Chapter 37 Junction Design: General Considerations

37.1 Introduction

Junctions are one of the critical elements in a highway transport system as they are the 'pinch points' where delay, accidents and emissions tend to be concentrated.

The optimum design solution for a particular set of conditions is complex and computer programs, specially written to assist with this process, enable a comparison of alternative designs to be made, in terms of the relationships between layout, the patterns of traffic demand and the resulting flows, capacities and delay. These programs can also be used to make assessments of the safety performance of the layouts of certain types of junction. Despite the availability of these aids, designing a junction continues to rely on the knowledge, experience and judgement of the designer.

Within a highway system, the basic purpose of a junction is to facilitate the transfer of traffic streams from one road to another in a safe and efficient manner. These transfers can be between roads of the same or different levels in the hierarchy (see Chapter 11). Ideally, such transfers should only be carried out between adjacent levels in the hierarchy. In other words, for example, transfers should not take place directly between local streets and primary distributors or between district distributors and access roads.

From the definition of its purpose, a junction can be described as an intersection between conflicting traffic streams or between motor vehicles and pedestrians and cyclists. The conflicts occurring at a junction can be categorised into three types:

- ❑ diverging: traffic streams from a common direction dividing themselves into two or more streams going in different directions;
- ❑ merging: traffic streams from two or more different directions joining together into a single stream going in one common direction; and
- ❑ crossing: the intersection of two traffic streams each entering from a different direction and leaving by a different exit.

Within these categories, further conflicts can arise from the different classes of vehicle making the manoeuvres, such as cyclists or buses, and between road vehicles and pedestrians.

These various manoeuvres must be carried out as safely as possible and sufficient capacity must be provided to minimise congestion, delay and fuel consumption. However, these two basic aims of junction design are sometimes in conflict. Thus, the junction designer requires a thorough knowledge of the various aspects and constraints affecting the safety and capacity performance of these important traffic facilities. It is vital, therefore, that designs are subjected to an independent safety audit (see Chapter 16).

37.2 Type of Junction

The various types of junction provide a hierarchy of layouts, which cater for increasing levels of traffic flow. These are:

- ❑ junctions without any designated priority;
- ❑ priority junctions (see Photograph 37.1);
- ❑ priority junctions with channelisation;
- ❑ roundabouts (see Photograph 37.2);
- ❑ traffic signal control (see Photograph 37.3); and
- ❑ grade–separated junctions.

Features of these junction types can sometimes be combined with advantage. For example, in some circumstances, a signal–controlled roundabout can have advantages over either a roundabout or a conventional signal layout. The overall network strategy may also influence the choice of junction type, for example, if positive management or control of traffic is desirable. Figure 37.1 gives an approximate guide to the magnitudes of major and minor road traffic flows that can be accommodated by particular types of junction and further information is available in Department of Transport publications (DOT, 1992 and DOT, 1981) [Sa]. Figure

Photograph 37.1: A typical priority junction.

Photograph 37.2: An urban roundabout.

Photograph 37.3: A signal–controlled junction on a district distribution road.

37.1 provides only a first estimate of the suitability of a particular layout. It does not take into account the pattern of movement through the junction, particularly the proportion of right–turning traffic or variations in the geometry of junction layout. For these reasons, undue reliance should not be placed on this Figure for design purposes.

37.3 Provision and Spacing of Junctions

The frequency and precise locations of junctions to be provided along a new road will depend upon its level in the road hierarchy (see Chapter 11), the proportion of non–local through traffic which it is intended to carry and the nature and presence of intersecting roads. If the number and importance of existing cross–routes would require too many junctions, it may be possible to combine two or more side–roads, before they reach the main road, giving benefits for road safety and junction capacity on the main road.

Junctions should be spaced at regular intervals and the minimum spacing should exceed the stopping sight distance appropriate for the 85th percentile speed of the major road (see Section 31.5). Greater distances should be provided, wherever possible, and particular care will be necessary when providing access to sites which generate large numbers of trips.

37.4 Design Issues and Objectives

The major sources of detrimental impact at junctions can be identified as accidents, congestion and delay, extra fuel consumption, air pollution and noise. The design objectives should set out to minimise these impacts.

Accidents

About two–thirds of personal injury accidents in urban areas occur at or near junctions. Whilst it has been recognised for some time that junctions are a major source of accidents and, although much effort has been put into their reduction, much remains to be done. Generally, the most effective method of reducing accidents at junctions is to separate the conflicting flows as much as possible.

The national average value of preventing a single personal injury accident (PIA) in a built–up area is estimated to be £31,460 at 1994 prices (see also Section 16.5). This value justifies considerable investment in improving the accident record at 'black spot' junctions.

Congestion and Delay

Congestion can spread rapidly when traffic demand exceeds the maximum capacity of a junction and is sensitive to the amount of excess demand and its duration. Thus, there is a continuing need to monitor the capacity at urban junctions. The cost of congestion at even a small urban junction can amount to hundreds of thousands of pounds every year.

Junction delays can be considered as delay due to the

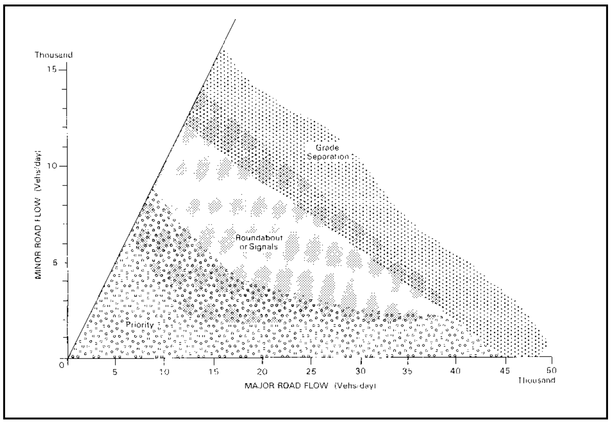

Figure 37.1: Type of junction appropriate for different fraffic flows on major/minor roads.

geometric layout and form of control and delay due to congested traffic conditions at the junction. Both sources of delay have to be considered when a particular design solution is being assessed. In general, the geometric source of delay will be predominant at lightly–trafficked junctions, whilst the congestion source is the major contributor to delay at heavily–trafficked junctions.

Junction delay is often only a few seconds per vehicle and rarely more than two minutes at any one location, unless in a particularly congested urban street network. Also, because short delays occur at frequent intervals, drivers tends to bear them without irritation although, when such delays are summed over thousands of journeys in urban areas, the effect on total travel–time can be very substantial.

In considering what level of delay could be acceptable, account should be taken of the overall network strategy. This may seek to minimise delay on some roads, such as bus routes, but accept longer delays elsewhere, as part of a queue–management strategy.

Fuel Consumption
A typical journey in an urban area on a district distributor road with frequent signal–controlled junctions consumes 50% more fuel than the same length of journey by urban motorway. This is caused by lower than optimum speed and greater frequency of stops/starts and speed changes.

Air Pollution and Noise
For a given flow of vehicles, air pollution and engine noise levels increase with congestion and, conversely, reductions in congestion lead to lower levels of traffic pollution. Whilst emissions and noise levels can be determined, a degree of uncertainty remains about their specific impacts on health or on the quality of life. Thus, estimates of overall environmental costs, which are based on generally–accepted monetary values, are the subject of continuing research. With moderate congestion at a small urban junction, it is estimated that approximately 30 tonnes of carbon dioxide (CO_2) are produced per annum. There is also increasing concern about the level of particulates which are emitted mainly from diesel–powered vehicles (see Chapters 9 and 17).

Design Objectives
The major objectives for junction design can be summarised as:

- ❑ minimising accident risk, particularly for vulnerable users;
- ❑ minimising accident severity;
- ❑ providing adequate capacity for vehicular traffic, such that the level of service is compatible with that provided on the approach roads, thus minimising congestion, as measured by the length and duration of queues on the approaches to the junction, and delay to vehicles passing through the junction;
- ❑ providing safe and convenient passage for cyclists and pedestrians, including people with visual or mobility impairment;
- ❑ minimising environmental impacts, such as air pollution and engine noise, by minimising fuel consumption through reductions in the number of speed changes and the number of stops/starts required at the junction;
- ❑ providing an economic solution, so that the cost of implementing the design will be, at least, offset by the economic benefits derived; and
- ❑ minimising conflicts between traffic activity at the junction and existing and planned roadside development in the vicinity.

It is likely that some of these objectives will conflict with each other and a balance will need to be struck. That balance should reflect background policies, such as giving priority to environmental concerns or to vulnerable road–users.

37.5 Design Principles

Principles of good junction design can be considered under four headings:

- ❑ general;
- ❑ geometric and operational requirements of vehicular traffic;
- ❑ safety; and
- ❑ provision for pedestrians and cyclists.

General
The geometric and the control aspects of a junction layout should be considered together to ensure a good design solution to a particular problem. The aim is to provide road–users with layouts that have consistent standards and are not likely to be confusing. On lengths of urban road, sequences of junctions should not, therefore, involve many different types of layout. For example, a length of road containing roundabouts, single–lane dualling, ghost islands, simple priority junctions and grade–separation would create uncertainty for road–users and increase the risk of accidents on that account. Similarly, a signal–controlled pedestrian crossing on one half of a carriageway and an uncontrolled crossing on the other could confuse pedestrians. The most efficient and safest schemes usually contain no surprises for road–users.

Major/minor priority layouts are the most common form of junction control, with the advantage that through traffic on the major road is not delayed. However, high speeds and any possibility of overtaking manoeuvres on the major road should be discouraged at priority junctions.

For more heavily–trafficked junctions, more complex forms of layout and more sophisticated control systems are required. Bearing in mind the uncertainty of traffic forecasting, a designer should always consider whether the layout and control system being designed could readily be converted to a different type of junction, such as signal–controlled, if this should prove necessary in the future.

The consideration of which movement should have priority is important at junctions. At priority junctions and roundabouts, these are fixed but at traffic signals priority is allocated to the different movements during the control cycle–time, which can either be varied for different times of day or be wholly demand–responsive. Also the overall network strategy will affect decisions on priority. Often, it will be appropriate for heavier volumes of traffic to have some measure of priority but care is needed to ensure that the minor flows are not too severely disadvantaged. In some circumstances, public transport vehicles and pedestrians may warrant priority at certain times of day.

Geometric and Operational

Several important principles governing the geometric and operational aspects of a design solution are set out below.

Layout to Suit Traffic Movements and Patterns

The layout should be designed to suit the traffic patterns with the principal movements generally being given the easiest paths. Ease of movement does not have to equate with high speed. Layouts which encourage a smooth, but slower, passage through a junction will be safer for vulnerable road–users. Wherever practicable, the layout should be designed so as to follow the shortest vehicular paths. This improves the smoothness of operation and makes it more readily understood by road–users. Unduly sharp radii, or complex paths involving several changes in direction, should normally be avoided, although in some areas, eg subject to traffic calming, they may be appropriate.

On entering a junction, users should always be able to see quickly, from both the layout and advance traffic signs, the path they should follow and the potential crossing, merging and diverging traffic streams that may be encountered. Drivers should be encouraged to slow down on entry to large roundabouts, so that they have time to see circulating cyclists. To achieve this, the layout, traffic islands, control devices, traffic signs and road markings should all be considered as a single design entity. Uphill approaches to a junction make it difficult for drivers to comprehend the layout and should be avoided wherever possible.

To an increasing extent, computer aided design (CAD) software packages are being used to examine and refine junction layouts. CAD can be used to allow engineers to view layouts from various perspectives and to check sightlines.

Layout to Suit Long Vehicles

Allowance should be made for the swept paths of long vehicles turning in areas where significant numbers of such vehicles can reasonably be expected to use a junction. The turning swept paths normally used are those generated by a 15.5m long articulated or semi–trailer vehicle, with a single axle at the rear of the trailer. However, in the case of staggered priority junctions, the design vehicle is represented by a 18.35m long vehicle with draw–bar trailer (DOT, 1995) [Sb].

Reduction and Separation of Conflicts

The choice of layout will govern the number and type of conflicting manoeuvres that have to be accommodated within a design solution. Roundabout layouts result in the least number of conflict points and eliminate crossing–points entirely, whilst T–junctions and staggered layouts have fewer conflict points than cross–roads. Traffic signal–controlled junctions should, in theory, eliminate most of the conflicting movements, by separating them in time.

Crossing, merging and diverging movements can usefully be separated by physical or painted ‘ghost’ islands, so that the number of traffic conflicts at any point is reduced. However, layouts which have numerous small traffic islands must be avoided as they are ineffective and confusing. Separation of traffic conflicts means that road–users are faced only with simple choices of direction at any one time.This can lead to greater safety. Nevertheless, for the separation of conflicts to be effective, the junction must be large enough to enable users to identify, in adequate time, those traffic streams that will conflict with their intended path and those that will not. Otherwise, gaps in the priority movement cannot be used efficiently by traffic entering the junction and the flow through the junction will not be optimised.

Visibility

It is important that all road–users have adequate visibility in each direction to see conflicting traffic movements in sufficient time to permit them to make their manoeuvres safely. This concept applies to all types of junction and to the visibility of pedestrians and cyclists. The specific requirements for each of the junction types is explained in detail in later chapters. Where possible, junctions should be positioned on level ground or in sags rather than at, or near, the crests of hills. As well as having adverse safety implications, poor visibility reduces the flow of turning movements that can be achieved.

Diverging and Merging Lanes

It is important to reduce the speed differences on high speed roads between through and turning traffic and, for this purpose, the incorporation of diverging and merging lanes into the design solution is useful.

Traffic, slowing down on the approach to an intersection in order to turn either left or right into an intersecting road, may impede following vehicles or cycles that are not turning. It is helpful, therefore, where space allows, to permit divergence of the two streams at a small angle by the provision of a diverging lane. Offside 'storage' lanes in the centre of single and dual carriageways are especially useful as they provide a safe space for vehicles waiting to turn right off the major road.

Nearside diverging lanes are useful where there is a heavy left turn from that approach road, especially on higher speed roads and on gradients. Likewise, merging lanes permit turning traffic to accelerate before joining the fast traffic streams on dual carriageway and other high speed roads, where this traffic would otherwise impede flow and be a source of hazard. However, they can also be hazardous when the capacity to absorb merging traffic has been taken up.

Provision for cyclists needs particular consideration, especially where high speed traffic crosses their path as it merges with, or diverges from, a main route. Cyclists are better segregated from these situations (see Chapter 23).

Traffic Signs and Road Markings

The importance of traffic signs and road markings in junction design is often under–rated. They are an integral part of the design process and should be considered from an early stage. No junction design is complete without these features. Advance direction and warning signs should be provided. Designs should be checked to ensure that the proposed layout can be properly signed. Care must be taken with the positioning of signs at the junction itself so that they do not interfere with visibility. Policy and detailed guidance on these aspects are given in the Traffic Signs Manual (HMG, 1994) (see Chapter 15).

Road Lighting

Road lighting will normally be provided at junctions in urban areas, especially when one of the intersecting roads already has lighting. It is recommended that, where road lighting is required at a junction, provision should be in accordance with the British Standard Code of Practice for Road Lighting (BSI, 1992). When an existing junction is being modified, the lighting provision should be checked for suitability with the new arrangement. Any alteration to the lighting should be carried out prior to, or at the same time as, the roadworks.

Safety

Safety considerations are a priority from initial concept to final design and layouts should be subject to safety audits, as described in Section 37.6 (see also Chapter 16).

For the same level and pattern of traffic flows, a major/minor priority junction will usually have more accidents per year than other junction types. These accidents will also be more serious than with other forms of control. For example, in the UK, the average cost of an accident at a priority junction is more than twice that at roundabouts and one and a half times that at traffic signals. The accidents are mainly associated with right–turns and are exacerbated in number and severity by high speeds and the possibility of overtaking manoeuvres on the major road. Key considerations in the attainment of a reduction in both the occurrence and severity of accidents are:

- ❑ a reduction of high vehicle speeds through the junction;
- ❑ the provision of clear visibility for all approaching traffic streams;
- ❑ appropriate geometric standards for the typical design vehicle; and
- ❑ integration of the traffic information and control systems within the junction layout.

Provision for Pedestrians and Cyclists (see Chapters 22 and 23)

The requirements of pedestrians and cyclists should be carefully considered from the start of the design of junctions, especially in central urban and suburban areas. It may be possible to provide separate routes for pedestrians and cyclists away from the junction, where road widths are less and traffic movements more predictable. This is not always desirable. Where significant numbers of cyclists are expected, consideration should be given to providing for them specifically by, for example, separating out their movements from those of other vehicles but still accommodating them within the carriageway through dedicated lane–space and advanced stop–lines at signals. For pedestrians, and sometimes for cyclists, one of the following facilities should be considered at the junction itself:

- ❑ central island refuges at unmarked crossing places;
- ❑ an unsignalised crossing, with or without central refuges;
- ❑ signal–controlled crossings; or
- ❑ a subway or footbridge.

The type of facility selected will depend upon the expected traffic volumes and the movements of both pedestrians and vehicles and should be designed in accordance with current recommendations and requirements (see Chapters 22 and 23).

At–grade pedestrian crossings on a major road should not be placed over ghost islands where there are no refuges. Defined at–grade pedestrian crossings on a minor road should be beyond the tangent points of the corner radii and should be sited to reduce to a minimum the width to be crossed by pedestrians, provided that they are not involved in lengthy detours from their desired paths. Central refuges should be used where possible. In urban areas, where large numbers of pedestrians are present, short lengths of guardrails should be used to channelise them onto crossings.

In some circumstances, it may be possible to combine facilities for pedestrians and cyclists. Any special provision should be designed to be convenient and easy to use; otherwise, it runs the risk of being ignored.

37.6 Evaluating Alternative Solutions

The uncertainties associated with forecasting future levels of urban traffic flow suggest that it is sensible to test a range of design flows in terms of the resulting alternative junction designs. This process should include varying the proportions of turning traffic, which can influence the type and scale of the junction proposed. This type of analysis can identify a range of proposals, which offer varying levels of service and other strengths and weaknesses.

Where the type of junction to be designed is not predetermined by other factors, assessments of safety performance, operational efficiency and resource costs can be used to assist in the choice of the best design. Evaluation of alternative proposals should cover the identification of which junctions are critical to the operation of the network and should examine the effects of capacity–overloads causing queueing and possible re–routeing using unsuitable roads. Cost–benefit studies will require the use of appropriate values of time for the people and vehicles involved and reference should be made to the Department of Transport's COBA 10 Manual and subsequent amendments (DOT, 1996a) (see Chapter 9) [Sc].

Safety Performance

The junction designer should be concerned with both accident prevention and severity minimisation. The safety performance of a scheme can be evaluated by making assessments of the likely accident–frequency through a safety audit, which is a process that seeks to ensure that highway and traffic schemes are as safe as practicable within the context of the purpose for which they are intended. Considerable research effort has been devoted to the development of models for predicting accident–frequency at junctions and on some kinds of links in urban areas (see Chapter 16).

The research had three objectives:

- ❑ to develop standards for road links and junctions;
- ❑ to build statistical accident–prediction models for junction design; and
- ❑ to design network accident appraisal software for local networks.

Several levels of accident–prediction models have been developed. The simplest models predict total accidents for the junction or link, while the most sophisticated take account of the effects of design geometry and environmental factors on a number of accident categories. Some simple models for pedestrian accidents are available, although not for accidents to pedal cyclists, and the models are insensitive to speed–management policies. The main application is in assessing the safety impacts of traffic engineering schemes, rather than specific measures for speed reduction or the safety of vulnerable road–users.

To be successful, the safety audit process must be well defined and must be systematically applied, at all stages of the planning, design and construction of a scheme. The design standards generally used for highway and traffic schemes take account of safety but, when the various elements of the design are brought together, the resulting scheme may not be the best in terms of safety. In addition, there may be compromises between safety and capacity or departures from standards necessitated by specific site conditions. Safety audits seek to take account of all of these issues and to highlight changes to the scheme design that would optimise safety within the overall scheme objectives (IHT, 1996; DOT, 1994a; and DOT 1994b) (see also Chapter 16) [Sb].

The elements of a junction that should be audited will depend, to some extent, on the nature of the scheme. The audit should identify how the various users would walk, drive or ride through the junction. As a guide, the following should be checked:

- ❑ geometric design: the type and layout of the junction, including horizontal and vertical alignments and cross–sections;
- ❑ road markings: including white lines, road studs, raised markings and delineators;
- ❑ road signs and street furniture: including lighting (intensity and location of posts), all types of signs, islands and bollards, pedestrian guardrails and safety fencing;
- ❑ road surface: including profile, effect on lighting and skid resistance and storm water provision;
- ❑ traffic management: including provision for pedestrians, cyclists and the disabled; speed limits and controls, junction control, waiting, loading and parking provision, traffic circulation, one–way streets and banned turns and provision for public transport;
- ❑ management of incidents: an assessment of the ability of the junction to accommodate emergency traffic management in the event of an accident; and
- ❑ road works and maintenance: including temporary working during construction, maintenance of schemes, and the signing and operation of road works on the existing network.

Operational Efficiency

Evaluation of the operational efficiency of a junction comprises three major components, namely:

- ❑ capacity analysis;
- ❑ determination of queueing characteristics; and
- ❑ determination of vehicular delay.

Capacity analysis is concerned with determining the ability of the junction to accommodate all the various movements. In the case of priority junctions and roundabouts, this will depend primarily on the arrival patterns of the priority movements, as well as on the junction layout, type of control and gap–acceptance characteristics. The case of signal–controlled junctions is different, in that the arrival patterns of the movements are considered simultaneously and there is no fixed priority, since it changes during the signal cycle.

The capacity of a road intersection for traffic making a particular movement is frequently specified, in terms of its throughput of passenger car units (pcu) per hour. Pcus are introduced to allow for differences in the amount of interference to other traffic by the addition of one extra vehicle to the traffic, according to the type of vehicle. For example, a large lorry is longer, wider and slower than the average car and, therefore, has a considerably greater effect on other vehicles by making it more difficult for them to overtake and by slowing down those which are forced to follow. On any particular section of road, under particular traffic conditions, the addition of one vehicle of a particular type, per hour, will reduce the average speed of the remaining vehicles by the same amount as the addition of, say, x cars of average size per hour. Under these conditions, one vehicle of this type is said to be equivalent to x passenger car units.

In the case of a bottleneck, in particular at an intersection, one can arrive at a slightly different definition, which is, however, equivalent to applying the one given to maximise flow conditions. This definition is that, if a particular type of vehicle, under saturated conditions, requires x times as much time at the intersection than is required by an average car then that type is equivalent to x passenger car units.

For priority junctions and roundabouts, it is normal to assume that heavy vehicles and buses are equivalent to two pcus. However, for saturation flow determination at traffic signals, it is normal to adopt the following values:

- ❑ car or light goods vehicle (LGV) = 1.0 pcu;
- ❑ medium goods vehicle = 1.5 pcu;
- ❑ heavy goods vehicle (HGV) = 2.3 pcu;
- ❑ bus/coach = 2.0 pcu;
- ❑ motor cycle = 0.4 pcu; and
- ❑ bicycle = 0.2 pcu.

The output of the capacity analysis is the servicing pattern, ie the ability of the junction to cater for the through movements of non–priority traffic. If the servicing pattern is input into a queueing model, together with the arrival pattern of the non–priority movements and the queue discipline regime (normally first–in–first–out), estimates can be made of the queue–lengths. If the queueing model is time–dependent, then the vehicular delay characteristics can be determined by integrating the queue–length distribution over time, using appropriate software.

The value of delay that emanates from the queueing model is 'operational' or 'congestion' delay and is due to other traffic. This has to be combined with 'geometric' delay to determine the total delay. It should be noted that geometric delay includes all fixed delay elements, due to both the layout of the junction and the control strategies that are applied to it.

The output of the evaluation process, in terms of queue–lengths (presence or absence of congestion) and total delay, is used to determine the operational efficiency of a particular design strategy. The analysis can be extended to estimate its efficiency in terms of fuel consumption.

Resource Costs

The generalised cost of operating a junction will comprise:

- ❑ time (delays) costs;
- ❑ vehicle operating costs; and
- ❑ accidents costs.

Although these are usually studied separately, for different purposes, the true optimisation of junction design should aim to minimise the aggregate of all of these costs, discounted over the anticipated life of the junction, in comparison with the capital cost of improving it (see also Chapter 9). Wider policy considerations may, however, constrain some of the parameters affecting this optimisation.

In addition to time costs arising from delay, operating costs will be incurred for each of the separate manoeuvres performed at a junction. Vehicle operating costs depend on the speed, type of manoeuvre and the distance travelled by each vehicle. These costs include the additional cost of fuel, oil, tyres, maintenance and depreciation caused by the layout of a junction and the changes in speed and direction of the vehicles travelling through it.

Assessment Programs

In assessing junction designs, account needs to be taken of both capacity and safety requirements. These may sometimes be in conflict and some junction types will perform better than others in each respect. A balance needs to be struck for the situation that exists at each junction. Advice is provided in the IHT/TRL leaflet Designing Junctions to Cut Delays and Accidents (IHT/TRL, 1993).

To facilitate the decisions involved in junction choice and design, the Transport Research Laboratory (TRL) has developed three computer programs for assessing isolated junctions. ARCADY 3 (Assessment and Roundabout Capacity and Delay) and PICADY 3 (Priority Intersection Capacity and Delay) deal respectively with roundabouts and major/minor priority junctions. OSCADY 3 (Optimised Signals Capacity and Delay) deals with traffic signal–controlled junctions. All of the programs operate on the same principles: given demand flows and turning movements for typical peak hours and the junction geometry, they predict where queues will form, how long they will last and when, and for how long, vehicles will be delayed (DOT, 1996b; DOT, 1993a; and DOT 1993b). These programs also make assessments of the frequency of accidents that might occur with a particular design for certain types of junction.

In addition, other programs can assist in the evaluation process. These include RODEL and ROBOSIGN (see Chapter 39), which address roundabout designs, and LINSIG and SIGSIGN (see Chapter 40), which can be used for the assessment of traffic signal designs. RODEL is especially useful, in that it can be used to generate geometric design parameters for a specified level of service.

37.7 References

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