Department for Transport

# Road Safety Good Practice Guide

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# Acknowledgements


The substance of this Guide was prepared by TRL Ltd. The main authors at TRL were Judith Barker and Chris Baguley. They would like to acknowledge the many staff at TRL who made significant contributions to both drafting parts of the Guide and advising on its content.

The authors are also indebted to all those highway authorities, central government departments and other organisations who responded either to a questionnaire or direct contact requesting information about their recent good examples of accident remedial schemes and their views on the contents of the Guide. The authors are particularly grateful to the following authorities who willingly provided information and photographs on specific sites:

Bracknell Forest Council
Ceredigion County Council
Glasgow City Council
Hertfordshire County Council
Kingston-upon-Hull City Council
London Borough of Sutton
Luton Borough Council
Oxfordshire County Council
Norfolk County Council
Southampton City Council
South Tyneside Metropolitan Borough Council
Sunderland City Council
Swindon Borough Council
Vale of Glamorgan Council
Wolverhampton City Council
York City Council

Most of the photographs in the main body of the text are provided courtesy of TRL Limited.


# 1. Introduction

## Purpose

1.1 This is the second publication in the DTLR's good practice advice series on local transport. This guide shares good practice, to help achieve the targets set out in DTLR's road safety strategy *Tomorrows roads safer for everyone* (DTLR, 2000b).

1.2 This guide has been developed primarily as a reference for local authority staff with an interest in road safety engineering and associated issues. However, we also hope that it will interest a wider audience, including the police, the Highways Agency, local health authorities, local communities, businesses, and transport interest groups.

1.3 It is hoped that the guide will particularly benefit those new to road safety engineering, whether they are just starting their careers or are transferring from a related discipline.

1.4 This guide is intended to be a living document, which will be updated over time as knowledge and experience develop. Consequently other existing and new examples of good practice will be sought and we particularly welcome feedback from practitioners (see chapter 8).

## Scope

1.5 A number of documents that advise on various aspects of road safety [1] management, including the design of engineering measures and schemes, are already in the public domain. This document aims to draw together existing advice as far as possible into one document, and to update it, based on the most recent experience of local authorities and agencies (see examples, Appendix A), and on research results.

1.6 Consequently, the level of detail varies, and it follows that this guide is not intended to be a fully comprehensive document to be used in isolation. Where a subject is covered in depth in up-to-date publications elsewhere, the subject may be dealt with more briefly and reference will be made to the other sources of information in the text. Additional references that may be of use are given only in the bibliography. Where there is little current published information available, we deal with the topic more fully in this guide.

1.7 The good practice in this guide is not only based on the full Local Transport Plans (LTPs) submitted by local authorities, but also on other aspects that DTLR considers good practice. Also included are innovative examples provided by local authorities, thought to be successful, but which are too recent to be proven so.

1.8 Strenuous efforts have been made to provide accurate, up-to-date and full coverage of the issues relating to road safety engineering and good practice, with the focus on engineering. However, it should be noted that much of the contents is taken on good faith and some subjective judgements have been relied upon in the choice of approach. Readers should also be aware that what constitutes good practice in one authority, or on a particular road, or under one set of specific conditions, may not be good practice if simply replicated elsewhere. This is due to the complexity of the many interacting factors affecting safety. Similarly, it should also be noted that there is not one definition of good practice, as no single definition could cover everything.

## Structure

1.9 This guide has eight chapters:

- **Chapter 1** comprises the above purpose and scope of this guide and a background introduction to road accidents in Great Britain. It also describes how safety problems are currently being tackled;
- **Chapter 2** looks at the management of road safety on the network, including staffing, training, planning, liaison and consultation processes. This chapter also considers the roles of road safety officers, road safety engineers and safety qualifications;
- **Chapter 3** describes the general principles of road safety work. The role of Local Transport Plans (LTPs) is discussed. It provides methods of identifying and prioritising problems using accident and casualty analysis techniques (including the need to consider urban and rural problems separately and how to take exposure to risk into account particularly for vulnerable road users). The chapter also deals with finding solutions to accident problems, prioritising schemes, and economic justification in terms of accident reductions. This chapter also raises issues relating to the funding, installation, Safety Audit, and monitoring of schemes;
- **Chapter 4** (in conjunction with Appendix A) comprises the main body of the guide. It describes specific national safety problems(including accident and casualty statistics not published elsewhere)and a selection of engineering measures offered as potential solutions, according to location and road type;
- **Chapter 5** describes many of the methods available to monitor and evaluate the success of schemes, including some which may be useful when accident numbers are small and the levels of exposure to risk are unknown;
- **Chapter 6** is the **bibliography**. It contains:

the contents list for the *Traffic Signs Manual* (TSM chapters one to eight);
a list of Traffic Advisory Leaflets (TALs);
a list of Local Transport Notes (LTNs);
a list of the highway standards and advice notes found in the *Design Manual for Roads and Bridges* (DMRB); and
a large list of other publications relevant to road safety, including those referred to in this guide. The latter are listed alphabetically by author;

- **Chapter 7** lists **abbreviations** used in this guide;
- **Chapter 8** describes how readers can give feedback to DTLR;
- **Appendix A** contains brief descriptions of individual engineering measures and key references on proven performance, where available. The appendix also gives one or more example schemes(generally) submitted by local authorities, with a brief description of their purpose and performance;
- **Appendix B** gives basic details on applying various statistical techniques, including some worked examples;
- **Appendix C** is the standard data input form for the safety scheme accident monitoring database, MOLASSES.

# Background

1.10 Over the last 50 years, the number of motor vehicles in Great Britain has increased dramatically. Motor traffic levels are about ten times greater today. In 1950 there were about 550 people injured in road accidents every day, about 14 of who were fatally injured.

1.11 Both central and local government have made substantial efforts to reduce the road accident toll and, despite the large increase in traffic, accident rates (per vehicle-km travelled) have declined dramatically. In1966, the number of fatalities peaked at 22 per day. Since then the number of fatalities has gradually fallen. In 1999, there were about nine and a half per day.

1.12 Many factors are involved. However, we can identify three major contributions to the drop in casualty numbers and their severity:

a) legislation requiring that seat belts be fitted (1967) and worn (1983onwards);

b) drink-driving legislation (the current legal limit of 80mg of alcohol in100ml of blood was introduced in 1967) and changes in the attitude of the public to drink-driving;

c) traffic calming schemes on local roads (1980s onwards).

1.13 In addition, in 1987 the government of the day focussed attention on road safety by setting a national target to reduce road accident casualties by one third by the year 2000 (compared with the 1981-85average). A great deal of effort and initiatives followed and since that target was set, road injuries have fallen by only 0.5 per cent but road deaths have fallen by 39 per cent and serious injuries by 45 per cent. However, the volume of traffic has increased by 160 per cent over the same period, and those slightly injured may previously have been seriously injured or killed.

1.14 Compared with the rest of the world, and the rest of Europe in particular, we have one of the lowest levels of road deaths per head of population, and per licensed motor vehicle (DTLR, 2000a). We also have one of the lowest car occupant deaths per car-km (Automobile Association AA, 1999a).

1.15 However, 320,310 people were still injured in a single year in road accidents in Great Britain (1999 data) of these casualties 3,423 were fatally injured nearly nine and a half a day (DTLR, 2000a) [2] . Although in many respects our roads are safe compared with others in Europe, our child pedestrian fatality rate is one of the highest in Europe (DTLR, 2000b).

1.16 While most road accident casualties in Great Britain are car occupants, this reflects the fact that the car is the main type of road transport.

Other types of road users are subject to a higher risk of accidents, despite their relatively low exposure on the network (in terms of time spent or distance travelled). These are known as vulnerable road users and include pedestrians, pedal cyclists, motor cyclists and equestrians. Many of these road users are children who suffer serious injuries, as they are generally less well protected in accidents than people in cars. The safety needs of vulnerable road users are extremely important.

1.17 DTLR published a national cycling strategy in 1996 (DTLR, 1996). *Encouraging walking: advice to local authorities* was published in March 2000 (DTLR, 2000c). It is a working guide for the people who turn policy into action. It is not an exhortation to the public to walk more, but aims to make it safer, easier and more convenient for them to choose to do so. It shows how improvements to the walking environment can be made at both the strategic and the tactical level.

1.18 Accidents place a large financial burden on the nation, not only in terms of the costs associated with personal injury but also in terms of damage to property. The current estimated annual savings from preventing all (including about Â£3,520 million damage only) road accidents is Â£16,310 million (DTLR, 2000a).

1.19 These statistics reflect the need for a continued, concentrated and well-managed approach in order to reduce the number and severity of accidents.

1.20 DTLR has published a road safety strategy *Tomorrows roads safer for everyone* (DTLR, 2000b) [3] . The strategy sets casualty reduction targets for the year 2010 (with progress to be measured by comparison with 1994-98 averages) [4] . The 2010 road safety casualty reduction targets are:

- **a 40 per cent reduction in the number of people killed or seriously injured in road accidents** [5] ;
- **a 50 per cent reduction in the number of children (under 16years of age) killed or seriously injured; and**
- **a 10 per cent reduction in the slight casualty rate, expressed as the number of people slightly injured per 100 million vehicle kilometres.**

1.21 The road safety strategy also outlines strategies to tackle problems associated with:

- children and the most vulnerable road users;
- driver training;
- drink, drugs and drowsiness;
- the road infrastructure;
- speeds;
- vehicle design and maintenance; and
- enforcement, education and information.

1.22 Alongside the safety strategy, DTLR published *New Directions in Speed Management A review of policy* (DTLR, 2000d). This contains the latest information on the relationship between vehicle speed and accidents and other factors including air quality, noise, quality of life, and health.

1.23 Directly or indirectly, everyone can influence road safety. We are all responsible for controlling the risk we expose ourselves to and the risk we subject others to. No one is excluded from using the road network, so everyone must work towards the common goal of accident reduction. Stakeholders will include:

- individual road users using the network for work or leisure (motorists, pedestrians, motorcyclists, pedal cyclists and equestrians, including those with special needs, such as those with disabilities); and
- those in national and local government, Northern Ireland, the Scottish Executive, the National

Assembly for Wales, government agencies, Transport for London, local authorities, the police, health, education, public transport, commercial companies, charities, research bodies and special interest groups.

1.24 There have been changes recently in the way local highway authorities(LHAs) bid for a share of DTLR funding. The Department has replaced the old Transport Policies and Programme (TPP) system with Local Transport Plans (LTPs) [6] . The funding for safety under TPP was ring-fenced and distributed annually, based to some extent on the road safety plans produced by local authorities. From 1999-00, authorities submit LTPs that cover all aspects of local transport management, including safety. Capital funding for road safety measures is now awarded as part of a wider block of local transport funding over which local authorities have discretion. From 2001-02, DTLR has given an indication of local transport funding levels for five years.

1.25 Two recently published documents give guidance on developing full LTPs (DTLR, 2000e) and examples of good practice in LTP development (DTLR, 2000f).

1.26 The first of these documents states that LTPs should describe the specific road safety policies in a local road safety strategy and that the strategy must contain local casualty reduction targets for 2005,broken down into annual milestone targets, so that local authorities can monitor progress. Authorities will want to establish targets to reflect the national targets.

1.27 The document goes on to outline the expected contents of a local safety strategy, including details of proposed and existing engineering schemes and non-engineering approaches. It emphasises the need for monitoring and the benefits of contributing to Great Britains central database, known as MOLASSES (Monitoring Of Local Authority Safety SchemES see Appendix C and paragraph 5.4 below). It requires the production of an annual progress report and tables of performance indicators for measuring progress. Guidance has been produced to assist authorities in monitoring and reporting on progress in implementing their Local Transport Plans, including progress towards all local objectives and targets (DTLR2001).

1.28 If safety is to improve, local highway authorities must allocate resources for staff and materials within the overall programme. These resources should be sufficient to design for safety, and allow authorities to implement, monitor and assess good practice. In the long term, if a coherent approach is adopted, society ought to profit from such an approach in terms of accident savings and an improved quality of life.

[1] This guide is concerned with road safety only. It does not deal directly with the security of persons or property.

[2] These include the figures for motorway and trunk road accidents, which comprise 12 percent of all casualties and, because of relatively high severities on trunk roads, 18 per cent ofall fatalities.

[3] The equivalent for motorway and trunk roads is the Highways Agency’s *Safety Strategy*, safety being one of eight strands of an overall strategy. The strategy aims to spread good practice and help those without any safety training. The Highways Agency published it in March 2000 (Highways Agency, 2000a).

[4] These targets are also those adopted by the Scottish Executive and the National Assembly for Wales. Implementation of the strategy will be taken forward by the UK and devolved administrations in accordance with their respective roles and responsibilities. Northern Ireland will have its own road safety strategy.

[5] The target for the motorway and trunk road network is a reduction of 33 per cent (Highways Agency, 2000a).

[6] Note that separate systems are in place in London, Wales and Scotland.

# 2. Local arrangements, liaison and consultation

## Management of safety

2.1 General principles of road safety management are dealt with in several documents. For examples, see LAA (1996), RoSPA (1995a), IHT(1990a, 1990b, 1999c).

2.2 The Road Traffic Act 1988 (Section 39), specified that local highway authorities must provide a road safety service. This service includes education, training and publicity (ETP) programmes and engineering schemes [7] . In other words, they must try to prevent as well as to cure road accidents. Local highway authorities vary greatly in how they provide this service.

2.3 The Highways Agency has 38 agents [8] to run, maintain and improve its trunk roads. These agents are generally not local authority employees. The boundary of each agents area does not generally coincide with county boundaries, and each area usually includes parts of several counties.

2.4 Most commonly, road safety officers (RSOs) take responsibility for the ETP programmes and road safety engineers (RSEs) plan, design and install the safety engineering schemes. Often these roles are carried out by personnel who are exclusively concerned with safety. In others these roles are part-time, carried out by several personnel alongside their other duties.

2.5 The *LAA Road Safety Code of Good Practice* (LAA, 1996)recommends one full-time RSO per 50,000 population and one full-time RSE per 1,000 personal injury accidents.

2.6 Local highway authorities must assign responsibilities clearly. Contracts delegating responsibility for certain aspects of safety should be carefully drafted. It is equally important to monitor compliance.

## Liaison and consultation

2.7 Paragraph 1.23 above lists many of those who have an impact on road safety. It is imperative that effective links are built and maintained between these players so that all of them remain informed about current strategies and have an opportunity to express opinions and work together to shape outcomes.

2.8 As a general rule, everyone likely to be affected by a planned course of action (eg the introduction of a new engineering scheme) should be consulted at appropriate points throughout the planning process.

2.9 Councillors (elected members), parish councils and local committees represent local communities who need to be kept informed of road safety issues and planning. Public consultation is invaluable and you can find practical advice in, for example, IHT (1996a) and IHT (1999b).

2.10 The structure and organisation of traffic policing varies from area to area. However, in general, traffic police will assist road users, enforce road traffic law and supervise any necessary temporary changes in traffic management. The police, ambulance and fire services may all be present at the scene of an accident. The police also play a significant role in encouraging, publicising and educating road users about traffic law. Sometimes the police will also be involved in Safety Audit and accident investigation.

2.11 The Crime and Disorder Act (1998) requires police and local authorities to carry out a three yearly audit of problems affecting their area and draw up a plan to deal with them (DTLR, 2000b). This should include road safety.

2.12 Therefore, the police [9] need to be informed of any relevant changes to the network, such as scheme installation, special events and road works. The links between the police and local authorities are invaluable and, indeed, they often collaborate in strategies such as speed management and setting speed limits, the provision and operation of speed cameras, training programmes, driver rehabilitation projects. In addition, the decriminalisation of parking offences and the proposed decriminalisation of unauthorised use of bus lanes will raise road safety issues and opportunities. The police can also advise on road traffic patterns and driver behaviour because of their specialised knowledge of the network.

2.13 Perhaps most importantly, the police collect all the information on reported road traffic accidents. For each accident resulting in personal injury, the police record the circumstances surrounding the accident and details of the vehicles and casualties. They may also include contributory factors, participant and witness statements, photographs or sketch plans. The accident, vehicle and casualty information is included in the national STATS19 accident database and this helps to identify the problems that road safety strategies must tackle.

2.14 Consultation between LHAs and HA agents is also important, particularly on schemes where the trunk road network adjoins or crosses the local network and for joint publicity initiatives. In addition, the trunk road network has been divided into core and non-core [10] elements and in the near future local authorities will take over responsibility for the non-core elements (DTLR, 1998a). It will take excellent liaison for the handover to go smoothly.

2.15 The various departments within a local authority should liaise to avoid conflicts of interest and to provide a cost-effective service. There is particular value in incorporating the efforts of RSOs and RSEs in the planning stages and especially when introducing innovative schemes. We generally recommend that communication with colleagues in:

- policy;
- planning and development;
- maintenance;
- highways (engineers responsible for new roads and major schemes);
- public transport;
- traffic management and control;
- access and mobility; and

- trading standards.

2.16 Consultation and co-operation between local authorities and outside bodies is also important. For example, develop links with:

- the general public;
- local residents and businesses;
- landowners and farmers;
- motoring organisations;
- driving instructors;
- cycle and motorcycle trainers;
- HGV driving instructors;
- freight transport groups;
- special interest road user groups;
- public transport companies;
- construction companies;
- charities;
- professional organisations (e.g. IHT, ICE, IRSO etc);
- environmental groups;
- private companies;
- teachers;
- local health authorities; and
- hospital trusts and other organisations (such as CAPT, RoSPA, CPRE etc).

2.17 There is often potential for joint projects perhaps targeting a road safety problem from more than one direction to make the most of financial and human resources. Some examples of this approach include:

- local highway engineers working with the local health authority on cycle scheme initiatives, to help meet both road safety and health of the nation targets;
- a local authority and a car manufacturer jointly funding training schemes for young drivers.

2.18 Local authorities can also benefit from co-working, sharing information and experience and acting consistently:

- locally, working with other authorities through, for example, the regional Government Offices and accident reduction working groups, Local Authority Road Safety Officers Association (LARSOA),Association of London Borough Road Safety Officers (ALBRSO),Transport for London and so on;
- at a national level through, for example, the DTLR, Highways Agency, County Surveyors Society, Parliamentary Advisory Committee on Transport Safety (PACTS), Local Government Association etc.

2.19 Some guidance on forming partnerships is given for the purpose of developing LTPs (DTLR, 2000e and 2000f).

2.20 Disseminating the results of local authority road safety work to a wide audience is essential. This can be done through formal or informal presentation and through publication, either individually or by gathering information from several sources together. DTLR regularly gathers, analyses and interprets this sort of information to develop its advice see also chapter 6.

2.21 It may be a good idea to set up a formal approach to consultation and liaison on a regular basis. The Gloucester Safer City project found this useful (DTLR, 2001b). For example, meetings could be pre-arranged at regular intervals and an annual diary of events, campaigns and initiatives could be issued.

## Role of road safety officers

2.22 In general terms, road safety officers are involved in education, training and publicity (ETP) and encouragement programmes. These approaches help to change road users attitudes and behaviour. The full benefits of these approaches are often long term. They may never be measurable as it may not be possible to assess their specific effects.

2.23 Education programmes are largely school-based. The programmes usually involve informing and advising teachers. They may have specific objectives or be part of a long-term development of learning and ideas. Programmes aimed at children will match their physical and mental development. Often, road safety education can be planned to complement other topics in the National Curriculum. Some programmes and advice can be directed through parents.

2.24 Training programmes are mostly targeted at specific types of road user or age group. They are designed to develop practical road use skills; for example, cycling and walking.

2.25 Publicity campaigns generally use the media, leaflets and advertising. These are often the only ways to reach a wide audience, and adults in particular. The campaigns may, for example, inform of new developments, changes to the network, traffic or the law. They provide advice on the latest best practice, or the most recent research. They often aim to change road user behaviour and attitudes to road safety. Many publicity campaigns are organised nationally by DTLR, for example. They target national problems or reflect national policy. These campaigns often rely heavily on support from local health authorities and schools for maximum effectiveness.

2.26 ETP programmes often involve a combination of the above approaches and may involve RSOs working together with other outside bodies.

2.27 It is important that ETP work is monitored so that future programmes can be even more effective.

## Role of road safety engineers

2.28 Road safety engineers are responsible for designing the road network to be as safe as possible, for all types of road user. They design road safety engineering schemes to reduce the number and severity of casualties and to prevent them in the first place.

2.29 Road safety engineering involves physical changes to the network. Nowadays this predominantly involves light, rather than heavy, engineering schemes (ie signing, marking, or making minor modifications to the existing road network), rather than constructing new roads.

2.30 An engineering scheme immediately affects all road users who travel through it and its effects are also measurable.

2.31 Chapter 3 outlines the general principles for road safety engineering work. Chapter 4 details a number of safety engineering accident-remedial treatment measures for use on a wide range of roads. Chapter 5 deals with the measurement and evaluation of the effects of safety engineering schemes. Appendix A contains examples of successful schemes installed by local authorities across Great Britain.

2.32 Road safety schemes must be *maintained*, just like the road network generally. Liaison with those responsible for maintenance (eg operating the UK Pavement Management System) is essential to ensure that new schemes are integrated within the maintenance programme. For optimal safety of the network, we generally recommend that you maintain the best value indicators specified as minimum levels for principal roads (BVPI96 see DTLR, 2000j) and for non-principal roads (BVPI97).

## Role of road planning officers

2.33 The Planning process should take account of road safety and planning offices must liaise closely with RSOs and RSEs.

## Road safety qualifications

2.34 Few people currently working in road safety have had any formal or comprehensive training in safety. However, many may have been trained in associated disciplines, such as civil engineering, teaching or traffic management.

2.35 In general, safety personnel have gained their valuable knowledge through observation and on-the-job experience. Some have also attended a few seminars or been on short training courses, for example in the use of specialised software. Currently [11] available safety qualifications include the National Vocational Qualifications (NVQs levels 3 and 4 contact IHT for details: iht@iht.org).

2.36 Other safety training available includes:

- two week RoSPA road safety engineering course (contact RoSPA);
- one week course for Road Safety Officers (contact BITER);
- road safety courses for local authority staff (contact local police);
- miscellaneous road Safety Audit courses (generally advertised in magazines and journals contact TMS Consultancy, for example);
- other miscellaneous road safety courses (contact PTRC, for example); and
- miscellaneous software training workshops such as for SafeNET, OSCADY, ARCADY, PICADY etc [12] . (contact TRL Limited).

This list is not comprehensive and several other courses are available within the UK.

[7] Safety on the motorway and trunk road network is the responsibility of the agents acting onbehalf of the Highways Agency.

[8] Including 14 Design, Build, Finance and Operate (DBFO) groups.

[9] Other emergency services will also need to be informed, when appropriate.

[10] Approximately one third of all trunk roads.

[11] A few personnel have qualifications that are no longer offered: Road Safety Engineering MSc (Middlesex University) is a notable example.

[12] SafeNET is used to estimate the frequency of accidents on an urban network (from traffic and pedestrian flow and geometric information provided). OSCADY, ARCADY and PICADY are used as aids to the design of signalised, roundabout and priority junctions, respectively.

# 3. General principles

3.1 This chapter outlines the general principles associated with road safety work, and engineering in particular. It begins by describing the role of road safety in Local Transport Plans (LTPs). It then goes on to describe accident and casualty analysis techniques to identify road safety problems. The next sections address how to find solutions to the problems and to prioritise work programmes and issues relating to the installation and Safety Audit of safety schemes. The final section stresses the importance of learning from the success or failure of a scheme.

## Integration with Local Transport Plans

3.2 A Local Transport Plan is a statutory document produced by a local authority. It sets out a five-year integrated transport strategy devised in partnership with the community [13] . The Local Transport Plan covers every transport related activity carried out by the local authority. Two recently published documents give guidance on developing full LTPs (DTLR, 2000e) and examples of good practice in LTP development (DTLR, 2000f).

3.3 It is not a requirement for a Local Transport Plan to present detailed lists of the schemes that the local authority will implement. Rather, the plan is required to present a local vision of what the community wants to achieve. Local authorities should develop this vision, as well as allother aspects of the Local Transport Plan, through public consultation.

3.4 The Local Transport Plan needs to take account of the data required for monitoring the performance of local safety schemes, and to ensure that accurate data is collected on a regular basis. Background sources of data may include the *National Travel Survey, Transport Statistics Great Britain* (DTLR, 2000h) and *Road Accidents Great Britain* (DTLR, 2000a). Local authorities need to ensure that casualty statistics are accurate and effectively monitored. This will involve close co-operation with the police. Local authorities also need to develop a comprehensive set of targets and performance indicators, which must include road safety Best Value Indicators (BVPI99 see DTLR 2000k,Best Value Performance Indicators 2001/02). These need to take account of national targets.

3.5 It is important to ensure that local safety schemes and other road safety activities are integrated with the aims and objectives of the Local Transport Plan. Local safety schemes and education, training and publicity initiatives should be designed in the context of an integrated approach to transport and careful consideration should be given to their effect on other activities.

3.6 The aims of the Local Transport Plan should be assessed in accordance with the Departments New Approach to Appraisal(NATA) [14] . NATA sets out the Governments five objectives for transport, which are:

- environment
- safety
- economy
- accessibility
- integration

Therefore when a new safety scheme is required, the impact against each of these objectives should be considered. To be consistent with NATA, the assessment should also examine the impact on local objectives, local problems and other issues including distribution and equity, practicality and public acceptability, and affordability and financial sustainability. However, as described below, the general principle is that the level of detailed appraisal should be that required to establish clearly whether the scheme represents value for money.

3.7 DTLR (2000j) has said that building in accessibility for disabled people in all new investment is a condition of public money being spent. Clearly, not all of the above questions would be relevant for each new scheme. However, it is important to realise that a new scheme will influence other activities within the Local Transport Plan. Local authorities are encouraged to develop causal chains in order to show this interaction. For example, a safer routes to school scheme may provide safer pedestrian crossing points. This improves safety, leading to more cycling and walking, which in turn leads to health benefits.

3.8 Each Local Transport Plan requires the setting of targets for each activity and road safety is no exception. The performance of local safety schemes should be measured against a series of local targets and the national targets for casualty reduction. Chapter 1 summarises the national targets.

3.9 Local authorities are encouraged to set targets that are tougher than the national target. In addition, the Local Transport Plan is required to have a local casualty reduction target for the year 2005 supported by annual milestones.

3.10 To achieve the objectives of the Local Transport Plan, it may be useful to use more sophisticated criteria for the selection of local safety schemes. As well as the normal criteria of a certain number of accidents within a given location, other criteria such as the severity of injury, flow levels and proximity to schools could be considered. A well designed scheme implemented outside schools may reduce accidents and casualties, improve social inclusion and encourage walking. However, the need to reduce casualties must remain the first priority. It is important that the criteria reflect the priorities of the Local Transport Plan.

3.11 The integrated approach of Local Transport Plans opens up the possibility of designing schemes that can address a number of issues at the same time. A simple example would be where a road is due for renewal and, although this is normally a maintenance issue, there is no reason why a safety scheme could not be included in the works. This integrated approach extends to the relationship between local planning authorities and developers. It is a requirement that developers take account of road safety in the design and layout of their proposals.

3.12 It is important that authorities should monitor the progress they are making in implementing their Local Transport Plans. Authorities have been asked to prepare Annual Progress Reports which identify the progress being made in working towards the local objectives, targets and outputs contained in their Local Transport Plans, including all road safety targets. These reports will also help to indicate the link between local and national targets, and may help to identify any barriers to the achievement of local objectives or targets.

## Accident and casualty analysis: identifying problems

3.13 Local authority engineers and others responsible for road safety need regularly to assess the problems on their network. This will involve studying accident patterns over a period of time according to location, circumstances and the vehicles and casualties involved. The relative size of the problems and the ability to tackle them must be assessed and suitable cost-effective solutions devised and planned.

3.14 Traditionally, this is known as an accident investigation and prevention (AIP) approach. Local authorities have reduced casualties by identifying the locations with the highest accident frequencies and giving them priority over others for remedial treatment as local safety schemes (LSS).

3.15 73 per cent of all accidents are concentrated on urban [15] roads. Consequently, traffic authorities have directed most of their casualty reduction efforts on these roads, tackling locations where accidents are tightly clustered (often at junctions).

3.16 This has proved successful and road safety engineering budgets have been spent accordingly. Of course, other factors such as the vehicle capacity of the road, land development, policy issues and environmental matters often affect budgeting decisions as well.

3.17 Many local authorities now programme their work to take other factors into account (as part of a speed management plan, for example) and adopt any of four strategic approaches:

- single site action addressing a specific site with a much higher than average concentration of accidents of a particular type;
- mass action addressing all locations having a similar accident problem over the whole area under consideration using proven remedial measures eg at all T-junctions;
- area action addressing a number of problems over a network of roads in one part of the total area under consideration; and
- route treatment addressing a number of problems on one or more routes ie adjoining road sections with broadly similar characteristics and traffic.

3.18 Methods for such approaches have been well-documented elsewhere, for example by the IHT (1990b) and RoSPA (1995b).

3.19 However, with the Governments integrated transport policy, there are now good reasons to broaden the approach to include analysis of:

- urban and rural [16] accidents separately (see paragraphs 3.36 to 3.40below)
- accident numbers *and* accident rates for all classes of road user, including vulnerable road users (see paragraphs 3.41 to 3.51 below)

- each class of road separately (see paragraphs 3.52 to 3.53 below).

3.20 The separate analyses suggested above should be carried out with a view to allocating resources to both urban and rural areas, and to each class of road, and to different classes of road user.

## Identifying and prioritising problems

3.21 Accident and casualty analysis is a complex procedure because the factors affecting accident occurrence are numerous and not independent. Ideally, the direction that a comprehensive accident analysis takes will be led by accident data. Experienced road safety engineers will carry out the analysis. They will understand the importance of different types of result and be able to identify and balance conflicting levels of accident risk [17] .

3.22 In practice, it may be useful to follow a guide (such as that in paragraph 3.23 below), which ensures that the key areas and types of accident are addressed. Further analyses should be carried out whenever budgets and the relevant expertise are available, and particularly if it is clear that special problems exist.

3.23 The basic approach for separate urban and rural accident analyses can both be summarised in the following steps.

- Look at injury accident data for the relevant area for a period of three to five years [18] . Plot the location of accidents on maps. This can be done with a GIS system or an accident analysis package, initially distinguishing killed and seriously injured (KSI), child accidents and/or other vulnerable groups separately.
- Examine accident patterns in terms of type, contributory factors [19] and location [20] , considering accident numbers and rates for each class of road [21] .
- Identify any significant changes in accident trends and factors overtime.
- For each road in the area, tabulate the results as you go.
- Prioritise roads for further investigation and treatment (see paragraphs 3.30 to 3.34 below).

3.24 It is important to consider not only the local picture, but the wider picture too. For example, over the same period:

a) have accident frequencies changed nationally (or over another large area, such as the neighbouring county)?

b) have traffic levels changed?

c) has the composition of traffic changed?

d) what other local or national events may have affected accident frequencies?

3.25 To explore a) above, some useful publications are:

- *Road Accidents Great Britain* The casualty report. This is published every year, the most recent being DTLR (2000a). DTLR also produce quarterly summary information.
- Some authorities publish road safety plans or accident reports in addition to their Local Transport Plans. The latter must be made publicly available and include their local road safety strategies.

- Transport for London, London Accident Analysis Unit (LAAU)publishes regular reports on the accident and casualty data for all the London authorities (see London Research Centre, 1999a, 1999b,1999c for examples);
- Publications by interest groups, such as the Child Accident Prevention Trust (CAPT, 2000a).

3.26 To explore b) and c) in paragraph 3.24 above, the possible safety effects of encouraging more cycling and walking (DTLR, 1996; DTLR, 2000c) and the possible effects of the Road Traffic Reduction Act(1997 and 1998) should be considered. Some useful publications are:

- *Transport Statistics Great Britain*. This is an annual publication (DTLR, 2000h). DTLR also produce quarterly summary information;
- *National Travel Survey;* and
- *National Household Census*.

3.27 Factors affecting d) in paragraph 3.24 above may include almost anything from the installation of a scheme (within the last three to five years), to temporary road closures, to a large sporting event, to a petrol shortage, to a new law or publicity campaign.

3.28 Any changes to the local network in terms of the road length understudy should also be taken into account. For example, the introduction of lower speed limits in villages and the new responsibilities for non-core trunk roads may both affect the proportion of rural and urban roads (and so casualties) in the network year by year.

3.29 It may be helpful to tabulate the results of the analysis, to assess the relative seriousness of problems to help prioritise them. This will be particularly useful in identifying any overall problems, such as speeding, skidding, or bend accidents. It may provide justification for a mass action treatment (see paragraph 3.17 above).

3.30 The information used on accident rates during the prioritisation process will vary, depending on the situation and the quantity and reliability of exposure data. The use of more than one type of accident analysis approach will often be appropriate.

3.31 When ranking problems a balanced assessment of all the data has to be achieved, based on:

- accident rate (see paragraphs 3.41 to 3.44 below);
- number of accidents; and
- severity of injuries sustained in accidents.

3.32 An intervention level is a numerical value of a measure of an accident problem (such as accidents/year, accidents/vehicle-km). If the values for a particular road exceed the relevant intervention levels, then select that road for more detailed analysis and subsequent treatment.

3.33 Over time, most of the worst accident problem sites have been cured. Accidents now tend to be spread more evenly across whole areas. For this reason, mass action, route action or area action remedial treatments may be preferable to treatments at a few specific sites (see paragraph 3.17 above). The treatments selected may be chosen to tackle one or more particular types of accident, rather than all accidents.

3.34 Low-cost measures may make these other approaches just as cost-effective as the traditional site-specific approach. In addition, some accident problems may be tackled more effectively through enforcement, training and publicity than by engineering alone.

## Data issues

3.35 The nationally collected accident database using material from theSTATS19 form, described in paragraph 2.13 above contains objective information about accidents. A sample form can be found in the back of RAGB (DTLR, 2000a). STATS20 (DTLR, 2000g) accompanies theSTATS19 form. It advises on the meaning of certain aspects of the form. The following points may also help in accident analysis:

- Many villages have 30 or 40 mph speed limits [22] . They are therefore classified as urban, even if the surrounding roads are rural and the land is predominantly not built on. It is not easy to identify such sites from accident data, except with the use of maps.
- The road type (was carriageway type) variable in STATS19 does not include the categories roundabout and one way street as either single or dual carriageways. The two together account for approximately 10 per cent of all accidents so take care to account for them in analyses that consider single and dual carriagewaysseparately. [23]
- There is no specific definition of a bend or the severity of a bend.

This is because in terms of safety many factors are important, including the type of approach, camber, super elevation, radius, transition, road surface, aspect, verge width, gradient etc. It is up to the reporting officer to decide how to classify the accident. In addition, a bend feature is only specified as a category in the vehicle manoeuvre variable. This means that the reporting officer may record the vehicles in an accident that happens at a junction on a bend as either a junction or a bend-related manoeuvre.

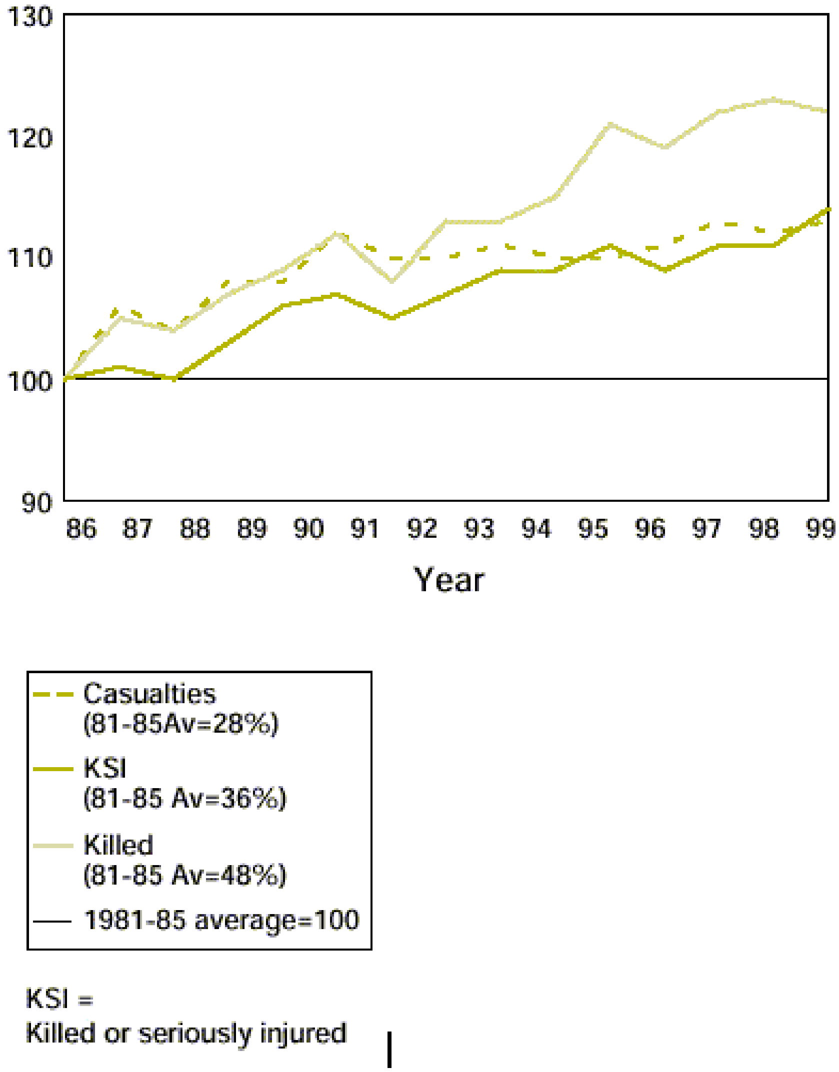
- Horses are now included as a vehicle type on the STATS19 form [24] .
- Police authorities should record all injury accidents. Of course, not all accidents are reported to the police. Research using hospital and insurance records has shown that recording levels for accidents involving vulnerable road users and for those involving only a single vehicle are particularly low (eg Mills, 1989; James, 1991).
- There is some evidence that the precise location given for an accident is often inaccurate. It may be hard to ascertain precisely where the accident occurred, with respect to where the vehicles came to a halt, particularly in the case of a high speed accident. Also, the police will not always attend the accident scene immediately after the accident.

## Importance of rural accident remedial work

3.36 Although rural accidents account for only 31 per cent of all casualties, these accidents contribute 44 per cent of the total cost of injury accidents in Great Britain because they result in more serious injuries than on urban roads. What is more, a study of the past decade shows that the proportion of total accidents and casualties in rural areas is increasing, particularly of the most severe accidents. In fact, currently59 per cent of all deaths occur on rural roads.

3.37 Fig. 3.1 shows the trend in the proportion of casualties on rural roads compared with the 1981-85 averages, by severity.

**Fig 3.1: Indices of the proportion of all casualties that were on rural roads(including motorways), by injury severity (1986-99)**




3.38 Rural roads (excluding those through villages) are less likely than urban ones to be treated with safety engineering schemes. The main reasons for this are that:

- local authorities tend to identify sites for treatment on the grounds of injury accident numbers; and
- accidents in rural areas are even more likely than those in urban areas to be widely scattered.

3.39 Intervention levels (see paragraph 3.32) suitable for urban (but not rural) roads will be well known to local authority RSEs from their knowledge of their local network. Intervention levels suitable for use in rural accident analysis [25] (including some relating to vulnerable road users) have been developed recently, based on national data (Barker et al, 1999). A methodology for rural accident analysis using these intervention levels is given in DTLR (2001a) and Barker et al (2001).

3.40 There is also another good practical and financial reason for considering the separate analysis of urban and rural roads. The *Highway Maintenance Code of Good Practice* (LAA, 1989)recommends creating a highway maintenance management strategy and a maintenance road hierarchy of urban and rural roads separately. It recommends that it should be further broken down by traffic flow and composition. Efficiencies will result if maintenance and safety scheme programmes can work together as suggested in paragraph3.74 below.

## Importance of exposure

3.41 It is well known that accidents are highly correlated with traffic flows and road length (for example, see Walmsley and Summersgill, 1998). In other words, you would generally expect to find more accidents on a long road with high flows than on a short road with low flows. It is important, therefore, to take account of exposure (or the opportunity for accidents to occur) when ranking accident problems.

3.42 Although it is also important to tackle the largest number of accidents and casualties possible with the budgets available, it is important to note that this does not necessarily mean treating the sites with most accidents. This is because sites with a high accident risk (ie the sites that do not have the largest number of accidents, but do show a greater propensity for accidents than one would expect for a given level of exposure to risk) are the sites that are most likely to be amenable to treatment.

3.43 Although the most important exposure variables are likely to be road length and vehicle flow, others will often be important too, especially when considering certain types of accidents. Examples include pedestrian flow, pedal cycle flow, junction and bend density (the number of junctions or bends per km of road).

3.44 In the case of vulnerable road users this approach is especially important as, although accident and casualty numbers may be low, their accident casualty risk is very high.

## Proxies for exposure variables

3.45 Often there will be no suitable exposure data available, especially for vulnerable road users. In this case suitable proxies need to be found.

3.46 Sometimes, accident risk can be calculated in terms of per head of population or population density, or per trip or per licensed vehicle etc, instead of per km travelled.

3.47 Another option not often considered is to use comparisons with another (control) area [26] where exposure levels such as the amount of cycling, for example, are considered similar to those in the area understudy. These comparisons remove the need to collect exposure data explicitly.

3.48 This method of comparing accident types between areas identifies accident types that feature disproportionately more often than their expected frequencies [27] would suggest.

3.49 To illustrate, if only 5 per cent of all accidents in the study area involve pedal cycles then, in terms of accident numbers, it is not immediately apparent that this is a high priority accident problem. Now, suppose we find that only 1 per cent of all accidents in a similar control area involve pedal cycles. Assuming that the level of cycling is similar in the two areas, it is evident that cycle accidents in the study area deserve further investigation. It is possible that such an accident type (because of its abnormally high level of risk) will be more amenable to preventative engineering treatments than another accident type with a higher observed and expected frequency of accidents.

3.50 Statistical tests may be used to evaluate whether the difference between the proportions of each accident type are unlikely to be due to chance (ie the difference between 5 per cent and 1 per cent in the example above). The statistical test used will depend on whether the control area is mutually exclusive of the study area see Appendix B5for details.

3.51 The use of the control does not, of course, prove that a problem exists. No control is perfect and the results may reflect different levels of exposure between the study and control areas. The control data could equally well camouflage a particular problem. Nevertheless, the use of a control is a valuable way of identifying accident characteristics for further investigation.

## Importance of traffic flows and road class

3.52 The relationship between accidents and vehicle flows is not a linear one (see Walmsley and Summersgill 1998). For this reason, it is recommended that roads with very different flow levels are not studied together. As detailed flow data are rarely available, grouping roads for analysis according to road class is one good alternative. Typically, accident and flow data are readily available by class of road.

3.53 There is a need to consider each class of road separately as far as intervention levels are concerned, because of the generally different levels of vehicle flow found on each class of road. For example, while motorways have higher accident numbers per kilometre than B/C/unclassified roads, they have much lower accident rates (per vehicle-km see Figs 3.2 and 3.3).

**Fig 3.2: Accidents per km by road class, GB 1999**

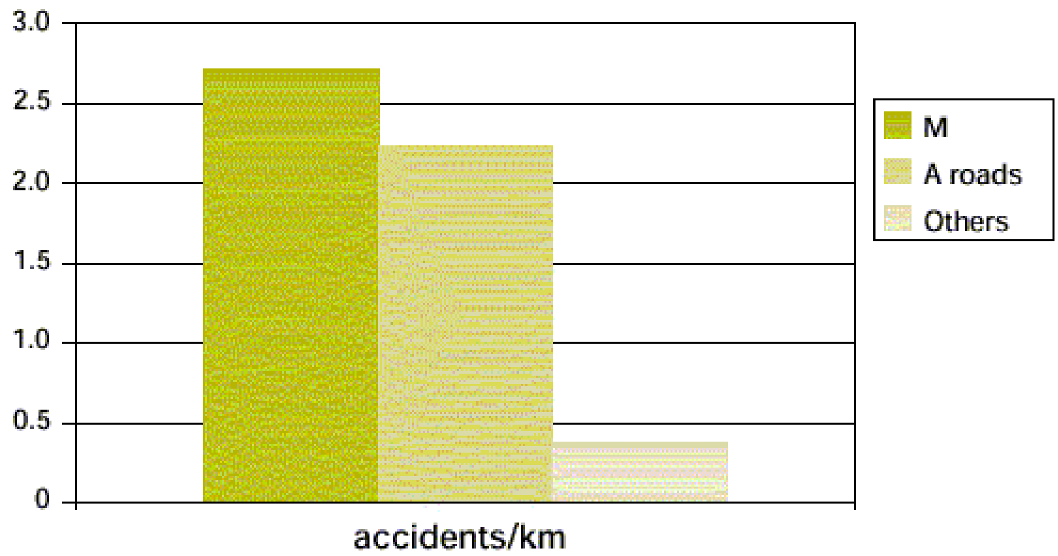
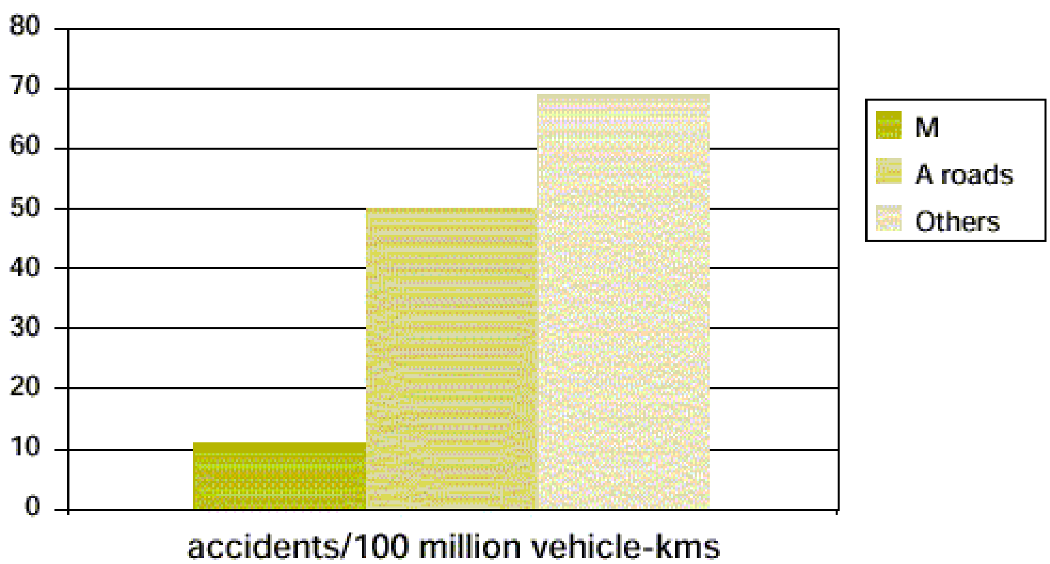



**Fig 3.3: Accidents rates (per 108 vehicle-kms)by road class, GB 1999**




# Finding solutions

## Detailed investigation

3.54 The next step in tackling the road safety problem is to investigate further the sites [28] identified as having problems. Once this has been done, and solutions identified a cost-benefit analysis (see 3.77 below, for example) will provide the final information required to prioritise remedial treatments.

3.55 It is important to consider road hierarchies. The actual use of different parts of the network should be assessed as it may not be in keeping with the design function of the road. If changes need to be made to address accident problems, then the method and overall potential effect of such changes will need to be addressed.

3.56 A more detailed accident and casualty analysis of the possible remedial sites will normally include plotting accidents on a larger scale map and considering the commonality of accident types and the movements of vehicles and pedestrians.

3.57 Stick diagrams [29] can be useful to identify predominant accident types, but become unmanageable if the number of accidents is greater than20 or so.

## Site visits

3.58 Site visits are an essential part of the detailed investigation process. Ideally, they should involve more than one person visiting a site on more than one occasion, in different weather, lighting and traffic conditions.

3.59 On-site observations of layout, signing, markings and traffic movements can often reveal possible explanations as to why accidents are happening that are not apparent from studying maps and accident reports alone.

3.60 The main reference sources for road layout, signing and marking are in paragraph 3.68 to 3.71 below and are listed in full in the first part of Chapter 6, the bibliography.

3.61 Typically, a site inspection should involve a road safety engineer addressing the following types of questions.

- Is there a consistency and clarity of approach in the quantity, quality, type and standard of maintenance of layout, signs and markings along the road?
- Is correct warning of a hazard given on the approach by use of the proper road markings hazard centre line, SLOW marking and so on as set out in the *Traffic Signs Manual* (TSM), Chapter 5 (see bibliography)?
- Are the markings and road studs properly maintained, so that they are clearly visible by day and by night and give the necessary minimum preview time (two seconds)?
- Are the prescribed warning signs provided (see TSM Chapter 4 for guidance)?
- Are the signs the correct distance from the hazard?
- Are the signs the correct size for the prevailing traffic speeds?
- Are the signs properly maintained and in good condition? (Worn or dirty signs cannot deliver the intended level of service.)
- Can the signs be clearly seen over the full recommended visibility distance or are they obscured by foliage, other signs, parked vehicles etc?
- Are the signs sited under trees or otherwise in deep shadow for much of the day? If so they may be prone to algae growth which obscures them and seriously degrades retroreflective performance. Fluorescent backing boards will greatly enhance conspicuity in daytime, when ultraviolet radiation is present.
- Are signs difficult to see because they are viewed against a complex background? (If so a yellow

backing board might greatly improve conspicuity).
- Are signs difficult to pick out at night because they compete for attention with brightly-lit advertisements, shop fronts etc? (If so, retroreflective yellow backing board might improve conspicuity).
- Have the needs of *all* road users and vehicle types been taken into account, as far as is practically possible?

## Vulnerable road users

3.62 It is important to promote cycling and walking (DTLR 1996 and 2000c)and it is known that pedestrians and cyclists and other vulnerable road users (such as equestrians and two-wheeled motor vehicle riders) have especially high levels of accident risk. Therefore, it is important to consider their needs and make provision for them.

3.63 For example, is there a need and would it be possible to provide:

- footways, cycle lanes, cycle tracks, bridleways?
- controlled or uncontrolled crossing facilities?
- grade separated crossings?
- crossing points for slip roads on major roads?
- facilities for cyclists where vehicles merge at high speed?
- roundabout designs to benefit cyclists and pedestrians (eg incorporating signals; or continental design with tighter entries to slow vehicles entering the circulating traffic flow Davies et al, 1997;TAL 09/97)?
- segregation?

## Detailed design

3.64 It is important that the objectives of introducing a scheme (such as speed reduction, improving pedestrian safety and so forth) are clearly thought out before beginning the detailed design process.

3.65 An *outline* scheme design should be drawn up which may include several different approaches and engineering measures for achieving the objectives of the scheme. The next stage is to identify the individual elements of a scheme and to put them together to form a cohesive, detailed design.

3.66 Engineers should consider all aspects of safety throughout the design process, as specified in the Contract (Design and Management)Regulations 1994 (HMSO, 1994a).

3.67 Engineers should consider the needs of all road users, including the disabled, pedestrians and motorists. They should also consider social inclusion [30] and accessibility.

3.68 *The Traffic Signs, Regulations and General Directions* (TSRGD HMSO, 1994c) provides drawings of all prescribed Traffic Signs together with relevant Regulations and Directions that apply to them. Detailed information and advice concerning design and application of signs, markings and other engineering measures are given in:

- *Traffic Signs Manual* Chapters one to eight (DTLR, various dates).The Chapter titles are given in the front of the bibliography and are referred to in the text as TSM Chapter No.
- Traffic Advisory Leaflets (DTLR, various dates). These are listed herein the front of the bibliography (Chapter 6) and are referred to in the text as TAL No./yr.
- Local Transport Notes (DTLR, various dates). Relevant ones are listed in the bibliography (after the Traffic Advisory Leaflets). They are referred to in the text as LTN No./yr.
- *Design Bulletin 32* (DTLR, 1992) and its companion guide (DTLR,1998c) cover the design of residential road and foot way layouts.
- *Transport in the Urban Environment* (IHT, 1997) promotes the design and management of urban transport infrastructure and systems. Part III includes safety related issues.

3.69 The principal documentation for trunk roads is:

- the set of Design Standards and advice notes brought together in *Design Manual for Roads and Bridges* (DMRB DTLR, various dates). The constituent parts of this document are given here in the bibliography (after the TALs and LTNs, Chapter 6) and referred to in the text as DMRB, XX No./yr.. Some of DMRB may be appropriate when considering non-trunk roads but the possible effect of differences in traffic flows and traffic mix should be reviewed.

3.70 If non-prescribed signs or markings are to be used then non-prescribed sign authorisation must be sought from DTLR.

3.71 The current advice on speed limits can be found in *Circular Roads1/93* (DTLR, 1993) and TAL 1/95. Since changes in legislation in 1999(DTLR, 1999c; Scottish Office, 1999; Welsh Office 1999), local authorities are free to introduce self-enforcing 20 mph zones and 20mph speed limits, where appropriate.

3.72 The design process will include drafting clear, well-annotated, vertical and horizontal drawings for the engineers. Outline plans should be on a scale of 1:5000 for a route. Otherwise they should be 1:2500or 1:1250. Full detailed plans should be on a scale of at least 1:500, or1:200 for a more complex scheme.

3.73 Consultation will largely take place after an outline scheme design has been proposed and before the full detailed design is finalised. Consultation can take up a significant amount of time and budget during the design process. Those to be consulted will vary from scheme to scheme, but will usually include internal consultees, local residents, emergency services and other representatives or road user groups likely to be affected by the scheme (see Chapter 2).

3.74 Ideally, consultations will include establishing that no other works are planned in the near future for the road that is to be treated, preferably for at least a three year period. This will ensure that:

- the scheme has a reasonable future lifespan;
- scheme monitoring will not be compromised; and
- different work schedules may be combined (such as maintenance and scheme installation) so that some necessary costs will be incurred only once.

3.75 It is important that sufficient money is set aside for monitoring a scheme. In the long term, monitoring will justify future similar schemes and make their design and installation more cost-effective.

3.76 The various stages of scheme design, consultation etc should all be well documented to reduce the amount of work necessary should a similar scheme be installed in future.

## Economic justification

3.77 The economic justification for installing a safety scheme is usually based on its economic return. This is generally calculated as an *estimated* First year rate of return (FYRR) which is an estimate of the monetary benefits to be gained in accident savings in the first year set against the cost of the scheme [31] . While many schemes will only save a small number of accidents a year, this can still produce a good rate of return.

3.78 Sometimes, particularly for the large schemes, the lifetime of the scheme may be taken into account with a net present value being calculated (calculated in a similar way to compound interest Highways Agency, 1996).

3.79 The estimated average accident prevention savings for accidents and casualties for 1999 (DTLR, 2000a) are:

**The estimated average accident prevention savings for accidents and casualties for 1999 (DTLR, 2000a)**

| Severity | £ per accident saved | | | | £ per casualty saved |
|---|---|---|---|---|---|
| | All | Urban | Rural | Motorways | All |
| Fatal | 1,262,090 | 1,182,910 | 1,316,780 | 1,361,690 | 1,089,130 |
| Serious | 146,890 | 138,490 | 162,180 | 166,720 | 122,380 |
| Slight | 14,540 | 13,690 | 16,570 | 19,550 | 9,440 |
| Average (all severities) | 49,920 | 38,620 | 83,350 | 62,280 | 34,540 |
| Damage only | 1,300 | 1,220 | 1,800 | 1,730 | – |

3.80 Predicting the percentage of accidents and casualties that are expected to be saved by a scheme is a difficult task. Consideration needs to be given to the recent accident history, the type of accident the scheme is designed to minimise, and the effect of the scheme on other (and potentially new) types of accident. The accidents to be saved should relate directly to the type and objectives of the scheme.

3.81 In some instances, robust information on the performance of particular measures may be available as a result of previous monitoring. For example, try the MOLASSES database, the SafeNET software (TAL08/99; TRL Limited, 1999), *Traffic calming in practice* (CSS et al,1994a) and as detailed in

Appendix A of this guide.

3.82 Take care to assess how the scheme will affect existing and surrounding roads and traffic to ensure that one problem is not solved by creating another (use SafeNET, for example).

3.83 When potential schemes are identified on the basis of high accident rates, the numbers of accidents to be targeted may be smaller than at low risk sites, but more likely to be treatable. Take this into account when estimating FYRRs. In other words, the potential proportion of all accidents saved may be greater at sites selected on the basis of having high accident *rates*, than purely on the basis of high *numbers* of accidents.

3.84 The IHT (1990b) recommends appropriate levels of FYRR to aim for when considering the implementation of single site, mass action, route action and area action schemes.

3.85 Some authorities weight their estimated FYRRs according to the severity of road accidents. Depending upon individual circumstances, it is possible that this can lead to greater attention being given towards treating roads with vulnerable road user casualties.

3.86 When calculating scheme costs, in addition to those for construction time and materials, take into account the contributions due to:

- design;
- consultation;
- traffic management;
- relocating statutory undertakers apparatus;
- providing power supplies;
- maintenance;
- monitoring;
- supervision of works; and
- Safety Audit.

## New Approach to Appraisal

3.87 As well as the use of economic indicators (such as FYRRs) the assessment of local safety schemes should examine wider impacts in accordance with the New Approach to Appraisal (NATA) as set out in DTLR (2000) Guidance on Full Local Transport Plans. This assessment involves the consideration of the Governments five objectives for transport:

- **environment** to protect the built and natural environment
- **safety** to improve safety
- **economy** to support sustainable economic activity and get good value for money
- **accessibility** to improve access to facilities for those without a car and to reduce severance
- **integration** to ensure that all decisions are taken in the context of the Governments integrated transport policy

Using this approach the impact against each of these objectives should be recorded in an Appraisal Summary Table. This table presents an unbiased summary of the impacts against the Governments objectives. To be consistent with NATA the summary should be supported by an assessment of how the measure meets local objectives and the extent to which problems are addressed. NATA also includes analyses of the impacts on distribution and equity, practicality and public acceptability, and affordability and financial sustainability.

The required level of detail will be proportionate to the size of the scheme. The general principle is that the appraisal should be conducted at a level of detail sufficient for the value for money of the proposal to be demonstrated clearly. A working note *Appraisal of LTP: advice on simplified procedure* provides guidance on the level of detail that may be appropriate for different policy instruments. For the majority of smaller safety schemes the key requirement is to ascertain that accident savings are likely and that together with any other associated benefits they exceed total costs imposed.

## Options for funding schemes

3.88 Central government funds the majority of local authority safety schemes. The government allocates funds largely based on LTPs (and the HA bidding process for trunk road schemes).

3.89 Other funding may come from:

- local highway authorities own capital and revenue budgets;
- local government (other departments, such as health and education);
- parish councils;
- local businesses (including money from developers);
- local organisations (such as the police);
- residents groups;
- research and development funding (governmental or private);
- special interest groups;
- charities;
- netting-off of fixed penalty fine revenue to fund speed limit and traffic signal enforcement cameras; and
- parking permits, meters and fines, road tolling (all subject to legislation).

## Installation issues

3.90 For urban roads, *Transport in the Urban Environment* (IHT,1997) deals with many relevant issues. The main documentation for scheme installation on trunk roads is the *Manual of Contract Documents for Highway Works* (DTLR, 1998b). However, much of this is relevant for works on local (particularly major) roads and local authorities often use it.

3.91 Qualified personnel who understand safe working procedures must supervise the installation of engineering schemes. There are legal issues to be considered.

3.92 Full and dated records should be kept detailing each phase of installation. This site diary information is often lacking, particularly when the client hands over aspects of the design and installation to one or more outside bodies. However, it is crucial for the monitoring process to provide valid results.

3.93 There is a need to consider any safety issues that may arise specifically during the installation period. This is particularly relevant when installation is spread over several days, or even months, and if the site is to be left unattended.

## Safety Audit

3.94 Safety Audit is a procedure introduced to prevent accidents. It is *not* an accident reduction procedure. In Safety Audit, safety (or accident potential) is formally, and objectively, considered at each stage of the design of a scheme.

3.95 A full Safety Audit will have four stages (IHT, 1996b):

- stage 1 feasibility/initial design;
- stage 2 preliminary design/draft plans;
- stage 3 detailed design; and
- stage 4 pre-opening (as soon as practical after completion).

3.96 A team of safety auditors carries out Safety Audits. They should be personnel with safety expertise and who are independent of the design team. The Safety Audit team will comprise more than one person and will include road safety engineers. It might also include police officers, road safety officers and other specialists, such as structural engineers. The size, breadth of expertise and number of members of the team will depend on the size and character of the scheme.

3.97 A prime objective of a Safety Audit is to consider the safety of all types of road users under *all* types of conditions, such as weather and time of day. The Safety Audit will not only consider the scheme itself, but its potential impact on the surrounding network. A necessary part of all Safety Audits will be to balance the needs of different road users (including those using all motorised transport, vulnerable road users and the disabled) under different conditions by assessing levels of accident risk. Naturally, the audit will also have to consider financial and design constraints.

3.98 Considering safety throughout the design process minimises the likelihood of unforeseen factors affecting the final costs. A final audit before opening the scheme is essential. This is because some aspects may be difficult to consider from two-dimensional plans and because installations may not match plans precisely.

3.99 In the longer term, Safety Audits encourage good design. They give safety a higher profile in the design process and act as a conduit for informing engineers of current safety understanding. The recommendations of safety auditors are not based on checking individual design elements against standards, but on considering how the scheme as a whole may affect overall safety, or deciding what to do when standards conflict.

3.100 It is recommended that a policy is adopted for Safety Audits to be carried out for all new road schemes and all modifications to the existing network, including re-design and maintenance.

3.101 Nationally, Safety Audits are only mandatory for trunk road schemes. The level of local authority safety auditing varies widely. Some authorities audit all schemes fully. Others reduce or eliminate the number of Safety Audit stages, depending on the scheme size, type or cost. The amount of documentation and the procedures for arbitration in the case of safety/design conflicts of interest also differ greatly between authorities. It is important that each authority has a clearly defined strategy and procedure for Safety Audit. The IHT (1996b)suggest that Safety Audit is a part of a broader road safety strategy: priorities for audit need to be set within the total programme of highway schemes.

3.102 There is considerable guidance on the legal consequences of Safety Audit (eg Stewart, 1995; Heath, 1995). Note that legal actions might result following accidents at a scheme, particularly if the adopted procedures have not been followed and are not well-documented.

3.103 When highway works are commissioned to outside bodies the need for Safety Audits should be identified and documented when the contract is let. The various stages should be monitored and well documented throughout the scheme planning, design and implementation. The processes and responsibilities for departures from procedures and recommendations should be clearly specified.

3.104 There is now a wealth of information, advice and experience on Safety Audit. Several sources are listed in the bibliography, but useful examples include:

- *Guidelines for Safety Audit of Highways* (IHT, 1996b)
- *Standards for Road Safety Audits* (DMRB, HD 19/94) and Advice Note for Road Safety Audits (DMRB, HA 42/94)
- *What goes wrong in highway design* (AA, 1999b).

3.105 In addition, some authorities and other practitioners have set up forums and support groups where safety auditors can discuss common problems and solutions.

3.106 Some authorities advocate Safety Audits of existing roads. These maybe useful to give a consistent approach or message to road users. This is particularly the case across networks where individual elements have been designed separately over time. However, many issues maybe identified during the detailed design stages of accident analysis and reduction programmes.

## Learning from success and failure

3.107 The importance of having good quality evidence about the performance of a safety scheme cannot be stressed enough; that is why monitoring is so important. The Guidance on LTP Annual Progress Reports emphasises the importance of ensuring that statistical information that is gathered about local targets including road safety targets is collected in a logical and well organised manner, using realistic sample sizes, and in accordance with existing statistical methodologies. Chapter 5 gives advice about the arrangements for monitoring the effects of individual safety schemes, but the following are some general points.

3.108 Do not repeat good schemes if better ones are available and appropriate.

3.109 Some schemes work well in some situations but will be inappropriate in others.

3.110 Some measures may work better alone or may only be effective when used in combination with other measures.

3.111 Sometimes an unsuccessful scheme need not be rejected outright. Investigations may prove that it only needs minor modifications to turn into a success.

3.112 Sometimes measures designed to reduce speeds may not do so, but may still reduce accidents by increasing driver awareness.

3.113 Sometimes it is hard to accept failure for financial or political reasons. However, it is important to be courageous and acknowledge that things did not go to plan. Consider challenging established policy and procedures if the evidence from monitoring warrants it.

3.114 Sometimes the effects of one scheme are hard to assess, perhaps because accident numbers are low or other factors influence the results. These problems can often be minimised or eliminated by considering data for a large number of similar schemes together. For example, pooling data related to changes at each site to reach an overall average figure. Such research can provide robust evidence about a scheme design in a way that is not feasible at a local level.

3.115 The MOLASSES database contains basic information about schemes installed on local authority roads *and* on trunk roads. The database is populated and managed at TRL (see web site at www.trl.co.uk/molasses). Contributors can interrogate the database for the latest evidence on the overall effectiveness of a type of measure in terms of accident reduction. It is planned that regular reports will also be produced. See Appendix C for an example data entry form.

3.116 Over the years, DTLR and HA have funded a wealth of research into the safety effects of engineering measures and safety schemes. Some have been studied only in the test and development stages using off-road trials and simulator studies. The most promising ideas have gone on to be installed at sites across Great Britain and further monitoring undertaken to establish the effects of these on-road trials. The results of these research projects are usually published or provoke further research. They are used in the development of the engineering design Standards and Advice notes, Traffic Advisory Leaflets, software such as SafeNET (TAL 08/99; TRL, 1999), and to shape road safety policy.

3.117 The TRL library has a vast amount of published research and maintains a database of international road research publications. A charge is made to provide some of this information.

3.118 Many of the more relevant publications are given in the bibliography, even if they have not been referred to directly in the text.

3.119 Chapter 4 describes accident problems at a national level and discusses potential engineering solutions (text in shaded boxes), by road type. It also includes a short section on non-engineering measures.

[13] Note that separate systems are in place in London, Wales and Scotland.

[14] For more details on the New Approach to Appraisal (NATA) see DTLR 2000e and paragraph 3.87.

[15] Urban (or built-up) roads are defined as those with speed limits of 40 mph or less.

[16] Rural (or non-built-up) roads are defined as those with speed limits of 50 mph or more. Roads through villages with speed limits of 20, 30 or 40 mph are not included. A rural road may or may not have buildings alongside it.

[17] Accident risk is a general term for the likelihood of an accident occurring, given a certain level of exposure.

[18] If accident numbers are high (hundreds or thousands) then one years data may be sufficient. However, if numbers are small and the data are broken down further into small groups by type of accident, for example, then the data will vary too much between years or sites for meaningful comparisons to be made and may be misleading. Much more than three to five years data will lead to a tendency for changes in flow and significant changes in the network to affect the accident picture.

[19] The analysis of the types of accident and the causal factors contributing to the accident is a vital step to reach an understanding of why accidents occur and how to treat the problem. Some of the most important aspects to be studied include casualty severity, weather and road surface condition, road layout and junction type, vehicle manoeuvres, vehicle types, vehicle speeds, driver compliance with the Highway Code, driver age, pedestrian involvement etc.

[20] This should include an analysis of types relevant to local and national targets and performance indicators in LTPs ie will include accidents involving child casualties, vulnerable road user casualties and analyses by severity.

[21] See also DTLR (2001a) and Barker et al (2001) for detailed methods.

[22] Government policy is now that speed limits in all villages should be 30 mph.

[23] The convention adopted in the casualty analyses in this guide is to combine these data with dual-carriageway data for motorway and A-road accidents and to combine them with single-carriageway data for accidents on lower class roads.

[24] In 1999, 181 horse rider casualties were reported, two of whom were fatally injured. 40 percent of casualties occurred on urban roads and 60 per cent on rural roads (DTLR, 2000a).It is not known how many horses were injured or involved in road accidents where the rider was uninjured.

[25] Intervention levels (see paragraph 3.32) suitable for motorway and trunk road accident analysis are provided annually to route managers under the Highways Agency Safety Strategy.

[26] Very often national data are suitable and readily available in RAGB (DTLR, 2000a). Other suitable Control areas might include the rest of the county, a group of neighbouring counties etc.

[27] See DTLR (2001a) and Barker (2001) for detailed method.

[28] Hereon, the term site may refer to short or long sections of road, or to a network of roads.

[29] A stick diagram is a table with one column for each accident. Each row of the table represents an accident, vehicle or casualty category (eg junction type, number of vehicles, type of vehicle, casualty severity etc). Pictograms showing vehicle movements or other categories are often used to facilitate quick analysis. The columns in stick diagrams are sorted by one or more row categories, repeatedly, so that predominant category types become apparent.

[30] Including issues that may affect road users travel patterns such as personal safety at night, the ability to combine parenthood and work etc.

[31] The simplest FYRR will be estimated as 100*(number of accidents in 12 months before installation predicted number of accidents in 12 months after installation)*(average cost of an accident)/total scheme costs. Note that there will be a considerable degree of uncertainty associated with the estimation of any such economic indicators.

# 4. Treatment selection

## Engineering measures

4.1 The nature of road safety problems commonly varies according to type of location. Due to the differing land use and traffic mix on the UK’s roads, appropriate solutions will also vary. In the following sections, we look at common problems and safety engineering treatments for improvement under a simple location classification of URBAN [32] and RURAL [33] , and the road types within these, as shown in the tree chart below.

**Figure 4.1**

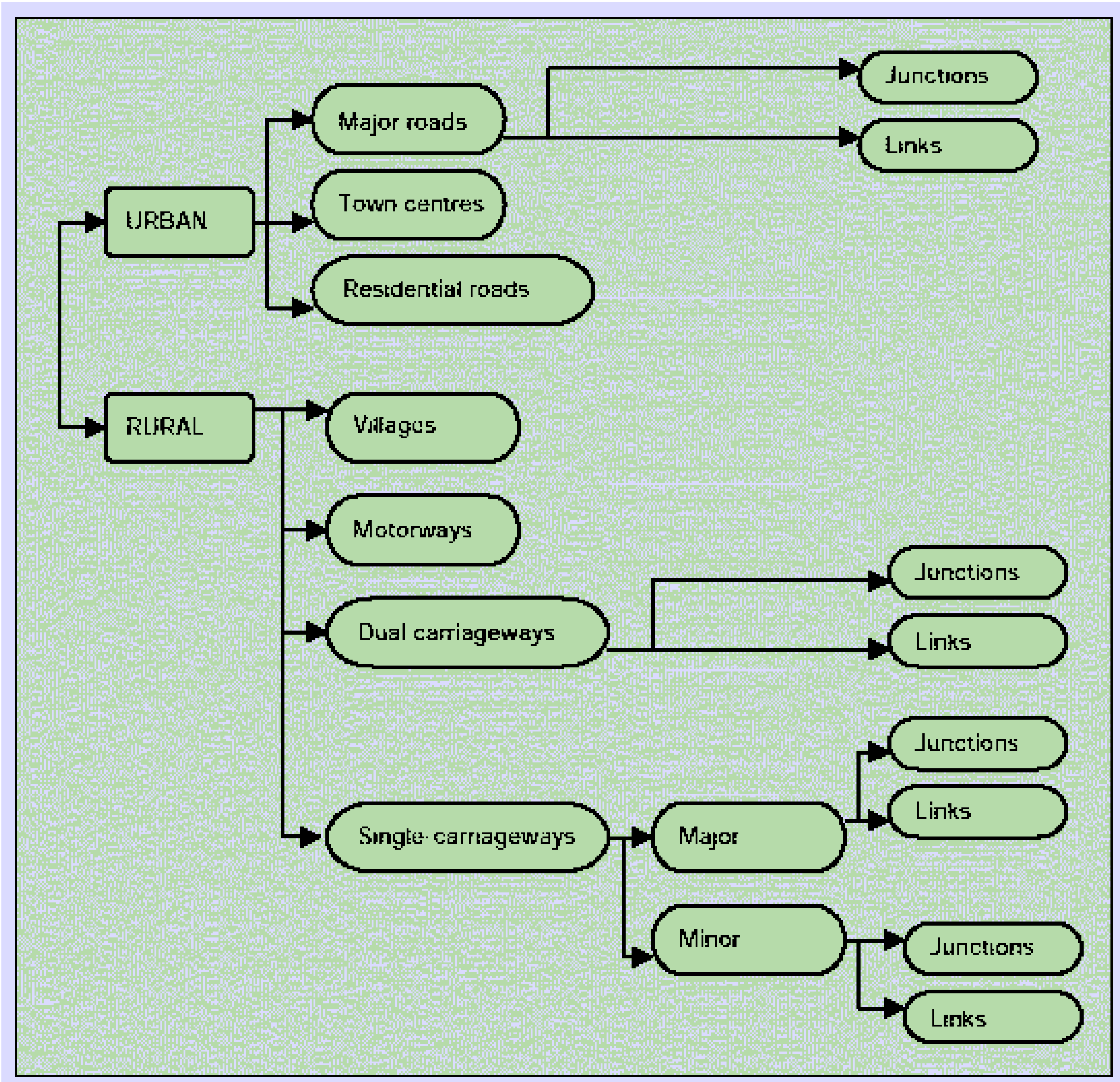

Junctions
Major roads
Links
URBAN
Town centres
Residential roads
RURAL
Villages
Motorways
Junctions
Dual carriageways
Links
Junctions
Links
Single carriageways
Major
Minor
Junctions
Links

**Figure 4.2a**

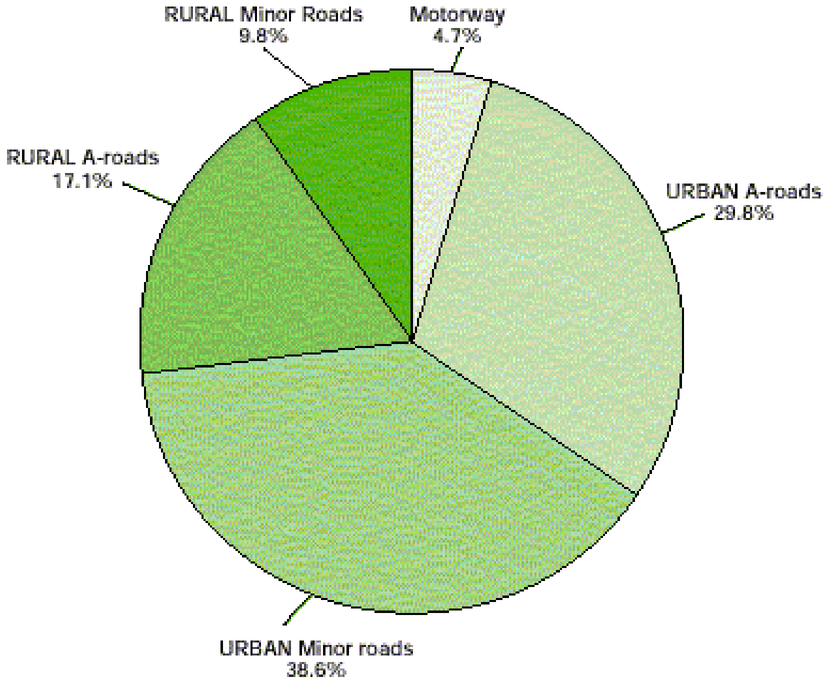
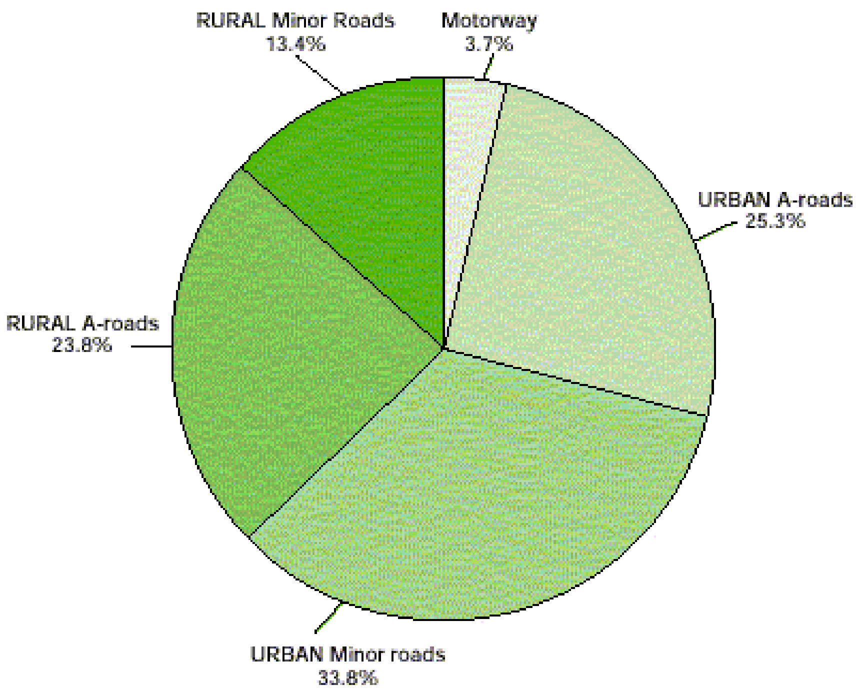

RURAL Minor Roads
9.8%
Motorway
4.7%
RURAL A-roads
17.1%
URBAN A-roads
29.8%
URBAN Minor roads
38.6%

**Figure 4.2b**


RURAL Minor Roads
13.4%
Motorway
3.7%
URBAN A-roads
25.3%
RURAL A-roads
23.8%
URBAN Minor roads
33.8%

4.2 Fig 4.2a above for reported road accidents in 1999 from STATS19 data clearly shows that the majority of casualties (over 68 per cent) occur on urban roads. Fig 4.2b shows the predominance of urban roads is slightly less marked when killed and seriously injured (KSI) casualties only are considered, with 59.1 per cent on urban roads. This reflects the generally higher severity of accidents on rural roads. However, achieving the Governments casualty reduction targets still means that all road authorities need to investigate safety problems and come up with solutions.

4.3 As discussed in Chapter 2 and in paragraph 3.8 above, the national casualty reduction targets need to be disaggregated to annual figures for the individual authority's road network. The authority will need to decide which combination of strategies of single site, mass action, a reaction or route treatment is likely to best achieve these targets. The remainder of this chapter discusses, in general terms, the main safety problems found at different types of road location in Great Britain. It also suggests common solutions.

More details on each type of treatment together with real examples are in Appendix A.

## Urban roads

**Figure 4.3a**

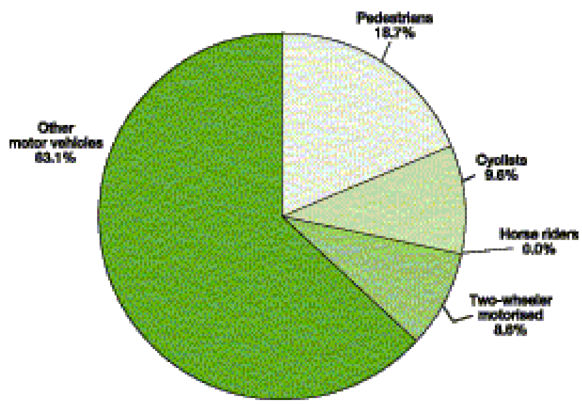
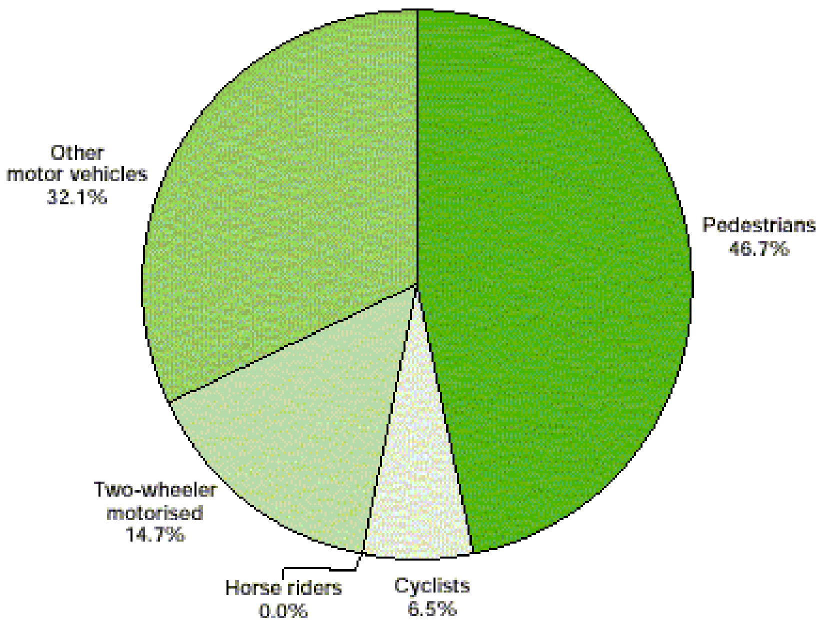



**Figure 4.3b**

All fatalities on urban roads 1999




4.4 Urban areas are more complex than rural ones and are where the majority of casualties occur (ie built-up roads in DTLR, 2000a). These figures mask large differences between the figures for different road users.

4.5 Fig 4.3a shows the breakdown of casualties on urban roads by casualty type. About 19 per cent are pedestrians, 10 per cent are cyclists, 9 per cent are two-wheeled motor vehicle users and the remainder (63 per cent) are users of other motorised vehicles. When fatalities alone are considered (Fig 4.3b) the figures are 47 per cent (pedestrians), 7 per cent (cyclists), 15 per cent (two-wheeled motor vehicle users) and 32 per cent (other motorised vehicle users).

4.6 The types of road user involved also differ substantially from one location to another. In town centres, casualties are often concentrated at specific locations. Outside these areas, they are more diffuse and include a markedly higher proportion of pedestrians and cyclists, particularly children (IHT, 1997).

4.7 The principle technique for tackling urban accidents is black spot treatment. Low cost solutions are applied to clusters of accidents with a factor in common. This approach has met with considerable success, but is becoming less beneficial as more and more sites are treated.

4.8 Urban Safety Management (USM) principles (TAL 3/90; IHT, 1990)were developed to address the urban accident problem more strategically, tackling both clustered and more thinly spread accidents. The approach was first demonstrated in five towns in the Urban Safety Project (Mackie et al, 1990). By managing traffic onto the right roads, the project achieved casualty reductions of 15 per cent.

4.9 The key elements of USM are:

- defining an appropriate road hierarchy;
- ensuring that traffic moves on the right roads;
- managing traffic speeds; and
- co-ordinating the activities which affect road safety (4.10).

4.10 USM deals with road safety problems as part of urban management. The process is flexible and involves a wide range of disciplines:

- traffic management;
- enforcement;
- education;
- training and publicity;
- health and education;
- public transport; and
- town planning.

4.11 A more comprehensive demonstration project has been undertaken in Gloucester (DTLR, Safer City Initiative, Gloucester Safer City, 2001b) to raise awareness of the principles and potential benefits.

4.12 Reducing inappropriate speeds is likely to be the single most important factor in improving urban safety. Lower speeds will benefit all urban road users, but particularly the large number of pedestrians and cyclists. Currently more than two-thirds of car drivers exceed 30 mph on roads with this limit (DTLR, 2000d). The disbenefit of increasing journey times of illegal, speeding drivers by reducing their speed should not be taken into account.

4.13 Taylor et al (2000) have shown that accident reductions typically of 5per cent per mile per hour in average speed are achievable. The greatest benefits occur on congested roads in town centres and on residential roads. Reducing the speeds of the fastest drivers is the key objective. Drivers who habitually travel faster than average are involved in more accidents in a years driving than those who travel at average speeds (Taylor et al, 2000).

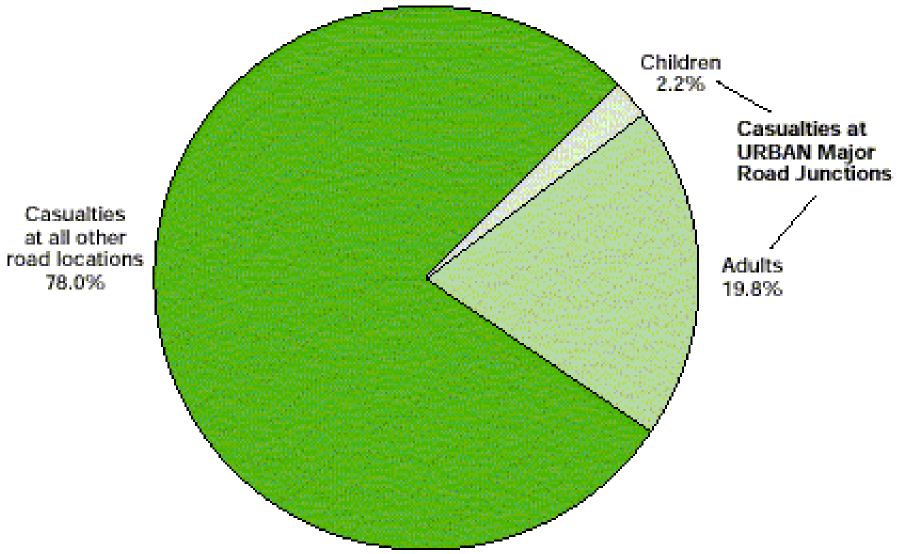
4.14 Your speed management policies must aim to achieve a safe distribution of speeds according to the function of the road. This means an average speed appropriate to the prevailing conditions, and all vehicles moving at speeds as close to this average as possible(Taylor et al, to be published 2001).

4.15 Techniques that are cost effective need to be applied which convey to drivers the risks involved on different types of road.

4.16 In the following sections, pie charts have been used, where possible, to illustrate the size of the casualty problem on each type of road classification. Adult and child casualties are shown separately as a percentage of all casualties on the network. For consistency, we have included all severities of casualty, but differing proportions are likely to apply if, for example, only fatal/serious casualties are considered (for example, see Figs 4.3a and 4.3b).

## Urban major road junctions

**Figure 4.4**




4.17 The number of casualties in accidents at junctions on major roads in the urban areas of Great Britain is currently 68,876 (1999 data). This represents 22 per cent of the total casualties on the network. The large volume of road users passing through them on conflicting paths often worsens the serious safety problems at these junctions. For the same level of turning traffic flows, an uncontrolled priority junction with a minor road will usually have more accidents per year than other junction types.

4.18 The speed of vehicles approaching a junction and the possibility of overtaking manoeuvres on the major road will also directly affect the number and severity of collisions. At traffic signals the risk of serious right angle collisions is increased if drivers infringe the red light, and the incidence of these infringements normally increases when drivers are approaching at high speeds despite the use of sophisticated speed discrimination or assessment systems (Baguley and Ray, 1989). These systems help those drivers who, by virtue of their position, may be genuinely caught in a dilemma if a green signal were to change, by extending the green phase. However, the systems only work up until the time at which the pre-set maximum green time is reached.

4.19 Important considerations are thus to incorporate, either in the design of junctions or as remedial action, features that will help to ensure slower speeds through the junction and increased awareness of drivers, for example:

- effective signing (DTLR, 1994);
- central refuges (Appendix A11);
- vehicle-activated signs (Appendix A25);
- other visual cues;
- speed cameras (Appendix A4);
- red-light cameras (Appendix A3); and

- MOVA signal system (TAL 03/97).

4.20 Problems can arise at uncontrolled junctions if there is any obstruction to drivers visibility. For example, this could be due to the building line, vegetation, parked vehicles or overtaking vehicles being masked by the vehicles being overtaken (despite the Highway Code stating that drivers should not be overtaking in these circumstances).

4.21 It is important that all road users have adequate visibility in each direction at a junction. This allows them to judge approaching traffic and to complete their manoeuvre with sufficient margins of safety. The visibility of vulnerable road users like pedestrians and cyclists is particularly important in this respect (see Chapters 4,5,7; DMRB, TD50/99; DMRB, TD 42/95).

4.22 For junctions that have been specifically designed to provide maximum capacity and yet are experiencing safety problems, it maybe advisable to consider a different form of control. In some situations a roundabout may be the best option. In others, the best solution may be a signalised junction (LTN 1/98; TAL 3/97; TAL 07/99; DMRB,TD 50/99) or a signalised roundabout (Appendix A15). The safest form of control will depend on the size of the junction, the overall level and pattern of traffic flow, and the presence of non-motorised road users (IHT, 1997). The use of the computer programs ARCADY, OSCADY, PICADY (Binning, 1998, 2000a, 2000b) is recommended to help design roundabouts, signals and major/minor priority junctions respectively. These programmes assess likely accident levels.

4.23 Evasive action to avoid a collision near a junction can often mean severe braking, but this relies on the friction between tyre and road surface being sufficiently high. Many highway authorities have found that one of the single most effective accident countermeasures (in the absence of speed reducing measures) has been the installation of anti-skid surfacing (Appendix A.1; DMRB, HD 28/94).

4.24 The presence of pedestrians and cyclists near the junction is another factor that can generate accidents and special consideration needs to be given to catering for these road users.

4.25 Design and modification to junction layouts must recognise that cyclists and pedestrians need to travel through junctions on their journeys (LTN 1/86). Where practical, the siting of separate routes for pedestrians and cyclists are generally recommended to be away from the junction where vehicle movements are more predictable. Ideally, they should cross where the road width can be minimised.

4.26 The installation of refuges where pedestrians normally choose to cross has been found to provide good safety benefits. The basic principles of a refuge are to:

- reduce the number of streams of traffic in which pedestrians need to decide when it is safe to cross;
- minimise the distance over which they are exposed to traffic; and
- provide a relatively safe central area (see Appendix A.11).

4.27 The journey to school by children on foot or bicycle is often hazardous and many local authorities have adopted a safe routes to school approach (paragraph 4.176 below and Appendix A18).

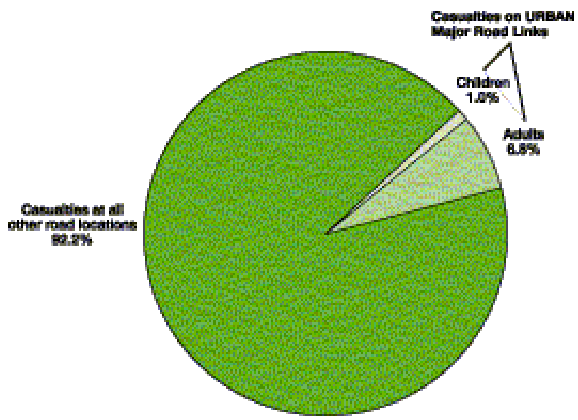
4.28 At signalised junctions, pedestrians and cyclists sometimes need exclusive signal stages. However, for adequate clearance and crossing times, the extended cycle time may lead to pedestrians seeking earlier opportunities to cross (ie against the red signal). Take great care in the system design (IHT, 1997; LTN 1/86).

4.29 Roundabouts have the advantage of slowing vehicle approach speeds on all arms of the junction, but are generally less safe for two-wheelers. All roundabout design and modifications should now cater for increased safety of cyclists and motorised two-wheelers. Continental design, with tighter entries, can help these road users (TAL 9/97; Davies et al, 1997).

4.30 For roads with heavy traffic flows the only solution may be to physically separate pedestrians by means of footbridges or subways. There is, however, a need to take account of pedestrians general reluctance or inability to take longer routes or apparently unnecessary steps or slopes, and concern about their own security (eg fear of underground passages and crime). Successful grade separation keeps the pedestrians on the level following their desired path, whilst vehicles undergo the change in level. Important issues such as siting, sight line, lighting, dimensions etc need careful consideration (IHT, 1997; DTLR,1998c and HA, 1996 for Trunk Roads contains useful design guidance).

## Urban major road links

**Figure 4.5**




4.31 On major road links in towns and cities in Great Britain, 24,428 people were injured in road accidents in 1999. This is about 8 per cent of all reported casualties.

4.32 Pedestrians tend to minimise their walking journey and will cross major roads where it is convenient to do so and not always where it is safest. The safest policy is normally to minimise conflict points between vehicles and pedestrians so that driver attention can be focussed at designated controlled crossing places.

4.33 Cyclists comprise 7 per cent of all casualties and motorised two-wheeler riders 8 per cent. In these accidents it is often the case that larger vehicle drivers fail to notice two-wheelers, probably due to their smaller physical size. Indeed, motorcycle and pedestrian accidents can be a particular problem in congested areas. Although studies of bicycle accidents have shown that most collisions with cyclists involve turning manoeuvres at junctions, more than a third are non-junction accidents, with cyclists often being hit from the rear. Accidents involving both motorcyclists and pedestrians are also a problem, particularly in congested conditions and at traffic signals.

4.34 On high flow major urban roads, where physical speed control devices are inappropriate to help reduce accidents, methods of automatic speed enforcement or speeding notification are in use to deliver accident reduction. These include speed cameras (Appendix A4) [34] and vehicle-activated speed signs (Appendix A25).

4.35 Adequate crossing facilities for pedestrians, with provision for disabled pedestrians, need to be provided along links. These include:

- refuges (Appendix A11);
- zebra crossings (LTN 1/95, 2/95; DTLR, 1998d);
- school crossing patrol (RoSPA, 1990; Appendix A7);
- signal controlled crossings (pelican crossings; puffin crossings which incorporate pedestrian detection; toucan crossings which incorporate a cycle crossing facility (TAL 10/93; LTN 1/95; LTN 2/95); pegasus crossings which cater for equestrians, cyclists and pedestrians); and
- grade separated crossings (ie subways or footbridges IHT, 1997).

4.36 Guard rail or fencing to channel pedestrians to the designated crossing may be deemed necessary on busy roads. However, their use should only be considered where the risks of walking onto the carriageway are very high, as they have a number of disadvantages. They are visually intrusive, reduce foot way width, can obscure children, and can cause access difficulties to commercial premises (see IHT, 1997).

4.37 The fact that a relatively high proportion of bicycle accidents occur on links strengthens the case for properly planned and designed facilities for cyclists, particularly in urban areas. While there is no single solution to providing a suitable infrastructure for cycling, the hierarchy of measures set out in *Cycle-friendly Infrastructure* (IHT et al, 1996a) should be carefully considered before choosing the design solution. This includes:

- traffic reduction;
- traffic calming;
- junction treatment and traffic management;
- redistribution of the carriageway; and
- cycle lanes and tracks.

If road links remain with heavier vehicles or with a high speed differential between cyclists and other road users, then the case for segregation on-carriageway or off-carriageway is strengthened (see Appendix A8).

4.38 For school children the safe routes to school approach is proving to be very successful (Paragraph 4.176 below and Appendix A18).

## Urban town centres

4.39 In many British towns, the main traffic routes often also have a commercial, shopping or residential function. These routes are commonly referred to as Mixed Priority Routes on account of this mix of functions with no clear priority. From a safety point of view, the variety of activities created by functions such as through traffic, local distribution traffic, residential, leisure, shopping frontages, pedestrians and cyclists is not ideal and gives rise to conflicts and accidents.

4.40 These roads have proved difficult to treat, partly due to the complexity and potential conflict of the activities and partly due to the perceived need to maintain high capacity for traffic flow, and to maintain relatively high levels of speed. In other words, the traffic function has been given priority over other activities.

4.41 Mixed Priority Routes are generally A or B class urban roads, and frequently radial roads which may pass through town centres. The speed limit is usually 30 mph, occasionally 40 mph. They are typically the main roads into and out of towns, and it is rarely feasible to provide alternatives to them.

4.42 Owing to the lack of specific definition in STATS19 accident data, it is difficult to determine a national figure for the number of accidents on Mixed Priority Routes, but 30 per cent of all casualties occur on urban A roads. Vulnerable road user groups of pedestrians and two-wheeled vehicle riders, prevalent in town centres, have casualty rates many times higher than those of car occupants (see IHT, 1997).

4.43 The benefits from reducing speeds on this type of road are particularly high offering up to a 7 per cent reduction in accidents per mph reduction in average speed (Taylor et al, 2000).

4.44 The most successful approaches to treating Mixed Priority Routes have involved instigating a change in road environment using a combination of measures to manage speed to appropriate levels, and to allocate different parts of the road space for the different functions. In particular the needs of the vulnerable road user have been a high priority. The through traffic function is still catered for but in a way that is compatible with the other users.

4.45 Consider the following measures when treating a Mixed Priority Route:

- separating the through-flow, distribution and access functions(Where there is insufficient width for separating functions, the through-flow function must be downgraded in priority);
- raising the priority given to pedestrians and cyclists, and giving them specific space such as cycle lanes and wider foot ways (LTN 2/86;LTN 1/89);
- using gateways to emphasise the transition from one type of road to another;
- reducing the difficulties of certain manoeuvres and preventing unsafe manoeuvres; and
- using narrow lanes and channelisation. (Care should be taken to ensure that provision for cyclists is still a consideration).

4.46 Depending upon the available road and pavement width, there are three broad types of treatment that can be applied to Mixed Priority Routes:

- full separation of functions;
- partial separation of functions; and
- one way solution for narrow roads, though appropriate traffic calming measures may also be essential to prevent an increase in speeds.

(See Appendix A2, A8, A10, A19 for examples).

4.47 Town centre roads also often include bus facilities. As with all other traffic management measures, features designed to ensure bus priority have to be considered in the context of safe design and operation. Clearly safety risks are minimised if full physical separation from other traffic can be achieved. However, lack of available road space often precludes this option.

4.48 The main problems of with-flow bus lanes (the most common form of bus priority) are maintaining segregation and ensuring that the lane is kept clear of obstruction [35] . It is also important to acknowledge that vehicles in the bus lane can move at a different speed from vehicles on the main carriageway. This can be a particular problem for pedestrians crossing the road. The road space taken up by the bus lane can result in less room for other road users such as cyclists.

4.49 Bus stops also have safety issues. There is always the danger of pedestrians stepping out from the kerb, especially at more informal bus stops. Many bus stops also suffer from illegal parking, which can impair safety.

4.50 There are a number of solutions to the problem associated with keeping bus facilities clear of obstruction. These are:

- colour differentiation of road surface;
- textural differences;
- partial segregation;
- full segregation;
- traffic islands; and
- roadside or bus mounted enforcement cameras.

Refer to Appendices A2, A7, A11, A17 and A19, TAL 07/95 and LTN1/97 for more details.

4.51 In general the best solution is probably the self-enforcing one of full segregation, though this may rarely be feasible.

4.52 The problems associated with pedestrians stepping out from bus stops onto the main carriageway can be limited by the use of pedestrian guard-rails at strategic locations. Pedestrian refuges to the rear of the stopped bus deter vehicles from overtaking and offer additional protection to the alighted passengers. (As a general rule, if passengers need to cross the road then they should be encouraged to cross behind the stationary vehicle see LTN 1/97).

4.53 Consideration needs to be given to possible conflicts between pedestrians and two-wheelers, particularly as some cities are trialling opening up bus lanes to motorcycle use. The problem of illegal parking at bus stops can be reduced by the use of bus boarders. These pavement build-outs (see example in Appendix A2) discourage parking opposite the bus stop. They have the advantage of bringing the bus to a stop in the main carriageway, helping to calm the traffic. They also ensure that passengers and pedestrians have a clearer view of their surroundings and are able to get on and off the bus more easily. (See LTN 1/97).

4.54 The design of traffic calming schemes on bus routes should take account of the following points:

- Road humps (Appendix A12) can adversely affect bus scheduling and can make passenger movement within the bus more difficult.
- Speed cushions (Appendix A21) have a minimal effect on buses and are a favoured solution on bus routes.
- Bus drivers must be able to negotiate chicanes and throttles used to create horizontal deflection (see

Appendix A6) as a speed control measure.

- The location of bus stops should be agreed between the operators, highway authority, and the police. Consult nearby property owners/occupiers and bus user groups when appropriate. Refer to Appendix A2 for more details.

## Urban Residential roads

4.55 Residential roads in urban areas [36] make up the largest category of accidents, accounting for 38.6 per cent of all casualties and 33.8 percent of fatal and serious casualties. Children make up a higher proportion of the casualties than they do on other roads. Accidents involving children are therefore an important category in any treatment programme.

**Figure 4.6a**

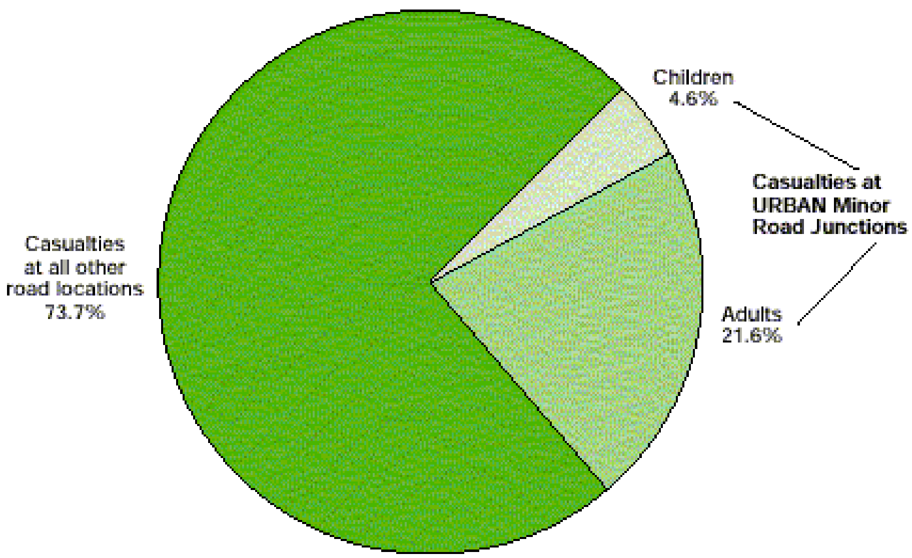
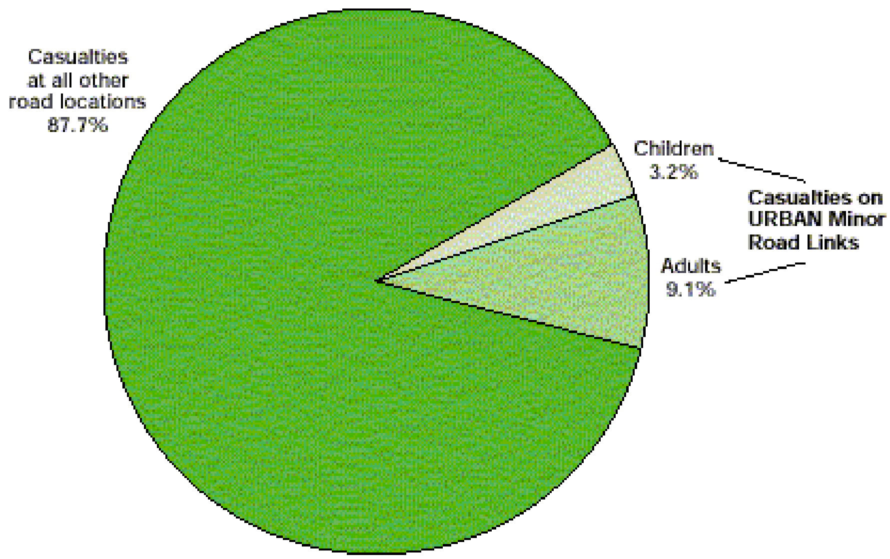



**Figure 4.6b**




4.56 26.2 per cent of all casualties occur at minor urban road junctions, which are likely to be largely on residential roads. The problems are the complexity and uncertainty of vehicle movements, especially turning traffic, too high a speed of the straight ahead traffic, masking of vehicles, and the interaction of pedestrians and two wheelers. Overall numbers of vehicles and pedestrians are generally low and their presence by an individual road user often unexpected. Accident numbers at any one junction are usually low, and so consider the cost effectiveness of options carefully.

4.57 12.3 per cent of all casualties occur on urban minor (residential) road links. As at residential road junctions, the proportion of children involved is higher than on major roads. The problem is usually one of inappropriate speed, and the presence of more vulnerable and inexperienced road users child pedestrians and child cyclists.

4.58 In recent years it has been recommended that efforts are made to eliminate through-traffic on residential roads using Urban Safety Management techniques, as described in 4.8. Speeds of the remaining traffic are then commonly reduced through the introduction of traffic calming measures, either as free standing schemes or as 20 mph zones (TAL 9/99; Appendix A23).

4.59 In 20 mph zones, appropriate speeds can be achieved through a combination of:

- road humps (Appendix A12);
- speed tables (Appendix A12); and
- horizontal deflections (such as chicanes, throttles or narrowing Appendix A6).

4.60 Traffic calming on links also reduces speeds on the approach to junctions. Extension of the foot way across the mouth of a side road by using a flat-topped hump (sometimes referred to as a foot way crossover), can help to slow turning traffic at a junction and deter through traffic (IHT, 1997; County Surveyors Society et al, 1994a).

4.61 To further break up the speed of traffic, mini-roundabouts may be used at busier junctions (Appendix A15).

4.62 The use of speed cushions (Appendix A21) is appropriate where speeds are not required to be so low as in 20 mph zones, and/or on bus routes or through routes for emergency vehicles.

4.63 The speed achieved by traffic calming measures is closely related to the spacing of the measures.

4.64 Chicanes have been used less extensively than vertical measures and there is more variability in their level of acceptance by the public(Webster, 1998).

4.65 20 mph speed limits without self-enforcing measures have only a minimal effect on vehicle speeds (see Appendix A23; DTLR, 1999c).

4.66 Physical traffic calming has achieved good reductions in casualties 60 per cent reduction for all casualties but 70 per cent reduction for children (Webster and Mackie, 1996), though a little of this effect results from some re-distribution of traffic.

4.67 On residential access roads drivers need to be given visual cues that indicate strongly that this road space is part of the environment where people live, walk, talk and play.

4.68 A way to treat such roads may be to create Home Zones (first installed successfully in Holland as *Woonerfs*). In these zones, the full road space is very much shared between motorised and non-motorised users. A pilot programme of nine schemes of different types is currently taking place in England and Wales (Layfield, 2000).

4.69 The speed of traffic is kept very low by the intricate nature of the street layout, the placement of street furniture and features, and by generating local ownership of schemes. However, these schemes are generally very costly.

## Rural roads

**Figure 4.7a**

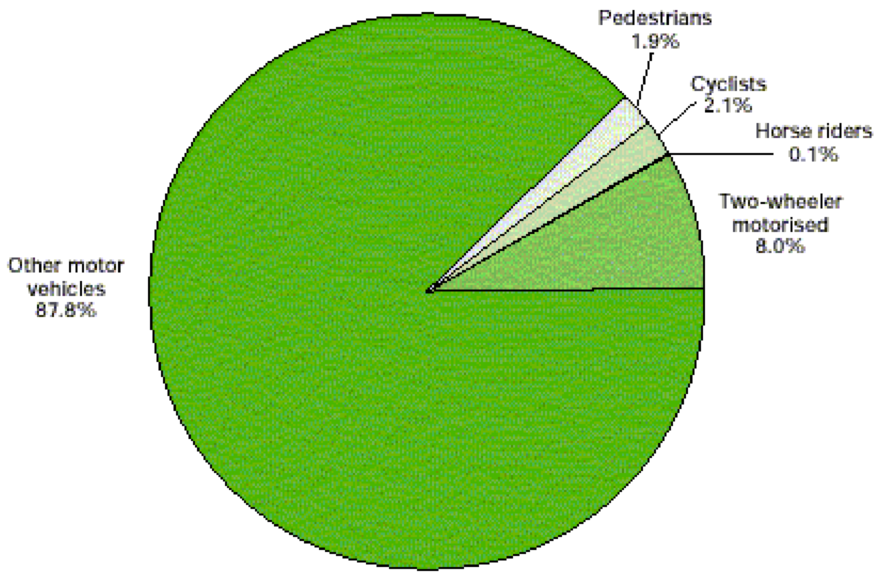
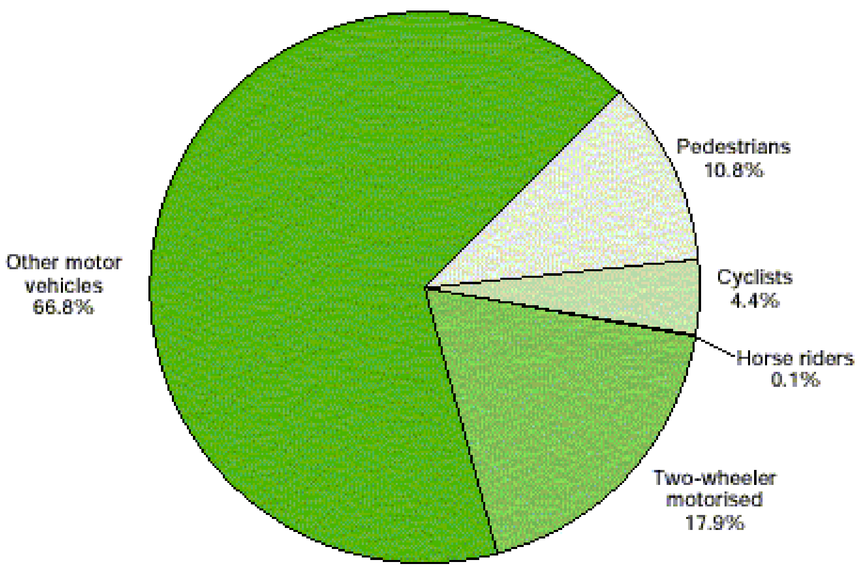



**Figure 4.7b**



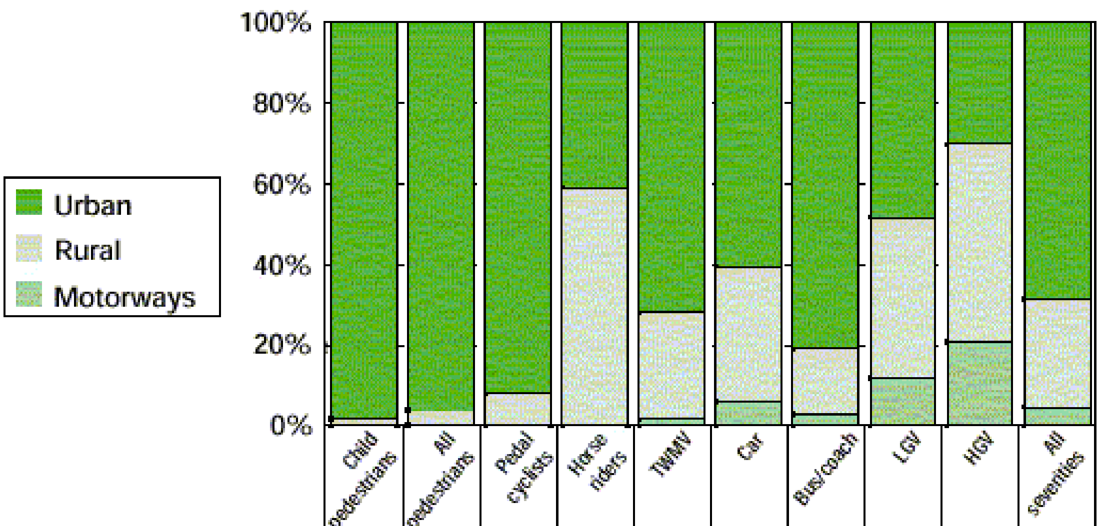

4.70 From Figs 4.7a and 4.7b it can be seen that the vulnerable road user groups on rural roads are again prevalent. As you might expect, they comprise higher proportions of the fatal than all-casualty category totals (though the proportions of pedestrian and pedal cycle casualties are lower than their urban equivalent, probably reflecting lower levels of walking and cycling).

4.71 A number of recent publications address rural accident problems and solutions separately from urban ones. For example, DTLR (2000a); IHT, 1999c; Barker (1997); Barker et al (1998); Barker et al (1999); Gardner and Gray (1998); Hughes and Amis (1996); Hughes et al (1997);Pickering et al (1986); and for villages, reports relating to the VISP study such as CSS and DOT (1994b); Wheeler and Taylor (1995);Wheeler and Taylor (1999); Taylor and Wheeler (2000). In addition, note that many of the Design Standards etc in the bibliography relating to trunk roads, may be useful in the design of local roads, particularly major rural roads.

4.72 More than half of all fatalities and a third of all seriously injured casualties occur on rural roads (speed limit 50 mph and above) see paragraphs 3.36 -3.40 above. Accident severity is higher on rural roads than in built-up areas (speed limit 40 mph and below), and vulnerable road users (pedestrians and cyclists) are particularly at risk. These results are, in part, likely to be due to generally higher vehicle speeds on rural than on urban roads. But of crucial importance is the fact that rural accidents are generally more thinly spread over a wider area than accidents in towns. Cost-effective treatment to prevent accidents is therefore more difficult to apply and the best locations for treatment harder to identify.

4.73 Figures 4.8a and 4.8b break down all casualties and all fatalities on rural and urban roads by casualty type. Figure 4.8b shows that almost a quarter of all pedestrian fatalities and almost a half of all pedal cyclist fatalities occurred on rural roads. These figures are worrying given that walking and cycling are mainly associated with urban travel.

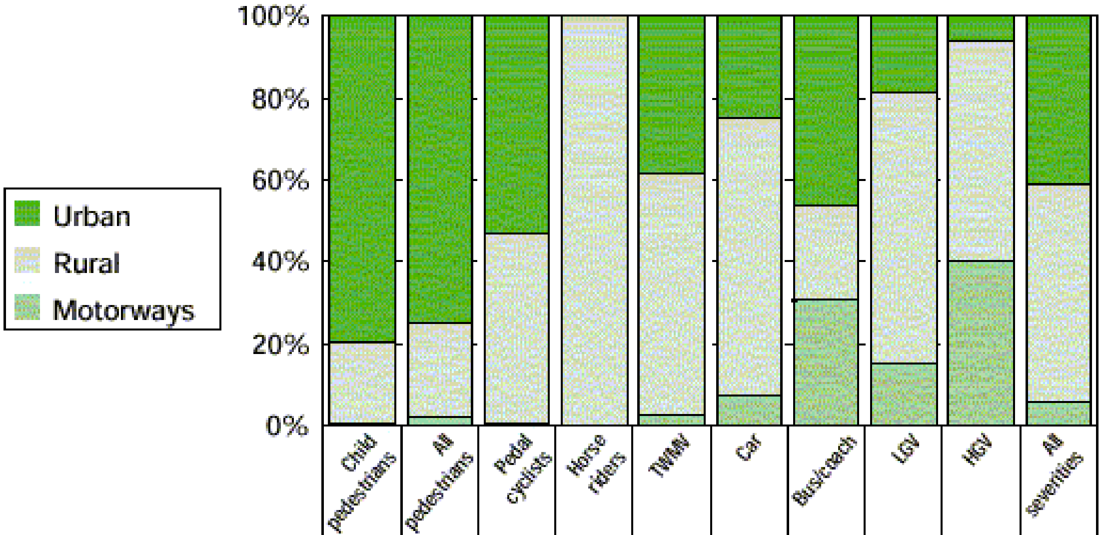
**Figure 4.8a**




| | Child pedestrians | All pedestrians | Pedal cyclists | Horse riders | TWMV | Car | Bus/coach | LGV | HGV | All severities |
|---|---|---|---|---|---|---|---|---|---|---|
| Urban | 16,553 | 41,204 | 20,990 | 74 | 18,830 | 123,599 | 9,578 | 3,448 | 1,057 | 219,759 |
| Rural | 318 | 1,602 | 1,836 | 107 | 6,904 | 68,232 | 1,890 | 2,841 | 1,698 | 85,687 |
| Motorways | 5 | 82 | 14 | 0 | 458 | 12,331 | 357 | 835 | 729 | 14,864 |

TWMV = Two-wheeled motor vehicles

**Figure 4.8b**




| | Child pedestrians | All pedestrians | Pedal cyclists | Horse riders | TWMV | Car | Bus/coach | LGV | HGV | All severities |
|---|---|---|---|---|---|---|---|---|---|---|
| Urban | 85 | 653 | 91 | 0 | 215 | 413 | 12 | 12 | 3 | 1,398 |
| Rural | 21 | 197 | 80 | 2 | 326 | 1,134 | 6 | 43 | 28 | 1,823 |
| Motorways | 1 | 20 | 1 | 0 | 16 | 125 | 8 | 10 | 21 | 202 |

TWMV = Two-wheeled motor vehicles

4.74 Two-thirds of accidents on rural roads occur on single carriageway roads. The accident rate (per vehicle-km) is higher on single carriageway roads than on dual carriageways and motorways.

4.75 TRL Report 304 (Barker et al, 1998) describes an analysis of the characteristics of injury accidents that occurred on all rural single carriageway roads in Great Britain in 1994-95, based on the nationalSTATS19 data-base.

4.76 Rural safety management should involve:

- identifying a functional hierarchy of roads and encouraging traffic on toll roads with an appropriate function; and
- managing vehicle speeds at the right level for the conditions on each type of road in the hierarchy.

4.77 Re-distributing traffic onto appropriate roads. Where alternative routes exist which enable heavy, through traffic to avoid villages, for example, or where rat-running is a problem, measures should aim to slow the traffic and thereby discourage the use of inappropriate roads. Other modifications may be necessary on alternative routes to cater for the additional traffic.

4.78 Managing vehicle speeds. On rural roads, speeds that are too high for the conditions are likely to be more of a problem than speeds in excess of the speed limit. High accident severity rates will be improved by reducing speeds. Vulnerable road users will particularly benefit.

4.79 Managing vehicle speeds will involve setting appropriate speed limits and the use of engineering and enforcement measures. Appropriate speed limits will be determined by many factors, including:

- traffic flows and speeds;
- pedestrian and vehicle traffic crossing the road;
- visibility splays;
- bends; and
- hills and other natural features.

(TAL 1/95; DTLR, 1999c).

4.80 A major contribution to reducing rural accidents and achieving national casualty reduction targets will be made by addressing accidents at bends and junctions. Reducing speeds that are inappropriately high for the conditions will help to tackle accidents involving loss of control, and lack of awareness of these hazards.

4.81 Given that rural accidents are usually widely and thinly spread, a widespread, low-cost treatment approach to specific accident problems will generally be more cost-effective than treating a small number of individual sites. Sometimes more expensive treatment will be justified at certain locations (junction re-building for example) but this will often be to alleviate capacity problems.

4.82 The low-cost requirement means that the emphasis for reducing speeds will be on signing and/or marking treatments, which should be applied consistently. For example, if bends are to be treated to try to reduce approach speeds, the same kind of treatment should be used at each location where it is intended to convey the same message. Drivers then know what to expect and are less likely to be surprised or confused by different information.

4.83 Three types of strategy should be considered:

- mass action;
- area action; and
- route treatment (see paragraph 3.17 above).

A combination of these approaches might be adopted. The choice will be determined largely by the existing accident patterns and the availability of cost-effective treatments for tackling the prevailing accidents.

4.84 These principles should be complemented appropriately by other techniques: for example, publicity campaigns or training programmes may be more suitable to address accidents involving young drivers, while temporary increased enforcement may be applicable for drink-driving problems.

## Rural Villages

4.85 Local councils and residents have voiced concern over many years about traffic nuisance and perceived safety problems in villages. This is normally expressed in terms of too much traffic travelling too fast through the village.

4.86 The scale of the national problem is not easy to define since it is difficult to extract the relevant accident data from the national STATS19database for all accidents in villages throughout the UK. Many villages have more of a perceived problem than a real one, as the numbers of injury accidents are often small. Nevertheless, there is often a case for the implementation of traffic calming type measures, as reductions in traffic speed can generally be expected to lead to reductions in accidents and casualties cost-effectively (Taylor et al, 2000; TAL 11/00).

4.87 Where traffic calming measures have been introduced in villages, they have reduced mean speeds by up to about 10 mph. Accidents (particularly the most severe accidents) have substantially reduced overall (Wheeler and Taylor, 2000; Taylor and Wheeler, 2000).

4.88 The differential between the speed limits inside and outside a village can be large. If drivers have been travelling along rural roads subject to the national speed limit for an appreciable distance, they may not recognise the need for greater care and lower speeds. They may be unaware of a lower speed limit or of their own speed and may respond late to the lower limit. In particular they may be unaware of the increased risk of an accident, especially with a vulnerable road user. Speeds observed through villages are often high compared to what is appropriate for the conditions.

4.89 The increased number of pedestrian movements and the greater concentration of cyclist and equestrian journeys within the environs of a village warrants special attention, particularly if accidents are taking place during the hours of darkness.

4.90 The principal aim is to alert drivers to the change in road environment. Although village name signs together with speed limit signs have been conventionally used to mark the entry to a village, a gateway can make this change more prominent (see Appendix A9).Ideally the gateway and a speed limit change should coincide with the boundary of the village, to provide all the visual cues together.

4.91 Gateways are generally not enough to produce speed reductions that are sustained throughout the village. Other features within the village are required and these may include:

- narrowings (eg pinch-points, build-outs see Appendix A6);
- traffic islands and pedestrian refuges (see Appendix A11; TAL07/95);
- coloured surfaces and markings (see Appendix A7 and A20; TSM Chapter 5, CSS, 2000; DMRB, TA 81/99);
- over-run areas at junctions (see TAL 12/93);
- mini-roundabouts (see Appendix A15);
- signs (see Appendix A20; TSM Chapters 3, 4, 5; and 7);
- speed cameras, if cost-effective (see Appendix A4).

4.92 Consider the need to light potential hazardous features where village lighting is poor or non-existent.

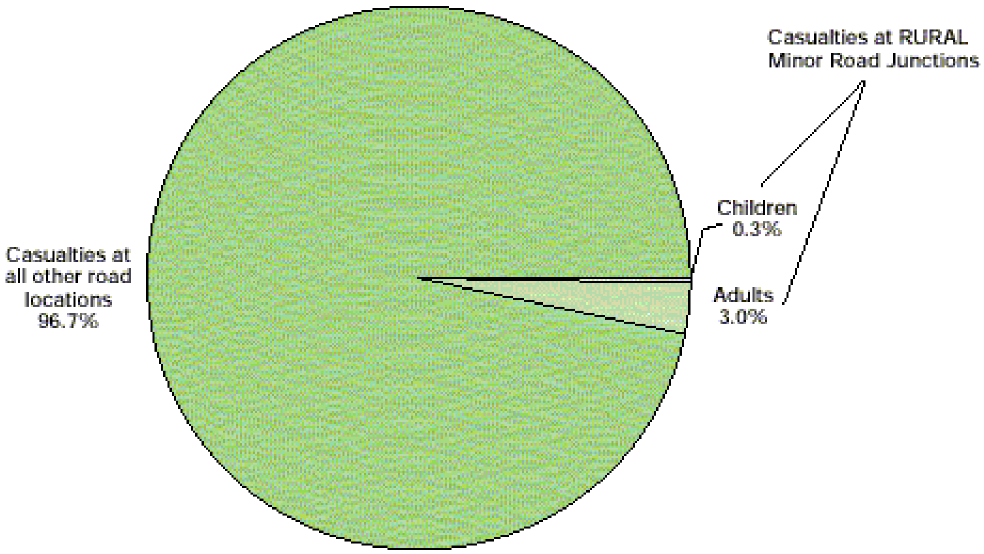
4.93 Features need to be designed sensitively to minimise impact on the rural character of villages and be located to minimise problems for local residents.

4.94 20 mph zones are only appropriate if supported by physical features that will ensure reduced speeds are achieved and are therefore unlikely to be used on major through routes.

4.95 A history of pedestrian injuries will need close examination to establish common factors. If pedestrians have been struck while walking along the road, check whether footways and perhaps lighting are adequate. If they have been hit while crossing the road, then it is likely that special provision is needed in the form of refuges and/or a zebra/pelican/puffin/toucan/pegasus crossing (see Appendix A10; LTN1/95; LTN 2/95). Where such measures involve a reduction in carriageway width, cyclist and equestrian needs should be considered and special provision made where feasible (see Appendix A8).

## Motorways

**Figure 4.9**




4.96 The Highways Agency is responsible for motorways [37] , so for completeness they are included here. Many of the problems and solutions are applicable on other major roads, especially dual-carriageways. In addition, some local authority schemes may include motorway/non-motorway intersections or roads/footways that cross, but do not intersect, motorways.

4.97 Almost 5 per cent of all casualties occur on motorways. Of these, about 6 per cent are children under 16 years of age.

4.98 Motorway junctions are relatively widely spaced and consequently only17 per cent of motorway casualties are injured in accidents at junctions. Motorways carry more traffic than other types of road but have the lowest accident rates and casualty severity indices [38] of all roads (11 accidents per 100 million vehicle-kms and 11 per cent casualty KSI index, compared with 50 per 100 million vehicle-kms and13 per cent casualty KSI index for all roads, respectively DTLR, 2000a). These statistics reflect the high quality (dual-carriageway) design and build of motorway roads, the use of hard shoulders, the low junction densities, one-way traffic flow and the low opportunities for pedestrian and pedal cycle conflicts.

4.99 However, when motorway accidents do occur, they frequently involve more than two vehicles and result in a number of injuries. This may be a consequence of high quantities of traffic, high speeds and vehicles driving too close together. On average, there are 2.27 vehicles and1.63 casualties per motorway accident, compared with averages of1.83 and 1.36, respectively, for all accidents. It is partly for this reason, and partly because of the distances involved for recovery and emergency vehicles, that motorway accidents are the most costly.

4.100 Accidents on motorways are also more likely to involve only one vehicle (22 per cent compared with an average of 14 per cent on all roads),perhaps as long periods of driving without a break and a lack of visual stimulation can result in driver fatigue or distraction.

4.101 Motorways do not permit pedestrian or small two-wheeler vehicle traffic and so the largest differentials between the speed and mass of individual vehicles will usually be between cars/TWMVs and goods vehicles (HGV/Luvs) [39] . Most often it is the drivers and passengers in the cars/TWMVs that are injured, however, when HGV/LGV occupants are injured, they tend to be severely injured (perhaps if they are unrestrained by seat belts or are trapped in wreckage). About 38 percent of all motorway casualties are injured as the result of an accident involving at least one HGV or LGV, and these casualties account for around half of all killed or seriously injured motorway casualties.

4.102 Although the vast majority of motorway casualties are car occupants (about 85 per cent), motorcyclists have accident rates about 10 times higher than the average for all road users (per vehicle-km travelled).4.103 Almost all children injured in motorway accidents (94 per cent) are car occupants. Of these, 78 per cent were rear seat passengers. Information regarding rear seat-belt wearing compliance by these children is not known.

4.104 The numbers of pedestrians injured in motorway accidents is small but still of concern, as exposure is so low. Pedestrians are at particular risk on hard shoulders, at roadworks and at motorway junctions.

4.105 Accident rates in the vicinity of roadworks are higher than on similar road sections without works. 50 mph speed limits for these sections are now common practice and are often enforced with speed cameras. The majority of accidents involve shunts. Drivers often drive too fast for the conditions, too close, too aggressively or without due care and attention. For advice see Health and Safety Executive, 2000.

4.106 Close-following behaviour can be addressed through the use of appropriately worded variable message signs which require special authorisation. Most of the motorway network is monitored by cameras and once an incident, or congestion, is spotted the effects can be minimised by informing drivers of the problem ahead and advising/encouraging/enforcing action or diversions [40] . Such signs can comprise dot matrix symbols or include a worded message.

4.107 When a problem persists at a particular location, the provision of static signs (TSM Chapter 4) should be considered and, if the traffic flow levels are suitably light, the use of chevron spacer road markings might be considered. (Appendix A5).

4.108 The safety problems relating to fatigue and distraction and those regarding pedestrians and motorcycles may best be addressed through non-engineering techniques but should still be borne in mind whenever engineering work is carried out.

4.109 Roadwork sections need to be carefully designed see TSM Chapter8. Attention needs to be given to the use, the extent, and the enforcement of a lower speed limit.

## Rural Dual-carriageways

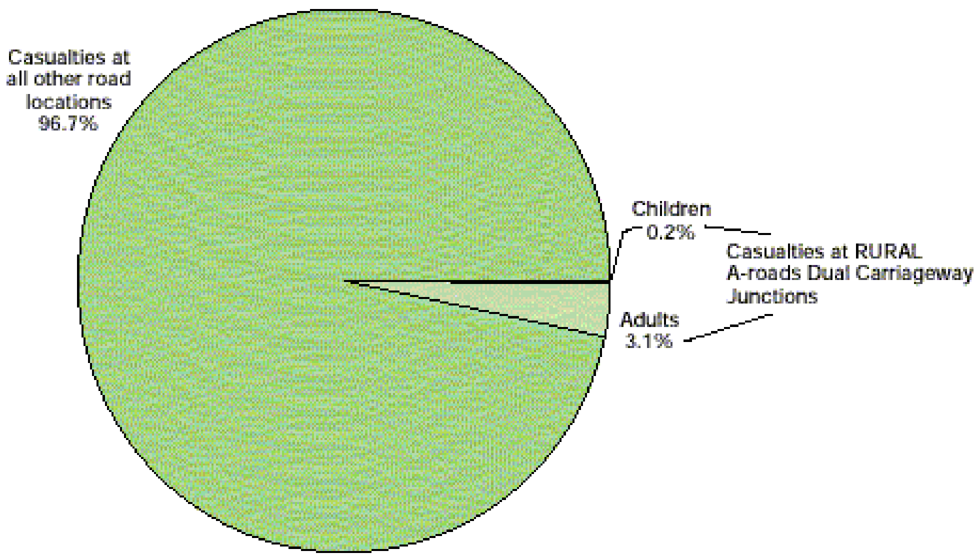
4.110 Many dual-carriageways, particularly the most recently built, are built to a high standard and designed to service the traffic they carry. Consequently, the accident problems on many dual-carriageway roads are similar to those observed on motorways (Walmsley and Summersgill, 1998). However, those built to older, lower standards may have more potential for improvement.

4.111 Although only about 4 per cent of all accidents occur on rural dual-carriageway A-roads, these accidents account for about 6 per cent of all casualties. The reasons for this are likely to be similar to those suggested for motorways in paragraph 4.99 above.

4.112 About half of casualties are injured in accidents on links and about half at junctions. The proportion at junctions is quite high when compared with that for all rural roads (38 per cent). The severities of rural dual-carriageway accidents are slightly higher than those on motorways with20 per cent of accidents resulting in fatal or serious injury (Barker et al,1999).

## Rural Dual carriageway junctions

**Figure 4.10**




4.113 Of the accidents at junctions, about 54 per cent are at roundabouts. Many of the problems at other junctions are a consequence of drivers difficulty in judging the speed and distance of other traffic, particularly at priority junctions.

4.114 The approaches to junctions should be adequately and clearly signed(see TSM Chapters 4 and 7 and TSRGD). This is of particular benefit to drivers on this type of road as safe opportunities to stop and consult a map or turn around may be few and far between. The provision of anti-skid surfacing on the approach to the junction may also be worthwhile (see Appendix A1; DMRB, HD 28/94).

4.115 Junctions (and traffic at or on the approaches) should be conspicuous and drivers should have adequate warning to slow down and be aware of the path they should take through the junction. Priorities should be clear. The provision of lighting may be appropriate, if a suitable power supply is nearby. Grade separation of the junction maybe appropriate for the most major junctions.

4.116 The provision of yellow bar markings on the approaches to at-grade roundabouts is one option for giving drivers advance warning of the junction ahead (only if the approach is high speed) and may be particularly suitable on approaches with little visual stimuli. See Appendix A26.

4.117 On large roundabouts lane markings may help guide drivers and riders through the junction (TSM Chapter 5). Two-wheeled vehicles often experience problems at roundabouts and their needs should always be considered (Appendix A8 and A15).

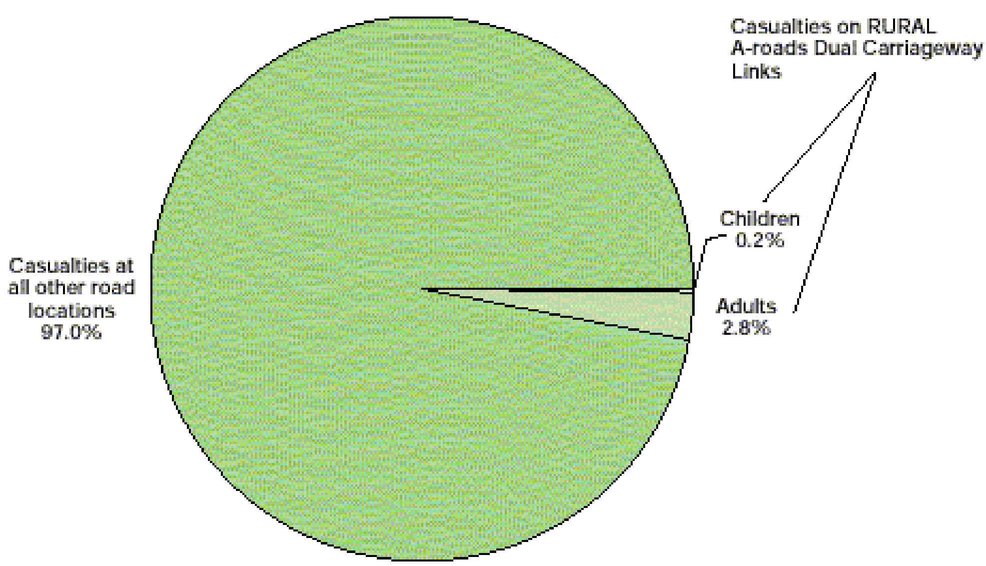
4.118 It is necessary to ensure that all accesses and not just those with other main roads are safe and of a suitable standard to accommodate the traffic using it. For example, laybys, private drives and businesses, farm accesses, bus stops etc should be designed so that traffic can join and leave the main road safely.

4.119 The safety of vulnerable road users crossing junctions should always be considered as junction widths can be very wide and traffic flow fast and heavy. The provision of signals with pedestrian phases can provide opportunities for pedestrians and cyclists to cross one arm of a junction in several stages (LTN 1/98; DMRB, TD 50/99). The provision of grade separated pedestrian, cycle and equestrian crossings may also be appropriate if flows are high enough (see paragraph 4.127).

4.120 If junctions are uncontrolled and traffic needs to cross the two carriageways in two stages, care should be taken that the central reservation holding area is sufficiently wide and that traffic on the main road is clearly visible to drivers using the gap.

## Rural Dual carriageway links

**Figure 4.11**



4.121 Where accident problems on links closely resemble those on motorways they should be treated accordingly.

4.122 A consistent approach along a route (for example, to indicate the relative severity of bends) is important (TSM Chapter 4; TSM Chapter 5;IHT, 1999).

4.123 In addition, care should be taken to ensure that hazards are adequately signed or marked in advance so that drivers can adjust their speed or position accordingly.

4.124 In general, as many visual cues as possible of the changing alignment of the carriageway should be provided at bends. These may include chevron boards, reflectorised posts, white lining etc (see TSM Chapter4 and TSM Chapter 5). On major routes that are predominantly straight, even moderate bends may need to be well signed (see TSM Chapter 4 and TSM Chapter 5).

4.125 The use of safety fences on the central reservation will substantially eliminate the opportunity for head-on collisions. Safety fences at the roadside can be used to protect vehicles leaving the road on the near side from hitting objects such as trees and lampposts and from going over embankments into gullies by guiding them back onto the carriageway. Gaps in the central reservation should be kept to a minimum and restricted to locations where they can be safely used.(See Appendix A13; DMRB, TD 19/85; DMRB, TD 32/93.)

4.126 On routes with high volumes of HGV traffic the provision of climbing lanes uphill for overtaking traffic and escape lanes downhill may be considered appropriate.

4.127 The provision of crossing facilities for non-motorised road users should be given consideration (LTN 1/95; LTN 2/95). Although on busy roads the provision of subways or bridges may be justified for non-motorised users, these must be carefully designed and positioned to encourage people to use them, given past experience of their unpopularity. In some recent cases, road levels have been altered to allow footways and cycle tracks to remain at ground level.

4.128 Depending on demand, consider the need to provide facilities for cyclists along rural dual carriageway links. If there is a demand from pedestrians, then under the Highways Act, the highway authority has to make provision for pedestrians. In certain circumstances it may be appropriate to provide a shared use cycle track and footway segregated from the main carriageway. The principles set out in *LTN2/86 Shared Use by Cyclists and Pedestrians*, will guide the designate the most appropriate solution.

## Rural Major single-carriageways

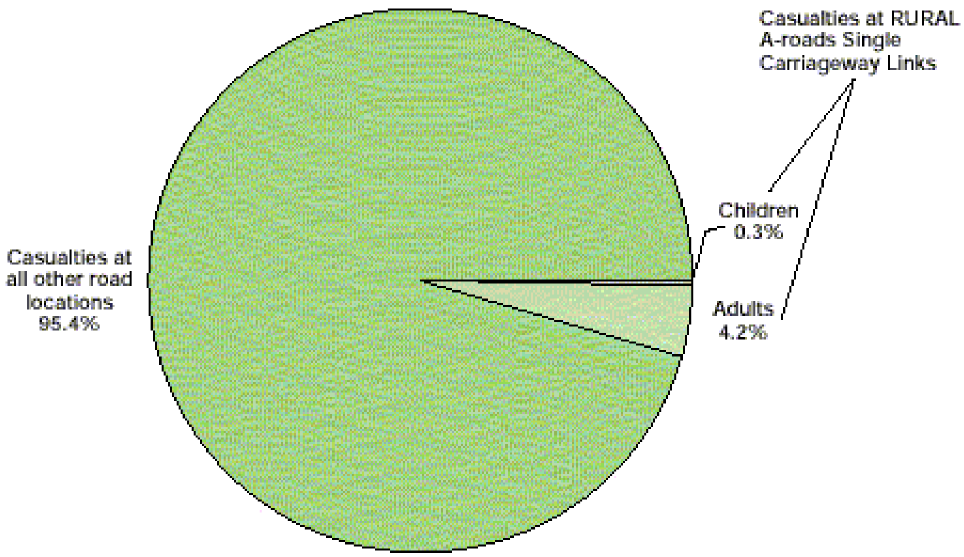
4.129 11 per cent of casualties occur on single-carriageway A-roads, 42 percent of who are injured at junctions.

4.130 About 28 per cent of accidents result in fatal or serious injury.

4.131 3 per cent of accidents involve at least one pedestrian, 2 per cent of vehicles in accidents are pedal cycles, 5 per cent are TWMVs and12 per cent are LGVs or PSVs [41] or HGVs.

4.132 Overall, these roads carry a similar amount of traffic per year as motorways do i.e. about 30 per cent of all rural traffic (Barker et al,1999). However, at seven times the kilometre length of motorways, the potential for major redesign is low on grounds of cost. Therefore, more cost-effective solutions have to be adopted.

**Figure 4.12**




4.133 Older drivers are more likely to be involved in accidents at junctions than younger drivers.

4.134 The number of potential conflict points should be minimised; T-junctions have lower accident rates than crossroads and multi-arm junctions should be avoided (IHT, 1999). The use of traffic signals should also be avoided where possible. As speeds and flows increase, advance warning becomes essential.

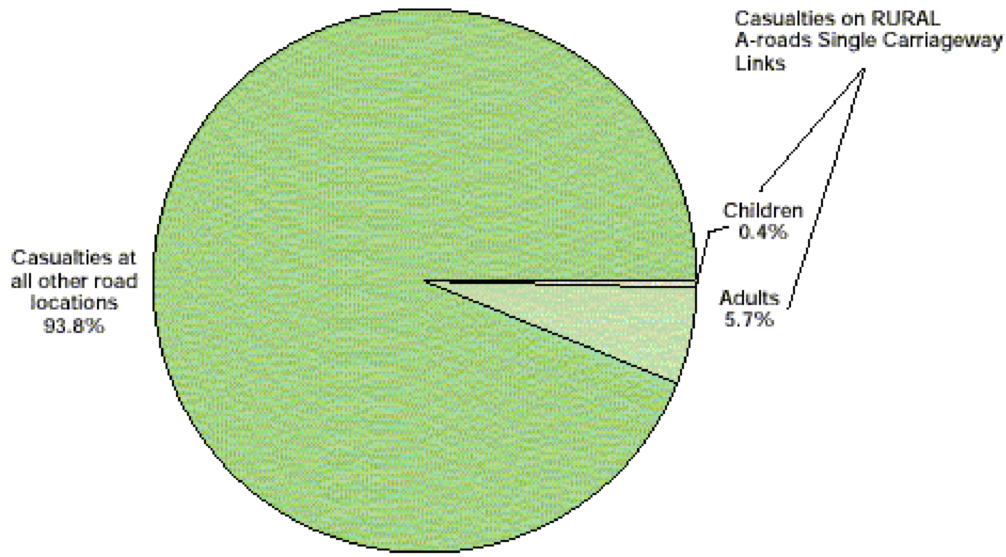
4.135 Anti-skid surfacing on high speed approaches can be effective (see Appendix A1 examples; DMRB, HD 28/94).

4.136 The presence of junctions must be made clear to drivers and riders with clear and consistent advance warning signs and carriageway markings (TSM Chapters 4 and 5) and by the presence of reflectorised posts, traffic islands and bollards. Through drivers must be alerted to the potential hazard of emerging traffic and encouraged to slow down; this is especially true where traffic turning off the major road impedes through traffic.

4.137 The design of turning facilities for major road traffic at T-junctions and crossroads is important. Vehicles, particularly cyclists, are vulnerable when positioned between fast traffic in both directions. Protected lanes for turning vehicles can reduce accidents, and conspicuous and consistent road markings are essential see TSM Chapter 5.

## Rural Major single-carriageway links

**Figure 4.13**




4.138 57 per cent of rural major single-carriageway casualties are injured on links.

4.139 Accidents on links are more likely than those at junctions to involve a single vehicle, young drivers, a pedestrian, bad weather, and (probably because vehicle impact speeds are, on average, higher on links) to result in more severe injuries.

4.140 Following distances are particularly important where forward visibility is restricted by, for example, hills and bends. The problem can be exacerbated by a wide carriageway which can encourage staggered following behaviour with shorter following distances (IHT, 1999c).

4.141 The use of white lining about 1m or more from the edge of the road (to provide a hard strip) or continuous centre hatching to reduce the effective carriageway width to, say, 7m is likely to reduce accidents (TSM Chapter 5; IHT, 1999c).

4.142 Double white lines are used to indicate stretches of road with limited forward visibility (at hills or bends) where it is unsafe to overtake. TSM Chapter 5 gives advice on usage.

4.143 Speed cameras are an increasingly realistic option to enforce speed limits when there is a speed related accident problem (IHT, 1999c). However, enforcement in remote areas is a problem where the availability of power to such sites is a factor (See Appendix A4).

4.144 Speed differentials of mixed traffic should be reduced as far as possible. Careful consideration should be given to providing for the needs of pedestrians and cyclists and the principles set out in the hierarchy of measures in *Cycle-friendly Infrastructure* (IHT et al, 1996a)will assist the designer to adopt the most appropriate solution. Where space permits, segregation of these vulnerable road users from motorised vehicles may be appropriate. In certain circumstances it may be appropriate to provide a shared use cycle track and footway and the principles set out in LTN 2/86 should be followed. If the road is frequently used by equestrians, the provision of bridleways, which can also be used by pedestrians and cyclists, may be considered. Provision of climbing lanes up, and escape lanes with arrester beds down, steep hills may be relevant where the traffic has a high HGV content and the required road width is available.

4.145 Icy conditions and wet roads can be the catalyst for accidents involving skidding. Drainage and skid resistance should be checked and, if conditions merit, remedial action and signing should be implemented quickly when dangerous conditions arise.

4.146 For roads with steep drops close to the carriageway safety fences should be considered (DMRB, TD 19/85; DMRB, TD 32/93). Where there is livestock adjacent to the road, roadside fencing must be well-maintained and secure to prevent animals from straying into the paths of vehicles.

## Rural Minor single-carriageways [42]

4.147 Although only about 10 per cent of all casualties in GB occurred on minor rural single-carriageway roads in 1999, these accounted for 15per cent of all fatalities.

4.148 The numbers of accidents per vehicle-km are also very high on these types of road. (45 accidents per 100 million vehicle-kms, compared with 26 for all rural roads Barker et al, 1999).

4.149 This is to some extent likely to be due to inappropriately high speeds on such roads, especially on links, leaving drivers little time to react and recover when emergency situations arise, frequently resulting in very serious injuries.

4.150 In addition, today, these roads are often carrying large volumes of traffic, far in excess of the levels for which they were designed. They are often built to older and lower design standards, and may not be subject to the same level of maintenance programming as those of more major roads and motorways.

4.151 The increased traffic has created rural roads that are unsafe for cycling, walking or horse riding. Efforts need to be made to reverse this perception especially on these minor roads if the aforementioned more healthy, often leisure pursuits are to be encouraged in favour of dependence on the motor car (IHT, 1999c).

4.152 Higher proportions of accidents than expected occur at night-timetaking into account the relative traffic levels during the hours of darkness compared with daylight (IHT, 1999c).

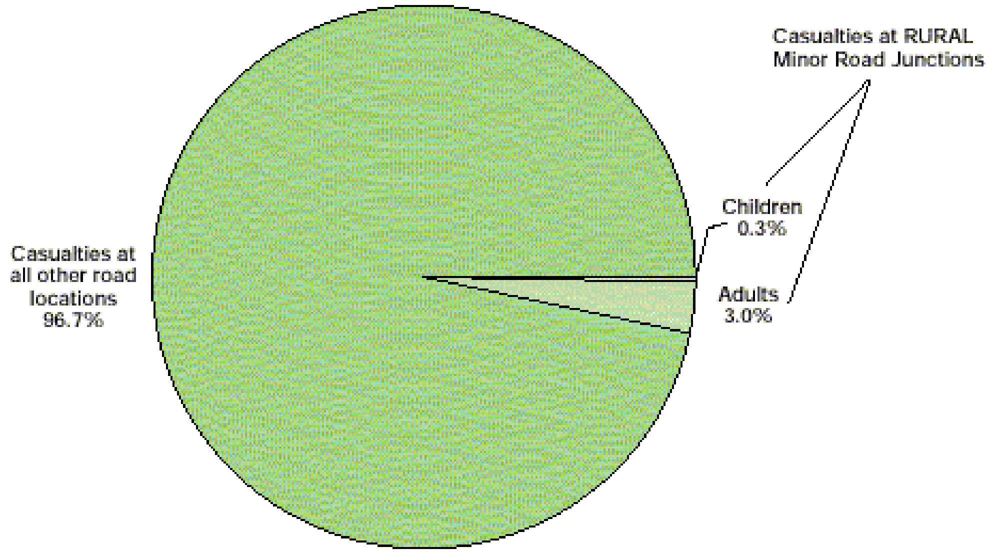
4.153 Rural locations are perhaps more likely to suffer from lower levels of regular maintenance than more major roads. Road surfaces therefore may become more slippery in general and this can produce problems for (especially two-wheeled) vehicle drivers and horse riders.

4.154 These roads are estimated to account for about 82 per cent of the total rural road length in Great Britain (Barker et al, 1999). Therefore, it is especially vital to adopt low-cost accident remedial measures, such as signing and marking in accordance with TSM Chapters 4 and 5.

4.155 In general, speed reducing measures and measures that act as alerting devices for hazards (eg supplementary plates on signs or rumble areas (TSM Chapter 7; Appendix A17)), which may be obscured or difficult to judge or detect, are recommended and many of these are discussed below.

## Rural Minor single-carriageways junctions

**Figure 4.14**




4.156 The situation with respect to numbers of casualties at junctions and on links tends to be reversed on minor roads in the rural environment in that fewer numbers occur at junctions, ie a third at junctions compared with two thirds on links. This may be largely due to the lower numbers of junctions and turning vehicles than in urban areas. Nevertheless over100 people were killed in 1999 at rural minor road junctions.

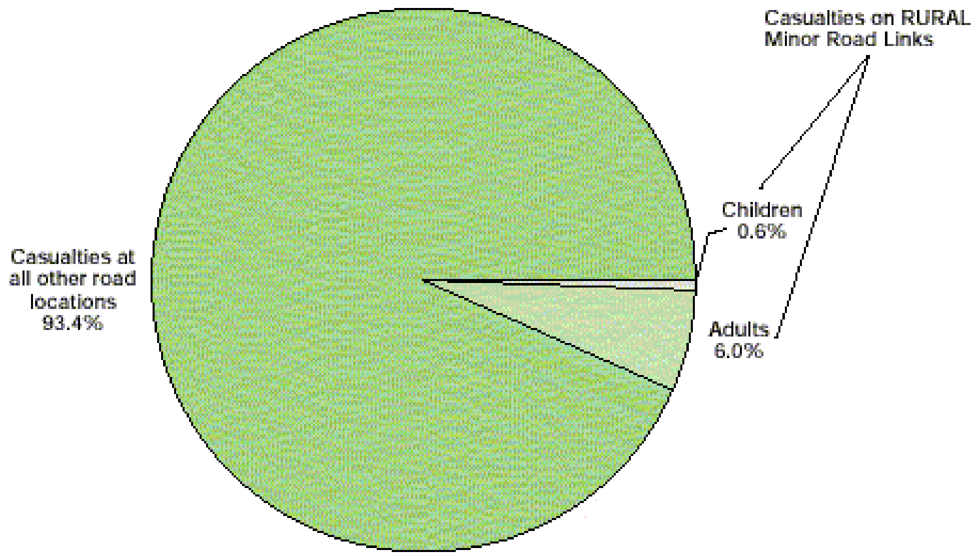
4.157 There can be a particular problem at crossroads where the road ahead, but not the junction, is clearly visible to those approaching drivers who need to give way or stop at the junction.

4.158 Junctions where minor road vehicles must give way to major road traffic need to be visible. Where skidding is evident or there are large numbers of recorded rear-end collisions, then there may be a case for special anti-skid surfacing to be laid in the approach to a rural junction (Appendix A1; DMRB, HD 28/94).

4.159 Vehicle-activated signs which warn drivers who are approaching too fast, of the junction ahead may be applicable at junctions with crossover accidents and high vehicle speeds on the approaches, if existing signing is of a high standard and if a power source is available (Appendix A25).

# Rural Minor single-carriageways links

**Figure 4.15**




4.160 Although only about 7 per cent of all casualties injured on roads in GB in 1999 were injured on minor rural single-carriageway roads, these accounted for about 12 per cent of all fatalities. This gives some indication that the severity of accidents on rural minor roads tends to be generally higher than on other roads, which may be largely attributable to vehicle speeds often being generally too high on such roads.

4.161 Many accidents on rural minor roads tend to be associated with vehicles leaving the carriageway following a loss of control on bends.

4.162 Physical features (vertical/horizontal deflections such as road humps/narrowings) will be largely inappropriate on, even minor, rural roads that carry high speed traffic. One aim of signing/marking is to convey the *impression* of a hazardous situation for example, markings can be used to give the impression of the road narrowing such as channelisation or edgelining in accordance with TSM Chapter5. These are **perceptual techniques.**

4.163 On minor unlit rural single-carriageway links without kerbs, TSM Chapter 5 recommends white lining systems. Such systems will include edge-lining and centre-lining using solid, dashed, or double lines as appropriate and as specified in TSM Chapter 5 see Appendix A20.

4.164 On wide roads, measures that appear to reduce the road width (eg centre channelisation) may be suitable to discourage overtaking and encourage lower speeds. The introduction of cycle tracks could also be considered to provide some degree of segregation between cycles and other traffic.

4.165 Options for making provision for equestrians, include bridleways, all purpose highways without motor vehicles [43] , or a margin at the side of the highway [44] . These may also help pedestrians and cyclists.

4.166 As mentioned above, a predominant type of accident site is bends. Therefore, it is recommended that measures suitable for use at or on the approach to bends should be considered, perhaps as a mass action approach if the problem is widespread and existing signing and markings comply with advice in TSM Chapters 4 and 5.

4.167 Vehicle-activated warning signs may be appropriate on the approaches to particularly hazardous bends. They alert drivers and slow and smooth vehicle speed profiles through a bend. If a power source is not easily available, the cost may be prohibitive (Appendix A25).

## Non-engineering measures

4.168 Although this guide is primarily concerned with engineering good practice, modifying the road environment should not be done in isolation and the approach to improving road safety must be an integrated one. There are other very important areas where road safety activity should be carried out in an organised and efficient manner, often co-ordinated by road safety officers.

### Role of road safety officers

4.169 In general terms, the role of an RSO is in education, training and publicity (ETP) and encouragement programmes. These approaches shape and change the behaviour and attitudes of individual road users. The full benefits of these approaches are often long term ones, which may never be measurable as their specific effects may not be able to be assessed in isolation.

4.170 Education programmes are largely school-based. The programmes usually involve informing and advising teachers, and they may have specific objectives or be part of a long-term development of learning and ideas. Those targeting children in particular will be shaped to match the physical and mental development of a child. Often, road safety education can be planned to complement other topics within the context of the National Curriculum. Some programmes and advice can be directed via parents.

4.171 Training programmes are mostly targeted at specific types of road user or age group and are designed to develop the practical skills required to use the road network safely.

4.172 Publicity campaigns generally use the media, leaflets and advertising to inform and advise road users. These are often the only ways to reach a wide audience and adults, in particular. The campaigns may, for example, inform of new developments, changes to the network, traffic or the law, advise of the latest best practice, advise of the most recent research. They will often aim to change road user behaviour and attitudes to road safety problems and issues. Many publicity campaigns are organised at a national level (by DTLR, for example) to target national problems or to reflect national policy. These campaigns often rely heavily on support at a local level to ensure maximum effectiveness (e.g. health authorities and schools).

4.173 ETP programmes often involve a combination of the above approaches and may involve RSOs working together with other outside bodies.

4.174 It is important that any ETP work is monitored in some way in order that the effectiveness of future programmes can be optimised.

4.175 Some of the more recent strategies that are relevant to the latest national casualty reduction targets are discussed below.

## Safe routes to school

4.176 About 34 per cent of pedestrians and cyclists killed or seriously injured in 1999 on Britains roads were children (under 16 years old), and one of the most common types of journey for unaccompanied children is, of course, the journey to school.

4.177 About a fifth of cars on the road in urban areas during the morning peak are taking children to school (DTLR, 1999a, DTLR, 2001c). Several major changes in traffic have occurred in just the last ten years and these include the fact that:

- the proportion of journeys to school by car has nearly doubled, from16 per cent to 30 per cent.
- the average length of the journey to school for secondary pupils has gone up by well over a third.

4.178 The problem directly affects more than nine million young people in education in the UK and their families. Indirectly it touches everyone through its effects on health, education, local air quality and congestion. The causes are complex and inter-related, but include:

- rising car ownership;
- a wider choice of schools other than neighbourhood schools;
- local changes in where people live and pupil numbers;
- inadequate bus services and high fares in some areas;
- increased traffic and fears about road safety;
- increased fears about personal safety, including bullying and abduction;
- children carrying more equipment and books to school; and
- parents under increasing pressure of time.

4.179 As a result, traffic and congestion is increased and, in many areas, fears about safety in traffic lead to less walking and cycling and more driving which in turn increases traffic. Local air quality and journey times deteriorate and the hazards for those who do travel to school in this way probably do increase.

4.180 Local authorities have been asked to include an integrated area-wide strategy for reducing car use and improving children’s safety on the journey to school in their Local Transport Plans. In this, they should indicate how they will work with individual schools to develop comprehensive school travel plans, which may include improved pavements or crossings, pedestrian and cycle training, escort schemes such as the walking bus and enhanced facilities within the school (see DTLR, 1999a).

## What is a school travel plan?

4.181 A high quality school travel plan puts forward a package of measures to improve safety and reduce car use. It is backed by a partnership to benefit children involving the school, education and transport officers from the local authority, the police and the health authority. It is based on consultation with teachers, parents, pupils and governors and other local people. The concept is intended to have more impact than initiatives which focus on a single issue or mode of travel as it uses measures which reinforce each other. It improves safety leading to reduced car use and still better safety.

4.182 A school travel plan works by looking in detail at children’s needs on the school journey and can be geared to the needs of a primary or a secondary school. Ideas often include a rota for parents to accompany younger children on a walking bus, cycle stands at the school, cycle training, and low fare deals for children using public transport. A school safety zone can transform children’s journeys with crossing points, traffic calming and lower speed limits on nearby roads.

## The walking bus

4.183 Many councils have to arrange education transport below the statutory or authority qualifying distances even when good, lit walking routes to school exist. Often the only reason a route might be deemed as being unsafe is if it passes through isolated areas. As a result the issues associated with personal security of children walking or cycling to school are so contentious that councils provide free transport for short distances even if there are no obvious hazards for a child to walk while accompanied by a responsible adult.

4.184 West Lothian and Hertfordshire County Councils were two of the first authorities to introduce the concept of a Walking Bus, around 1997. It is perhaps best described as a mobile patrol. The patrol walks along a designated part of the route, with the objective being to provide an adult presence, not to escort children but to keep a watchful eye on them as they walk to school. It aims simply to:

- encourage less use of the car for short trips;
- enable children to get more exercise and learn pedestrian skills; and
- promote friendship and conversation between children.

4.185 The school plots pupils homes on a map, as well as carrying out a survey to find out how many potential passengers would be willing to participate. Safe Bus Stop gathering areas can be selected, which should be as near to large areas of children’s homes as possible. The routes should, of course, keep the need to cross roads to a minimum, and use safe crossing places wherever possible.

4.186 Schemes are commonly administered by the School Crossing Patrol Unit, which trains and recruits applicants on similar lines to that of their existing staff. Detailed guidance on operating a walking bus scheme is in DTLR (1999a).

4.187 A typical cost has been found to be about Â£4,000 per year for each Walking Bus. However, the scheme can be extremely cost effective when compared with the cost of providing a real bus which can easily be more than Â£15,000 a year.

## Pre-school Children’s Traffic Club

4.188 The concept of a Traffic Club for pre-school children originated in Scandinavia and has been operating in the UK since about 1990. The aim of the clubs is to involve parents or carers in teaching road safety to their children using both indoor and outdoor exercises set out in a series of books.

4.189 An evaluation of the pilot scheme Children’s Traffic Club in the Eastern Region County Councils revealed various successes, including a contribution to a 12 per cent reduction in all casualties and a 4 percent reduction in pedestrian casualties between four-year before and after periods. However, the most significant change was a 20 percent reduction in casualties involving children emerging from behind a vehicle (Bryan-Brown, 1995).

## Primary school training

4.190 Material for various child road safety education programmes has been produced over many years. Some is aimed at the five and six year age range (Reception, Year 1 and possibly Year 2) (DTLR, 1998f and1998g), but these can go up to age 12 by incorporating the subject within other main subjects like Mathematics, English, Science, Geography etc. (Thomson et al, 1996; Clayton et al, 1998).

4.191 This type of education is generally accepted to be effective, although it is very difficult, if not impossible, to demonstrate rigorously that the training has reduced casualties. In Sunderland for example, comparisons of periods before and after introduction of pilot schemes seemed to indicate that the pedestrian training is associated with a drop in casualty numbers of 36 per cent. However, this was not statistically significant as there was a general downward trend in casualties for the same period. However, observations by the road safety officers did show that the proportions of children performing safely at four crossings improved markedly and this was sustained one year after receiving training.

4.192 The schemes normally need to enlist volunteer trainers (like school staff, governors, parents, grand parents, and voluntary organisations see Kerbcraft (DTLR, 1998g)). However, by law, everyone working with children under the age of eight years must comply with the Children’s Act 1989. This means that all volunteers and staff must complete a Police Criminal Records Office form. This must be submitted through the Education Department as the training scheme is non-registered and their agreement must be obtained. These checks can take time to process. The forms need to be submitted in good time so that the scheme can begin on schedule.

4.193 It is, if course, important to ensure good liaison and approval from all interested parties involved, like the head teachers, parents, road safety officer team and the police.

## Cycle training

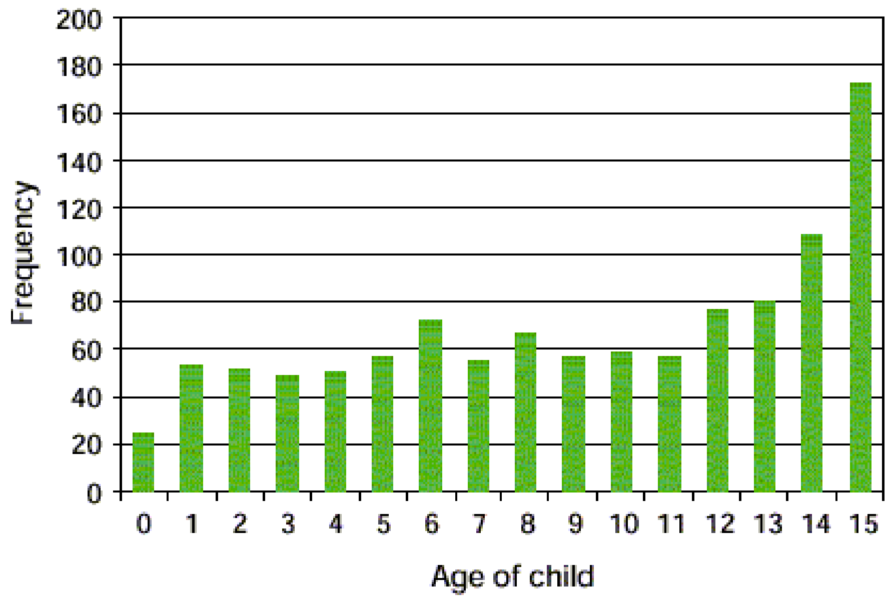
4.194 Road sense training for child cyclists has been provided for many years, normally out of school hours, and is regarded as a valuable exercise.

4.195 Savill and Bryan-Brown (1996) evaluated eight schemes around the UK. Groups of 13-year old children who had received training at age11 were given a cycle riding and knowledge test by the local road safety officers. The study concluded that these children did indeed possess significantly safer riding skills and knowledge than those who had not taken part in the cycle courses.4.196 A relatively new extension to cycle training carried out by some authorities (such as Surrey County Council) is safe cycling classes held for both parents and children. This also provides adults with useful points to be wary of when cycling with young children.

## Pre-driver training

4.197 There is recent concern for the mid-teenager group. For example, the number of casualties killed or injured in cars appears to begin to rise sharply from the age of 14, with more than twice the numbers of casualties recorded for 15-year olds than any other single year child age-group under 14. Also, the 12 to 15 year age band is the only one where girls are proportionately more involved than boys.

**Figure 4.16**




4.198 Young drivers in the 17 and over age groups, continue to be a major problem, with casualty numbers of 18-year olds being about eight times higher than most of the single year child age-groups.

4.199 There appears to be a need to focus on both trying to instil responsible attitudes to driving while still in school. It is also advisable to get new immediate messages across to girls. For example, they should be told that they need to be aware when travelling with their young friends when these drivers are taking unacceptable risks, and ways in which they can try to modify such behaviour.

## Adult road user training

4.200 Road safety officers should not ignore adult education and many carryout adult road user education programmes. For example, they train older road users how to use new crossings like pelicans and toucans, or advise regular drivers how to deal with a particular problem. This can be done by either roadside training or targeted publicity campaigns.

4.201 An example of this was Surrey County Council who successfully tackled a localised nose-to-tail collision problem by targeting residents with direct, narrow frontal access to their driveways off a busy main road. The council distributed leaflets advising resident drivers of the safety problem and to signal and slow down gradually, well in advance of their manoeuvre.

## Publicity

4.202 Publicity campaigns are expensive but can be extremely effective, even though they may take many years to bring about a lasting change in attitude (such as the well-known change in public attitude towards drinking and driving). A study of evaluated campaigns has concluded that a well-designed publicity campaign can typically produce a 30 percent reduction in casualties in the target group (Delhomme et al, 1999).

4.203 Recent areas where it has been identified that there is a need for publicity campaigns to be focused (DTLR, 2000b) are:

- improving child road safety;
- preventing speeding;
- drink and drugs driving;
- drowsiness;
- motorcycles;
- use of cycle helmets;
- mobile phones; and
- company car drivers (for both employers as well as employee drivers).

[32] Urban (or built-up) roads are defined as those with speed limits of 40mph or less.

[33] Rural (or non-built-up) roads are defined as those with speed limits of 50mph or more. Roads through villages with speed limits of 20, 30 or 40mph are not included. A rural road may or may not have buildings alongside it.

[34] The police operate speed cameras. Local authorities must liaise with the police where the use of cameras is proposed.

[35] Over recent years, some authorities in London have introduced roadside or bus-mounted cameras to identify offenders.

[36] In STATS19 data these have been assumed to be non A class single-carriageway roads in built-up areas with speed limits of 40 mph or less.

[37] Some local authorities are responsible for motorway standard roads and some are Highways Agency Agents.

[38] Casualty severity index (Casualty KSI index) = 100*Number of killed and seriously injured casualties/All casualties.

[39] TWMV = Two-wheeled motor vehicle; HGV = Heavy Goods vehicle; LGV = Light Goods Vehicle.

[40] On the M25, an interactive system of variable speed limits has been introduced. Speed limits change according to the prevalent traffic conditions ahead.

[41] PSV = Public Service Vehicle

[42] These have been defined as all non-motorway or A-roads with speed limits of 50mph or more.

[43] Introduced by means of a traffic regulation order.

[44] Under powers available under Section 71 of the Highways Act 1980.

# 5. Measuring effectiveness

## Monitoring matters

5.1 Through the LTP Annual Progress Reports authorities will monitor the progress that they are making in working towards the achievement of their local road safety targets contained in their Local Transport Plans(see Chapter 3). In addition, authorities are expected to monitor the effects of individual safety schemes. The following Chapter sets out advice on measuring the effects of such schemes.

5.2 What is required is some knowledge of how driver behaviour changes following the introduction of a scheme and, ultimately what are the effects of behavioural changes on accident frequencies and casualties.

5.3 Monitoring these changes is the only valid and objective way to be able to demonstrate the relative (cost-) benefits, and success in saving casualties, between more than one safety scheme. The results of monitoring feed into future work, rejecting less successful types of schemes in favour of more successful ones, or helping to make decisions about a number of small schemes over a single costly one. Ultimately, this should produce greater accident reductions and fewer casualties.

5.4 The County Surveyors Society and Highways Agency's MOLASSES database stores information on safety schemes installed on local and trunk roads across Great Britain. The database can be interrogated to obtain information regarding the accident reductions achieved across all sites of a certain type eg roundabouts, road humps etc. See the web site at www.trl.co.uk/molasses and Appendix C for an example data entry form. However, note that TRL Limited, who manage the database, will accept data in almost any format.

## When to monitor

5.5 The monitoring studies for measuring the effect of a safety scheme are usually by *before* and *after* analysis of factors that are likely to have a bearing on the safety of road users at the particular treated site(s).Although not an exhaustive list these may include:

- spot speed;
- speed variance;
- traffic conflict studies;
- traffic volumes;
- journey time/delay;
- compliance with traffic control devices;
- skid resistance;
- sight line/passing sight distance/super elevation;
- pedestrian safety gaps/kerb delay/crossing times;
- road accidents; and
- weather/season.

5.6 *Before* measurements should be made as close as possible to the time when the scheme is implemented. Ideally, this would be during the month before (except for accident monitoring see paragraph5.33). However, in some cases it may be sensible to make observations only after the changes, for example, with attitude surveys.

5.7 It would, of course, be impractical to carry out detailed behavioural studies for all minor alterations, but studies may be particularly important for expensive schemes like area-wide or mass action treatments. It must be noted, however, that the behavioural or geometric variables listed above have the disadvantage that they do not give a direct measure of the magnitude of safety improvement since the precise relation to accidents is uncertain. However, despite this drawback objective measurements are often considered very worthwhile, since they can give a good indication of a change in safety.

5.8 Measurements should not be taken during the installation period. Additionally, after installation, a week or more should be allowed as an adjustment period for road users to become familiar with the new scheme.

5.9 *After* measurements should commence within one month of site work being completed. It is often desirable to take several sets of after measurements, at various time intervals after the scheme is introduced, to investigate the extent to which any initial effect is sustained and to allow for seasonal variations.

5.10 Where possible, monitoring should take place under normal traffic conditions and not coincide with, for example, school and bank holidays, market days, early-closing days, poor weather or roadworks.

5.11 When comparing data between sites, it is useful if all monitoring can be carried out at the same time, or if careful cyclic monitoring techniques are planned in the design of trials. If several schemes with different installation periods are involved then consideration could be given to planning equivalent monitoring periods with respect to installation dates.

5.12 It should be remembered that *before* monitoring can never be repeated! It is important, therefore, to check *before* data before a scheme is installed.

5.13 It would be disappointing, to say the least, if there was not an immediate and noticeable improvement in driving behaviour at a scheme (eg particularly a reduction in speed in, say, a traffic calming scheme). What is more important, however, is that a worthwhile underlying improvement (that results in casualty savings) remains after any initial novelty effect has worn off. It is this underlying improvement which is the most important to measure. Experience from earlier research suggests that changes in behaviour should have stabilised by12 months after installation and this is, therefore, recommended as a suitable period to judge the value of the scheme in behavioural terms.

5.14 The ultimate measurement to consider is the effect of the scheme on accidents and casualties. The main (but probably not the only)justification for introducing a scheme will probably be to improve safety. Many schemes are designed to achieve reductions in vehicle speed and, given the now well-proven correlation between speed and accident reductions (Taylor et al, 2000), one might reasonably expect accidents to be reduced also. However, when monitoring only one scheme or a small number of schemes over a short time, accident monitoring alone will only be a weak indicator, as it is most unlikely that small numbers of accidents and short time-scale of the monitoring will allow any changes to be statistically significant.

5.15 The extent of *before* and *after* measurements required is considered separately for each of the monitoring options discussed below.

## Control sites

5.16 In a perfect monitoring trial, there would be an equivalent site to the treated site (the Test site) at which no changes were made throughout the monitoring period. Data from this perfect Control site would be entirely representative of what might have happened at the Test site had the scheme not been introduced. It would allow a more accurate comparison between *before* and *after* data, taking account of any general changes in driving behaviour, travel patterns, weather, economic activity, etc.

5.17 Unfortunately, it is rare indeed to find an individual site that matches the Test site in all respects, but Control sites should generally have similar features, traffic levels and traffic mix to Test sites. Generally, attempts by researchers (eg Hauer, 1992) to find suitable Control data for trial sites has led to difficulties in the interpretation of unstable data. In addition, collection of detailed Control data may add significantly to the cost of monitoring. If the Test site is a route or area, then similar route/s or area/s may be suitable as Controls. If the Test site is small, then using a large Control may be worthwhile because, by combining data from many sites, any fluctuations at individual sites will tend to cancel each other out giving a more accurate overall picture. This may include using data for a whole town, county, or even readily available national data covering the same period; eg if a junction is improved, then the control group may be all (similar type) junctions within the county.

5.18 In some cases, it may not be necessary to collect Control data, but to make the assumption that conditions at the Test site would have changed little, if at all, during the period of the trial. Thus the Control would be no change, and the *after* data directly compared with the *before* data.

5.19 It is most desirable to have a Control in situations where outside influences are thought to have affected the Test site, for example, when a major external change occurs at the same time as the implementation of the scheme, or during the monitoring period. An example of such a change might be the opening of a parallel route that diverts traffic from the route through the scheme. If the scheme is installed, then an appropriate Control must be found, or direct *before-after* comparisons will be misleading.

5.20 In some instances, if a newly installed measure targets traffic in only one direction, traffic travelling in the other direction may provide suitable Control data. However, it should be noted that drivers might drive through the site in both directions and be familiar with the measure, which may affect their behaviour.

5.21 Alternatively, in some instances, it may be suitable to use data from vehicles upstream of a measure as control data. However, again, drivers may be familiar with the measure if they have travelled through the site on a previous occasion, and this may affect their behaviour.

## Overall assessment of monitoring

5.22 The quality of the overall assessment will greatly depend on the number of monitoring options employed for each scheme and the amount of data collected for each. Obviously, the cost of monitoring is inextricably linked to the amount of data to be collected, analysed and reported on. It must be decided for each scheme, which of the engineering measures in the scheme will be monitored separately, in addition to the assessment of the effectiveness of the whole scheme.

## Data quality

5.23 The conclusions of any monitoring programme are only as good as the reliability of the data on which they are based. Experience has shown considerable variation in the quality of data collection even when collected against a prior written specification. As a consequence, for data where an element of choice or selection exists on the part of the data-collector, a site visit by the agent responsible for commissioning the monitoring is always recommended to be able to brief the data-collector carefully on his or her duties.

5.24 Examples where data quality can be impaired through inadequate briefing include:

- collection in inappropriate weather conditions;
- collection at inappropriate locations;
- measuring both directions of travel (without identifying each measurement), when only one is required or both required separately; and
- not collecting sufficient, or even any, before data.

5.25 Where relevant, the same equipment and, preferably, personnel should be used for *before* and *after* monitoring to ensure the consistency of results.

5.26 Experience also suggests that automatic equipment should be checked more than once a week to ensure it is continuing to operate correctly and has not been vandalised.

5.27 In the case of attitude surveys, it is desirable that the commissioning agent attends the interviewer briefing meeting to maintain consistency of approach and hence quality of the data collected.

5.28 Data that can be collected automatically must still be analysed consistently. Careful specification, briefing and supervision of the analysis will be essential to obtain reliable results.

5.29 Back-up plans should be in place in case things do go wrong. It is recommended that a contingency element be included in the monitoring budget in case of such problems (eg vandalism, theft, bad weather).

## Police involvement and publicity

5.30 It is usual to consult in detail with local police about proposed schemes and it would be particularly important to emphasise to them that any change in the level or type of policing at the site could upset the validity of the measurements being made. A specific request should therefore be made to the local police not to assist the scheme in any way, most particularly with respect to enforcement.

5.31 During the *after* monitoring period (typically one year, and three years for accidents), a similar police presence to the before period is desirable. However, through co-ordination with the police, radar traps or any other direct enforcement of speed limits should be avoided near the times that any speed measurements in connection with the trial are being made (unless, of course, enforcement is part of the scheme).

5.32 Early results are often very encouraging, but most innovative measures suffer from a novelty effect, which reduces with time. It is therefore important not to rush to the residents, press, councillors or pressure groups with these early results, as they are unlikely to be sustained. Ideally, wait for the 12 months *after* measurements to be analysed before announcing results.

## Accident monitoring

5.33 For every safety scheme installed, the change in injury accident rates between the *before* and *after* periods will be a major consideration. Normally, all injury accidents which occurred in a period of three years before and three years after the introduction of the measures would be considered, but a preliminary look at the data one year after would be valuable.

5.34 Accident data should always be collected and examined for changes in the accident categories that a scheme is addressing. However, it is highly unlikely that a statistically significant result would be produced at a single site. This is much more likely to be achieved if the data from several schemes are combined and there are large changes.

5.35 The monitoring database MOLASSES addresses this problem by gathering together accident and design information from all local authorities and Highways Agency agents. By pooling all the information available for a particular type of scheme, a more robust picture of effectiveness can be achieved (see paragraph 5.4 above and Appendix C).

5.36 Many of the monitoring options discussed below are proxies for accident monitoring.

5.37 Monitoring accidents is important to ensure that the scheme has not introduced a new problem. It is also important as a reference tool to allow more accurate assessments of future benefits, when similar measures are used at other locations.

5.38 Statistical tests for analysing accident data are outlined from paragraph 5.113 onwards.

## Monitoring vehicle speeds

5.39 The most important traffic parameter to be investigated for most schemes will usually be the measurement of vehicle speeds. Changes in speeds are a measure of a change in behaviour, indicating that drivers have reacted directly to the measures in a quantifiable way. A measure of the effect of the scheme on speeds could be obtained in one of three ways:

- an examination of the way in which individual components of the scheme work using automatic equipment, probably operating continuously for a seven day period, but giving breakdowns by time of day. Automatic equipment can either measure speeds of (most usefully) all individual vehicles [45] or (more commonly) bin [46] data from all vehicles passing within a certain time period (eg 30 minutes). The data will include all detected vehicles including congestion;
- an examination of the way in which individual components of the scheme work by measuring the speeds of free-flowing [47] vehicles with radar guns; and
- the overall journey effect, taking the scheme as a whole from journey time measurements.

5.40 The first two options involve spot measurements of speeds. These can give valuable information about changes in behaviour at one point, or about elements of the scheme, but not of the scheme as a whole. The third option, average speeds calculated from journey time measurements (over a measured distance commonly referred to as journey speeds), is an excellent method of assessing the effect of the scheme as a whole, particularly for a large scheme, a village scheme, or a route scheme.

5.41 If the speeds of cars and heavy vehicles are to be measured separately, then radar or laser measurements may be the most appropriate method as automatic equipment generally only gives a crude breakdown of the mix of traffic in the overall sample. A combination of all three forms of measurement would provide the most complete picture but is unlikely to be financially viable.

5.42 Monitoring equipment should be made safe and secure. This will often involve chaining data loggers and cameras to lampposts or installing unobtrusive lockable cabinets at the roadside.

5.43 As mentioned in paragraph 5.13 above, with any new road engineering measure, an *initial* effect on speeds is to be expected. Frequently, the initial effect is greater than the longer-term (underlying) effect, observed once drivers have become used to the new measures. One would therefore expect a gradual return towards the *before* level of behaviour, after the introduction of any novel scheme. It is important to be sure that the underlying effect of the measures is a lasting improvement and speed data should ideally be collected at intervals over a period of twelve months to assess any relaxation towards *before* levels.

5.44 The most commonly studied characteristics of speed used to identify changes are mean speeds and 85th percentile speeds [48] . Research (Taylor et al, 2000) has shown that the most important determinants of accidents are:

- the mean speed;
- the variability of speed; and
- the percentage of vehicles exceeding the speed limit, and the margin by which they do so.

Accident predictive relationships are available which use either the first two or the second two of these measures. Equipment that records individual vehicle speeds best allows these speed distribution parameters to be determined accurately.

## Automatic speed monitoring

5.45 Automatic spot speed measurements (for weekly periods, say) will generate considerable amounts of data, which may be suitable for detailed analysis, but will generally only give information at specific points about traffic behaviour as a whole (as determined by the lead vehicles of platoons) [49] . They are, however, likely to provide the only data relating to weekend and night-time speeds.

As the equipment would be expected to provide seven days of data, at *least* one set of *before* and two sets of *after* measurements (one month *after* and 12months *after*) would be recommended.

5.46 Automatic vehicle speed detectors use either loops or tubes (or similar devices) as sensors. Loop installation is expensive, but the cost should only be incurred once. Tubes must be installed each time data are collected (probably three times) and can break after short periods of operation. It is these installation and retrieval costs which largely determine the cost of the measurements, not the length of time for which the equipment remains on site. An advantage of automatic (over radar/laser) speed measurements is that flows, and sometimes vehicle headways, are also measured as a consequence.

## Radar or laser speed monitoring

5.47 A more flexible tool in the investigation of speeds is the radar gun, or the more recent laser gun. These instruments enable the measurement of changes in drivers choice of speed. They also allow separate measurements of cars and heavy vehicles and, being highly portable, allow measurements to be made at several points in the scheme on one day (dependent on flow). Another advantage of speed measurement by radar or laser guns is that they do not require the installation of tubes or loops, as does automatic equipment.

5.48 With radar guns, data are collected only over relatively short periods of time, so they are more liable to inconsistencies from the inherent variability of speed data. For this reason, *before* data should be collected on at least two separate occasions (with at least 200measurements per occasion at each monitoring point) giving at least400 measurements for each monitoring point.

5.49 Care should be taken to ensure that the radar or laser guns are used as unobtrusively as possible to avoid influencing driving behaviour.

5.50 To ensure accuracy of readings care should also be taken to point the meter as straight as possible along the road in line with the vehicle movement (an error of 10 either way will cause the meter to under-read by 1 1/2 per cent). Particular care needs to be exercised with radar guns in avoiding secondary reflections from other moving vehicles, which can cause spurious readings; for example, they are usually impractical for use on busy dual carriageways.

5.51 The *before* and *after* speed surveys should ideally be made at the same time of day and day of week, at each measuring position. The number of occasions on which data should be collected in the *after* period will depend on the depth of the investigation.

5.52 In order to examine any changes in speeds as drivers become used to the scheme over time, measurements should be made on at least four occasions (eg 1 month, 3 months, 6 months and 12 months) after the scheme is introduced.

5.53 The variation in mean speed between samples (taken on consecutive days, for example) can be of the same order as the variation in speeds before and after schemes are installed if sample sizes are not large enough (see paragraph 5.106 statistical test for difference in means).Therefore, it is recommended that on each *after* occasion, at least 200measurements should be made at each measuring point. If *after* measurements were made only twice (one month and one year) it would only be possible to indicate that there had been a change over the year, but not how quickly it had occurred.

**Table 5.1 Summary of benefits and disbenefits of automatic versus radar/laser vehicle speed measurement**

| | Automated traffic counters | Radar or laser guns |
|---|---|---|
| **Benefits** | Record all time periods (i.e. possible to isolate results for particular times or days of week) | Immediate (no installation of equipment required) |
| | Large amounts of data | Easy to isolate readings for individual vehicles, exclude certain vehicles etc |
| | Traffic flows also collected | Good to get indicative rather than comprehensive result |
| | Repeat monitoring periods easy if loop/tube equipment remains on site | |
| **Disbenefits** | May be difficult to install tubes/loops (unsuitable position, difficulty in fixing to road, may require traffic management) | Often hard to use discretely which might affect vehicle speeds |
| | May not be able to isolate individual vehicle speeds (depending on logger type) | On low flow rods, hard to get sufficient sample size without intensive use of staff resources |
| | May require cabinet installation | |

## Where to monitor vehicle speeds

5.54 The positions within each scheme at which speeds should be measured can only be determined for a particular scheme and the set of measures envisaged. However, ideally, measurements would be made in both directions at:

- each entry to a scheme;
- at any spots where accidents tended to occur; and
- at, or on the approach to, and after each individual measure or element of the scheme.

5.55 The spots at which speed measurements are made must be chosen carefully to avoid unwanted variability; eg on the approach to a measure but not in close proximity to other speed influencing features, such as pelican crossings or junctions.

5.56 It is imperative that locations are reproducible between periods and well documented (eg at third lamppost north of junction, 52 m west of garage exit).

5.57 The measurement and analysis of speed data is likely to be the largest cost in the assessment of any scheme. The number of measurement points is directly linked to the overall cost, both in terms of data collection and analysis.

5.58 For larger schemes it may be appropriate to monitor speeds with automatic and radar equipment and to monitor journey times.

5.59 When results from more than one scheme are to be combined, some effort should be made to make monitoring points comparable between schemes ie at similar features to allow cross-comparisons to be made.

## Journey time monitoring

5.60 One method of considering the overall effect of a scheme would be through the measurement of changes in journey times through it, particularly if the scheme covers a whole route. If measures are designed to reduce speeds, then journey time measurements will not only provide an estimate of any extra time added to the journey by the measures, but also by how much the average speed through the whole scheme has changed.

5.61 Journey time measurements, by sampling vehicles travelling through a scheme over several hours, are likely to be more robust than small sample radar spot speed measurements (ie less between-sample variability). One *before* and two *after* (one month *after* and 12 months *after*) measurements should be sufficient to give an indication of any overall relaxation to *before* levels.

5.62 Journey time measurements have traditionally been labour-intensive. They involve recording the registration number and time as a vehicle passes into and out of the scheme (which may involve monitoring at more than two locations) and subsequently matching the registration numbers. Video image processing equipment is now available to identify registration numbers from video records, providing the raw data for computer matching programmes.

5.63 Peak and off-peak journey times may need to be explored separately.

5.64 Observers in instrumented cars can also measure journey times, just as they are used to investigate urban networks. However, this method is open to experimenter bias because they would often have the freedom to choose their own speed or the particular vehicle to follow through a scheme. It may also take considerably longer than the fixed observer/video method to collect enough data.

## Flow monitoring

5.65 If there is an alternative parallel route to which drivers could divert in order to avoid a scheme, or part of it, then flow is an important parameter to measure accurately. It is unlikely that drivers would change their basic route for just one small scheme, but they might divert to parallel side roads if they saw an advantage in this (eg to avoid driving over a series of humps). It is recommended that flows should then be recorded and classified on both the original and alternative routes.

5.66 Background information on traffic flow data is likely to be available already for some roads, particularly major ones. If this is not fully classified (ie detailing volumes of heavy vehicles, two-wheeled motor vehicles and pedal cyclists separately), or up-to-date, then a classified flow count would be required as part of the monitoring programme. However, flow data is often easy to collect as a by-product of, or in conjunction with, other measurements (eg automatic speed monitors record flows as well as speeds).

5.67 As an alternative to automatic flow counts, observers at the roadside or on junction arms can carry out manual classified counts (particularly for junction turning counts). The count period should not normally be less than one hour but will depend upon flow levels and hourly, daily and seasonal variability of traffic. A 12-hour period is often used. Scaling factors based on national averages may be used to scale one hour flows (Highways Agency, 1996).

## Monitoring pedestrian movements

5.68 Measures of exposure to risk for pedestrians are not well known because there is little data available for pedestrian movements. However, a project commissioned by DTLR has attempted to establish the requirements for long term monitoring of pedestrian activity (see Ross Silcock, 1998).

5.69 Any objective measurements of pedestrian behaviour and how it changes as a result of a scheme is often best investigated by the analysis of video recordings. The main parameter to be measured is usually where pedestrians choose to cross and whether their waiting time has changed or safety gaps improved as a result of the scheme. Such issues can also be investigated using on-site observers or, less comprehensively, but at lower cost, with attitude surveys.

## Monitoring pedal cycle and two-wheeled motor vehicle movements

5.70 Two-wheeler flows tend to be extremely low, compared with those of other motor vehicles, and therefore assessing, subjectively or objectively, the effect of the scheme on cyclists or motorcyclists is very difficult.

5.71 Automatic vehicle speed logging equipment does not consistently identify two-wheeled traffic. Analysis of video recordings is likely to be expensive but may yield some information. The best option may be to ask the police to stop two-wheelers in surveys with other road users and canvass their opinions or where schemes relate specifically to cyclists, for interviewers to stop them.

## Monitoring vehicle (time or distance) headways [50] or inter-vehicle gaps

5.72 Monitoring headways is likely to be most useful in a context where increasing the gaps between vehicles would be expected to improve safety (motorway chevron installations, for example). This needs automatic vehicle logging using loop detectors.

5.73 The extent to which changes in inter-vehicle gaps makes it easier for pedestrians to cross the road is not easy to assess directly. It is easier to examine this matter through pedestrian studies or attitude surveys.

## Monitoring traffic conflicts

5.74 The traffic conflict technique is simply a formalised method of observing and recording near-miss situations at a specific location(Transport and Road Research Laboratory, 1987). Conflicts have been demonstrated to be related to actual collisions (see Asmussen, 1984); however, the relationships are somewhat complex and vary with the types of manoeuvres, road geometry and road users involved.

5.75 The collection of conflict data for a traffic stream is usually carried out by a trained observer, located in an unobtrusive position, where he or she can watch vehicles along a section of road (eg 100m), normally from the rear as they approach a junction. This needs to be sustained for relatively long periods (one to five hours) during which they record the details of near-miss incidents, normally recognised by brakelights (or swerving). The observer assigns a defined severity grade to each conflict incident (see Transport and Road Research Laboratory, 1987for details).

5.76 The process is relatively labour intensive, requiring teams of trained observers, and may only be practical at junction-type locations owing to the limited distance over which observers can be expected to monitor. However, at certain locations they can be a valuable diagnostic tool in helping to highlight the circumstances and frequency in which road users are experiencing safety problems.

5.77 Conflict studies can also provide a means of evaluating a location before and after introduction of a safety scheme. The data is usually expressed in the form of daily rates of particular types of conflict. The rates are normally simply compared to answer the questions:

i) Has the remedial measure(s) successfully alleviated the problem(s)identified in the *before* study?

ii) Has the remedial measure introduced any undesirable secondary effects that may cause other safety problems?

5.78 If a full statistically valid result is required then, as we are dealing herewith separate behavioural events (though remember that there is always a degree of subjectivity in how they are recorded), the frequency of conflicts can be analysed using the same methods as for accidents, as described below from paragraph 5.110 onwards.

## Attitude surveys

5.79 The views of drivers, other road users, residents and traders about schemes are important. Ideally, some form of survey should be undertaken, preferably during the month after the installation of the scheme, to provide general feedback. However, the objectives, size and type of the proposed survey need to be carefully balanced against the costs of carrying it out.

5.80 Separate questionnaires for each of the target groups may be desirable.

5.81 The design of the questionnaire is very important. Questions must be clear and concise with open or specified-choice answers required. They should address all the key points pertaining to the particular scheme under evaluation. The questionnaire should be tested and designed for average completion in a maximum of, say, five minutes for a street interview, and 20 minutes for a home interview or postal questionnaire. Consideration may also need to be given to providing incentives for respondents to maximise response rates and accuracy.

5.82 Such surveys may require prior approval (from elected members, for example). Sufficient lead-time must be allowed for their consultation.

5.83 In most situations, only *after* attitude surveys will be needed in a monitoring programme, because it is difficult to ask about a scheme which does not yet exist, except in general terms about existing conditions. It is also likely that there might be a questionnaire survey to canvass local views as part of the consultation process about the scheme itself. It would not be desirable to conflict with any consultation process.

5.84 For most schemes it will also be appropriate to canvass the views of the emergency services, bus operators and others after scheme installation (as well as at the planning stage as part of the consultation process).

5.85 Remember that those who feel strongly are the most likely to respond to a postal survey, consultation etc., and their views may not be representative of the majority.

## Road user surveys

5.86 The most efficient way to survey road user opinions is usually to stop them as they pass through the scheme and ask them to complete a questionnaire.

5.87 It is unlikely that enough motor vehicle drivers will park in or near the scheme and be available for interview. Only police officers can ask drivers to stop. Therefore a police presence and a suitable lay-by, or sufficient road width for other vehicles to overtake, would be required.

5.88 Useful information about the relative effectiveness of the various measures could be investigated through a questionnaire. It would also be possible to seek road users views about the aesthetics of the scheme, or ways in which the measures might be improved.

5.89 The views of residents and non-residents may differ considerably. It might be useful to investigate them separately.

5.90 It may also be useful to collect some personal details about interviewees, such as their gender, age and whether they walk, cycle, drive or motorcycle through the scheme at other times.

5.91 A sample size of 200 interviewees or more is the minimum recommended, depending on the need to allow for stratified sampling and more detailed examination of data through cross-tabulation.

## Environmental monitoring

5.92 If it is expected that the measures proposed might have an effect on noise generated (when introducing certain speed-reducing or alerting devices, for example), then some noise measurements would be desirable. However, these are expensive and could only be justified with larger schemes. Overall noise levels generally decrease with lower speeds, but the character of the noise may be affected by vehicles crossing a measure (eg a road hump) and by greater acceleration or deceleration. Whether the noise is a nuisance may also need to be assessed through a survey and complaints monitoring.

5.93 Both general background traffic noise and individual vehicle noise should be measured, both before and after introducing the scheme. One set of measurements in each period should be sufficient to provide a reasonable assessment of the change in noise.

5.94 Schemes that encourage a change in driving style may cause an increase in vehicle emissions. However, if the scheme also encourages a decrease in traffic flow, this can counteract these increases. The evidence so far suggests that the effect on air quality is likely to be small.

5.95 Quantifying the effect of a scheme on air quality is problematic because of the variability of measured concentrations. There is an underlying downward trend in traffic emissions as new vehicles, which comply with stricter emission limits, enter the fleet. Weather can also affect air quality, both seasonally and year to year.

5.96 It is therefore important that surveys are designed carefully. *Before* and *after* surveys should be carried out for at least three months and at the same time of year. Monitoring sites should be chosen to include those roads on which the main measures will be installed and the roads that you might expect traffic to use in order to avoid them. The sites should be located close to the emission source (ie close to the kerb) so as to be able to detect, with some confidence, the changes in air quality resulting from changes in emissions as a result of changes in driving pattern or traffic flow. A control site, outside the scheme and preferably away from main roads, should be included within the surveys in order to distinguish between the changes in air quality brought about by the measures and those resulting from cleaner traffic and differences in weather conditions occurring between sampling periods.

5.97 Local authorities have a duty under Part IV of the Environment Act1995 to review and assess air quality in their areas. The *UK Air Quality Strategy* identifies eight pollutants that should be included in local air quality management. Of these, nitrogen dioxide ($NO_2$) and particles($PM_{10}$) are probably of most interest, as in some areas concentrations of these pollutants regularly exceed the current air quality standards. Road traffic makes a large contribution to emissions of these pollutants, and so their inclusion in routine surveys should be considered. Benzene and Carbon Monoxide should also be considered because of their importance in terms of local air quality and also because they are largely derived from vehicle exhausts. There are several methods of determining concentrations of these pollutants (for example, diffusion tubes, automatic and battery operated samplers).

5.98 If pollution levels exceed set levels then an Air Quality Management Area has to be declared. In these cases, local authorities are required to develop and implement air quality action plans, and it will be all the more important to evaluate the air quality and other environmental effects of any new road safety measures to minimise any conflict between them. It is necessary to adopt a balanced approach so that as far as possible, measures which reduce accidents do not seriously prejudice air quality.

5.99 If a scheme causes a change in the number of parking spaces available, then it might be desirable to survey parking habits on the main and surrounding roads. *Before* and *after* data, would be required and, therefore, an assessment of the likely effect of the scheme on parking would have to be made at the planning stage. Two monitoring options might be to examine the number and the percentage of spaces in use over the period. Less objective information could also be made available from a resident or road user survey, in particular by canvassing any effect on traders.

5.100 Schemes planned for major roads designed to accommodate high flows may change the level of severance between the land use on both sides of the road. Severance will be a function of the demand to cross the road and the opportunities for being able to do so. This can be investigated through video analysis of pedestrian behaviour and crossing patterns, but this approach is expensive to analyse and changes in behaviour are likely to be small and difficult to identify, or prove. Severance is usually, therefore, most appropriately investigated subjectively through the attitude survey of road users, residents and traders.

5.101 The aesthetics of a scheme are extremely subjective. Also a particular measure in one location may be generally welcomed, whereas the same measure might cause disquiet in a more environmentally-sensitive area. It is important to consider aesthetics as part of the planning process and in public consultations. There may be a conflict of interest, as drivers need clear, bold measures, which catch their attention, while most residents are likely to prefer features that blend harmoniously with the local environment. The easiest way to monitor perceived effects is through opinion surveys.

5.102 It is often extremely valuable to have drivers' eye-view video and still photographic records of a scheme both before and after the safety engineering measures are introduced. They are useful in resolving subsequent queries about the changes and provide a ready means for interested parties to experience the scheme without the need to visit it. They are also useful to provide illustrations for reports and presentations, particularly of unusual or novel elements of a scheme.

## Evaluation

5.103 Having devoted considerable effort and expenditure to improving hazardous sites, there is a need to evaluate these improvements.

5.104 This section briefly outlines the evaluation of schemes based on some of the types of monitoring already described. It mentions the simple statistical tests needed to interpret the results. Appendix B gives further detail.

5.105 To obtain statistically reliable results for accident changes, it is normally necessary to wait several years after introducing the counter measure or package of measures has been introduced. It is, however, assumed that the user of this Guide will need to interpret accident and other data practically without necessarily having a full understanding of the underlying statistical theory, which can be quite complex. It is, however, important that the user is sufficiently confident with his or her analysis. If in doubt, it is strongly advised that help is sought from a professional statistician.

## Evaluation of traffic speed data

5.106 The t-distribution can be used to compare whether any changes in the measured mean speeds in two periods of measurement are statistically significant (see Appendix B.1). It can also test whether there is a significant difference between the speeds of groups of different vehicle types. The same tests can be used for similar types of measurements of traffic like travel times, vehicle headways, and pedestrian safety gaps.

5.107 If a particular scheme was actually intended to significantly change the speed distribution (eg to affect changes to the highest speed drivers only to produce a markedly skewed distribution), then a Kolmogorov-Smirnovtest would be appropriate (Appendix B.2). This is a powerful non-parametric test applicable for analysis on distributions that are not Normally distributed.

## Evaluation of public perception

5.108 Often one of the main reasons why an area-wide scheme has been implemented is that residents have campaigned strongly for something to be done. Thus, it could be argued that one important factor to evaluate is how the residents and other road users feel about the safety elements of the scheme.

5.109 Results of opinion surveys tend to be reported in many different ways and the importance of designing questionnaires carefully and properly has already been stressed. Evaluation of public opinion by authorities tends to be a relatively straightforward matter of recording the level of public acceptance of the scheme, and the extent to which the public believe the scheme as a whole or perhaps certain aspects of the scheme have been a success (or otherwise).

## Evaluation of accident changes

5.110 In evaluating a treatment or scheme the answers to the following questions will usually be required:

- has the scheme been effective?
- if so, how effective has it been?

5.111 The rare and random nature of road accidents can lead to quite large fluctuations in frequencies at a site from year to year, even though there has been no change in the underlying accident rate. This extra variability makes the effect of the treatment more difficult to detect, but a test of statistical significance can be used to determine whether the observed change in accident frequency is likely to have occurred by chance or not.

5.112 The use of control sites has already been discussed. It should be noted, however, that even when sites have been selected that represent good control groups which take account of the environmental influences, there are other confounding factors that need to be considered. These are discussed in later sections below.

## Standard tests of accident changes

5.113 The following tests are those recommended and described in RoSPA,(1995b) which also contains simple worked numerical examples. For practical purposes it is sufficient to assume that the *before* and *after* accidents are drawn from a Normal distribution (see Graphpad Software Inc, 1999).

5.114 This means that we can use the chi-squared test to answer the first question as to whether the remedial action has been effective, ie whether the accident changes at the site were statistically significant. The common way of applying this is described in Section 5.116.However, the size of that change may first be investigated by using the Tanner k test.

### The Tanner k test (magnitude of the change)

5.115 It is possible that although accident levels reduced at a treated site in an *After* period, the general level of accidents is also reducing; the real reduction at the site due to the treatment being *less* than the actual numbers observed (ie overestimating effectiveness). Conversely, if the general level of accidents is increasing, an underestimate of the treatment would be obtained. The Tanner k test can be used to show

how the accident numbers at a site change relative to control data(see Appendix B.3).

### The Chi-Squared test (significance of the change)

5.116 The chi-squared test is traditionally used to determine whether a change in accidents is statistically significant or whether it could have happened by chance. The test makes certain distributional assumptions that may not strictly be appropriate when sites with high accident numbers have been treated (see discussion of the regression-to-mean effect in Section 5.119). Nevertheless it is easy to apply and is a good measure of whether the scheme was effective.

5.117 The test involves comparing data from the treated site with the untreated control sites by calculating the value of the statistic, chi-square, and looking this up in a table with the appropriate degrees of freedom to determine whether it has exceeded the appropriate table value (see Appendix B.4).

### Test for statistical significance between two proportions

5.118 This test tells us whether the difference in the distributions of accident types in the study and control samples are significantly different from each other or if the difference is likely to have occurred by chance (see Appendix B.5). For example, it could be used to determine whether the proportion of accidents in the study area that involve cyclists is greater than expected (ie disproportionately large compared with the proportion of accidents in the control area that involve cyclists).

## Other factors to consider

### Regression to the mean

5.119 This effect, sometimes called bias by selection, complicates evaluations at sites with high accident numbers (blackspot sites) in that these sites have often been chosen following a year with particularly high numbers occurring. In practice their accidents will tend to reduce in the next year even if no treatment is applied. Even if three-year accident totals are considered at the worst accident sites ina n area, it is likely that the accident frequencies were at the high end of the naturally occurring random fluctuations, and in subsequent years these sites will experience lower numbers. This is known as regression-to-the-mean.

5.120 In practice it is believed that the regression-to-the-mean effect can over-state the effect of a treatment by 5 to 30 per cent, chiefly dependent on the length of accident period chosen. Possibly the most straightforward way of allowing for both the regression-to-mean effect and changes in the environment would be to use control sites chosen in exactly the same way as the treated sites, and identified as having similar problems, but *left* untreated. In practice, as stated earlier, it is both difficult to find matched control sites and, if investigated, to justify not treating them.

5.121 There has been much debate among statisticians over many years on this subject and the best way to deal with it (see: Wright and Boyle, 1987; Hauer et al, 1983; Abbess et al, 1981; Maher and Mountain,1988; Kulmala, 1994).

5.122 The effect does, however, tend to be diminished if longer periods of time are selected. For example, in a study in two counties, Abbess et al (1981), calculated that regression-to-mean had the following effects at high accident sites (ie more than eight injury accidents per year), on average, on their accident rate:

**Table 5.2 Empirical regression-to-mean effects on accident rate**

| Regression-to-mean change in annual accident rate | Period of accident data considered |
|---|---|
| 15 to 26 per cent | one year |
| 7 to 15 per cent | two years |
| 5 to 11 per cent | three years |

5.123 It is suggested, therefore, that where the highest accident sites are chosen for treatment, then the above levels of allowance should be made when quoting the actual reduction in accidents that the schemes have produced. The way in which a more accurate estimation can be obtained is rather complex requiring use of data from similar sites to the treated sites but a method described by Abbess et al (1981) is outlined in Appendix B.6.

## Accident migration

5.124 The existence of accident migration is a fairly controversial issue but has been reported to be a real effect (Mountain et al, 1992; Boyle et al, 1984; Persaud, 1987). It is simply that an increase in accidents tends to be observed at sites adjoining a successfully treated site, giving an apparent transfer or migration of accidents. It is unclear precisely why this effect occurs but is hypothesised that drivers are compensating for the improved safety at treated sites by being less cautious elsewhere.

5.125 Obviously to detect such an occurrence, you need to compare the accident frequencies before and after implementation of a scheme and those for the surrounding area with a suitable control group.

5.126 However, research and practical evidence (eg Brindle, 1986; Websterand Mackie, 1996) have demonstrated that local area traffic restraint schemes do not create a significant increase in accidents on surrounding roads. Mountain (1998) has more recently concluded tha ta more likely explanation for any observed increase is a reverse regression-to-mean effect arising due to bias in the selection of the neighbouring sites.

## Behaviour adaptation

5.127 The effect of road users tending to alter their behaviour following introduction of a new safety improvement, is now generally more accepted than the original, more controversial, philosophy of risk compensation or risk homeostasis theory. The latter suggested that road users maintain a fixed level of accepted risk, and so will take more risks when given greater accident protection, for example, by seat belts or anti-lock brakes.

5.128 However, Trimpop and Wilde (1994) concluded that accidents are not necessarily the result of risk-taking desire, but more of an inappropriate action based on faulty risk assessment. The challenge for the road engineer is to introduce schemes that minimise the chances of road users making faulty assessments; for example, in ensuring consistency in road users expectations for the level of road surface friction, super elevation on bends, design of junctions and so forth.

5.129 Grayson (1996) concluded that evidence that adaptive or compensating processes are seriously reducing the effectiveness of safety measures is slender and poses little threat to current road safety practice.

## Economic evaluation

5.130 For every scheme, the evaluation should include an indication of the benefits actually achieved in relation to cost. Even if the scheme has been designed to tackle a very specific target group of accidents, it is normal practice to include all accidents at the site in a full evaluation, in case the measure has had the unforeseen effect of increasing other accident types.

5.131 The previous sections have already outlined how the best estimate of the size of the effect of a scheme (or group of schemes) on accidents can be determined. If the site was one of the worst blackspots in the area, then make some allowance for the regression-to-mean effect.

## First Year Rate of Return (FYRR)

5.132 If the evaluation period (for both *before* and *after* periods) was, say, three years then the saving in accident frequency (per year) should first be calculated. The monetary value of these accidents is then calculated using the current figures (see 3.79 above or DTLR, 2000a). Highway authorities normally then calculate and quote the First Year Rate of Return to give a rough guide to the value of a scheme, ie

**Formula**

$$FYRR = \frac{\text{Value of annual accident savings}}{\text{Cost of scheme*}} \times 100$$

* A more accurate figure would be obtained by including only maintenance costs in this year and also increased journey time costs if this is applicable.

## Net Present Value (NPV)

5.133 In some cases it may be advisable to carry out an evaluation which expresses the difference between costs and benefits that may accrue over several years, eg particularly if the installation covers more than one year or there are known to be inevitable new maintenance costs in future years. This accrual needs to be against a common year price base.

5.134 In the Net Present Value approach there is a need to take account of money having a changing value over time because of the opportunity to earn interest or the cost of paying interest on borrowed capital.

5.135 The major factors affecting present value are the timing of the expenditure and the discount (interest) rate. The higher the discount rate, the lower the present value of an expenditure at a specified time in the future. If the discount rate for highways is 6 per cent, then Â£1 of value this year, if it accrues next year would be valued at 6 per cent less (i.e. 94p, and the following year 88p etc).

5.136 The overall economic effectiveness of a scheme is indicated by the Net Present Value (NPV), which is obtained by subtracting the Present Value of Costs (PVC, which must also be discounted if spread over more than one year) from the Present Value of Benefits (PVB). This technique is described in more detail with examples in COBA (DMRBvol. 13); RoSPA (1995b).

[45] Commonly referred to as PVRs per vehicle records.

[46] When data are binned, only the average values of speed for the vehicles passing within each time period are stored.

[47] Free-flowing vehicles are those where the driver has a clear choice of speed and is not influenced by a vehicle ahead.

[48] The speed at or below which 85 per cent of the vehicles in a speed measurement sample set were travelling.

[49] Automatic individual vehicle speed logging equipment will provide data that (with extra technical effort) could be disaggregated according to headway information to isolate data from free-flowing vehicles.

[50] A distance headway is the gap between the front of one vehicle and the front of the next vehicle at a moment in time. A time headway is the gap in time between the front of one vehicle passing a point and the arrival of the front of the next vehicle at that point.

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Chapter 4. Warning Signs (1986)

Chapter 5. Road Markings (1985)

Chapter 6. Illumination of Signs*

Chapter 7. The Design of Traffic Signs (1997)

Chapter 8. Traffic Safety Measures and Signs for Road Works and Temporary Situations (1991)

* To be published

[Note: Current advice relating to speed limit signs is given in TAL 1/95]

**Traffic Advisory Leaflets**

TAL 10/00: Road humps: discomfort, noise, and ground-borne vibration

TAL 11/00: Village Traffic Calming reducing accidents

TAL 12/00: Urban Street Activity in 20mph Zones Ayres Road Area, Old Trafford

TAL 06/00: Monitoring Walking

TAL 05/00: Traffic Calming Bibliography

TAL 04/00: Cycling Bibliography

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TAL 02/98: Lincoln Historic Core Zone Newport Arch

TAL 01/98: Speed Cushion Schemes

TAL 12/97: Chicane Schemes

TAL 11/97: Cycling to Work

TAL 10/97: Halifax Historic Core Zone

TAL 09/97: Cyclists at Roundabouts: Continental Design Geometry

TAL 08/97: Cycling Bibliography

TAL 07/97: Supply and Demand for Cycle Parking

TAL 05/97: Cycles and Lorries

TAL 04/97: Rising Bollards

TAL 03/97: The MOVA Signal Control System

TAL 02/97: Traffic Calming on Major Roads A49, Craven Arms, Shropshire

TAL 01/97: Cyclists at Road Narrowings

TAL 10/96: Traffic Calming Bibliography

TAL 08/96: Road Humps and Ground-Borne Vibrations

TAL 07/96: Highways (Road Humps) Regulations 1996

TAL 06/96: Traffic Calming Traffic and Vehicle Noise

TAL 05/96: Further Development of Advanced Stop Lines

TAL 04/96: Traffic Management and Emissions

TAL 03/96: Bike and Ride

TAL 02/96: 75mm High Road Humps

TAL 01/96: Traffic Management in Historic Areas

TAL 08/95: Traffic Models for Cycling

TAL 07/95: Traffic Islands for Speed Control

TAL 06/95: Pedestrian Crossing Assessment and Design

TAL 05/95: Parking for Disabled People

TAL 04/95: The SCOOT Urban Traffic Control System

TAL 03/95: Cycle Routes

TAL 02/95: Raised Rib Markings

TAL 01/95: Speed Limit Signs

TAL 11/94: Traffic Calming Regulations (Scotland)

TAL 09/94: Horizontal Deflections

TAL 07/94: Thumps Thermoplastic Road Humps

TAL 04/94: Speed Cushions

TAL 03/94: Fire and Ambulance Services Traffic Calming: A Code of Practice

TAL 02/94: Entry Treatments

TAL 01/94: VISP A Summary

TAL 13/93: Gateways

TAL 12/93: Overrun Areas

TAL 11/93: Rumble Devices

TAL 10/93: Toucan An Unsegregated Crossing for Pedestrians and Cyclists

TAL 09/93: Cycling in Pedestrian Areas

TAL 08/93: Advanced Stop Lines for Cyclists

TAL 07/93: Traffic Calming Regulations

TAL 04/93: Pavement Parking

TAL 03/93: Traffic Calming Special Authorisations

TAL 07/91: 20mph Speed Limit Zones

TAL 05/91: Audible and Tactile Signals at Pelican Crossings

TAL 04/91: Audible and Tactile Signals at Signal Controlled Crossings

TAL 03/91: Speed Control Humps Scotland, England and Wales

TAL 03/90: Urban Safety Management Guidelines from IHT

TAL 02/90: Speed Control Humps (superseded by TAL 07/96).

TAL 09/89: The South-East Cambridge Cycle Route

TAL 08/89: Innovatory Cycle Scheme Manchester Mancunian Way Signalled Cycle Crossing

**Local Transport Notes**

LTN 1/98 The installation of traffic signals and associated equipment

LTN 1/97 Keeping buses moving: A guide to traffic management to assist buses in urban areas

LTN 2/95 The design of pedestrian crossings

LTN 1/95 The assessment of pedestrian crossings

LTN 1/94 The design and use of directional informatory signs

LTN 1/89 Making way for cyclists: Planning, design and legal aspects of providing for cyclists

LTN 2/87 Signs for cycle facilities

LTN 1/87 Getting the right balance: Guidance on vehicle restriction inpedestrian zones

LTN 2/86 Shared use by cyclists and pedestrians

LTN 1/86 Cyclists at road crossings and junctions

LTN 1/83 Signs for cycle facilities

LTN 1/79 Ways of helping cyclists in built up areas

**Departmental Standards and Advice Notes in the Design Manual for Roads and Bridges**

Note that these apply to trunk roads but some of the advice may be appropriate for non-trunk roads. (In particular, consideration should be given to traffic level and mix of road user type.)

**Departmental Advice Notes**

HA 12/81 Management of Contractual Claim (not applicable to Northern Ireland)

HA 13/81 The Planting of Trees and Shrubs (not applicable for use in Scotland, Northern Ireland; Addendum applicable for use in Northern Ireland)

HA 19/82 Engineer/Contractor Relationship on Trunk Road Contracts(not applicable to Northern Ireland)

HA 37/97 Hydraulic Design of Road Edge Surface Water Channels

HA 39/98 Edge of Pavement Details

HA 40/89 Determination of Pipe and Bedding Combinations for Drainage Works

HA 41/90 A Perimeter for Road Drainage Layers

HA 42/94 Road Safety Audits HA 43/91 Geotechnical Considerations and Techniques for Widening Highway Earthworks

HA 43/91 Geotechnical Considerations and Techniques for Widening Highway Earthworks

HA 44/91 Earthworks: Design and Preparation of Contract Documents(paragraph 3-5 is superseded by paragraph 2.22 of SA 3/93(MCHW 0.3.3)) [Incorporating Amendment No. 1 dated April 1995] Scottish Addendum applicable for use in Scotland, Northern Ireland Addendum applicable for use in Northern Ireland

HA 46/92 Quality Assurance for Highway Design

HA 48/93 Maintenance of Highway Earthworks and Drainage

HA 55/92 Landform and Alignment

HA 56/92 Planting, Vegetation and Soils

HA 57/92 Integration with Rural Landscapes

HA 58/92 The Road Corridor [Amendment No. 1 Retaining Walls (Chapter 3)February 1997]

HA 59/92 Nature Conservation [Amendment No.1 Badgers (Chapter 5.3)February 1997]

HA 60/92 Heritage

HA 61/92 Contract and Maintenance Implementation

HA 62/92 Widening Options and Techniques

HA 63/92 Improvement Techniques

HA 65/94 Design Guide for Environmental Barriers

HA 66/95 Environmental Barriers Technical Requirements

HA 67/93 The Wildflower Handbook

HA 68/94 Design Methods for the Reinforcement of Highway Slopes by Reinforced Soil and Soil Nailing Techniques

HA 70/94 Construction of Highway Earthworks

HA 71/95 The Effects of Highway Construction on Flood Plains[Incorporating Amendment No. 1 (August 1998)]

HA 72/94 Use and Limitations of Ground Penetrating Radar for Pavement Assessment

HA 73/95 Site Investigation for Highway Works on Contaminated Land

HA 74/95 Design and Construction of Lime Stabilised Capping

HA 75/95 Trunk Roads and Archaeological Mitigation

HA 78/96 Design of Outfalls for Surface Water Channels

HA 79/97 Edge of Pavement Details for Porous Asphalt Surface Courses

HA 80/99 Nature Conservation Management in Relation to Bats

HA 81/99 Nature Conservation in Relation to Otters

TA 8/80 Carriageway Markings. Markings for Right Turning Movements at Cross Road Junctions Northern Ireland Addendum applicable for use in Northern Ireland

TA 11/81 Traffic Surveys by Roadside Interview (Clauses 6.1, 6.2, 6.5 and Figures 1 to 5 are superseded by Ch. 8 of TSM) Scottish Addendum applicable for use in Scotland, Northern Ireland Addendum applicable for use in Northern Ireland

TA 12/81 Traffic Signals on High Speed Roads Northern Ireland Addendum applicable for use in Northern Ireland

TA 19/81 Reflectorisation of Traffic Signs (Clauses 7.6 and 7.7 are superseded by Ch.8 of TSM) Scottish Addendum applicable for use in Scotland, Northern Ireland Addendum applicable for use in Northern Ireland

TA 22/81 Vehicle Speed Measurement on All Purpose Roads

TA 23/81 Junctions and Accesses: Determination of Size of Roundabouts and Major/Minor Junctions Scottish Addendum applicable for use in Scotland

TA 30/82 Choice between Options for Trunk Road Schemes Scottish Addendum applicable for use in Scotland

TA 44/92 Capacities, Queues, Delays and Accidents at Road Junctions Computer Programs ARCADY/3 and PICADY/3 (TRRL)

TA 45/85 Treatment of Gaps in Central Reserve Safety Fences

TA 46/97 Traffic Flow Ranges for Use in the Assessment of New Rural Road Standards

TA 48/92 Layout of Grade Separated Junctions

TA 49/86 Appraisal of New and Replacement Lighting on Trunk Roads and Trunk Road Motorways [and Amendment No 3 dated July 1990]Scottish Addendum applicable for use in Scotland

TA 56/87 Hazardous Cattle Crossings: Use of Flashing Amber Lamps Northern Ireland Addendum applicable for use in Northern Ireland

TA 57/87 Roadside Features [Chapter 2 is superseded by TA 69/96] Scottish Addendum applicable for use in Scotland, Northern Ireland Addendum applicable for use in Northern Ireland

TA 58/92 Traffic Signs and Road Markings for Lane Gains and Lane Drops on All Purpose Dual Carriageway and Motorway Trunk Roads

TA 60/90 The Use of Variable Message Signs on All Purpose and Motorway Trunk Roads Northern Ireland Addendum applicable for use in Northern Ireland

TA 61/94 Currency of the Traffic Signs Manual

TA 63/97 Convoy Working

TA 64/94 Narrow Lane and Tidal Flow Operations at Road Works on Motorways and Dual Carriage Trunk Roads with Full Width hard Shoulders

TA 66/95 Police Observation Platforms on Motorways

TA 67/95 Providing for Cyclists

TA 68/96 The Assessment and Design of Pedestrian Crossings

TA 69/96 The Location and Layout of Lay-bys

* TA 70/97 Motorway. Introduction

* TA 71/97 Motorways. Overview

* TA 72/97 National Motorway Communication Systems (NMCS)

* TA 73/97 Motorway Emergency Telephones

* TA 74/97 Motorway Signalling

* TA 75/97 Motorway Transmission Design

* TA 76/97 Motorway Control Offices

* TA 77/97 Motorways

TA 78/97 Design of Road Markings at Roundabouts

TA 79/99 Traffic Capacity of Urban Roads [Amendment No. 1 (May 1999)]

TA 80/99 Surface Drainage of Wide Carriageways

TA 81/99 Coloured Surfacing on Urban Roads

TA 82/99 The Installation of Traffic Signals and Associated Equipment

* TA 70/97 now include Annex A which is specific to England and Annex C, to TA 77/97 which is specific to Wales.

**Departmental Standards**

HD 19/94 Road Safety Audits

HD 20/92 Loop Detectors for Motorways

HD 22/92 Ground Investigation and Earthworks Procedure for Geotechnical Certification [Incorporating Amendment No. 1 dated June 1993 and Amendment No. 2 April 1994]

HD 23/99 General Information

HD 24/96 Traffic Assessment

HD 25/94 Foundations

HD 26/94 Pavement Design [Amendment No. 1 (March 1995, Amendment No. 2 ( February 1996) and Amendment No. 3 (February 1998)]

HD 27/94 Pavement Construction Methods [Amendment No. 1 (March1995) and Amendment No.2 (February 1999)]

HD 28/94 Skidding Resistance [Amendment No. 1 (February 1999)]

HD 29/94 Structural Assessment Methods [Amendment No. 1 (November1996) and Amendment No.2 (May 1999)]

HD 30/99 Structural Assessment of Road Pavements

HD 31/94 Maintenance of Bituminous Roads [Amendment No. 1 (March1995) and Amendment No. 2 (February 1998)]

HD 32/94 Maintenance of Concrete Roads

HD 33/96 Surface and Sub-surface Drainage System for Highways

HD 34/93 Implementation and Use of the Quality Control Reporting System

HD 35/95 Technical Information

HD 36/99 Surfacing Material for New and Maintenance Construction

HD 37/99 Bituminous Surfacing Materials and Techniques [Amendment No.1 (May 1999)]

HD 38/97 Concrete Surfacing and Materials [Amendment No.1 (May 1999)]

TD 6/79 Transverse yellow bar markings at roundabouts

TD 7/80 Type Approval of Traffic Control Equipment (not applicable to Northern Ireland)

TD 9/93 Highway Link Design

TD 11/82 Use of Certain Departmental Standards in the Design and Assessment of Trunk Road Schemes Scottish Addendum applicable for use in Scotland

TD 16/93 Geometric Design of Roundabouts

TD 17/85 Criteria for the Provision of Closed Circuit Television on Motorways Northern Ireland Addendum applicable for use in Northern Ireland

TD 18/85 Criteria for the Use of Gantries for Traffic Signs and Matrix Traffic Signals on Trunk Roads and Trunk Road Motorways. Scottish Addendum applicable for use in Scotland, Northern Ireland Addendum applicable for use in Northern Ireland

TD 19/85 Safety Fences and Barriers [Amendment No. 1 dated 11/86]Scottish Addendum applicable for use in Scotland

TD 22/92 Layout of Grade Separated Junctions

TD 23/86 Trunk Roads and Trunk Road Motorways: Inspection and Maintenance of Road Lighting Scottish Addendum applicable for use in Scotland

TD 24/97 All Purpose Trunk Roads: Maintenance of Traffic Signals

TD 25/86 Trunk Roads and Trunk Road Motorways: Maintenance of Traffic Signs Scottish Addendum applicable for use in Scotland, Northern Ireland Addendum applicable for use in Northern Ireland

TD 26/86 Trunk Roads and Trunk Road Motorways: Maintenance of Road Markings Northern Ireland Addendum applicable for use in Northern Ireland

TD 27/96 Cross Sections and Headrooms [This document supersedes TD27/86 and SH 2/92]

TD 30/87 Design of Road Lighting for All Purpose Trunk Roads Scottish Addendum applicable for use in Scotland, Northern Ireland Addendum applicable for use in Northern Ireland

TD 32/93 Wire Rope Safety Fence

TD 33/90 The Use of Variable Message Signs on All Purpose and Motorway Trunk Roads Northern Ireland Addendum applicable for use in Northern Ireland

TD 34/91 Design of Road Lighting for Motorway Trunk Roads Scottish Addendum applicable for use in Scotland, Northern Ireland Addendum applicable for use in Northern Ireland

TD 35/91 All Purpose Trunk Roads MOVA System of Traffic Control at Signals

TD 36/93 Subways for Pedestrians and Pedal Cyclists. Layout and Dimensions

TD 37/93 Scheme Assessment Reporting

TD 39/94 The Design of Major Interchanges

TD 40/94 Layout of Compact Grade Separated Junctions

TD 41/95 Vehicular Access to All Purpose Trunk Roads

TD 42/95 Geometric Design of Major/Minor Priority Junctions

TD 45/94 Motorway Incident Detection and Automatic Signalling (MIDAS)

TD 46/94 Motorway Signalling

TD 49/97 Mobile Lane Closures Supersedes those of Chapter 8, Topic 6 that deal with Mobile Lane Closures

TD 50/99 The Geometric Design of Signal Controlled Junctions

**Departmental SH Standards for use in Scotland only**

SH 6/73 Criteria for Traffic Light Signals at Junctions

SH 5/77 Implementation of Bus Priorities

SH 7/83 Specification for Road and Bridge Works: Soil Suitability for Earthworking Use of the Moisture Condition Apparatus [and Amendment No 1 dated February 1989]

SH 3/84 Model Contract Document for Topographical Surveys

SH 4/86 Scottish Routine Maintenance Management System

SH 5/88 Damage to Bridges by Road Vehicles Traffic Signs at Bridges

SH 4/89 Geotechnical Certification Procedures: Trunk Road Ground Conditions [and Amendment No 1 dated March 1990]

SH 5/89 Topographical Surveys: Certification Procedures [and Amendment No 1 dated November 1989]

SH 1/97 The Traffic and Economic Assessment of Road Schemes in Scotland

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# 7. Abbreviations

| | |
|---|---|
| AA | Automobile Association |
| AIP | Accident investigation and prevention |
| ARCADY | TRL software aid to design roundabout junctions |
| BITER | British Institute of Traffic Education and Research |
| CAPT | Child Accident Prevention Trust |
| CCTV | Closed circuit television |
| CPRE | Council for the Protection of Rural England |
| CSS | County Surveyors Society |
| DTLR | Department for the Environment, Transport and the Regions |
| DoE NI | Department of the Environment for Northern Ireland |
| DMRB | Design Manual for Roads and Bridges |
| 85th percentile | The speed at or below which 85 per cent of the vehicles in aspeed speed measurement sample set were travelling |

| | |
|---|---|
| ETP | Education, training and publicity |
| FYRR | First Year Rate of Return |
| GB | Great Britain |
| GIS | Geographical information system |
| HA | Highways Agency |
| HGV | Heavy goods vehicle |
| HMSO | Her Majesty's Stationery Office (now TSO) |
| HSE | Health and Safety Executive |
| ICE | Institute of Civil Engineers |
| IHT | Institution of Highways and Transportation |
| IRSO | Institute of Road Safety Officers |
| KSI (casualty) | Killed and seriously injured casualties in road accidents |
| KSI (accident) | Accidents in which at least one casualty was killed or seriously injured |
| LAA | Local Authority Association |
| LGV | Light goods vehicle |
| LHA | Local highway authority |
| LTN | Local Transport Note |
| LTP | Local Transport Plans |
| MCAP | Medical Commission for Accident Prevention |
| MOLASSES | Monitoring Local Authority Safety Schemes A database managed by TRL Limited storing information about local and trunk road safety schemes which can be interrogated to ascertain the overall effectiveness of specific engineering measures. (See also the web site www.trl.co.uk/molasses) |
| MOVA | Microprocessor optimised vehicle actuation |
| NATA | New Approach To Appraisal |
| NPV | Net Present Value |
| NVQ | National Vocational Qualification |
| OSCADY | TRL software aid for designing signalised junctions |

| | |
|---|---|
| PIA | Personal injury accident |
| PICADY | TRL software aid for designing priority junctions |
| PSV | Public service vehicle |
| PTRC | Planning, transportation, research and computation |
| PVR | Per vehicle record used to describe the type of automatic equipment that can measure speeds of all individual vehicles |
| RAGB | Road Accidents in Great Britain |
| RoSPA | Royal Society for the Prevention of Accidents |
| RSE | Road safety engineer |
| RSO | Road safety officer |
| RSR | Road safety research |
| RTRA | Road Traffic Reduction Act |
| SafeNET | TRL software used to estimate the frequency of accidents on a network (when traffic and pedestrian flow and geometric information are provided) |
| SCOOT | Split cycle offset optimisation technique |
| SO | Scottish Office |
| STATS19 | Database of standardised accident reports (using theSTATS19 report form) sent to the Department of the Environment, Transport and the Regions by all police forces in Great Britain |
| STATS20 | Document with instructions for the completion of STATS19 road accident reports |
| TAL | Traffic Advisory Leaflet |
| TPP | Transport Policies and Programme |
| TRANSYT | Traffic Network Study Tool |
| TRL | Transport Research Laboratory (now TRL Limited) |
| TSM | Traffic Signs Manual (Chapters 1-8) |
| TSO | The Stationery Office |
| TSRGD | Traffic Signs Regulations and General Directions (see Bibliography HMSO,1994c) |
| TWMV | Two-wheeler motorised vehicles |
| UK | United Kingdom |
| USM | Urban Safety Management |

| | |
|---|---|
| UTC | Urban traffic control system |
| VISP | Village speed control project (see references) |
| WO | Welsh Office |

# 8. Feedback

We expect to review and update this guide. If you would like to make any suggestions or can offer any further site examples, please e-mail Miss C Britt:Caroline.Britt@dft.gsi.gov.uk, in the first instance, by 31 December 2001.We will consider all feedback in preparing the next update.

# Appendix A

**Road accident countermeasures**

**A.1 Anti-skid/high-friction surfacings**
High-friction surfacings: suburban
High-friction surfacings: urban

**A.2 Bus stops and bus lanes**
Mixed priority route: use of bus boarders
Bus route: coloured bus lanes and staggered bus bays

**A.3 Red light cameras**
Red light cameras: urban locations

**A.4 Speed cameras**
Speed cameras: various urban locations
Speed camera: suburban

**A.5 Chevron markings**
Chevrons: motorway

**A.6 Chicanes/narrowings**
Chicanes: residential estate
Chicanes: major road traffic calming

**A.7 Coloured road surfacing**
Coloured road surfacing: used outside a school
Coloured road surfacing: and cycle lanes

**A.8 Cycling facilities**
Cycle track at roundabout: use of coloured road surfacing
Annular cycle track at multiple roundabout

**A.9 Gateways**
Gateways: rural village
Gateways and other treatments: rural village

**A.10 Pedestrian crossings**
Pedestrian crossings
Traffic calming: raised zebras, humps, mini roundabouts

**A.11 Refuges/traffic islands**
Pedestrian refuge: principal radial route

**A.12 Road humps and raised junctions**
Road humps: residential road

**A.13 Road restraint systems**
Safety barriers: rural dual carriageway

**A.14 Rising bollards**
Road closure using a rising bollard

**A.15 Roundabouts and mini-roundabouts**
Mini roundabouts: residential
Mini roundabout: semi-rural

**A.16 Roundel road markings**

**A.17 Rumble devices**

**A.18 Safe routes to school**
School zone

**A.19 Segregation**
Segregation: urban town centre

**A.20 Signs and markings**
Road marking: with other measures - on principal road

**A.21 Speed cushions**
Cushions and humps in 20mph zone: Residential estate
Speed cushions: residential distributor road
Speed cushions: shopping street

**A.22 Speed limits**
Speed limit change: rural village

**A.23 20mph zones**
20mph zones: residential estate

**A.24 Traffic signals**
Traffic signals: rural T-junction

# Appendix B

Statistical Tests