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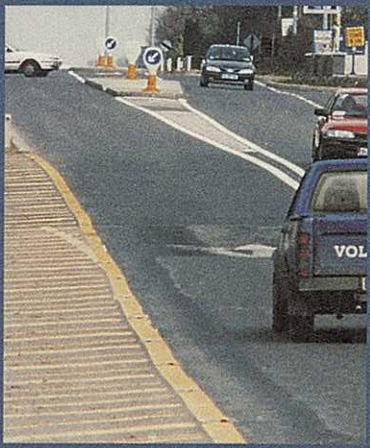
A Guide to Road Safety Engineering in Ireland



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Note: This document is a copy of the original content of A Guide to Road Safety Engineering in Ireland, published in 1996, which is no longer in print.

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About this guide

Each year approximately 400 people are killed and 10,000 people injured on Irish roads. This guide sets out to explain how road accidents happen, and how they can be studied and analysed with a view to designing and implementing measures to improve safety on the roads in Ireland. The guide is intended for use mainly by engineers, technicians and draughtsmen working in local authorities.

The main purpose of this guide is to explain how road accidents can be reduced by introducing low-cost road engineering measures (in most cases this refers to measures costing up to £20,000 in 1995). The guide takes a "data led" approach to defining accident problems by concentrating on the study of accident reports rather than examining the road network purely from a design viewpoint.

The guide explores engineering approaches to both accident reduction and accident prevention. The approaches to accident reduction are based on ways of intervening in situations where accidents are known to have been occurring over a number of years. Accident prevention is more likely to be related to new roads or improvement schemes where there are potential risks associated with their design or construction.

The content of each chapter is summarised below.

Chapter 1 – Introduction
This chapter describes the scale of the road accident problem in Ireland, outlines the responsibilities for road safety engineering, and looks at the range of information including research currently available on the subject in Ireland and elsewhere.

Chapter 2 - How road accidents happen
This chapter defines road accidents, and explains how they are caused.

Chapter 3 - Road accident data and costs
This chapter explains how accident data is collected, stored and retrieved. This is illustrated with an example showing how information related to one accident passes through the system. The cost of road accidents is also discussed.

Chapter 4 - Planning a road safety strategy
This chapter describes how local authorities can plan to reduce road accidents. The principles behind the production of a Road Safety Plan are discussed. Objectives and resources for introducing accident reduction measures and methods of monitoring are described.

Chapter 5 - Single site road safety problems
This chapter concentrates on road accident problems specific to one location. It explains how accidents are analysed and how additional information can be obtained from site visits and traffic surveys. The definition of road safety problems is explained, together with a description of how accidents costs are determined.

Options for treatment are explained, with some practical help in overcoming defined problems in both rural and urban areas. A simple method for arriving a accident savings and economic benefits is described.

All of these processes are illustrated with reference to a case study.

Chapter 6 - Road safety problems along routes
This chapter describes how road accident problems along routes can be identified, analysed and treated. The format is the same as in Chapter 5, and again the processes are illustrated by the use of a case study.

Chapter 7 - Mass action methods of treating road safety problems
This chapter describes how accident problems at junctions and along routes can be tackled using the mass action approach. It explains how sites and routes with similar accident types can be grouped together and a single treatment applied. The format is similar to that used in Chapter 5 and a case study illustrates the use of mass action methods.

Chapter 8 - Area-wide road safety problems
This chapter describes how road accident problems can be treated on an area-wide basis. In this context, an area is defined as a number of minor roads lying between major roads or natural features. The area-wide approach is generally more applicable to urban areas, where this method has been applied successfully in a number of European countries. Again the format is the same as in Chapter 5, with a case study to illustrate the area-wide approach.

Chapter 9 - Road accident prevention
This chapter outlines how future road accident problems can be avoided by applying a safety checking procedure to new roads. The issue of locations with perceived rather than measured safety problems is discussed.

Appendices 1 - 4
The appendices contain information on scheme ranking and statistical tests and an explanation of more rigorous economic evaluation methods.

Glossary
The glossary provides a definition of terms used in the guide.

How to use this guide

By working through the whole of this guide, an engineer should understand the basics of road safety engineering and be able to contribute to improving safety on the roads.

In order to be able to analyse in detail and treat a particular accident problem the engineer will need to decide whether the problem is confined to a single site (Chapter 5) or is part of a route (Chapter 6) or is an area problem (Chapter 8) and should consult the appropriate chapter. It may be that the problem can be treated on a mass action basis in which case the relevant information is found in Chapter 7. These four chapters have been written in such a way as to be self-contained, and an engineer need only refer to one chapter for each particular type of problem. Part of the methodology for each approach is the same and consequently some text is repeated in each of these chapters.

If an engineer is looking at a site where no accidents have occurred or at the design of a new road or an improvement to an existing road, then Chapter 9 gives information on these topics.

The Appendix 1- 4 gives more information on statistical tests and economic evaluations.

The Glossary of Terms will help to explain the definitions of most of the terms used within the guide.

Reference numbers appear in the text (e.g. (1)) and within the tables at the end of Chapters 5, 6, 7 and 8. A detailed list of references is given at the end of the document.

How this guide was funded

The production of this guide has been funded through the Technical Assistance Programme (TAP) for the Operational Programme for Transport 1994/1999.

Status of this guide

This guide is intended to describe ways in which road accidents can be reduced using low-cost road engineering measures. Local authorities are encouraged to adopt the methods described within the guide. However, responsibility for the investigation of road accidents and the subsequent application of measures rests with the local authority. The suggested remedial measures within this guide should not be deemed as either the formal or only answers to any particular situation or set of circumstances. Any measures suggested in this guide need to be considered and applied with due care and forethought and should not be relied upon in isolation from other sources of advice and information.

Acknowledgements

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Members of the Steering Group were:
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John O'Flynn- County Engineer, Waterford
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Tony O'Connell - ·Department of the Environment
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Case study material and examples of remedial measures implemented have been provided by Finbarr Crowley and the relevant local authorities. The case study information has been taken on good faith and is in part illustrative.

1. Introduction

1.1. The scale of the road accident problem in Ireland

In a typical year, in excess of 400 people are killed and 10,000 injured in more than 6,000 road accidents in Ireland (1). In addition, 16,000 material damage accidents are recorded annually by the Gardaí. These accidents are estimated to cost some £600 million (at 1995 costs).

Road Accident Facts Ireland (RAF) is published annually by the National Roads Authority (NRA), and provides a comprehensive source of national statistics on road accidents. Some of the information from Road Accident Facts Ireland is summarised in Table 1.1 ,Figure 1.1**.** and Figure 1.2.

Casualty Class	Injuries (%)	Fatalities (%)
Pedestrians	13.4	31.5
Pedal Cyclists	7.1	5.6
Motor Cyclists	8.9	12.3
Car Users	61.3	43.4
Other Road Users	9.3	7.2
Total	**100.0**	**100.0**

Table 1.1Casualty percentages for each road user

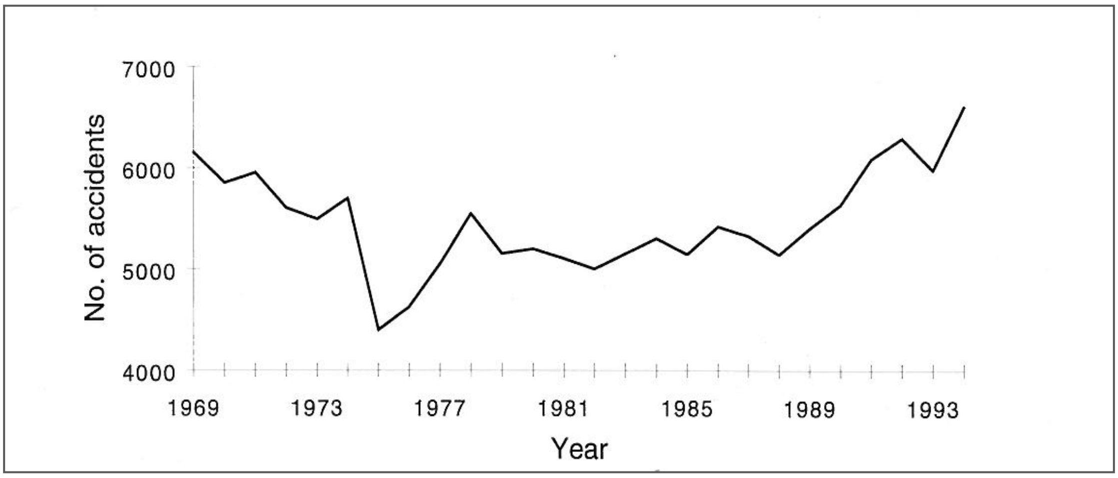


Figure 1.1Fatal and injury accident trends in Ireland between 1969 and 1994

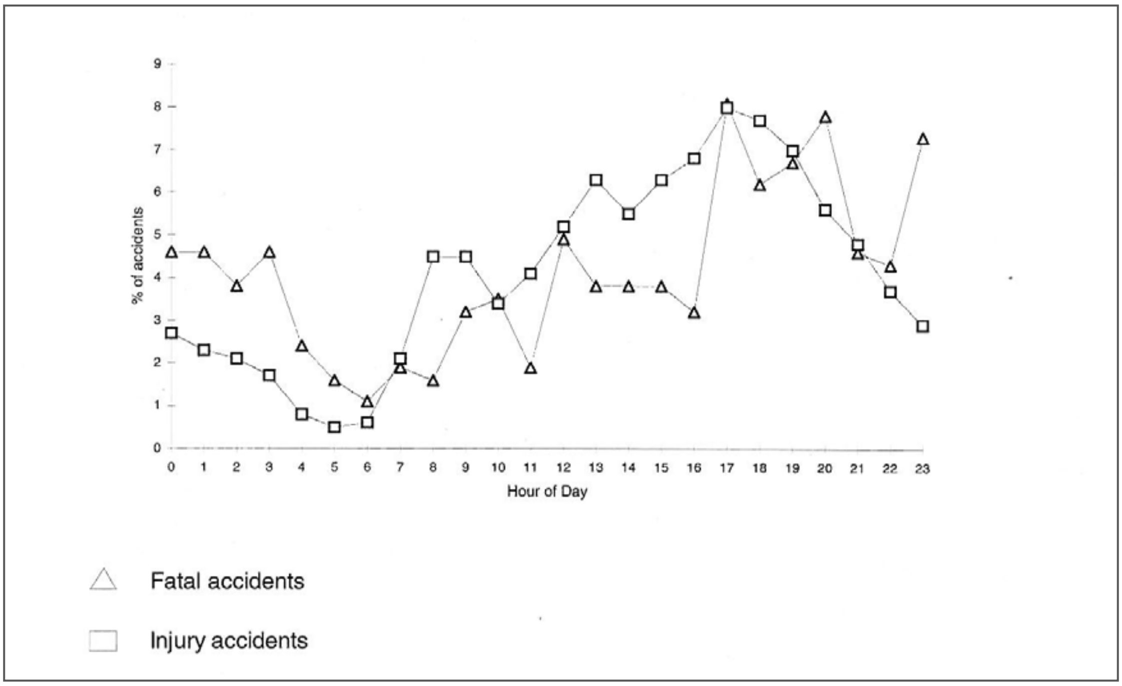


Figure 1.2 Percentage of fatal and injury accidents by time of day

Figure 1.2 shows the percentage of fatal and injury accidents by time of day. Just over one third (35%) of all accidents occurred during the hours of darkness.

Almost half (44%) of all fatal and injury accidents took place outside built-up areas, including 64% of all fatal accidents. Almost one third (29%) of all accidents, and 40% of all fatal accidents occurred on the National Routes.

1.2. Responsibilities for safety engineering in Ireland

Overall responsibility for road safety lies with the Department of the Environment. An Garda Siochana are responsible for traffic law enforcement, and the National Safety Council (NSC) for road safety education and publicity. Larger local authorities employ full time Road Safety Officers and smaller authorities part time officers.

The National Roads Authority has two distinct functions in respect of road safety. First, the Authority funds maintenance and improvement schemes on the National Routes. Secondly, the Authority is responsible for all information, advisory and research services in the field of road safety, and in respect of all roads. Some of these services, particularly those in the field of safety engineering, are described in 1.3 (a) below.

Local authorities generally undertake work on National Routes on behalf of the NRA. Local authorities are responsible for all other roads, and the enormous amount of work undertaken on the network has a significant impact on road safety.

1.3. Information and research

a) Ireland

The traffic accident report forms (C(T)68) as filled out by An Garda Siochana for all reported accidents are processed by the National Roads Authority and stored at their headquarters in Dublin. The NRA transfers the details of each accident onto a computer database and sends a photocopy of the C(T)68 form to the relevant local authority. The database is used to compile Road Accident Facts in addition to "High Accident Location" reports (2) and overlays describing accident rates and location on the National Roads.

The National Roads Authority is responsible for research, information and advisory services on all aspects of road safety. Staff from the NRA keep in touch with developments in road safety in other European countries.

In addition, some research work on road safety is carried out in Irish Universities, for example in the Department of Psychology of Trinity College and in the Faculty of Engineering at University College Cork.

The County and City Engineers' Association, in co-operation with local authorities, the Department of the Environment and the National Roads Authority, produce guidelines on various aspects of road design and construction many of which have an impact on road safety.

b) Great Britain

Information on road accidents in Britain is held by local authorities and by the Department of Transport (DoT). The DoT uses the accident data to produce Road Accidents Great Britain (3) on an annual basis, and to monitor nationally how accident patterns are changing. Local authorities use the data to prepare Road Safety Plans, to produce annual statistics and to examine accident problem locations.

Much of the research work in Britain is carried out by the Transport Research Laboratory (TRL) under contract to the DoT. The TRL regularly publish their results in the form of reports.

The Royal Society for the Prevention of Accidents (RoSPA) is active in organising road safety engineering training and providing road safety publicity material. The British Institute for Traffic Education and Research (BITER) also organise road safety training and undertake research work.

Many British universities have programmes of research into road safety matters. This research includes vehicle safety and road user behaviour as well as the road engineering element. The Universities of Newcastle, Leeds, Southampton and University College London are particularly active in this type of research.

The AA Foundation for Road Safety Research has a well established record in sponsoring research into road safety at universities and local authorities.

The professional bodies sometimes undertake research into road safety issues, although they generally produce reports related to "good practice" rather than original research. The Institution of Highways and Transportation is particularly active, producing guidelines on Accident Reduction and Prevention (4), Safety Audit (5) and Urban Safety Management (6).

Local authorities themselves undertake research into accidents within their areas. The local authorities' associations often co-ordinate work through the County Surveyors' Society to produce guidelines on current practice. The local authority associations all contributed to the Road Safety Code of Good Practice published in 1989 (7).

Research findings are often reported in the technical press, notably the monthly publication Traffic Engineering and Control.

c) Northern Ireland
Information on road accidents in Northern Ireland is held by the Department of the Environment (DoE). The Royal Ulster Constabulary collect the accident data and produce a summary in their Road Traffic Accident Statistics publication on an annual basis (8).

d) Europe
Several European countries undertake research into road safety issues. In recent years there has been co-operation between countries through the Drive project and other EU initiatives including the Forum of European Road Safety Research Institutes (FERSI). The European Road Safety Federation (ERSF) publishes a regular newsletter on road safety issues.

In the Netherlands, the SWOV (Stichting Wetenschappelijk Onderzoek Verkeersveiligheid) Institute for Road Safety Research performs a similar function to the TRL in the UK. Research papers are often printed in English.

In France this role is carried out by an organisation known as INRETS (lnstitut Nationale de Recherche sure les Transports et les Securites).

The Scandinavian countries also carry out considerable research into road safety. In Sweden, the Swedish Road and Transport Research Institute (VTI) co-ordinate some of this work and in the Nordic countries they produce an English language road safety magazine.

Many universities throughout Europe have research programmes into road safety. As in the UK, research is carried out into vehicle safety and road user behaviour as well as the effects of road design and layout.

e) Other countries
In the USA, safety work is carried out both at national and state levels. On a national level, the Federal Highways Administration (FHA) and the Transportation Research Bureau (TRB) are particularly active.

Both Australia and New Zealand have made significant contributions to the understanding of road safety problems. In Australia the states of Victoria and New South Wales are particularly active, while in New Zealand activity is co-ordinated by Transit New Zealand and the Land Transport Safety Authority.

1.4. Implications of accident investigation work

There is an argument that, if a local authority investigates a location with an accident record and finds that there was a common road factor related to the accidents then any subsequent change to the road will be an "admission of guilt" by that local authority. However, it could equally be argued that the local authority would be negligent if it failed to act in these circumstances and an additional accident of a similar type occurred in the future.

Furthermore, the "ideal" solution to an accident problem may not be feasible or cost effective within a particular countermeasures programme.

For example, at a junction between a minor road and a National Route there have been 5 injury accidents in a 3 year period involving vehicles turning right into the side road being hit in the rear by following traffic when the road was wet. Here the "ideal" solution would be to prohibit the right turn as this would remove the conflict, but this would be unacceptable to local drivers and very difficult to enforce. An alternative would be to construct a roundabout, but this would be very expensive, would involve land acquisition and would introduce delays to main road traffic. The low-cost solution might be to improve advance signing to make the junction more conspicuous and to introduce anti-skid surfacing to reduce braking distances in the wet. Figure 1.3 shows an example of the use of anti-skid surfacing in advance of a junction.

In this example, the local authority is not admitting any liability for the accidents that have occurred since in the time there were 5 accidents, perhaps 3 million vehicles have turned right without having an accident. However, the local authority is acknowledging that for a small expenditure the likelihood of accidents occurring in the future is reduced.

Figure 1.3 Anti-skid surfacing in advance of a junction

2. How road accidents happen

2.1. Definition of a road traffic accident

It is possible to define a road traffic accident in two ways.

The first definition clarifies exactly what is meant by a road accident within the context of this guide:

"A road traffic accident is an accident resulting in personal injury, which involves one or more vehicles, occurs on a public road, and is reported to and recorded by the Gardaí."

This guide concentrates on injury accidents because the reporting level of material damage accidents is variable and the information recorded is minimal. This point is discussed further in Chapter 3.

The second definition of a road accident relates to their complex nature:

"A road accident is a rare, random, multi-factor event preceded by a situation in which one or more road users have failed to cope with their environment" (9)

2.1.1. Road accidents as rare events

Despite there being more than 6,000 road accidents involving personal injury or death in Ireland each year, road accidents are comparatively rare events both in terms of their occurrence on the road network and in terms of an individual person's experience of them.

For example, at a particular junction there have been 6 injury accidents in a 3 year period. Approximately 7,000 vehicles per day pass through the junction, and more than 7.5 million vehicles will have passed through the junction in the three year period. This represents one injury accident for every 1.25 million vehicle movements through the junction.

In terms of an everyday occurrence, injury accidents are rare to individual road users. However, on average, one in six drivers would expect to be involved in one accident involving injury in a driving life of around 40 years or 640,000 km. The risks of being involved in non-injury accidents are much greater. In addition, road users are at risk as passengers, cyclists and pedestrians. The fact that each road user can expect to be involved in a road accident during their life puts more emphasis on reducing this level of risk.

2.1.2. Road accidents as random events

Road accidents can be considered as random in both time and location. This randomness is based on the premise that each individual accident has the same statistical chance of occurring at any time and at any point on a road network. In other words, it is impossible to predict accurately where or when the next road accident will occur.

From a statistical point of view, road accidents are considered to be true “random” events. However, certain situations do arise in which road accidents occur more frequently than expected, or where accidents cluster closely together at a location. These situations are often associated with varying levels of risk.

The assumption that road accidents are randomly occurring events is used in the statistical techniques associated with accident investigation. These statistical tests can be used to show whether a particular group of accidents is a significant departure from the general trend. Statistical tests are explained in more detail in Appendix 2.

Figure 2.1 describes a situation where there is a clear indication that the level of risk that underlies the distribution has changed. A real change in accident occurrence has occurred in 1988 and a new long-term average has been established. This change could be due to a change in traffic levels, or a change in the nature of the road itself.

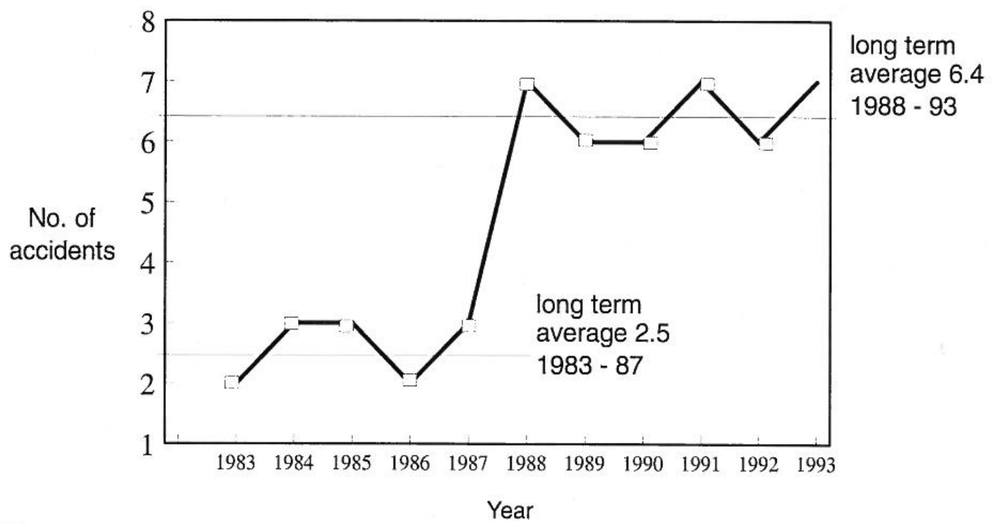


Figure 2.1 Situation where the level of risk that underlies the distribution has changed

A change in accident frequency over time can be used to detect an unusual factor at a site. Considering accidents over time is also the basis for the "before and after" evaluation of the effect of a remedial measure at a site. "Before and after" studies are explained in more detail in Chapters 5 to 8.

2.2. Accident causation

This section looks at the many different factors that can contribute to how, when and where accidents happen.

2.2.1. Road accidents as multi-factor events

It is an over-simplification to state that one "thing" or "person" has been the sole cause of a road accident. The "cause" of an accident is normally a combination of factors identified in the circumstances leading up to the accident.

Each set of accident causation circumstances is unique and therefore every accident is a unique event. In broad terms, the factors found in each set of circumstances fall into three categories:

- Road and environmental factors
- Vehicle factors
- Human factors

These factors often combine together and result in a road accident.

Road and environment factors
Problems in the road and the environment can contribute to road accidents. It may be that the signs or road markings do not make the road layout clear to drivers or pedestrians, or that the road alignment itself is giving the wrong message to drivers. Figure 2.2 shows an example of a roundabout which is not clearly visible from the approach but where the road beyond the roundabout is clearly visible. This leads to the possibility of overshoot accidents taking place. In order to improve the situation, it may be necessary to block off the view ahead by planting mature trees within the verge as part of a package of measures.

Figure 2.2 Example of a roundabout which is not clearly visible from the approach

Vehicle factors
The most common vehicle factors which contribute to road accidents are those involving lack of regular maintenance by the user of the vehicle. Defective tyres and brakes feature most frequently.

Human factors
Studies have been carried out to determine the level of human factor involvement in road accidents. The studies have all shown that the human factor is by far the most dominant feature in road accidents and it is generally accepted that there is some human factor in play in about 95% of all accidents (10) (11).

The level of "blame" that can be attached to a road user involved in an accident can vary from a moment's hesitation or lack of concentration through to criminal behaviour.

A recent study at Leeds University showed considerable evidence of both human and environmental factors combining in accident causation. It is possible to influence human behaviour by engineering means. For example, a driver's perception of a bend can be highlighted by the use of road signs and the driver will reduce speed accordingly. Figure 2.3 gives an example of this.

Figure 2.3

Work carried out at University College Cork in 1994 suggests that in Ireland driver/rider factors are the most important contributors to the cause of road accidents followed by road condition factors (12). This is true for both urban and rural situations and for all casualty types.

2.2.2. Road accidents as "chains of events"

A road accident can be seen as the culmination of a "chain of events" with the road, vehicle and human factors referred to above forming the links in the chain. Each "chain of events" is unique to a particular accident. Figure 2.4 illustrates this concept.

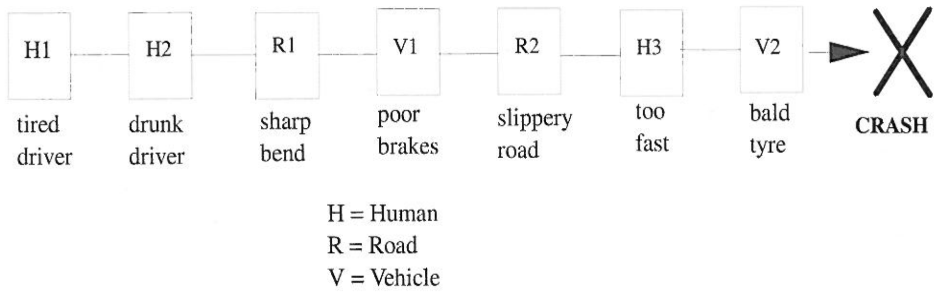


Figure 2.4 Chain of events for an accident

2.3. Principles of road accident analysis

When considering a group of accidents at a particular location as a series of events in time, it must be remembered that each accident is unique and has a unique "chain of events". The essence of road accident analysis is to identify similarities between accidents and to establish factors common to a number of the accidents so that the “chain” can be broken. If the common factors relate to the road itself, then measures can be applied to the road which will reduce the likelihood of similar accidents occurring in the future.

In order to identify the common factors in a group of accidents, each accident needs to be studied in some depth. It will always be necessary to examine the site where the accidents took place, and it will often be necessary to collect additional information such as traffic flows or speeds.

Road accident problems can be tackled on a single site, a route or an area-wide basis. The ways in which these problems are investigated and treated are set out in Chapters 5, 6 and 8. A group of single sites (or routes) displaying similar accident problems can be looked at together and treated on a "mass action" basis- this method is discussed in Chapter 7.

Chapter 9 looks at safety checking and examines some general road safety principles.

An overview of the scale of the road accident problem in Ireland together with an analysis of accident causation and potential strategies for countermeasures has been carried out by the NRA (13). The low cost site-specific measures are identified as having the greatest potential economic benefits.

2.4. Summary

- Road accidents can be described as "rare, random, multi-factor events".
- An accident can be seen as a "chain of events", the three main contributory factors being the road environment, the vehicle and the road user.
- The principle of road accident analysis is to identify and remove highway factors leading to road accident causation.

3. Road accident data and costs

It is essential that any organisation with an interest in road accident reduction should obtain an overview of the accident problems and patterns. This overview will form the basis for comparisons between individual problem situations and expected levels. In addition to looking at an overview of accident problems, it is essential to have good quality data relating to individual accidents.

In order to help assess the scale of the problem, road accidents can be ascribed an economic cost. This cost can be used to illustrate the overall scale of the problem in economic terms, and to justify the implementation of road safety schemes.

3.1. Road accident data in Ireland

Before any attempts can be made to reduce road accidents it is essential that the quality of the data relating to the accidents is of a high standard.

In Ireland it is An Garda Siochana who collects the basic data for road accidents involving personal injury. They also record a limited amount of data for some material damage accidents. The data is then collated by staff at the NRA, and subsequently distributed to local authorities.

3.1.1. Reporting levels

The Gardaí can only record data for those accidents that are reported, and a substantial number of road accidents are not reported at all. The reporting levels depend on accident severity, casualty class, and accident location. The NRA consider that whilst almost all road accidents involving a fatality are recorded. Only 45% of injury accidents are reported and recorded. Studies carried out in the UK show that around 70% of all injury accidents may be reported to the police (14).

A **fatal accident** is one where one or more persons dies as a result of the accident within a period of 30 days from the date of the accident.

A **serious injury accident** is one where one or more casualties is detained in hospital as an in-patient or suffers from certain serious injuries.

A **minor injury accident** is one where injuries are minor (such as sprains or bruises) and the casualties are not detained in hospital.

A **material damage accident** is one where there are no injuries to persons, but damage is caused to a vehicle or property. For the material damage accidents, a very small proportion is recorded (less than 10%).

Levels of reporting generally are lower than average for single vehicle accidents, and for accidents involving children, pedal-cyclists and motor-cyclists.

Under-reporting is not consistent throughout Ireland, but is most prevalent in particularly busy urban areas.

It is important to be aware of the situation regarding under-reporting of road accidents especially when investigating cases where vulnerable road users are involved in accidents.

Despite the limitations of the data available, the Garda accident records provide a reasonably accurate and consistent source of information. Other less reliable or more subjective sources of information on road accidents should be treated with caution.

3.1.2. Accident reporting system - C(T)68

The requirement by central government for the submission of personal injury accident data to a consistent format has resulted in the production of the national C(T)68 reporting system.

An example of the C(T)68 form is shown in Figure 3.1. The form includes details relating to the accident, its location, the vehicles and casualties involved. One of the most important parts of the form is the Garda officer's sketch of the accident.

The following shows how information for a particular accident is recorded by the Gardaí, transferred to a C(T)68 form and then put onto the national computer system.

1. The Garda attends the scene of an accident after receiving an emergency call.

2. The Garda attending the scene fills in details in a notebook.

3. Accident details are recorded in a ledger at the Garda station.

4. The Garda officer completes the details on the C(T)68 form. A copy of the form is retained at the Garda station, and the original is sent to the NRA.

5. NRA staff check the details in the C(T)68 form, validate the data using consistency checks and enter the information onto the computer system (15). The information is then used to produce Road Accident Facts Ireland, the High Accident Location reports and the computer generated overlay plots.

6. The C(T)68 is stored in a filing system at NRA headquarters for future reference.

7. A copy of the C(T)68 is passed to the relevant local authority where it is stored for future reference.

It takes approximately six weeks from the time of the accident to the time that the copy of the C(T)68 arrives at a local authority.

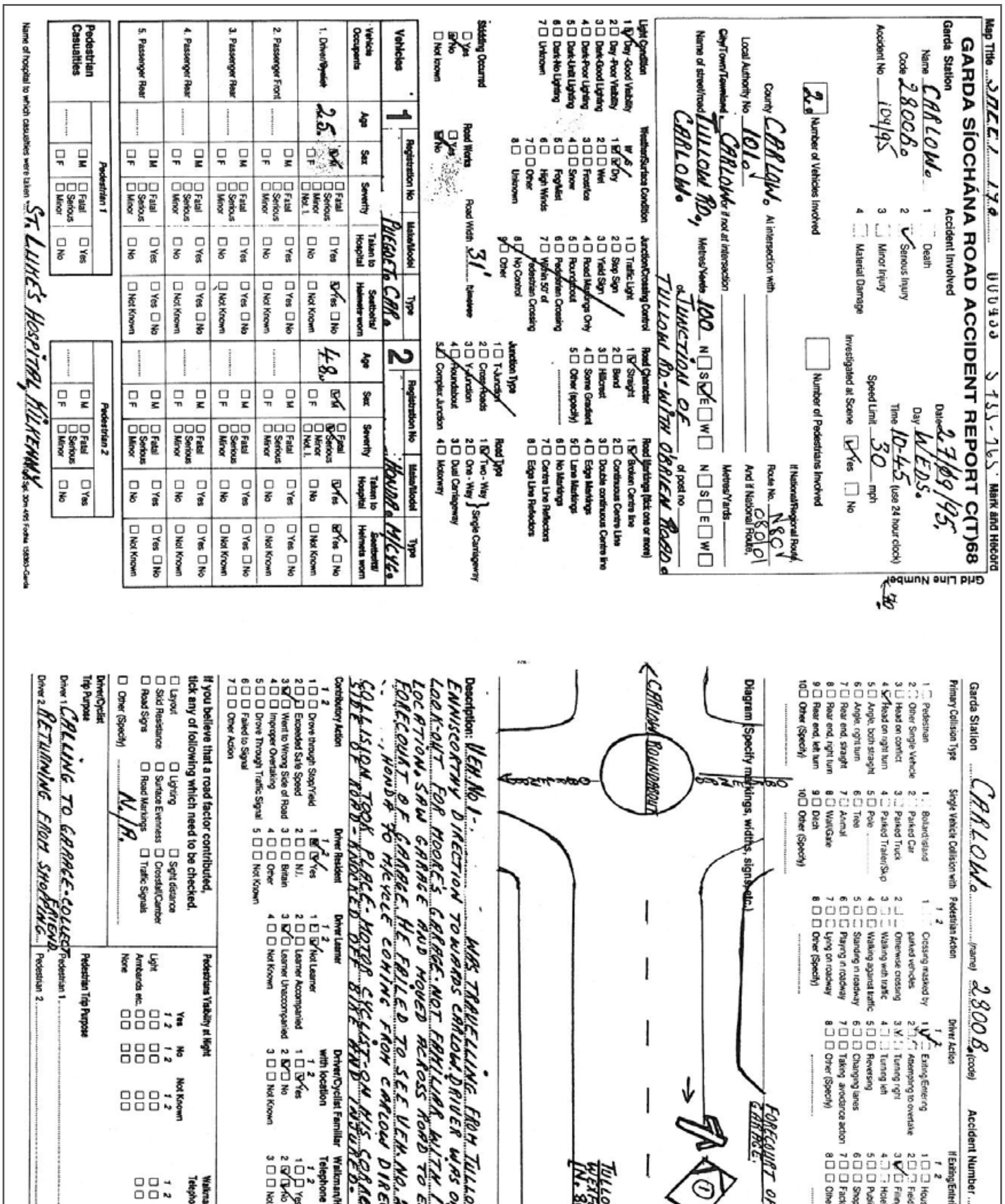


Figure 3.1C(T)68 Form (Source: NRA)

3.2. Components of an efficient local accident data system

The quality of any accident analysis work depends largely on the data available. The most important aspects of this are an accurate description of:

- the accident location
- the vehicle turning movements
- the circumstances of the accident, for example, the road condition, the time of day

Some local authorities code their C(T)68 forms onto a local computer system to improve the accessibility of the information. Others choose to keep manual records and in some cases a combination of manual and computer based reference systems are used.

A typical example is the situation in Westmeath. Here, the C(T)68 forms are received from the NRA and stored in date order by month and year. Around 300 records are kept for each year. From 1985 the records have also been coded onto a computer based system. Information on accident location, time of accident, weather, road condition, injuries, vehicle involvement, and accident description is stored. The system can be interrogated to identify routes and "townlands" (areas).

Whether the system is computer based or manual, there are some basic requirements which will help to simplify the task of accident investigation:

- the retrieval of accident data at a particular site (or route or area)
- the identification of sites (or routes or areas) with high accident numbers
- the identification of sites (or routes or areas) with common accident types
- the identification of accidents with common road user types
- the ability to relate the above information to the hard copy C(T)68 forms

A computer system should be capable of providing at least the information above. If a manual storage system is used, then accident maps should be used to help identify high accident locations. Both systems will work more efficiently if the C(T)68 forms are easily accessible and stored in chronological order.

Manual systems using maps of accident locations are useful as a quick means of reference and are readily understood by the general public. However, their preparation and updating are time consuming, particularly where more than 250 accidents per year are recorded. A manual system rapidly loses its value should staff resources be unavailable to update it on a regular basis.

Computer database systems are commercially available that will provide most, if not all, of the facilities listed above. Accident data needs to be added to the system on a regular basis, in order to keep up to date.

An authority adopting good practices would be in a position to identify high risk locations and to locate the accident records required to carry out detailed analysis. It should also be able to monitor any changes in accident numbers or specific accident types on an authority-wide basis.

3.2.1. Computerised accident systems

For a local authority wishing to store its accident data on a computer system, it is recommended that the system should have the following features as standard:

- Basic accident data from the C(T)68 records should be stored in such a way that it can be cross-referenced to the hard copy C(T)68 records.
- The system should store key information about each individual accident including route type, accident type, road user details and accident circumstances.

- The system should be able to store at least 10 years of accident records.
- The system should be capable of identifying sites, routes and areas with high numbers of total accidents or accident clusters of a particular type.
- The system should be capable of retrieving information for any given single site, route section or area.
- The system should be capable of retrieving information for a series of accidents of a particular type.
- The system should be capable of presenting information in the form of accident and casualty totals (see Section 3.3.1 i) and plain language details of the individual accidents (see section 3.3.1ii).
- The system should be capable of producing plots showing the distribution of the accidents.
- The system should allow for the setting up of monitoring systems for single sites, route sections and areas and should update the tables when new data becomes available (see Section 4.6.1).
- The computer system should enable new data to be added and validated simply and efficiently.
- The system should be able to run on a standard PC.
- The system should be easy to use and should require the minimum of training for the user.

Additional features offered by the computer system may be of benefit to the use, but are not essential. These may include:

- The cross-tabulation of data for any single site, route section, area or accidents of a particular type (see Section 3.3.1iii).
- The ability to set up trend monitoring tables and to update these each year, including the manual inputting of the national totals where the complete national accident data is not stored (see Section 4.6.2).
- The ability to alert the user when the values at single sites, route section or areas being monitored are significantly different from target values to quickly warn of problems or advise of successes.
- The ability to alert the user when the annual trend indices are significantly different from the previous year.
- The ability to store other accident information, for example damage accidents investigated by Area Engineers, and to cross-reference this data within the computer system.
- The ability to specify other output formats that may be of use for specialist reports or requests (see Section 3.3.1viii)
- The ability to interface to other computer systems used within the authority to give scope for more general analysis of the complete picture regarding traffic data, population characteristics and any other information that is stored for the local authority.
- The ability to modify the database structure as new information becomes available or the data which is being collected is changed.

3.3. Use of accident data

There are five principle stages to road safety engineering work:

- identification of the road accident problems
- diagnosis of the problems identified
- design and evaluation of engineering measures to reduce the problems
- implementation of remedial measures
- evaluation and monitoring

Accurate accident data is essential for both identifying and diagnosing road accident problems. Having designed and implemented an accident data system, the accident data can be used in a number of ways. This section considers who will use the data, and what type of output will be needed for accident investigation work.

3.3.1. Methods of presenting information

A description of some of the ways in which accident data could be presented is given below. A computer system for storing accident data can present much of this information without recourse to manual intervention.

i) Accident and casualty totals
The total number of accidents at a site or in an area is an important item of data. The number of casualties, the number of accidents involving different classes of vehicles or different age groups can also be useful. An example of this is shown in Table 3.1. Note that the number of casualties usually exceeds the number of accidents.

Location: Junction of Oldfield Cross and Church Rd	
Total accidents:	
Fatal	2
Serious	6
Slight	10
Total	18
Total casualties:	
Fatal	3
Serious	7
Slight	12
Total	22

Table 3.1 Accident totals at a site

ii) Accident details
This refers to details of one or more accidents occurring at a site, route or area. The information can be in the form of a summary of each accident or in "stick diagram" format. A stick diagram is a column of information representing the most important factors relating to a road accident. This arrangement of data can help to identify common factors within groups of accidents. An example of a stick diagram is shown in Figure 3.2.

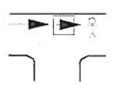
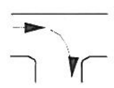
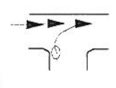
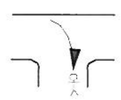
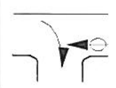
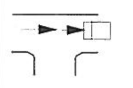
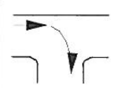
Accident ref.	F920	G568	F456	G345	G534	F789	G146
Day and Date	Mon 12/12/92	Wed 01/04/91	Thur 15/07/93	Fri 17/08/91	Fri 25/11/91	Tues 08/07/94	Sat 03/11/94
Time	1130	2130	1030	0640	2045	0700	2250
Severity	Fatal	Slight	Slight	Serious	Slight	Serious	Slight
Visibility							
Road condition	Wet		Wet			Wet	
No. of cas.	2	2	1	1	1	2	2
Casualty 1 Sex:Age	M:36	M:28	M:17	M:59	M:27	M:62	F:14
Casualty 2 Sex:Age	F:34	M:48				F:64	F:13
Number of vehicles	2	2	2	1	2	2	2
Veh 1 type	Car	Car	Pedal Cycle	Car	Car	Van	Minibus
Veh 2 type	Van	Car	Car		Motor cycle	Car	Car
Turning move-ments							
Comments	car stops for ped and van shunts into rear	car hit from rear	p/c pulls out leading to shunt	pedestrian lying in road	car turns right across m/c	van slows for stat traffic. Van shunts into rear	minibus hit from rear

Figure 3.2 Example of a stick diagram

iii) Tables

Accident details may be cross referenced to compare for example, casualty class by age or junction type by vehicle manoeuvre. This information can be presented as a simple cross-tabulation, or by graphical methods. Figure 3.3 shows an example of a cross-tabulation. Tables of this type can only readily be produced by a comprehensive computer system.

Accidents by day of week and time, 1990 - 1994

Time	Day of week							
	Sun	Mon	Tues	Wed	Thur	Fri	Sat	Total
0001-0059	37	13	15	14	10	9	39	137
0100-0159	21	6	7	3	5	3	16	61
0200-0259	16	3	2	2	3	6	13	45
0300-0359	8	1	2	1	2	3	5	22
0400-0459	4	5	2	0	0	1	5	17
0500-0559	4	2	4	3	2	6	2	23
0600-0659	4	3	6	7	2	9	3	34
0700-0759	5	28	38	34	31	29	11	176
0800-0859	6	65	82	88	76	69	14	400
0900-0959	8	27	36	42	36	35	26	210
1000-1059	21	34	33	23	25	33	45	214
1100-1159	35	33	39	32	34	47	49	269
1200-1259	44	46	58	41	45	57	72	363
1300-1359	45	55	48	57	56	58	77	396
1400-1459	58	51	37	46	41	38	82	353
1500-1559	67	77	71	76	73	136	89	589
1600-1659	56	85	88	85	83	124	68	589
1700-1759	65	122	100	121	79	116	76	679
1800-1859	56	85	84	80	68	87	70	530
1900-1959	49	55	63	52	56	64	63	402
2000-2059	39	49	51	57	52	50	40	338
2100-2159	28	24	28	26	21	33	31	191
2200-2259	24	28	23	30	30	36	42	213
2300-2359	36	36	24	24	43	59	61	283
Total	736	933	941	944	873	1108	999	6534

Figure 3.3 Example of a cross-tabulation

iv) Accident plotting

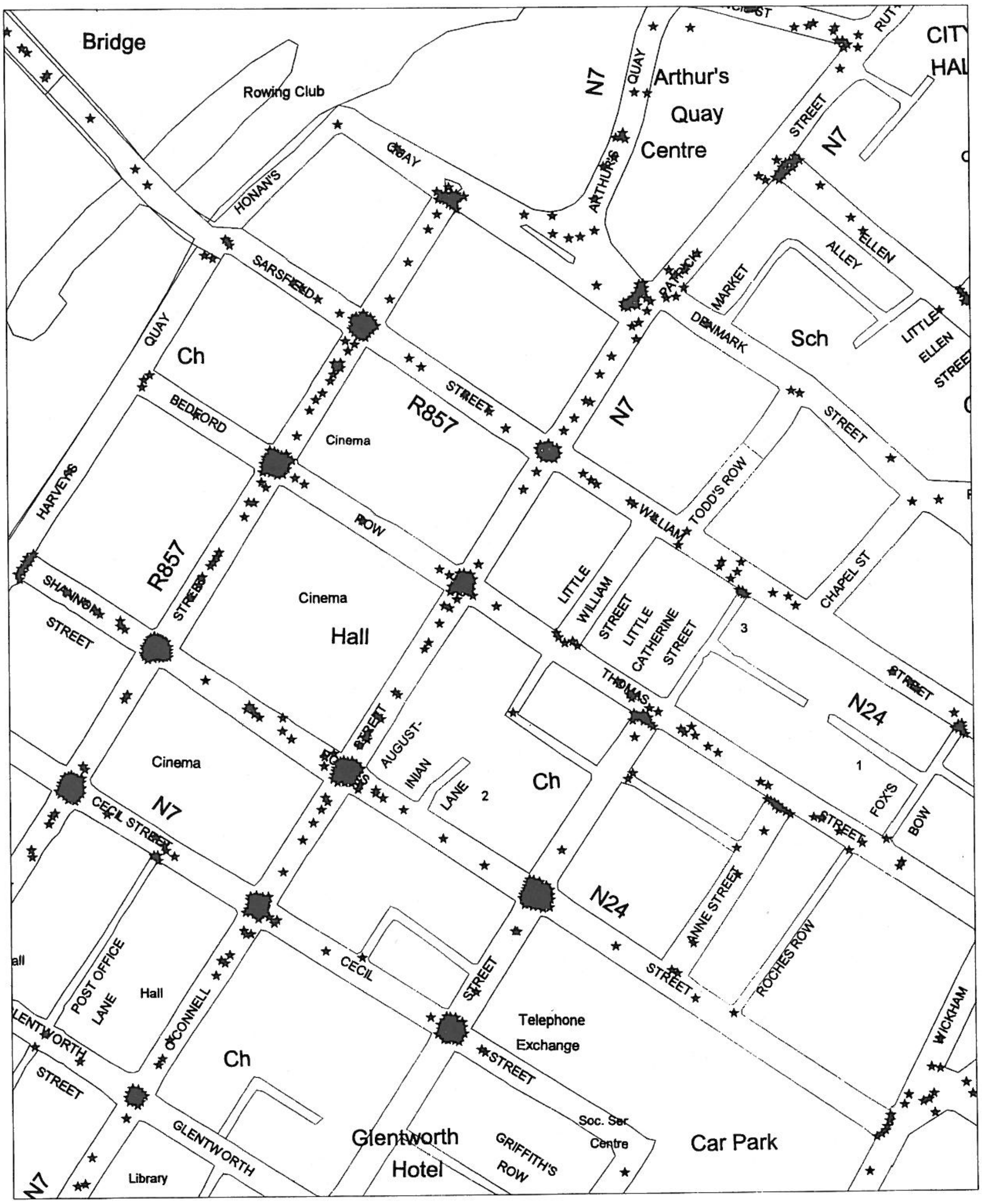
The main use of an accident plot is to show accident data in terms of location, number and severity. A plot can show only certain accident types, for example the occurrence of accidents involving child pedestrians under 10 years old.

The NRA has a computer system for plotting accidents on both national and local roads throughout Ireland, and publishes a book of plots showing high accident locations on National Routes. Figure 3.4 shows a plot of all accidents in Limerick City Centre from 1990 to 1994.

Manual plotting with pins or coloured markers placed on wall maps to indicate high frequency locations can be very useful. Colour coding and different shaped markers can be used to identify different year's accidents and different severities or accident types.

v) Problem site listings

Lists of accident problem sites can be produced in a number of ways. For example, a list of sites with more than 4 accidents in the most recent 3 year period, with sites listed in descending number of accidents, would give an immediate indication of single site accident problems in an area. A list of all sites with more than 3 accidents involving child pedestrians in the most recent 3 year period would highlight problem sites for this particularly vulnerable road user group.



e

ntre 1990-1994

(Source: Limerick Corporation)

vi) Statistical test results

Information can be produced to compare site or area characteristics with "control levels" for a group of similar sites. Control levels describe the expected performance of a location, taken from the average for a large number of similar sites.

vii) Monitoring

Monitoring can provide information on progress towards accident reduction with completed schemes. It can also act as an early warning system in cases where accidents have increased following site changes. A computer based monitoring system can be used on a regular basis without a great deal of staff resource.

3.4. Road accident costs

There is a cost incurred to the community when a road accident takes place. Accident costs can be classified into lost output due to death or injury, the human costs of pain, grief and suffering, and the resource cost in terms of hospital, emergency service, damage to property, and insurance costs (16) (17).

In 1994 the individual costs of road accidents in Ireland, based on the "willingness to pay" method referred to in the references above, were as follows:

Fatal accident	£913,140
Serious injury accident	£108,080
Minor injury accident	£10,630
Material damage accident	£1,050

Total accident costs for 1993 can be derived by multiplying these figures by the number of reported accidents in each category:

Fatal accidents	(371 x £913,140)	= £338,774,940
Serious injury	(1,594 x £108,080)	= £172,279,520
Minor injury	(4,645 x £10,630)	= £ 49,376,350
Total		= £560,430,810

Dividing the total accident cost by the number of reported injury accidents (6,610) gives an average injury accident cost of £84,785. However, for every reported injury accident there is likely to be a number of material damage accidents. If an allowance is made for the material damage accidents, then the average cost of a recorded injury accident becomes £118,550. (This assumes that for each injury accident that is recorded, a certain number of damage accidents will occur).

In this guide, the average cost of an injury accident, £118,550, (including an allowance for material damage) is used in most calculations.

Road accident costs are used to express costs to the community on a national basis. On a local basis they are used in estimating the potential cost savings to be derived from accident reduction schemes as part of economic assessments. This is described in more detail in later chapters.

3.5. Summary

- An Garda Siochana collect the basic data for accidents involving personal injury in Ireland.
- The NRA collate this information and distribute it to the local authorities.
- In order to carry out accident analysis work it is essential to maintain an efficient set of accident records.
- The most effective way of storing and analysing accident records is with a computerised system.
- Road accidents are given an economic cost in order to quantify the scale of the problem and carry out economic assessment.

4. Planning a Road Safety Strategy

4.1. Safety Management

It is important for a local authority to plan carefully the way in which it intends to reduce road accidents in its area (6). Objectives can be set for both accident reduction and prevention. The involvement of other agencies should be sought to help meet these objectives. It is also important that a monitoring system is set up so that progress towards meeting accident reduction objectives can be measured.

4.1.1. National context

The NRA produces Road Accident Facts Ireland on an annual basis. This document shows overall trends in road accidents over a period of time and splits accidents into a number of types. It provides a good overall picture of road accidents in the country and enables changes in legislation to be monitored.

In addition, the NRA has carried out a number of investigations into road accident problems based on accident data supplied by the Gardaí. This work includes investigations at single sites and routes and the production of High Accident Locations reports which relate to the National Routes.

4.1.2. Action at a local level

Local authorities have a vital role in reducing road accidents in Ireland. In addition to their responsibilities for the National Routes on behalf of the NRA, they are directly responsible for the local roads where 70% of all road accidents occur. In terms of planning road safety strategies, it may be necessary to look at the National Routes separately from local roads.

The Road Accident Facts Ireland document is very important for local authorities as it enables them to look at the accident trends in their own area and to compare these trends with the national picture.

Local authorities should look beyond road improvements to reduce road accidents, and the inter-action of different agencies in this type of work is important. Engineers should work particularly closely with road safety officers and the Gardaí.

The current situation
An analysis of local authority activity in the area of road safety engineering was carried out in 1994 as part of the production of this guide. Each local authority was sent a questionnaire to determine how this work is carried out. A total of 32 authorities replied, and a summary of the findings is given below:

- Road safety engineering is carried out exclusively on a part-time basis in Ireland, mainly by staff in Central Roads design teams.
- About one third of the local authorities use maps to detect accident problem sites, while about one fifth use computers.
- There is a need for staff training in this area of work.

The questionnaire returns showed wide differences, both in terms of the amount of road safety engineering being carried out in different areas of Ireland, and in terms of the strategies in place to tackle the problem.

The most effective way for a local authority to establish a strategy for reducing road accidents is to draw up a Road Safety Plan.

4.2. Road Safety Plans and objectives

The purpose of a Road Safety Plan is to establish local road accident reduction objectives and to develop a strategy for achieving those objectives.

The plan should indicate ways in which the authority intends to co-ordinate road safety policies with other related agencies. The plan may also include reference to the technical and resource implications of achieving accident reduction objectives.

The plan should set out a series of realistic and achievable accident reduction objectives that can be monitored within a quantitative framework. These may include short, medium and long-term objectives for various road user groups or accident categories.

The principle of monitoring and evaluation is central to all aspects of road safety engineering, and is an important part of the plan.

The plan should be reviewed around once every two years in order to assess progress.

It is suggested that the following areas will need to be addressed in a local authority's Road Safety Plan:

- A statement of the main road accident problems within the area
- Strategies for tackling problems on local roads
- Data storage and retrieval
- Criteria for action- "reaction levels"
- Methods for identifying high risk locations
- Prioritising of road safety schemes
- Checking safety aspects of new schemes
- Relationships with other agencies
- Monitoring the effectiveness of schemes

4.3. Accident reduction and prevention strategies

There are two complementary approaches to accident investigation work – accident reduction and accident prevention.

Accident reduction involves taking measures to reduce the number and severity of accidents at sites where there is a known accident record.

Accident prevention is the application of measures to prevent accidents from taking place in the future on new roads and at locations where there have been no recorded accidents.

The ways in which accidents can be reduced or prevented fall into three categories:

- Road safety engineering measures
- Vehicle safety improvements
- Measures aimed at improving road user behaviour

These categories relate to the multi-factor nature of accidents described in Chapter 2. This guide concentrates on the ways in which road engineering measures can be introduced to reduce and prevent accidents. In some cases it is useful to link behavioural remedies such as education, training and publicity to road engineering measures.

4.3.1. Approaches to accident reduction

The four approaches to accident reduction are:

- Single site
- Route action
- Mass action
- Area-wide action

Single site road accidents occurring at an individual site are examined in detail, common accident types are identified and measures introduced to treat the problems identified. An example could be the introduction of a chevron sign on a bend with a loss of control accident problem. The single site approach is dealt with further in Chapter 5.

Route action sections of road are identified and treated together. An example of this could be the introduction of edge line markings along a route with a record of vehicles leaving the road, or the introduction of traffic calming and gateways through a village on a National Route. The route action approach is dealt with further in Chapter 6.

Mass action groups of sites are identified with common accident causes and a single measure introduced at all the sites. An example of this approach could be to identify a series of sites with wet skid accidents and apply anti-skid surfacing to those sites. This approach is dealt with further in Chapter 7. The mass action approach is particularly useful in rural areas on local roads with small accident numbers.

Area-wide action parts of an urban area are identified where accidents of a particular type can be identified, but are not confined to single sites or routes. An example of this could be the introduction of traffic calming to reduce pedestrian accidents in an urban area. This approach is dealt with further in Chapter 8.

These approaches illustrate the various ways in which an authority can tackle its road accident problems. Each approach has a different emphasis, and is likely to produce a variation in the type of accident likely to be treated. A feature of each approach is a systematic methodology involving reaction levels, the identification of high-risk locations, accident analysis techniques, prioritising schemes, and monitoring.

Co-ordination of accident reduction strategies

One of the objectives of a road safety plan would be to devise a works programme that would involve a combination of the four approaches discussed above as a strategy for accident reduction. Figure 4.1 shows how each approach to accident reduction can be used on roads in one part of a local authority's area.

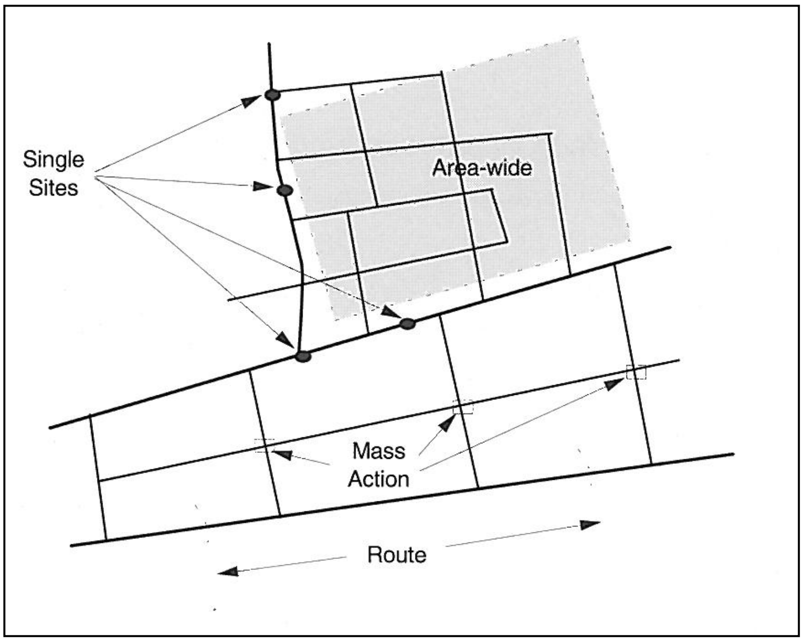


Figure 4.1

4.3.2. Approaches to accident prevention

Future road accident problems can often be prevented by carrying out safety checks of any proposals to construct new roads or to improve existing roads. It is likely that many road schemes will be carried out for reasons other than to improve safety, and it is important that safety is given a high priority in the design of such schemes.

Chapter 9 describes a method for carrying out safety checks on proposed road improvement schemes and new roads. The chapter also discusses ways that perceived safety problems can be addressed.

4.4. Involvement of other agencies

An important part of a local strategy towards accident reduction and prevention concerns relationships with other agencies. These may be close colleagues such as road safety officers and planners, or staff working for different organisations such as the Gardaí.

Every strategy, whether for the reduction or prevention of accidents, must be based on the clearly recognised opportunities available to reduce road accidents.

The strategies which can be defined for engineering, education and enforcement will be different due to the differing opportunities for accident reduction and prevention provided by these disciplines. However, in many cases there will be considerable opportunities for co-operation.

For example, it would be unwise for engineers to devise and put into use a pedestrian safety scheme without considering the public education and training which should be implemented in parallel.

Gardaí often need to be involved with schemes designed for vehicle control. Garda units need close liaison with engineers so that problems they detect from every day policing can be related to accident studies and the programmes for remedial measures.

4.5. Resources and objectives

4.5.1. Resources

A local authority accident reduction and prevention strategy cannot be undertaken without both direct expenditure and staff time and training. There are considerable benefits in terms of efficient allocation of resources to a local authority that embarks on such a strategy.

4.5.2. Direct Expenditure

Resources will be required to implement schemes on both National Routes and on local roads. The emphasis in this guide is on low-cost measures generally costing less than £20,000. However, there may be certain sites where expenditure greater than this can be justified. In addition, area-wide measures are likely to exceed £20,000. Funds for equipment such as computer hardware and software are also clearly important.

4.5.3. Staff time and training

It must be recognised that analysing road accidents and designing safety engineering measures is a labour intensive activity. Whereas the cost of designing a major road scheme may be in the order of 10% of the capital cost of the scheme, the cost of designing a low-cost accident reduction scheme can often exceed the scheme cost.

Guidance in this area is provided by the Institution of Highways and Transportation (IHT) in their Accident Reduction and Prevention Guidelines (4).

Based on practice elsewhere, it may be appropriate to consider one trained person per 200 accidents for an initial period in order to set up an accident data system and to undertake some initial problem site identification, and design of solutions. Some authorities may wish to consider combining accident work with, say, traffic calming, or to share safety responsibilities between staff in order to achieve a "fulltime equivalent" working arrangement.

Safety engineering is a specialised area of work, and therefore staff training should be given a high priority.

4.5.4. Objectives of road safety schemes

The objectives for an accident reduction strategy should be to achieve satisfactory accident reduction from expenditure not exceeding certain levels. Objectives set by a local authority may be different for the local roads and the National Routes passing through their area.

The economic objectives of a scheme can be expressed in terms of the potential First Year Rate of Return (FYRR). The FYRR is a simple, practical method of economic evaluation that compares the scheme cost with the expected safety benefit, expressed in terms of road accident cost savings. The use of FYRR is explained in detail in Chapter 5. Some local authorities may wish to use the more economically rigorous method of Net Present Value (NPV) explained in Appendix 4. The NPV method may be more appropriate where accident problems demand high cost solutions.

The maximum cost of an accident reduction scheme is constrained by the degree of benefit expected. Nationally, there are many potential schemes costing substantially less than £20,000 and it is in relation to such schemes that the expression "low cost" is used. Nevertheless it should be recognised that authorities with high accident levels in urban areas (particularly in Dublin and Cork) could show that remedial schemes costing considerably more than £20,000 are fully justified in terms of their First Year Rate of Return.

4.6. Monitoring

4.6.1. Purpose of monitoring

The level and type of road accidents need to be monitored and compared with national trends. A monitoring system should be designed to give an early warning of problems at an individual scheme, and to provide data for developing guidelines for safety engineering work in the future.

Those authorities with computer databases should set up automatic monitoring systems. Table 4.1 shows an example of an automatic monitoring system for single sites. The system should be designed so that the records are examined for equal periods of time before and after the introduction of the scheme. As more accident data is added to the database, so the number of months of monitoring increases. If a computer system is not available then sites should be monitored on a manual basis.

ENGINEERS DEPARTMENT TRAFFIC ACCIDENT REMEDIAL MEASURES MONITORING SYSTEM LATEST UPDATE CARRIED OUT ON 12-10-94 AT 13:46									
Scheme/ Site	**Proposed works**	**Works period**	**Final cost (000)**	**Mths of data**	**Total accs Before**	**Total accs After**	**Main acc types**	**Reduc in accs %**	**Rate of return %**
Church Rd/ Cross St	Ped. guard rail	13/9/88 - 9/11/88	1.00	70	20	20	Ped	0	0
Station Rd	Remove Trees/ Chevrons	13/8/88 - 2/10/88	2.0	66	8	2	loss of control	75	480
North Rd/ Bridge St	Junction stagger/ Guard rail/ Add.signs	5/12/88 - 19/2/89	6.0	69	17	11	fail to conform	35	153
East Ave/ Railway Rd	Chevrons /Add. hatching	17/6/88 - 12/7/88	1.0	64	20	11	loss of control	45	1470
St James' Alley	Retexture /Chevrons /Realign bend	3/2/88 - 5/2/88	8.0	67	8	9	loss of control	-13	-19

Table 4.1 An automatic monitoring system for single sites

Monitoring the effect of accident reduction and prevention measures is required at two levels - for all the roads within the local authority area, and for individual safety schemes or groups of schemes.

4.6.2. Monitoring throughout a local authority area

Each local authority should aim to measure the change in accident and casualty numbers over time. These local trends can then be compared with national trends reported annually in Road Accident Facts Ireland.

Accident trends in a local authority area can be monitored annually by the production of a report made available to interested parties. The report should compare the last year's accident and casualty statistics with previous years.

Information within the report should concentrate on the following aspects:

- Accident location - accidents by class of road, urban or rural, junction or non-junction;
- Road users involved - type and class of road user and severity of injury;
- Vehicle types;
- Accident time- time of day, day of week, month;
- Road conditions- dry/wet/icy, daylight/darkness.

Table 4.2 Comparing local accident trends with the national average for vulnerable road users shows an example of a table comparing local accident trends with the national average for vulnerable road users.

Road user type	%LA accs 1993	% National accs 1993	Comment
pedestrians	20%	13%	significant problem
car users	55%	61%	less than national average
pedal cyclists	10%	7%	more than national average
motor cyclists	9%	9%	national average

Table 4.2 Comparing local accident trends with the national average for vulnerable road users

4.6.3. Scheme monitoring

Having chosen and implemented a measure to reduce road accidents it is important to monitor the effect for the following reasons:

- As an early warning system, so that if accidents increase, further steps can be taken quickly to reverse the situation;
- To quantify any change in accidents and to find out whether there is any change over time in the effectiveness of the treatment;
- To evaluate the benefits of the scheme in relation to the original scheme objectives.

Individual scheme monitoring can help to build up an authority's "control data" by showing how effective various measures have been. This will help decision making about future schemes and will remove the reliance on national and international data.

The effectiveness of a safety improvement can be measured by undertaking a "before and after" analysis. Before and after studies are described in more detail in Chapters 5 to 8 and in Appendix 2.

4.7. Summary

- Accident reduction and prevention strategies should be planned on both a local and national level.
- Accident reduction strategies involve treating single sites, routes, mass action sites and areas.
- Accident prevention strategies involve the safety checking of road schemes.
- Financial objectives can be set for road safety schemes to ensure that resources are allocated efficiently.
- All work carried out should be monitored to establish actual benefits.

5. Single Site Road Safety Problems

A single site is considered to be a problem if the number of accidents that have been recorded at a location over a given period of time is greater than a predetermined "reaction level". The site itself is normally defined either as a short length of road (up to 300 metres) or a road junction.

Single sites can occur in both urban and rural situations. The general methodology for investigation is similar in both situations, but there are important differences in emphasis between urban and rural sites. These are referred to throughout the chapter.

5.1. Methodology

This chapter describes how road safety problems at individual locations or "single sites" are identified, analysed and treated. The basic methodology for studying and treating single site road safety problems is shown below:

- Identify the accident problem sites
- Rank the sites into priority order
- Analyse the accident and other data at individual sites
- Carry out a site visit
- Define the accident problems
- Examine possible remedial measures
- Estimate the accident savings
- Calculate the economic benefits
- Decide on a remedial measure or measures
- Document the decision in a scheme report
- Prioritise the implementation of measures based on economic assessment
- Implement the remedial measure(s)
- Monitor the effectiveness of the measure(s)
- Update the scheme report.

5.1.1. Objectives

Within the methodology described above, there are a number of important objectives for single site road safety work.

- Each site should have a "treatable" accident problem.
- Each treated site should achieve a minimum 30-40% reduction in accidents.
- Each treated site should achieve a minimum 100% economic rate of return.

These objectives are developed more fully within this chapter.

5.2. Identifying sites for treatment

Some sites will have been identified by the public through letters of complaint. Such complaints should be considered by checking the numbers of accidents at the site and deciding whether further investigation is justified.

Sites where fatal accidents have been recorded should be routinely checked in order to establish whether the fatal accident forms part of a pattern of accidents at the site. This check should be carried out as soon as details of a fatal accident are received by the local authority.

A more proactive method is to identify sites for treatment by looking at the available accident data. This is normally carried out by looking for the individual sites with the highest numbers of accidents in a given period.

The first stage of the investigation process is to study the available accident data in a logical manner in order to identify and rank problem sites.

5.2.1. Time period for analysis

The time period chosen for analysis of the accidents should comprise full 12 month periods, although these do not have to be calendar years. If there are a large number of accidents at a site, then a three year period may be a sufficient period to study. In most cases a five year period would be preferred. If a longer period is chosen, it is more likely that some changes could have been made to the site or the adjacent sections of road which may have influenced the accident record. A judgement has to be made so that enough accidents are examined during a period when little change has taken place to the road network.

It is suggested that a five year time period is preferable in both urban and rural areas. However if sufficient accident data is available, a three year time period could be used in large urban areas.

5.2.2. Reaction levels

In order to determine which sites should be looked at in detail a "reaction level" needs to be established. This is normally set by deciding on a particular number of accidents in a given time period. For example a reaction level of more than three accidents in a three year period at a single site in an urban area could be a starting point for deciding whether to investigate the site further.

Reaction levels should be set in relation to the resources available at a local authority. If a local authority has one member of staff working on safety engineering, and this person is expected to collate all accident data as well as undertaking safety studies, it would be pointless to set a reaction level so low that it produces 200 sites for investigation. However, the reaction level should not be set so high that it produces too few sites for investigation.

It is suggested that the following minimum reaction levels be adopted:

- Five accidents in a five year period at an **urban** location.
- Three accidents in a five year period at a **rural** location.

5.2.3. "Treatable" accidents

In addition to producing a list of sites with high accident numbers, it is important to try to identify sites which have "treatable" accident problems amenable to road engineering treatments. These are sites where there are likely to be common road factors within the accident pattern. Figure 5.1 shows a site with a dominant right turn accident problem, along with other more individual accident types.

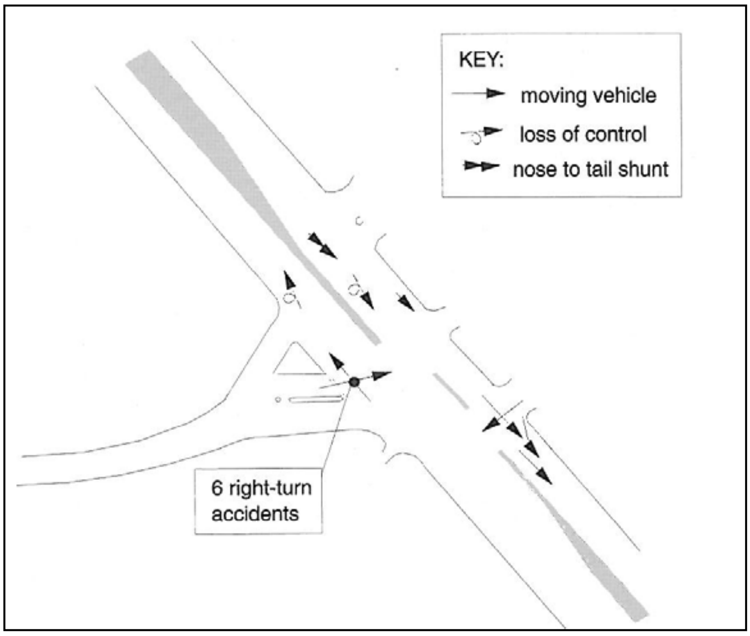


Figure 5.1 Site with a dominant right-turn accident problem

It may be that on first examination of the data there are no obvious common factors, and a decision then has to be taken whether to undertake an in-depth study or to look at another site which may be more easily treated.

5.3. Methods of ranking single site locations

5.3.1. Accident totals

The simplest way of ranking accident sites is to list them in descending order of fatal and injury accident total; the site at the top of the list having the highest number of accidents for a three or five year period. In a local authority with mixed land use it may be useful to split the lists into urban and rural sites.

A high accident number does not necessarily imply a treatable problem - it may simply be a function of the size and type of the junction and the traffic flow. In order to identify "treatable" accident problem sites it will be necessary to carry out further analysis at individual sites from the list.

An accident total listing needs to be updated at regular intervals. It should indicate improving or worsening safety records at sites and should point to the best way to target resources.

Table 5.1 shows the number of potential sites for various local authority areas for the period 1990-1992.

Area	No. of potential sites with more than 3 accidents in 3 years
Dublin City	315
Cork City	63
Waterford	17

Table 5.1 Number of potential sites for various local authority areas for the period 1990-1992

5.3.2. Accident rates

The NRA has developed a method for ranking sites based on accident rates, whereby the accident total is divided by a measure of traffic flow giving accidents per million vehicle kilometres. The actual accident rate is then compared with the expected accident rate for that site. In this type of ranking system the traffic flow acts as an index of exposure for accidents, since it is assumed that accidents are related to the number of vehicles passing through the site.

This method of ranking is more appropriate to National Routes than to local roads and to rural rather than urban roads. An example of how to calculate accident rates is given in Appendix 1.

The relationship between the number of accidents and traffic volume is shown conceptually in Figure 5.2.

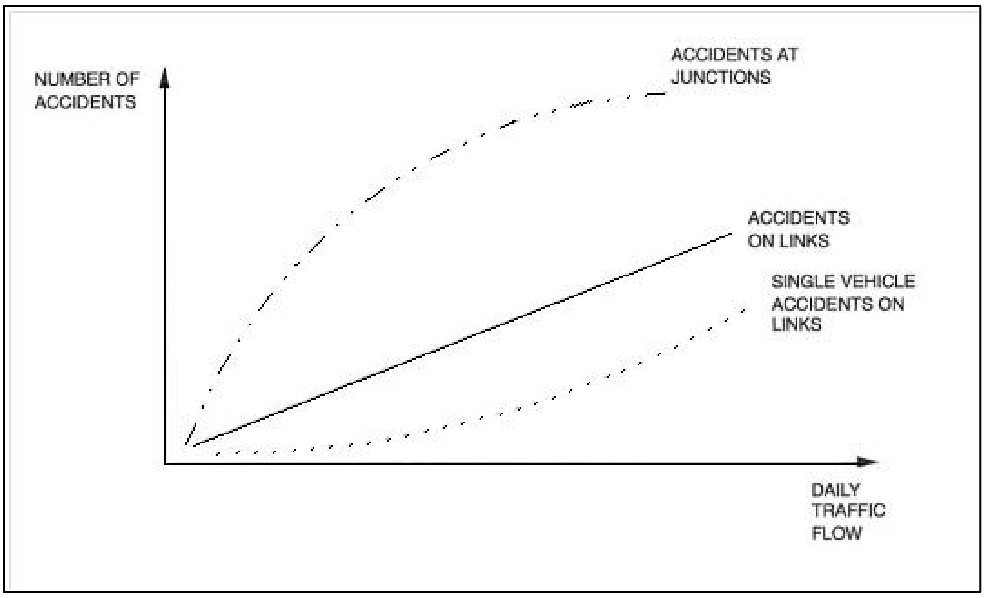


Figure 5.2 The relationship between the number of accidents and traffic volume

As with accident total listings, accident rate listings do not necessarily generate treatable sites. In addition, this method can result in the sites with the highest accident rates being those with low traffic flow levels and low accident numbers.

5.3.3. Consistency of ranking method

It is advised that a consistent approach to ranking is adopted for all single site investigations in a local authority area. One of the obvious problems in using accident rates on local roads is that the traffic flow data will not generally be available. In these circumstances ranking sites on accident numbers is considered a better method and the most appropriate to local roads.

5.3.4. Purpose of ranking procedures

The purpose of ranking problem sites is to produce a list of sites which can be considered for further analysis.

Figure 5.3 shows a flow chart illustrating the use of ranking procedures to identify a series of single sites with potential for treatment. These sites will be generated through a combination of analysing requests from the public, fatal accident sites and from the problem site rankings generated from the C(T)68 database.

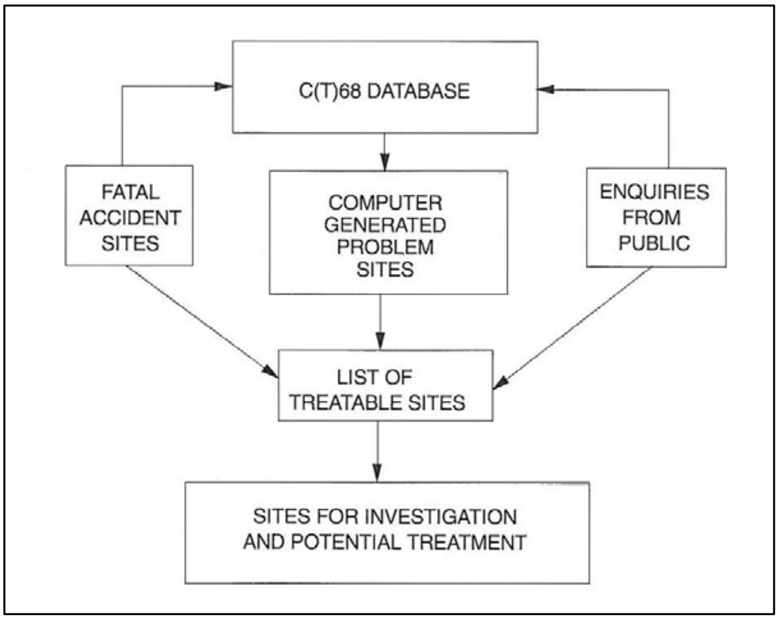


Figure 5.3 Ranking procedures to identify a series of single sites with potential for treatment

Having produced a list of sites for possible treatment, the next stage of the process looks at how individual sites are examined in more detail.

5.4. Examining road accident data in detail

The examination of accident data at a single site is concerned with the identification of the factors which can explain how the various road users failed to cope immediately prior to the accidents. The analysis should aim to highlight factors common to a number of accidents at the site. The object of the analysis is to arrive at low-cost road engineering measures which will improve the safety at the site. These engineering measures will sometimes be complemented with behavioural or enforcement measures in co-operation with staff from other agencies.

5.4.1. Basic data

The first step in the work is to examine the accident details available. Inspection of all accident data and any available Garda records is essential. It would be helpful to examine any material damage accident reports that may be available from either the Gardaí or from Area Engineers' records.

This data can be tabulated for each accident in a group to indicate common features or possible causes. The method normally used to group accidents is to produce a "stick diagram" for each accident and then to produce an "accident grid". An example of an accident grid is shown in Figure 5.4. Information contained within each stick on the grid is taken from the C(T)68 form for that accident.

The accident grid is used to identify common factors in the accidents. The "sticks" representing each accident can be moved about to change the accident grid and this helps in locating these common factors. For example, at a particular site it may be obvious that a number of accidents have occurred in the dark. By grouping together all the dark accidents it may be possible to find other common factors such as the direction of travel, or manoeuvre type within this sub-group.

Figure 5.4 shows how the previous accident grid has been sorted to group together the wet road and dark accident clusters. It can now be seen that each of the three wet road accidents also involved a nose-tail shunt. This repeated accident problem may well suggest that the road surface is in need of improvement.

Once the main turning movements have been identified, the accidents can be located onto a plan, and depicted either by their stick diagrams, or by "bubble diagrams". An example of a bubble diagram drawn up from Figure 5.5 is shown in Figure 5.6.

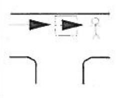
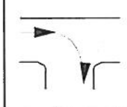
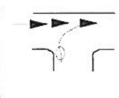
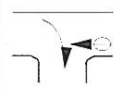
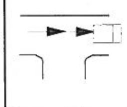
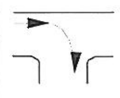
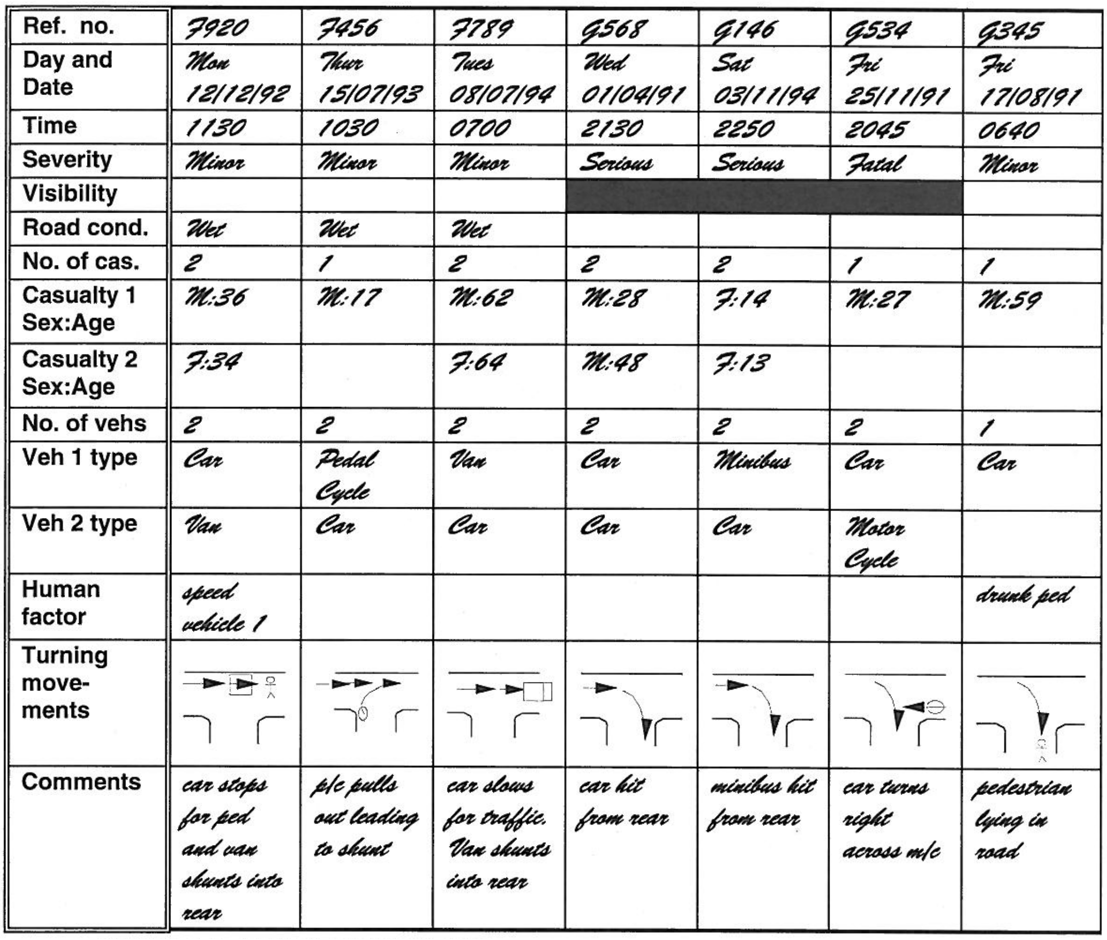
Ref. no.	F920	G568	F456	G345	G534	F789	G146
Day and Date	Mon 12/12/92	Wed 01/04/91	Thur 15/07/93	Fri 17/08/91	Fri 25/11/91	Tues 08/07/94	Sat 03/11/94
Time	1130	2130	1030	0640	2045	0700	2250
Severity	Minor	Serious	Minor	Minor	Fatal	Minor	Serious
Visibility							
Road cond.	Wet		Wet			Wet	
No. of cas.	2	2	1	1	1	2	2
Casualty 1 Sex:Age	M:36	M:28	M:17	M:59	M:27	M:62	F:14
Casualty 2 Sex:Age	F:34	M:48				F:64	F:13
No. of vehs	2	2	2	1	2	2	2
Veh 1 type	Car	Car	Pedal Cycle	Car	Car	Van	Minibus
Veh 2 type	Van	Car	Car		Motor cycle	Car	Car
Human factor	speed vehicle 1			drunk ped			
Turning move-ments							
Comments	car stops for ped and van shunts into rear	car hit from rear	p/c pulls out leading to shunt	pedestrian lying in road	car turns right across m/c	car slows for traffic. Van shunts into rear	minibus hit from rear

Figure 5.4 Accident grid showing "stick diagrams" for a 3-arm junction



Ref. no.	F920	F456	F789	G568	G146	G534	G345
Day and Date	Mon 12/12/92	Thur 15/07/93	Tues 08/07/94	Wed 01/04/91	Sat 03/11/94	Fri 25/11/91	Fri 17/08/91
Time	1130	1030	0700	2130	2250	2045	0640
Severity	Minor	Minor	Minor	Serious	Serious	Fatal	Minor
Visibility							
Road cond.	Wet	Wet	Wet				
No. of cas.	2	1	2	2	2	1	1
Casualty 1 Sex:Age	M:36	M:17	M:62	M:28	F:14	M:27	M:59
Casualty 2 Sex:Age	F:34		F:64	M:48	F:13		
No. of vehs	2	2	2	2	2	2	1
Veh 1 type	Car	Pedal Cycle	Van	Car	Minibus	Car	Car
Veh 2 type	Van	Car	Car	Car	Car	Motor Cycle	
Human factor	speed vehicle 1						drunk ped
Turning movements							
Comments	car stops for ped and van shunts into rear	p/c pulls out leading to shunt	car slows for traffic. Van shunts into rear	car hit from rear	minibus hit from rear	car turns right across m/c	pedestrian lying in road

Figure 5.5 Sorted accident grid

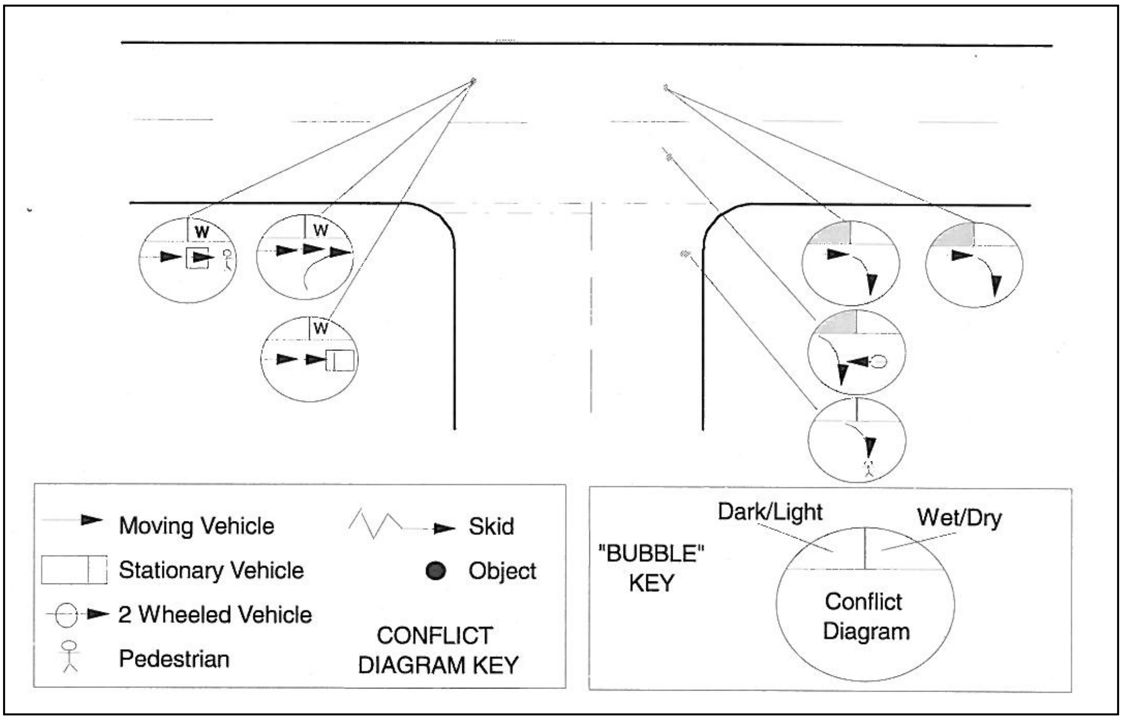


Figure 5.6 Bubble diagram showing turning movements from Figure 5.4 and Figure 5.6

5.4.2. Statistical techniques

It is often important to carry out some level of statistical analysis of the road accidents at a site. Annual accidents totals should be studied to establish whether there is an increasing or decreasing trend. Also the percentage of accidents that occurred in each month of the year, on each day of the week and in each hour of the day should be established to see if there is any obvious pattern. Information regarding day and time should be used to establish when to carry out the site visit.

If accidents are increasing at a site, a statistical test can be carried out to establish whether this increase in accidents represents a significant departure from a long-term trend, implying the possibility of an increase in risk. The "Poisson" test is used to determine the significance of change over time.

The percentages of the following standard indicators should be calculated at this stage:

- Accidents that occurred in the dark
- Accidents that occurred in the wet
- Accidents involving pedestrians
- Single vehicle accidents with loss of control
- Accidents involving two-wheeled vehicles
- Accidents involving commercial vehicles

These percentages should be compared with expected values or "norms" obtained from county-wide information (known as "control data") on locations of a similar type. Where this comparison reveals a higher than expected value at a given site, a statistical test can be undertaken to see if this represents a significant departure from the "norm". For example, a site with 10 accidents may include 6 on a wet road surface i.e. 60%, compared to an expected wet road accident rate of 40%.

Tests can also be carried out to conduct before and after studies, comparing the performance of a treated site with appropriate control data.

Appendix 2 introduces simple statistical techniques, such as the "Chi-squared" test, which will help to identify accident problems and to establish whether these problems have any statistical significance.

5.4.3. Collecting additional information

Once the accident record information for a particular site has been studied, it will usually be necessary to collect further information.
The most common sources of this additional information are:

- Site visits
- Traffic volume and speed data
- Conflict studies

The site visit
The site visit is a very important element in any accident investigation as this may help to reveal reasons for the accidents that were not apparent from the accident data alone. Such visits should only take place after the initial accident study has been completed. This should avoid the pre-judgement of accident problems that can happen if the site is visited before the accident data is examined.

The site should ideally be visited at the same time that the accidents have happened, and in the same weather conditions. For example a site where the majority of accidents happen in the dark and wet should be seen in those conditions. However, it will also be necessary to visit the site in good conditions so that all relevant site details can be noted.

The engineer should try to understand the site from the point of view of those involved in the accidents. For example, if a number of the accidents involved a right turn out of a minor road, then the engineer should make that manoeuvre a number of times while at the site, and observe others making the manoeuvre. If the accident involved injuries to pedestrians then the engineer should explore the site on foot.

The site visit should be used to note road features and all street furniture. These features should be recorded on suitable scale plans of the site.

The use of photographs and video, taken at driver eye height, pedestrian eye height or as an overall view from the side or above can be an invaluable aid in the office and at presentations. Figure 5.7 is a photograph taken at driver eye height just before the crest of a hill.

Figure 5.7 Photo taken at driver eye height

In conjunction with on-site investigation, collecting information from local people, either living in the area or regular users of the route or foot-way in the area will provide data covering activity over an extended time period. The local shop owner or resident may be worthy of interview in order to complement the accident details. However, all this information should always be used with extreme care as it will undoubtedly contain subjective statements and opinions.

The local Gardaí often have knowledge of both recorded and unrecorded accidents at a site and should be contacted during the investigation.

It is useful to take a summary of the accident data to the site visit so that the specific circumstances of each accident can be checked. It is also useful to take a checklist of details; an example of a checklist for use in both urban and rural situations is included at the end of this chapter.

In some circumstances it will be necessary to take detailed site measurements. For example, if the accident analysis has revealed a problem with visibility to the right at a T-junction, the visibility splay should be measured, or in a case where overtaking accidents have been identified, forward visibility should be measured. Information on site measurement is available from the NRA (18).

With respect to skid resistance (19), a graphical trace of SCRIM readings for National Routes is provided annually to each Local Authority. This should be checked at the site if wet skidding or loss of control is reported by the Gardaí or is evident as a factor from the accident data.

Traffic data
A whole range of traffic data can be collected and may be required to assist with the analysis of safety problems at a site. The traffic data will also be useful in determining the type of measures that may be applicable at the site. However, it should be noted that the collection of additional traffic data can considerably increase the cost of an accident study and so in the majority of cases is unlikely to be justifiable on a cost basis.

Vehicle and pedestrian counts
Although the relationship between traffic flows and accidents is complex, traffic volume is clearly an important factor in accident occurrence. In addition, capacity may need to be taken into account when proposing solutions, particularly in urban situations.

The number of vehicles and pedestrians passing through a site will provide useful information on exposure to risk of the various road user groups. Pedestrian counts are nearly always carried out manually. Vehicle counts can be undertaken manually or automatically using pneumatic tubes (or buried loops) and a counter. The latter method will give better statistical information, since it will normally be placed on site for a seven day period.

Records of existing counts should be examined to determine whether the appropriate information is already available (20) (21). Ideally any counts should be up to date and contain any specific information required to supplement the accident data.

For example, pedal cycle flows will be required where these vehicles appear in a significant proportion of the accidents. Comparing previous counts with more recent ones may reveal some changes in traffic patterns that could help to explain changes in accident patterns.

It may be necessary to undertake new counts, and these should be specifically tailored to tie in with the accident record. For example, the count should be carried out on the day of the week when there are most accidents and may need to classify pedestrians into different age groups. Alternatively, short duration counts may be sufficient to supplement existing data.

Speed checks
The relationship between speed and accident occurrence has been the subject of much research. In urban residential areas the crucial speed is about 20 mph (30 kph).

- At 20 mph (30 km/hr), 5% of pedestrians struck by a car will be killed.
- At 30 mph (50 km/hr), 45% of pedestrians struck by a car will be killed.
- At 40 mph (60 km/hr), 85% of pedestrians struck by a car will be killed.

On a more general level, recent research has shown an average 5% reduction in accidents for each 1 mph reduction in traffic speed (22). Figure 5.8 illustrates this concept.

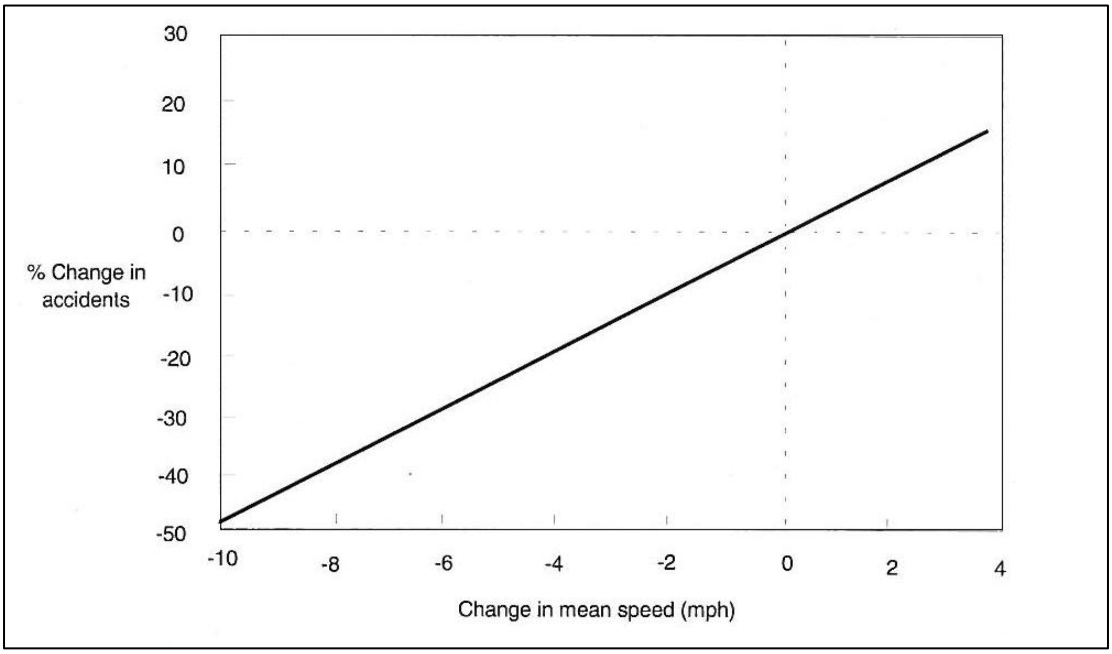


Figure 5.8 Relationship between speed and accident occurrence

Knowledge of the speed of vehicles at an accident problem site is often useful. Again there may be information already available, but it is usually better to undertake new surveys tailored to the accident data. However the use of a single speed figure can sometimes be misleading, since this can mask the occasional high speed vehicle. For this type of work it is suggested that both the 85 percentile speed and the mean speed are calculated. Traffic speed information can either be collected manually using a hand-held radar, or automatically using pneumatic tubes (or buried loops) and a counter.

Conflict studies

It may be that the site under study has low numbers of accidents, or that the recorded accident data does not reveal any particular common factors that can be treated. In these circumstances one way in which more data can be obtained is by the use of "conflict studies".

A method for undertaking a conflict study is given in Appendix 3, and the relevant section should be read before a conflict study is carried out.

A conflict study may reveal some particular problems at a site which were not obvious from the accident data. However, by their definition conflicts are not accidents and any additional information gleaned from a conflict study should be related back to the accident data available.

Conflict studies can also be used as a diagnostic tool in conjunction with accident data to investigate the nature of the problem. In this approach, an investigator would observe conflicts representing the dominant accident pattern in order to learn more about the potential circumstances leading up to the accidents.

5.5. Defining road accident problems

Once the accident analysis, additional surveys and site investigations have been carried out, the accident problems for the site can be defined. The definition of the problem should be as precise as possible so that a specific measure can be designed to tackle the problem. At sites with a large number of accidents there could be more than one safety problem that needs to be treated.

An example of how to define road accident problems for single sites is given in Sections 1-3 of the case study (Sections 5.5 and 5.6) at the back of this chapter.

5.6. Treating the accident problems identified

Once the accident problems have been identified and additional information has been collected to enhance the accident data, the next stage is to consider what accident remedial measures could be introduced at the site to treat the accident problems identified and to estimate potential accident savings based on each remedial measure.

5.6.1. Possible remedial measures

Each site has its own specific accident problems related to the traffic, road, and road user behaviour characteristics at that site. It is therefore not possible to prescribe particular standard solutions. This section of the guide is intended to give guidance on possible remedial measures, rather than to dictate specific solutions to problems.

A list of possible remedial measures that can be used at urban and rural sites is provided at the end of this chapter (Tables and Forms: Table 5.1) along with illustrations of a few of the measures taken from case studies in Ireland. In many cases the treatment can be adapted for use in either rural or urban environments. However some treatments are more appropriate to the urban or rural situation and this is indicated within the list.

The list identifies the most common accident types for which measures have been shown to be effective and suggest ways in which these accident types can be treated with more or less standard solutions. However, the measures should be seen as providing guidance only, and should not be seen as a short-cut to undertaking detailed analysis of the accidents at a site. For the detailed application of certain measures, the Traffic Signs Manual should be consulted (23).

Where possible, the potential accident savings for each type of remedy are given in the table. These are sometimes averages produced from a number of separate studies. These figures suggest a percentage accident reduction produced by a remedial measure taken in isolation. Where a combination of measures is introduced it does not necessarily follow that the total effect will approximate to the sum of individual percentages taken for each measure applied.

A series of reports on the safety benefits of a range of measures has been compiled by the UK County Surveyors' Society. These reports are referred to as "SAGAR" reports (Standing Advisory Group on Accident Reduction) and are included in the list. Each report contains information from a variety of local authority sources in the UK. A study of the benefits of measures carried out in Northern Ireland gives examples of successful schemes throughout the province (24)•

Local authorities should operate their own monitoring procedures and use the results to establish the effectiveness of various measures in their own areas.

5.6.2. The use of traffic signs and road markings

Table 5.1 refers to solutions that include the use of road signs and markings. The signs and markings used in road safety schemes should conform to the provisions of the signs regulations or directions of the Minister for the Environment, as appropriate. It is recommended that the procedures for the provision of signs and markings set out in the Department of the Environment Traffic Signs Manual should be followed.

5.7. Estimating accident savings and economic benefits

In order to arrive at a solution to an accident problem at a single site, a number of options are considered for improving safety and an economic assessment of the potential benefits of each option is carried out so that the most cost effective option is implemented.

5.7.1. Accident savings

There may well be more than one way of solving some of the accident problems at a site, and in order to compare different options it is important to be able to estimate, as accurately as possible, how many accidents will be saved. Accident savings can be estimated in one of two ways:

Overall accident savings
Using information from previous sites where a similar treatment has taken place it is possible to estimate the likely accident saving at the site to be treated. This information should ideally be taken from local monitoring of schemes, but where local authorities are new to this work the information may not be available and other sources may have to be used. The information in Tables and Forms: Table 5.1 at the back of this chapter gives some broad indications of accident reduction in percentage terms. For example at sites where anti-skid surfacing has been introduced, accidents on a wet road surface have reduced by 80%.

Different studies have shown a range of results for the same type of treatment, and it may be appropriate to provide "optimistic" and "pessimistic" evaluations based on this range.

Particular accident savings
In this method it is assumed that unless something is done at the site the existing pattern of accidents will be repeated over time. The accident record is re-examined and each accident assessed to determine whether that particular accident would have happened if the proposed measure had been implemented. It is sometimes difficult to be positive about whether an accident would have happened or not, and this method can also generate "optimistic" and "pessimistic" values for accident savings.

Using one or other method it is possible to estimate the number of accidents that will be saved by introducing a particular scheme. The next step is to put a monetary value on the saving.

An example of how to estimate accident savings is shown in Sections 5 and 6 of the case study (Sections 5.5 and 5.6) at the end of this chapter.

5.7.2. Economic assessment

The method of economic assessment described here is the First Year Rate of Return (FYRR). It is a simple way of calculating whether a scheme can be justified in economic terms. The method can be used to rank different options at a site, and to rank proposals at different sites. The FYRR is calculated using the formula:

$$\%FYRR = \frac{\text{Annual Accident Savings} \times 100}{\text{Scheme cost}}$$

It should be noted that there is a more rigorous method of economic assessment of proposals known as the Net Present Value (NPV). The NPV method takes a longer term view than FYRR, and calculates benefits over a 10 or 15 year scheme life, using discount factors to assess costs and benefits at year I prices. It may be more appropriate to use the NPV method for higher cost schemes. The NPV method is explained in detail in the Appendix.

The overall accident savings are calculated according to one of the methods described in Section 5.7.1.

The 1994 accident cost figures were described in Section 3.4 as follows:

- Fatal accident £913,140
- Serious injury accident £ 108,080
- Minor injury accident £ 10,630
- Material damage accident £ 1,050
- Average cost of a reported injury accident (including an allowance for material damage) £ 118,550

If individual accident costs are used in the economic assessment, then a site with an accident history that includes just one fatal accident will have very high accident costs due to that one fatal accident. Yet the occurrence of the fatal injuries could be due solely to chance, perhaps the fact that the person killed was elderly. For this reason the average cost of a reported injury accident should be used within the economic assessment in almost all cases.

The exception to this rule would be a site with a much higher than expected proportion of fatal and serious accidents. For example, on a high speed road with one fatal and three serious injury accidents but no minor injury accidents. In this case an assessment based on individual accident costs may be justified.

Example - Site 1:
5 accidents in 3 years: 1 fatal injury accident and 4 minor injury accidents.

The proportion of fatal and serious accidents at this site is 20%. The national average is 31 %. It would therefore not be justified to use the individual costs, and the average cost should be used. So, using the average cost of £118,550, the yearly accident cost for the site is:

[5 x £118,550]/3 = £592,750/3 = £197,583 per year

Example - Site 2:
5 accidents in 3 years: 2 fatal injury accidents, 2 serious injury accidents, 1 minor injury accident.

The proportion of fatal and serious accidents at this site is 80%. The national average is 31%. It would therefore be justified to use the individual costs. So, using the individual costs, the yearly accident cost for the site is:

[2 x £913,140 + 2 x £108,080 + £10,630]/3 = £2,053,070/3 = £684,357 per year

(Note that the cost for site 2 does not take account of material damage accidents.)

It is important to note that within all economic assessment work, calculations should be based on accidents rather than casualty figures. This is because the objective is to reduce accidents, regardless of the number of casualties that occur within each individual incident.

The scheme costs need to be estimated by the normal methods adopted by the local authority. At this stage budgetary estimates will be sufficient to compare options or compare sites.

An example of a FYRR calculation is given in Sections 5.5 and 5.6 at the end of this chapter.

5.8. Comparison between options for treatment at a site

After carrying out the estimates of accident reduction and the economic assessment at a site it is now possible to decide on the optimum treatment at that site.

The most efficient way to decide on the preferred option at a single site is to rank the options in order of FYRR. The option with the highest FYRR is then chosen for implementation.

However, there should be a note of caution here in that high FYRR values are generally achieved with schemes costing little money but saving fewer accidents. The number of accidents saved within each option should also be taken into account, probably as a proportion of the total number of accidents at the site.

5.9. Report writing

At this stage, the accident investigation carried out so far should be written up in a clear and concise format. Monitoring the effectiveness of remedial schemes is made easier if the accident study is well documented. Each report should include the following aspects:

- Accident analysis
- Site comments

- Statement of problem
- Options for improvement
- Expected accident savings
- Preferred option
- Recommendation.

The report should be accompanied by plans showing the accident locations and patterns, and sketch plans of the options.

5.10. Implementation of remedial measures

Once a decision has been made on the most effective measure (or series of measures) to be carried out at a site, then the implementation of the work can be arranged.

Good records of costs and dates of work on site will be necessary so that scheme monitoring can be carried out effectively.

Some schemes, particularly those targeted at vulnerable road users, will benefit from direct publicity of the scheme details within the community.

5.11. Prioritisation of schemes

Having decided upon the optimum treatment for an individual site, the local authority should prioritise all potential single site schemes within their area. This can be done in a number of ways, for example using either economic criteria, the potential for accident savings or the total number of accidents in the before period. As with chasing options for treatment at a site (Section 5.8), the most efficient means of prioritising is to use the potential First Year Rate of Return for the preferred option at each site. In addition, it is suggested that a minimum predicted accident reduction of 30% should be achievable for each preferred option. Table 5.2 shows an example of the prioritisation process.

Site name	Accidents per year	Treatable acc. Type	Scheme description	Scheme cost (£)	% Acc savings	Acc savings per year (£)	FYRR %
St Mary's Rd	3.8	Right turners	Signing	5,500	32	113,265	2060
North Rd	4.4	Cyclists	Cycle crossing	12,000	45	184,229	1540
St Bridget's Rd	8.2	Shunts	Anti-skid	20,000	31	236,777	1185
Dublin Rd	3.0	Fail to conform	Traffic signals	25,000	63	176,046	705
South St	2.4	Pedestrians	Pelican crossing	17,000	35	78,243	460

Table 5.2The prioritisation process

5.12. Scheme monitoring

Having carried out treatments at a site, or series of sites, it is essential to monitor the effects. Reference has already been made to monitoring in Chapter 4.

An early indication of safety benefits can be obtained from before and after traffic and speed surveys, and from conflict studies (see Appendix 3). However, the most direct indicator of a scheme's success is a change in accident frequency which can be attributed to the scheme. Therefore, the main feature of an evaluation will be the comparison of accident frequency after the remedy has been applied with what would have been expected had nothing been done.

The main problem is to distinguish between a change due to the remedial treatment and a change due to other sources. A statistical test (Chi-squared) can be used to compare before and after site data with suitable control data for similar time periods (see Appendix 2). The control data should be derived from similar untreated sites, or from "area" controls, such as all accidents in the County.

An example of a form that can be used to record site specific information for use in before and after studies is included at the end of this chapter.

An example of scheme monitoring is given in Sections 5.5 and 5.6 at the end of this chapter.

5.13. Summary

This chapter has described the methodology for carrying out a site-specific accident investigation. The main points are as follows:

- Identify the safety problems based on historical injury accident records.
- Define the accident problems by analysing the data, then carrying out a site visit.
- Collect any additional data as necessary.
- Investigate options for treatment within a cost/benefit framework.
- Implement the scheme and monitor the results.

5. Chapter 5: Tables and Forms

- Possible remedial measures for single sites
- Illustrations
- Site visit checklist
- Before and after accident record for single site investigation
- Single site case study – 1
- Single site case study – 2

5.1. Possible remedial measures for single sites

Junction type	Accident type	Accident sub-type	Possible remedy {R=rural, U=urban)	% Accident reduction	Ref.
Uncontrolled	Overshoot	Wet road	Anti-skid surfacing	30-60% all accs, 80% wet	(25) (26)
Uncontrolled	Overshoot	Wet road	Re-surface		
Uncontrolled	Overshoot	Wet road	Re-texture existing surface		
Uncontrolled	Overshoot	Wet road	Improve drainage		
Uncontrolled	Overshoot	Dark	Improve/introduce lighting	50% dark accs	(27)
Uncontrolled	Overshoot	Dark	Improve reflectivity of signs		
Uncontrolled	Overshoot	Dark	Improve signing		
Uncontrolled	Overshoot	Dark	Improve road markings		(28)
Uncontrolled	Overshoot	Cross roads	Introduce refuge in side road		(29)
Uncontrolled	Overshoot	Cross roads	Introduce stagger (R)	50-85%	(16)
Uncontrolled	Overshoot	Cross roads	Introduce traffic signals (U)	30-50%	(30) (31)
Uncontrolled	Re-start		Improve sight distance	30%	
Uncontrolled	Re-start		Reduce speed on main road		
Uncontrolled	Turning	Cross roads	Introduce stagger (R)	50-85%	(32)
Uncontrolled	Turning	Shunts on main road	Anti-skid, re-surface, re-texture	30-60%, 80%wet	(25) (26)
Uncontrolled	Turning	Shunts on main road	Improve junction conspicuitv		
Uncontrolled	Turning	General	Prohibit turns (U)		
Uncontrolled	Turning	General	Channelisation by road markings only	20%	
Uncontrolled	Turning	General	Channelisation by physical islands	20%	
Uncontrolled	Turning	General	Right turn lanes	33%	
Uncontrolled	Turning	General	Widen to near-side (R)		
Uncontrolled	Turning	General	Construct roundabout (R)	47% (Netherlands), 30-50%	(33) (34)
Uncontrolled	Turning	General	Introduce mini roundabout (U)	30-40%	(35) (36)
Uncontrolled	Turning	General	Install traffic signals (U)	30-50%	(36) (37)
Uncontrolled	Pedestrian		Install pedestrian refuges		
Uncontrolled	Pedestrian		Provide controlled crossings (U)	18% all aces,2 8% peds	(37) (38) (39) (40)
Uncontrolled	Pedestrian		Provide pedestrian guard rail	10%	

Tables and Forms: Table 5.1 Possible remedial measures for single sites

Junction type	Accident type	Accident sub-type	Possible remedy {R=rural, U=urban)	% Accident reduction	Ref.
Roundabout	Entering	Wet road	Anti-skid, re-surface, re-texture on approach	30-60% all aces, 80% wet	(25) (26)
		Dark	Improve/introduce lighting	50% dark aces	(27)
			Improve reflectivity of signs		
			Install paved chevrons		
		Loss of control	Improve signing (position of chevrons)		
			Warning signs		
			Flexible chevron signs		
			Yellow bar markings	50%	(41) (42)
			Count-down markers		
			Rumble strips/areas	35%	(43)
		Shunts	Improve visibility on channelising island		
			Anti-skid, re-surface, re-texture	30-60% all accs, 80% wet	(25) (26)
		General	Increase entry deflection		
			Reduce approach width		
			Reduce visibility on approach if too great		
	Leaving		Remove adverse camber		
			Reduce exit radius		
	Circulating		Improve visibility to right on entry		
			Improve forward visibility		
			Reduce circulating width		
	Two-wheelers	Cyclists	Provide alternative route		
			Provide crossing facility		
		General	Square off entry		
			Provide backing board on central island.		
			Provide traffic signals	30% cycle aces	(44)
	Pedestrians		Install pedestrian guard rail	10%	
			Provide controlled crossings (U)	18% all accs, 28% ped accs	(37) (38) (39) (40)

Tables and Forms: Table 5.1 Possible remedial measures for single sites (ctd.)

Junction type	Accident type	Accident sub-type	Possible remedy {R=rural, U=urban)	% Accident reduction	Ref.
Traffic signals	Overshooting stop line	Wet road	Anti-skid, re-surface, re-texture on approach	30-60% all accs, 80% wet	(25) (26)
		General	Improve visibility to signal heads		
			Provide additional signal heads (overhead or extra height)		
			Provide warning signs		
			Provide speed discrimination		
	Red light breaking		Camera	20-60% fail to yield	(45)
			Improve enforcement		
			Improve conspicuity of junction		
	Turning		Prohibit turns		
			Amend signal staging		
			Construct roundabout	47% (Netherlands), 30-50%	(33) (34)
			Introduce road markings		
	Pedestrians		Provide pedestrian stage		(30)
			Provide pedestrian refuges		
			Install pedestrian guard rail (high visibility type)		
	Cyclists		Provide advanced stop lines		(46)
			Provide controlled crossing facility (U)		
Slip Roads	Merging		Acceleration and deceleration lanes (R)	30-50%	
			Yellow bar markings	25%	(42)
General	Speed		Variable message signs		

Tables and Forms: Table 5.1 Possible remedial measures for single sites (ctd.)

Junction type	Accident type	Accident sub-type	Possible remedy {R=rural, U=urban)	% Accident reduction	Ref.
Non-junction	Pedestrian	School journey	School crossing patrol (U)		
		Child	Education, training, publicity		
			High visibility guard rails		
		Adult	Provide controlled crossing (U)	18% ped accs, 28% all accs	(37) (38) (39) (40)
			Install pedestrian refuges		
			Provide pedestrian guard rails		
	Cyclist		Provide controlled crossing (U)		
	Loss of control	Wet road	Anti skid, re-surface, re-texture	30-60% all accs, 80% wet	(25) (26)
		Dark	Install or improve lighting	50% dark accs	(27)
			Provide edge delineation		(47)
		Bends	Improve horizontal alignment (R)	60-80%	(25)
			Provide super-elevation	60%	
			Install chevron signs, bend warning signs	70%	(47)
			Mount existing signs on backing boards		(48)
			Introduce advisory speed limit (R)		
			Provide edge delineation		(47)
		General	Install safety fence	15% fatals on d/cway, 90% head-on	(49)
			Re-site roadside objects	10% m/way fatals	
			Provide breakable/frangible objects	reduce severity	
			Introduce crash cushions	reduce severity from 67%- 14%	(48)
	Approach to village		Gateway treatment (R)	45% (Germany)	(50)
	General		Variable message signs		

Tables and Forms: Table 5.1 Possible remedial measures for single sites (ctd.)

5.2. Illustrations

Tables and Forms: Figure 5.1 Advance warning signs, overtaking prohibition, channelisation and chevron signs

Tables and Forms: Figure 5.2 Advance warning signs, overtaking prohibition, channelisation and chevron signs

A combination of advance warning signs, overtaking prohibition, channellisation and chevron signs may provide a solution at the junction of two major roads where "overshoot" accidents are occurring.

Tables and Forms: Figure 5.3 Ghost island hatching

At junctions where right turning vehicles are being struck in the rear or side-swiped, the use of ghost island hatching to provide channellisation may be a solution where volumes are reasonably high

Tables and Forms: Figure 5.4 At low volume junctions an overtaking prohibition may be a possible solution

Tables and Forms: Figure 5.5 At roundabouts where overshoot accidents are reported, check that the chevron sign is as close to the centre of the field of view as possible

Tables and Forms: Figure 5.6 Consideration should be given to advancing the stop line and phasing out the hard shoulder at locations where emerging right turners are being struck by oncoming vehicles

5.3. Site visit checklist

Site visit checklist for a site-specific accident investigation			
General Information	Name of site:	Road number:	
	Date of visit:	Time of visit:	
	Weather conditions:	Road surface conditions:	
	Photo description:	prints/slides/video	
	Number recorded injury accidents in 3 years/5 years:		
	Accident period from:	to:	
	Brief description of accident problem:		
Nature of the road	Carriageway type: Single/dual	Carriageway width:	
	Number of lanes:	Lane widths:	
	Footway:	Y/N	width:
	Verge:	Y/N	width:
	Hard shoulder:	Y/N	width:
	Central reserve:	Y/N	width:
	Central refuge:	Y/N	width:
	Kerb build-out:	Y/N	width:
	Kerb:	Y/N	width:
	Road hump:	Y/N	width:
	Speed limit:		
	Vertical profile:	level/gradient/crest/valley	
	Bend:	Y/N	approx. horizontal radius:
	Visibility restrictions:	Y/N	comment:
	Other comments		
Drainage & surface condition	Channels:		
	Drainage:		
	Cross fall:	Y/N	comment:
	Superelevation:	Y/N	comment:
	Surface type:		condition:
	Other comments:		
Junction details	Junction site:	Y/N	
	Type of junction:		
	Hard islands:	Y/N	comment:
	Ghost islands:	Y/N	comment:
	Stacking space for turning:	Y/N	comment:
	Turning radii:		
	Visibility restrictions:	approach:	restriction:
		approach:	restriction:
		approach:	restriction:
	Other comments:		
Lighting	Provision:	Y/N	
	Type:	height:	Set back from c/way:
	Intensity:		Siting:
	Other comments:		

Tables and Forms: Table 5.2 Site visit checklist

Site visit checklist for a site-specific accident investigation											
Signs		Sign 1	Sign 2	Sign 3	Sign 4	Sign 5	Sign 6	Sign 7	Sign 8	Sign 9	Sign 10
	Sign Type										
	Siting										
	Reflectivity										
	Illumination										
	Size of face										
	X. ht of letters										
	Pole size										
	Set back from c'way										
	Conspicuity										
	Condition										
	Comments										
Markings		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9	Type 10
	Marking Type										
	Siting										
	Reflectivity										
	Conspicutiy										
	Condition										
	Comments										

Tables and Forms: Table 5.2 Site visit checklist (ctd.)

Site visit checklist for a site-specific accident investigation			
Other features	Bus route:	Y/N	
	Bus stops:	Y/N	
	Bus shelters:	Y/N	
	Lay-by:	Y/N	
	Accesses:	Y/N	
	HGV route:	Y/N	
	Parking:	Y/N	
	Stationary vehs:	Y/N	
	Safety fence	Y/N	
	Land use type:		
	Street furniture details:		set back from c'way
	Trees		set back from c'way
	Other comments		
Provision for vulnerable road users	Footway:	Y/N	
	Pedestrian facility	Y/N	type:
	Observed usage during site visit		
	Guard rails	Y/N type:	siting:
		height:	siting:
	Specific signing	Y/N	comment:
	School route	Y/N	comment:
	School crossing patrol	Y/N	comment:
	Cycle facilities	Y/N	type:
	Cycle route	Y/N	comment:
	Observed cycle usage during visit		
	Specific signing	Y/N	comment:
	Other comments		
Sketch plan of route	Record details of relevance to accident problems and attach checklist		
Further speed surveys required	Speed survey	Y/N *manual/automatic*	
	Traffic count	Y/N *manual/automatic*	
	Pedestrian count	Y/N *manual/automatic*	
	Conflict study	Y/N SCRIM test	Y/N
	Other:	Y/N	type:

Tables and Forms: Table 5.2 Site visit checklist (ctd.)

5.4. Before and after accident record for single site investigation

1. **Site name:**

   Road number:

2. **Before data:**

   Brief description of site before measures carried out:
   Photographic record: *slides/prints/video*
   Number of injury accidents in *3 year/5 year* before period:
   Dominant accident type(s):
   Number of accidents:
   Number of material damage accidents in *3 year/5 year* before period:
   Control data: (NB time periods should be same as for site data)
   Number of accidents in rest of county for *3 year/5 year* before period:

3. **Description of remedial measures:**

4. **Implementation date:**

5. **After data: (NB time periods should be same length as before period)**

   Photographic record: *slides/prints/video*
   Number of injury accidents in *3 year/5 year* after period:
   Dominant accident type(s):
   Number of accidents:
   Number of material damage accidents in *3 year/5 year* after period:
   Control data: (NB time periods should be same as for site data)
   Number of accidents in rest of county for *3 year/5 year* after period:

6. **Chi-squared test table:**

	Site data	**Control data**	**Totals**
Before			
After			
Totals			

Chi-squared value	
Significance level	
Interpretation	

5.5. Single Site Case Study – 1

5.5.1. Skew Bridge at Tivoli, Lower Glanmire Road (NS), Cork

1. Location
The site is located at the Skew Bridge at Tivoli on the N8 Lower Glanmire Road, Cork.

2. Accident analysis
During the 2 year period 1990 and 91 there were 5 injury accidents and 5 material damage accidents recorded at the site. Since the records for material damage accidents are incomplete, the accident analysis concentrates on the injury accidents.

Of the 5 injury accidents:

2 involved serious injury
3 involved minor injury
2 (40%) were on a wet road surface
3 (60%) were in the dark
5 (100%) involved loss of control (all 5 travelling from Cork)
2 (40%) were single vehicle accidents (in both the vehicle hit the bridge parapet wall)
3 (60%) were head-on

Details of the accidents are shown on the accident grid (Tables and Forms: Figure 5.7).

3. Results of site visit
The road is a single carriageway approximately 8m wide with footways on both sides; the road is lit and subject to a 30 mph speed limit. The skew railway bridge means that traffic approaching from either side has to negotiate a left, then a right hand bend.

The road is a National Route with an AADT of approximately 30,000 vehicles and with approximately 14% HGVs.

Details of the site are shown on the photographs.

4. Definition of the accident problem
Drivers travelling from Cork losing control of their vehicle as they negotiated the bends on the bridge. The vehicles are then crossing the carriageway and colliding with oncoming vehicles or the bridge parapet wall. Inappropriate high speed may have been a causation factor.

5. Possible remedial measures

- Extend the bridge deck by 2.5m eastwards — £150,000- too expensive
- Extend the bridge deck by 6.5m eastwards — £310,000 - too expensive
- Construct a new bridge — £500,000 - too expensive
- Improve warning signs

Preferred option: Improve warning signs - bend will be highlighted
Estimated cost: £10,000

6. Accident savings
Of the 5 injury accidents, it is estimated that 50% of the loss of control accidents would be saved.

2.5 accidents saved in 2 years = 1.25 per year

Accident cost saving = 1.25 x £118,550 = £148,188 per year

7. Economic calculation

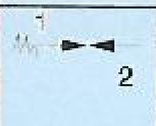
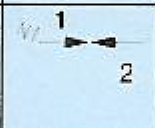
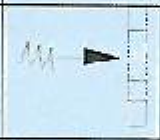
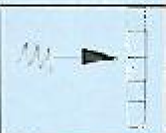
$$FYRR = \frac{\text{Accident cost saving / year x 100}}{\text{Scheme cost}}$$

$$FYRR = \frac{148,188 \times 100}{10,000}$$

$$=1482\%$$

8. Monitoring

Remedial measures as shown in the photographs were completed in December 1992. Up to June 1994 there had been two injury accidents (1.33/year). The early indications are that the remedial scheme has been successful although the "after" accidents suggest that approach speeds are still too high. Proposals have been put forward to introduce rumble areas on the approaches to the bridge.

Accident ref. no.	01244	01704	7	04107	04279
Day and Date	Friday 19/1/90	Monday 19/2/90	Sunday 9/6/91	Tuesday 13/8/91	Thursday 15/8/91
Time	18.15	23.55	03.00	02.15	12.05
Severity	Minor injury	Minor injury	Serious injury	Serious injury	Minor injury
Visibility					
Grid Ref	702722	702722	703723	707724	702722
Road condition	Dry	Wet	Wet	Dry	Dry
No. of casualties	1	3	4	3	7
Casualty 1 Sex:Age	M:38	M:29	M:20	M:28	M:30
Casualty 2 Sex:Age		M:27	F:18	M:20	F:28
Casualty 3 Sex:Age		M:53	M:20	M:20	F:1
Casualty 4 Sex:Age			F:19		M:37
Casualty 5 Sex:Age					F:37
Casualty 6 Sex:Age					M:4
Casualty 7 Sex:Age					F:6
Number of vehicles	2	2	1	1	4
Vehicle 1 type	Car	Car	Car	Car	Lorry
Vehicle 2 type	Car	Van			Car
Vehicle 3 type					Car
Vehicle 4 type					Van
Turning movements					
Comments	Head-on	Head-on	Loss of control	Loss of control	Head-on

Tables and Forms: Figure 5.7 Accident grid for Tivoli Bridge

Tables and Forms: Figure 5.8 Before the investigation: Approach from Glanmire

Tables and Forms: Figure 5.9 After implementation of remedial measures: Approach from Glanmire

5.6. Single Site Case Study – 2

5.6.1. Ballymascanlon Bridge, Louth

1. Location
The site is located on the R173 Carlingford-Dundalk Road in County Louth.

2. Accident analysis
During the 5 year period 1987 to 91 there were 7 injury accidents and 9 material damage accidents at the site. Since the records for material damage accidents are incomplete, the accident analysis concentrates on the injury accidents.

Of the 7 injury accidents:

2 were fatal
2 involved serious injury
3 involved minor injury
3 were on a wet road surface
5 were in the dark
7 involved loss of control (6 of these travelling towards Dundalk)
5 were single vehicle accidents
2 were head-on

Details of the accidents are shown on the accident grid (Tables and Forms: Figure 5.10).

3. Results of site visit
The road is a single carriageway between 7m & 8m wide with no footways; the road is unlit and subject to national speed limit. Approaching from the south-east the road has a long straight section followed by a severe left hand bend. At the apex of the bend is the junction with Deerpark Road immediately followed by Ballymascanlon Bridge which carries the road over the river. Continuing north-west there is a sharp right hand bend before the road straightens out. There is a considerable amount of foliage close to the road which tends to mask the forward visibility of the bend.

The road is a busy traffic route with an AADT of approximately 5000 vehicles and about 20% HGVs.

Details of the site are shown on the plan and photographs

4. Definition of the accident problem
Drivers travelling towards Dundalk not appreciating the severity of the bend and losing control of their vehicle. The problem is particularly acute at night. Inappropriate high speed may have been a causation factor.

5. Possible remedial measures

- Realign bend — Too expensive > £30,000
- Widen road through bend — Too expensive > £30,000
- Improve carriageway markings and signs
- Introduce street lighting — Inappropriate
- Introduce cats' eyes
- Cut back foliage

Preferred option:

Improve carriageway markings and signs - bend will be highlighted
Introduce cats' eyes - better delineation at night
Cut back foliage - improved forward visibility
Estimated cost: £29,000

6. Accident savings

Of the 7 injury accidents, it is estimated that 50% of the loss of control accidents would be saved.

3 accidents saved in 5 years: 0.6 per year

Accident cost saving: 0.6 x £118,550 = £71,130 per year

In this case, there are 2 fatal, 2 serious and 3 minor injury accidents. The proportion of fatal and serious (57% of the total) is higher than expected, and the use of individual costs may be justified.

7. Economic calculation

$$FYRR = \frac{\text{Accident cost saving / year x 100}}{\text{Scheme cost}}$$

$$FYRR = \frac{\text{£71,130 x 100}}{29{,}000}$$

$$= 245\%$$

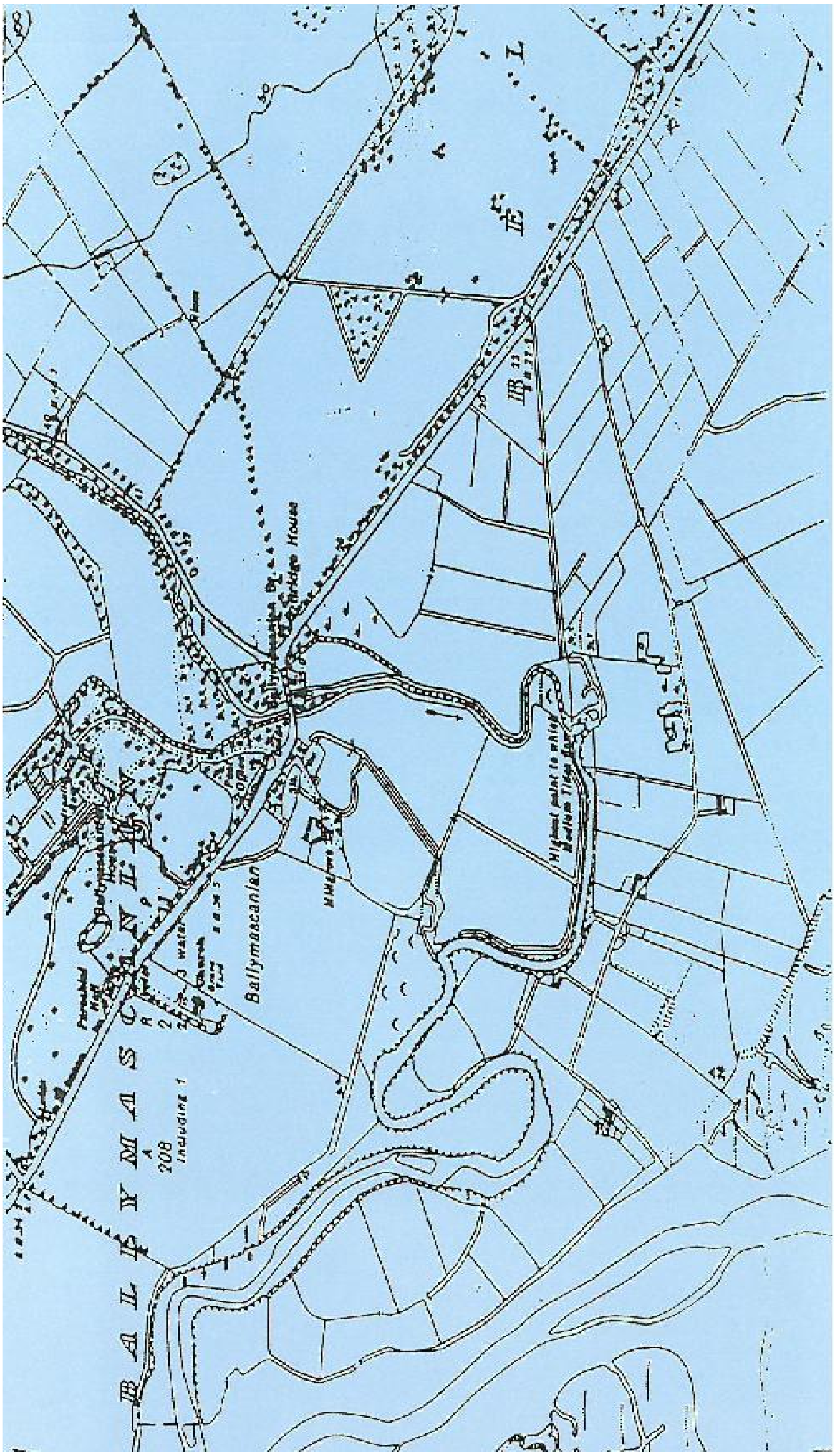
8. Monitoring

Remedial measures as shown in the photographs were completed in Autumn 1993. Up to June 1995 there had been three material damage accidents and no injury accidents.

The early indications are that the remedial scheme has been successful although the site needs to be monitored over a longer period to determine success in statistical terms.

	1	2	3	4	5	6	7
Ref	001	3053	3823	1118	0221	0320	6773
Date	1/1/88	29/7/89	14/7/90	15/7/91	24/8/91	6/11/91	16/12/91
Day	Friday	Saturday	Saturday	Tuesday	Saturday	Wednesday	Monday
Time	04.00	07.30	00.40	10.05	23.10	00.00	02.20
Severity	Minor	Serious	Minor	Serious	Fatal	Fatal	Minor
Weather	Rain	Rain	Fine	Fine	Fine	Fine	Rain
Visibility	Dark		Dark		Dark	Dark	Dark
Road Surface	Wet	Wet	Dry	Dry	Dry	Dry	Wet
No Vehicles	2	2	1	1	1	1	1
Vehicle1	Car	Lorry	M/cycle	Car	Car	Car	Car
Vehicle 2	Car	Van					
No of casualties	2	3	2	1	3	5	1
Casualty 1	Driver V2	Driver V2	Driver V1	Driver V1	Driver V1	Driver V1	Driver V1
Casualty 2	FSP V1	FSP V2	Pillion V1		FSP V1	FSP V1	
Turning movement	2 1	1 2					
Accident type	Loss of control - head on	Loss of control - head on	Loss of control	Loss of control	Loss of control	Loss of control	Loss of control

Tables and Forms: Figure 5.10 Accident Grid for Ballymascanlon Bridge



Tables and Forms: Figure 5.11 Site plan for Balymascanlon Bridge (Source: NRA)

Tables and Forms: Figure 5.12 Before the investigation: Approach from the South-West in advance of Bridge House

Tables and Forms: Figure 5.13 After the investigation: Approach from the South-West in advance of Bridge House

6. Road safety problems along routes

Road accidents do not always cluster at single locations, especially in rural areas. It is often more appropriate to look at lengths of road or routes to identify accident problems.

The accident problem along a route can be defined by the number of accidents per length of road over a particular period of time. Examples of routes suitable for study in this way include:

- a length of rural road with a series of bends
- a length of road through a village
- a length of urban road with a number of minor road junctions

Usually, the highway characteristics will not change significantly throughout the route. For example, it is unlikely that a route would consist of sections of both dual and single carriageway.

The aim of this type of investigation is to determine whether there is a common factor within the accidents occurring throughout the length of the route. For example, it may be that a particular route has a wet road accident problem occurring at both junctions and bends along its length. However, it may be that the analysis of a route will identify site-specific accident problems occurring at certain junctions along the route, which can then be treated as single site problems (see Chapter 5).

Figure 6.1 shows an example of a route with a right turn problem at two consecutive junctions.

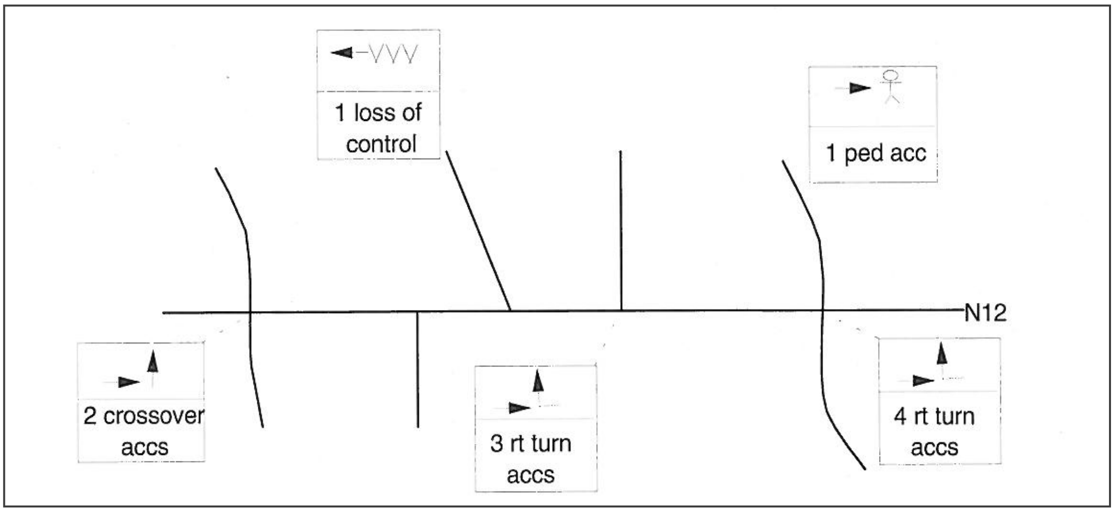


Figure 6.1Route with a right-turn problem at two consecutive junctions

Route accident problems can occur in both urban and rural situations. The general methodology for investigation is similar in both situations, but any differences in emphasis between urban and rural routes are referred to throughout the chapter.

6.1. Methodology

This chapter describes how road safety problems along routes are identified, analysed and treated. The basic methodology for studying and treating road safety problems along routes is shown below:

- Identify the lengths of road with accident problems
- Rank the identified route lengths into priority order
- Analyse the accident and other data for the route
- Define the accident problems in terms of route and/or site specific clusters
- Examine possible remedial measures
- Estimate the accident savings
- Calculate the economic benefits
- Decide on a remedial measure or set of measures in terms of route and/or site specific clusters
- Document the decision in a scheme report
- Implement the remedial measure(s)
- Monitor the effectiveness of the measure(s)
- Update the scheme report

6.1.1. Objectives

Within the methodology described above, there are a number of important objectives for road safety work along routes:

- Each route should have "treatable" accident problems.
- Each treated route should achieve a minimum 30-40% reduction in accidents.
- Each treated route should achieve a minimum 100% economic rate of return.

These objectives are explained in more detail later in this chapter.

6.2. Identifying routes for treatment

Some routes will have been identified by the public through letters of complaint. Such complaints should be considered by checking the numbers of accidents along the route and deciding whether further investigation is justified.

It may be that a route is highlighted because of a number of individual sites along the route each with a small number of accidents. While the individual sites may not justify treatment, there may be some road factors common to the individual sites, which could lend themselves to treatment on a route basis.

A more proactive method is to identify routes for treatment by studying the available accident data. This is normally done by looking for routes with the highest numbers of accidents (per unit length of road) within a given time period.

The first stage of the investigation process is to examine the accident data in a logical manner in order to identify and rank the route lengths.

6.2.1. Time period for analysis

The time period chosen for analysis of the accidents should comprise full 12 month periods, although these do not have to be calendar years. In most cases a five year period would be most appropriate. However, if there are a large number of accidents along a route, then a three year period may be sufficient. The longer the time period, the more likely it is that some changes could have been made along the route that may have influenced the accident record.

6.2.2. Reaction levels

A "reaction level" needs to be established to determine which routes should be looked at in detail. This is normally set by defining a minimum number of accidents occurring on a fixed length of road in a given time period. For example, a reaction level of more than three accidents per kilometre in a five year period could be a starting point for deciding whether to investigate the route further.

Reaction levels should be set in relation to the resources available at a local authority. A local authority may wish to concentrate most of its efforts on single site accident treatments (see Chapter 5), but could also set an objective of undertaking work on two route studies per year. In this case there would be no need to identify 20 routes for treatment, but a reaction level to identify perhaps four routes would be appropriate.

It is suggested that the following minimum reaction levels are used provided that there have been no significant changes to the route during the time period:

- five accidents per km in a five year period at an **urban** location
- three accidents per km in a five year period at a **rural** location

Alternatively, routes where there has been at least one accident per km per year over a five year period could be chosen for investigation.

6.2.3. "Treatable" accidents

In addition to producing a list of routes with high accident numbers per unit length, it is important to try to identify routes that are likely to have "treatable" accident problems that are amenable to road engineering treatments. In other words, routes where there are likely to be common road factors within the accident pattern.
Examples of typical route related problems are:

Treatable route problems in urban situations - Examples include child pedestrian accidents on residential streets and local distributor roads, cycle accidents on distributor roads and adult pedestrian accidents in shopping streets.

Treatable route problems in rural situations - Examples include loss of control accidents throughout a series of bends on a single carriageway road, adult pedestrian accidents through the main road in a village, dark accidents on an unlit main road and shunt accidents involving right turning traffic at a series of minor road junctions.

Figure 6.2 and Figure 6.3 show plots of different accident types marked along a route in an urban area and a rural area respectively.

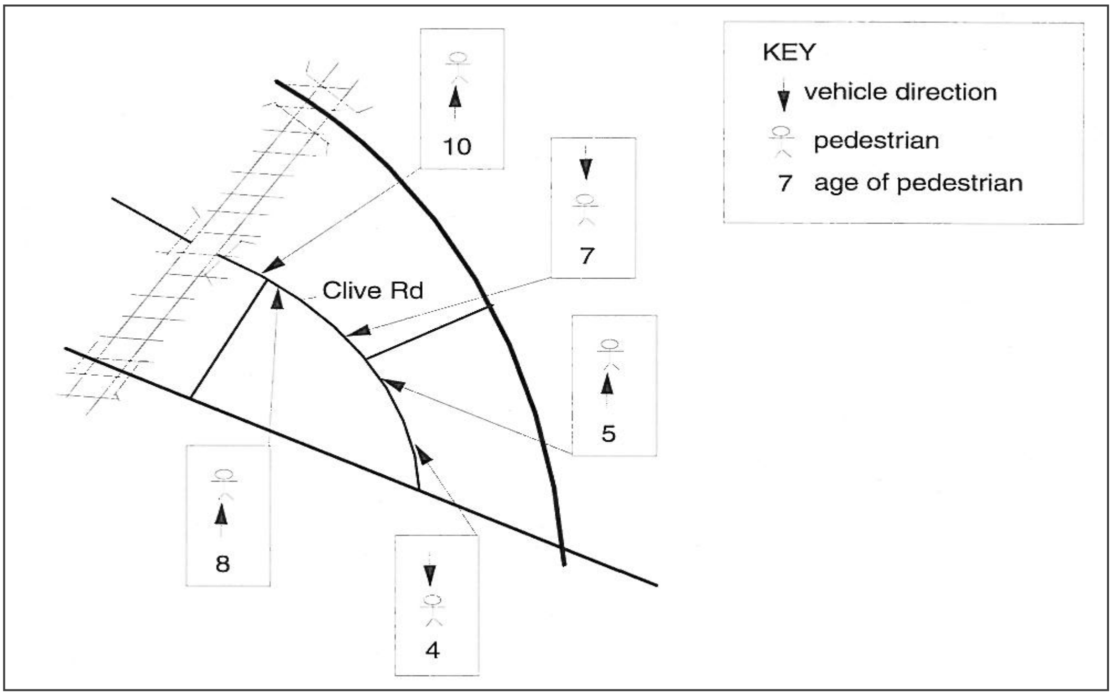


Figure 6.2 Urban: Child pedestrians on a local distributor road

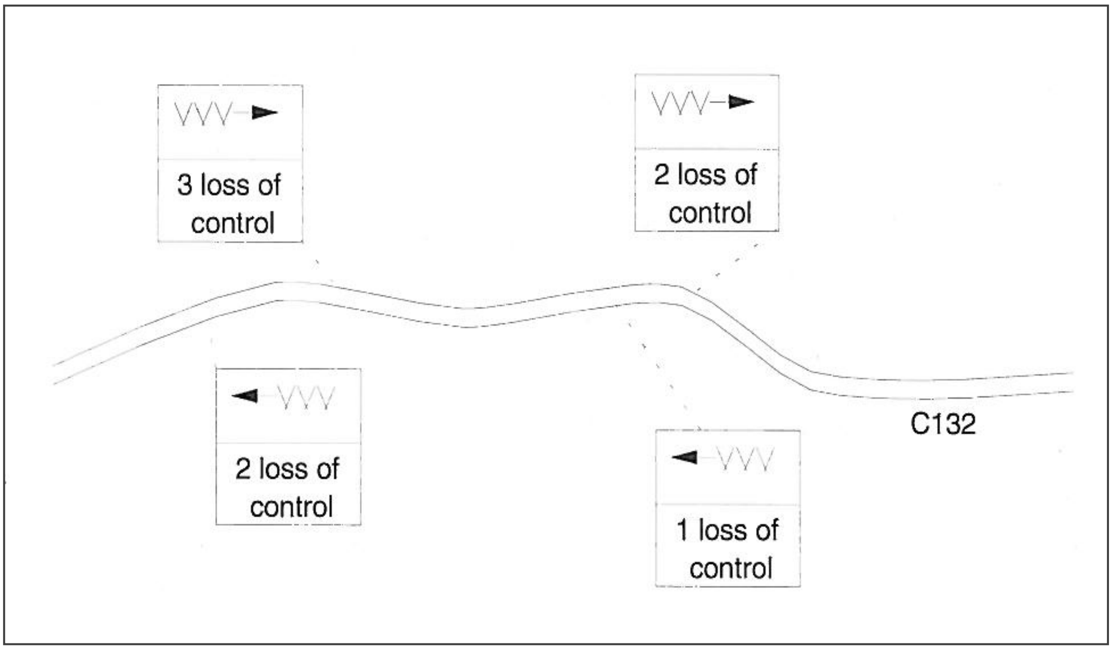


Figure 6.3 Rural: Loss of control on a series of bends

It may be that on first examination of the data there are no obvious common factors. A decision then has to be taken whether to undertake an in-depth study or to look at another route that may be more easily treated. One factor to consider within this decision would be a comparison of the accident rate for the route with a local or national "norm" or expected value. A method for calculating accident rate is given in Appendix 1.

In a situation where accident rate is higher than expected, but where a "treatable" pattern is hard to find, further investigation is justified. It may well be that a general measure related to consistency of road markings and/or signing, or some form of traffic calming, will have an effect in reducing accidents.

6.3. Methods of ranking routes for further study and treatment

6.3.1. Accidents per unit length

The simplest way of ranking routes is to list them in descending order of accidents per kilometre; the route at the top of the list having the highest number of accidents per kilometre per year. In a local authority with mixed land use it may be useful to split the lists into urban and rural routes.

A high number of accidents per kilometre do not necessarily imply a treatable problem- it may reflect a number of single site problems along the route, or be due to exceptionally high traffic flows along the road. In order to identify "treatable" accident problems along a route it will be necessary to carry out further analysis at individual lengths of road on the list.

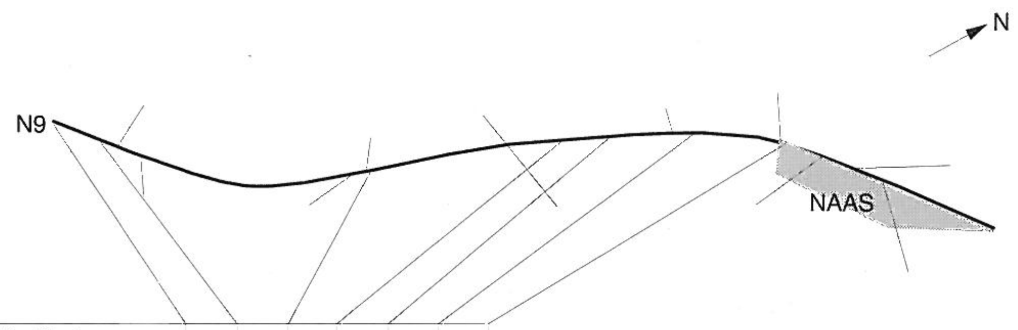
A ranking system for routes in Westmeath would show the following potential route problems for the period 1990 – 92:

- 3 lengths of road with 5 or more accidents per km in 3 years on National Routes;
- 7 lengths of road with 3 or more accidents per km in 3 years on local roads.

These 10 lengths of road represent around 21% of the recorded accidents in Westmeath for the 3 year period.

6.3.2. Accident rates

The NRA has developed a method for ranking routes based on accident rates, whereby the accident total is divided by a measure of traffic flow giving accidents per million vehicle kilometres (51). Figure 6.4 shows High Accident Locations on National Route 9 in Kildare.



Section Number	19-7	19-8	20-1	20-2	20-3	20-4
Section Length Mls	0.39	2.31	1.73	0.22	0.80	0.52
High Risk				+		
Fatal Accidents		1				
F. & P.I Accidents	2	6	4	4	1	2
Accident Rate	0.4	0.2	0.2	1.8	0.1	0.4

Significantly high accident density +

Figure 6.4 High Accident Locations on National Route 9 in Kildare

This method is discussed in Chapter 5 (Section 5.3.2) and an explanation of how accident rates are calculated is given in Appendix 1.

6.3.3. Consistency of ranking method

It is advised that a consistent approach to ranking is adopted for all routes in a local authority area. Due to the absence of flow data for many local roads, it may be appropriate to use accident numbers per unit length of road for all situations, rather than accident rate where flows are available.

6.3.4. Purpose of ranking procedures

The purpose of ranking routes with road safety problems is to produce a list of lengths of road that can be considered for further analysis.

Figure 6.5 shows a flow chart illustrating the use of ranking procedures to identify a series of routes with potential for treatment.

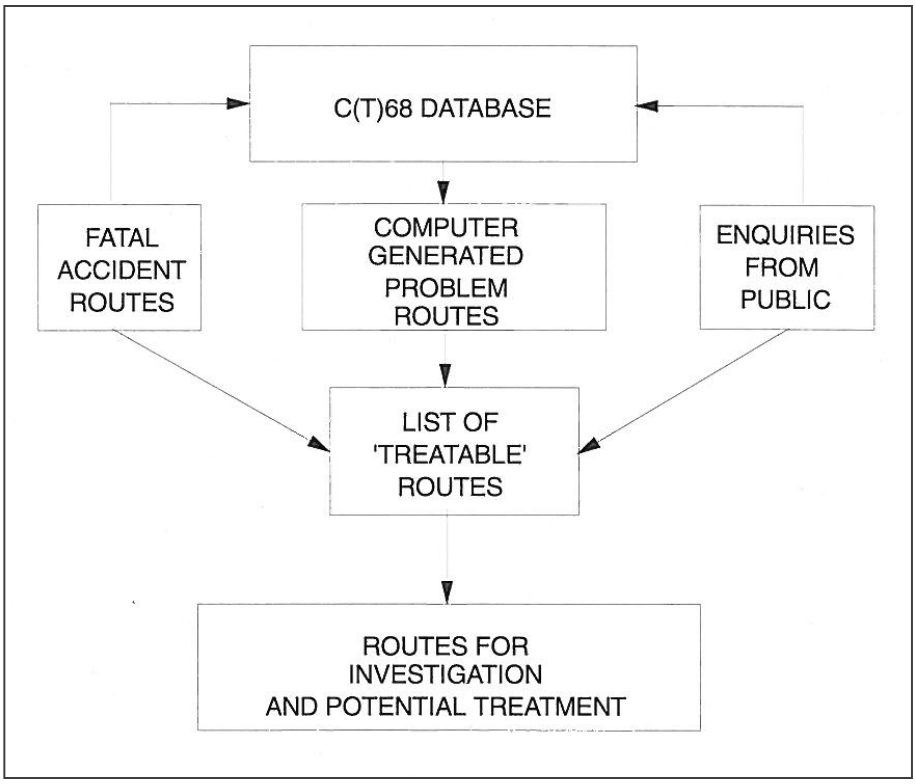


Figure 6.5 Use of ranking procedures to identify a series of routes with potential for treatment

Having produced a list of routes for possible treatment, the next stage of the process is to examine each route in more detail.

6.4. Examining route accident data in detail

The in-depth analysis of a length of road is concerned with the identification of the factors which can explain how the various road users failed to cope immediately prior to the accidents. The analysis should aim to highlight factors common to a number of accidents along the route. The object of the analysis is to arrive at engineering measures that will improve the safety along the route. These engineering measures will sometimes be complemented with behavioural or enforcement techniques, in co-operation with staff from other agencies.

6.4.1. Basic data

The first step in the work is to examine the accident details available. Inspection of all accident data and any available Garda records is essential. Although it may be helpful to examine any material damage accident reports that may be available from either the Gardai or from Area Engineers' records, the level of reporting is low and the amount of information may not be sufficient to provide further details for study.

An analysis of the route as a whole is essential to determine general trends, for example, the proportion of pedestrian accidents on a local distributor road, or the proportion of loss of control accidents on a rural road. These figures can be compared with averages for the county as a whole, to determine whether the route problems are worse than expected.

The accident data can be tabulated for each accident in a group to indicate common features or possible causes. The method normally used to group accidents is to produce a "stick diagram" for each accident and then to produce an "accident grid". Figure 6.6 shows an example of an accident grid.

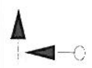
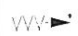
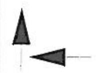
Accident ref. no.	C65	C21	C15	C92	C81	C48	C56	C32	C12
Date	3/2/91	21/10/91	1/12/91	2/3/92	12/7/92	14/1/93	27/9/93	3/4/94	2/9/94
Time		21.50	19.50					23.30	
Severity	Minor	Minor	Serious	Minor	Minor	Minor	Serious	Serious	Minor
Visibility									
Road condition	Wet	Wet		Wet	Wet	Wet	Wet	Wet	
No. of casualties	1	1	2	2	2	1	1	1	2
Casualty 1 Sex:Age	F:39	M:21	M:26	F:34	F:61	M:48	M:41	F:34	M:66
Casualty 2 Sex:Age			M:58	F:48	M:38				M:12
Number of vehicles	2		2	2	2	2	2	1	2
Vehicle 1 type	Car	Car	Car	Car	Car	Car	Car	Car	Car
Vehicle 2 type	Car		M/cycle		Van	Van	Car		Van
Human factor		alcohol							
Turning move-ments									
Comment	River Bridge	Poll Road	Douglas Rd/ Barston Lane	Douglas Rd/ Barston Lane	Cam Lane	Douglas Rd/ Barston Lane	River Bridge	Cony Hill	Douglas Rd/ Barston Lane

Figure 6.6 Accident grid sorted by date of occurrence

The accident grid is used to identify common factors in the accidents. The "sticks" representing each accident can be moved about to change the accident grid and this helps in locating these common factors. For example, along a particular length of road it may be obvious that a number of accidents have occurred on a wet road. By grouping together all the wet road accidents it may be possible to find other common factors such as the direction of travel, or time of day within this sub-group.

Alternatively, the sticks could be sorted by accident location as shown in Figure 6.7. This grid shows that the accidents described in Figure 6.6 have occurred at five separate locations along the route, and that wet road accidents are a persistent problem throughout this stretch of road.

Accident ref. no.	C21	C92	C48	C15	C12	C32	C56	C65	C81
Date	21/10/91	2/3/92	14/1/93	1/12/91	2/9/94	3/4/94	27/9/93	3/2/91	12/7/92
Time	21.50			19.50		23.30			
Severity	Minor	Minor	Minor	Serious	Minor	Serious	Serious	Minor	Minor
Visibility									
Road condition	Wet	Wet	Wet			Wet	Wet	Wet	Wet
No. of casualties	1	2	1	2	2	1	1	1	2
Casualty 1 Sex:Age	M:21	F:34	M:48	M:26	M:66	F:34	M:41	F:39	F:61
Casualty 2 Sex:Age		F:48		M:58	M:12				M:38
Number of vehicles		2	2	2	2	1	2	2	2
Vehicle 1 type	Car	Car	Car	Car	Car	Car	Car	Car	Car
Vehicle 2 type			Van	M/cycle	Van		Car	Car	Van
Human factor	alcohol								
Turning move-ments									
Comment	Pool Road	Douglas Rd/ Barston Lane	Douglas Rd/ Barston Lane	Douglas Rd/ Barston Lane	Douglas Rd/ Barston Lane	Cony Hill	River Bridge	River Bridge	Cam Lane

Figure 6.7 Accident grid sorted by location

When the main factors have been recorded, the accidents can be located onto a plan, and depicted either by their stick diagrams, or by "bubble diagrams". Figure 6.8 shows an example of a bubble diagram. This should reveal whether the route is composed of a series of discrete cluster sites, or if there are genuine route related problems along the length.

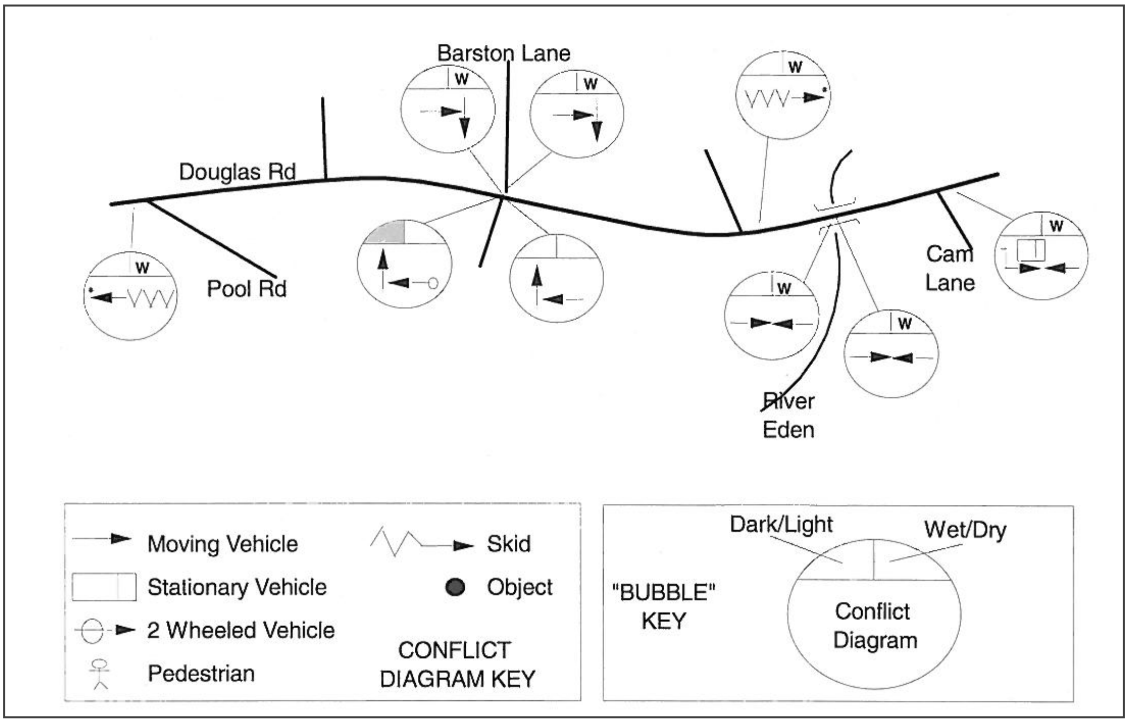


Figure 6.8

In the case of Figure 6.8 there is a cluster site with four accidents at Douglas Road/ Barston Lane. A further two accidents occurred at the river bridge. Wet road accidents occur consistently throughout the route.

6.4.2. Statistical techniques

It is often important to carry out some level of statistical analysis of the road accidents along a route.

It is sometimes useful to compare the accident rate for a route with a rate for other roads of a similar type in the same county.

More information on the calculation of accident totals and standard indicators is given in Chapter 5 (Section 5.4.2). Appendix 2 introduces simple, statistical techniques which will help to identify accident problems and to establish whether these problems have any "statistical significance".

For example, in Figure 6.6, Figure 6.7 and Figure 6.8, 78% of the accidents took place on a wet road surface. The "norm" for this type of road suggests that around 35% of accidents would be expected to take place in the wet. A statistical test will reveal whether the over-representation of wet road accidents at this location is "statistically significant", or just due to random fluctuation.

6.4.3. Collecting additional information

Once the accident record information for a particular length of road has been studied, it will be necessary to collect further information.

The most common sources of this additional information are:

- site visits
- traffic data
- conflict studies

The site visit
The site visit is a very important element in any accident investigation and should be carried out as described in Chapter 5, Section 5.4.3. Video studies are particularly useful for route investigations, especially when taken from inside a vehicle travelling along the route.

An example of a site visit checklist for route investigations is included at the end of this chapter.

Traffic data
A whole range of traffic data can be collected and may be required to assist with the analysis of safety problems along a route. The traffic data will also be useful in determining the type of measures that may be applicable along the route. However, it should be noted that the collection of additional traffic data can considerably increase the cost of an accident study and so it is unlikely that its cost will always be justifiable.

i) Vehicle and pedestrian counts
The use of vehicle and pedestrian counts in route investigations is similar to that in single site investigations (Chapter 5, Section 5.4.3). In addition, for route studies, through route counts are particularly useful and origin and destination surveys could be important on urban residential roads where it is thought that through traffic is causing a problem.

ii) Speed checks
The relationship between speed and accident occurrence is discussed in Chapter 5 (Section 5.4.3).

Knowledge of the speed of vehicles along a route is often useful. Although there may be information already available, it is usually better to undertake new surveys tailored to the accident data. Traffic speed information can either be collected manually using a hand-held radar, or automatically using pneumatic tubes (or buried loops) and a counter.

Consideration must be given to undertaking speed surveys at a number of locations on a route, so that an overall profile of speed is obtained, as opposed to a spot speed at one or two specific locations.

Conflict studies
Conflict studies have been referred to in Chapter 5 (Section 5.4.3) as a way of supplementing site specific accident data, in order to find out more about why road users are failing to cope with their environment. In a route context, the conflict study technique may be useful if the route is composed of a series of junctions exhibiting accident problems.

A method for undertaking a conflict study is given in Appendix 3.

6.5. Defining road accident problems

Once the accident analysis, additional surveys and site investigations have been carried out, the accident problems along the route can be defined. The definition of the problem should be as precise as possible so that a specific measure can be designed to tackle the defined problem. Along routes with a large number of accidents there could be more than one safety problem that needs to be treated.

The problems should be defined very clearly, and a distinction should be made between:

- site specific clusters with individual problems and
- overall route problems

The case study at the back of this chapter (Sections 6.1- 6.4) gives an example of how to define road accident problems for routes.

6.6. Treating the accident problems identified

So far this chapter has concentrated on the identification of accident problems, and the enhancement of accident data through the collection of additional information. Consideration can now be given to what accident remedial measures should be introduced along the route to treat the accident problem identified.

6.6.1. Possible remedial measures

It is important to state that each length of road has its own specific accident problems related to the traffic, road, and road user behaviour characteristics along the route. It is therefore very difficult to prescribe particular standard solutions. This section of the manual is intended to give guidance on possible remedial measures, rather than to dictate specific solutions to problems.

Traffic calming can be used on both urban routes and on the approaches to villages (52).

A list of measures that can be used along urban and rural routes is given at the end of this chapter (Tables and Forms: Table 6.1) together with illustrations of some of the measures. Section 5.6.1gives guidance on the use of a similar list for single site investigations.

6.6.2. The use of traffic signs and road markings

Tables and Forms: Table 6.1 refers to solutions that include the use of road signs and markings. The signs and markings used in road safety schemes should conform with the provisions of the signs regulations or directions of the Minister for the Environment, as appropriate. It is recommended that the procedures for the provision of signs and markings set out in the Department of the Environment Traffic Signs Manual should be followed.

Thermoplastic rumble strips can be used as a speed control device (53). These can be placed on the approaches to unexpected hazards on rural roads, the approaches to roundabouts or traffic signals and the approaches to towns and villages on two-lane roads.

6.7. Estimating accident savings and economic benefits

The next step is to choose a number of options for improving safety and to carry out an economic assessment of the potential benefits of each option.

6.7.1. Accident savings

There may be more than one way of solving some of the accident problems along a route, and in order to compare different options it is important to be able to estimate how many accidents will be saved. Accident savings can be estimated in one of two ways.

a) Overall accident savings
Using information from previous routes where a similar treatment has taken place it is possible to estimate the likely accident saving at the route to be treated. This information should ideally 'be taken from local monitoring of schemes, but where local authorities are new to this work, other sources may have to be used. The information in the list of measures (Tables and Forms: Table 6.1) gives some broad indications of accident reduction in percentage terms. For example, along routes where street lighting has been introduced, accidents in the dark have reduced by 50%.

Different studies have shown a range of results for the same type of treatment. It may be appropriate to provide "optimistic" and "pessimistic" evaluations based on this range.

b) Particular accident savings
In this method it is assumed that unless something is done along the route the existing pattern of accidents will be repeated over time. The accident record is re-examined and each accident assessed to determine whether that particular accident would have happened if the scheme had been implemented. It is sometimes difficult to be positive about whether an

accident would have happened or not, and this method can also generate "optimistic" and "pessimistic" values for accident savings:

Using one or other method it is possible to estimate the number of accidents that will be saved by introducing a particular scheme. The next step is to put a monetary value on the saving.

Section 6.5.1 of the case study at the back of this chapter show an example of how to estimate accident savings.

6.7.2. Economic assessment

The First Year Rate of Return (FYRR) method of economic assessment described in Section 5.7.2 can be used to rank different options along a route, and to rank proposals at different lengths of road.

A more rigorous method of economic assessment usually only used for higher cost schemes known as the Net Present Value (NPV) is explained in more detail in Appendix 4.

An example of an FYRR calculation is given in Section 6.5.1 of the case study at the end of this chapter.

6.8. Comparison between options for treatment along a route

Once the estimates of accident reduction and the economic assessment along a route have been carried out, it is now possible to choose the optimum treatment.

This is likely to be a combination of site specific measures at cluster sites, and route treatments throughout the road length. It may be necessary to rank the options if resources for treatment are limited.

Options should be ranked in order of FYRR. The option with the highest FYRR is then chosen for implementation. However, there should be a note of caution here in that high FYRR values are generally achieved with schemes costing little money but saving fewer accidents. The number of accidents saved within each particular option should also be taken into account, probably in terms of the proportion of the total number of accidents.

Table 6.1 shows options to treat a pedestrian accident problem along an urban route with 15 pedestrian accidents in five years have been ranked according to their FYRR.

Option	Scheme Cost (£)	Accident Savings (% of total)	FYRR (%)
Traffic calming road humps	12,000	50	1165
One way systems	5,000	20	1120
Road closure	20,000	75	1050
Traffic calming chicanes	15,000	35	650
Two pedestrian crossings	30,000	25	235

Table 6.1 Options to treat a pedestrian accident problem along an urban route

A similar approach can be taken to prioritising a series of different routes once the preferred option for each route has been decided.

6.9. Report writing

The route investigation carried out so far should be written up in a clear and concise format. Monitoring the effectiveness of schemes will be made easier if the initial accident study is well documented. Each report should include the following aspects:

- accident analysis - site clusters and route length
- comments from the site visit
- statement of the problem - site clusters and route length
- options for improvement - site clusters and route length
- expected accident savings
- preferred option
- recommendations - site clusters and route length.

The report should be accompanied by plans showing the accident locations and patterns, and plans of the options.

6.10. Implementation of remedial measures

Once a decision has been made on the most effective measure (or series of measures) to be carried out along a route, then the implementation of the work can be arranged. Good records of costs and dates of work on site will be necessary so that scheme monitoring can be carried out effectively.

Schemes targeted at vulnerable road users in particular will benefit from clear, direct publicity within the local community.

6.11. Scheme monitoring

Having carried out treatments along a route it is essential to monitor the effects. Reference has already been made to monitoring in Chapter 4 and Chapter 5 (Section 5.11). A comment on scheme monitoring is given in Section 6.5.1 of the case study at the end of this chapter.

A form that can be used to record information for use in before and after studies is included at the end of the chapter.

6.12. Summary

This chapter has described the methodology for analysing common problems along a specific length of road or route. The main points are as follows:

- Identify the road safety problems based on historical injury accident data.
- Define the accident problems by analysing the data and carrying out a site visit.
- Determine whether problems occur along the whole route, or are specific to individual locations.
- Collect any additional data as necessary.
- Investigate options for treatment within a cost/benefit framework.
- Implement the scheme and monitor the results.

6. Chapter 6: Tables and Forms

- Possible remedial measures for route problems
- Illustrations
- Site visit checklist
- Before and after accident record for route investigation
- Route case study

6.1. Possible remedial measures for problems along routes

Route type	Accident type	Accident sub-type	Possible remedy	% Accident Reduction	Ref.
Rural	Loss of control or shunts	Wet road	Anti-skid or re-surface approach	30-60% all accs, 80% wet	(25) (26)
	Loss of control	Bends	Improve radius of bends	60-80%	(25)
			Improve signing of bends (chevrons, warning signs)	70-80%	(47) (50)
			Introduce rumble strips		(23)
			Remove street furniture	10% mway fatals	
			Protect street furniture		
	Dark		Edge of carriageway markings		(47)
			Hazard marker posts	50-70%	(47)
			Improve reflectivity of signs		
			Introduce/improve street lighting	50% dark accs	(27)
			Improve road markings		
	Pedestrians	Walking beside road	Provide footway		
			Provide warning signs		
		Crossing road	Provide pedestrian refuges		
			Provide warning signs		
	Overtaking		Introduce double white line system		
			Improve overtaking sight distance		
			Introduce central hatching with/without physical islands	50%	(47)
	General	Speed Related	Automatic speed warning signs	35% (Netherlands)	(54)
			Speed limits on rural de-restricted roads	21%	(55)
		Fog	Various		(56)

Tables and Forms: Table 6.1 Possible remedial measures for problems along routes

Route type	Accident type	Accident sub-type	Possible remedy	% Accident Reduction	Ref.
Motorway	Rear end shunt,loss of control		Chevrons on carriageway		(57)
	Dark		Introduce lighting		(58)
	Speed related		Introduction of speed limits	40%	(55)
Urban	Shunt accidents	Wet road	Anti-skid or re-surface approach	30-60% all accs, 80% wet	(25) (26)
	Dark		Edqe of carriaqeway markings		(47)
			Improve street lighting	50% dark accs	(27)
			Improve road markings		
	Pedestrians		30kph streets (limited traffic calming)	24% all accs, 78% serious cas (Denmark)	(59)
			Traffic calming		
			Road humps	90% ped accs, 71% all accs	(60) (61)
			Provide pedestrian refuges		
			Provide pedestrian guard rails		
			Build out footways at crossing points		
			Provide controlled crossings	18% ped accs,28% all accs	(37) (39; 38) (40)
		Crossing behind parked cars	Prohibit parking		
			Create parking lay-bys		
	Cyclists		Provide cycle lanes		
			Provide cycle tracks/routes	20%	(62) (63) (64)
			Provide cycle crossings		
			Sign onto suitable alternative routes		
			Traffic calming	50% cycle accs	(62)
	Speed related		Introduction of speed limits	6-20%	(55)
			Central hatching	30%	(47)

Tables and Forms: Table 6.1 Possible remedial measures for problems along routes (ctd.)

Route type	Accident type	Accident sub-type	Possible remedy	% Accident Reduction	Ref.
Routes through villages	Pedestrians		Build out footway at crossing point		
			Provide controlled crossings	18% ped accs, 28% all accs	(37) (38) (39) (40)
	Speed related		Reduce carriageway width - widen footways		
			Reduce carriageway width - central refuges		
			Priority flow at narrow points		
			Mini-roundabouts at iunctions		
			Road markings, speed limit markings		
			Speed limit signs on backing boards		(50)
			Contrasting road surface treatments		
			Introduce speed limit in combination with above measures		
			Gateways at end of village	45% (Germany)	(65) (66)
			Gateways with signs	7% reduction in speed	(52) (66)
			Gateways with narrowings	10% reduction in speed	(67) (66)
			Gateways with physical measures in village	9-13% reduction in speed	(66) (67) (52)

Tables and Forms: Table 6.1 Possible remedial measures for problems along routes

6.2. Illustrations

Tables and Forms: Figure 6.1 If there is a need to reduce speed at the approach to a roundabout, thermoplastic rumble strips can be installed as shown here on the N20 at Mallow.

Tables and Forms: Figure 6.2 Thermoplastic rumble strips

Tables and Forms: Figure 6.3 Gateway treatments on the approaches to Watergrasshill

Tables and Forms: Figure 6.4 Gateway treatments on the approaches to Watergrasshill

Tables and Forms: Figure 6.5 Gateway treatment

Tables and Forms: Figure 6.6 Gateway treatment. Note the provision of a nearside cycle lane

6.3. Site visit checklist for route studies

It is suggested that the route be divided into sections. Each section should be surveyed using this form.

Site visit checklist for route studies			
General Information	Name of route:	Road number:	
	Date of visit:	Time of visit:	
	Weather conditions:	Road surface conditions:	
	Photo description:	prints/slides/video	
	Number recorded injury accidents in 3 years/5 years:		
	Accident period from:	to:	
	Brief description of accident problem:		
Nature of the road	Length of route		
	Carriageway type: Single/dual		
	Carriageway width:		
	Number of lanes:	Lane widths:	
	Footway:	Y/N	width:
	Verge:	Y/N	width:
	Hard shoulder:	Y/N	width:
	Central reserve:	Y/N	width:
	Central refuge:	Y/N	width:
	Kerb build-out:	Y/N	width:
	Kerb:	Y/N	height:
	Road hump:	Y/N	height:
	Speed limit:		
	Vertical profile:	level/gradient/crest/valley	
	Bend:	Y/N	approx. horizontal radius:
	Visibility restrictions:	Y/N	comment:
	Other comments		
Drainage & surface condition	Channels:		
	Drainage:		
	Cross fall:	Y/N	comment:
	Superelevation:	Y/N	comment:
	Surface type:		condition:
	Other comments:		

Tables and Forms: Table 6.2 Site visit checklist for route studies

Site visit checklist for route studies			
Details of junctions along route	Type of junction:		
	Hard islands:	Y/N	comment:
	Ghost islands:	Y/N	comment:
	Stacking space for turning:	Y/N	comment:
	Turning radii:		
	Visibility restrictions:	approach:	restriction:
		approach:	restriction:
		approach:	restriction:
	Other comments:		
Lighting	Provision:	Y/N	
	Type:	height:	Set back from c/way:
	Intensity:		Siting:
	Other comments:		

Tables and Forms: Table 6.2 Site visit checklist for route studies (ctd.)

Site visit checklist for route studies											
Signs		Sign 1	Sign 2	Sign 3	Sign 4	Sign 5	Sign 6	Sign 7	Sign 8	Sign 9	Sign 10
	Sign Type										
	Siting										
	Reflectivity										
	Illumination										
	Size of face										
	X. ht of letters										
	Pole size										
	Set back from c'way										
	Conspicuity										
	Condition										
	Comments										
Markings		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9	Type 10
	Marking Type										
	Siting										
	Reflectivity										
	Conspicutiy										
	Condition										
	Comments										

Site visit checklist for route studies			
Other features:	Bus route:	Y/N	
	Bus stops:	Y/N	
	Bus shelters:	Y/N	
	Lay-by:	Y/N	
	Accesses:	Y/N	
	HGV route:	Y/N	
	Parking:	Y/N	
	Stationary vehicles:	Y/N	
	Safety fence	Y/N	
	Land use type:		
	Street furniture details:		set back from c'way
	Trees		set back from c'way
	Other comments		
Provision for vulnerable road users	Footway:	Y/N	
	Pedestrian facility	Y/N	type:
	Observed usage during site visit		
	Guard rails	Y/N type:	siting:
		height:	siting:
	Specific signing	Y/N	comment:
	School route	Y/N	comment:
	School crossing patrol	Y/N	comment:
	Cycle facilities	Y/N	type:
	Cycle route	Y/N	comment:
	Observed cycle usage during visit		
	Specific signing	Y/N	comment:
	Other comments		
Sketch plan of route	Record details of relevance to accident problems and attach checklist		
Further speed surveys required	Speed survey	Y/N *manual/automatic*	
	Traffic count	Y/N *manual/automatic*	
	Pedestrian count	Y/N *manual/automatic*	
	Conflict study	Y/N SCRIM test	Y/N
	Other:	Y/N	type:

Tables and Forms: Table 6.2 Site visit checklist for route studies (ctd.)

6.4. Before and after accident record for route investigation

1. Route name:

Road number:

2. Before data:

Brief description of route before measures carried out:
Photographic record: *slides/prints/video*
Number of injury accidents in 3 year/5 year before period:
Dominant accident type(s):
Number of accidents:
Number of material damage accidents in 3 year/5 year before period:
Control data: (NB time periods should be same as for route data)
Number of accidents in rest of county for 3 year/5 year before period:

3. Description of remedial measures:

4. Implementation date:

5. After data: (NB time periods should be same length as before period)

Photographic record: *slides/prints/video*
Number of injury accidents in 3 year/5 year before period:
Dominant accident type:
Number of accidents:
Number of material damage accidents in 3 year/5 year before period:
Control data: (NB time periods should be same as for route data)
Number of accidents in rest of county for 3 year/5 year before period:

6. Chi-squared test tables:

	Route Data	**Control Data**	**Totals**
Before			
After			
Totals			

Chi-squared value	
Significance level	
Interpretation	

6.5. Route Case Study

6.5.1. Grace Park Road, Dublin

1. Location
The route is 800m in length and is located north of the city centre in the Drumcondra area, between Griffith Avenue and Richmond Road.

2. Accident Analysis
Between January 1989 and December 1989 a total of 6 injury accidents were recorded for the stretch of road between Ormond Road North and Griffith A venue.

Of the 6 injury accidents:-

2 involved serious injury, and 4 involved minor injury
1 (17%) occurred in the dark
3 (50%) occurred on a wet road surface
5 (83%) involved some form of loss of control
3 (50%) were head-on collisions

Details of the accidents are shown on the accident grid, and on the bubble diagram of the route. The accidents were distributed along the route between Grace Park Terrace and Ormond Road North. Five of the accidents involved loss of control and three involved head-on collisions.

3. Results of the site visit
The road is an urban single carriageway between 7 and I Om in width. Proceeding south from Griffith Avenue the road widens to around 10m at All Hallows College, and travels through a sweeping "S" bend, straightening out north of Ormond Road North. The road is subject to a 30 mph speed limit, and is lit. The road can be described as a local distributor, carrying around 1,000 vehicles per day.

Details are shown on the photos and location plan.

4. Definition of the accident problem
The accident problem is characterised by loss of control accidents some of which result in head-on collisions. The accidents are considered to relate to inappropriately high speed, in relation to the horizontal alignment of the road.

5. Possible remedial measures

- Re-align Grace Park Road - too expensive and unacceptable land take.
- Road humps - unacceptable to emergency services on this route.
- Introduce other speed reducing measures

Preferred option:

Introduce rumble strips as a speed reducing measure, together with bend warning signs, slow carriageway markings, and localised high skid resistant road surfacing.

Estimated cost: £12,000.

Note: Some of the rumble strips had to be removed due to unacceptably high noise levels.

6. Accident savings
Of the 6 injury accidents, it was estimated that the above measures would reduce loss of control and speed related accidents by 40%.

Annual saving = 2 accidents

Accident cost saving = 2 x £118,550 = £237,110 per year

7. Economic Calculation

$$FYRR = \frac{\underline{\textit{Accident cost saving per year x 100}}}{\textit{Scheme cost}}$$

$$FYRR = \frac{\underline{237{,}110 \times 100)}}{12{,}000}$$

$$FYRR = 1975\%$$

8. Monitoring

Remedial measures as shown in the photographs were completed in 1992.

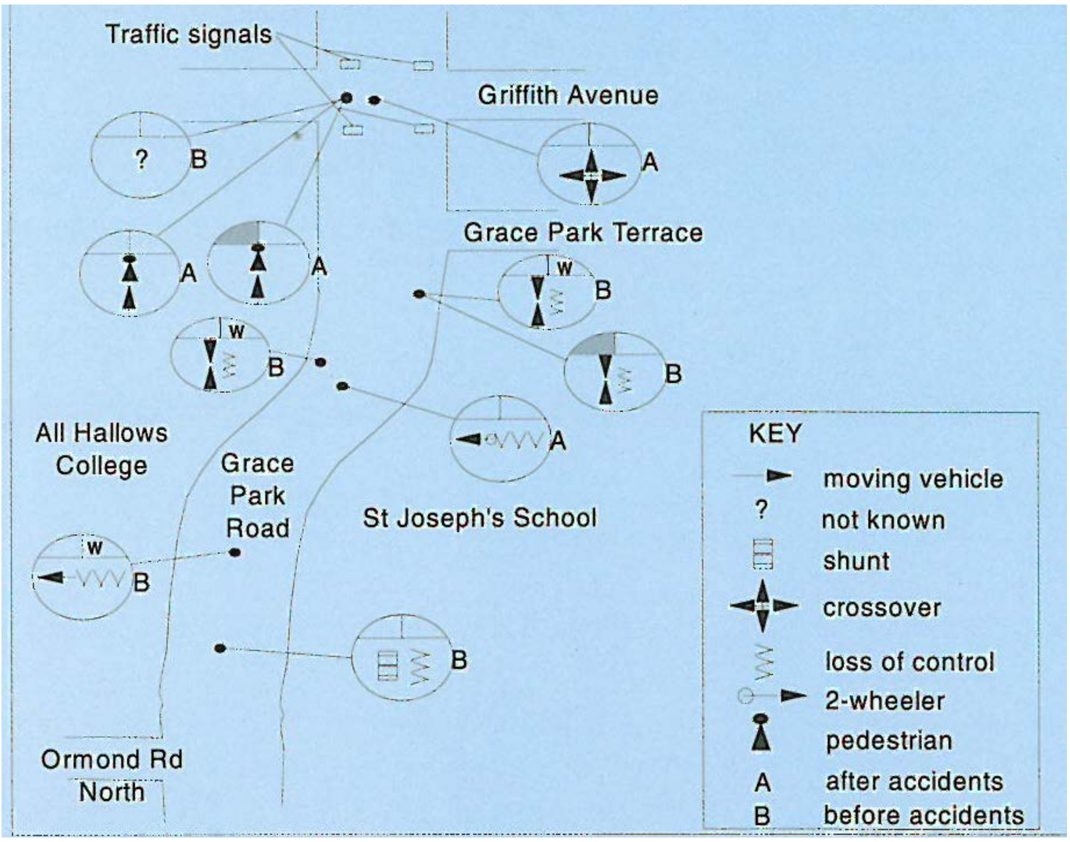
During 1990 and 1991, there were 4 reported injury accidents, three of which took place at the junction with Griffith Avenue. It appears that the scheme has been successful in reducing loss of control collisions along Grace Park Road.

Accident grid for Grace Park Road residents

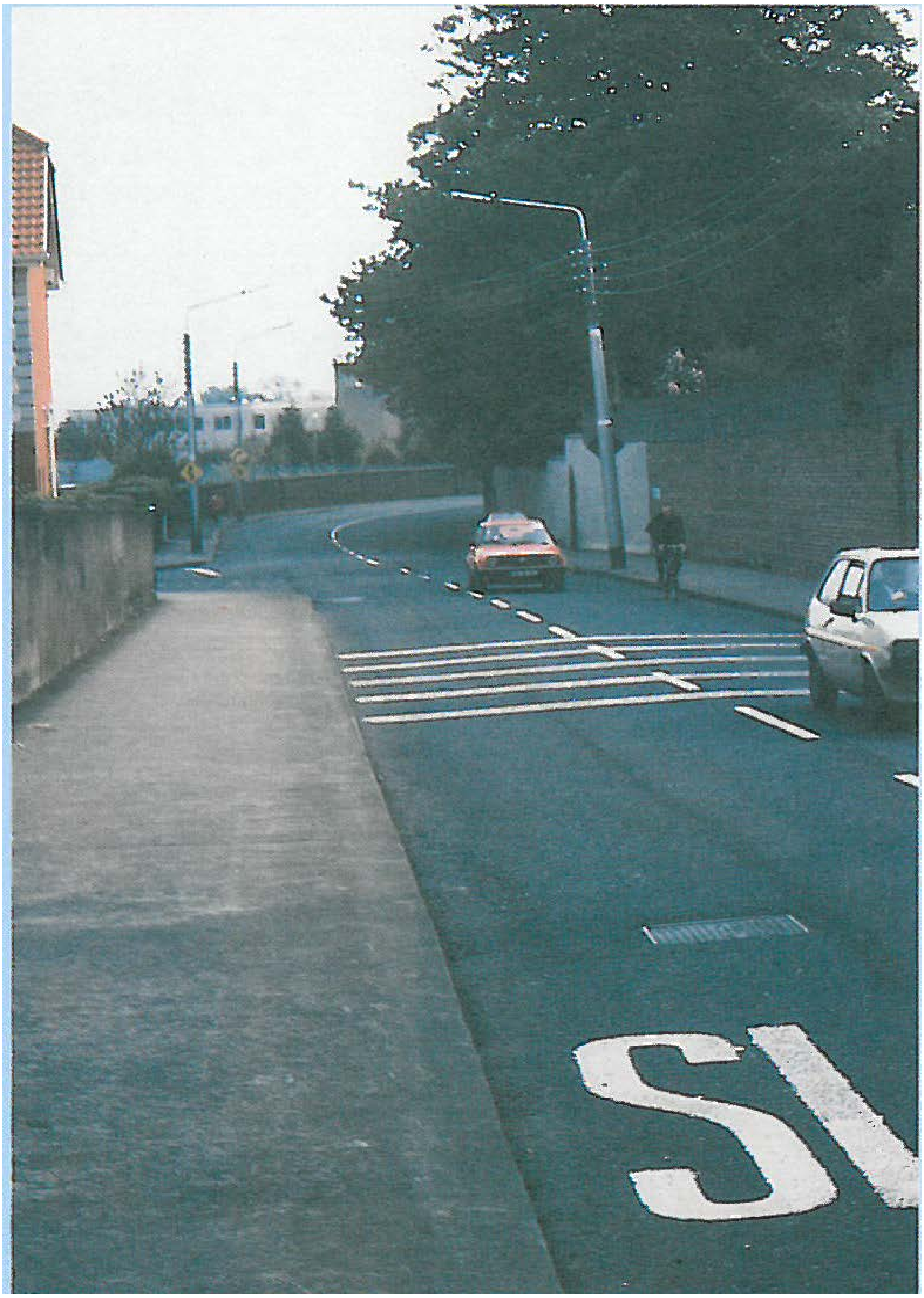
Before | **After**

Date	28/02/1989	09/03/1989	25/03/1989	03/06/1989	03/08/1989	22/10/1989	19/01/1990	22/06/1990	30/03/1991	08/09/1991
Severity	Minor	Minor	Serious	Serious	Minor	Minor	Minor	Minor	Serious	Minor
Time	11:00	19:25	14:00	07:25	11:20	07:55	07:45	08:30	00:45	16:30
Visibility		[redacted]							[redacted]	
Road cond.	Dry	Dry	Wet	Wet	Wet	Dry	Dry	Dry	Dry	Dry
No. of cas.	n/k	1	4	2	4	2		1	1	1
Cas. 1 type:age								ped:10	ped	
Veh. 1 type	n/k	Car	Car	Car	Car	Car	Car	Car	Bus	Motorcycle
Veh .2 type			Van			Motorcycle				
Accident Type	n/k	Head-on	Head-on loss of control	Loss of control	Head-on loss of control	Shunt, loss of control	Red light runner/spe ed	Ped crosses road	Ped crossed road	Single veh, Loss of control
Turning movements	n/k									
Comment				Direction not known			Directions not known		Drunk driver	Direction not known

Tables and Forms: Figure 6.7Accident grid for Grace Park Road



Tables and Forms: Figure 6.8 Bubble diagram for Grace Park Road



Tables and Forms: Figure 6.9 Grace Park Road looking Southbound from North of Grace Park Terrace

7. Mass action methods for treating specific accident types

This chapter describes how a single engineering measure can be applied to treat a specific accident problem that occurs at a number of sites.

Chapters 5 and 6 described how road accidents can be treated on a single site and route basis. It is often the case however that similar accident types occur in very small numbers throughout a large geographic area. For example, in rural areas there could be a number of priority junctions with one or two accidents in a three year period all involving a vehicle failing to yield. None of the individual sites might warrant a specific site treatment, but all the sites could be grouped together and a single treatment applied to all sites. This type of approach to accident reduction is known as the "mass action" approach.

The mass action approach can be used to treat a combination of individual sites or routes where accidents occur. The key to this type of work is identifying common accident types, rather than locations in the first instance. Having identified the prevailing accident types, a search can then be made for locations. This type of search is made much easier if a computerised accident database exists.

The mass action approach can be adopted in both urban and rural situations. The general methodology for investigation is similar in both situations, but there are important differences in emphasis between urban and rural sites. These are referred to throughout this chapter.

In terms of remedies, the mass action approach employs simple, low-cost measures that have proved their effectiveness at other locations. The situation in many rural locations can lead to the adoption of the mass action approach to treat accident problems at sites with low accident numbers. This may form an effective alternative to the site specific approach described in Chapter 5.

7.1. Methodology

This chapter describes how road safety problems can be tackled using the mass action approach. The basic methodology for investigating road safety problems and providing solutions on a mass action basis is shown below:

- Identify the accident types to be treated
- Identify the sites where the particular accident types occur
- Decide on the measure to be used to treat each accident type
- Estimate the accident savings
- Calculate the economic benefits
- Rank the different treatments
- Write a report
- Implement the chosen measure(s)
- Monitor the effectiveness of the measure(s)
- Update the report

7.1.1. Objectives

Within the methodology described above, there are a number of important objectives for mass action road safety work. These objectives are developed more fully within this chapter.

- Each accident type should occur at a number of locations
- Each accident type should be "treatable" by a simply applied method
- The overall mass action programme should achieve a minimum 30% reduction in accidents
- The overall mass action programme should achieve a minimum 50% economic rate of return.

These objectives are explained in more detail later in this chapter.

7.2. Identifying accident types for treatment

There are a number of accident types that lend themselves to mass action treatment. The common factor between the accident types is that they can be treated with a well established remedy that is known to produce accident savings. Due to the likely low accident numbers, the remedies will be of low cost in most cases. Figure 7.1 gives examples of the accident types most commonly treated in this way together with possible remedies.

Urban/rural	Site/route	Accident type	Remedy
Urban	Site	Pedestrian	Guard rails
Both	Site	Wet road skids	Anti-skid surfacing
Both	Site	Failure to yield at priority junctions	Improve signing and lining
Rural	Site	Loss of control at bends	Improve signing Rumble strips
Rural	Route	Dark accidents	Route delineation
Urban	Route	Dark accidents	Improve lighting

Figure 7.1 Examples of the accident types that most commonly receive mass action treatment

The mass action approach can also be used to identify locations where vulnerable road users are most at risk. In this case, the accident type specified would be "pedestrians", "child pedestrians" or "pedal cyclists".

In order to identify which accident types should be treated it is necessary to know how many of each type occur within the local authority area. This is relatively easy to obtain if the accidents are stored on a computer database.

For those authorities with a computer based recording system the database can be searched for the relevant information within the accident causation factors recorded on the C(T)68 forms. The total number of each accident type will give an indication of the relative size of the problem for each accident type.

7.2.1. Identifying sites for treatment

Having established the numbers of accidents within each accident type it is necessary to locate each site where accidents of the particular type have occurred.
If a plotting facility is available as part of the computer system, then this can be easily achieved. If this facility is not available then the accidents will have to be plotted manually.

Each site identified should be examined to find whether accidents of other types occur at the site. If the total number of accidents at a site is high then it may be more appropriate to treat the site in the way described in Chapter 5.

7.2.2. Time period for analysis

The accident types and locations should be established by investigating at least a three year period. If this does not generate sufficient accident numbers then a five year period should be used. However, the longer the time period, the more likely it is that some changes could have been made to the sites or on adjacent sections of road which may have influenced the accident record.

It is suggested that at least three years be used for urban situations, and at least five years for rural situations.

7.2.3. Reaction levels

Mass action programmes require a different approach to reaction levels compared to single sites and routes. In order to apply a mass action treatment it is necessary to have a minimum number of sites with the same accident type. This is more important than the number of accidents at an individual site.

It is suggested that the following minimum reaction levels be adopted:

- Five locations with a similar accident type in an **urban** area
- Three locations with a similar accident type in a **rural** area.

Each of the locations should have one or two accidents of a similar type in a three or five year period. If a location has more than two accidents in the time period it is likely that it will feature in a single site programme as discussed in Chapter 5.

For example, a local authority may find that six priority junctions in a town have each had one "fail to yield" accident in the last three years. This would satisfy the reaction level for a mass action programme of installing improved road signs and markings at each of the junctions.

Figure 7.2 shows a plan of the junctions, with accidents depicted in bubble diagrams.

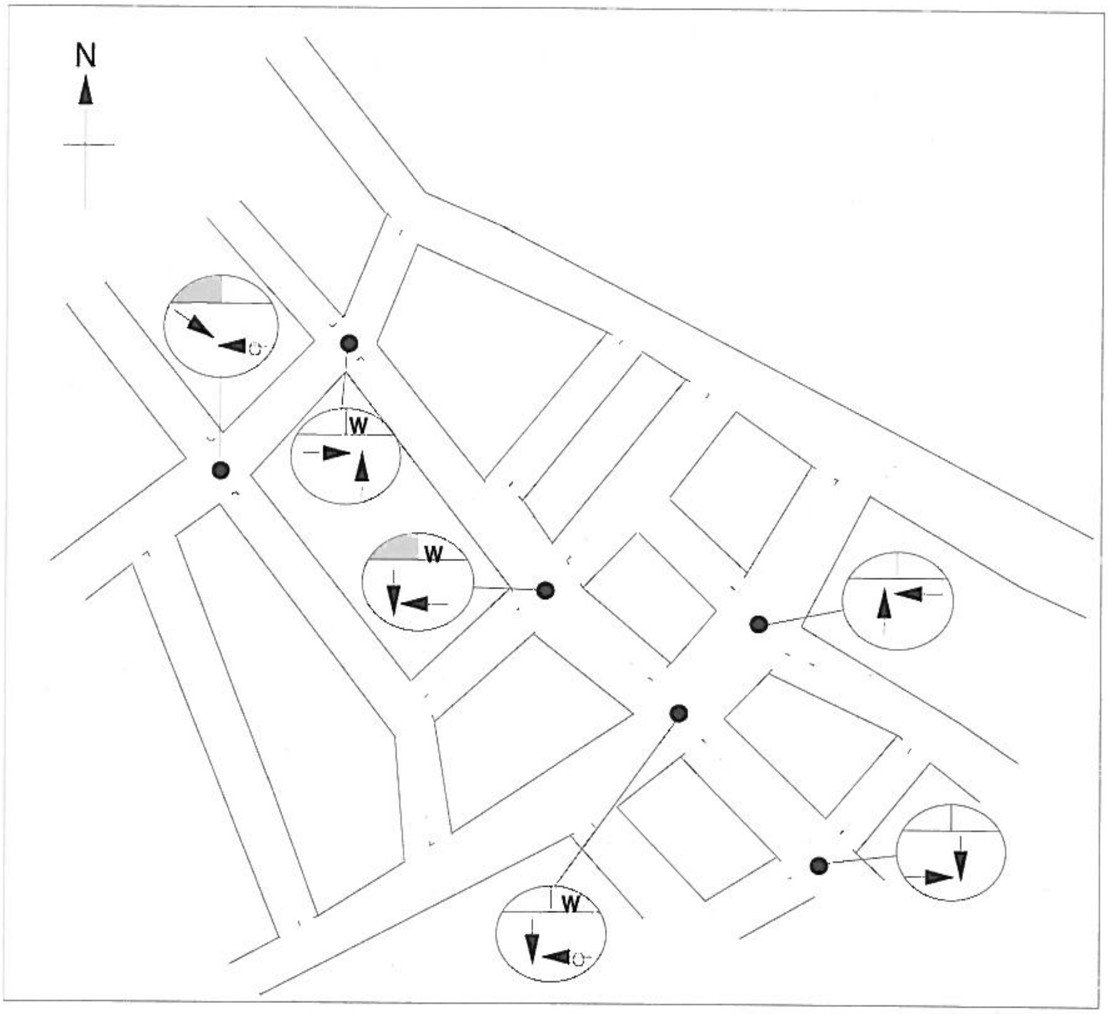


Figure 7.2 Plan of the junctions with "fail to yield" accidents

7.3. Method of ranking mass action programmes

Different mass action programmes can be produced to treat different accident types. It may be necessary to rank the programmes to determine a priority order for action, particularly where the resources available are sufficient for just one or two mass action programmes.

The simplest way of ranking mass action programmes is to list each accident type in descending order of accident total; the accident type at the top of the list having the highest number of accidents for a three or five year period.

Some sites will have more than one accident problem. For example, a minor road junction may have a wet skid accident on one approach, and a fail to yield accident on another. Problems will also occur at sites where a different site specific accident cluster is evident. In these cases the ranking systems need to be modified, and some sites may be taken out altogether or included in a site specific accident problem listing.

7.4. Examining road accident data in detail

The level of accident analysis required for producing a mass action programme is not as exacting as for the other methods of accident reduction. However it is necessary to know three elements for each site that will form part of the proposed mass action programme:

i) the exact location of each site
ii) that there is consistency of accident types throughout all sites
iii) the total number of accidents at each site

7.4.1. Basic data

The first step is to examine the accident details available. Inspection of all accident data and any Garda records is essential. Although it may be helpful to look at any material damage accident reports, the level of reporting is low and the level of information may be insufficient to provide further details for study.

7.4.2. Collecting additional information

Once the accident information for each site has been examined it will be necessary to collect further information from site visits.

The site visit
In the context of a mass action programme the site visit need not be as detailed as it is for the other methods of accident reduction. The features to be established from a site visit will depend on the accident type to be treated and the proposed measures to reduce the accidents. For example, for a fail to yield accident the position and condition of road signs and markings should be checked, and for a wet road accident, the state of the road surface should be checked.

It is useful to take a summary of the accident data to the site visit so that the specific circumstances of each accident can be checked. It is also useful to take a checklist of details that are normally noted.

7.5. Defining road accident problems

The examination of accident details and the site visit should confirm that each site within the group is suitable for a mass action approach to accident reduction. This is shown in section 7.3 of the case study at the end of this chapter.

7.6. Treating the accident problems identified

So far this chapter has concentrated on the identification of accident problems, and the enhancement of accident data through the collection of additional information. With mass action remedies it is possible to be more prescriptive than with single site or route treatments.

7.6.1. 7Possible remedial measures

For a mass action programme the remedies should be simple and effective. It should be possible to introduce a single standard measure at all the sites to be treated.

A list of measures that can be used at urban and rural locations is provided in Tables and Forms: Table 7.1 at the end of this chapter. How to make use of a similar list for single site investigations is described in Chapter 5, Section 5.6.1.

7.6.2. The use of traffic signs and road markings

Tables and Forms: Table 7.1 refers to solutions that include the use of road signs and markings. The signs and markings used in road safety schemes should conform with the provisions of the signs regulations or directions of the Minister for the Environment, as appropriate. It is recommended that the procedures for the provision of signs and markings set out in the Department of the Environment Traffic Signs Manual should be followed.

7.7. Estimating accident savings and economic benefits

The mass action approach involves the adoption of a single measure to improve safety at all the sites identified. An economic assessment can be made of the potential benefits of each mass action programme so that the most cost effective programme is implemented.

7.7.1. Accident savings

Unlike the other methods of accident reduction, it is only possible to calculate accident savings on a global basis when the mass action approach is adopted.

Overall accident savings
Using information from previous sites where a similar treatment has taken place it is possible to estimate the likely accident saving at the sites to be treated. This information should ideally be taken from local monitoring of schemes, but where local authorities are new to this work the information may not be available and other sources may have to be used. The information in the list of remedial measures gives some broad indications of accident reduction in percentage terms. For example at locations where hazard marker posts have been installed, accidents have reduced by between 50% to 70%.

Different studies have shown a range of results for the same type of treatment, and it may be appropriate to provide "optimistic" and "pessimistic" evaluations based on this range.

An example of how accident savings are calculated is given in Section 7.3 of the case study at the end of this chapter.

7.7.2. Economic assessment

The First Year Rate of Return (FYRR) method of economic assessment described in Chapter 5 (Section 5.7.2) is a simple way of calculating whether a mass action programme can be justified in economic terms. The method can be used to rank different programmes targeted at different accident types.

An example of an FYRR calculation is shown in Section 7.3 of the case study at the end of this chapter.

7.8. Report writing

At this stage, the mass action programmes should be written up in a clear and concise format. Monitoring the effectiveness of a mass action programme will be made easier if the initial accident study is well documented. Each report should include the following aspects:

- Identification of the accident type
- Identification of locations with that accident type
- Statement of the problem
- Options for treatment
- Expected accident savings
- Recommendations

The report should be accompanied by plans showing the accident locations and options.

7.9. Implementation of mass action programme

Once a decision has been made on the mass action programme to be carried out, then the implementation of the work can be arranged. Good records of costs and dates of work on each site will be necessary so that monitoring of the whole programme can be carried out effectively.

7.10. Programme monitoring

Having carried out a mass action programme at a series of locations, it is essential to monitor its effect. Reference has already been made to monitoring in Chapter 4 and Chapter 5 (Section 5.10). However, monitoring of mass action programmes involves looking at the total number of accidents before and after treatment across all treated sites, rather than at selected sites. An example of monitoring can be found in Section 7.3 of the mass action case study.

An example of a form that can be used to record data for use in before and after studies is given at the end of this chapter.

7.11. The mass action approach and other strategies

The mass action approach should be seen as complementary to site specific (Chapter 5) and route action (Chapter 6). In urban areas a safety plan should include a site specific, route and mass action strategy. In rural areas where accident numbers are low, the mass action approach may be more appropriate than site specific and route strategies.

7.12. Summary

This chapter has described the methodology for treating common problems by analysing specific accident types. The main points are:

- Identify the accident types and the locations where these accidents occur.
- Investigate options for treatment within a cost/benefit framework.
- Implement the treatment and monitor the results.

7. Chapter 7: Tables and Forms

- Possible remedial measures for mass action investigations
- Before and after accident record form

7.1. Possible mass action remedial measures

Location	Accident Type	Accident sub-type	Possible remedy	% Accident reduction	Ref.
Rural roads	Loss of control	Wet road	Anti skid surfacing	30-60% all accs, 80% wet	(25) (26)
			Re-texture existing surface		
		Dark	Edge of carriageway markings		(28)
			Hazard marker posts	50-70%	(47)
			Cats' eyes		
	Dark		High reflective signs	up to 78%	(50)
	Overtaking		Introduce double white lines		
Rural bends	Loss of control		Improve warning signs/chevrons		(50)
		Wet road	Re-texture existing surface		
Uncontrolled junction	Overshoot		Improve signs and markings	16%	(68)
		Wet road	Anti-skid on minor road approaches	30-60% all, 80% wet	(25) (26)
Traffic signals	Shunt	Wet road	Anti-skid surfacing	30-60% all, 80% wet	(25) (26)
	Pedestrians		Pedestrian guardrail	10%	
		Children	High visibility pedestrian guardrail		
Roundabouts	Loss of control	Dark			
		Hitting central island	Flexible chevron signs		
	Overshoot		Yellow bar markings on approach	50%	(41) (42)
			Rumble strips on approach	35%	(43)
Pedestrian crossings	Shunt	Wet	Anti-skid surfacing	30-60% all, 80% wet	(25) (26)
	Pedestrians	Near crossing		10%	
		Near crossing - children	High visibility guardrail		
Schools	Pedestrians		Improve warning signs		

Tables and Forms: Table 7.1 Possible mass action remedial measures

7.2. Before and after accident record for mass action investigations

1. Number of sites: **Accident type:**

2. Before data:

Brief description of sites before measures carried out:
Photographic record: *slides/prints/video*
Number of injury accidents in *3 year/5 year* before period:
Dominant accident type:
Number of accidents:
Number of material damage accidents in *3 year/5 year* before period:
Control data: (NB time periods should be same as for route data)
Number of accidents in rest of county for *3 year/5 year* before period:

3. Description of remedial measures:

4. Implementation date:

5. After data: (NB time periods should be same length as before period)

Photographic record: *slides/prints/video*
Number of injury accidents in *3 year/5 year* after period:
Dominant accident type:
Number of accidents:
Number of material damage accidents in *3 year/5 year* after period:
Control data: (NB time periods should be same as for site data)
Number of accidents in rest of county for *3 year/5 year* after period:

6. Chi-squared test table:

	Site Data	**Control Data**	**Totals**
Before			
After			
Totals			

Chi-squared value	
Significance Level	
Interpretation	

7.3. Mass Action Case Study

7.3.1. Fail to yield accidents

1. Accident type

A search through the accident data of a county revealed that, outside built-up areas, there were 10 locations where 2 or more accidents in a 5 year period involved a vehicle failing to yield from a minor road into a major road, and where the minor road had road markings but no yield sign.

2. Accident analysis

The accident record for the 10 sites was as follows:

Site No	*Fail to yield* accidents	Other accidents
1	3	1
2	2	2
3	2	0
4	3	1
5	2	1
6	3	0
7	3	1
8	3	0
9	2	5
10	2	2
Total	25	13

Examination of all accidents at the 10 locations showed that at one of the sites where there were 2 accidents involving a failure to yield, there were a further 5 accidents of various types in the 5 year period (Site No 9). This site was considered to be more suitable for a single site treatment and was not subject to a mass action treatment.

3. Site visits

Site visits were carried out to each of the 9 locations. The site visits revealed that at 2 of the sites there were already yield signs in place (Site Nos 8 and 10), despite the fact that the C(T)68 forms had shown that only road markings were present. At four of the other sites it was considered that the maintenance of the road markings was poor, and that the markings should be replaced.

4. Proposed mass action treatment

The proposed mass action treatment was to install yield signs on the minor roads at the 7 locations without yield signs. In addition, to repaint the road markings at the 4 sites where the existing markings were in a poor state of maintenance.

Site No	Fail to yield accidents	Other accidents	Treatment
1	3	1	2 yield signs
2	2	2	1 yield sign/repaint markings
3	2	0	1 yield sign
4	3	1	2 yield signs/repaint markings
5	2	1	1 yield sign
6	3	0	1 yield sign/repaint markings
7	3	1	1 yield sign/repaint markings
Total	18	6	

5. Cost
The total estimated cost for erecting yield signs at 7 locations and repainting road markings at 4 locations was £6,500.

6. Accident savings
The 7 locations had between them 18 "fail to yield" accidents in the 5 year period. It was estimated that the introduction of yield signs would reduce accidents of this type by 30%.

5.4 accidents saved in 5 years = 1.08 per year

Accident cost saving: 1.08 x £118,550 = £128,034 per year

7. Economic calculation

$$FYRR = \frac{\text{Accident cost saving per year} \times 100}{\text{Scheme cost}}$$

$$FYRR = \frac{1.08 \times 118{,}550 \times 100}{6{,}500}$$

$$FYRR = 1970\%$$

8. Implementation
Work was completed at the 7 sites in 1992 at an actual cost of £6,940.

9. Monitoring
In the two years since implementation there have been 4 fail to yield accidents at the sites (a reduction from 3.6/year to 2/year). This is in line with the predicted decrease. There have been 2 accidents of other types at the sites, showing that there has been no increase in other accidents.

A Chi Squared Test has been carried out to determine whether the reduction in fail to yield accidents is statistically significant.

	7 Sites	Control	Totals
Before	9	460	469
After	4	520	524
Totals	13	980	993

Chi Squared = 1.74. This gives a significance level of better than 20%.

The test result is only indicative that there has been a real reduction in accidents. The sites should continue to be monitored so that a longer time period can be used to check the significance of the results.

8. Area-wide road safety problems

Previous chapters have looked at ways of reducing road accidents by examining single sites and routes where the accidents cluster together. However, it is sometimes the case that certain categories of road accidents are scattered throughout an area without producing any "treatable" accident clusters. An example of this is the spread of pedestrian accidents throughout residential roads in an urban area.

The area-wide treatment of road accident problems is generally confined to urban areas in larger towns and cities although the method can be applied to areas within small towns and even villages. The general methodology for investigation is similar in each situation, although this chapter refers mainly to the urban situation.

The majority of roads contained in an area under investigation are generally those with no strategic traffic function, typically residential roads, but may be bounded by traffic routes.
The treatments available on an area-wide basis tend to be more general than for single sites and routes. Traffic calming in some form is often used to treat area-wide accident problems.

8.1. Methodology

This chapter describes how road safety problems are identified, analysed and treated on an area-wide basis. The basic methodology for studying and treating area-wide road safety problems is shown below:

- Identify the general areas with an accident problem
- Define the boundary of each area
- Rank the areas into priority order
- Analyse the accident and other data within each area
- Carry out a site visit
- Define the accident problems
- Examine possible remedial measures
- Estimate accident savings
- Calculate economic benefits
- Decide on a remedial measure or measures
- Document the decision in a report
- Consult the relevant bodies
- Implement the remedial measures
- Monitor the effectiveness of the measure(s)

8.1.1. Objectives

Within the methodology described above, there are a number of important objectives for area-wide road safety work:

- Each area should have a reported accident problem
- Each treated area should achieve a minimum 40-50% reduction in accidents
- Each treated area should achieve a minimum 50% economic rate of return

This chapter explains the methodology and objectives of treating area-wide road safety problems in more detail.

8.2. Identifying areas for treatment

Potential areas for treatment are normally identified by looking for grid squares with the highest numbers of accidents in a given period, but where the accidents do not cluster together at single sites or along routes. Accidents involving vulnerable road users (pedestrians, cyclists) often reveal the areas most likely to be appropriate for area-wide treatments. Having identified the grid squares, the actual area boundaries are defined as described in Section 8.2.5.

The identification process is made much easier with a computer based accident system. Where this does not exist, areas can be identified by referring to C(T)68 forms and manually plotting different types of accidents onto a map.

Figure 8.1 shows a plot of child pedestrian accidents in a large urban area.

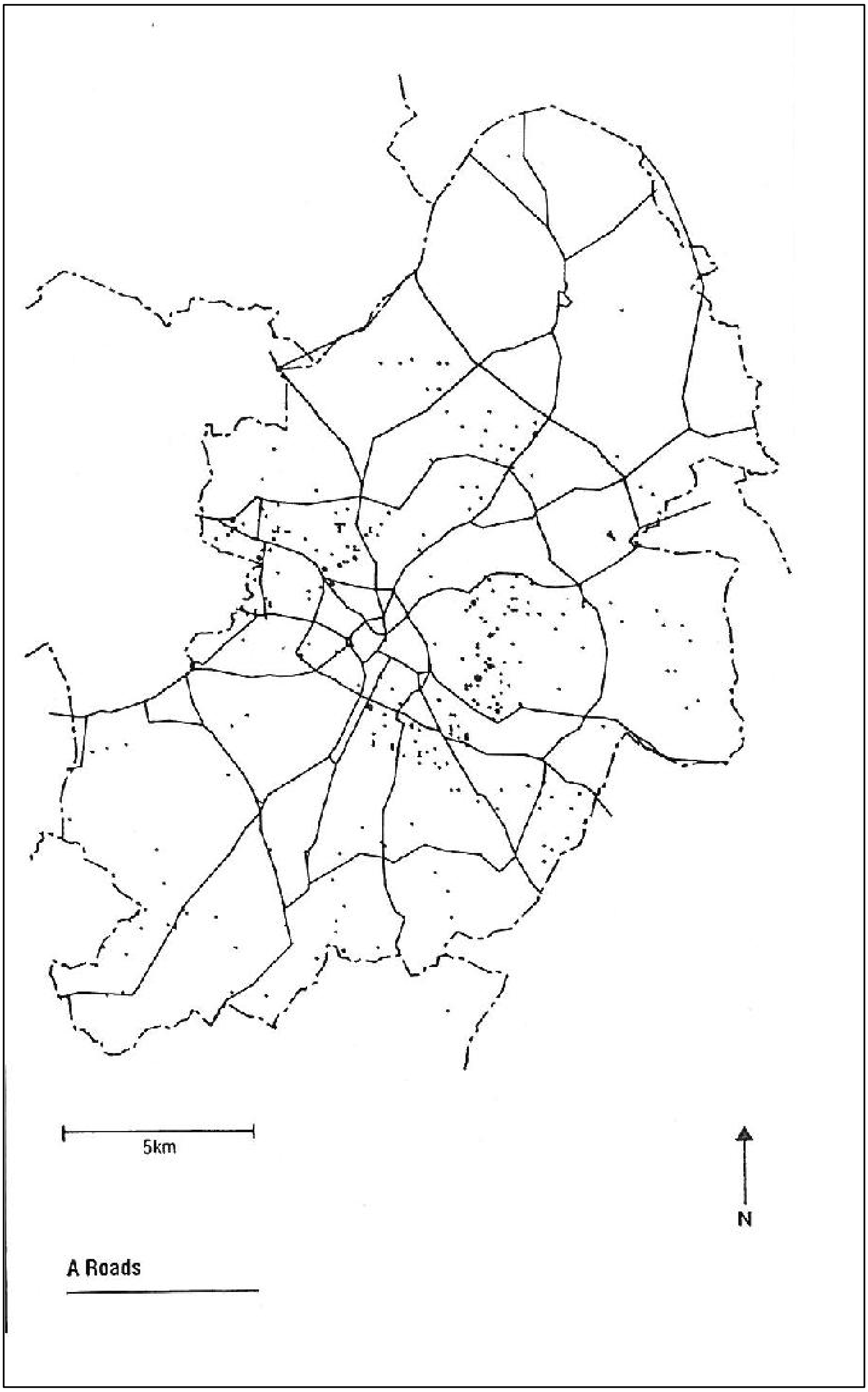


Figure 8.1 Plot of child pedestrian accidents in Birmingham

(Source: AA Foundation, Birmingham City Council)

8.2.1. Time period for analysis

The time period chosen for analysis of the accidents should comprise full 12 month periods, although these do not have to be calendar years. A five year period is normally used for area-wide studies since accident numbers in individual roads are likely to be small. Care should be taken to find out if there have been any substantial changes in the area which may have influenced the accident record.

8.2.2. Reaction levels

It is more difficult to establish nation-wide reaction levels for area-wide investigation than it is for single sites and routes. Clearly the number of accidents in a residential area of Dublin will be different from a residential area in a small town.

Most counties are unlikely to have more than three or four potential areas for treatment and it is suggested that a programme of study should be produced to investigate each area over a period of time.

There are likely to be more potential areas for treatment in the cities, and here it is suggested that the following minimum reaction level be adopted:

- More than 40 accidents in a five year period per kilometre square in cities
- More than 15 accidents in a five year period per kilometre square in towns

8.2.3. Approach to area-wide studies

An area-wide study may involve the analysis of large numbers of accidents, distributed throughout a number of roads of different classes within an urban area. The approach should involve an initial investigation of all accidents to identify trends and high-risk user groups.

The boundary to the area should take account of both natural features and major traffic routes. The analysis of problems is likely to include the identification of site-specific and route problems on boundary roads that may need treatment in their own right.

Within the residential streets, it is likely that accidents will be more dispersed and the treatments will probably be implemented throughout the area.

8.2.4. “Treatable” Accidents

Chapters 5 and 6 outlined the approach to identifying treatable accidents at sites and routes. The discovery of distinct common causes within accidents may not always be possible for an area-wide study. Within an area that has a comparatively high number of accidents, it is more likely that the analysis will reveal groups of accidents involving "vulnerable" road users, for example pedestrians, child pedestrians and cyclists. However, the possibility of finding site specific or route problems with more specific types of treatable accident should not be overlooked.

8.2.5. Defining the boundary of an area

Having established where a general problem area may exist by reference to grid squares it is necessary to identify the actual boundary of the area to be investigated.

The area should ideally be one bordered by main traffic routes (National Routes) or by features such as rivers or railways. The roads within .the area are generally those with no strategic traffic function. Figure 8.2 shows an area bounded to the west by a railway line, to the north and south by a major traffic route and to the north-east by a park.

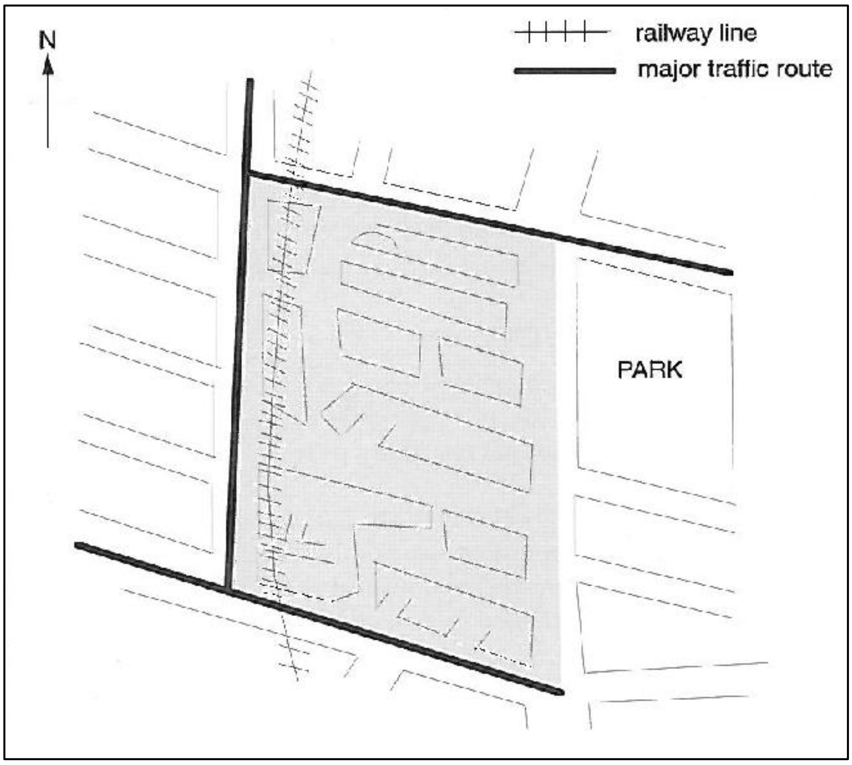


Figure 8.2 Area bounded by railway line and major traffic route

It is important to remember that implementing measures in one area could transfer the problem to a neighbouring area. This should be kept in mind when boundaries are being established and attempts should be made to establish as discrete an area as possible.
The investigation of the area defined can then be carried out.

8.3. Method of identifying and ranking areas for treatment

The purpose of ranking problems on an area-wide basis is to produce a list of areas which can be considered for further analysis.

8.3.1. Accident totals

The simplest way of ranking potential areas for treatment is to list them in descending order of accident total; the area at the top of the list having the highest number of accidents for a five year period.

8.3.2. Accidents per kilometre square

In order to compare the relative road safety problems between areas it is possible to rank the areas by comparing the number of accidents per kilometre square. A list can then be produced with top priority given to the area with the highest accident number per kilometre square.
Such a method would reveal the following potential areas for the three year period 1990-1992:

- 23 areas with more than 40 accidents per km^2 in Dublin City
- 4 areas with more than 40 accidents per km^2 in Cork City
- 3 areas with more than 40 accidents per km^2 in Limerick City

8.3.3. Specific accident types

Identifying areas by specific accident type can lead towards potential solutions. For example, identifying areas by pedestrian accident numbers can produce a list of areas where traffic calming measures are likely to reduce accidents.

Most local authorities will find it relatively straight-forward to identify one or two areas with high accident numbers. For those authorities in large cities with more areas highlighted in this manner, the list could be modified by a search for pedestrian accidents only, and ranked in descending order of pedestrian accident total.

Having produced a list of sites for possible treatment, the next stage of the process looks at bow individual areas are examined in more detail.

8.4. Examining area accident data in detail

The object of the area-wide accident analysis is to arrive at engineering measures which will improve road safety in the area. These engineering measures will sometimes be complemented with behavioural or enforcement techniques, in cooperation with staff from other agencies.

8.4.1. Basic data

The first step in the work is to examine the accident details available. Inspection of all accident data and any available Garda records is essential.

The first use of the data should be to examine the accidents on a "global" basis. This will identify the spread of accidents throughout the day, the week and the year. It will also identify the road users most commonly involved in the accidents. For example, it will be important to know the proportion of child pedestrian accidents, and the proportion of accidents involving parked vehicles, compared to expected figures for the local authority.

Each accident in the area can be tabulated to indicate common features or possible causes. The method normally used to group accidents is to produce a "stick diagram" for each accident and then to produce an "accident grid".

The accident grid can be used to identify common factors in the accidents. The "sticks" representing each accident can be moved about to change the accident grid and this helps in locating these common factors. For example, in a particular area it may become clear that a number of accidents have involved child pedestrians; by grouping together all the child pedestrian accidents it may be possible to find other common factors such as crossing behind parked vehicles within this sub-group.

A plot of all the accidents should be made so that individual accidents can be located as accurately as possible. The plot should identify different accident types where appropriate. For example, accidents involving child and adult pedestrians, or accidents involving parked vehicles could be highlighted. It may be useful to depict each accident type with symbols on a plan of the area. An example of an accident plot of this type is shown in Figure 8.3. At this stage it will be possible to determine whether any site specific or route problems are evident within the area being studied.

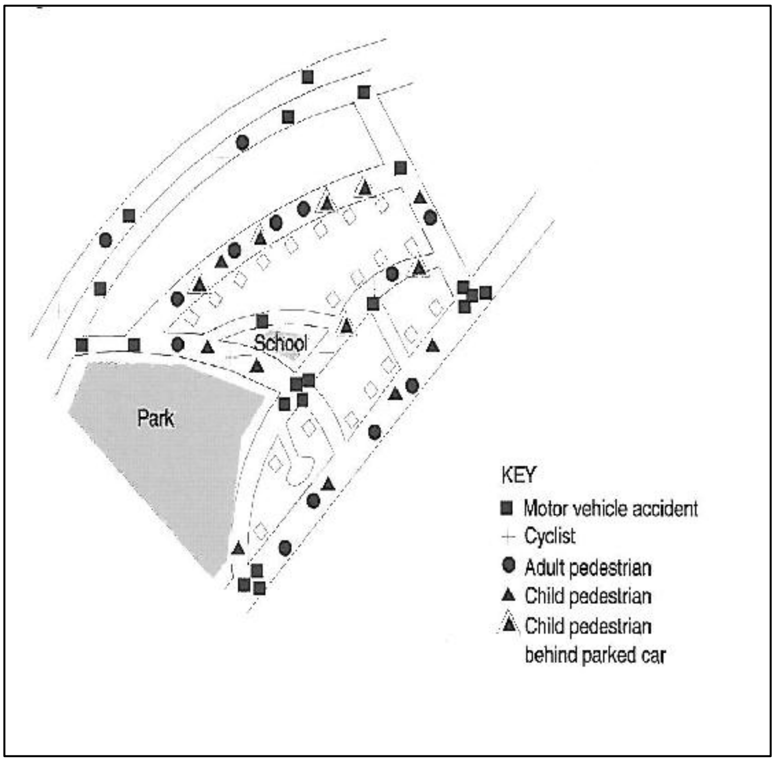


Figure 8.3 Example of an accident plot

Inspection of individual C(T)68 forms may provide the journey details of those involved in accidents. This information can reveal whether the drivers are passing through the area or live within the area, and assist in determining the possible remedial measures that may be appropriate. An example of accident analysis in an area is given in Section 8.5 of the case study at the end of this chapter.

8.4.2. Statistical techniques

It is often important to carry out some level of statistical analysis of the road accidents in an area. The principles are similar to those described in Chapter 5 (Section 5.4.2) for single site investigations. Of particular interest will be comparisons for pedestrians, child pedestrians, and pedal cyclists.

8.4.3. Collecting additional information

Once the accident record information for a particular area has been studied, it will usually be necessary to collect further information.
The most common sources of this additional information are:

- Site visits
- Consultation
- Traffic data

The site visit
The site visit is a very important element in any accident investigation and is described in detail in Chapter 5, Section 5.4.3.

For area-wide investigations, all the roads throughout the area should be visited. The land use adjacent to the roads should be noted so that features such as schools, playing fields and shops can be identified. Highway features such as road and footway widths, the position of signs, lengths of road where vehicles are parked, traffic regulation orders, and the position of bus stops may be important. Pedestrian routes through the area and any crossing facilities should be located. All these features should be recorded on suitable scale plans of the area.

An example of a site visit checklist is given at the end of this chapter.

Informal consultation
In conjunction with on-site investigation, collecting information from local people, either living in the area or regular users of the roads or footways in the area will provide data covering activity over an extended time period. The local shop owner or resident may be worthy of interview in order to complement the accident details.

However, all this information should always be used with extreme care as it will undoubtedly contain subjective statements and opinions.

The local Garda officer often has knowledge of both recorded and unrecorded accidents in an area and should be contacted during the investigation.

Traffic data
A whole range of traffic data can be collected and may be required to assist with the analysis of safety problems in an area. The traffic data will also be useful in determining the type of measures that may be applicable. However, it should be noted that the collection of additional traffic data can increase considerably the cost of an accident study.

Vehicle and pedestrian counts
The potential for traffic diversion may need to be taken into account when proposing solutions for area-wide problems and so traffic volume is clearly an important factor.
The number of vehicles passing through an area and pedestrian activities on the roads will provide useful information on exposure to risk of the various road user groups.
A full origin and destination survey can be used to quantify the volume of through traffic in an area. However, collection of this type of information is particularly expensive.
More information on the collection and use of traffic counts is given in Section 5.4.3.

Speed checks
Knowledge of the speed of vehicles on roads within an urban area is very important when carrying out an area-wide study and it is usually preferable to undertake new speed surveys which can be tailored to the accident data.
The relationship between speed and accident casualty rates is discussed in Section 5.4.3.

8.5. Formal consultation

In addition to the informal consultation referred to in Section 8.4.3, it may be appropriate to carry out more formal perception studies, in order to obtain a structured local view on safety issues. This should be undertaken with a postal or household questionnaire survey of a sample of residents, schools and businesses from within the area.

At this stage, discussions with the emergency services can prove very useful. An explanation of the accident problems in the area, and the possible approaches to solutions can be weighed against the needs for access for fire service and ambulance vehicles, for example.

8.6. Identifying the road hierarchy within an area

The analysis of traffic and speed data will assist in the identification of the road hierarchy for the area under study. Roads should be classified in terms of their strategic importance. Generally speaking roads within a study of this type will fall into one of three or four categories:

- Access or residential streets
- Local distributor roads
- District distributor roads
- Primary traffic routes

Figure 8.4 illustrates the road hierarchy from the example in Figure 8.3.

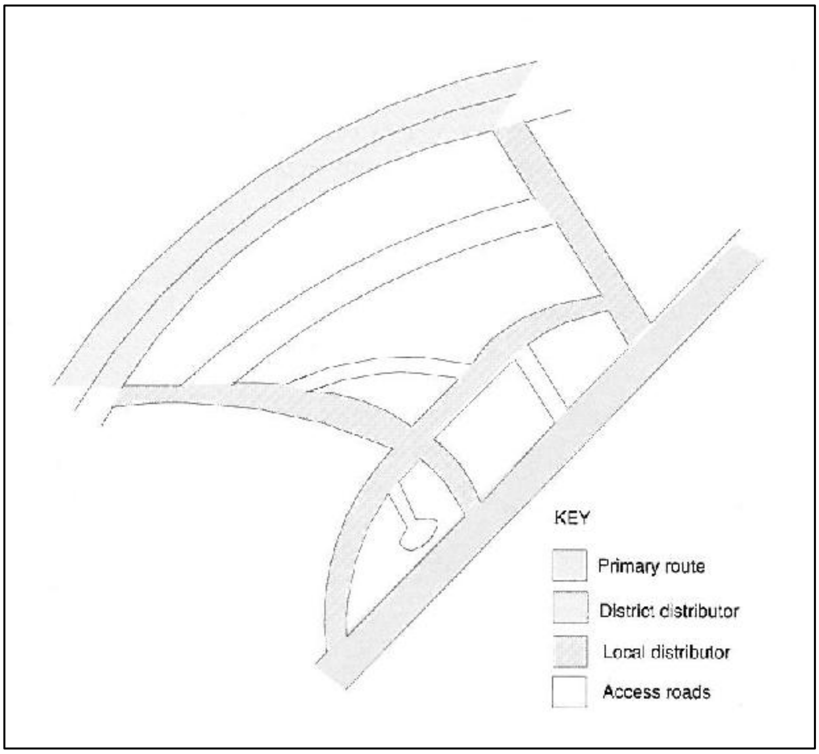


Figure 8.4 Road hierarchy from Figure 8.3

The position within the hierarchy is determined by the volume of traffic (in relation to local comparisons), and the extent to which the route is used by traffic with an origin and destination outside of that particular road. Section 8.5 of the case study at the end of this chapter illustrates the road hierarchy for a specific area.

It is unlikely that the eventual treatments on primary routes will be similar to those on access streets. Indeed, it is often the case that the primary route forms the boundary to an area under study.

8.7. Defining road accident problems

Once the accident analysis, additional surveys and site investigations have been carried out, the accident problems for the area can be defined. The definition of the problems should be as precise as possible so that a specific measure or a package of measures can be designed to tackle the problems. In areas with a large number of accidents there could be more than one safety problem that needs to be treated.
The accident problems should be defined in terms of:

- Overall comparisons with expected levels
- Identification of site specific problems
- Identification of route problems
- Identification of overall area-wide problem

The accident problems should then be compared with the existing road hierarchy, in order to design a strategy for treating the problems. It may be the case that some roads with residential purpose are being used as local distributors, and that any scheme will have to attempt to change the existing hierarchy by reducing the impact of traffic on that street, as part of the area-wide treatments.

The next stage of the engineering process is to undertake an economic assessment of options for remedial treatment.

8.8. Treating the accident problems identified

So far this chapter has concentrated on the identification of accident problems, and the enhancement of accident data through the collection of additional information. Consideration can now be given to what remedial measures should be introduced throughout the area.

8.8.1. Approach to remedial measures

Within area-wide studies, there may be site specific, route, and/or more general area-wide accident problems. The approach to treating the site and route problems is similar to that described in Chapters 5 and 6 respectively. The approach to treating area-wide problems must have due regard to the road hierarchy that has been defined, and the accident problems that require attention.

It is likely that some area-wide treatments will require either measures of traffic severance or traffic calming (53). Traffic severance generally means implementing road closures and one-way systems in order to re-distribute traffic throughout an area. Traffic calming permits access, but attempts to reduce the speed of traffic through the implementation of horizontal and vertical features such as chicanes and road humps. Road authorities should refer to Section 38 of the 1994 Road Traffic Act when designing schemes.

Figure 8.5 shows an example of road humps, one of the most popular speed control devices for residential roads (69). Road humps installed by Dublin Corporation over a 1.25 km length of road have reduced the speed of traffic by 20-40%. Authorities wishing to install road humps should note that specific warrants are required for the use of these devices. Horizontal features like chicanes, kerb build-outs and road narrowing can be effective in reducing speed. Figure 8.6 shows an example of chicanes.

Figure 8.5 Example of road humps

Figure 8.6 Example of chicanes

Care must be taken to ensure that the transfer of traffic and accidents is minimised. Severance and calming treatments can not be applied throughout the road hierarchy, without regard for the volume and type of traffic being carried. This theme is developed in more detail in the next section.

8.8.2. Possible remedial measures

It is important to state that each area has its own specific accident problems related to the traffic, road, and road user behaviour characteristics within the area. It is therefore very difficult to prescribe particular standard solutions. This section is intended to give guidance on possible remedial measures, rather than to dictate specific solutions to problems.

A list of measures that can be used for area-wide treatment is provided at the end of this chapter (Tables and Forms: Table 8.1). The references are based on work carried out throughout northern Europe since 1970. Section 5.7.2 should be referred to for guidance on how the list should be used.

8.8.3. The use of traffic signs and road markings

Table 8.1 refers to solutions that include the use of road signs and markings. The signs and markings used in road safety schemes should conform with the provisions of the signs regulations or directions of the Minister for the Environment, as appropriate. It is recommended that the procedures for the provision of signs and markings set out in the Department of the Environment Traffic Signs Manual should be followed.

8.9. Estimating accident savings and economic benefits

The approach taken to arriving at a solution to accident problems in an area is to generate a number of options for improving safety and to carry out an economic assessment of the potential benefits of each option so that the most cost effective option is implemented.

8.9.1. Accident savings

Where there is more than one way of solving some of the accident problems in an area it is important to be able to estimate how many accidents will be saved by each option. Accident savings can be estimated in one of two ways using "overall" or "particular" accident savings as described in Section 5.7.1.

An example of how to calculate accident savings is given in Section 8.5 of the area-wide case study at the back of this chapter.

8.9.2. Economic assessment

The method of economic assessment described in Section 5.7.2 is the First Year Rate of Return (FYRR) and can be used to rank different options for an area, and to rank proposals for different areas.

An example of an economic assessment is shown in the case study at the end of this chapter.

8.9.3. Comparison between options for treatment for an area

After carrying out the estimates of accident reduction and the economic assessment for an area it is now possible to decide on the best treatment in the area. The easiest way to do this is to rank the options in order of FYRR. The option with the highest FYRR is then chosen for implementation.

8.9.4. Further consultation

Informal consultations may have taken place during the analysis stage of an area-wide study as suggested earlier in this chapter. Prior to implementation, it is important that the views of the local community are considered, so that local people understand the reasons why the scheme is being undertaken. An exhibition of the options, with the opportunity for formal response, is recommended. An example from a model constructed to demonstrate proposals for a scheme in Watergrasshill is shown in Figure 8.7.

Figure 8.7 Model demonstrating proposals for a scheme in Watergrasshill

Publicity, designed specifically to increase local awareness of area-wide schemes, is particularly appropriate, as it provides opportunities to explain measures to the road users who are most at risk, and who are likely to benefit most from the improvements.

In addition, the views of the emergency services should be obtained since their travel times through an area may be increased by the implementation of some options.

There may well be a statutory requirement for consultation if traffic orders are to be introduced as part of the scheme.

8.10. Implementation of treatment

Once a decision has been made on the most effective measure (or series of measures) to be carried out in an area, then the implementation of the work can be arranged. Good records of costs and dates of work on site will be necessary so that scheme monitoring can be carried out effectively.

8.10.1. The Fermoy traffic accident study

An area traffic scheme has been implemented in Fermoy following a study into the road accidents in the town in the mid 1980's. The following accident statistics refer to accidents in Fermoy between 1970 and 1984 (Table 8.1)

Casualty type	Number of accs	% of total accs
Pedestrian under 15	29	21%
Adult pedestrian, daylight	18	13%
Adult pedestrian, darkness	22	15%
Pedal cycle	9	7%
Motor cycle	27	20%
Other	36	23%

Table 8.1Accident statistics for Fermoy between 1970 and 1984

Pedestrians and pedal cyclists accounted for more than 55% of the total accidents in Fermoy. A number of treatments were implemented including the installation of pedestrian refuges and footpath widening as shown in Figure 8.8. Complementary strategies on enforcement and education were introduced at the same time.

Figure 8.8 Installation of pedestrian refuges and footpath widening in Fermoy

8.11. Report Writing

At this stage in the investigation process, the area-wide study should be written up in a clear and concise format. Monitoring the effectiveness of area-wide treatments will be made easier if the initial accident study is well documented.
Each report should include the following aspects:

- General accident analysis throughout area
- Specific analysis of the problems

- Site comments
- Traffic and speed data analysis
- Initial consultations
- Statement of the problems (sites, routes and/or areas)
- Identification of the road hierarchy
- Options for improvement
- Expected accident savings
- Preferred option
- Further consultation
- Recommendation

The report should be accompanied by plans showing the accident locations and patterns, and plans of the options.

8.12. Scheme monitoring

Having carried out treatments in an area it is essential to monitor the effects. For an area-wide study, it is important to monitor the number of accidents as well as traffic speeds and flows. Reference has already been made to monitoring in Chapter 4 and Chapter 5 (Section 5.12).

In addition to the potential accident benefits of a scheme introduced on an area-wide basis, there could be considerable changes to traffic patterns through the area.

For example, if traffic calming measures are introduced then traffic speeds will be reduced and traffic flows may reduce in the affected road but increase in adjacent roads. Any monitoring should investigate the possibility of transfer of traffic onto alternative routes.

Table 8.2 shows the results of a speed monitoring programme in an area where traffic calming has been implemented successfully. This subject is illustrated in Section 8.5 of the case study at the end of this chapter.

Road Name	85%ile speed (mph) before Implementation	85%ile speed (mph) 6 weeks after implementation	85%ile speed (mph) 6 months after implementation
Railway Rd (Eastbound) (Westbound)	34.6 32.8	13.4 13.6	13.9 14.1
Cork Rd (Northbound) (Southbound)	33.4 34.6	11.7 10.8	12.3 10.5
Church Ave (Eastbound) (Westbound)	31.7 36.2	14.2 14.9	14.1 15.3

Table 8.2 Results of a speed monitoring programme in an area where traffic calming has been implemented

An example of a form used to collect information for use in before and after studies is included at the end of this chapter.

8.13. Summary

This chapter looks at the analysis and treatment of accidents within a defined urban area. The main points are:

- Define the boundaries of those areas to be investigated
- Rank the areas to be investigated according to the number of accidents per square kilometre
- Identify the road accident problems in the area in terms of overall problems as well as site specific and route problems
- Carry out a visit to the area once accident analysis and statistical tests have been carried out
- Establish the road hierarchy in the area under investigation
- Initiate a consultation process with the local community and emergency services
- Look at possible remedial measures and carry out economic assessments
- Write a report prior to implementation of remedial measures which will be beneficial once the monitoring process is started
- Monitor the effects of the scheme on speeds and accidents, both inside the area and on the boundary and adjacent roads

8. Chapter 8: Tables and Forms

- Possible remedial measures for area-wide investigations
- Illustrations
- Site visit checklist
- Before and after accident record for area-wide investigations
- Area-wide case study

8.1. Possible remedial measures for area-wide investigations

Location	Accident type	Accident sub-type	Possible remedy	% Accident reduction	Ref.
Residential roads	All accident types (especially those involving vulnerable road users)		Traffic management including road closures	13% all accs, 33% pedal cyclists	(70)
			Traffic calming by vertical features (ramps)		(69)
			Traffic calming by horizontal features (build-outs, chicanes etc)		
Shopping areas	All accident types (especially those involving vulnerable road users)		Traffic calming by vertical features (speed cushions)	43% pedestrians	(71)
			Traffic calming by horizontal features (build-outs, chicanes etc)		
			Full pedestrianisation		(72)
			Partial pedestrianisation		
		At pedestrian crossings	Ramps at crossing points		
			Build-outs at crossing points		
Villages			Gateways and traffic calming		(73) (53)
General					(74) (22) (6) (72) (75) (60) (59) (61) (76) (77) (78) (79) (71) (80) (70) (81) (69) (66) (82)

Tables and Forms: Table 8.1 Possible remedial measures for area-wide investigations

8.2. Illustrations

Tables and Forms: Figure 8.1Example of speed cushions in Moabit, Berlin

Tables and Forms: Figure 8.2 Example of speed cushions in Moabit, Berlin

Tables and Forms: Figure 8.3 Example of Dutch woonerf

Tables and Forms: Figure 8.4 Example of Dutch woonerf

Tables and Forms: Figure 8.5 Traffic severance (road closure) in Birmingham, UK

Tables and Forms: Figure 8.6 Provision for cyclists in The Hague, Netherlands

8.3. Site visit checklist

Site visit checklist for area-wide studies			
General Information	Name of site:	Road number:	
	Date of visit:	Time of visit:	
	Weather conditions:	Road surface conditions:	
	Photo description:	prints/slides/video	
	Number recorded injury accidents in 3 years/5 years:		
	Accident period from:	to:	
	Brief description of accident problem:		
Nature of the road	Carriageway type: Single/dual	Carriageway width:	
	Number of lanes:	Lane widths:	
	Footway:	Y/N	width:
	Verge:	Y/N	width:
	Hard shoulder:	Y/N	width:
	Central reserve:	Y/N	width:
	Central refuge:	Y/N	width:
	Kerb build-out:	Y/N	width:
	Kerb:	Y/N	width:
	Road hump:	Y/N	width:
	Speed limit:		
	Vertical profile:	level/gradient/crest/valley	
	Bend:	Y/N	approx. horizontal radius:
	Visibility restrictions:	Y/N	comment:
	Other comments		
Drainage & surface condition	Channels:		
	Drainage:		
	Cross fall:	Y/N	comment:
	Superelevation:	Y/N	comment:
	Surface type:		condition:
	Other comments:		
Junction details	Junction site:	Y/N	
	Type of junction:		
	Hard islands:	Y/N	comment:
	Ghost islands:	Y/N	comment:
	Stacking space for turning:	Y/N	comment:
	Turning radii:		
	Visibility restrictions:	approach:	restriction:
		approach:	restriction:
		approach:	restriction:
	Other comments:		
Lighting	Provision:	Y/N	
	Type:	height:	Set back from c/way:
	Intensity:		Siting:
	Other comments:		

Tables and Forms: Table 8.2 Site visit checklist for area-wide studies

Site visit checklist for area-wide studies											
Signs		Sign 1	Sign 2	Sign 3	Sign 4	Sign 5	Sign 6	Sign 7	Sign 8	Sign 9	Sign 10
	Sign Type										
	Siting										
	Reflectivity										
	Illumination										
	Size of face										
	X. ht of letters										
	Pole size										
	Set back from c'way										
	Conspicuity										
	Condition										
	Comments										
Markings		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9	Type 10
	Marking Type										
	Siting										
	Reflectivity										
	Conspicutiy										
	Condition										
	Comments										

Tables and Forms: Table 8.2 Site visit checklist for area-wide studies (ctd.)

Site visit checklist for area-wide studies			
Other features	Bus route:	Y/N	
	Bus stops:	Y/N	
	Bus shelters:	Y/N	
	Lay-by:	Y/N	
	Accesses:	Y/N	
	HGV route:	Y/N	
	Parking:	Y/N	
	Stationary vehicles:	Y/N	
	Safety fence	Y/N	
	Land use type:		
	Street furniture details:		set back from c'way
	Trees		set back from c'way
	Other comments		
Provision for vulnerable road users	Footway:	Y/N	
	Pedestrian facility	Y/N	type:
	Observed usage during site visit		
	Guard rails	Y/N type: height:	siting: siting:
	Specific signing	Y/N	comment:
	School route	Y/N	comment:
	School crossing patrol	Y/N	comment:
	Cycle facilities	Y/N	type:
	Cycle route	Y/N	comment:
	Observed cycle usage during visit		
	Specific signing	Y/N	comment:
	Other comments		
Sketch plan of area	Record details of relevance to accident problems and attach checklist		
Further speed surveys required	Speed survey	Y/N *manual/automatic*	
	Traffic count	Y/N *manual/automatic*	
	Pedestrian count	Y/N *manual/automatic*	
	Conflict study	Y/N SCRIM test	Y/N
	Other:	Y/N	type:

Tables and Forms: Table 8.2 Site visit checklist for area-wide studies (ctd.)

8.4. Before and after accident record for area-wide investigations

1. Area name:

2. Before data:

Brief description of area before measures carried out:

Photographic record: *slides/prints/video*
Number of injury accidents in *3 year/5 year* before period:
Dominant accident type(s):
Number of accidents:
Number of material damage accidents in *3 year/5 year* before period:
Control data: (NB time periods should be same as for site data)
Number of accidents in rest of county for *3 year/5 year* before period:

3. Description of remedial measures:

4. Implementation date:

5. After data: (NB time periods should be same length as before period)

Photographic record: *slides/prints/video*
Number of injury accidents in *3 year/5 year* after period:
Dominant accident type(s):
Number of accidents:
Number of material damage accidents in *3 year/5 year* after period:
Control data: (NB time periods should be same as for site data)
Number of accidents in rest of county for *3 year/5 year* after period:

6. Chi-squared test table:

	Area Data	**Control Data**	**Totals**
Before			
After			
Totals			

Chi-squared value	
Significance level	
Interpretation	

8.5. Area-wide Case Study

8.5.1. Seven Streets Area, Sparkhill, Birmingham, England

1. Location
The area consists of a total of nine roads within the Sparkhill area of Birmingham, England. The area is shown on the location plan (Tables and Forms: Figure 8.8).

2. Accident analysis
In the 5 year period 1987 to 1991 there were a total of 41 accidents within the area.

Of these accidents:

22 (54%) involved a child pedestrian
All 9 roads had at least 1 pedestrian accident each
23% of accidents occurred in the dark
9 (22%) involved an adult pedestrian
2 roads had 7 pedestrian accidents
30% occurred in the wet

Detailed examination of the child pedestrian accidents showed that almost all the children lived in the area, many injured in the road in which they lived. The majority of children were under 11 years old. The drivers involved in these accidents generally lived outside the area.

3. Site visits
The area is predominantly residential with mostly terraced housing with no off-street parking. All the roads are single carriageway with footways both sides with an adequate system of street lighting. The roads bounding the area are all distributor roads. Most of the roads are long and straight and there is a considerable amount of on-street parking.

4. Other information
Traffic flows on the roads are generally between 100 and 200 vehicles per hour in the peak periods.

Traffic speeds are generally between 20 and 35 mph (85 percentile).

In terms of road hierarchy, Moseley Road is a primary route, and Highgate Road is a district distributor road. Brighton Road, Ladypool Road and Clifton Road are local distributors, with the remaining routes being access roads.

5. Definition of the accident problem
Accidents involving pedestrians, especially children under 11 years. Drivers involved in the accidents are usually passing through the area.

6. Possible remedial measure

- Road closures but: removes through traffic; unpopular with residents; unacceptable to emergency services
- One-way streets but: removes some through traffic; detours for residents; likely to increase speeds
- Traffic calming but: reduces speeds; discourages through traffic; through traffic not prohibited

Preferred option:
The use of traffic calming including road humps.

7. Cost
The estimated cost for introducing traffic calming throughout the area is £170,000.

8. Accident savings
It is estimated that traffic calming will reduce accidents by 40%.

16.4 accidents in 5 years = 3.28 accidents per year

Using UK 1993 accident costs:

Accident cost saving = 3.28 x £40,040/ year = £131,331 per year

9. Economic calculation

$$FYRR = \frac{\text{Accident cost saving per year x 100}}{\text{Scheme cost}}$$

$$FYRR = \frac{131{,}331 \times 100}{170{,}000}$$

$$= 77\%$$

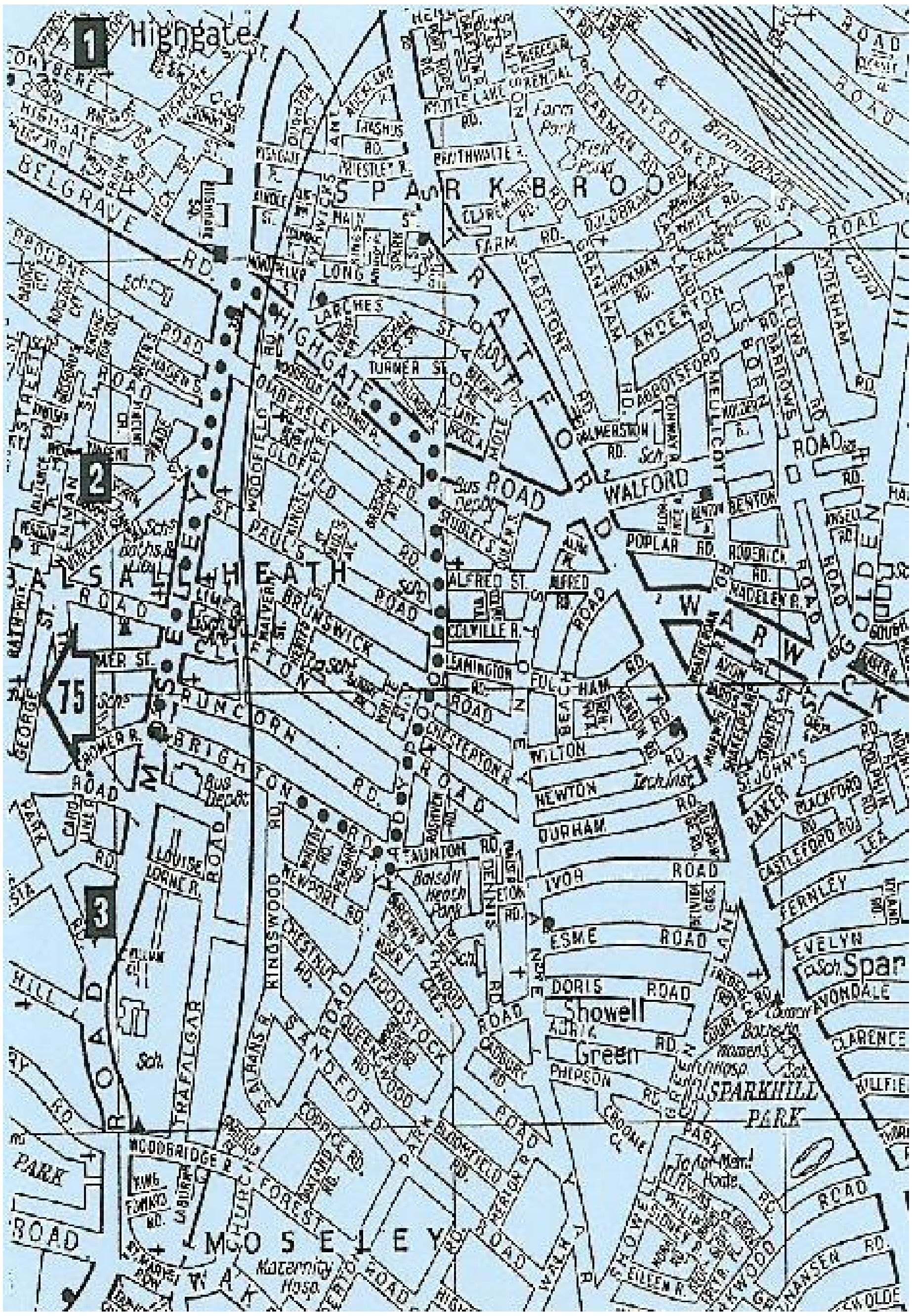
10. Implementation
Public consultation took place in 1993, and work was completed on site in July 1994. Illustrations of the implemented measures are included at the end of the case study.

11. Monitoring
In the 5 year period 1987-91 there was an average of 8 accidents/year. In the first 6 months since implementation there was just one reported injury accident.

Accident levels will continue to be monitored to establish whether the predicted reductions will take place. Traffic volume and speed will be monitored throughout the area (early indications are that speeds have reduced).

In addition, traffic and accident levels will be monitored on adjacent roads to determine whether there has been a transfer of either traffic or accidents.

Tables and Forms: Figure 8.7 Example of traffic calming treatment within the Seven Streets Area



Tables and Forms: Figure 8.8 Location plan for the Seven Streets area (Source: TMS Consultancy)

9. Road Accident Prevention

The majority of this guide has concentrated on methods that seek to reduce the number and severity of accidents at locations where accidents have happened in the past. This chapter outlines ways in which accidents can be prevented on new roads, and existing roads with little or no accident record.

There is often a difference between the safety record at a location in terms of recorded injury accidents and the perception of safety problems. In addition, it can be worthwhile identifying any existing features of design and layout that are incompatible with current design standards on roads with low accident numbers.

The perception of safety problems by the general public can result in considerable pressure being put on a local authority to "do something before someone is killed".
It should be acknowledged that in some circumstances a local authority will be obliged to act even though there is no record of injury accidents. In these cases the authority must take great care not to make the situation worse.

As far as new roads or improvements to roads are concerned, road accidents can be prevented by adopting a system of safety checking during the design process.

9.1. Safety checking of new roads

New roads and road improvement schemes are introduced for a number of reasons.

For example, a new road may be constructed to relieve congestion, or to open up land for development. The designers of highway schemes often have to design within tight budgets and time scales and may be restricted by the availability of land. These conflicting constraints sometimes mean that safety is not given a high priority during the scheme design. The purpose of a safety check is to provide a balance in favour of safety.

The idea behind safety checking is that possible future safety problems are identified and eliminated at an early stage in the design process. In addition, it can give an opportunity to suggest ways in which proven safety measures can be included in scheme designs.

9.1.1. A safety checking system

Safety checking should be carried out in a systematic manner, ideally at several points during the design process.

Suggested times for the checking to be carried out on a major road scheme are as follows:

- Check 1 - Feasibility study
- Check 2 - Completion of preliminary design
- Check 3 - Completion of detailed design
- Check 4 - Completion of construction prior to opening

On more minor schemes, it may be sufficient to carry out a safety check once during the design process and again when the scheme has been completed on site.

The purpose of each safety check is as follows:

- Check 1: To examine the choice of route, the standards applicable and the number and types of junctions.
- Check 2: To assess horizontal and vertical alignments, sight-lines and layouts of junctions.
- Check 3: To assess detailed junction layout, road markings, signs, lighting, landscaping and other design details.
- Check 4: To examine the completed scheme by driving, walking or cycling along the new route (as appropriate). The scheme should also be examined during the hours of darkness to ensure that night time safety standards have been achieved.

Each check should consider the safety of the scheme from the point of view of all road users.

9.1.2. Staff requirements

Safety checking is best done by at least two people. Staff undertaking safety checking should have received some training in the subject and ideally should have some safety engineering experience.

9.1.3. Items to be checked

It is very important to note that a safety check does not simply mean a check on design standards. There are many examples of roads well below design standards that are comparatively safe, while some roads that meet all current standards have poor safety records.

The interaction between design features needs to be thoroughly examined as problems can emerge despite two individual design elements being designed to standard. For example, a section of safety fence is erected in accordance with standards, and a series of lamp columns is installed at the required set-back from the kerb edge. However, if the columns are placed on the road side of the barrier, as shown in Figure 9.1, vehicles can be guided by the barrier into a serious collision with one of the lamp columns. An accident of this type is shown in Figure 9.2.

Plans of proposals should be checked thoroughly to ensure that there are no elements in the design that may lead to accidents.

Figure 9.1 Columns placed on the road side of the barrier

Figure 9.2 Accident where vehicle was guided by the barrier into a serious collision with a column

Further examples of potential problems are shown in the illustrations at the end of this chapter.

Part of the task involves trying to visualise the scheme in three dimensions and then imagining what it will be like to drive, walk and cycle through the scheme. Of course, during the final safety check when the scheme is completed it will be possible to actually carry out these activities.

The safety of all road users during different conditions needs to be considered. For example, "would it be safe for a pedestrian to cross the road at this point in the dark?", or "would a bus driver have sufficient visibility to pull out of this lay-by safely?"

A site visit must be carried out at each stage of the safety check so that a clear impression of the finished scheme is obtained. The site visit should include the area adjacent to the scheme so that potential sources of large volumes of pedestrians and cyclists can be noted (for example schools and colleges).

Checklists can be used during the checking process so that nothing is overlooked. However, over-reliance on checklists can lead to some combinations of elements being missed. Local authorities may wish to generate their own checklists or they could use those contained in the IHT Guidelines on Road Safety Audit (5)•

9.1.4. Opportunities to modify designs

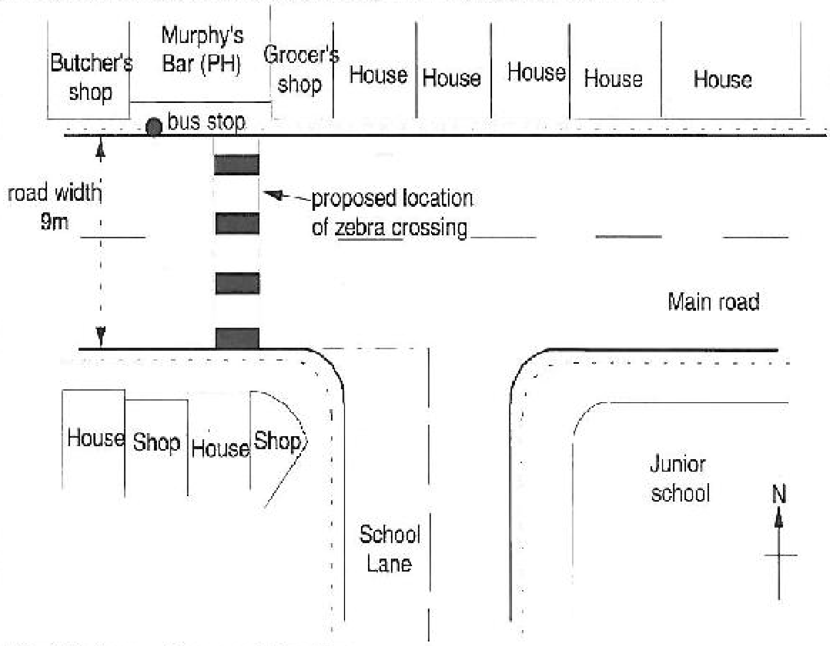
In addition to checking scheme designs for potential safety problems, the safety check can also be used to suggest the inclusion of features that are known to reduce accidents (see the lists of remedial measures in Chapters 5 to 8). For example, where a pedestrian guard-rail is part of a scheme, the specification of high visibility guard-rail is likely to give an additional safety benefit to child pedestrians.

9.1.5. Reporting procedure

Following the safety check, a report should be prepared which defines clearly the safety problems and then suggests ways in which the problems can be eliminated or reduced. These suggestions should be discussed in detail with the designer and agreement sought as to the final design to be used.

Figure 9.3 shows an extract from a safety check report which includes a location plan. The scheme involves the introduction of a zebra crossing on a national road passing through a village. The land uses fronting the road are shown on the location plan.

Perdon County Council
Safety check 3: Introduction of a zebra crossing on main road.



1. Safety issues for consideration

1.1 *Problem*
The location of the zebra crossing immediately outside the public house may encourage drunk pedestrians to step out into the path of moving traffic. Children crossing to the school from the houses on the north side of the road are unlikely to use the crossing. Traffic turning left from School Lane turns straight into the crossing.
Recommendation
(i) The zebra crossing could be moved to the east side of the junction.
(ii) Alternatively the crossing could be moved away from the pub exit to the west of its current location and guard rails could be installed on the North side of the road to encourage school children to use the crossing.

1.2 *Problem*
Pedestrians, particularly the elderly are vulnerable when crossing wide roads.
Recommendation
The crossing should be narrowed down by building out the kerbs.

1.3 *Problem*
Buses stopped at the bus stop to the west of the crossing could mask pedestrians stepping onto the crossing for drivers travelling eastbound.
Recommendation
The bus stop should be moved to the east side of the crossing.

1.4 *Problem*
High speed traffic approaching the crossing may have difficulty stopping when the road is wet. This could lead to shunt accidents or pedestrians struck on the crossing.
Recommendation
Install an anti-skid road surface on each approach.

Figure 9.3 Extract from a safety check report

9.1.6. Responsibilities

It is important to remember that the project engineer is still responsible for the scheme, and is not obliged to take into account the comments made in the safety check report. However if any recommendations are not acted upon, the project engineer should produce an exception report explaining why those recommendations are not being implemented.

9.1.7. Feedback and monitoring

The project engineer should provide feedback to those involved with safety checking. A simple response form is a useful tool for providing this feedback. Table 9.1 shows the response form for the safety check extract in Figure 9.3. A blank copy of this form is provided at the end of this chapter.

Feedback on Road Safety Check Report ***Report no: A3521/1***			
Paragraph no. in Safety check report	**Problem accepted (yes/no)**	**Recommended measure accepted (yes/no)**	**Alternative measures / comments**
1.1	yes	yes (ii)	
1.2	yes	no	central refuge to be installed
1.3	yes	yes	
1.4	no	no	speed of traffic will be calmed by other measures in village

Table 9.1Feedback from above safety check report

Monitoring of the scheme after completion is important for both the design team and the safety checkers.

9.2. Safety checking of sites with no recorded accidents

There are many locations on any road network where there are perceived safety problems but no recorded accidents. It could be that there have been a number of material damage accidents (or even injury accidents) at a site that have not been reported to the Gardaí. One way of assessing sites with no reported accidents is to look for fresh collision debris, particularly at junctions, although this will provide no information as to how the accidents have happened.

On the other hand, there are genuine cases where despite apparent problems, accidents do not take place. For example, it could be that the visibility at a junction is so poor that road users understand the problem and take particular care.

Safety checking of existing roads has the same main objectives and principles as with new roads with emphasis given to identifying those existing features which produce potentially unsafe conditions or induce unsafe behaviour. However, before proceeding to make a major change based on sub-standard road alignment, an attempt should be made to understand the relationship between the design standard and accident occurrence.

9.2.1. Relationship between design standards and accident occurrence

There is no simple relationship between the standard of road design (83) (84) (85) and accident occurrence. Accident problems can occur where a combination of substandard elements are found. For example, the construction of a sub-standard horizontal and vertical alignment on a high speed road can lead to loss of control accidents.

There are also examples of new roads built to achieve modem design standards, with poor accident records. Such roads may meet the design standard for, say, 85kph, but certain aspects of the alignment could encourage 85%ile speeds in excess of this, leading to an increase in risk.

It is also apparent that locations with no or very few accidents can be found where current design standards are not met. Such a location could be described as "safe" by a road safety engineer.

This is clearly a complex subject, with no straight-forward explanation. More information on general safety principles can be found within the IHT Safety Audit Guidelines, Chapter 5 (5). This examines the general relationships between accident occurrence and geometric design, road surface condition, road markings, road signs, traffic management and road works. For example, within the section on geometric design, access control is considered, suggesting that for each additional access point per mile on rural roads there will be a 7% increase in accidents.

9.2.2. Improvements to existing roads with low accident records

Despite a low or zero accident record, in situations where the road is sub-standard, there is often a temptation on the part of the local authority to carry out work to bring the road up to standard. From an accident reduction point of view it is not possible to justify expenditure at such locations since the accident record cannot be improved. However, there is often pressure on the local authority to take action.

At locations with no accidents local authorities should undertake major improvement work with caution, as it is sometimes possible to make a section of road "less safe" in terms of its accident record by improving standards. For example, improving visibility can lead in some instances to an increase in driving speed, with a corresponding increase in accident risk.

In circumstances where there is pressure to improve a location with a low or zero accident record, the following measures can generally be undertaken without a significant increase in risk, although care should be taken that conflict and accidents are not simply transferred to the next potential hazard point on the network:

- Consistency of route signing
- Introduction of chevron signs on bends
- Introduction of yield signs
- Visibility improvements through cutting back foliage
- Introduction of anti-skid surfacing
- Introduction of speed enforcement cameras
- Introduction of traffic calming

The cost effectiveness of these treatments is poor, where there is a low or zero accident record in the before period. From the point of view of allocating resources where need is greatest, local authorities are advised to concentrate on locations with existing "treatable" accident records (see Chapters 5-8), and to limit expenditure on roads with no accidents to a minimum. Any measures that are carried out should be closely monitored, along with adjacent locations, in order to ensure that accident risk has not been transferred.

9.3. Summary

This chapter explores how road accidents can be prevented with particular reference to Safety Checking of new roads and road improvements as well as assessing sites with no recorded accidents.

9. Chapter 9: Illustrations and forms

- Illustrations of potential safety problems
- Safety check report feedback form

9.1. Illustrations of potential safety problems

Tables and Forms: Figure 9.1 Tree and hedgerow growth may unnecessarily reduce sight distance

Tables and Forms: Figure 9.2 Care needs to be taken to ensure safe traffic management during construction schemes

Tables and Forms: Figure 9.3 Unprotected signs on splitter islands on high speed roads can cause a potential hazard

Tables and Forms: Figure 9.4 Nearside signal heads can be obscured by high-sided vehicles. In these cases a high mast arm signal head is useful

Tables and Forms: Figure 9.5 Trees can obscure traffic signals

9.2. Safety Check Report Feedback Form

Feedback on Safety Check Report			
Paragraph no. in Safety Check Report	**Problem accepted (yes/no)**	**Recommended measure accepted (yes/no)**	**Alternative measures/ Comments**

Tables and Forms: Table 9.1 Safety check report feedback form

1. Appendix 1 - Calculating an Accident Rate

1.1. Calculation of an accident rate for a route study

In Chapter 6, it was stated that it is sometimes useful to compare the accident rate for a route with a rate for other roads of a similar type in the same local authority.

The accident rate is a way of describing the number of injury accidents in relation to traffic flow and is often expressed in terms of accidents per 100 million vehicle kilometres.

Take, for example, a single carriageway rural route 3.2 km in length with 31 accidents in a 3 year period. The annual average traffic flow for that route is 13,579 vehicles.

The annual accident rate can be calculated as follows:

$$\frac{\text{No. of accidents x } 10^6}{\text{No. of days in period x traffic flow x length of route}}$$

$$\frac{31 \text{ x } 10^6}{3 \text{ x } 365 \text{ x } 13579 \text{ x } 3.2}$$

= 0.65 accidents per million vehicle kilometres

= 65 accidents per 100 million vehicle kilometres

This figure can then be compared with a national or local average.

2. Appendix 2 - Statistical Analysis of Collision Data

Once initial percentage calculations have been carried out for accidents at a particular site, on a route or at an area-wide location as discussed in Chapters 5, 6 and 8 respectively, it may be necessary to carry out further analysis of the data to establish its true significance.

Averages or norms are often used to help establish the significance of accident parameters, for example, whether or not the proportion of dark accidents on a particular section of a route is significantly high and therefore worth investigating.

Statistical tests are used to establish the significance of the difference between the norm and a site or route value, and to determine whether this difference is due to random fluctuation, or a real problem associated with the site or route. The tests are also used to examine the probability of certain events occurring.

The statistical analysis techniques frequently used in accident investigation are:

- Norms and Standard Deviation calculations
- The Poisson test
- The Chi Squared test
- The k test

These techniques and the interpretation of their results are explained below.

2.1. Averages or norms and the standard deviation

Accident analysis work often involves comparisons between different sets of statistics, in order to define problems. It is important to know whether the level of accidents is higher than expected, for example whether the proportion of wet road accidents at a site is worse than average.

When considering the occurrence of accidents over a period of time, for example on a particular route, the route can be divided into sections of equal length and the number of accidents in each section recorded. The average is found by dividing the total number of accidents by the number of sections in the route. This form of average is known as the "arithmetic mean" or the "norm".

However, the norm as a single value is insufficient as a means of describing the occurrence of accidents on that route as it does not show how accidents are dispersed along the route, nor the extent to which large groups of accidents are occurring at a few locations. The most suitable measure for determining the dispersion of accidents per section compared with the norm is the "standard deviation".

The standard deviation can be calculated once the norm has been calculated.

For example, to calculate the norm and standard deviation for accidents along a route:

If:

x = number of accidents within a route section.
n = number of equal length sections comprising the route.
A = the sum of all the x values = Σx = total accidents on the route.

Then the $Norm = A/n$
and the Standard Deviation S = *the square root of* $[(\Sigma x^2 - n\{A/n\}^2)/(n-1)]$

To understand whether or not this figure is significant and therefore whether further investigation of sections of the route are necessary, the coefficient of variation must be calculated as follows:

The coefficient of variation $Cv = nS/A$

When the coefficient of variation, Cv is greater than 1.0, the Standard Deviation, S, is considered to be "very substantial" and therefore significant.

Example

A section of road is divided into 10 sections of equal length and the number of accidents within each section is noted:

Section	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
No of accidents	8	4	5	11	3	14	6	7	4	5

Therefore, using the above notation:

$$x = 8,4,5,11,3,14,6,7,4,5$$

$$n = 10$$

$$A = \Sigma x = 8 + 4 + 5 + 11 + 3 + 14 + 6 + 7 + 4 + 5 = 67$$

$$Norm = A/n = 67/10 = 6.7$$

Standard Deviation S = *the square root of* $[(\Sigma x^2 - n\{A/n\}^2)/(n-1)]$

$$\Sigma x^2 = 64 + 16 + 25 + 121 + 9 + 196 + 36 + 49 + 16 + 25 = 557$$

S = *the square root of* $\frac{[557 - 10 \times 6.7^2/10]}{9} = 3.47$

$$Cv = 3.47/6.7 = 0.52$$

As Cv is less than 1.0, the Standard Deviation is not very substantial, but those sections where the number of accidents is greater than, or equal to, the norm plus the standard deviation, i.e. those sections with more than 10.17 accidents, warrant detailed investigation on this route i.e. Sections 4 and 6.

2.2. The Poisson test

Often a site is identified where accident numbers have increased in recent times. The Poisson test can be used to determine whether the recent increase is likely to persist or whether the increase was due to random fluctuation and therefore the number of accidents at the site will return to previous levels. In other words the Poisson test is used to calculate the probability of a particular number of accidents occurring at a location in a given year when the long term average for that location is known.

Example

Suppose the accident figures for a given site were as follows:

Year 1 = 3 accidents
Year 2 = 1 accident
Year 3 = 3 accidents
Year 4 = 2 accidents
Year 5 = 6 accidents

It is important to find out whether the 6 accidents in year 5 happened by chance or whether there has been some change at the site which will mean that in year 6 accident levels are likely to remain high.

The long term average or norm at the site is 3 accidents per year

$$\frac{\textit{number of accidents}}{\textit{no. of years}} = \frac{[3 + 1 + 3 + 2 + 6]}{5} = \frac{1.5}{5} = 3$$

So, what is the probability of 6 accidents occurring in year 5 when the long term average is 3, purely due to random fluctuation?

The Poisson Probability (Single Factor Values) tables at the end Appendix 2 are used to determine this. By looking down the left hand column for k= 6 (the number of accidents in year 5) and following across that row to the column for λ= 3 (the long term average or norm) the value of 0.0505 is found. This means that the probability of 6 accidents occurring at a site where the long term average is 3 is 0.0504, or 5.04%.

In practical terms it is more important to know how likely it is that more than 6 accidents will occur at the site. Therefore the probabilities for k = 6, k = 7, k = 8 etc. must be added together.

This gives a total of:

$$0.0504 + 0.0216 + 0.0081 + 0.0027 + 0.0008 + 0.0002 + 0.0001 = 0.0839$$

Therefore the probability of getting 6 or more accidents due to random fluctuation is 8.39%.

In statistical terms this probability is known as the "significance level".

The figure of 8.39% can be looked at in another way. It can be said that there is a 91.61% (100- 8.39) chance that a real increase in accidents has occurred. This is known as the "confidence level".

The Poisson test is an important check when determining whether or not to carry out an investigation at a site or on a route, as using this test will reduce the likelihood of reacting to changes in accident levels that are merely due to random fluctuation.

2.3. The Chi Squared test

This test can be used in two ways:

- to determine whether the number of accidents of a particular type is "significantly" higher than at similar sites
- to determine whether there has been a "significant" change in the number of accidents at a site after treatment has been carried out

An example of how to use the Chi Squared test to examine accident types and its use in before and after studies is detailed below.

Example 1
On a stretch of road there is a specific site with the following accident record: Accidents when the road is wet = 6; accidents when the road is dry = 3

On the rest of the road over the same period the accident record was:
Wet road accidents= 38; Dry road accidents= 100
This information is known as the control data.

It is necessary to establish whether the distribution of wet road and dry road accidents at the site is significantly different from what would be expected.
This is done by putting the above information into a table and using it to calculate the Chi Squared (X^2) value.

	Site/Route	**Control**	**Total**
Wet	6 (a)	38 (c)	44 (g)
Dry	3 (b)	100 (d)	103 (h)
Total	9 (e)	138 (f)	147 (n)

The letters a to h and n, in the table refer to the letters in the formula below used in calculating the value of Chi Squared:

$$X^2 = \frac{n[(ad - bc) - n/2]^2}{efgh}$$

So for this example:

$$X^2 = \frac{147[(6x100 - 3x38) - 147/2]^2}{9 \times 138 \times 44 \times 103}$$

$$=4.44$$

Referring to the Chi Squared Distribution Table given at the end of Appendix 2 and looking along the line v = 1 within the main table, the closest value to the 4.44 calculated above appearing on this line is 3.841. The figure above this is the "significance level" for this value of X^2. Therefore the significance level is .05 or 5%.

This means that the probability of getting 6 wet road accidents at a site with a total of 9 accidents by chance when other similar sites have 38 wet out of 138, is only 5%.

Another way of looking at this is to say that there is a 95% (100 % - 5%) chance that the number of wet accidents did not occur by chance. This is known as the "confidence level".
(Note: The above formula allows for Yates' correction. This overcomes the inaccuracies which occur when applying the Chi Squared test to data such as accident frequencies which can only have whole number values).
Example 2
A set of traffic signals has been introduced at a cross-roads junction on a local distributor road in an urban area. The scheme was introduced three years ago and needs to be monitored.

The control data to be used is from other cross-roads junctions on similar roads in the same urban area.

The important question to be answered by a before and after study is whether the scheme was effective in reducing accidents. The Chi Squared test compares data from the treated site with data from similar but untreated sites, known as control data. The test determines whether any changes at the site are statistically significant.

The number of accidents recorded before and after the treatment is shown in the following table:

	Site	**Control**	**Total**
Before	10 (a)	149 (c)	159 (g)
After	2 (b)	133 (d)	135 (h)
Total	12 (e)	282 (f)	294 (n)

These figures are then put into the formula:

$$X^2 = \frac{n[(ad - bc) - n/2]^2}{efgh}$$

So,

$$X^2 = \frac{294[(10x133 - 2x149) - 294/2]^2}{12 \times 282 \times 159 \times 135}$$

$$= 3.17$$

Referring to the Chi Squared Distribution Table given at the end of Appendix 2 and looking along the first line (v = 1) within the main table, the value for X^2 of 3.17 lies between 2.706 and 3.841.

This corresponds to a value of the significance level (on the line above) between 0.10 and 0.05. This is normally quoted in percentage terms as "better than 10% significant".

The result means that there is only a 10% likelihood of the change in accidents being due to random fluctuation, or a 90% (100%- 10%) confidence that a real change in accidents has taken place at the junction.

2.4. The k test

The k test is another test used in before and after evaluation of a site, route or area wide study.

It is possible that although accident levels may have decreased at a treated site, if the general level of accidents is also decreasing then the "real" reduction at the treated site is less than that claimed. The k test can be used to indicate the degree of change that has occurred in a particular situation and also whether the change was an increase or decrease i.e. the test shows how changes in accident numbers at a site or route are occurring relative to control data.

For a given site/route the value of k is calculated as follows:

$$k = \frac{b/a}{d/c}$$

Where:
a is the "before" accidents at the site/route/area
b is the "after" accidents at the site/route/area
c is the "before" control figure
d is the "after" control figure

If $k < 1$ then there is a decrease in accidents relative to the control;
If $k = 1$ then there is no change relative to the control;
If $k > 1$ then there is an increase relative to controls.
The percentage change at the site is $(k - 1) \times 100\%$.

Example
A route has a record of 12 accidents before treatment and 7 after; and there were 106 accidents in the control area in the same before period and 142 accidents in the control area in the same after period.

So,

$$k = \frac{7/12}{142/106}$$

$$=0.44$$

Therefore $k < 1$ which signifies a decrease in accidents relative to controls.

And the percentage change = $(k - 1) \times 100\% = -56\%$

i.e. there has been a 56% reduction in accidents, relative to control levels.

For a number of sites or routes which have had the same treatment, individual values of k can be calculated.

2.5. Interpretation of significance levels

Having calculated the percentage probability (i.e. the significance level) in any of the above tests, it is necessary to interpret the results into some practical meaning.

The following table acts as a general guide:

Significance level (%)	Confidence level (%)	Subjective interpretation
1	99	highly acceptable result
5	95	acceptable result
10	90	fair result
20	80	indicative result

A significance level greater than 20% (or confidence level less than 80%) is said to be not significant.

The practical significance of a result should also be borne in mind: For example, it may be that some signs have been erected on a road through a village with the effect of reducing the 85 percentile speed limit from 46 mph to 42 mph. This result is probably highly significant in statistical terms, possibly at the 99% confidence level.

However, for pedestrians crossing the road, similar injuries will be received if struck by a vehicle travelling at 42 mph to those received if struck at 46 mph. As far as pedestrians are concerned, the reduction in speed has little practical significance.

Poisson Probability (Single Factor Values) Table (extract)

k=	λ=									
	2.1	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.8**	**2.9**	**3.0**
0	.1225	.1108	.1003	.0907	.0821	.0743	.0672	.0608	.0550	.0498
1	.2572	.2438	.2306	.2177	.2052	.1931	.1815	.1703	.1596	.1494
2	.2700	.2681	.2652	.2613	.2565	.2510	.2450	.2384	.2314	.2240
3	.1890	.1966	.2033	.2090	.2138	.2176	.2205	.2225	.2237	.2240
4	.0992	.1082	.1169	.1254	.1336	.1414	.1488	.1557	.1622	.1680
5	.0417	.0476	.0538	.0602	.0668	.0735	.0804	.0872	.0940	.1008
6	.0146	.0174	.0206	.0241	.0278	.0319	.0362	.0407	.0455	.0504
7	.0044	.0055	.0068	.0083	.0099	.0118	.0139	.0163	.0188	.0216
8	.0011	.0015	.0019	.0025	.0031	.0038	.0047	.0057	.0068	.0081
9	.0003	.0004	.0005	.0007	.0009	.0011	.0014	.0018	.0022	.0027
10	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0006	.0008
11	.0000	.0000	.0000	.0000	.0000	.0001	.0001	.0001	.0002	.0002
12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001

Chi Squared Table (extract)

V=	α=								
	0.5	**0.3**	**0.25**	**0.2**	**0.1**	**0.05**	**0.025**	**0.02**	**0.01**
1	0.455	1.074	1.323	1.642	2.706	3.841	5.024	5.412	6.635
2	1.386	2.408	2.773	3.219	4.605	5.991	7.738	7.824	9.21
3	2.366	3.665	4.108	4.642	6.251	7.815	9.348	9.837	11.345
4	3.357	4.878	5.385	5.989	7.779	9.488	11.143	11.668	13.277
5	4.351	6.064	6.626	7.289	9.236	11.07	12.832	13.388	15.086

Note: A full set of statistical tables should be obtained by engineers wishing to carry out statistical tests.

3. Appendix 3 - Conflict Studies

It is possible to obtain more data at locations by carrying out conflict studies.

The technique involves observation of the conflicts, or "near accidents", experienced by road users. Conflicts can be defined as "situations involving one or more road users who approach each other such that there is a risk of collision if their movements remain unchanged".

In a conflict study the numbers of conflicts are recorded and graded according to the scale of severity ranging from controlled evasive manoeuvres to extreme emergency action. More information on this can be found in TRL Reports LR551 (86) and SR545 (87) and in the IHT guidelines on the subject (88). Conflict studies carried out at rural intersections in the United Kingdom found a predictive relationship between the number of serious conflicts and recorded injury accidents.

Work on conflict studies has been also been carried out in Scandinavian countries, particularly Sweden (89).

Conflict studies can be used in three situations:

- Where, as part of the accident investigation, it would be useful to collect conflict data to supplement the accident data for a particular dominant accident type. This type of conflict study must be carried out after the accident analysis has been undertaken. For example, a fail to yield accident problem is identified at a priority cross-roads and it is not clear whether the accidents involve "restarts" or "overshoots". A conflict study could determine which of these two problems is most likely to have contributed to the accidents.

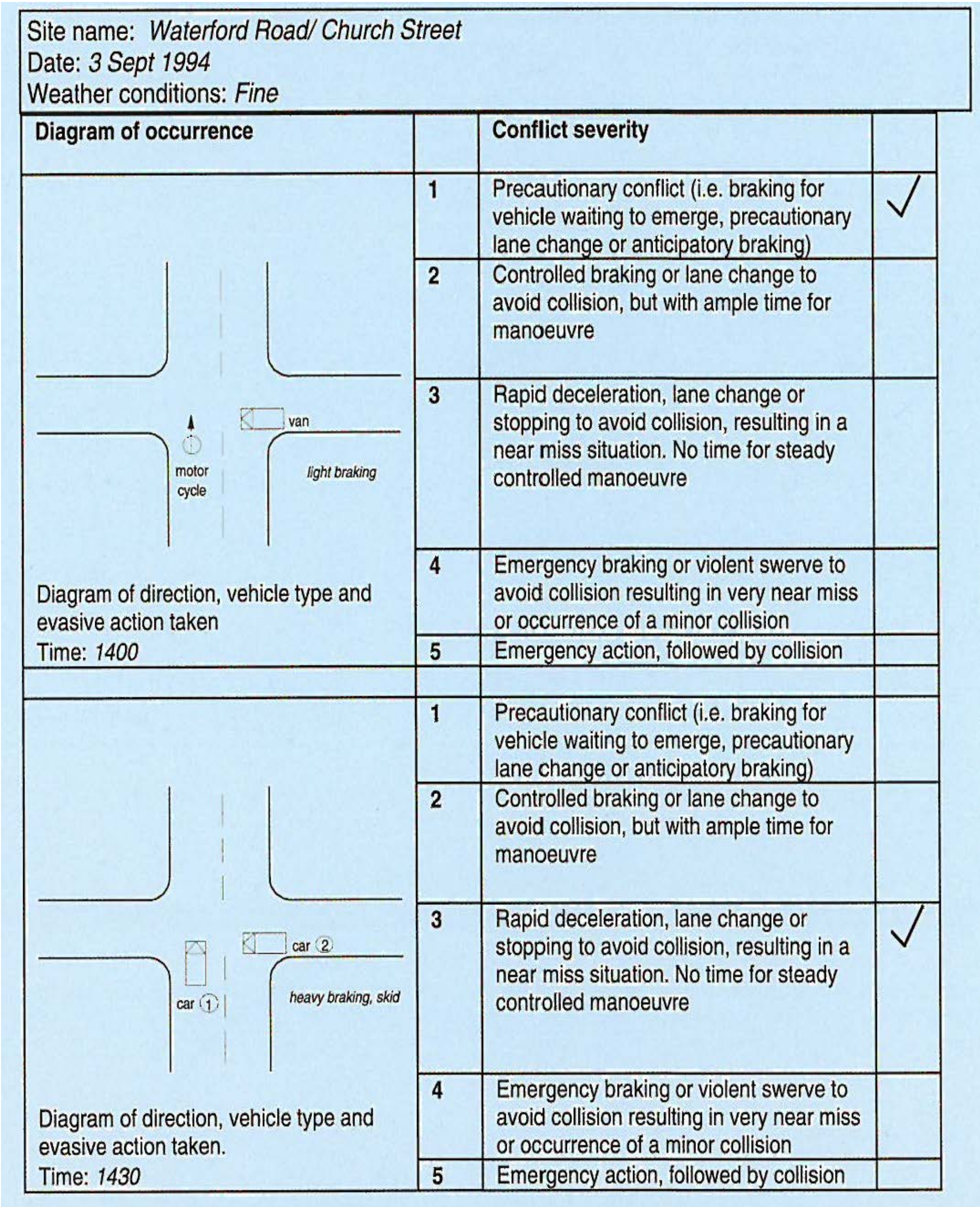
- Conflict studies can be used as a before-and-after technique for monitoring the effects of an experimental scheme, or in cases where prediction of the benefits of the scheme is needed in the short term. For example, a right-turn accident problem at a major/minor junction could be treated with improvements to visibility, road signs and markings. A conflict study can be carried out before and after the improvements take place. In the before period, right-turn conflicts similar to the dominant accident type should be recorded. A reduction in this type of conflict in the after period would suggest that the scheme is likely to be successful in terms of accident reduction.

- Conflict studies can be used as a substitute for recorded accidents in those cases where no accident data has been recorded. For example, within a local housing estate, residents are aware of cycle accidents that have occurred at a junction. There are no recorded injury accidents at the junction, possibly due to underreporting of this particular user group. A conflict study could help to establish levels of risk for pedal cyclists at the location which may establish a need for an improvement to the junction or some other remedial measure.

Conflict studies should be carried out by trained observers. The conflict data should be used to identify particular manoeuvres, road user groups or site factors that contribute to the conflicts and that could lead to accidents. The technique has been developed from a traditional approach based on vehicle turning movements, to embrace study methods for both vehicle and pedestrian conflicts.

When carrying out a conflict study, the observers should be positioned so that all movements can be recorded and studies should take place for as long a period as practical (ideally over a 12 hour period). If the conflict study is to supplement recorded accidents, then the observations should be carried out under similar conditions to those of the recorded accidents. For example, if accidents have occurred in darkness, the conflict studies should be carried out in darkness.

The conflicts can be graded from 1 (slight) to 5 (minor collision), according to severity. In many cases a slight/serious distinction will suffice. The figure below shows an example of a completed conflict study form, and a blank copy is provided at the end of this appendix.



Site name: *Waterford Road/ Church Street*
Date: *3 Sept 1994*
Weather conditions: *Fine*

Diagram of occurrence		Conflict severity	
Diagram of direction, vehicle type and evasive action taken Time: *1400*	1	Precautionary conflict (i.e. braking for vehicle waiting to emerge, precautionary lane change or anticipatory braking)	✓
	2	Controlled braking or lane change to avoid collision, but with ample time for manoeuvre	
	3	Rapid deceleration, lane change or stopping to avoid collision, resulting in a near miss situation. No time for steady controlled manoeuvre	
	4	Emergency braking or violent swerve to avoid collision resulting in very near miss or occurrence of a minor collision	
	5	Emergency action, followed by collision	
Diagram of direction, vehicle type and evasive action taken. Time: *1430*	1	Precautionary conflict (i.e. braking for vehicle waiting to emerge, precautionary lane change or anticipatory braking)	
	2	Controlled braking or lane change to avoid collision, but with ample time for manoeuvre	
	3	Rapid deceleration, lane change or stopping to avoid collision, resulting in a near miss situation. No time for steady controlled manoeuvre	✓
	4	Emergency braking or violent swerve to avoid collision resulting in very near miss or occurrence of a minor collision	
	5	Emergency action, followed by collision	

Completed conflict study form

3.1. Completed Conflict Study Form

A conflict study of a dominant accident type may reveal some interesting points not immediately obvious from the historical accident data, and is a useful form of discipline for carrying out a site visit. However, it should be remembered that conflicts are not the same as accidents and results of conflict studies should not be given the same importance as details of actual accidents. By their very nature, conflicts are accidents that have been avoided, and therefore the "chain of events" is incomplete.

3.2. Conflict Study Form

Site name: Date: Weather Conditions:			
Diagram of Occurrence		Conflict Severity	
Diagram of direction, vehicle type and evasive action taken Time:	1	Precautionary conflict (i.e. braking for vehicle waiting to emerge, precautionary lane change or anticipatory braking)	
	2	Controlled braking or lane change to avoid collision, but with ample time for manoeuvre	
	3	Rapid deceleration, lane change or stopping to avoid collision, resulting in a near miss situation. No time for steady controlled manoeuvre	
	4	Emergency braking or violent swerve to avoid collision resulting in very near miss or occurrence of a minor collision	
	5	Emergency action, followed by collision	
Diagram of direction, vehicle type and evasive action taken Time:	1	Precautionary conflict (i.e. braking for vehicle waiting to emerge, precautionary lane change or anticipatory braking)	
	2	Controlled braking or lane change to avoid collision, but with ample time for manoeuvre	
	3	Rapid deceleration, lane change or stopping to avoid collision, resulting in a near miss situation. No time for steady controlled manoeuvre	
	4	Emergency braking or violent swerve to avoid collision resulting in very near miss or occurrence of a minor collision	
	5	Emergency action, followed by collision	

Example of Conflict Study Form

4. Appendix 4 - Alternative Economic Evaluation Method

4.1. Economic evaluation- the Net Present Value (NPV)

In Chapters 5 to 8, the method used to calculate the economic benefits of a scheme was the First Year Rate of Return (FYRR).

In some cases, however, a method is required which expresses the difference between costs and benefits of the scheme over a period of several years rather than just the first year. This is particularly the case with large schemes that may be constructed over a number of years, for example, lighting on a length of several kilometres of rural road, or a major traffic calming scheme in a large town or city.

In this case it is not possible simply to add up the nominal value of the benefits; future benefits must be adjusted, or "discounted" before being summed to a "present value". This method of calculating benefits over several years is known as the Net Present Value (NPV).

The current discount rate for highway schemes is 7%. This means that £1 of benefit this year is valued at £1 but if it accrues next year we value it at 7% less, i.e. at 93p. A further year's delay will reduce the benefit again, by 7% of 93p, i.e. to 87p and so on. Benefits once discounted by the appropriate factor, are then summed to a "present value".

The overall economic worth of a scheme is indicated by the Net Present Value (NPV). This results from subtracting the Present Value of Costs (PVC, for costs must also be discounted if they are spread over more than one year) from the Present Value of Benefits (PVB):

$$PV = PVB - PVC$$

Only if the NPV is positive is the scheme worthwhile.

An example of economic assessment
This procedure can be demonstrated by an example in which the expected costs of a remedial measure include initial expenditure of £24,000 spread evenly over 2 years and annual maintenance costs for 5 years of £1,500. The benefits from accident savings are expected to be £14,000 per annum for 2 years and then £5,000 per annum for another 3 years. Note that benefits only start to accumulate once the scheme is completed.

The benefit net of cost is therefore £12,500 per annum for 2 years and £3,500 per annum for the following 3 years. The Net Present Value calculation is illustrated in the following table.

Year (1)	Discount factor (2)	Cost(£) (3)	Benefit(£) (4)	Net cost(·) or benefit(+) (4)-(3)=(5)	Present value of net cost(-) or benefit(+) (5)x(2) = (6)
0	1.00	12,000		-12,000	-12,000
1	0.93	12,000		-12,000	-11,160
2	0.87	1,500	14,000	12,500	10,875
3	0.82	1,500	14,000	12,500	10,250
4	0.76	1,500	5,000	3,500	2,660
5	0.71	1,500	5,000	3,500	2,485
6	0.67	1,500	5,000	3,500	2,345

The benefit net of cost using the NPV method is therefore:

-12,000 – 11,160 + 10,875 + 10,250 +2,660 + 2,485 + 2,345 = £5,455

Net Present Value assessment criteria

The economic criteria for scheme assessment using the NPV approach is as follows:

- all schemes where the NPV is positive are worthwhile in economic terms
- within the options for a particular site, the most worthwhile is the option with the highest NPV
- schemes (and options within schemes) are ranked in order of their NPV/PVC ratios (so that those with the greatest benefit per unit of cost have the highest rank)

If it is possible to undertake all schemes with a positive NPV, the third criterion above has no practical importance. However, if funds are limited so that not all worthwhile schemes can be undertaken, those with the highest NPV/PVC ratios are preferable on economic grounds.

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11. Glossary of Terms

Accident Analysis
The investigation of road accidents

Accident Grid
A way of displaying accident details in order to highlight dominant accident types.

Accident Prevention
Strategies aimed at preventing accidents from taking place on new roads or existing roads with few recorded accidents.

Accident Rate
Accident frequency divided by some measure of exposure to risk, for example traffic flow or population.

Accident Record
The official Garda documentation describing a road accident

Accident Reduction
Strategies aimed at reducing accident frequencies.

Accident Remedial Measure
An engineering solution to an accident problem

Accident Severity
The severity of the most seriously injured casualty.

Anti-Skid Surface
A road surface treatment with a high skid resistance.

Area-Wide
An approach taken throughout an area of a town or city.

Before and After Study
A comparison of accident frequency before and after the implementation of a road safety scheme.

Breaking a Red Light
Going through red traffic lights.

Casualty
Someone who is killed or injured in a road accident.

Casualty Class
A distinction between drivers, passengers and pedestrians.

Child
A person aged 14 years or under.

Chi Squared Test
Statistical test used to compare observed events against expected.

Conflict Studies
A means of estimating accidents by observing driving behaviour.

Confidence Level
The confidence in a statistical result, expressed as a percentage.

Contributory Factors
The events that lead to a road accident.

Control Data
A series of data used for comparison purposes.

Cost Benefit Analysis
The economic evaluation of a scheme.

Countermeasure
A road safety treatment.

Cross Over Accident
An accident where a vehicle emerges from a side road into the path of a vehicle on the main road.

C(T)68
The accident report form used by the Gardai.

Dominant Accident Pattern
See Treatable Accidents.

Economic Rate of Return
The amount of economic benefit from a scheme.

Evaluation
The assessment of the effectiveness of road safety measures.

Fatal Injury
The death of an accident victim occurring within 30 days of the accident as a result of injuries sustained during the accident.

Fatal Accident
A road accident in which one or more of the people involved are killed within 30 days of the accident.

Fatality Rate
The number of road deaths divided by some measure of vehicle usage, for example traffic flow.

Chi Squared Test
Statistical test used to compare observed events against expected.

Conflict Studies
A means of estimating accidents by observing driving behaviour.

Confidence Level
The confidence in a statistical result, expressed as a percentage.

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Fatality Rate
The number of road deaths divided by some measure of vehicle usage, for example traffic flow.

First Year Rate of Return (FYRR)
A means of economic assessment.

Gateway
One or more features highlighting the start of a village.

High Risk Location
A location with a higher than expected accident problem.

Hours of Darkness
The period coinciding with lighting up time, i.e. half an hour after sunset to half an hour before sunrise.

Injury Accident
A road accident in which one or more of the people involved requires medical treatment.

Injury Severity
A measure of the seriousness of the injuries sustained in a road accident.

K-Test
A statistical test used to indicate the degree of change that has occurred in "before and after" studies.

Links
A stretch of road between major junctions.

Local Safety Scheme
A safety scheme implemented on a local road.

Low Cost Measure
A safety scheme costing less than a set amount to implement.

Loss of Control
An accident characterised by the driver/rider losing control of the vehicle.

Mass Action Site
A set of single sites with a common problem, for example, wet skid.

Material Damage Accident
An accident in which there are no deaths, serious or slight injuries, but where damage has been caused to a vehicle or property.

Measure of Exposure
A measure of vehicle usage which is used to calculate rates, for example traffic flow.

Minor Injury
An injury of a minor character such as a sprain or bruise.

Minor Road Accident
A road accident in which there are no deaths or serious injuries but where one or more of the people involved receives minor injuries.

Monitoring
A continuous check on the performance of a scheme.

Norm
An expected value.

Net Present Value (NPV)
A means of economic assessment.

Overshoot Accident
An accident in which a side road vehicle fails to stop and emerges into the path of a vehicle on the main road.

Pedestrian
A person walking, any person riding a toy cycle on the footway, a person pushing a bicycle, pushing or pulling another vehicle, an occupant of a pram or wheelchair or a person who alights safely from a vehicle.

Poisson Test
A statistical test used to calculate the probability of accident frequency in a given year, when the long-term average is known.

Powered Two-Wheelers (P2W)
Mopeds, scooters, motor cycle solos and combinations.

Primary Safety Features
Measures taken to prevent accidents from occurring.

Restart Accident
An accident in which a vehicle coming from a side road gives way then restarts, emerging into the path of a vehicle on the main road.

Restrained Occupant
A vehicle driver or passenger wearing some form of seat belt.

Road Accident
A road accident resulting in personal injury, which occurred on the public highway, involved one or more vehicles, and was recorded by the police.

Road Environment
The road and its adjacent land use.

Road Hierarchy
The classification of roads according to function and traffic volume

Road Safety
All aspects of safety relating to roads, the road user and the vehicle

Road Safety Education
The promotion of safe use of roads

Road Safety Plan
A written plan defining an integrated approach to road safety work

Roadside Object
Objects situated adjacent to the carriageway, including items of street furniture and natural features such as trees, ditches and hedges but excluding pedestrians.

Route Action Site
A route with a high accident frequency or rate

Safety Check
A system for checking highway engineering schemes for safety problems

Safety Engineer
A local authority employee with responsibility for traffic safety schemes and safety checking.

SCRIM Test
A means of testing the skid resistance of a road surface.

Secondary Safety Features
Measures taken to reduce the severity of accidents.

Serious Injury
An injury which, in the opinion of the investigating officer, is of sufficient seriousness to endanger the life of the injured party or to threaten long term and perhaps more permanent disability.

Serious Road Accident
A road accident in which one or more of the people involved requires overnight hospital treatment.

Single Site
An individual accident problem site

Staggered Junction
An offset crossroads

Statistical Significance
The percentage probability of an event occurring due to chance

Statistical Test
A quantitative means of assessing whether a figure or set of figures is different from expected.

"Stick" Diagram
A means of portraying accidents on a grid to examine dominant factors

Street Furniture
Permanent objects located on the highway.

TRL
The Transport Research Laboratory. A UK research organisation

Target Group
The section of the population to whom road safety measures are aimed

Through Traffic
Traffic which does not have its origin or destination within the area of interest.

Traffic Calming
Self enforcing engineering measures implemented mainly in residential areas to reduce vehicle speeds to around 20 mph.

Traffic Flow
The number of vehicles passing through a site during a specific time period

Traffic Severance
An area-wide traffic management treatment in which emphasis is given to restricting movement, for example using road closures and turning bans

Treatable Accidents
A group of accidents with a common cause that have a potential for reduction by remedial measures

Trend
An underlying pattern of accidents

Urban Safety Management
A structured approach to accident prevention

Under Reporting
The fact that not all road accidents are reported to the police

Vulnerable Road Users
Road users who are more likely to be injured when involved in accidents, for example, children, pedestrians, cyclists and the elderly.

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