signal control of the single node junction itself represents an improvement of road conditions for cyclists in comparison with a priority-controlled junction.

3.19 The provision of cycle facilities on the carriageway is addressed in the Traffic Advisory Leaflet series, **TD 50 (DMRB 6.2.3)**, **TA 67 (DMRB 5.2.4)**, Cycle-Friendly Infrastructure Guidelines for Planning and Design (1996) and The National Cycle Network Guidelines and Practical Details (1997). See references in Chapter 5. Various techniques are used nationally to create crossing facilities with local variations in practice. It is recommended that an examination is made of local practices and a liaison established with the relevant department of the Local Authority at an early stage in the design procedure.

Facilities for Pedestrians and Cyclists

3.20 Correctly located crossings are critical to walking and cycling activities and can help overcome severance created by busy roads. A balance needs to be struck between the legitimate needs of all road users. This balance will be influenced by the location of the junction and the volume of pedestrian and cycle traffic. In an urban situation, at-grade facilities may be more appropriate. The location of at-grade cycle or pedestrian crossings, whether controlled or uncontrolled, at slip roads of grade-separated intersections should be avoided wherever possible, particularly where approach speeds are likely to be in excess of 40mph. The crossings should be positioned away from locations where drivers might be applying maximum acceleration **TA 67 (DMRB 5.2.4)**. In such circumstances segregated facilities may be more appropriate.

3.21 From a pedestrian perspective an ideal crossing facility would be safe, coincide with desire lines, allow for crossing the junction in all directions, provide sufficient space to accommodate pedestrian capacity and provide adequate opportunity for traversing the junction with quick response to demand.

3.22 A list of Traffic Advisory Leaflets and Local Transport Notes relating to pedestrian and cycle facilities can be seen in Chapter 5.

At-Grade Facilities for Pedestrians and Cyclists

3.23 Pedestrian and cycle flows should initially be considered as two different movements. If their individual requirements turn out to be similar, then consideration should be given to providing joint facilities such as Toucan crossings. The shared use of space by pedestrians and cyclists should only be considered as a last resort when all other solutions have been dismissed. Unsegregated shared use should be avoided, particularly in heavily used urban contexts.

3.24 Pedestrian facilities are sometimes provided by stopping all traffic movements and introducing a “pedestrian stage” during which pedestrians can cross all arms of the junction. The disadvantage of this method is that the pedestrian stage results in considerable lost time which seriously degrades the capacity of the junction and forces the use of long signal cycle times. This in turn means that pedestrian waiting times are long with the corresponding increased risk of pedestrians crossing against the “red man” signal.

3.25 The pedestrian facilities can often be designed in such a way that the pedestrian is able to cross when non-conflicting streams of traffic are running. In this case a specific signal would indicate when it is appropriate for the pedestrian to cross. These are referred to as “walk-with-traffic” pedestrian facilities and are described in **TA 15 (DMRB 8.1.1)**.

3.26 The provision of walk-with-traffic pedestrian facilities separates pedestrian routes into a series of relatively short sections between safe refuges. As a result shorter green man periods are required at the points of conflict and the pedestrian-to-traffic intergreen periods are shorter.

3.27 Walk with traffic pedestrian facilities require the provision of a pedestrian/cycle facility on a junction exit which is not at a natural stop line (an entry does provide a natural stop line). These facilities can be designed as self-contained crossings but co-ordinated with the main junction. However, they may adversely affect the vehicular capacity of the junction.

Grade-Separated Facilities for Pedestrians and Cyclists

3.28 The provision of grade-separated facilities for pedestrian or cycle movements should be based on a range of factors. These include pedestrian flows and composition, the type and width of the proposed infrastructure to cross the junction, levels and gradients, exposure of pedestrians and cyclists to hazards such as high winds, adverse weather conditions and noise, construction and maintenance costs, and finally, the scope for combining cyclist and pedestrian movements. For segregated facilities to be attractive to users they must be safe and secure. This is achieved by providing good visibility to the user’s destination.

3.29 Consideration should be given to cyclists who may not use grade-separation if it involves steep inclines. Therefore, to protect cyclists from potentially dangerous sections of the junction they should be provided with attractive routes that are easy to negotiate. These may not necessarily involve dual use with pedestrians. Each location needs to be assessed on its individual merits; the current and forecast demand for a grade-separated facility and the acceptability/feasibility of the facility. Successful grade-separation can be achieved if the facilities are provided along natural desire lines and routes are short with minimal incline.

Single Node Crossroads

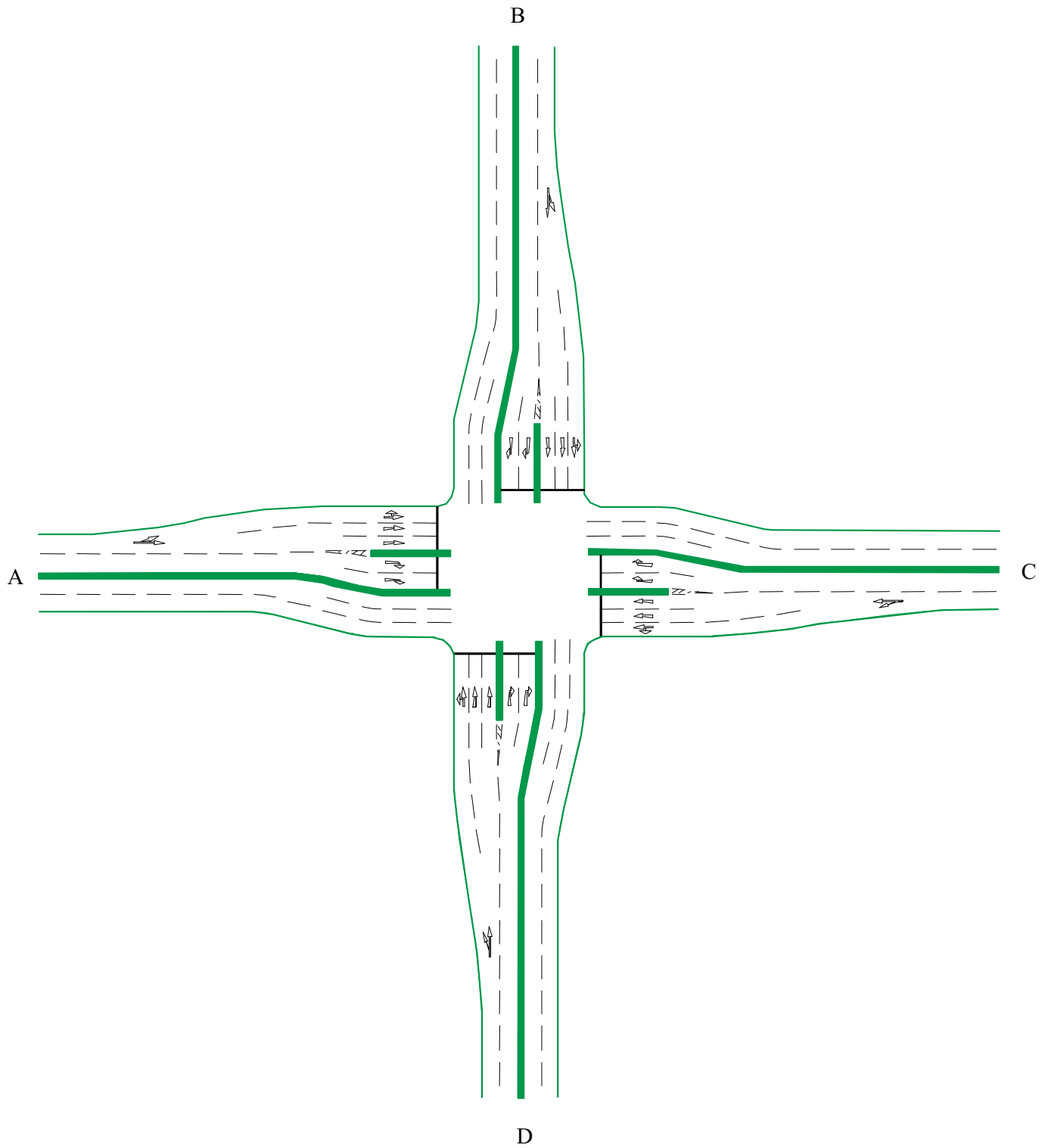


Figure 3/1: Single Node Crossroads

3.30 This is a common form of complex signal controlled junction. All traffic movements have assigned traffic lanes and are positively controlled at a single node or point of conflict. The number of traffic lanes and the length of flares at the stop line are dictated by the requirements of the traffic flows through the junction. Drivers understand this type of junction

and there are no requirements for internal signal co-ordination.

3.31 Because all the conflicts take place at a single point the capacity of the junction is dependent on both geometry and a signal sequence that minimises lost time in the signal cycle.

Sig-nabout

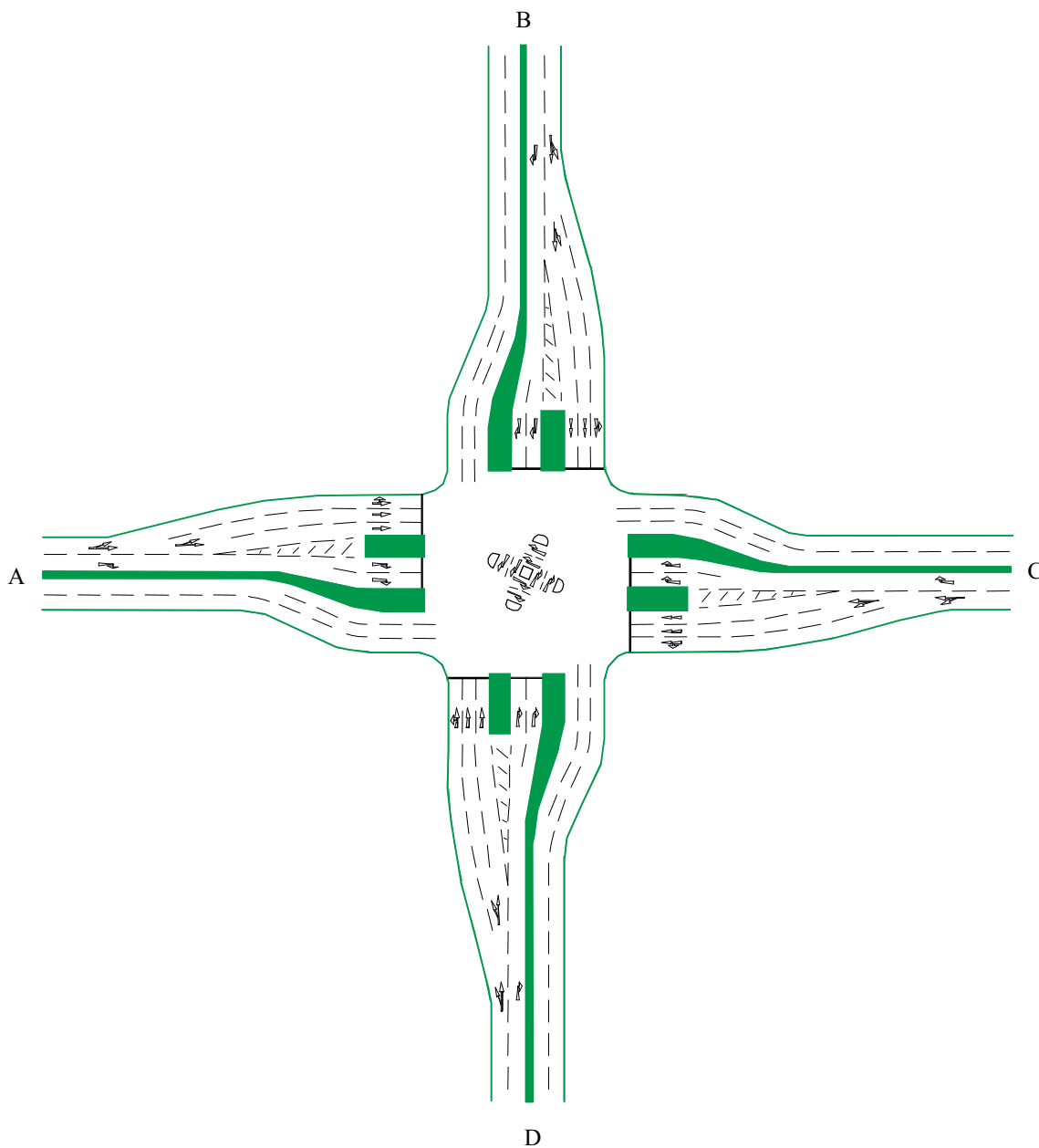


Figure 3/2: Sig-nabout

3.32 The geometry of the junction is similar to the single node crossroads with three essential differences:

- the flares on the approach arms are wide but short to provide relatively high capacity with short cycle times;
- an element of deflection for the ahead movements through the junction is incorporated in the geometry, thus helping to reduce traffic speed;
- carriageway markings in the central area (or node) of the junction are used to position and direct right turning traffic;
- right turning vehicles are generally not positively controlled but can accept gaps in opposing traffic movements and make use of intergreen times to negotiate the junction. There is however some potential for separate control of a dominant right turn.

3.33 The aim of the signal sequence is to control the four conflict groups in two stages rather than the four that are required with fully signalled right turns. This is achieved by clearing right turning vehicles in the more frequent intergreen periods resulting from a short cycle time.

3.34 A short cycle time is used so that the flared approaches contribute their maximum effect. The resulting increase in lost time is offset by the right turn movements taking place during the intergreen periods. The right turning traffic is not positively controlled and can accept gaps in the opposing traffic flow in the period preceding the intergreen.

3.35 A short cycle time is also necessary to achieve sufficient capacity for right turning traffic and two right turn lanes are used to store the right turning vehicles in the centre of the junction. The short cycle time provides a sufficient number of intergreen periods to accommodate the demand for the right turn.

3.36 The layout of the junction provides right turning vehicles with a segregated stop line. Because a right turning motorist would normally associate a segregated stop line with a fully signalled right turn manoeuvre, it is necessary to consider appropriate signing to emphasise the opposed nature of the turn.

3.37 Walk-with-traffic pedestrian facilities can be provided across the entry arms in a similar manner to the single node crossroads. However, the unique control strategy of the junction means that similar pedestrian facilities cannot be provided across the exit lanes and exit Pelican or Puffin Crossings might be necessary. These facilities may be remote from the junction but linked to the junction control system.

3.38 This form of junction is not as beneficial to the cyclist as the single node crossroads due to the opposed nature of the right turn movements. It is recommended that if special provision for cyclists is required then this should be segregated if possible. This may be by a variety of means depending on the volume of cycle traffic, desire lines and the ability to segregate the crossing vertically or horizontally away from the conflict point of the junction without unduly affecting the convenience of the cyclists.

Signalised Roundabouts

3.39 A signalised roundabout operates differently from a normal roundabout (see definition of 'normal roundabout' in **TD 16 (DMRB 6.2.3)**). Traffic signals control driver behaviour by dictating how a vehicle proceeds through the junction. The controlled platooning of traffic around and through a junction has the effect of limiting vehicle speeds, improving lane discipline and reducing the need for weaving. The guidance for the geometric design standards for signalised roundabouts that are full, partially or part-time signal controlled is set out in **TD 50 (DMRB 6.2.3)**.

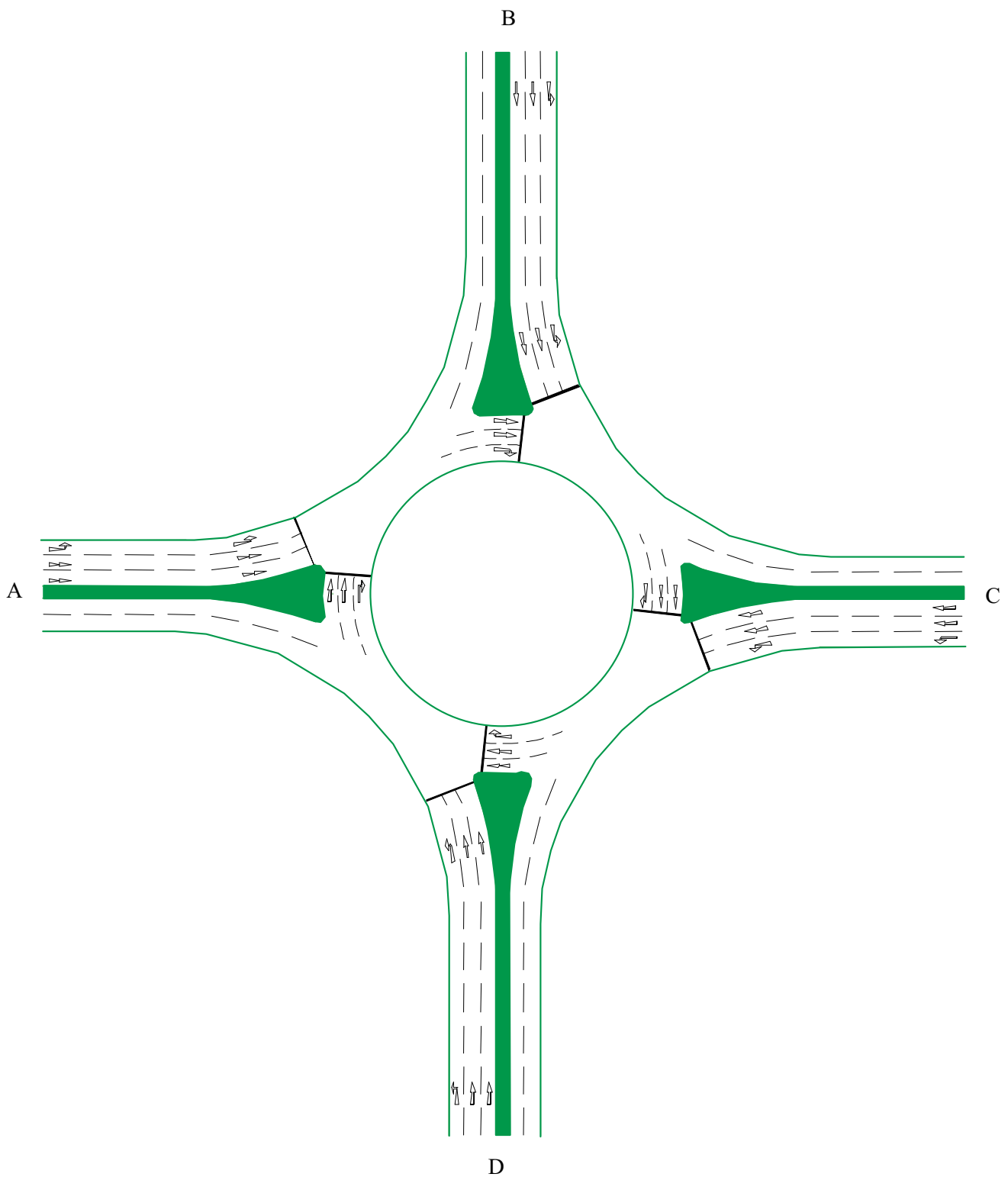


Figure 3/3: Signalised Roundabout

3.40 This group of junctions includes both roundabouts and various forms of traffic signal controlled gyratory systems. The junctions may be purpose designed for traffic signal control, but many are the result of the introduction of signal control to an existing roundabout or gyratory system to overcome operational problems. For example many motorway interchanges now operate with some form of traffic signal control.

3.41 These junctions are well understood by drivers and seldom cause confusion provided there are well designed lane-use markings. **TD 78 (DMRB 6.2.3)** and **TD 16 (DMRB 6.2.3)** give advice on the design of road markings at roundabouts. Although the advice contained in these documents is not directed at traffic signal controlled junctions, many of the road marking principles are considered applicable, for example, spiral markings.

3.42 These junctions are an example of the technique of separating conflicts geometrically with the entry arms forming a series of simple nodes at their junctions with the circulatory carriageway.

3.43 At multi-node junctions such as signalled roundabouts and gyratories the control strategy will have a different emphasis. At these junctions the conflicts are separated geometrically and often controlled by two signal stages. The signal phase and stage design at each node is simple as only two conflicting traffic movements need to be resolved, and the control strategy will concentrate on the most efficient co-ordination of the traffic signals between the nodes. The overall efficiency of the junction will depend on how well the signals can be co-ordinated. It is not always necessary to signalise all approaches to a roundabout and the choice of which arms to signalise will be a fundamental design issue. However, if all arms are signalised it improves safety for cyclists and pedestrians at the junction.

3.44 At some roundabouts an efficient pattern of signal co-ordination may be difficult to implement due to the journey times between nodes and traffic turning proportions. In these circumstances the signal timings and co-ordination will involve a compromise.

3.45 For example it is usually possible to design efficient traffic signal co-ordination on roundabouts and gyratory systems which have only three signalised arms. The aim of the co-ordination in these cases will be to achieve the situation where once a vehicle has passed the stop line on its entry arm it will negotiate the first internal circulatory stop line at green.

3.46 Co-ordination becomes much more difficult when the number of signalised arms increases above three. In these cases it is usually difficult to achieve the ideal signal co-ordination which is possible with only three signalised arms, and the design process will need to identify the most efficient compromise.

3.47 The performance of these junctions is sensitive to both signal co-ordination between the stop lines and the queue lengths on the circulatory carriageway. Both these parameters will be affected by the cycle time chosen and lengthening the cycle time may well have the effect of reducing capacity.

3.48 In comparison with single node junctions, these junctions will occupy a larger surface area and therefore result in greater disruption of pedestrian desire lines.

3.49 To offset this, the large junction will generally incorporate more conflict points that can be used to the advantage of pedestrians. Each of these gives an opportunity for specifically signalled walk-with-traffic pedestrian facilities across both the entry lanes and the circulatory carriageway. The large central island gives opportunities to provide relatively direct routes across the junction.

3.50 It is not always possible to provide walk-with-traffic facilities across the exit lanes of the junction. If the pedestrian desire lines indicate a need for facilities across the exit lanes then exit Puffin/Toucan crossings may be considered although these could have an impact on the overall capacity of the junction.

3.51 The provision of traffic signals at roundabouts and gyratory systems generally improves the situation for cyclists but they remain vulnerable while traversing the circulatory carriageway. The facilities described in **TD 50 (DMRB 6.2.3)** can assist cyclists to become established in their correct lanes.

3.52 If there are high volumes of cyclists on a particular desire line, then facilities should be provided to cater for this traffic. This may involve the provision of crossing facilities either across the central island or by removing some road space to provide a dedicated cycle lane.

Through-about

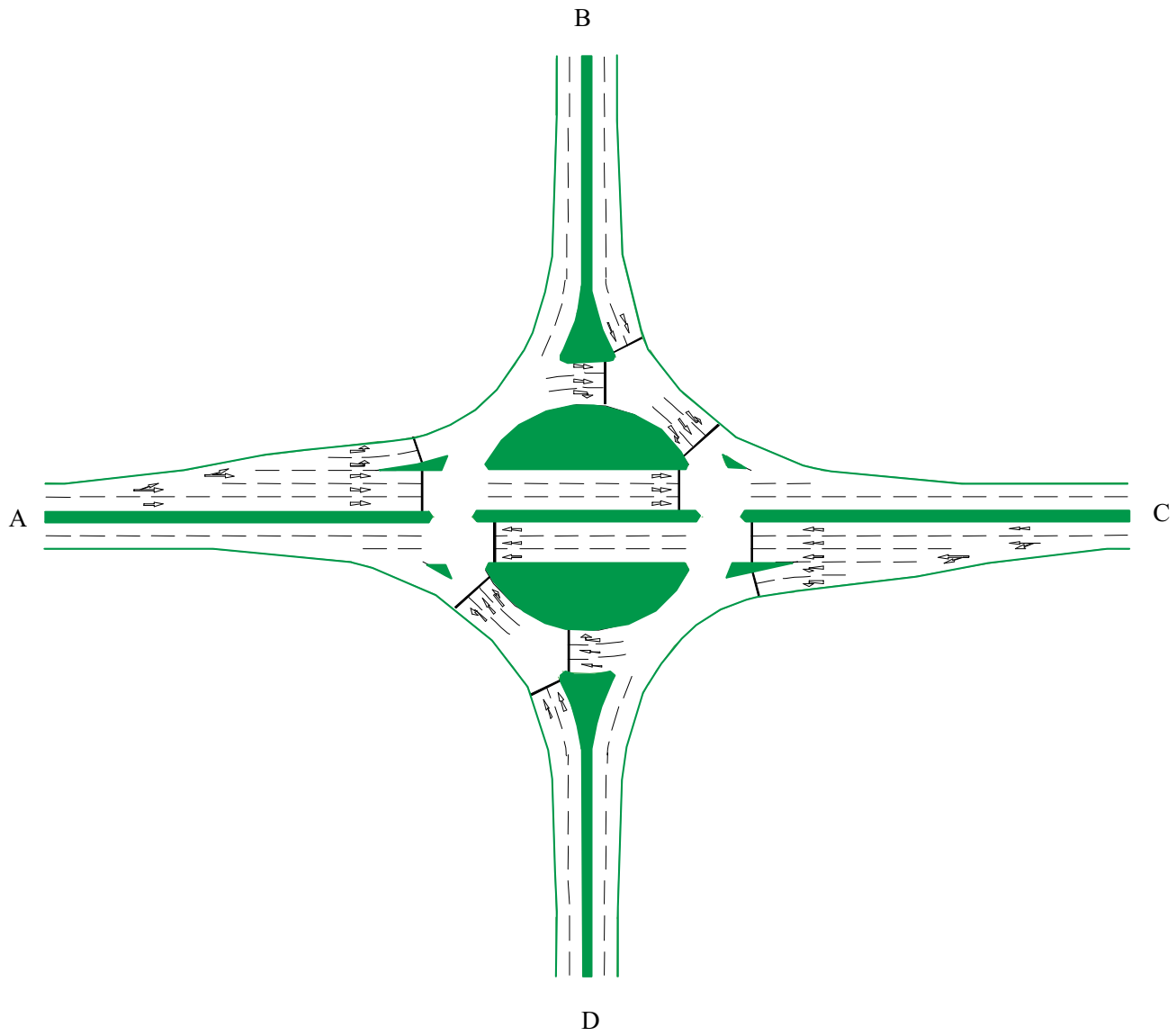


Figure 3/4: Through-About

3.53 These junctions are also referred to as “hamburgers” and “fly-through roundabouts”. They are usually the result of modifications to existing priority or signalised roundabouts. The modification takes the major through traffic movements out of the circulatory carriageway and routes them directly across the central island of the roundabout. Traffic signal control is then used at some or all of the points of conflict.

3.54 The resulting benefit is that major traffic movements are removed from some of the conflicts on the circulatory carriageway and this should provide increased capacity. However the disadvantage is that the junction is less efficient in handling turning movements and the benefit of increased capacity to the through movements can be quickly lost if traffic patterns change significantly.

3.55 This type of junction is not very common and drivers will require clear direction signing if they are to appreciate the ‘roundabout’ nature of the right turns from the main through route to the side roads.

3.56 Again, these junctions separate conflicts into a series of simple nodes and the control strategy will aim to provide the most efficient signal co-ordination. In addition to the nodes on the gyratory carriageway, the co-ordination of the two nodes controlling the through traffic movement will also need to be considered. For further information refer to Chapter 4.

3.57 The provision of pedestrian facilities is more difficult than at a signalised roundabout as the central island is crossed by a major traffic flow. A large signalised junction of this type does not provide a good environment for pedestrians. There are longer walking distances and the many stop lines create longer waiting times. Walk-with-traffic facilities can be provided across the central link at the internal stop lines. Co-ordinated exit pedestrian crossings can also be used. However, segregated pedestrian facilities are recommended for junctions of this complexity.

3.58 This junction provides a controlled route for cyclists crossing the junction via the central link. Cyclists using the circulatory carriageway experience the same conditions as at the signalised roundabout and the same comments apply. For heavily trafficked through-about junctions cycle movements should be separated from vehicular movements to provide a safe environment for cyclists.

Double-through-about

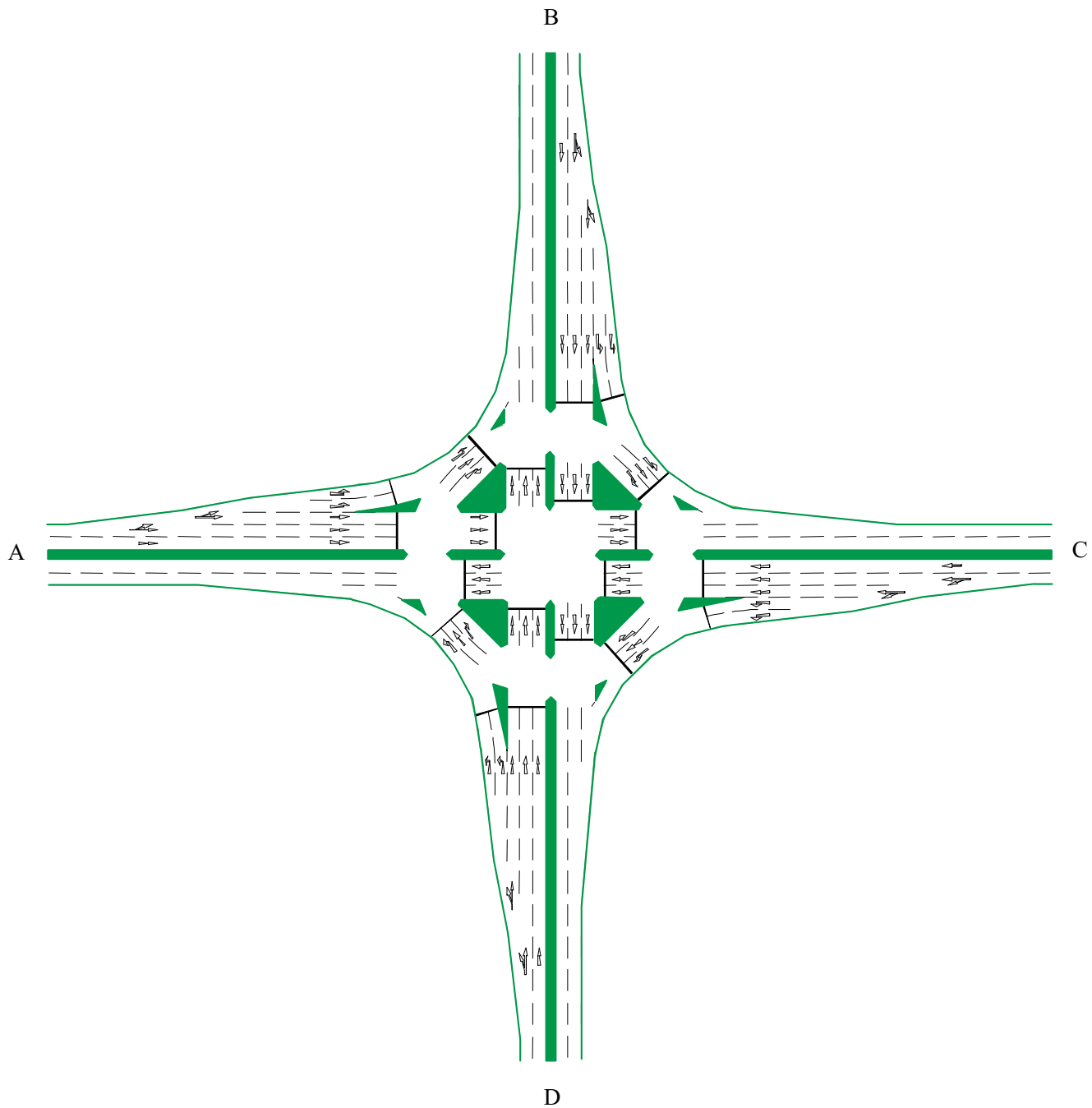


Figure 3/5: Double-Through-About

3.59 This junction is a development of the hamburger principle but with two conflicting traffic movements routed across the central island of the roundabout. It is also referred to as a “hot-cross-bun”. This type of junction is advantageous if the predominant movements are the two straight head flows since it reduces the conflicts on the circulatory carriageway. Traffic signal control is used at some or all of the resulting points of conflict. The same general comments apply to the double-through-about as to the through-about with some additional characteristics.

3.60 The two routes across the middle of the junction create short links in the centre. These links are likely to have limited capacity for storing queued traffic and as a consequence:

- a. a signal sequence that clears the central links of through traffic on a stage change away from these movements will be necessary;
- b. right turning traffic could benefit from turning right into the centre section after manoeuvring left at the first stop line.

3.61 The junction uses a large number of traffic signal heads and care is needed to avoid confusing indications. For further information refer to **TD 50 (DMRB 6.2.3)**.

3.62 Facilities for pedestrians and cyclists can be provided at double-through-about junctions but in practice this would involve a long circuitous route through the junction. These facilities would not be attractive. Therefore, they may not be well used. If there is a high volume of pedestrians and cyclists using a specific location then the double-through-about may not be the most appropriate junction type. In this case a simpler layout could be considered where greater priority can be given to pedestrians and cyclists or possibly incorporating a high quality grade-separated facility.

4. PRELIMINARY DESIGN AND TESTING

General

4.1 The aim of the preliminary design will be to produce a signal control strategy and geometric layout which, within the relevant constraints and cost benefit parameters, meets the performance requirements in the Design Year. The process will be an iteration of design, testing and optimisation.

4.2 The design will address the issues identified in the data gathering stage, one of the most important of which will be the actual and/or predicted traffic flows through the junction.

Choice of Layout

4.3 Chapter 3 and Annex A describe generic junction types and their likely relative performance. An initial geometric layout may need to be selected as a starting point for the design.

4.4 Where there is an existing junction at the site the chosen layout is likely to be developed from this and will need to address any problems that are presently occurring or predicted. If there is no existing junction at the site then predicted traffic movements will give important clues as to which type of junction is likely to be the most efficient.

4.5 It is possible that more than one layout will meet the design requirements and several options should be tested to ensure the optimal option is achieved in terms of the performance criteria identified in the appraisal summary as required by the Overseeing Organisation.

Lane Usage

4.6 The allocation of traffic lanes to the particular traffic movements will be an important element of the geometric design of any large signal controlled junction.

4.7 This allocation of traffic lanes applies not only to the entry stoplines but also to the traffic routes taken through the junction.

4.8 In the interests of safety, routes that require vehicles to weave or merge within the junction should be avoided. Ideally, traffic movements should be

directed to traffic lanes at the entry stoplines and the layout should enable vehicles to pass through the junction without changing lane.

4.9 The use of lane destination markings together with spiral lane markings on gyratory carriageways, are beneficial in reducing weaving and improving efficient traffic movement through the junction.

Stopline Saturation Flow

4.10 Stopline saturation flow is one of the main parameters affecting the operation of a signal controlled junction. In the context of signal controlled junction design, the stopline saturation flow is the rate at which queued traffic discharges across the stoplines during the green signal period.

4.11 The stopline saturation flows will determine the volume of traffic that should be able to move across the stoplines during each green right of way period in the signal cycle.

4.12 Methods have been determined for calculating the likely saturation flow at a stopline based on both the geometry of the traffic lanes feeding that stopline, and also the geometric paths of vehicles after they have passed that stopline.

4.13 These relationships are described in the TRRL Research Report RR 67. Some of the signal controlled junction assessment programs will derive these theoretical stopline saturation flows from the relevant geometric data.

4.14 For the purpose of preliminary geometric design it is recommended that a conservative value be used for the stopline saturation flows so that a high degree of confidence in the predicted performance of the junction is achieved when the junction is tested.

4.15 Predicted stopline saturation flows may not be achieved in practice for several reasons:

- traffic lanes may become blocked;
- local driver behaviour;
- flares on the approach lanes may not be used in the manner predicted.

4.16 The use of flared lanes in practice is considered in more detail below.

Capacity

4.17 A principal aim of the junction will be to provide sufficient capacity within the constraints of the particular site in order to meet or exceed the requirements of the junction in the design year.

4.18 The capacity of a junction is limited by its geometric layout and the initial design will be concerned with allocating sufficient traffic lanes to the various traffic movements to suit the signal sequence.

4.19 Some of these traffic lanes may extend only a short distance back from the stop line. These short lanes or “flares” are achieved by local widening of the carriageway. The concept of the flared approach is fundamental to the geometric design of large signal controlled junctions. The effect of flared approaches on capacity needs to be fully understood if the flares are to be designed effectively.

4.20 The purpose of the flared approach is to improve the capacity at the stoplines. The performance of the short traffic lanes will be affected by several factors:

- their length;
- their occupancy;
- whether or not the discharge from the flared lane is maintained over the green period.

4.21 A common cause of a junction failing to perform as predicted at the design stage is to assume that the saturation flow of the flared lane is constant over the green signal period. This will only be true if the green period is no longer than is required to discharge the queue in the flared lane. Once the queue in the flared lane has completely discharged then the flare ceases to contribute to the capacity of the stopline. This last point is important and is considered in more detail below.

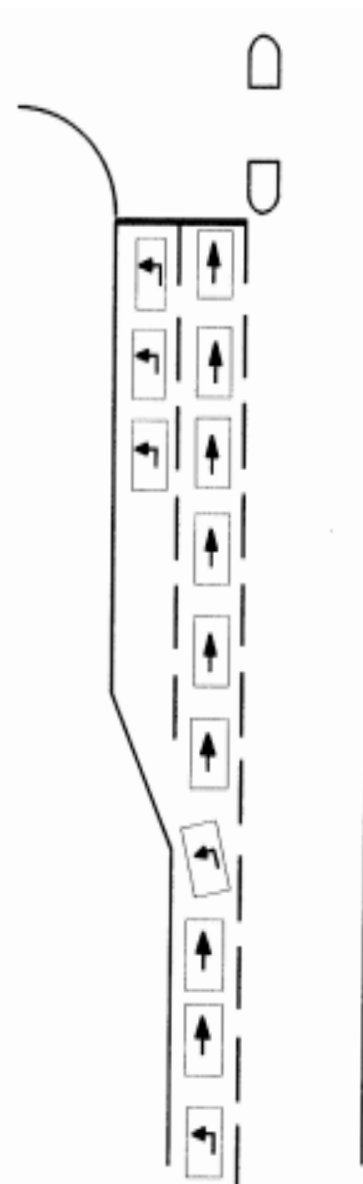


Figure 4/1: Typical Use of a Flared Approach

4.22 Figure 4/1 illustrates a common situation where a flared approach has been provided to form a dedicated left turn facility. The length of the left turn flare will usually have been chosen to accommodate site constraints or, in more favourable circumstances, the queue for the left turning traffic movement indicated from testing of the junction layout. In the example shown it can accommodate 6 pcus and is approximately 35 metres long.

4.23 The Figure illustrates how traffic conditions may result in a flare failing to deliver the expected capacity. The key factor is that after 6 pcus have queued in the

ahead lane, left turning vehicles will be prevented from entering the left turn flare. The actual number of pcus able to use the flare will therefore depend on the distribution of left turning vehicles in the traffic arriving at the junction.

4.24 If this distribution is 1 in 3 (ie 33% left turning traffic) then on average only 2 or 3 left turning vehicles will be able to enter the flare before it is blocked by traffic queuing in the ahead lane. While the actual arrival of left turning vehicles is a little more complex than in this simple analogy, it remains unlikely that over a period of time the flare will be able to deliver more than a proportion of its potential performance.

4.25 In this simple example the flare would need to be more than twice as long as originally estimated if the predicted 6 pcus are to be able to access it during the red signal period.

4.26 The consideration of flared approaches becomes more complex as the number of flared lanes and the traffic movements allocated to them is increased.

Testing

4.27 Once preliminary junction geometry has been identified it will be necessary to test both the design and the control strategy to assess its performance.

4.28 This Advice Note does not describe in detail the techniques for calculating the capacity of a signal-controlled junction. The basic techniques were originally published by Webster and Cobbe and described in the Ministry of Transport Road Research Technical Paper No. 56. 1966, Traffic Signals published by HMSO (No longer available).

4.29 There are several computer programs available which aid the assessment of the performance of traffic signal controlled junctions. They are all based on the relationships described by Webster and Cobbe and will give reliable estimates if they are used correctly.

4.30 Whether using either a manual or a computerised assessment technique, the model should accurately reflect both the geometry and the control strategy of the junction. The illustration of the left turn flare above is a good example of the care with which a model needs to be constructed if it is to give reliable results. Other factors that should be considered include:

- the actual performance of a left turning facility controlled by a give way sign;

- queues of opposed right turning traffic blocking an associated ahead traffic movement;
- reduction of stopline saturation flow after traffic in flares has discharged;
- the influence of the exit lane geometry on the traffic distribution on the entry lanes;
- the effect of pedestrian and cycle facilities;
- priority lanes.

4.31 Microprocessor based traffic signal controllers can make use of complex phase and stage structures to optimise capacity and flexibility at large signal controlled junctions. If the junction design uses these techniques the model will need to reflect them.

5. REFERENCES

Cyclists

1. Design Manual for Roads and Bridges, Volume 5 Assessment and Preparation of Road Schemes, Section 2 Preparation and Implementation, Part 4, TA 67/95 Providing for Cyclists.
2. Design Manual for Roads and Bridges, Volume 6 Road Geometry, Section 3 Highway Features, Part 3, TA 57/87 Roadside Features.
3. Local Transport Note (1/86) - Cyclists at Road Crossings and Junctions.
4. Traffic Advisory Leaflet (8/93) - Advanced Stop Lines for Cyclists.
5. Traffic Advisory Leaflet (4/01) - Cycling Bibliography.
6. Traffic Advisory Leaflet (4/98) - Toucan Crossing Development.
7. Traffic Advisory Leaflet (10/93) "Toucan" an Unsegregated Crossing for Pedestrians and Cyclists.
8. Cycling Advice Note (1/89).
9. Cycling Advice Note (1/90).
10. Cycle-Friendly Infrastructure Guidelines for Planning and Design, The Bicycle Association 1996.
11. The National Cycle Network Guidelines and Practical Details, Issue 2, Sustrans, March 1997.
14. Local Transport Note (1/95) - The Assessment of Pedestrian Crossings.
15. Local Transport Note (2/95) - The Design of Pedestrian Crossings.
16. Disability Unit Circular (1/91).
17. Guidance on the Use of Tactile Paving Surfaces.
18. Traffic Advisory Leaflet (4/91) Audible and Tactile Signals at Pelican Crossings.
19. Traffic Advisory Leaflet (5/91) Audible and Tactile Signals at Signal Controlled Junctions.
20. Statutory Instruments 1997 No. 2400 ROAD TRAFFIC. The Zebra, Pelican and Puffin Pedestrian Crossings Regulations and General Directions 1997.
21. Guidelines for Providing for Journeys on Foot, The Institution of Highways & Transportation.
22. Local Transport Note (2/95) Design of Pedestrian Crossings.
23. Traffic Advisory Leaflet (4/91) Audible and Tactile Signals at Pelican Crossings.

Tramways

24. Railway Safety Principles and Guidance part 2 section G.

There may be variations between Local Authorities in the interpretation of the advice contained in the above document and it is important that when such facilities are being considered at a junction, they should conform in style and technique with local practices.

It is recommended that consultation with the appropriate Local Authority be established at an early stage to assist the design of suitable facilities.

Pedestrians

12. Design Manual for Roads and Bridges, Volume 8 Traffic Signs and Lighting, Section 1 Traffic Signs and Control Equipment, Part 1, TA 15/81 Pedestrian Facilities at Traffic Signal Installations.
13. Design Manual for Roads and Bridges, Volume 6 Road Geometry, Section 3 Highway Features, Part 3, TA 57/87 Roadside Features.

Signal Controlled Junctions

- 25 TRRL Research Report RR67 - The prediction of saturation flows for road junctions controlled by traffic signals.
- 26 TRRL Research Report RR170 - "MOVA": Traffic responsive, self-optimising signal control for isolated intersections.
- 27 The Sheepscar signal system: an alternative approach to signal design. - M S Hallworth, Traffic Engineering and Control, August 1983.
- 28 Traffic Advisory Leaflet (5/91) Audible and Tactile Signals at Signal Controlled Junctions.

Roundabouts

- 29 Design Manual for Roads and Bridges, Volume 6 Road Geometry, Section 2 Junctions, Part 3, TD 50/99 The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts.
- 30 Design Manual for Roads and Bridges, Volume 6 Road Geometry, Section 2 Junctions, Part 3, TD 78/97 Design of Road Markings at Roundabouts.
- 31 Design Manual for Roads and Bridges, Volume 6 Road Geometry, Section 2 Junctions, Part 3, TD 16/93 Geometric Design of Roundabouts.
- 32 State of the Art Review - The Design of Roundabouts - Mike Brown, TRL.
- 33 "Sig-nabout" - The Development and Trial of a Novel Junction Design - P J Webb, Road Traffic Monitoring and Control, Conference Publication No.391.
- 34 Signalling roundabouts - 1. Circular arguments. - M S Hallworth, Traffic Engineering and Control, June 1992.
- 35 Traffic signal control of roundabouts. - P Davies, Traffic Engineering and Control, July 1980.

Computer Software

- 36 OSCADY (Optimised Signal Capacity and Delay) - TRRL computer program for the assessment of isolated traffic signal controlled junctions.
- 37 LINSIG - JCT Consultancy Traffic Signal Design and Analysis Program.
- 38 TRANSYT - TRRL computer program for determining and studying optimum fixed time, co-ordinated, traffic signal timings for a network.
- 39 TRRL Research Report RR274 - The use of TRANSYT at signalised roundabouts.
- 40 TRRL Research Report RR888 - User guide to TRANSYT version 8.
- 41 Application Guide 8 - TRANSYT/9 Users Manual - Transport and Road Research Laboratory.
- 42 Application Guide 28 - TRANSYT/10 User Guide - Transport and Road Research Laboratory.

General

- 43 Road Research Technical Paper 56. - F Webster and B Cobbe, HMSO, 1966. (Out of Print).
- 44 Transport in the Urban Environment, The Institution of Highways & Transportation, June 1997.
- 45 Guidelines for Planning for Public Transport in Developments, The Institution of Highways & Transportation, March 1999.
- 46 Statutory Instruments 1997 No.2400 ROAD TRAFFIC. The Zebra, Pelican and Puffin Pedestrian Crossings Regulations and General Directions 1997.
- 47 Highways Agency CODE OF PRACTICE CONSULTANCY Revised Code of Practice Sections 1 to 5. Issue 4. December 1997. Oscar Faber.

6. ENQUIRIES

All technical enquiries or comments on this Advice Note should be sent in writing as appropriate to:

Divisional Director
The Highways Agency
Romney House
43 Marsham Street
London
SW1P 3PY

A Pickett
Divisional Director

Chief Road Engineer
Scottish Executive Development Department
Victoria Quay
Edinburgh
EH6 6QQ

J HOWISON
Chief Road Engineer

Chief Highway Engineer
Transport Directorate
Welsh Assembly Government
Llywodraeth Cynulliad Cymru
Crown Buildings
Cardiff
CF10 3NQ

J R REES
Chief Highway Engineer
Transport Directorate

Assistant Director of Engineering
Department for Regional Development
Roads Service
Clarence Court
10-18 Adelaide Street
Belfast BT2 8GB

D O'HAGAN
Assistant Director of Engineering

ANNEX A: RELATIVE JUNCTION PERFORMANCE

General

1. The aim of this Annex is to comment further on the characteristics and relative performance of the junction layouts described in Chapter 3. It is intended that this information will help in the initial selection of junction layouts for preliminary design and testing.

2. The annex also contains a suggested process for selecting junction layouts in the form of a matrix of principal junction characteristics.

Relative performance

3. The performance of each of the generic junction types described in Chapter 3 has been tested (using the appropriate junction simulation programs) in the circumstances where two roads meet in the form of a four arm junction accommodating all traffic movements. The 24 groups of traffic flows described in Annex B were passed through each of the junctions. The geometry of the junctions was symmetrical and remained constant for each test. No attempt was made to optimise the layouts for the varying traffic conditions.

4. To simplify the test procedure fixed cycle times and stylised junction layouts based on the figures in Chapter 3 were used. The simple assumption was made that the various traffic movements would use available traffic lanes equally.

Cycle times

5. Each of the gyratory (see section on Definitions, Annex D) junctions was assumed to be approximately 80 metres in diameter. This was considered to be about the smallest practical size that will accommodate four signalled arms. A cycle time of 60 seconds was chosen as being a general cycle time most likely to represent the optimum for gyratory junctions of this size.

6. A cycle time of 60 seconds was also used for the Sig-nabout.

7. The crossroads was tested with a cycle time of 90 seconds. This was chosen as representing the most often used maximum cycle time for single node junctions.

8. It should be stressed that the tests were intended to give an indication of the relative performance of the junctions under fixed conditions. In most cases the actual best reserve capacity that might be achieved on a particular layout will be found by optimising the design.

Method of assessment

9. The following methods for analysing junctions are given as suggestions only. Whilst manual methods of analysis can be used, the use of software where appropriate would generally be preferred and the methods available are discussed.

Single Node Intersections (Crossroads, T-junction etc)

10. These junctions are straightforward to model because traffic passes through only one stop line and there are no co-ordination problems to take into account. Hence, computer programs such as OSCADY and LINSIG are ideal for modelling junctions of this nature. However, the effect of any flaring on the approaches and merging on the exits needs to be taken into account. LINSIG can be used for almost any junction configuration whereas OSCADY is limited to a maximum of four arms.

Sig-nabout

11. Whilst the Sig-nabout can be considered as a single node intersection, it has one property which makes it difficult to model. This relates to the dual right turn lanes that are opposed. Both LINSIG and OSCADY can be used to assess this type of junction.

Signalised Roundabouts

12. With the exception of a new generation of software that works on micro simulation traffic analysis, there is no software currently available that accurately predicts traffic behaviour at signalised roundabouts. This new generation of software has not been discussed here because it was not used to test the generic junction types assessed in this section. Whilst the software for single intersections (LINSIG & OSCADY) will predict conditions at a specific node, it will not give any predictions as to how the nodes are to

be co-ordinated. The only software available to do this is TRANSYT - written specifically to optimise signal timings on a network.

13. A best approach using TRANSYT is to first construct a lane/flow diagram that indicates what traffic is using which lane on both the entry and circulatory arms. Once assembled, these can be used to directly specify the major/minor shared link structure that will ensure accurate portrayal of entry/exit movements throughout the roundabout. Weightings often need to be applied that constrain internal queuing and also promote safe platoon progression through the roundabout. The TRANSYT results should be very carefully checked for circulatory queuing that might block-back, and also to confirm achievement of satisfactory platoon progression through the roundabout. The printing and studying of the TRANSYT graphs provides a vital aid for this checking exercise. In practice, signalled roundabouts work best when the timings are co-ordinated for safety and 'good progression' reasons, rather than simply for minimum delay. Accordingly, since TRANSYT is designed to produce timings that minimise delay, further adjustment of applied weightings may be necessary to maximise capacity. The latter is often a requisite in congested conditions.

14. Working from the lane/flow diagrams described above, an alternative approach to using TRANSYT is to apply manual calculation techniques to derive initial timings and then adjust the offsets iteratively until there is an acceptable answer with respect to safety and capacity.

Through-about & Double-through-about

15. LINSIG has the capability to resolve co-ordination problems by the control strategy. If the appropriate clearout times are included in the design, then the junction can be considered as a single node intersection. TRANSYT would have the added benefit of being able to predict delays more accurately for traffic stopped at internal stop lines.

Compound Signal Junctions

16. The compound signalised junction has several nodes and as a signalled roundabout it can be modelled using TRANSYT. If the co-ordination is fixed for integrity reasons it may be feasible to use LINSIG or OSCADY to model the individual nodes. However, TRANSYT may still be required to assess the overall junction delays. Since the critical part of the junction

design is in the determination of numbers of lanes, it would seem sensible to use LINSIG or OSCADY to establish this on a node by node basis. Then, if necessary, use TRANSYT to assess co-ordination and linking. The crucial stage in the design will be to ensure that each individual junction has adequate capacity, an assessment of this can be carried out using LINSIG or OSCADY. The linking can either be carried out manually or by careful use of TRANSYT.

Junctions Assessed

17. The junctions were assessed using proprietary traffic signal assessment programs. TRANSYT was used for the multi-node junctions. It is at present the only program that can assess and optimise linked signal networks. LINSIG was used for the single node junctions as it simulates the operation of TR 0141 specification microprocessor based traffic signal controllers. A new generation of micro simulation programs are becoming more widely available.

Results

18. The results of the tests in terms of both practical reserve capacity and delay are shown on Figure A/1.

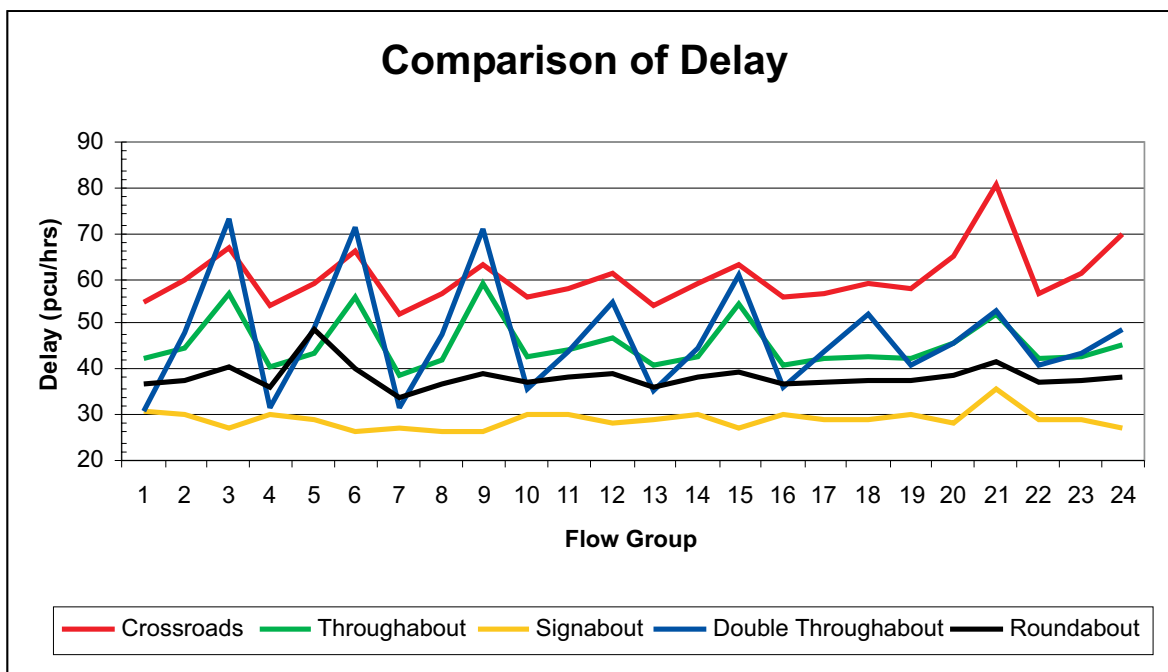
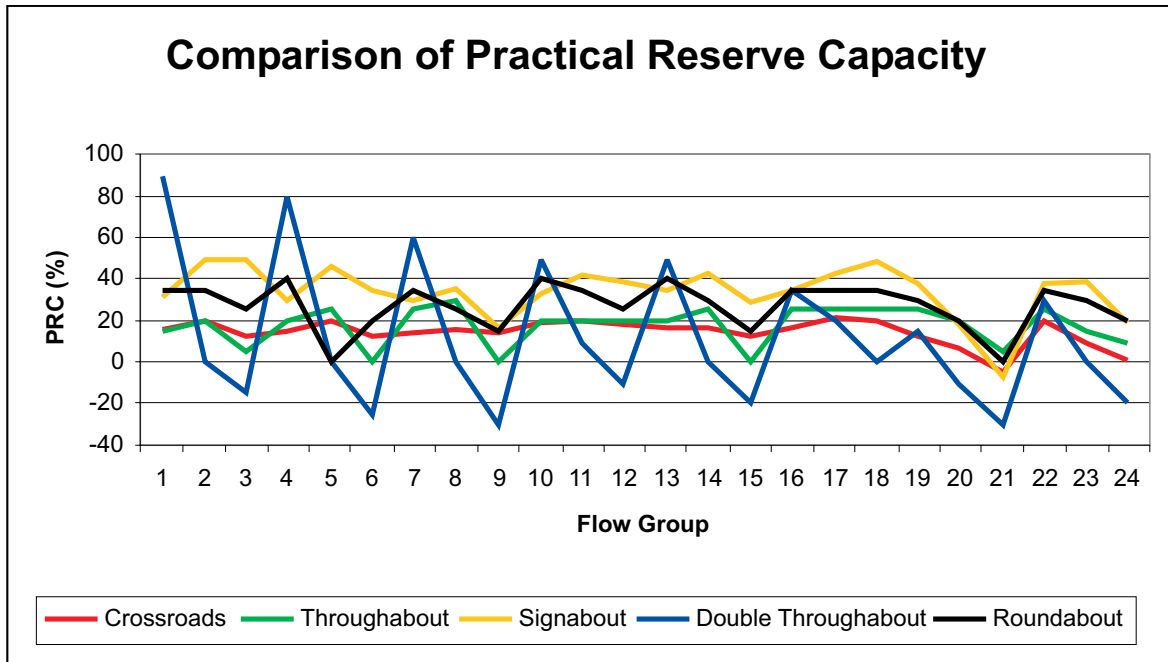


Figure A/1: Comparison of Relative Practical Reserve Capacity and Delay

Initial Selection

19. It is likely that the initial selection will be between a single node layout such as a signalled cross roads or the Sig-nabout, and some form of multi-node roundabout gyratory system.

20. The through-about and double-through-about junctions are most likely to be considered as specific modifications if the initial testing indicates these layouts may suit the specific conditions.

21. The principal considerations in the decision process are likely to be:

- Capacity;
- Geometry;
- Number of arms needed at the junction;
- Vehicle speeds;
- Pedestrian and cycle facilities;
- U turn manoeuvres;
- Right turn manoeuvres;
- Driver comprehension;
- Public transport provision.

Capacity (under test conditions)

Crossroads: the capacity is relatively stable and assumes fully signalled right turns.

Roundabout: the capacity is likely to be higher than a crossroads but more sensitive to variations in turning movements. The test conditions assume optimum lane use. The capacity of the roundabout is sensitive to lane use patterns, particularly on the circulatory carriageway.

Sig-nabout: likely to return highest capacity of the three junction types.

Geometry

Crossroads: likely to result in the most compact footprint at the intersection but may require longer flares on the approaches.

Roundabout: likely to result in the largest footprint at the intersection.

Sig-nabout: with its short cycle time the junction must make use of short, wide flares at the intersection.

Number of arms

Crossroads: 4 arms are considered to be the practical maximum as more will require additional stages in the cycle which will quickly erode the capacity.

Roundabout: can accommodate more than four arms. Signal co-ordination becomes more difficult as the number of signalised arms increases.

Sig-nabout: this junction can only be used with 4 arm intersections.

Vehicle speeds

Crossroads: there is no natural speed reducing geometry on the ahead traffic movement.

Roundabout: the geometry of the junction naturally results in a tendency for vehicle speeds to reduce on the approaches.

Sig-nabout: ahead traffic tends to be slowed by the deflection provided, but the uncontrolled, gap seeking nature of the right turns means the junction must not be used on high speed roads.

Pedestrian and cycle facilities

22. The question of pedestrian and cycle facilities in respect of the various types of junction has been considered in Chapter 3.

U turn manoeuvres

Crossroads: U-turn manoeuvres cannot be accommodated at the point of conflict. However, observations show that they do occur and banning such movements can create problems with enforcement and safety elsewhere in the network.

Roundabout: U-turn manoeuvres are accommodated.

Sig-nabout: U-turn manoeuvres cannot be accommodated at the point of conflict.

Right turn manoeuvres

Crossroads: Right turn manoeuvres can be fully signalled at the point of conflict.

Roundabout: Right turn manoeuvres are carried out using the circulatory carriageway. The conflicts are dispersed spatially at the intermediate nodes.

Sig-nabout: Right turn manoeuvres are uncontrolled and opposed. They are carried out in 2 lanes during the intergreen period and through gaps in the opposing traffic.

Driver comprehension

Crossroads: common form of junction control that is well understood.

Roundabout: common form of junction control that is well understood.

Sig-nabout: unusual form of junction control. Drivers may misunderstand the uncontrolled nature of the right turns.

These principal characteristics are summarised in Table A-1 on the following page.

Principal Characteristics	Signal Controlled Crossroads	Signalised Roundabout or Gyratory	Sig-nabout
Capacity	Must be determined by testing	Must be determined by testing	Likely to have highest capacity at short cycle times
Geometry	Smaller footprint than gyratory but may use longer approach flares	Generally largest footprint	Similar local footprint to crossroads with short local flares
No. of arms	Practical maximum of 4 at point of conflict	Can accommodate more than 4 arms	Must use 4 arms
Vehicle speeds	Generally no deflection to slow ahead traffic movements. Should not be used where approach speeds are high	Speed reduction is inherent in the geometry of the junction	Some deflection to slow down ahead movements. Should not be used where approach speeds are high
Pedestrian & cycle	At-grade facilities can be provided but can reduce capacity	At grade measures often require numerous crossing points. If there are high volumes of pedestrians and cyclists and high traffic speeds then segregation should be considered	Difficult to provide at grade pedestrian crossing facilities
U turn facility	No	Yes	No
Right turn provision	Fully controlled right turns can be provided	Right turn conflicts are resolved geometrically	Right turns are gap seeking in 2 lanes
Driver comprehensibility	Good	Good	Possible confusion over right turn control

Table A-1 Principal junction characteristics

23. The relative performance of the remaining junction layouts are considered below.

Through-about

24. Consideration of a through-about is most likely to arise as a further test of a signalised roundabout in circumstances where there is a dominant traffic movement across the junction on the major road.

25. Figure A/1 may give the impression that the through-about does not perform as well as the signalised roundabout. The lower performance is due in part to an assumption that the control strategy would clear through traffic from the central links in both directions before giving right of way to the circulatory carriageway. This would ensure maximum storage space for any vehicles turning right into the central links from the circulatory carriageway.

26. If the clear out period is removed in one or both directions then lost time will be reduced and capacity may be improved. It is inevitable that some through traffic will be stopped in the internal links and in this situation consideration will need to be given to storage space for any vehicles turning right into the central links from the circulatory carriageway.

27. For small through-about the clear out period may be important from a safety point of view as drivers will not expect to be stopped at a close second stopline. As the through-about becomes larger, stopping the tail end of a platoon in the central links becomes less of a problem as the reservoir space becomes greater.

28. For large through-about with a central link in the range of 200 metres or more, co-ordination may not be necessary because the two nodes can be treated as separate junctions. In these situations the co-ordination

and capacity of the whole junction may become more important than the co-ordination through the link.

29. Where there is no clear out period, and/or when vehicles turn right into the central links from the circulatory carriageway, consideration will also need to be given to the starting co-ordination of the nodes controlling the central links.

30. The through-about exhibits the following general junction characteristics in addition to those of the signalised roundabout:

- the natural deflection provided by the roundabout is removed from the traffic on the through links consequently vehicle speeds may not be reduced;
- the right turn from the traffic streams using the central links is carried out using the circulatory carriageway;
- these junctions are not common and drivers may not easily understand the nature of the right turn from the traffic streams using the central links.

Double-through-about

31. The double-through-about gives very good performance with flow groups with low turning movements but this deteriorates rapidly as turning movements increase. The junction could be considered where the traffic patterns show dominant movements across the junction from all four arms.

32. The short central links have limited storage space for queuing traffic and a control strategy of clearing the central links of through traffic on stage changes is important.

33. This junction is unique and drivers may not easily understand the nature of the right turn from the traffic streams using the central links.

Modifications or Hybrids

34. The junction testing may suggest options that are modifications to the generic layouts and result in Hybrids with some of the features of several junctions. Some examples are given below:

Signal Controlled Crossroads

35. **Double node crossroads.**

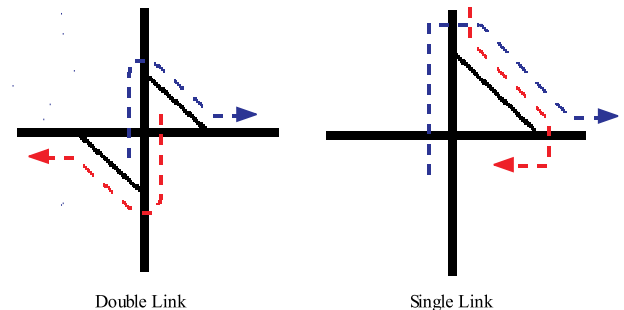


Figure A/2: Double Node Crossroads

In this modification the single node has been stretched along the axis of one of the arms to form a two-node junction. The feature of this arrangement is that a reservoir is formed into which right turning traffic can move and stack while their parent traffic streams have right of way. These vehicles then clear the junction when the two opposing arms gain right of way. An example of this technique is illustrated in Annex C.

Signalised Roundabout

36. **Bypassed node.**

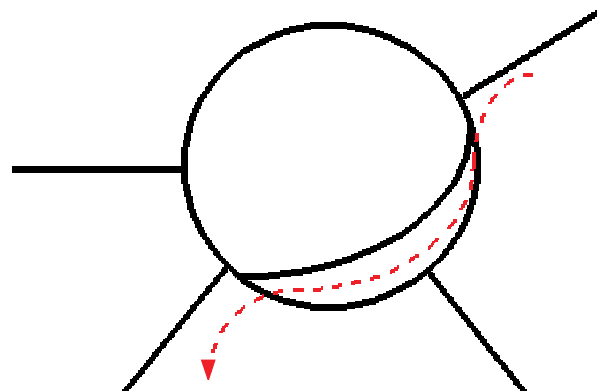


Figure A/3: Bypassed Node

Here a critical stream has been routed past one of the nodes on the circulatory carriageway by constructing a link in the central island. An example of this technique is illustrated in Annex C.

Through-about

37. **Half Through-about.**

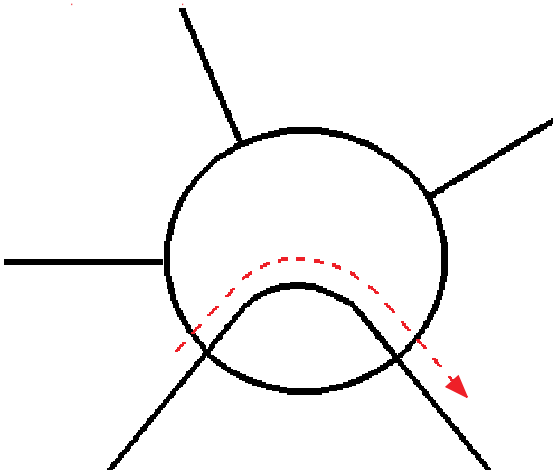


Figure A/4: Half Through Node

In this modification a critical stream has been routed across the central carriageway by means of a one way link. An example of this technique is illustrated in Annex C.

38. It can be seen from the above options and the practical examples in Annex C that a solution to a specific situation may incorporate a combination of features from several of the generic junction types in the form of a hybrid, and a flexible approach to the selection and design process will often result in a satisfactory conclusion.

ANNEX B: TRAFFIC FLOW GROUPS USED FOR CAPACITY TESTS

General

This annex details the traffic flows which were used to test the junction layouts described in Chapter 3.

The Flow Sets

Each of the tests was carried out with a total inflow to the junction of 6000 vehicles. This represented a typical peak hour traffic flow through a semi-urban crossroads. These 6000 vehicles were allocated to the approach arms in eight sets of traffic flows. Each of these eight sets allocated traffic to the approach arms in different proportions.

The Flow Groups

Each of the eight flow sets was then further sub-divided into three flow groups. Each of these flow groups presents the junctions with varying proportions of turning traffic.

Each junction was therefore tested with 24 groups of traffic flows each representing a different pattern of traffic movements between the four approach arms.

While the possible combinations of traffic movements through a four-arm junction are numerous, the flow sets used cover most of the situations likely to occur in practice.

The results of the tests are discussed in Annex A.

Figure B/1 shows all of the flow groups in greater detail.

Set 1

Traffic flow into junction	Flow Group 1	Flow Group 2	Flow Group 3
B 1500 ↓ A → 1500 ← C ↑ 1500 D	10% 80% 10% ↓ ↓ ↓ 10% ↑ 10% 80% → ← 80% 10% ↓ 10% 10% 80% 10% ↓ ↓ ↓	20% 60% 20% ↓ ↓ ↓ 20% ↑ 20% 60% → ← 60% 20% ↓ 20% 20% 60% 20% ↓ ↓ ↓	30% 40% 30% ↓ ↓ ↓ 30% ↑ 30% 40% → ← 40% 30% ↓ 30% 30% 40% 30% ↓ ↓ ↓

Set 2

Traffic flow into junction	Flow Group 4	Flow Group 5	Flow Group 6
B 1200 ↓ A → 1800 ← C ↑ 1200 D	10% 80% 10% ↓ ↓ ↓ 10% ↑ 10% 80% → ← 80% 10% ↓ 10% 10% 80% 10% ↓ ↓ ↓	20% 60% 20% ↓ ↓ ↓ 20% ↑ 20% 60% → ← 60% 20% ↓ 20% 20% 60% 20% ↓ ↓ ↓	30% 40% 30% ↓ ↓ ↓ 30% ↑ 30% 40% → ← 40% 30% ↓ 30% 30% 40% 30% ↓ ↓ ↓

Set 3

Traffic flow into junction	Flow Group 7	Flow Group 8	Flow Group 9
B 900 ↓ A → 2100 ← C ↑ 900 D	10% 80% 10% ↓ ↓ ↓ 10% ↑ 10% 80% → ← 80% 10% ↓ 10% 10% 80% 10% ↓ ↓ ↓	20% 60% 20% ↓ ↓ ↓ 20% ↑ 20% 60% → ← 60% 20% ↓ 20% 20% 60% 20% ↓ ↓ ↓	30% 40% 30% ↓ ↓ ↓ 30% ↑ 30% 40% → ← 40% 30% ↓ 30% 30% 40% 30% ↓ ↓ ↓

Set 4

Traffic flow into junction	Flow Group 10	Flow Group 11	Flow Group 12
B 1500 ↓ A → 1500 ← C ↑ 1500 D	10% 80% 10% ↓ ↓ ↓ 15% ↑ 15% 70% → ← 70% 15% ↓ 15% 10% 80% 10% ↓ ↓ ↓	20% 60% 20% ↓ ↓ ↓ 15% ↑ 15% 70% → ← 70% 15% ↓ 15% 20% 60% 20% ↓ ↓ ↓	30% 40% 30% ↓ ↓ ↓ 15% ↑ 15% 70% → ← 70% 15% ↓ 15% 30% 40% 30% ↓ ↓ ↓

Figure B/1: Flow Groups Used in Capacity Tests (Page 1)

Set 5

Traffic flow into junction	Flow Group 13	Flow Group 14	Flow Group 15
<p style="text-align: center;">B</p> <p style="text-align: center;">1200</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">A C</p> <p style="text-align: center;">1800 → ← 1800</p> <p style="text-align: center;">↑</p> <p style="text-align: center;">1200</p> <p style="text-align: center;">D</p>	<p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">10% ↑ ↑ 10%</p> <p style="text-align: center;">80% → ← 80%</p> <p style="text-align: center;">10% ↓ ↓ 10%</p> <p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↑</p>	<p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">20% ↑ ↑ 20%</p> <p style="text-align: center;">60% → ← 60%</p> <p style="text-align: center;">20% ↓ ↓ 20%</p> <p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↑</p>	<p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">30% ↑ ↑ 30%</p> <p style="text-align: center;">40% → ← 40%</p> <p style="text-align: center;">30% ↓ ↓ 30%</p> <p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↑</p>

Set 6

Traffic flow into junction	Flow Group 16	Flow Group 17	Flow Group 18
<p style="text-align: center;">B</p> <p style="text-align: center;">1200</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">A C</p> <p style="text-align: center;">1800 → ← 1800</p> <p style="text-align: center;">↑</p> <p style="text-align: center;">1200</p> <p style="text-align: center;">D</p>	<p style="text-align: center;">10% 80% 10%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">15% ↑ ↑ 15%</p> <p style="text-align: center;">70% → ← 70%</p> <p style="text-align: center;">15% ↓ ↓ 15%</p> <p style="text-align: center;">10% 80% 10%</p> <p style="text-align: center;">↑</p>	<p style="text-align: center;">20% 60% 20%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">15% ↑ ↑ 15%</p> <p style="text-align: center;">70% → ← 70%</p> <p style="text-align: center;">15% ↓ ↓ 15%</p> <p style="text-align: center;">20% 60% 20%</p> <p style="text-align: center;">↑</p>	<p style="text-align: center;">30% 40% 30%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">15% ↑ ↑ 15%</p> <p style="text-align: center;">70% → ← 70%</p> <p style="text-align: center;">15% ↓ ↓ 15%</p> <p style="text-align: center;">30% 40% 30%</p> <p style="text-align: center;">↑</p>

Set 7

Traffic flow into junction	Flow Group 19	Flow Group 20	Flow Group 21
<p style="text-align: center;">B</p> <p style="text-align: center;">1200</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">A C</p> <p style="text-align: center;">1800 → ← 1800</p> <p style="text-align: center;">↑</p> <p style="text-align: center;">1200</p> <p style="text-align: center;">D</p>	<p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">15% ↑ ↑ 15%</p> <p style="text-align: center;">65% → ← 70%</p> <p style="text-align: center;">20% ↓ ↓ 15%</p> <p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↑</p>	<p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">15% ↑ ↑ 15%</p> <p style="text-align: center;">55% → ← 70%</p> <p style="text-align: center;">30% ↓ ↓ 15%</p> <p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↑</p>	<p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">15% ↑ ↑ 15%</p> <p style="text-align: center;">45% → ← 70%</p> <p style="text-align: center;">40% ↓ ↓ 15%</p> <p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↑</p>

Set 8

Traffic flow into junction	Flow Group 22	Flow Group 23	Flow Group 24
<p style="text-align: center;">B</p> <p style="text-align: center;">1200</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">A C</p> <p style="text-align: center;">1800 → ← 1800</p> <p style="text-align: center;">↑</p> <p style="text-align: center;">1200</p> <p style="text-align: center;">D</p>	<p style="text-align: center;">20% 65% 15%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">15% ↑ ↑ 15%</p> <p style="text-align: center;">70% → ← 70%</p> <p style="text-align: center;">15% ↓ ↓ 15%</p> <p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↑</p>	<p style="text-align: center;">30% 55% 15%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">15% ↑ ↑ 15%</p> <p style="text-align: center;">70% → ← 70%</p> <p style="text-align: center;">15% ↓ ↓ 15%</p> <p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↑</p>	<p style="text-align: center;">40% 45% 15%</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">15% ↑ ↑ 15%</p> <p style="text-align: center;">70% → ← 70%</p> <p style="text-align: center;">15% ↓ ↓ 15%</p> <p style="text-align: center;">15% 70% 15%</p> <p style="text-align: center;">↑</p>

Figure B/1: Flow Groups Used in Capacity Tests (Page 2)

ANNEX C: COMPOUND SIGNAL CONTROLLED JUNCTIONS

1. A Compound Signal Controlled Junction (CSCJ) can be defined as a group of separate, but inter-related, 'simple' signal controlled junctions. A signalised roundabout could be considered as a special case of a CSCJ. Most of the junctions considered so far fit into a particular generic type of either a crossroads or a form of gyratory. The CSCJ can be any combination of simple junctions arranged to suit both topography and desire lines. There are three fundamental principles involved in the design of a CSCJ which are briefly described as follows:

i. **All major traffic conflicts signalised**

In order to optimise capacity and safety, all major traffic conflicts should be signalised. Light traffic movements, which would typically only require a very short green, could be controlled under a 'give way', thereby reducing the number of individual junctions.

ii. **Minimum conflicts at a single junction**

The capacity of any given approach to the junction is a direct function of green time and number of lanes. If the number of conflicts can be minimised at each individual node, green time can be maximised and the cycle time can be kept to a minimum. Hence, it is desirable to reduce the number of conflicts at each junction to two.

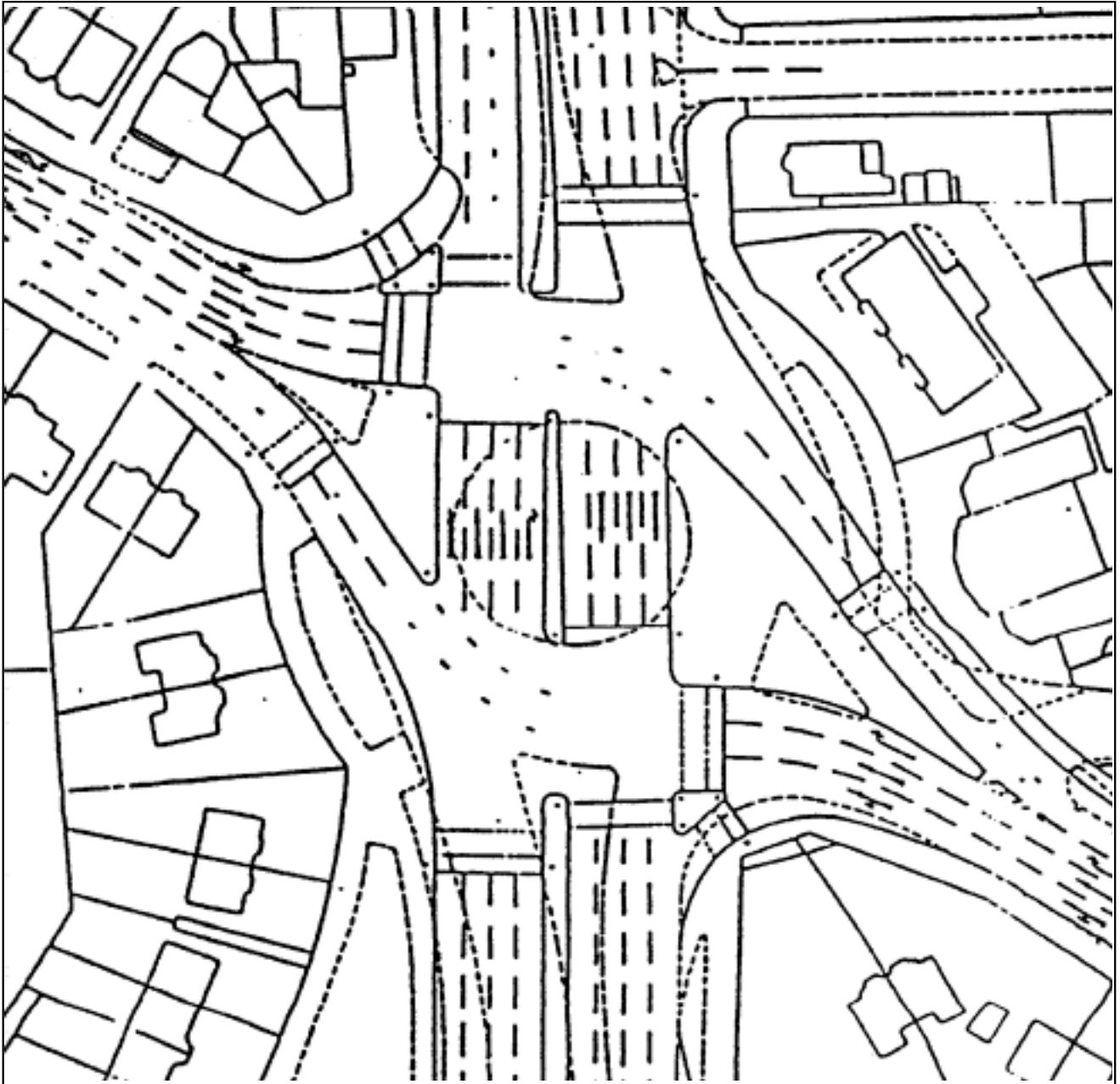
iii. **Majority flows given the most direct route**

It is important that the majority flows are given a direct route through the junction to minimise delay and keep saturation flows to a maximum. The minority flows may need to be diverted to enable the number of conflicting movements at any one individual junction to be kept to a minimum.

iv. **Co-ordination and safety relationships**

The co-ordination of closely spaced signal controlled junctions is a vital factor in the performance and safety of the overall junction. Front and tail end co-ordination must be considered carefully when linking the individual junctions. Once established, it may not be desirable to alter the sequence beyond defined limits and it may be necessary to protect the sequence integrity.

2. There are many CSCJs around the UK that may consist of two or three small junctions. The large purpose built CSCJs which cater for five or more intersecting arms are few in number but are increasing. West Yorkshire built the first major CSCJ (Sheepscar) in the mid 1980s which consists of seven junctions. They have recently added another on the Leeds Inner Ring Road.



**Figure C/1: Two Node Crossroads Between Western Boulevard and Nuttall Road
in Nottingham**

3. This “stretched” two node crossroads was a conversion of an original roundabout. The crossroads was stretched to create a high capacity storage reservoir in the centre of the junction to accommodate right turning traffic from two of the arms.

4. The layout allows these two right turns to occur in parallel with their parent traffic streams.



Figure C/2: Half Through-About - Sherwin Arms, Nottingham

5. This “partial through-about” signalised junction design was converted from a conventional five arm roundabout.
6. The route through the centre of the junction carries traffic in one direction only and the junction does not incur the lost time generated by the central link

clearance period associated with a conventional hamburger junction.

7. A feature of the junction is that traffic on the main A52 Trunk Road makes a dog leg movement through the roundabout. Only the conflicts with the A52 are signalised, with the other three arms operating under priority control.

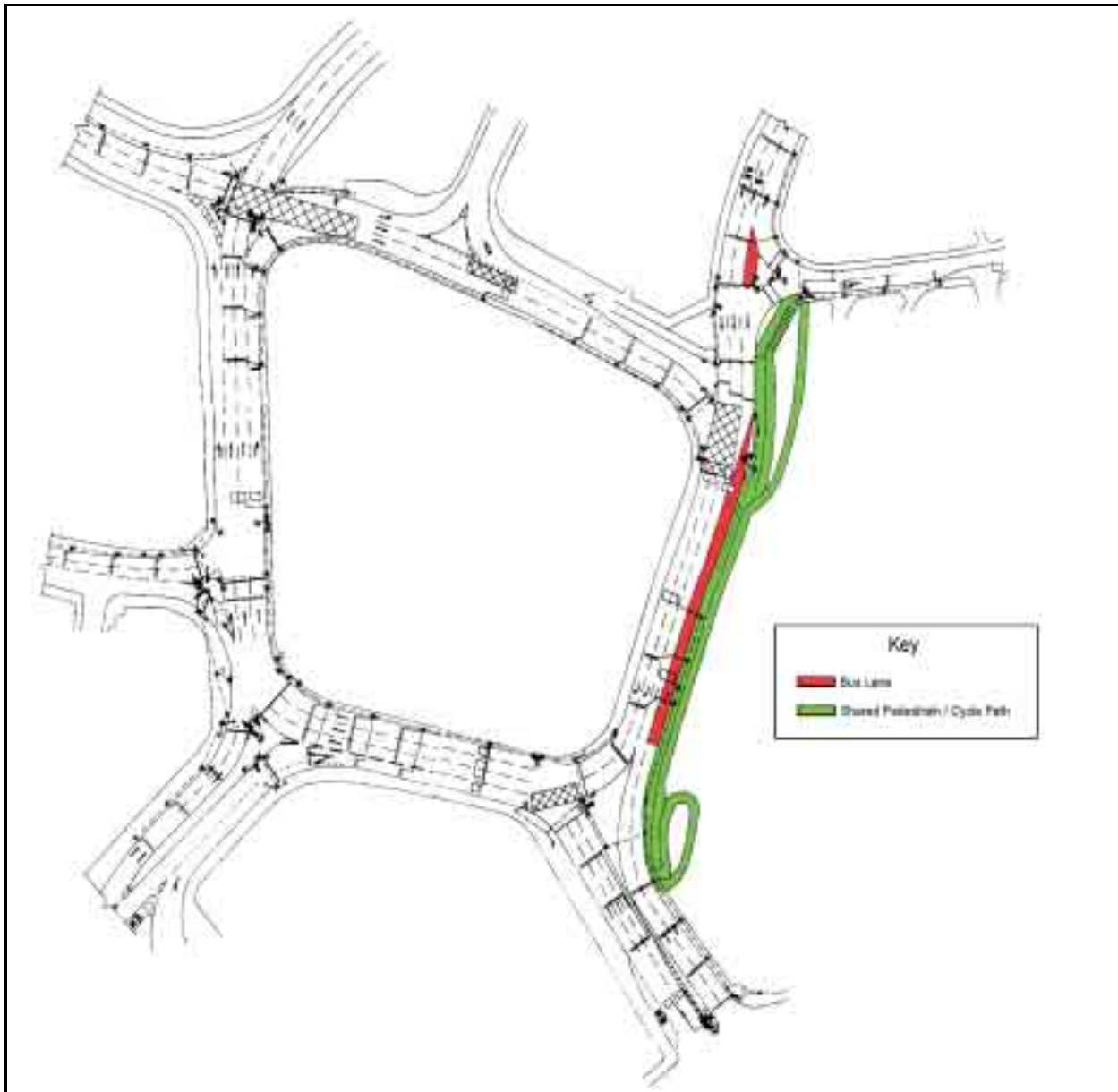


Figure C/3: Traffic Signal Controlled Gyratory - Exe Bridges in Exeter

8. This traffic signal controlled gyratory has been modified to incorporate a bus/lorry lane and shared cycle/pedestrian facility.

9. The bus/lorry lane, shown in red on the plan has been incorporated at the expense of an existing traffic lane reducing the circulatory carriageway from 4 to 3 lanes on the east of the junction. The shared cycle/pedestrian facility has been segregated from the road using pedestrian guard railing and connects to the subways running under the gyratory.

ANNEX D: DEFINITIONS

General

1. This Annex defines the principal terms and concepts which are used in the geometric design of large signal controlled junctions.
2. The definitions published in this document are in addition to those detailed in **TD 50 (DMRB 6.2.3)**.

Definitions:

All Red	All sets of signal heads display red simultaneously stopping all vehicular traffic – may be used to allow pedestrians to cross a junction.	Filter Arrow	The electrical circuit that controls a single aspect green arrow head positioned alongside a 3 aspect signal head controlled by a separate phase (referred to as the associated main phase). The Filter Arrow always turns to green while the associated main phase is at red and normally terminates green at the moment when the main phase starts green
Conflict	A condition where two conflicting signal phases are amber or green at the same time.	Gap Change	A change in traffic signal indication that occurs on the termination of a vehicle extension period.
Conflict Point	The point where at least one conflict could occur between two traffic streams if they were admitted onto the intersection at the same time.	Green Man Signal	A green aspect specifically to inform pedestrians.
Control System	A method of co-ordination of any system usually by reference to a central controlling centre.	Gyratory	Gyratories are road systems which consist of one-way links connected together, so as to make it possible for traffic to circulate along one or more links before exiting. They can take a variety of forms but are most characterised by ‘roundabouts’ that are usually built as entities rather than configured from a number of existing roads. (Transport in the Urban Environment. IHT 1997)
Controller	The logic equipment that contains the algorithm for controlling the signalised intersection.	Indicative Arrow	The electrical circuit which controls a single aspect green arrow head (arrow pointing to the right) positioned alongside the secondary signal (i.e. far side of junction) of the associated main phase signal head. This is used only to assist opposed right turns. The indicative green arrow can only appear while the associated main phase is at green and normally finishes with the termination of the associated main phase green period. Note that the term filter should not be used in this context.
Co-ordination	A system of linking adjacent traffic signals with a common cycle time or multiple thereof.		
Cycle Time	The time taken for one complete sequence of the operation of the traffic signals.		
Delay	The difference between the time it takes a vehicle to pass through a signal controlled junction, or network, and the time it would take to travel the same route if there were no control facilities.		

Lost Time	The sum of periods of time during a single cycle when no vehicular traffic is moving.	Short Lanes	These may exist whenever the number of lanes at the stopline(s) on an arm on the junction is greater than the number of lanes feeding through from the next junction upstream. They can be formed by constructing local widening of the carriageway at the junction to increase the stopline capacity. They often occur however as a result of parked or other stationary vehicles obstructing what would otherwise have been a full kerbside lane.
Merging	The action of vehicles changing lanes by moving into gaps between vehicles.		
Opposed Right Turn	A right turn manoeuvre which may, for part of the signal cycle, be carried out while giving way to oncoming or opposing traffic. Note that this method of right turn control is only considered appropriate with single right turn lanes (except at a sig-nabout).		
Pedestrian Crossing	A facility to enable pedestrians to cross the carriageway, for example Pelicans, Puffins, Toucans, Zebras.		
Pedestrian Stage	A specific period within the signal cycle when only pedestrian phases are permitted to display a green signal.		
Platoon	A number of vehicles travelling closely as a group.		
Red Man Signal	A red light display to advise pedestrians not to cross.		
Reserve Capacity	Expressed as a percentage, it is the amount by which traffic flows at a junction can be increased until the theoretical maximum capacity of the junction is reached. It represents the amount of additional traffic that can pass through the junction before saturation occurs.		
Saturation	The condition where an arm of a junction does not, during its green period of the cycle, fully discharge the queue of traffic which has built up at the stopline during the preceding red period.		
SCOOT	Split Cycle Offset Optimisation Technique.		