10_ Visibility

10.1_ Introduction

10.1.1 This section of MfS2 incorporates Section 7.5 of MfS1. It is based on a combination of the research carried out by TRL[23], the research carried out by TMS Consultancy for MfS2[66], a review of recent research and international standards and the outcome of public inquiries since MfS1 was published (see Example below).

10.1.2 Sight distance parameters can be based on various models, such as stopping sight distance, overtaking distance or gap acceptance. UK practice generally focuses on Stopping Sight Distance (SSD). The effect of sight distance on the capacity of priority junctions is discussed in **Chapter 9** above.

10.1.3 This section provides guidance on SSDs for streets where 85th percentile speeds are up to 60 kph (37mph). This will generally be achieved within 30mph limits and may be achieved in some 40mph limits.

Inspectors at public inquiries have accepted that SSD guidance in MfS1 applies to non-residential streets. At an appeal into a development of some 100 dwellings, accessed from the B5215 Leigh Road in Wigan, the Inspector concluded that MfS1 did apply, notwithstanding the volume of traffic (approximately 1,700vph peak times) or the classification of the highway (part of the Strategic Route Network).

10.1.4 Stopping sight distance (SSD) is the distance drivers need to be able to see ahead and they can stop within from a given speed. It is calculated from the speed of the vehicle, the time required for a driver to identify a hazard and then begin to brake (the perception-reaction time), and the vehicle's rate of deceleration. For new streets, the design speed for the location under consideration is set by the designer. For existing streets, the 85th percentile wet-weather speed is used.

10.1.5 The basic formula for calculating SSD (in metres) is:

$$SSD = vt + v^2/2(d+0.1a)$$

where:
v = speed (m/s)
t = driver perception-reaction time (seconds)
d = deceleration (m/s^2)
a = longitudinal gradient (%)
(+ for upgrades and - for downgrades)

10.1.6 The Desirable Minimum SSDs in general use prior to MfS1 were based on a driver perception-reaction time of 2 seconds and a deceleration rate of 2.45 m/s^2 (equivalent to 0.25g, where g is acceleration due to gravity (9.81 m/s^2)). The Absolute Minimum SSD values kept the same reaction time of 2 seconds, but assumed a deceleration rate of 3.68 m/s^2 (0.375g).

10.1.7 The SSD values recommended in MfS1 were based on a perception-reaction time of 1.5 seconds and a deceleration rate of 0.45g (4.41 m/s^2). This value is appropriate for cars and other light vehicles, but heavy goods vehicles and buses have different deceleration characteristics. When deciding whether to carry out separate checks for cars, HGV and bus SSDs, highway authorities should consider the following factors:

- Volume of HGVs and buses
- Proportion of HGVs and buses
- Presence of priority lanes which may enable higher bus/HGV speeds

10.1.8 As a guide, it is suggested that bus/HGV SSD should not need to be assessed when the combined proportion of HGV and bus traffic is less than 5% of traffic flow, subject to consideration of local circumstances.

10.1.9 Based on international vehicle standards (see Example) HGVs must be able to achieve peak deceleration rates of at least 0.509g. However, allowing for the delay in the maximum effectiveness of air braking systems, overall minimum stopping distances are also specified which reduce the minimum overall deceleration rate[A] under the regulations to some 0.36g. Real life tests carried out by ROSPA (also see Example) indicate that these values are likely to be exceeded in practice and therefore the pre-MfS1 Absolute Minimum value of 0.375g is recommended for HGVs. These average deceleration rates already allow for the time taken for air braking systems to apply and therefore the same reaction time of 1.5 seconds should be used.

10.1.10 For buses, the limiting design factor is passenger comfort and safety rather than the ability of the vehicle to stop, and therefore for buses, the recommended maximum deceleration rate is the same as the pre-MfS1 Absolute Minimum value of 0.375g, as used for the pre-MfS1 Absolute Minimum SSD values.

[A] The minimum overall deceleration rate means the deceleration rate, expressed as a uniform value, from the instant when the brakes begin to be applied when the vehicle stops, required by the standards.

10.1.11 Where designers wish to determine different SSD values for HGVs and buses it will be necessary to use appropriate design speeds for these classes of vehicle. Where SSD is being calculated for existing highways, actual 85th percentile values for these types of vehicles should be measured and the worst case SSD be used for horizontal measurements of visibility.

10.1.12 Based on free flow vehicle speeds travelling in 30mph limits given in Transport Statistics Bulletin 2008[45], buses travel at 90% of the average speed for all vehicles.

HGV Braking Performance

Minimum standards for lorry braking systems are set out in the UNECE Vehicle Regulation 13[67], which requires that the mean fully developed deceleration rate achieved by the braking system (with the engine disconnected) should be at least 5.0m/s^2 (0.509g). In addition, the stopping distance of the vehicle must be no more than $0.15v+v^2/130$, where v=vehicle speed in kph (up to 60kph), and $0.15v+v^2/103.5$ (v up to 90kph).

At 50kph the maximum allowable stopping distance is therefore 26.7m, and this is equivalent to a minimum overall braking rate of 3.6m/s^2 or 0.37g.

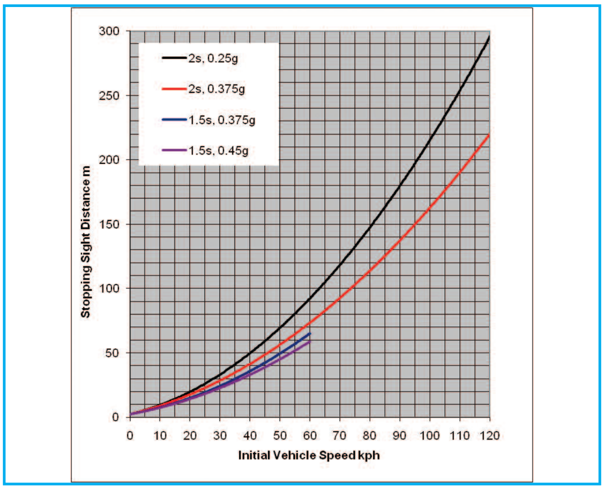
A series of real life braking tests were carried out by ROSPA using a wide range of vehicles in 2001, as reported in http://www.rospa.com/RoadSafety/AdviceAndInformation/Driving/hgv-truck-braking-systems.aspx

Deceleration rates have been calculated from the results of these tests which show that the minimum overall braking rate achieved was 0.44g, for a 36 tonne Foden vehicle, which stopped in 20.68m from 30mph. (One vehicle did take longer to stop, at 27m, but this was on a down slope). Cars were also tested by ROSPA, and the best performing of these was a Ford Mondeo, which stopped from 30mph in 7.14m, an overall deceleration rate of 1.27g.

10.1.13 In summary, recommended values for reaction times and deceleration rates for SSD calculations are given in Table 10.1 below and the resulting SSD values for initial speeds of up to 120kph are shown on the graph beneath.

Design Speed	Vehicle Type	Reaction Time	Deceleration Rate	Comments
60kph and below	Light vehicles	1.5s	0.45g	
	HGVs	1.5s	0.375g	See 10.1.9
	Buses	1.5s	0.375g	See 10.1.10
Above 60kph	All vehicles	2s	0.375g (Absolute Min SSD)	As TD 9/93
	All vehicles	2s	0.25g (Desirable Min SSD)	As TD 9/93

Table 10.1: Summary of Recommended SSD Criteria



Graph showing recommended SSD values, allowing for bonnet length.

10.2_ Visibility Requirements

10.2.1 Visibility should be checked at junctions and along the street. Forward visibility is measured horizontally and vertically.

10.2.2 Using plan views of proposed layouts, checks for visibility in the horizontal plane ensure that views are not obscured by vertical obstructions.

10.2.3 Checking visibility in the vertical plane is then carried out to ensure that views in the horizontal plane are not compromised by obstructions such as the crest of a hill, or a bridge at a dip in the road ahead. It also takes into account the variation in driver eye height and the height range of obstructions. Eye height is assumed to range from 1.05m (for car drivers) to 2m (for bus and HGV drivers).

10.2.4 Drivers need to be able to see obstructions from 2m high down to a point 600 mm above the carriageway. The latter dimension is used to ensure small children can be seen.

10.2.5 The SSD figure relates to the position of the driver. However the distance between the driver and the front of the vehicle is typically up to 2.4m, which is a significant proportion of shorter stopping distances. It is therefore recommended that for assessments of SSD, an allowance is made by adding 2.4m to the distance calculated using the formula.

10.3_ Forward Visibility

10.3.1 The minimum forward visibility required is equal to the minimum SSD, based on the design speed at the location being considered. It is checked by measuring between points on a curve along the centreline of the inner traffic lane (see Fig.10.1).

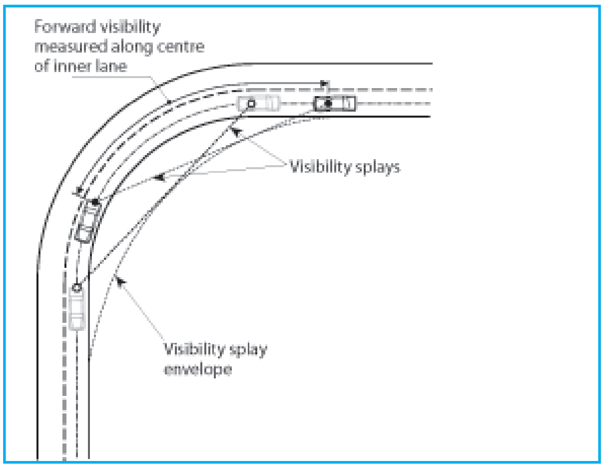
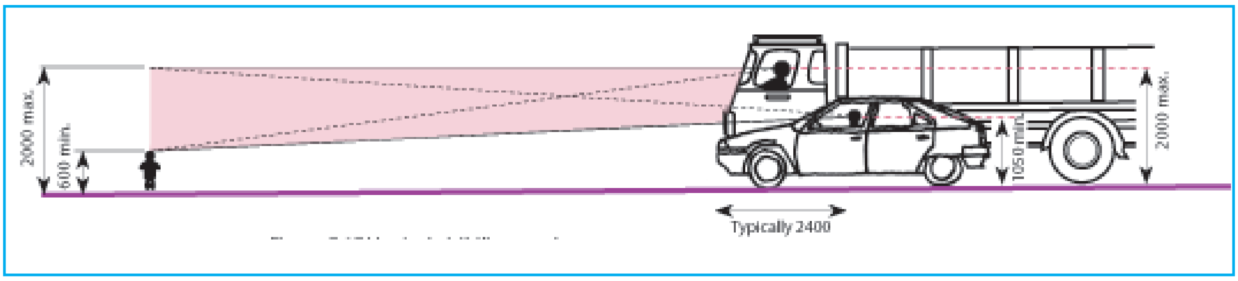


Figure 10.1 - Measurement of forward visibility

10.3.2 However there will be situations in locations with design speeds of 60kph or less where it is desirable and appropriate to restrict forward visibility to control traffic speed - research carried out for MfS1 describes how forward visibility influences speed. An historic example is shown below.

Spaniards Inn, Hampstead – historic building restricting forward visibility and carriageway width



10.4_ Visibility At Priority Junctions

10.4.1 The visibility splay at a junction ensures there is adequate inter-visibility between vehicles on the major and minor arms.

10.4.2 It has often been assumed that a failure to provide visibility at priority junctions in accordance with the values recommended in MfS1 or DMRB (as appropriate) will result in an increased risk of injury collisions. Research carried out by TMS Consultancy for MfS2[66] has found no evidence of this (see research summary below). Research into cycle safety at T-junctions found that higher cycle collision rates are associated with greater visibility[55].

High Risk Collision Sites and Y Distance Visibility

Introduction

The accepted approach to visibility at priority junctions has been to provide a minimum stopping sight distance value appropriate to a particular design speed. The assumption made by some designers and road safety auditors is that this value provides a minimum road safety requirement, and that collision risk will increase if the SSD is not achieved.

The purpose of this research was to examine this assumption and to identify whether or not a direct relationship can be established between variations in Y distance SSD and collision frequency at priority junctions.

Methodology

Site Selection

A series of "high risk" priority junctions was identified as the basis for research. Uncontrolled crossroads and T- junctions were selected for all classes of road throughout all 20, 30 and 40mph speed limits in Nottinghamshire, Sandwell, Lambeth, and Glasgow. For each area a list of all non-pedestrian collisions was ranked in descending order of collision total for a recent five-year period, with over 1500 collisions listed in total. Each location was then analysed in detail to identify specific collision characteristics.

Collision Analysis

Collisions involving vehicles emerging from junctions into the path of vehicles on the main road, together with nose-to-tail shunts on the minor road were identified as the type of incident that could have been caused by "poor visibility". The locations were then ranked in descending order of these types of crashes, and site visits were carried out at the "worst" sites.

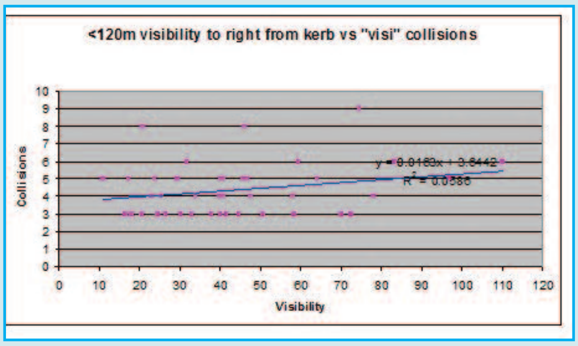
In addition to the 626 potential "poor visibility" collisions, a record was made of 203 collisions involving main road shunts, 46 collisions involving main road bus passengers, 22 collisions involving main road large goods vehicles, and 216 collisions involving main road two-wheeled vehicles. There is a concern that these types of collisions could be over-represented at locations with poor visibility.

Site Visits

Two investigators visited each location, and measured visibility to the left and right, from a point on the side road, 2.4m back from the main road channel line. Visibility was measured from a height of 1.05m, to a point at the kerb edge and a second point 1m out from the kerb edge, where observations showed that visibility increased.

Summary of Findings

- "High risk" sites were defined as locations that had three or more potential poor visibility collisions - in a five year period (94 in total). Of these 90 were on 30mph roads, with 3 on 40mph roads. At 55 of the 94 locations the worst case visibility (either to the left or right) was restricted to less than 120m. Thus in relation to the total number of uncontrolled junctions that exist, the proportion of "high risk" sites where visibility is less than that recommended for 70kph in DMRB is likely to be very low. It is possible that some former high risk priority junctions have been converted to other forms of junction control.
- In two thirds of the cases where visibility was less than 120m, the restriction was due to parked vehicles or street furniture. It is not possible to determine whether the parking was present at the time of the collision.
- Linear regression to compare potential poor visibility collisions with Y distance has a very low R^2 value, which shows that the variation in collision frequency was explained by factors other than Y distance visibility, for a large number of different situations. Therefore Y distance cannot be seen as a single deterministic factor at these high-risk collision locations (see example graph below).



- A series of collision types at high risk locations where Y distance was less than 45m were compared with locations with more than 45m visibility. There were no statistically significant differences between the two sets of data. The data analysed included main road bus and large goods vehicle collisions, and the research did not find high numbers of collisions involving these types of vehicles at low visibility sites.

Collision type	No & % in sites <45m vis	No & % in sites >45m vis
Potential visi collisions in dark	40 (31.75%)	90 (30.3%)
Main road shunts	24 (8.79%)	50 (9.11%)
Bus passenger	10 (3.66%)	10 (1.82%)
Main road HGV	1 (0.37%)	5 (0.91%)
Main road two-wheeled.	38 (13.92%)	85 (15.58%)

Conclusions

- This study has been unable to demonstrate that road safety concerns regarding reduced Y distance are directly associated with increased collision risk at "high-risk" urban sites;
- Previous research for MfS1 demonstrated that main road speed is influenced by road width and forward visibility. Many of the locations in this study were straight roads with good forward visibility. The ability of the driver to stop is likely to be affected by more than just what is happening in the side road and an understanding of the factors influencing main road speed is important when assessing visibility requirements.

Visibility measured to right, to nearside kerb.

	No. of sites	No. collisions	Collisions per year	Collisions per site per year
0-20m	4	16	3.2	0.80
20-40m	14	58	11.6	0.83
40-60m	15	64	12.8	0.85
60-80m	5	24	4.8	0.96
80-100m	2	11	2.2	1.10
100-120m	1	6	1.2	1.20
120m+	48	208	41.6	0.87

10.5_ X and Y Distances

Measurement of X and Y distances

10.5.1 The distance back along the minor arm from which visibility is measured is known as the X distance (Figure 10.2). It is generally measured back from the 'give way' line (or the main road channel line if no such markings are provided).

10.5.2 This distance is normally measured along the centreline of the minor arm for simplicity, but in some circumstances (for example where there is a wide splitter island on the minor arm) it will be more appropriate to measure it from the actual position of the driver.

10.5.3 The Y distance represents the distance that a driver who is about to exit from the minor arm can see to the left and right along the main alignment. For simplicity it has previously been measured along the nearside kerb line of the main arm, although vehicles will normally be travelling at a distance from the kerb line. Therefore a more accurate assessment of visibility splay is made by measuring to the nearside edge of the vehicle track. The measurement is taken from the point where this line intersects the centreline of the minor arm (unless, as above, there is a splitter island in the minor arm).

10.5.4 When the main alignment is curved and the minor arm joins on the outside of a bend, another check is necessary to make sure that an approaching vehicle on the main arm is visible over the whole of the Y distance. This is done by drawing an additional sight line which meets the kerb line at a tangent.

10.5.5 Some circumstances make it unlikely that vehicles approaching from the left on the main arm will cross the centreline of the main arm - opposing flows may be physically segregated at that point, for example. If so, the visibility splay to the left can be measured to the centreline of the main arm.

Recommended values for X and Y distances

10.5.6 An X distance of 2.4m should normally be used in most built-up situations, as this represents a reasonable maximum distance between the front of a car and the driver's eye.

10.5.7 Longer X distances enable drivers to look for gaps as they approach the junction. This increases junction capacity for the minor arm, and so may be justified in some circumstances, but it also increases the possibility that drivers on the minor approach will fail to take account of other road users, particularly pedestrians and cyclists. Longer X distances may also result in more shunt collisions on the minor arm. TRL Report No. 184[68] found that collision risk increased with greater minor-road sight distance.

10.5.8 A minimum X distance of 2m may be considered in some slow-speed situations when flows on the minor arm are low, but using this value will mean that the front of some vehicles will protrude slightly into the running carriageway of the major arm, and many drivers will tend to cautiously nose out into traffic. The ability of drivers and cyclists to see this overhang from a reasonable distance, and to manoeuvre around it without undue difficulty, should be considered. This also applies in lightly-trafficked rural lanes.

10.5.9 The Y distance should be based on the recommended SSD values. However, based on the research referred to above, unless there is local evidence to the contrary, a reduction in visibility below recommended levels will not necessarily lead to a significant problem.

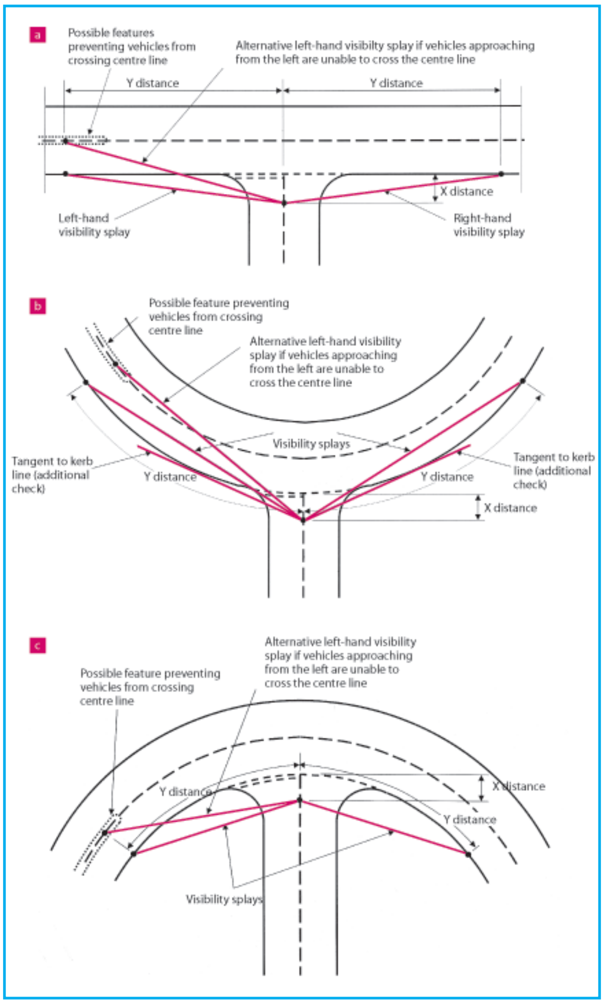


Figure 10.2

10.6_ Visibility Along The Street Edge

10.6.1 Vehicle exits at the back edge of the footway mean that emerging drivers will have to take account of people on the footway. The absence of wide visibility splays at minor accesses will encourage drivers to emerge more cautiously - similarly to how vehicles pull out when visibility along the carriageway is restricted (see Example below)

10.6.2 . Consideration should be given to whether this will be appropriate, taking into account the following:

- the frequency of vehicle movements;
- the amount of pedestrian activity; and
- the width of the footway.

10.6.3 When it is judged that footway visibility splays are to be provided, consideration should be given to the best means of achieving this in a manner sympathetic to the visual appearance of the street (Figure 10.3). This may include:

- the use of boundary railings rather than walls; and
- the omission of boundary walls or fences at the exit location.

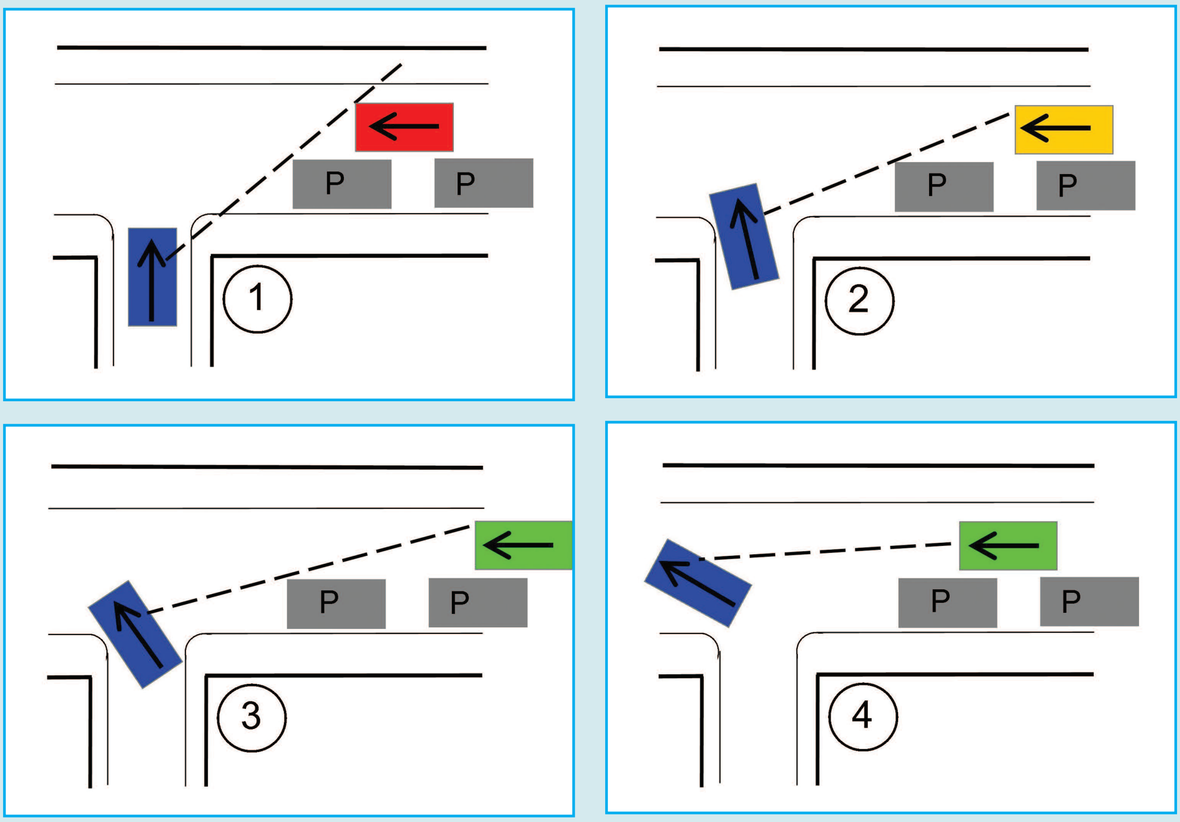
Figure 10.3

Access to commercial property with limited visibility.

10.7_ Obstacles To Visibility

10.7.1 Parking in visibility splays in built-up areas is quite common, yet it does not appear to create significant problems in practice. Ideally, defined parking bays should be provided outside the visibility splay. However, in some circumstances, where speeds are low, some encroachment may be acceptable. (See Example below.)

10.7.2 The impact of other obstacles, such as street trees and street lighting columns, should be assessed in terms of their impact on the overall envelope of visibility. In general, occasional obstacles to visibility that are not large enough to fully obscure a whole vehicle or a pedestrian, including a child or wheelchair user, will not have a significant impact on road safety.



At urban junctions where visibility is limited by buildings and parked cars, drivers of vehicles on the minor arm tend to nose out carefully until they can see oncoming traffic, and vice-versa.

In the images above, the blue car moves forward slowly until it can see far enough past the parked vehicles to see that the gap to the next oncoming vehicle is long enough for it to pull out. Drivers on the major route will also be able to see the vehicle pulling forward slowly and may slow down or stop to allow it to pull out.