EUROPEAN ROAD ASSESSMENT PROGRAMME
PILOT PHASE TECHNICAL REPORT

by David Lynam, Tom Sutch, Jeremy Broughton (TRL), and
Stephen D Lawson (AA Foundation for Road Safety Research)

May 2003

CONTENTS

Executive summary

The AA Foundation for Road Safety Research, on behalf of the European Road Assessment Programme (EuroRAP), commissioned TRL to develop and pilot a process for assessing the relative safety performance of European roads, which could be developed into a regular programme benchmarking the safety of roads being achieved in different countries.

EuroRAP has been designed as a complementary activity to the European New Car Assessment Programme (EuroNCAP) that was developed to crash-test cars and award cars a star rating. EuroRAP has been piloted to rate Europe's various roads for safety in a similar way.

This report describes how the EuroRAP development work led to the definition of two new standard test protocols:

- a standard road inspection for safety features (the Road Protection Score);
- measurement and mapping of the rate at which people are killed and seriously injured.

The pilot year of EuroRAP dealt with major roads outside built-up areas, because an early conclusion of the work has been that it is on these roads that most deaths in Europe occur. The pilot programme has also shown that, generally, there is good information available on the busiest and "fastest" of these roads – the motorways – but that these roads are also the safest. There is generally much less information readily available on the non-motorway roads where road-users are more likely to be killed.

The need to benchmark roads across Europe on a regular and routine basis means that it was important for the pilot programme not only to develop a potentially reliable and robust way of comparing road performance, but also to demonstrate that such comparisons produce results that will be useful to the motoring public, policy makers, highway providers and operators alike.

The pilot programme was planned in three parts:

- general international comparisons of death rates on the road networks of different European countries;
- analysis and mapping of fatal and serious accident rates occurring on major roads outside built-up areas in Britain, the Netherlands and Sweden; and
- an inspection of the safety quality of the road infrastructure in different countries to identify the extent to which roads protect road-users from accidents, and from death and serious injury when accidents do occur.

This report focuses on the collation and analysis of data for Great Britain, Sweden, the Netherlands, and the region of Catalonia in Spain, and on initial road inspections in Britain, Sweden, the Netherlands, and Germany.

The international comparisons used data from the International Road Traffic and Accident Database (IRTAD) maintained by the German Federal Highway Research Institute BASt. The comparisons are restricted to fatality rates because of the significant differences between countries in the reporting of non-fatal accidents. Data are generally for the period 1999-2001.

The results have demonstrated that wide differences exist between countries. Motorway fatality rates ranged from 2.1 deaths per billion vehicle-km in Great Britain to 14.1 in Portugal. Rates for A-level roads outside urban areas showed a similarly wide range: from 6.2 deaths per billion veh-km in Great Britain to 22.9 in Austria. A supplementary analysis calculated the average daily flow on these two types of road. Both comparisons showed both road categories to be rather busier in Great Britain than in other countries.

For the comparison of accident rates for individual road sections within and between countries, a process was needed by which accident and traffic flow data could be assigned to road sections. The networks being investigated needed to be divided into these road sections such that, as far as possible, the design of the road within the section is uniform, and the traffic flow over this length was consistent.

The key policy target across Europe is the reduction of death and serious injuries on the roads. To give a good chance of obtaining repeatable results, separate sections should ideally have a total of at least 20 accidents resulting in death or serious injury. This means that the network in Britain, for example, was typically divided into road sections of 10-20 kms. To allow for the known difference in definition of serious accidents between countries, and for the different reporting rates, for future work the number of fatal and serious accidents will be standardised against their ratio to the reported number of fatalities for each country.

Conclusions on the distribution of fatal and serious injury accidents

- Reflecting the policy requirements, except where specifically mentioned, this report focuses on the analysis of fatal and serious accidents.
- The majority of deaths in Europe occur on roads outside built-up areas.
- The majority of deaths on roads outside built-up areas are on single carriageway roads.

<u>In Britain</u>

- Nine per cent of deaths outside built-up areas are on the motorways, 19 per cent on dual carriageways, 38 per cent on single carriageways of national or regional importance and 34 per cent on other single carriageways.
- The fatal and serious accident rate of the 'A' road network is about four times that of the national motorway network.
- In overall terms, the average fatal and serious accident rate on the British national 'A' road network is significantly lower (about 37 per cent lower) than that on the regional (local authority) 'A' road network. This is mainly due to the greater occurrence of small urban areas on the latter network.
- There is significant difference between the fatal and serious accident rates for dual, single and mixed dual/single road sections, with the dual carriageway rates averaging less than half that for the single carriageways, and the mixed sections about 70 per cent of the single carriageway rate.
- Within the dual carriageway group, sections with grade-separated junctions have significantly lower fatal and serious accident rates than those with at-grade junctions, averaging about half the rate for the latter sections.
- There are significant differences in fatal and serious accident rates between roads with less than 10,000 AADT, roads with 10,000 to 20,000 AADT, and roads with more than

20,000 AADT. (The ratio of these differences is about 2.1: 1.6: 1.) This downward trend in accident rates continues at higher flows, but the differences become smaller.

In the Netherlands

- The fatal and serious accident rates on non-motorway national roads are about four times those on motorways.
- Within this non-motorway national road group, rates on divided roads and single carriageway roads are about 3 times and 5 times respectively those on motorways.
- Rates on single carriageway roads where slower traffic is excluded are 50 per cent lower than other single carriageway roads.

In Sweden

- Rates on national 'A' roads are about three times those on Swedish motorways.
- Flows on Swedish roads are much lower than flows on equivalent road types in Britain and the Netherlands.
- Rates on divided roads with grade-separated junctions are only 50 per cent higher than rates on motorways.
- Rates on single carriageways are about 3 times those of motorways. Rates on multilane roads are similar to those on wide single carriageways.

In Catalonia

- Rates on national 'A' roads are less than double the rates on motorways.
- The network examined included a much wider range of regional roads than in the other countries.

In all four areas (Britain, the Netherlands, Sweden, and Catalonia) the general pattern of rates between different parts of the road system is relatively similar; further investigation is needed in the next stage of the programme to assess whether the differences that do exist reflect design differences within the various general road types. After adjusting for reporting differences, the motorway rates for Britain, Sweden and the Netherlands are roughly similar, but rates for Catalonian motorways are much higher. Rates for each road type are higher in Catalonia reflecting in part different driving behaviour. Rates for single carriageway roads in Britain are almost 50 per cent higher than in Sweden, probably reflecting the greater density of small populated areas along the British routes.

Conclusions and lessons for the full EuroRAP programme

- A database has been produced which gives a good picture of the variation in fatal and serious accident rates on British non-built-up main roads.
- Similar data are being collated for Sweden, with the help of the Swedish National Road Administration, for the Netherlands, with the help of the Transport Research Centre of the Dutch Ministry of Transport, and for Catalonia, with the help of Servei Català de Trànsit.
- Most death and serious injury on interurban roads in Europe is associated with just four main types of impact: “head to head” impacts; impacts at junctions; impacts with objects close to the road; and impacts with vulnerable road-users.
- An initial protocol has been developed, in collaboration with the Swedish National Road Administration and others with international expertise, for a procedure for “drive through” inspection of routes, and the programme includes trials on roads in seven European countries. This protocol is being refined and developed further during the first

main year of the project, and will allow allocation of a “Road Protection Score” to these roads.

- It has been possible to agree on the programme methodology and analysis methods with policy and technical experts representing different interests from across Europe.

Identifying road sections with high and low fatal and serious accident rates

- The three significantly different flow groups within the 'A' class roads described above should be analysed separately when identifying road sections with relatively high or low accident rates for their group, insofar as the flows indicate different functional demands for these roads.
- Fatal and serious accident rates for the short road sections are substantially different from the group averages. These need to be treated with caution as they may vary between time periods. But these short links, sometimes linking main routes, can represent higher risks than longer sections within the main part of the network.
- Sections of non-motorway roads in Britain with higher than average fatal and serious accident rates are distributed throughout the national and regional networks. About 3000kms of regional road and 900kms of national road have rates at least twice the average rate for 'A' class roads, representing about 30 per cent and 10 per cent of the network lengths respectively.
- Over 100kms of motorway sections have rates about twice the average rate for motorways, representing 4 per cent of the motorway network.

Benchmarking safety – additional potential uses of the data

- EuroRAP is concerned with identifying stretches of road with poor safety performance resulting in significant death and serious injury. The data does, however, provide scope, if required, to investigate road sections of much smaller length that show particularly high accident rates.
- The analyses could support procedures to set standards for hierarchies and appropriate speed for different road section design.
- The potential for fatal and serious accident reduction from improvements in road network design and management can be identified. For example, if those road sections with accident rates above the group average in Britain were brought up to the standard of the group average, an annual total of some 1700 fatal and serious accidents (ie 20 per cent of the total accidents in this network) would be saved.
- The data sets being assembled are capable of being interrogated at a later stage using modelling techniques to analyse the extent to which individual high-level design factors are associated with accident risk.

EUROPEAN ROAD ASSESSMENT PROGRAMME

PILOT PHASE TECHNICAL REPORT

INTERNATIONAL FATALITY RATES, HIGH-LEVEL DESIGN FACTORS AFFECTING DEATH AND SERIOUS INJURY ON THE ROAD NETWORK AND DEVELOPMENT OF THE ROAD PROTECTION SCORE FOR EUROPE

1 OBJECTIVES

The AA Foundation for Road Safety Research, on behalf of the European Road Assessment Programme, commissioned TRL to develop and pilot a process for assessing the relative safety performance of European roads, which could be developed into a regular programme monitoring the safety quality of roads in different countries. The pilot has formed the first foundation year of the programme.

The objectives of such a programme were to:

- establish a programme of systematic risk assessment and bench marking that would help cut death and serious injury rapidly;
- identify major safety shortcomings on roads amenable to practical remedy;
- ensure assessment of risk lies at the heart of strategic decisions on route improvements, crash protection and standards of route management; and
- forge partnerships among those responsible for a safe road system.

Underlying the programme are objectives to ensure greater awareness and understanding by road-users, authorities, and policy-makers and engineers alike of where fatal and serious road accidents occur, and the successful practical actions that can be taken to provide protection.

It is important, therefore, for the pilot programme not only to develop a potentially robust way of comparing road performance, but also to demonstrate that such comparisons produce results that can be communicated in a form useful to the stakeholders – the motoring public, policy-makers, and highway providers and operators.

1.1 European Road Assessment Programme philosophy and context

The European Road Assessment Programme was designed as a complementary activity to the European New Car Assessment Programme (EuroNCAP), developed by leading motoring organisations working with the UK and Swedish governments and others in the 1990s. EuroNCAP involved buying new cars from showrooms, crash testing them and awarding each vehicle a star rating depending upon the protection given. There is general agreement on the overall benefit of EuroNCAP in saving lives.

Development of a Safe Road System is a shared responsibility between road authorities, vehicle manufacturers, and road-users. Despite the success of EuroNCAP, there are still about 40,000 deaths annually on the roads of EU member states. A similar rating system for roads would help optimise the combined effect of road and vehicle safety, and ensure that improvements in vehicle design are not undermined by poor quality (1-star) roads. In simple terms, EuroRAP was therefore piloted to rate Europe's various roads for safety.

Traditionally, road-user error has been seen as the biggest cause of accidents, and the focus for remedial measures has been to eliminate these errors as far as possible. Whilst it is important to ensure that those errors which arise from direct violation of traffic law, or from lack of road-user skill, continue to be targeted, the programme recognises that error cannot be removed completely. The road system should be designed and managed to provide a forgiving environment for those who are involved in accidents whilst driving within the law.

This approach is consistent with the application of health and safety regulations in other activities, and adopts risk assessment as the basis for deciding appropriate levels of protection for road-users. These levels should be based on biomechanical criteria to set limits on the forces that the body should suffer during impact. These provide a common basis for linking road and vehicle design.

Vital to EuroRAP are two new standard test protocols. The first introduces a standard road inspection for safety features, the second measures and maps the rate at which people are being killed and seriously injured.

The programme focuses on dealing with death and serious injury (rather than simply "all collisions") with the philosophy that roads and vehicles must be developed together using best-affordable technology to protect against injury, and particularly against high-energy impacts.

The emphasis of the pilot programme was to identify which roads have most fatal and serious injury accidents, and what the key design characteristics are associated with these roads. From 2003 onwards, it is planned to have assembled data from at least 6 European countries, and to have a well tested process in place which can be extended to include more countries and to cover a larger proportion of the road network.

2 SAFETY COMPARISONS AT DIFFERENT LEVELS

International benchmarking at several different levels gives different types of information. Safety records are often compared at national level, but these are based, at best, on an average accident or casualty rate per vehicle kilometre driven for the whole country, and take no account of the pattern of traffic levels and different types of road within the different countries. They give a general indication of the level of safety throughout the country, and an average for all modes.

The aim in this programme is more detailed, to compare the safety performance of road sections that perform similar functions in different countries. As part of this comparison, the programme will also look closely at the variation in safety performance within each country, on different parts of the same road network. Assessment at this level will provide a measure of the average performance along routes. This assessment is not aimed at identifying individual high risk sites (“blackspots”), but if these are common along the route, this will be reflected in the overall route performance.

Fatal and serious injury accident rates will reflect not just road standards, but also the traffic safety rules, road-user behaviour, levels of traffic flow, and nature of the vehicle fleets in the different countries. To understand more clearly differences in the influence of road design and management on fatal and serious injury accidents, it is necessary also to inspect the road quality directly.

The pilot study was therefore planned in three parts:

- general international comparisons of death rates on the road networks of different European countries;
- analysis and mapping of fatal and serious accident rates occurring on major roads outside built-up areas in Britain, the Netherlands and Sweden; and
- an inspection of the safety quality of the road infrastructure in different countries to identify the extent to which it protects road-users from death and serious injury.

2.1 International comparisons

This used the IRTAD (Elsner *et al*, 2000) database. It provides national comparisons of fatality rates for motorways and for those 'A' class roads outside built-up areas for which the country provides information. It shows some of the differences that the programme needs to take into account, and also shows the extent of the network that needs to be compared in order to cover a substantial proportion of fatal accidents.

2.2 Accident rates over road lengths

This involved defining suitable road sections for comparison in each country and assembling data on accidents, traffic and basic safety design features for these sections. It provides the core information from which to identify variability in fatal accident rates between and within countries. This variability can be illustrated on road network maps, and the relative risk communicated in an accessible way.

Data are presented and compared for parts of the road network in Britain, the Netherlands, Sweden, and the region of Catalonia in Spain. Accident data from some 20,000kms of British roads, and another 10,000kms of roads in other countries, has been analysed for this pilot phase.

2.3 Comparison of infrastructure design

This involved an in-car survey of a sample of roads in each country during which observers assessed the safety features of the road design with respect to four common accident types – "head-to head" impacts, those at junctions, single-vehicle run-off-the road impacts, and those ivolving vulnerable road-users. A permanent video record was made for more detailed analysis.

In this pilot phase, some 3,000kms of roads in Britain, the Netherlands, Sweden, and Germany were inspected.

3 ANALYSIS AND PRESENTATION OF ACCIDENT RATES: KEY FACTORS

3.1 Road network structures

Most developed countries have a defined structure for their road network, with a national road network managed by one or more highway authorities. New roads on these networks are built to a high standard. Below that there is usually a network of main roads, either defined as a regional network, or as a primary, non-national, road network. The network descriptions, the responsible authorities, and the design standards differ for these networks.

National design standards are usually developed by the national road authority and designate the standard of any new roads built, or major improvements made, to that national network at any particular time. Roads may still operate to lower standards, which were current at the time when they were built, if they have not been subsequently improved. If major changes have been made in the layout aspects of the design standards, it may not be possible to reflect them wholly in subsequent improvements.

Highway authorities responsible for the roads outside the national network may follow the national standards, but usually there is no requirement for them to do so, and they may develop their own more limited standards.

Most countries hold very good information on their motorway network, which is built and managed to a well-defined standard. Non-motorway standard roads within the national network may operate to less consistent standards, and there is likely to be even greater variation in the regional road networks. Data availability is similarly progressively less good for each lower network tier.

3.2 Distribution of accidents between road networks

For this programme, interest lies in the more serious accidents, as they reflect both the likelihood of an accident occurring, and also the ability of the road design to contain that accident without serious injury. Not only is this the policy focus, but these accidents are also likely to be reported more consistently than minor accidents.

In most European countries, the majority of the fatal accidents occur outside built-up areas, despite the majority of accidents of all severity still occurring within built-up areas. Although a high proportion of the accidents on motorways is fatal or serious, the absolute number of accidents on these roads is low. The majority of deaths on roads outside built-up areas is on single carriageway roads. (In Britain 9 per cent of deaths on roads outside built-up areas are on the motorways, 19 per cent on dual carriageways and 72 per cent on single carriageways.)

To make sure that the programme assesses those roads on which a high proportion of high severity accidents occurrs, it is necessary to include the national non-motorway roads, and the main regional roads.

3.3 Influence of design choices on accident rates

Differences in average accident rates (of whatever severity) between countries may occur for several reasons. Different proportions of the network may be built to a fundamentally different standard (eg the proportion of motorways may differ), design choices may differ in terms of number of lanes or junctions designs, or a variety of road management choices (eg signing, marking and speed limit) may have been used to achieve safer operation.

In comparing countries, the study will look at both the overall standard of the networks that are performing similar functions, and also the extent to which design variations within a network give rise to difference in safety performance. The latter will be investigated by within-country comparisons.

Comparisons between accident rates in different countries will also highlight the wide range of cultural and social factors (such as attitudes to drink-driving, speed and seatbelt- and helmet-wearing) that give rise to different patterns of road-user behaviour between countries, and different driving standards, enforcement and education policies. Protection becomes more important for groups such as younger drivers and passengers who may be less inclined to protect themselves through seatbelt-wearing. Within countries these differences should be minimised, but local differences may still occur.

3.4 Variation of accident rates with flow

Many studies (see for example Walmesley and Summersgill, 1998) have shown that the frequency of accidents does not vary linearly with flow. Figure 1 illustrates the expected relationship between accident frequency and flow, and accident rate and flow. As accident rate is used in this study as a main measure of comparison, the rates need to be grouped accordingly to the flow level that they represent. This is important when comparing between parts of the same network carrying different levels of flow, because the performance of roads needs to be compared in terms of how well roads cater for a common demand. It is also important, as traffic flow levels differ substantially between countries.

3.5 Repeatability of performance ratings

In order to ensure that real, and consistent, differences in performance are measured, it is important that the rates calculated will be repeatable over time, assuming no change is made to the network. This mainly requires that sufficiently large accident numbers are being compared to limit the effects of chance differences between years. Figure 2 shows the spread of points produced if total numbers of fatal and serious accidents are compared for two different time periods for British main roads. Although the general relationship is strong, it is clear that the variation in accident frequency can become quite large when the numbers fall below about 20 accidents per road section.

The variability of group estimates with different combinations of road sections is investigated in more detail in Section 5. Repeatability is particularly necessary when identifying sections that lie well outside average performance.

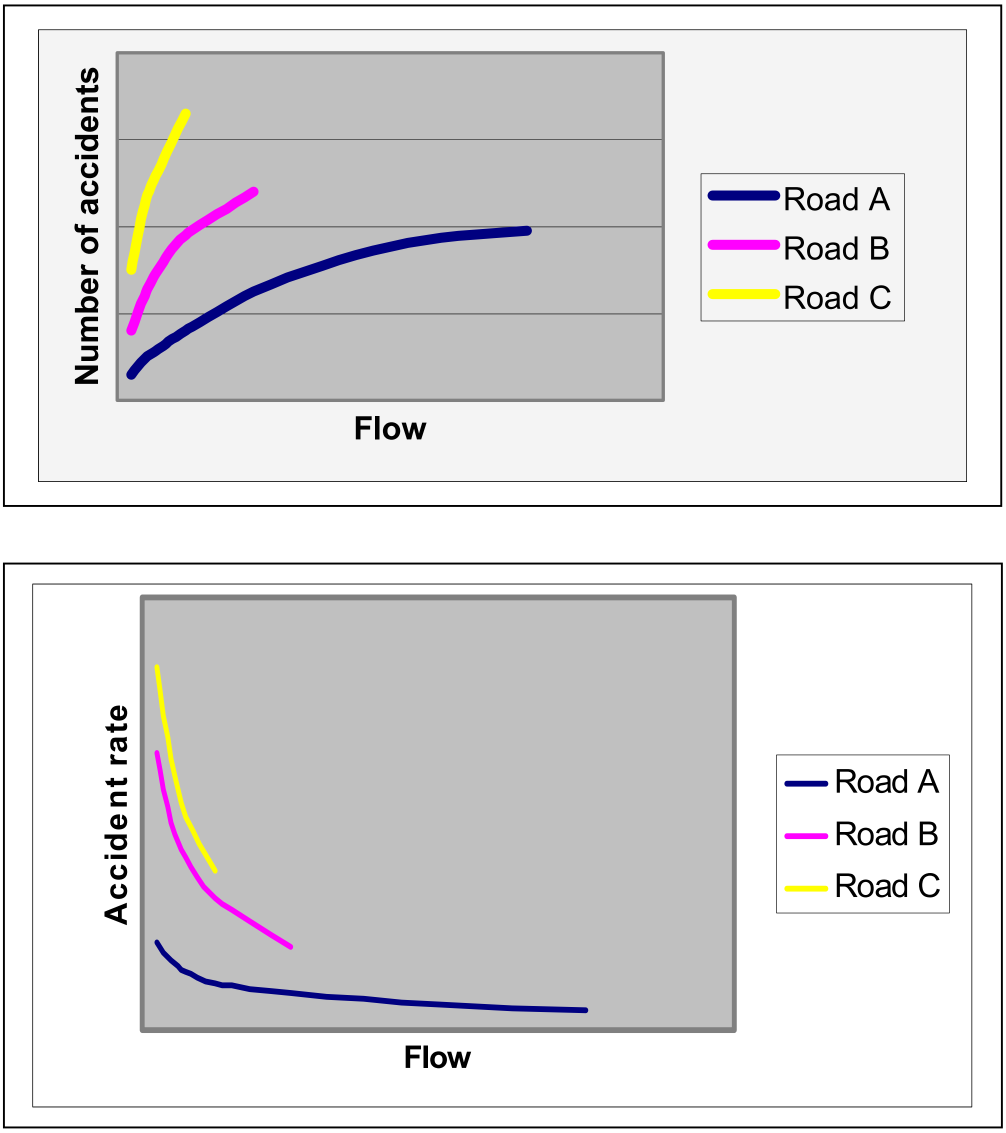

Figure 1 Typical variation of accident frequency and accident rate with traffic flow

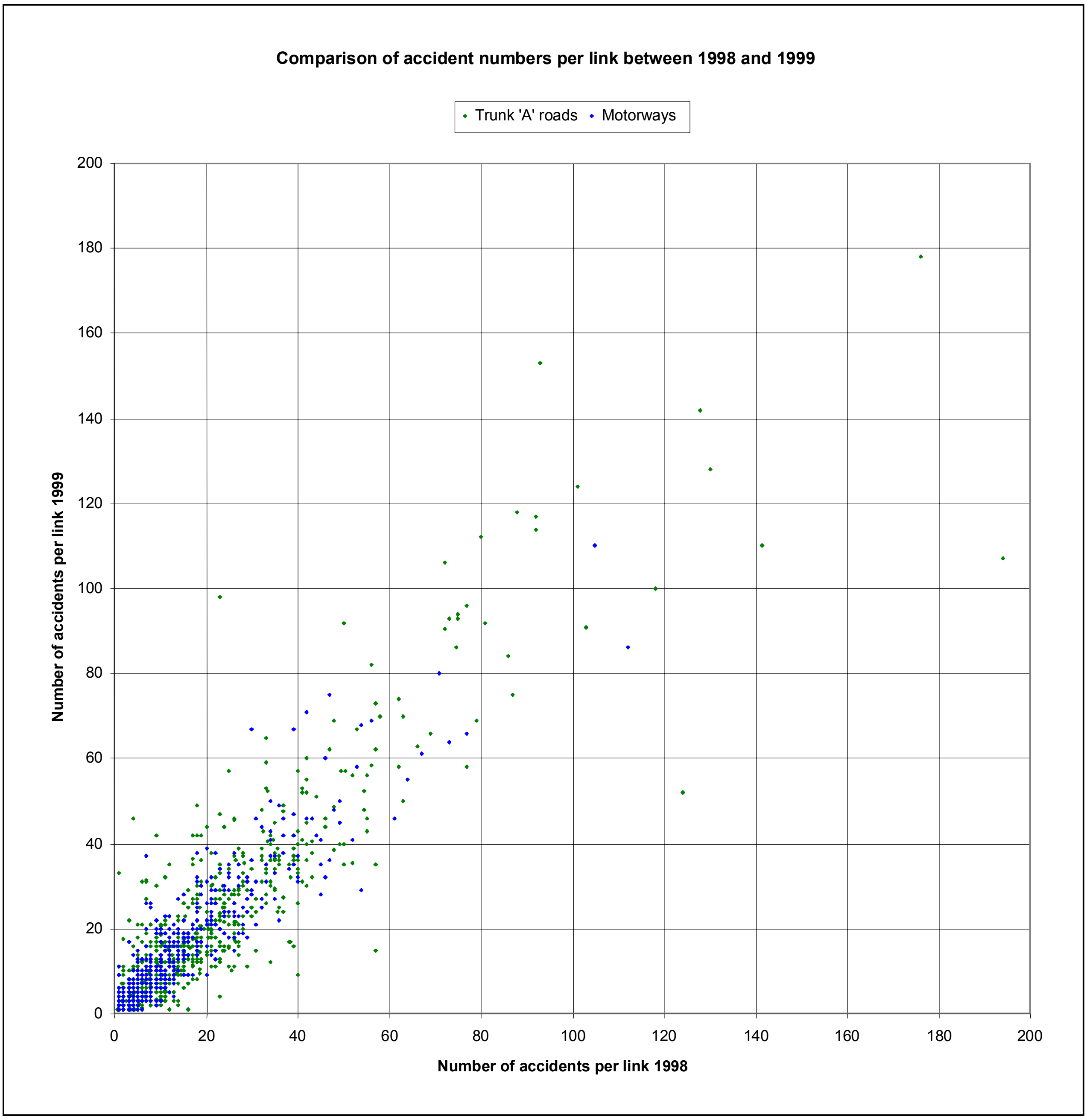

Figure 2 Repeatability of the number of fatal and serious accidents on road sections between time periods

3.6 High and low speed accidents

The initial aim of the pilot year was to focus on interurban routes and therefore mainly on higher speed accidents, and these were the data presented at www.eurorap.org in February 2002. However, many such routes, particularly on the regional road network, include significant distance on sections with lower speed limits when the route passes through villages or small towns. It is also quite common in some European countries to set short lengths of lower speed limit in the vicinity of junctions or other hazards.

The accident rates developed since February 2002, therefore, included all fatal and serious accidents along the chosen section. In this way, the sections, when mapped, created integrated routes, and gave a realistic indication of the total numbers of accidents occurring over longer routes.

3.7 Comparison within and between countries

Comparisons within countries can be made with reasonable confidence, if it can be assumed that the quality of the data is relatively similar.

When comparing between countries, there is often inconsistency. The reporting of fatal accidents is relatively consistent between countries, and there are well accepted factors for adjusting for different definitions for "time to die". Reporting of non-fatal accidents is much more variable, but a common approach has been agreed between British, Dutch and Swedish experts about the best way of allowing for this when making comparisons between countries. It is very unlikely that there will be sufficient fatal accidents to meet the criteria suggested above of 20 accidents per road section per three years, and extending the accident period to more years will increase the likelihood that there will be significant network changes over the period of investigation.

For this study, therefore, the total of fatal and serious accidents will be used. To allow for the known difference in definition of serious accidents between countries, and for the different reporting rates, these numbers will be standardised against the ratio of "fatalities" to "fatal and serious accidents"(F&S) for each country. The method allows variability between short road sections to be compared, within each country, whilst estimating the overall group averages within the countries to a common basis. The ratios used during the pilot year are shown in section 5.6.4

3.8 Presentation

The presentation of the comparisons will include:

- maps, showing the distribution of road sections within the network with relatively high and low accident rates;
- charts showing the mean rates for different groups of road sections, and the distribution of section values in relation to the mean; and
- lists of specific road sections with particularly high or low accident rates, or road infrastructure ratings.

4 INTERNATIONAL COMPARISONS

4.1 Nature of IRTAD data

The best source for such international comparisons is the International Road Traffic and Accident Database (IRTAD), maintained by the German Federal Highway Research Institute, BASt (Elsner *et al*, 2000). This institute devotes considerable effort to collecting and checking national data from many countries, including all those of Western Europe.

The IRTAD database uses a small number of categories of road type, of which two are relevant to this report:

- motorways; and
- A-level roads outside urban areas.

The main index that is used to compare the level of safety is the rate of accidents or casualties per million vehicle-km of traffic. Other indices are also quoted in the technical literature, such as rates per km of road or per head of population. These are less satisfactory, however, since accidents and casualties are a direct, if unintended, consequence of travel by road – which is measured by traffic volume. Thus, the main types of data to be analysed are:

(i) numbers of accidents and casualties on motorways and A-level roads outside urban areas, by country;

(ii) volumes of traffic on motorways and A-level roads outside urban areas, by country;

(iii) national lengths of motorways and A-level roads outside urban areas; comparing traffic volumes with road lengths will provide average flows on these roads, and show the relative intensity of use of the national networks.

National statistical agencies in the various countries collect these types of information and have supplied aggregate data to IRTAD for many years. There are two main problems with the data from IRTAD: gaps in the data, and inconsistencies between countries. The collection of information about traffic volume and road length in a country depends upon the resources devoted to the task, and certain countries are unable to supply IRTAD with particular types of information.

Lack of consistency is a greater problem with accident data, which are collected by local police - often with little central direction and supervision. There are few common definitions within Europe for the collection of accident data, and moreover it is known that reporting standards vary considerably. Countries are asked to supply IRTAD with the number of people who were killed or hospitalised, and the number of injury accidents. Few countries supply the number of people who were hospitalised, presumably because of the effort required to check whether an accident victim was actually hospitalised.

Of the other two items of data, the number killed is the more useful since it is generally well reported by the local police. Many countries include in their statistics those who died within 30 days of an accident, some use a shorter period, but IRTAD adjusts the statistics from these countries to allow for the shorter reporting period. The number of injury accidents is less useful because of the variability of national reporting standards and definitions - in particular, the minimum level of injury before an accident is recorded as an injury accident.

The aim of the analyses presented in the next section is to compare data averaged over the period 1999-2001. The lack of recent data means that an earlier period has to be adopted in a few cases, but national rates change relatively slowly and this is unlikely to affect the comparisons. IRTAD includes data for the United Kingdom rather than Great Britain. The United Kingdom comprises Great Britain and Northern Ireland, and the recording of statistics in Northern Ireland and Great Britain differs in certain respects that limit the data that can be supplied to IRTAD. Accordingly, the next section analyses data for Great Britain rather than

IRTAD data for the United Kingdom, taking trunk roads as the A-level roads outside urban areas.

4.2 Fatal accident rate comparisons

Data were sought for the 15 EU member states plus Switzerland and Norway; those countries appearing in the Figure have supplied IRTAD with traffic volumes *and* the number of people killed on either motorways or A-level roads outside urban areas. Greece and Spain are notable omissions from Figure 3, but RACE and RACC, the motoring organisations in Spain, are in consultation with their governments about access to data. Where both rates are available, the ratio of the two gives an indication of whether the national classifications of "A-level roads outside urban areas" are consistent. The ratio ranges from 3.0 in Great Britain to 5.3 in the Netherlands. This suggests that the classification is reasonably consistent between countries, although the range of roads appears somewhat lower in Great Britain than in Germany and the Netherlands, for example. The rates are displayed in the chart below; the rate for Italy was provided, separately, by the Italian motoring club, ACI.

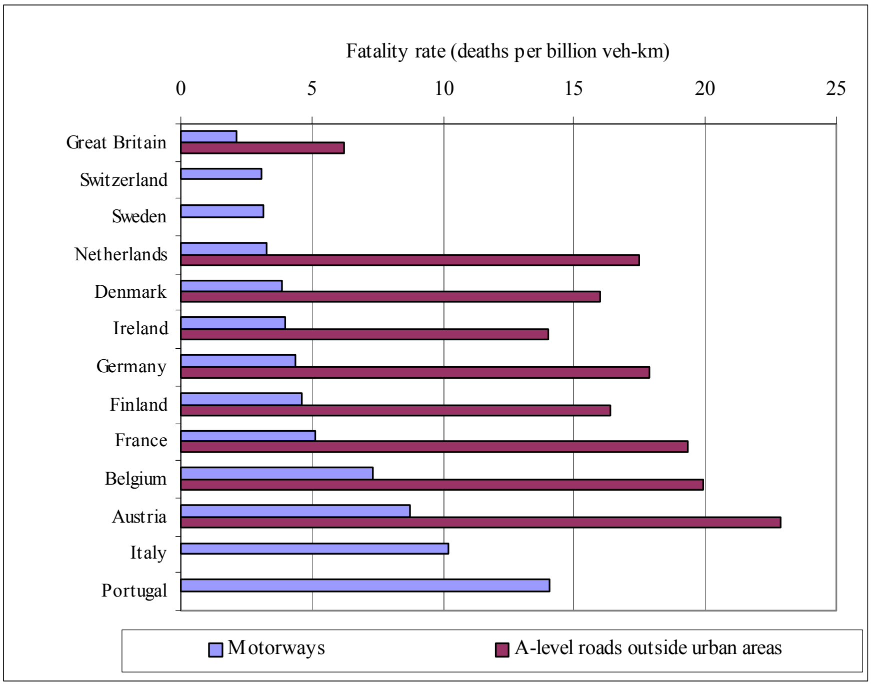

Figure 3 Fatality rates (deaths per billion vehicle-km) 1999-2001

4.3 Flow comparisons

The average daily flow across 'A' road network can be calculated from the volume of traffic and the overall length of road.

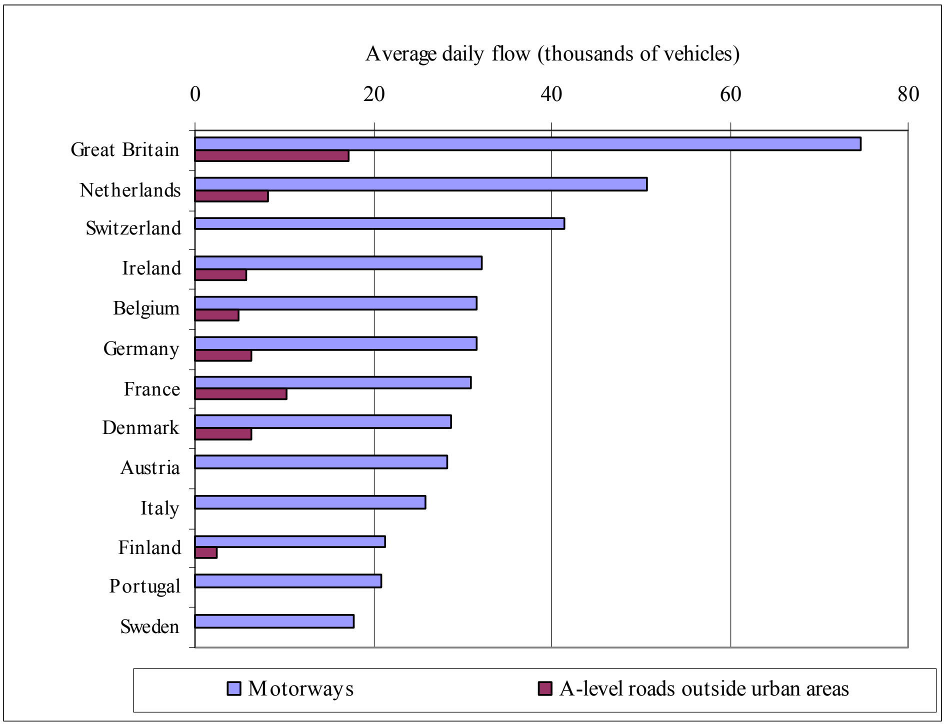

Figure 4 Comparison of average annual daily flows between countries 1999-2001

The average motorway flows vary widely, by a factor of almost four between Sweden and Great Britain. The range is even greater for A-level roads outside urban areas, with a factor of over seven between Finland and Great Britain. The major road network of Great Britain is clearly the most heavily trafficked in Europe.

4.4 Ratios of accident severities

Section 2.1 mentioned that the variability of national reporting standards and definitions leads to problems that affect international comparisons of the number of people injured (rather than killed) in road accidents. The consequences will be examined briefly using the IRTAD data. Figure 5 shows the values that have been calculated for:

(Number of injury accidents)/(Number of people killed)

Even if reporting standards and definitions were consistent, some variation would be expected between countries. The variation in Figure 5 is far greater, however, and it is clear that the police in Great Britain and Switzerland record a much wider range of accidents than, for example, the police in Finland and Denmark.

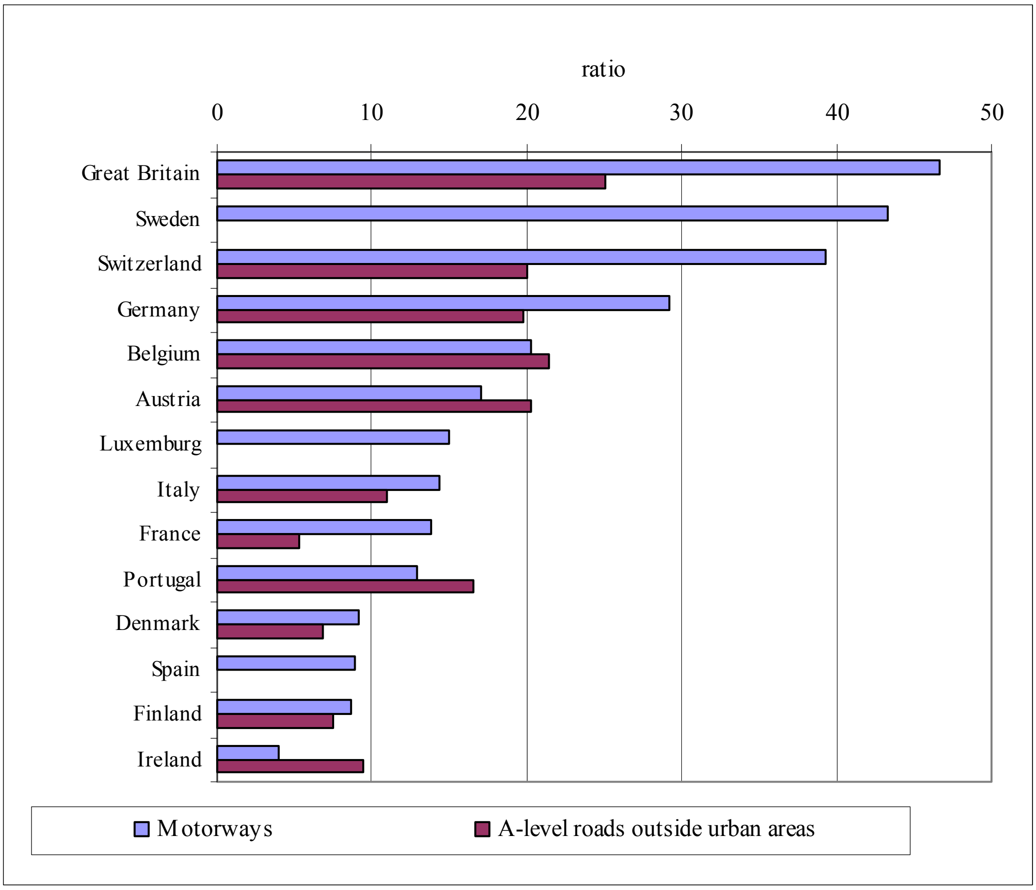

Figure 5 Ratio of number of injury accidents to number of fatalities 1999-2001

4.5 Road network to be considered

Only a small proportion of fatal accidents occurs on motorways in each country, typically 5-10 per cent, as shown in Figure 6. To ensure that conclusions from the study can impact policies relating to a substantial number of accidents, it will be necessary to collect data from a wider range of roads.

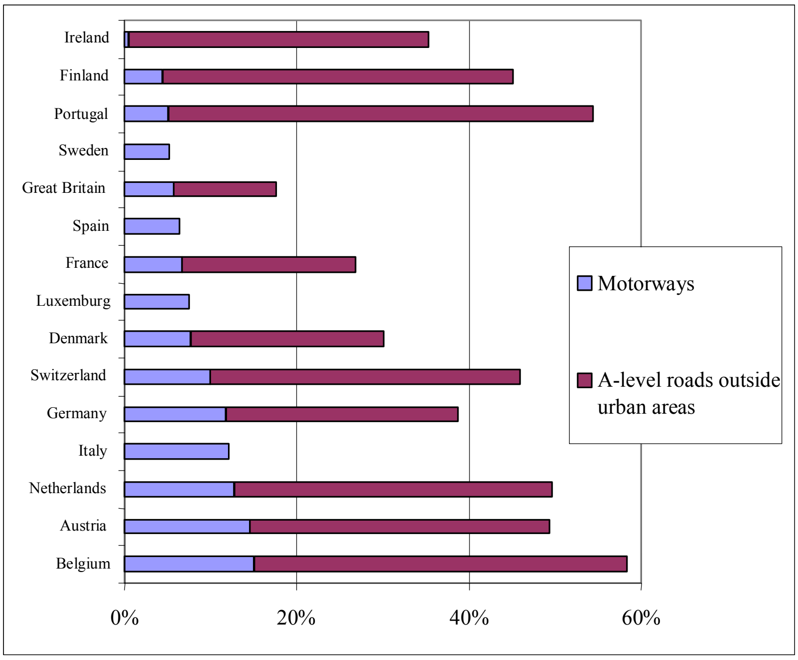

Figure 6 Percentage of fatal accidents on different parts of the road network

Initially, the focus will be on roads outside urban areas. The IRTAD data in Figure 6 show that inclusion of 'A' roads outside urban areas increases the proportion of fatal accidents covered to around 40 per cent in some countries, which seems a practical target.

The data supplied to IRTAD for "A-level roads" do not necessarily cover all higher quality roads in these countries - for example, the data for Britain cover the network that is the responsibility of the national Highways Agency. If all 'A' class roads in Britain outside urban areas were included, over 40 per cent of the fatal accidents in Britain would be included.

4.6 Comparing fatality rates over time

Figure 7 shows data collected by IRTAD for motorway fatalities over the last 20 years for a range of countries (Elsner *et al*, 2000). The Y axis shows number of fatal accidents per billion veh-kms; the X axis shows annual average daily traffic flow. The curves illustrating the pattern of change in the data show the extent to which the numbers of fatalities have reduced over that period. They also illustrate the changes in traffic flow that have occurred over the same period. They do not, however, give a good indication of the variation of accident rate with flow at any specific period in time. The changes observed over the 20 year period have been strongly influenced by safety developments in road and vehicle design and changes in driver behaviour over the period.

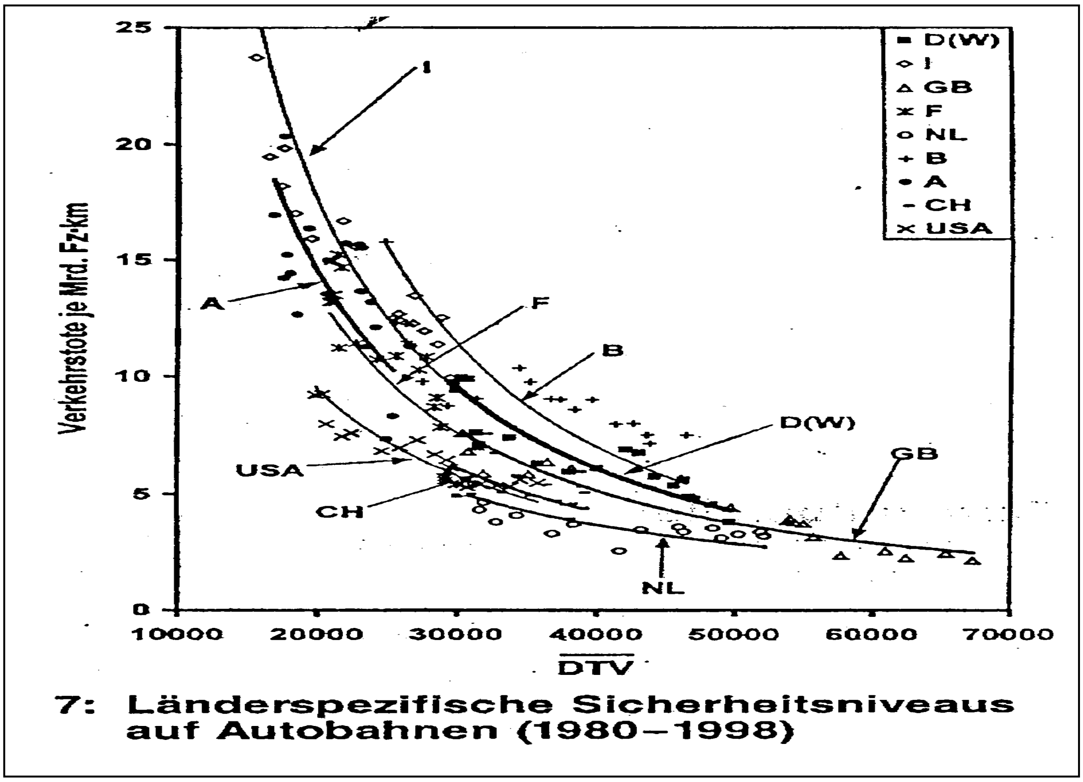

Figure 7 Change in motorway accident rates over time (from IRTAD)

5 COMPARISONS OF FATAL AND SERIOUS ACCIDENT RATES OVER ROAD LENGTHS

5.1 Access to data

Data relating to the motorway network are usually held by the national roads authority in each country. Data are generally available on both accidents and traffic flow. These data are available nationally for Britain, the Netherlands, and Sweden, and for Catalonia were obtained from the Catalonian highway authority.

Comprehensive data for non-motorway 'A' roads are generally not held centrally. In the pilot year, data for Sweden and Netherlands have been obtained from the national road authority which covers a larger network than simply the motorways, although in the Netherlands, most of the roads in the sample are divided. Further data at more provincial level will be sought in the next stages in the project. In Britain, data have been provided by the Department for Transport, for all 'A' roads. In Catalonia, the local highway authority was able to supply data over a large network of roads of varying function.

Britain, the Netherlands and Sweden were selected for the pilot stage partly because they were expected to have particular strengths in the collection and presentation of the data, coupled with innovative philosophies on the reduction of death and serious injury. As the project extends to a larger number of countries, the quality and availability of data may be more limited, particularly the traffic flow data.

There is an apparent contradiction in the collection of road accident data in that data management and recording is often best for the safest roads in any country and for those countries where accident rates are lowest.

5.2 Data needed

Appendix A shows the data requested from each country that wishes to take part in the study; this includes data on basic road design, where this is available, in order to help understand the differences in accident rate observed.

In order to produce the data required for EuroRAP analyses, a process is needed by which accident and traffic flow data can be assigned to road sections of perhaps 10-20kms length. The networks being investigated need to be divided into these road sections, such that as far as possible the design of the road within the section is uniform, and the traffic flow over this length is consistent. In practice, these general principles will not be fully met as, particularly for the lower class roads, road design and flow vary frequently along a route. The choice of sections will therefore be a compromise between these various objectives.

For considering group averages, all road sections, however small, can be used, as they can be amalgamated into groups of consistent character. But to identify road sections of lower or higher standard which demonstrate differences in general road standard performance, it is necessary to consider sections that meet the length criteria proposed. For these comparisons to be repeatable, the analysis of the British data (Appendix B) shows that the total of fatal and serious accidents over a three year period, for links at least 5km long, provides a reasonable measure.

5.3 Data sources

Britain

Annual accident data are available for Great Britain, for fatal, serious, and slight injury accidents, identified by the road number and grid reference of the location of the accidents. Accidents can be uniquely related to road sections that are similarly identified by road number, and grid co-ordinates defining the start and end of the road section.

Traffic flows are available from an annual traffic census, which comprises a mixture of permanent and variable counting sites. These provide a good coverage of the motorways and 'A' roads, which make up the major road network in Britain. Part of this network is the national (or Trunk) road network; the remainder is the responsibility of the local highway authorities and is of regional importance (described as primary roads).

Both of these data sources are available from the Department for Transport. Computerised maps of this network are available from commercial sources.

The Netherlands

Data for the national road network in the Netherlands was provided by The Transport Research Centre (Adviesdienst Verkeer en Vervoer) of the Dutch Ministry of Transport, Public Works and Water Management. The Dutch network comprises 3500km of national roads (mainly dual carriageway with segregated junctions) and 12000kms of Provincial roads (mostly single carriageway with speed limits of 80kph). Accident data are available for the whole of this network. For the provincial roads, data are physically held by the Provinces, but they will supply them to the Research Centre on request.

Traffic counts are made at 400 permanent sites on the national network, with counting undertaken periodically at another 800 sites. These will form the basis for the links for which the Dutch data will be supplied. A similar system is operated by most of the provinces.

Data from the national road system were used for the pilot year; these will be extended to the provincial network in subsequent years.

Sweden

The Swedish National Road Administration (SNRA) has provided data for a sample of national and regional roads in Sweden.

Accident data are held by SNRA for the national road network, listed on a link and node basis by road name.

SNRA defines three main categories of rural road – motorway, 2-lane roads of width 9m to 13m, and 2-lane roads of width 6m to 8.9m. Between 1998 and 2000, approximately 45 per cent of veh-kms occurred on the motorway sections resulting in 14 per cent of the total fatalities on the network. A similar proportion of veh-kms occurred on the wider 2-lane network, but resulted in 69 per cent of the fatalities. The “wide 2-lane” category also includes some roads with four traffic lanes and at-grade junctions.

Catalonia

Data have been provided by Servei Català de Trànsit (SCT). SCT holds a database of all accidents reported in Catalonia. Deaths are only recorded if they occur within 24 hours of the accident, but standard factors are applied to convert these where necessary to reflect deaths within 30 days. SCT collates traffic flow data from several state, Catalan and local council sources.

5.4 Generating road section data

Britain

Each traffic census point can be considered to represent a section of road. Short or low flow sections with less than 20 fatal and serious accidents in three years were combined using the following target criteria:

- they had the same road number;
- they were adjacent;
- they were part of the same network (national or regional); and
- they had similar flows (differences up to 10,000 vehicles per day were accepted).

These criteria produced many sections of mixed design, but there were still a number of links that could not be combined further and still failed to meet the targets of a minimum length of 5kms and a minimum of twenty accidents. For the motorway and National 'A' roads, over 80 per cent of the total veh-kms were on links which met the full criteria, but for Regional 'A' roads the proportion was lower, at about 60 per cent. This means there is likely to be more variability in the rates for individual sections of these roads, and these might vary more between years.

All British accident data in this part of the report are for the period 1997-1999 and traffic counts from the year 1998. A total of 883 links were defined covering the 22,400km network.

Sweden

For the link-based definition required for EuroRAP, road sections have been combined manually to provide a set of links consistent with other countries. The Swedish network being analysed has a length of 8500km, and has been divided into 430 links.

Accidents coded to nodes have been divided equally between the main roads joining the node. However, the traffic flow level and consequent accident numbers on the Swedish network are very low compared with those in the other countries. The numbers of accidents per link are thus very much lower than the criteria sought. For the average accident rates for different networks described in section 5.6.2, this is not important, but there is likely to be considerable random variation in the rates for individual links. Even over 3 years, about a quarter of the sections identified have no fatal and serious accidents. The Swedish accident data were averaged over the period 1990-1998.

Netherlands

The Dutch data were provided separately for every section at which road geometry changed, eg all additional turning lanes or merging widths at junctions. The basic data-set, therefore, included some 9000 items covering the 3500km network. The initial risk rate mapping was done with this complete data-set. For further analysis of the distribution of link rates, this data-set was initially reduced to 1000 sections, and then these were further combined to create 450 links. The Dutch accident data were averaged over the period 1995-1998.

Catalonia

The Servei Català de Trànsit, working with the general principles outlined above, defined a set of 404 links covering 3411kms of road network. However, the detailed process used concentrated on the roads with the higher numbers of accidents, so these initial data may overestimate the average accident rates for all roads of these types in Catalonia. Roads are defined as motorways, Via convenciale, and Via preferente; in each case their central separation, junction grade separation and responsible highway authority is recorded. The Catalonian accident data related to the period 1998-2000.

5.5 Comparative networks within Great Britain

The database developed above for Great Britain was used to investigate variations in the fatal and serious accident rate within the motorway and 'A' road networks. The results are summarised in this section, and described in detail in Appendices B and D.

The accident rates for different parts of the network are summarised in Table 5.1.

Table 5.1 Fatal and serious accident rates for different British roads

	Fatal and serious accident rate per billion vehicle km	No of accidents
All National roads	30.8	12,573
National 'A' roads	49.0	9,276
Other primary (regional) 'A' roads	79.6	9,462
Motorways	15.0	3,297
Dual carriageways with grade-separated junctions	27.3	687
Dual carriageways with at-grade junctions	51.7	1,329
Single (2-lane) carriageways	86.4	8,187

Key conclusions that can be drawn from the analyses are:

- the average fatal and serious accident rate for the 'A' road network is about four times higher than that for the national motorway network;
- the average fatal and serious accident rates on the national and regional 'A' road networks are significantly different from each other. The higher rate for the regional network is strongly influenced by both the lower proportion of higher flow roads in the regional network, and the greater likelihood of these routes passing through more populated areas and including a substantial proportion of accidents on sections with lower speed limits.

The 'A' road network is made up of roads of varying design, with both dual carriageway and single carriageway sections. Part of the dual carriageway network has grade-separated junctions, and part has at-grade junctions. Although the process of combination of links into road sections sought to maintain consistency of design as far as possible, a substantial proportion of sections contained both dual and single carriageway links. In some cases, this was a basic feature of route design; in other cases, it resulted from the need to develop sufficiently long sections to have repeatable accident numbers.

- There is a significant difference between the fatal and serious accident rates for dual, single and mixed dual/single road sections, with the dual carriageway rates averaging less than half that for the single carriageways, and the mixed category averaging rates about 70 per cent of the single carriageway rate.

- Within the dual carriageway group, sections with grade-separated junctions have rates averaging about half the rate for sections with at-grade junctions, and this difference is significant.

The variation of fatal and serious accident rate with traffic flow has already been discussed in section 3.4. The data show very little variation in fatal and serious accident rate with flow for motorway sections, but considerably greater variation of accident rate with flow within the 'A' road network.

- There are significant differences in fatal and serious accident rate between roads with less than 10,000 AADT, roads with 10,000 to 20,000 AADT, roads with 20,000 to 30,000 AADT, and roads with more than 30,000 AADT. Different flow groups should, therefore, be considered separately when identifying sections with relatively high or low fatal and serious accident rates for their group, so that roads are judged against a common flow criteria.

The possibility of relatively higher fatal and serious accident rates being associated with short road section lengths was raised in section 3.5.

- Fatal and serious accident rates for the shorter sections can be substantially different from the group averages, although there is considerable variation between the rates for the short sections. This may be due to a proportionately high influence on rates from the accidents at junctions at the ends of the short sections, or to the lack of settled flows and driving behaviour over short sections. For motorways and dual carriageways, these differences are significant up to section lengths of 10kms. This needs to be recognised where rates have to be quoted for short sections.

5.6 Comparison with Dutch, Swedish and Catalonian data

5.6.1 Rates for The Netherlands

Motorways (Autosnelweg) make up 70 per cent of the Dutch roads for which data were available in the pilot year. The remainder is split roughly equally between other divided roads (Autoweg) and 2-lane roads. The latter type includes some roads with restrictions on lower speed vehicles, but there are not enough in this sample to analyse separately.

Table 5.2 Fatal and serious accident rates for different Dutch roads

	Fatal and serious accident rate per billion vehicle km	No of killed and seriously injured
National roads	22.8	8,513
Other regional main roads	N/A	N/A
Motorways (Autosnelweg)	19.7	6,213
Other divided roads (Autoweg)	61.4	904
Single (2-lane) carriageways	96.0	1,396

5.6.2 Rates for Sweden

Rates on national (non-motorway) roads are about three times the motorway rate; the rate for all national roads is double the motorway rate. Generally, flows on Swedish roads are much lower than those on equivalent road types in Britain and the Netherlands. Rates on divided roads with grade-separated junctions are only 50 per cent higher than rates on motorways. Rates on single carriageways (ie undivided roads) are about three times those of motorways. Rates on multilane roads are similar to those on wide 2-lane roads.

Table 5.3 Fatal and serious accident rates for different Swedish roads

	Fatal and serious accident rate per billion vehicle km	**No of killed and seriously injured**
National roads	41.6	2025
Other regional main roads	N/A	N/A
Motorways	21.2	541
Other divided roads	32.3	79
4 lane roads	50.9	137
Single (2 lane) carriageways: 9-13m	59.3	951
Single (2 lane) carriageways: <9m	60.6	317

5.6.3 Rates for Catalonia

Half the road length in the sample is managed by the State, and both State and regional authorities manage all types of road. Overall, the rate for the State roads is only about 60 per cent of the rate for regional roads, but for a particular type of road the rates are similar. The network examined includes a wider range of regional roads than the networks for the other three countries.

Table 5.4 Fatal and serious accident rates for different Catalonian roads

	Fatal and serious accident rate per billion vehicle km	**No of accidents**
National (State) roads	56.97	1952
Other regional roads	92.78	3440
Motorways	36.0	1233
Other divided	82.9	627
Single (2 lane) carriageways	110.3	3531

5.6.4 Comparison between countries

Numbers of fatal accidents can be compared on a fairly consistent basis between countries. Where national data recording methods assume different lengths of "time to die" in their definition of a road accident fatality, there are well-accepted conversion factors for adjusting for this. For this study, however, it has been necessary to compare recorded numbers of fatal and serious accidents, or fatalities and seriously injured casualties, between countries. It is known that both definitions and reporting levels of serious injuries vary considerably between countries, so no simple conversion factors exist. In order to provide a more consistent basis for comparison between fatal and serious accidents, we have applied a factor to the individual route section estimates for each country, based on the national ratio of:

(Number of fatal and serious accidents)/(Number of fatalities)

This means that the adjusted total number of fatal and serious accidents will be in the same proportion as the total fatalities for each country. Strictly speaking, accidents and casualties should not be mixed in the same expression, but the data are available in different forms in different countries. Mixing these variables will not cause a problem unless the number of fatalities per fatal accident is very different between countries.

The ratios for the four countries are shown in Table 5.5. The factor shown is the ratio with either fatal and serious accidents or fatalities and seriously injured casualties, depending on the category used by each country in reporting its data.

Table 5.5 Comparison factors for fatal and serious accident rates (per billion vehicle km) between different countries

	GB	NL	S	ESP
Ratio of fatal and serious accidents to fatalities	5.85			3.38
Ratio of fatalities and seriously injured casualties to fatalities	7.73	7.75	6.03	

In practice, this ratio may differ between different types of road, but for the initial comparison (Table 5.6), the same ratio has been applied to all roads in each country for which data are available.

Table 5.6 Fatal and serious accident rates (per billion vehicle km) for different countries

<table>
<tr><th></th><th>GB</th><th>NL</th><th>S</th><th>ESP</th></tr>
<tr><td>National 'A' roads</td><td>49</td><td>59</td><td>56</td><td>108</td></tr>
<tr><td>Other primary (regional) 'A' roads</td><td>80</td><td></td><td></td><td></td></tr>
<tr><td>Motorways</td><td>15</td><td>15</td><td>20</td><td>62</td></tr>
<tr><td>Dual carriageways with grade-separated junctions</td><td>27</td><td rowspan="2">) 46)</td><td>31</td><td rowspan="2">) 143)</td></tr>
<tr><td>Dual carriageways with at-grade junctions</td><td>51</td><td></td></tr>
<tr><td>Multilane single carriageways</td><td></td><td></td><td>49</td><td></td></tr>
<tr><td>Wide single carriageways</td><td></td><td></td><td>58</td><td></td></tr>
<tr><td>Single (2-lane) carriageways</td><td>86</td><td>72</td><td>59</td><td>191</td></tr>
</table>

In all four areas (Britain, the Netherlands, Sweden, and Catalonia), the general pattern of rates between different parts of the road system is relatively similar. Further investigation is needed in the next stage of the project, to assess whether the differences that do exist reflect design differences within the various general road types. After adjusting for reporting differences, the motorway rates for Britain, the Netherlands and Sweden are roughly similar, but rates for Catalonian motorways are much higher. Rates for each road type are higher in Catalonia reflecting, in part, different driving behaviour, but there may also be a small upward bias due to the roads selected for assessment in Catalonia. Rates for single carriageway roads in Britain are almost 50 per cent higher than in Sweden, probably reflecting the greater density of lowly populated areas along the British routes.

5.7 Rate maps

5.7.1 Alternative rate maps for Britain

As an illustration of the different types of information that can be shown, Figures 8, 9, 10, and 11 map the distribution of the calculated fatal and serious accident rates across the British network, using four different measures of the data described in section 3.6. Each provides a different picture of accident distribution.

Fatal and serious accident rates per kilometre of road (Figure 8) show where the highest and lowest numbers of accidents occur within the network. More fatal and serious accidents occur on roads with higher flows, so the motorways and high flow 'A' roads will be highlighted on this map.

Accident rates per vehicle kilometre travelled (Figure 9) take account of the general effect of traffic flow. On this basis, motorways are indicated as relatively safe roads because of their higher design, whereas, as shown in the preceding analysis, single carriageway 'A' roads have the highest fatal and serious accident rates.

Fatal and serious accident rates related to group averages (Figure 10) show which roads have higher or lower accident rates, after the expected variability between different road groups are taken into account. For this figure, four separate road groups have been considered - motorways, 'A' roads with daily flows below 10,000, 'A' roads with flows between 10,000 and 20,000, and 'A' roads with flows over 20,000.

Combining the results from Figure 8 and Figure 10, enables the potential savings in accidents to be estimated (Figure 11), assuming that all road sections could be improved to rates similar to the current average for their groups. A good discussion of some of the issues in this type of approach is offered by McGuigan (1982).

For each Figure, roads have been colour coded according to whether they fall in the low, medium, high or very high band for each type of rate. (Different maps can be produced to show different aspects of the safety situation. Figure 9, for example, differs from that published on the EuroRAP in February 2002 website in that it includes accidents on both low and high speed sections of the route, to give a rate including all types of fatal and serious accidents. The original website material focused on the accident rates on the higher speed sections of the routes. (To emphasise the differences between Figures 8-11, a simpler risk banding has been used than in Figure 12; Figure 9 also uses an updated accident search algorithm.))

5.7.2 Maps for other countries

Similar maps can be produced for each of the other countries. Figure 12 compares the maps of rates per veh-km, using provisional data for all four countries.

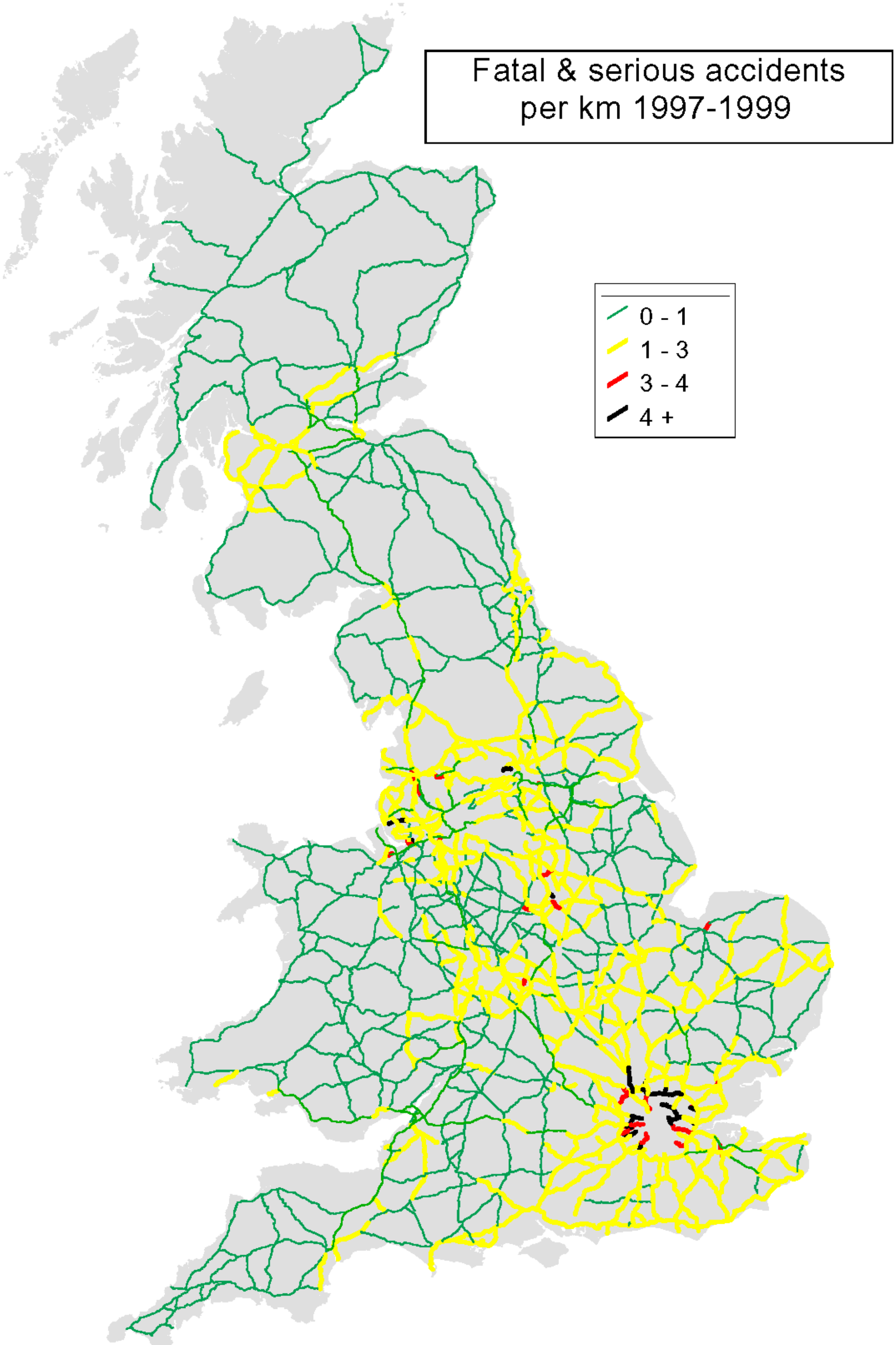

Figure 8 Fatal and serious accidents per km in Britain

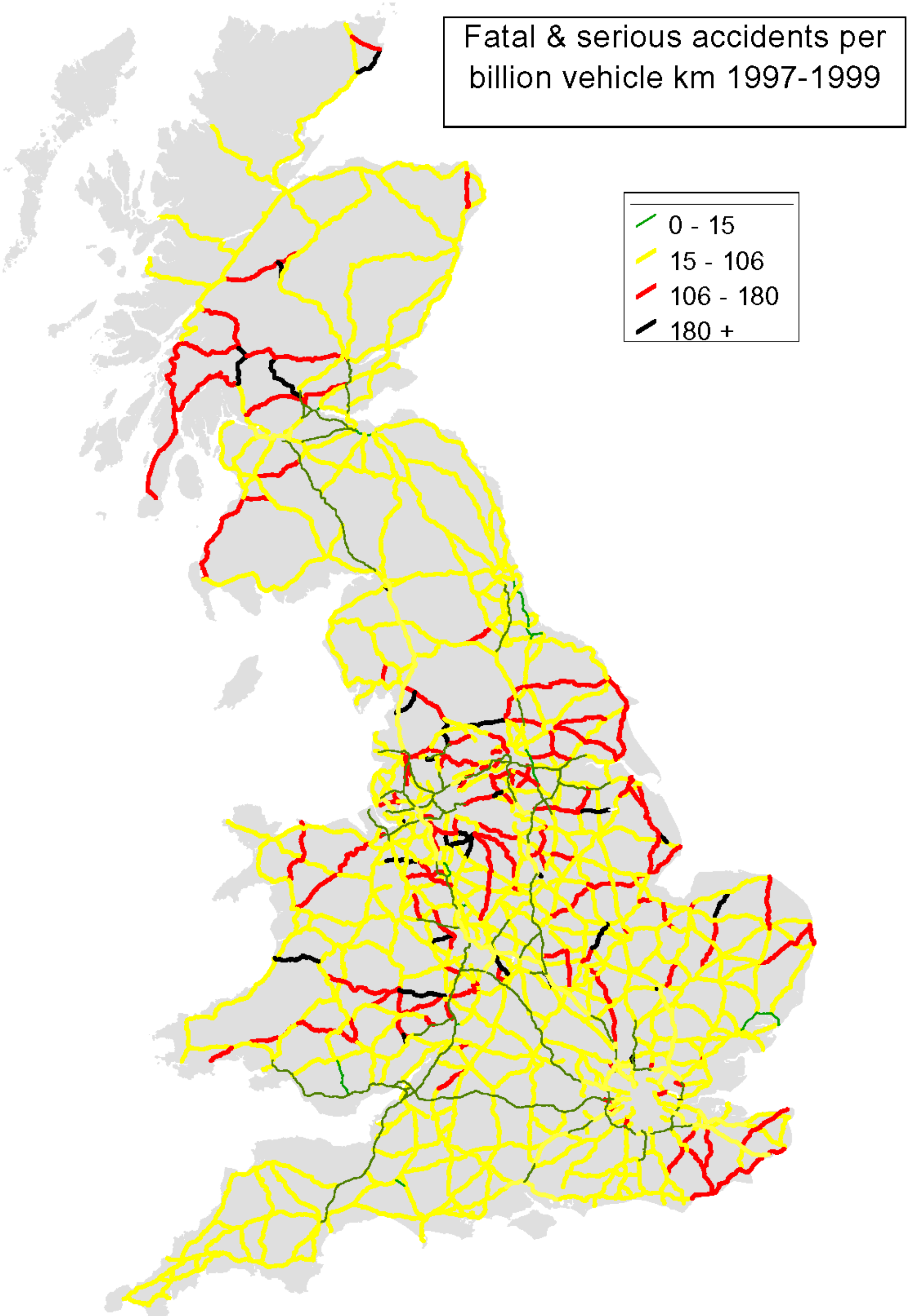

Figure 9 Fatal and serious accident per vehicle-km in Britain

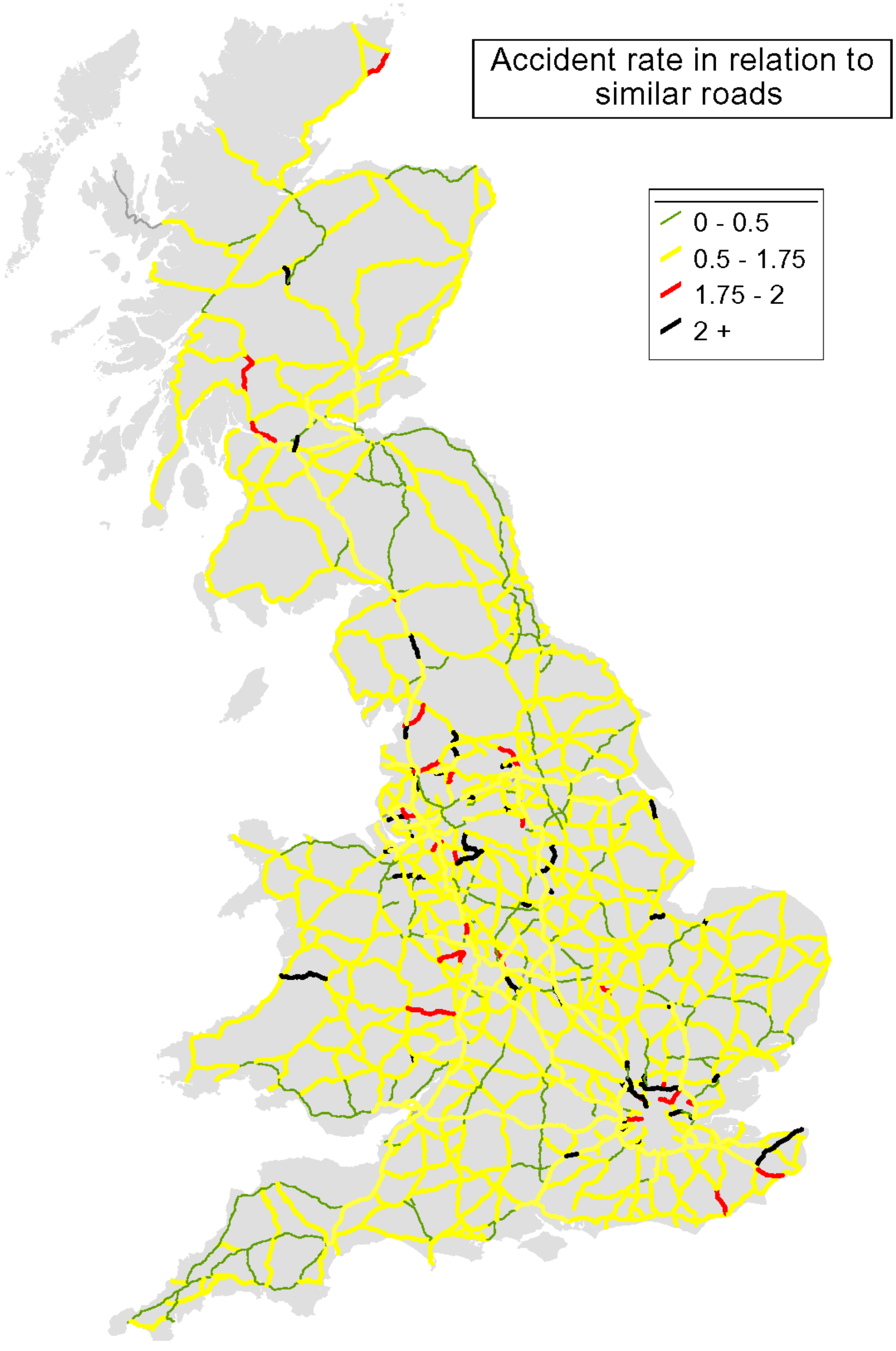

Figure 10 Ratio of accident rate per vehicle-km to rate for similar British roads

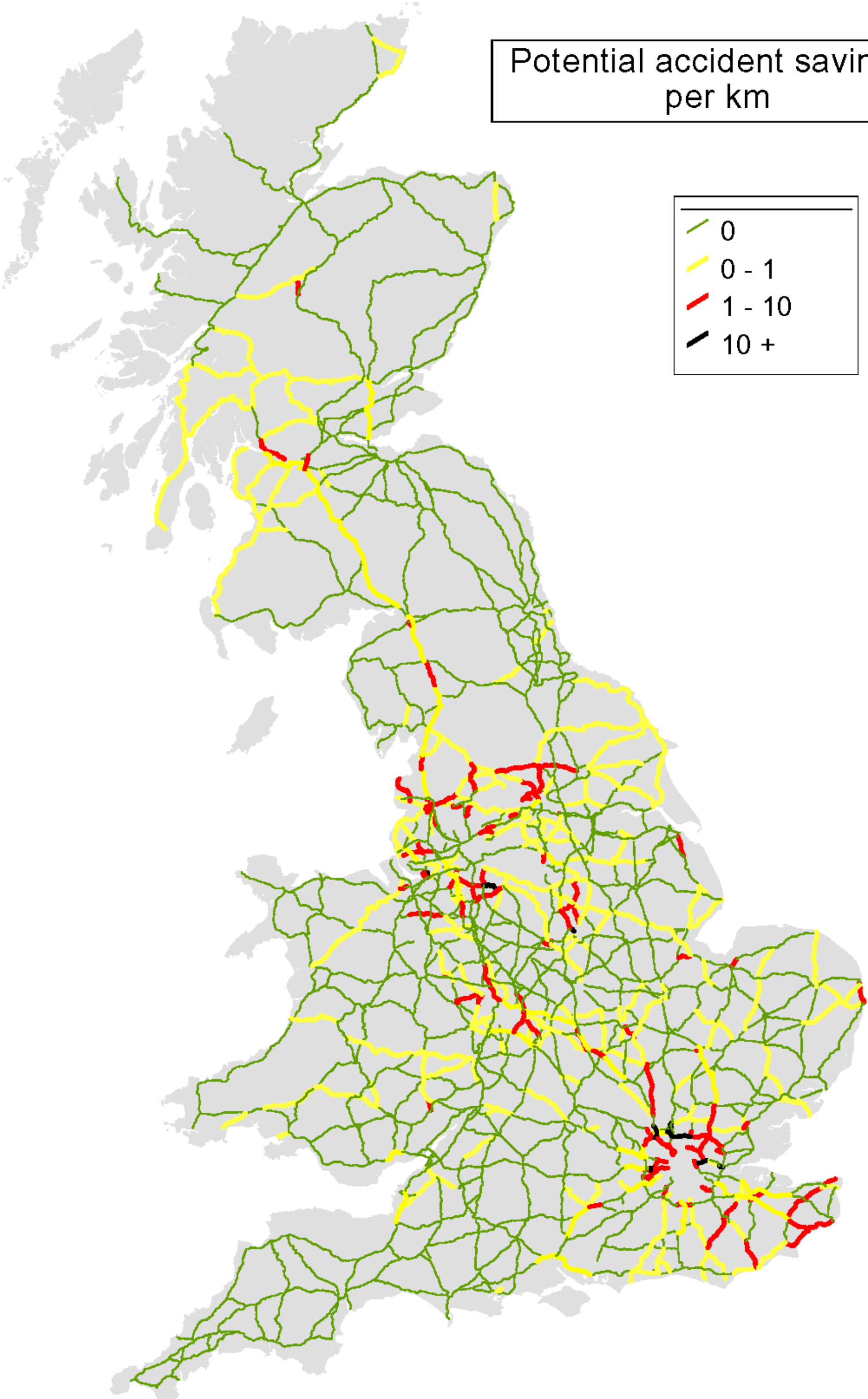

Figure 11 Potential savings in fatal and serious accidents if group average rates achieved

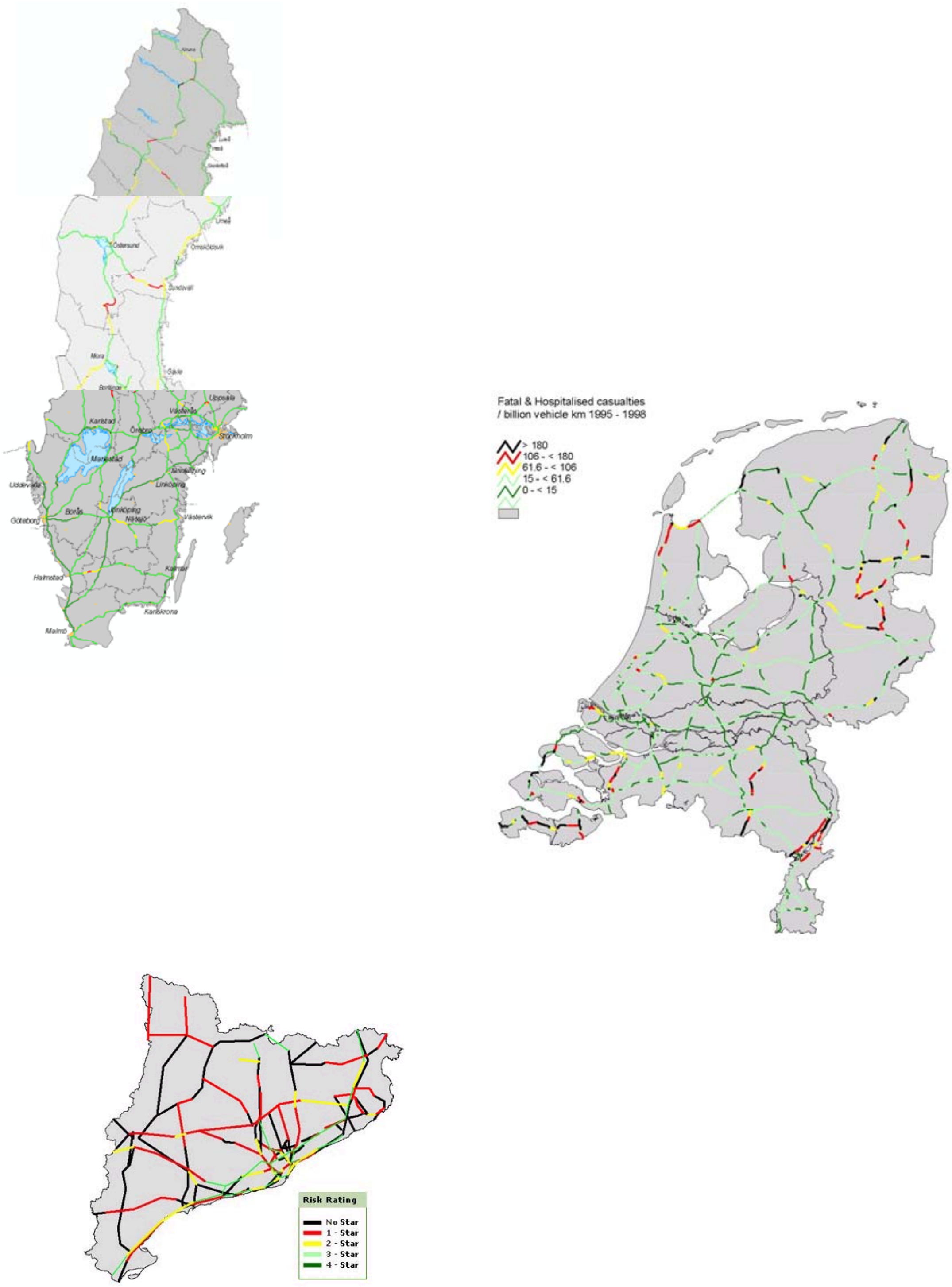

Figure 12 Accident Rates per billion vehicle kms in Sweden, the Netherlands and Catalonia (provisional data)

5.8 Assessing individual road sections

Figure 9 showed the risk to individual drivers on different road sections. The distribution of these risk rates across the British network is illustrated in Figure 13 below. The distribution has been divided into five risk bands grouped slightly differently to the colour codes in Figure 9. The bands have been chosen to fall roughly around the mean, but also to highlight the small but significant number of links with very high risk.

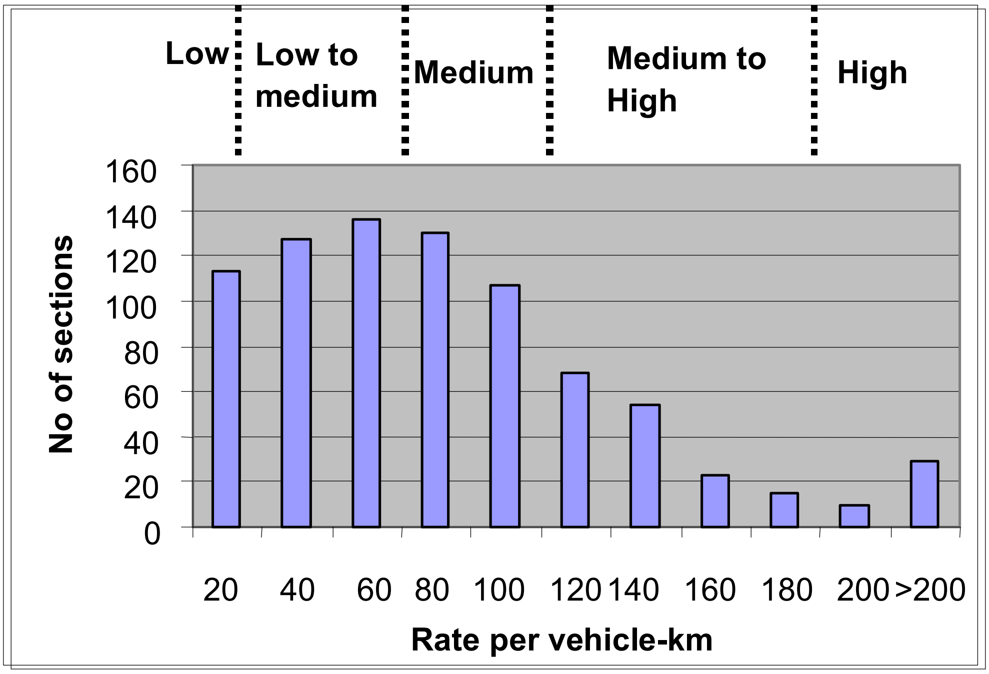

Figure 13 Distribution of risk for all British route sections

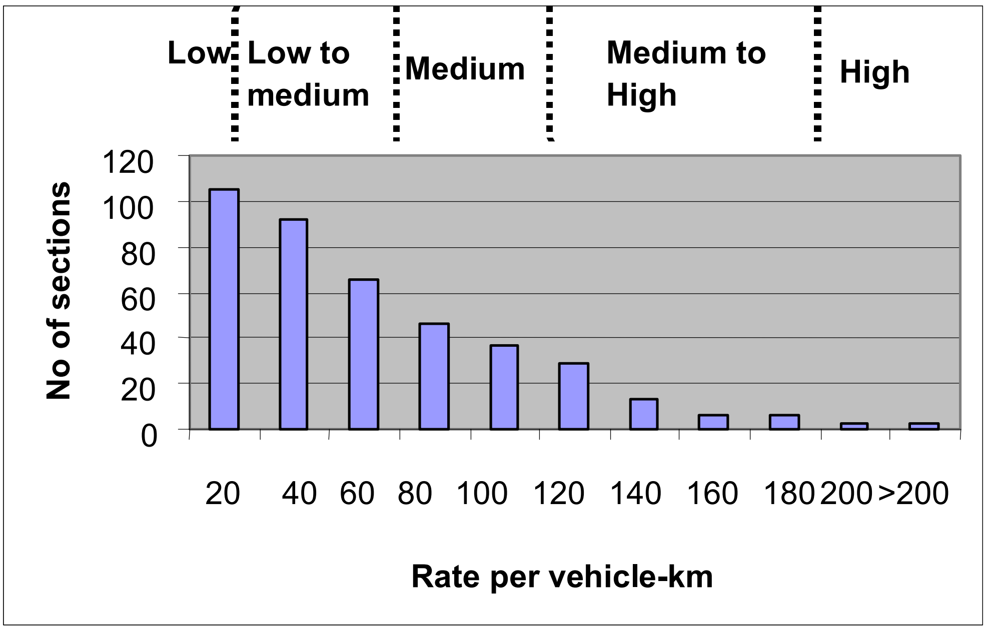

Figure 14 Distribution of risk for British national network sections

A differently shaped distribution is obtained if only the national roads are considered. This network is more similar to those mapped for Sweden and the Netherlands in the pilot year. In this case, the network, as expected, is of a generally higher quality, with very few sections falling within the High risk band (Figure 14).

But for considering roads for treatment, it is more relevant to assess the spread of risk among roads providing a similar function, in this case indicated by traffic flow levels.

Figure 15 shows the distribution of the amount of traffic on road sections with differing fatal and serious accident rates relative to the mean rate for the group, for each of the four road groups considered.

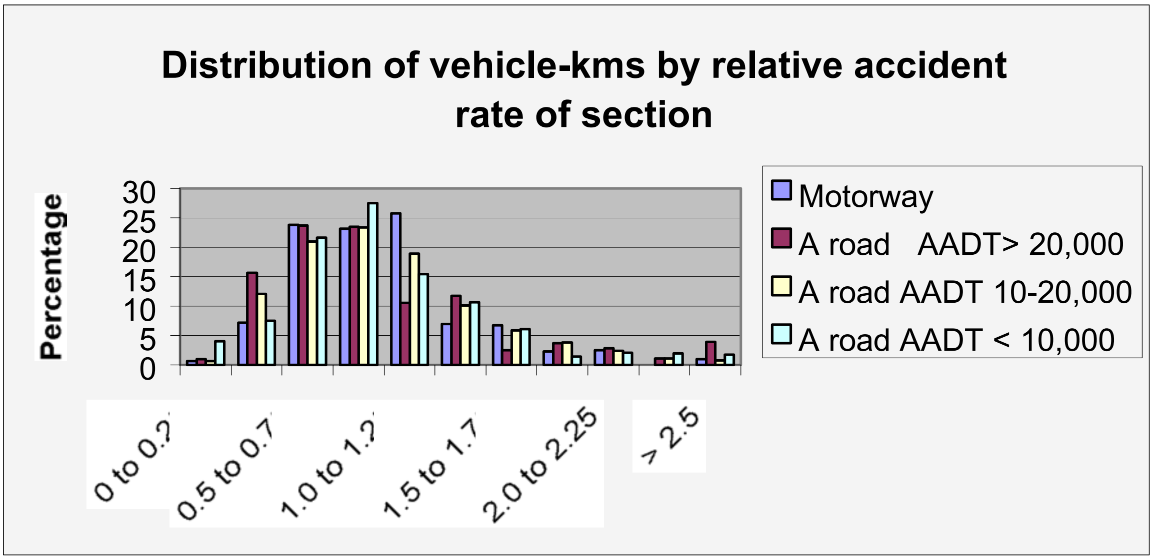

Figure 15 Distribution of vehicle-kms by relative fatal and serious accident rate

The four different groups show slightly different distributions, but each has a small proportion (about 5 per cent) of its network which averages more than twice the average fatal and serious accident rate for the group.

Care needs to be exercised in establishing which sections have particularly high and low rates, and interpreting the reasons for these differences. A variety of factors may contribute to these rates. The four groups illustrated are separated only by whether the road is a motorway, and for non-motorway roads, by the three-flow categories having the biggest differences in group accident rates.

Other factors affecting rates may include: number of lanes, carriageway type, junction type, speed limit, frequency of junctions, proportion of goods vehicles, and local topography (bendiness and hilliness). Some of these have already been shown to be important in the earlier analysis. Data will be available for some, but not all, of these factors in the databases being compiled.

To take account fully of the effects of these factors and their interactions requires a fatal and serious accident model to be developed. This would provide a more comprehensive analysis (and may be used in subsequent parts of the programme). The output would be in the form of an "expected" accident rate for any specific road section based on its known geometric and traffic characteristics. Sections identified following such an analysis would highlight where actual accident rates still differed substantively from these "expected" rates. Figure 11 approximates to this by demonstrating the potential number of accidents that would be saved on each link if its rate were no higher than the average rate for its flow group.

Whilst a modelling approach would give better confidence that the known reasons for expecting differences had been fully taken into account, it would not show so clearly the differences in design choices that give rise to overall differences in network accident rates, eg the proportion of the network that is built to a higher standard, or the extent to which traffic management regimes are operated which maintain lower accident rates despite lower design standards.

However, if the simpler approach is adopted, sections with high rates will need to be examined in more detail before concluding that remedial action is required. Non-experts are likely to prefer the face validity of the simpler approach; experts are likely to want also to see the more detailed analysis done in parallel.

Non-engineering factors may also play an important part in variations in accident rates between sections. It will be important to establish whether there are any features about a particular site that encourage more risky behaviour by the road-users.

Sections on non-motorway roads with higher than average rates are distributed throughout the national and regional networks. About 55 per cent of the network of both regional and national roads have rates above the average for each network. About 10 per cent of the national road length, and 30 per cent of the regional road network, have a rate at least twice the overall average rate for the combined network. More than 100 kms of motorway sections have rates about twice the average rate for motorways, representing 4 per cent of the motorway network.

If rates on all roads were brought within twice the average rate on those roads, then 16 per cent of all fatal and serious accidents on the whole network (ie about 1000 accidents) would be saved. If rates on all roads could be brought down to the current average rate for each network, then up to 27 per cent of the fatal and serious accidents on the network (ie about 1700 accidents) might be saved.

6 COMPARISONS OF INFRASTRUCTURE STANDARD

6.1 Methodology and justification – the *Road Protection Score*

The third stage of the pilot programme involved a direct visual inspection of road quality. This is different from a normal road safety audit in that its aim is to assess the general standard of a route, not identify individual sites of concern. A survey such as this may identify individual sites, or short lengths of road, which would benefit from improvement, but these are unlikely to have a substantial effect on overall accident rates along the route unless they occur frequently, or the local risk is very high.

The aim of this survey is to produce a score for each route section that enables it to be compared with other sections. The comparison of routes on the basis of this Road Protection Score (RPS) is likely to be different from that produced by comparison of accident rates for several reasons – for example, because the latter will also include the rate of seat-belt wearing which differs between countries. The RPS focuses on the road design and the standard of road-based safety features. "Protection" in this sense describes protection from accidents (elements of primary safety) and protection from injury when collisions do occur (secondary safety). The RPS should therefore be related as closely as possible to:

- the design elements known to affect the likelihood of an accident occurring;
- the safety features known to mitigate injury severity.

These two factors can be combined in a risk matrix to provide an overall assessment of risk for a route. Risk tables then need to be developed for each of the two parts so that the effect on risk both of increased provision of protection and of low cost remedial measures to avoid accidents can be assessed. Different ways of reducing risk will be appropriate in different situations.

The aim of this assessment is to evaluate the safety that is "built in" to the road through its design, in combination with the way traffic is managed on it.

The fundamental philosophy underpinning this is that the development of a Safe Road System is a shared responsibility between road authorities, vehicle manufacturers, and road-users. An approach which can be represented in terms of the biomechanical outcome from any impacts, that is the forces which the impact exerts on the human body, will provide a common basis for rating systems for vehicles and roads and help optimise their combined effect.

The effectiveness of different infrastructure designs, and particularly the protective systems, in providing a safe environment is strongly related to the speeds of traffic on those roads. Both the biomechanical outcomes and the likelihood of an accident occurring will depend heavily on the speed that drivers adopt. The likelihood of an accident occurring will also depend on the behaviour that the road-users adopt in response to the road design. These aspects, therefore, also need to be encapsulated in the rating system.

This approach recognises that road-user errors cannot be removed completely, and therefore the design needs to provide a forgiving environment for those who are involved in accidents whilst driving within the law.

6.2 Accident patterns

Four types of accident contribute about 80 per cent of all fatal and serious accidents on major roads outside built-up areas. The four types are head-on "meeting" accidents, accidents at junctions, single-vehicle run-off-the-road accidents and accidents involving vulnerable road-users. The total percentage is common to many countries, but the distribution of the accident proportion between the four types differs according to the existing nature of the road network and the traffic patterns in each country. For example, the dominant factor in Sweden is head-on collisions, with junctions accidents making up a relatively small proportion of the total. The opposite is true in Great Britain. Examples from several countries are illustrated in Table 6.1. The main source of these data is from the report on Safety Strategies for Rural Roads (OECD, 1999). British and Swedish data have been added from national sources. Care needs to be taken in interpreting differences between countries as the accident recording systems define these accident types in different ways. It is also unclear exactly which vulnerable road-users were included in the fourth group in the figures given in the OECD report. Nevertheless, these accidents appear to categorise the majority of sources of error and injury in all these countries.

Table 6.1 Distribution of fatal accidents types on rural roads within different European countries

Country	Accident type (%)			
	Head on collisions	**Single vehicle run off the road**	**Junction**	**Pedestrian, pedal cyclist, etc**
Sweden	34	30	12	13
Denmark	26	25	27	11
France	20	40	18	6
Hungary	31	23	8	22
Switzerland	16	51	21	6
Britain	19	26	27	9

Another accident type, which occurs relatively frequently but often without serious injury, is “rear end shunt”, ie one vehicle running into the back of another. On motorways, this type of accident can make up 50 per cent of all fatal and serious accidents, but on single carriageways in Britain, they only account for about 10 per cent of these accidents. Some of these accidents are at junctions; they will be included in that category by a country which uses “junction” as an accident location, but not by those countries that categorise junction accidents as those impacts occurring between vehicles with a large angle of incidence between them (eg side impacts). Away from junctions, these accidents result more from driver behaviour than from road design, and have not been included as a separate group in the pilot. For the pilot phase, this accident type has not been included, but it is seen as an important accident group in Germany, so may be included in later analyses.

6.3 Format of the protocol

The aim in developing the protocol is to produce an assessment which:

- identifies important differences in road design or management which are likely to lead to different probabilities of fatal and serious accidents;
- can be made either directly during the inspection drives, or subsequently from the video of the drive, at reasonable cost.

The pilot protocols were based on the general principles outlined above, but at this stage were kept relatively simple, and did not include different target ratings for roads of different speeds.

The protocols were based on the four main accident types listed above. From the research evidence, the road design characteristics and safety features most likely to influence these accidents are:

Intersection accidents

Reducing number and improving quality of junctions. Junctions at which the main road has to cede priority will be treated separately from road junctions or private accesses which cede priority to the main road. A lower number of the latter will reduce accident risk. This is true for the former, but for these the type of junction is also important, with roundabouts giving rise to less serious accidents than signalised junctions. Within the roundabout group, junctions with more deflection on entry, and without a large number of lanes, thus reducing the effect of this deflection, will be safer.

Link accidents involving head on collisions with other vehicles

Dividing carriageway – this could be by road markings, narrow median strips, wide median strips, or safety fences. Each gives a different degree of protection. The legal regulations regarding crossing central road markings may influence their effectiveness in reducing these accidents. The only direct evidence is for safety barriers on median strips, although all devices which increase vehicle separation would be expected to have some effect. Wider carriageways should, therefore, also decrease the frequency of this accident type. The degree of variation in vertical alignment, which is known to affect accident frequency, may also mainly influence this accident group.

Link accidents involving single vehicles running off the nearside of the road

Safety fences to prevent direct contact with hard roadside objects, and prevent vehicles running down embankments, will improve safety. A narrow hard strip (in GB, a metre strip) between the running lane and the verge also reduces accidents by about 20 per cent, but no separate evidence is available for the effect on more serious accidents. A direct link has also been shown with bendiness of the road. Loss-of-control accidents are more frequent on narrow winding roads, but straight roads with unstimulating environments, although not having direct loss of control, may result in run of accidents through driver fatigue or loss of attention.

Link accidents involving pedestrians and cyclists

Where there are substantial numbers of pedestrians and cyclists using the roadway, or wanting to cross it, safety will be improved if vehicle speeds are reduced, if continuous walking or cycle paths are provided alongside the road, if a median strip is present, or if only a single running lane is used in each direction.

Although separate protocols have not been developed for different road speeds in the pilot, the assessment should reflect whether the road is operating at a speed consistent with its safety standard. Where this is not occurring, the road protection score could be reduced. The drive through survey recorded the speed of the survey car in each section, but this did not necessarily represent a good estimate of “free flow” traffic speeds during those times of the day when congestion prevented a relatively free choice of speed.

Table 6.2 summarises the factors by which the four aspects of road design were scored during the pilot inspections. For the pilot study, these focussed mainly on injury protection measures.

Table 6.2 Items contributing to road design scores

Star ratings scored for these design elements	Items contributing to the ratings
Median treatment	Safety barrier Median width
Roadside treatment	Presence of safety barrier Width of safety zone Alignments (bends and hills)
Intersections	Major junction design type Frequency of minor road access
Provision for pedestrians and cyclists (where appropriate)	Facilities for crossing Segregated paths or facilities along road

Each of the four design elements was given a score between 1 and 4, based on a combination of the same range of scores for each individual items contributing to the design element rating. The scores for the four design elements were then combined in proportion to the frequency (averaged across the countries shown in Table 6.2) with which the accident types matched to these design elements occurred.

An indication of the differences in design leading to different scores for each design element is given in Appendix C.

The structure of the protocol reflects the focus on protecting the road-user from serious injury, by identifying the main accident categories which lead to death on the road. The items within the categories reflect research studies carried out in UK and elsewhere. Further evidence from other European countries will be collected to confirm and extend the design items included, and to improve on the design descriptions used to assess the scores for each design element.

Each country has its own detailed design standards. There are some common technical analyses underlying these standards, but they have been developed over time in different ways. The inspection surveys do not attempt to address the detailed design adopted in each country (the inputs), but rather the extent to which outcomes of injury protection and accident avoidance have been realised within current practice through carriageway separation, junction design, forgiving roadsides and pedestrian and cyclist protection.

6.4 Inspection survey design

A drive-through inspection of 1000kms of British roads and about twice this length of mainland Europe roads was carried out. The British survey included English, Scottish and Welsh roads. The survey in mainland Europe included roads in the Netherlands, Sweden, and Germany. The routes in the Netherlands, Sweden and Germany were chosen with the help of the programme collaborators from those countries. Inspections will be extended to other countries during subsequent years of the programme.

The survey routes included a variety of national and regional roads in each country, as well as linking motorway sections. In Britain, the route was chosen to include some of the road sections that appeared to have relatively low or high fatal and serious accident rates. A video record of the roads driven over has been compiled. This formed the basis of subsequent analysis to develop appropriate scoring systems. During the drives, an observer recorded a simple assessment of the route, based on the main items proposed for subsequent analysis, but also including comments on any special features. This more subjective rating provides a firsthand impression from within the car as it travels over the road. These ratings are intended to relate to route sections of at least 5kms but, in principle, new assessments could be made each time there is a sustained change in road standard or speed limit.

6.5 Further development of protocols and scoring systems

Scoring systems will be refined during the first full year of the programme, following discussion of results with stakeholders. The videotapes from the pilot programme allow various scoring systems to be investigated, both in terms of the items included, and the consistency with which they assess the same road sections.

Assessment of the infrastructure standard is aggregated over the route length and across a variety of road features. It is expected that this might most readily be done by defining a set of expected safety principles, for different road functions, which would each receive a maximum score, and subtracting from this according to the variance from the expected design elements and safety features.

A Safe Road System could be defined as one in which the road design was such that few errors made while driving within the law resulted in fatal or serious injury. Such a system can be defined in biomechanical terms by ensuring that collision speeds are compatible with the nature of the object collided with. But the assessment system must also be capable of defining levels of performance that do not fully meet these criteria, as only the very best current designs are likely to do so. These are more difficult to define solely using biomechanical criteria, so links will need to be established between these and more common forms of road feature definition. Accident avoidance then becomes more important to the assessment.

For example, when considering junctions, the expected standard might state a maximum number of junctions per km, and a specific junction design to be used, eg one grade-separated junction per 3km. Points could be subtracted from the score if either a larger number of junctions were present, or the junctions were of lower standard, or both.

Different ways of quantifying will be needed for different types of feature. Whilst numbers of junctions can be counted directly, the extent to which, for example, roadside signs are protected by barriers will need to be judged, and given a general rating.

The protocol will be applied to existing roads, built at varying dates. The most recent ones will be built to current design standards, which can be expected to be consistent with best practice safety principles. But earlier roads may fall below these standards, either because they were built to earlier standards, or because they are now operating at traffic levels different from those envisaged when they were designed. Partial improvements may have been made over the life of the road, so that the standard of some parts is different from others.

The eventual aim is for the RPS to be the primary assessment and ranking system against which star ratings for roads are awarded

6.6 Some lessons from initial surveys

Road Protection Scores assigned under the pilot protocol varied from 1 to 4.

In broad terms, the scoring system (as described in Appendix C) meant that motorways scored around a maximum of 4, and dual carriageways varied from 3 to 4, while the poorest quality single carriageways scored very little more than 1. Good quality single carriageways, especially those with wide central separation and/or wide side strips, could score well over 2. Where some central physical separation was added, the score could improve towards 3. These roads would also score higher if speeds are well below those on dual carriageway roads.

Innovative types of central separation were observed in Sweden (wire rope fences dividing 3 lane roads into alternate 2 lane + 1 lane layouts) and in the Netherlands (low level physical obstacles within a marked central metre strip to discourage overtaking).

Plotting these RPS scores against the average accident rates established from the risk mapping protocols illustrates the potential accident saving through improving the various design elements. A much greater saving in rate is achieved in improving from a score of 1 to 2 than from 3 to 4, but the greatest absolute number of accidents saved will also depend on the accident concentration on the link.

7 CONCLUSIONS

7.1 Conclusions and lessons for the full EuroRAP programme

- A database has been produced which gives a good picture of the variation in fatal and serious accident rate on British rural main roads. It provides a simple basis for identifying road sections with relatively high and low fatal and serious accident rates, and gives some indications of potential reasons for differences.
- Similar data has been collated for the national road network in Sweden, with the help of the Swedish National Road Administration, and in the Netherlands, with the help of the Transport Research Centre of the Dutch Ministry of Transport. Data has also been collated for a wide range of rural roads in Catalonia, with the help of the Catalonian Servei Català de Trànsit. This latter data is particularly useful for the pilot stage as it gives some insight into the accident rates on different roads for Spain, which nationally has a substantially higher fatality rate than the other three countries for which data are included.
- A preliminary protocol has been developed, in collaboration with the Swedish National Road Administration, for a procedure for drive-through inspection of routes, and this has been trialled on roads in several European countries.

7.2 Distributions of fatal and serious injury accidents

- The majority of deaths in Europe occur on roads outside built-up areas.
- The majority of deaths on roads outside built-up areas are on single carriageway roads.

<u>In Britain</u>

- Nine per cent of deaths on roads outside built-up areas are on the motorways, 19 per cent on dual carriageways, 38 per cent on single carriageway roads of national or regional importance, and 34 per cent on other single carriageways.
- The fatal and serious accident rate of the 'A' road network is about four times that of the national motorway network.
- In overall terms, the average fatal and serious accident rate on the British national 'A' road network is significantly lower than that on the regional 'A' road network. This difference is influenced by both the lower proportion of higher flow roads in the regional network, and the greater likelihood of the latter routes passing through more populated areas.
- There is significant difference between the fatal and serious accident rates for dual, single and mixed dual/single road sections, with the dual carriageway rates averaging less than half that for the single carriageways, and the mixed category rates averaging about 70 per cent of the single carriageway rate.
- Within the dual carriageway group, sections with grade-separated junctions have fatal and serious accident rates averaging about half the rate for sections with at-grade junctions.
- There are significant differences in the fatal and serious accident rate between roads with less than 10,000 AADT, roads with 10,000 to 20,000 AADT, roads with 20,000 to 30,000 AADT, and roads with more than 30,000 AADT. The EuroRAP programme will seek to explain the implications of this for roads policy, design and management.

In the Netherlands

- The fatal and serious accident rates on non-motorway national roads are about four times those on the motorways.
- Within this non-motorway national road group, rates on divided roads and single carriageway roads are about 3 times and 5 times respectively those on motorways.
- Rates on single carriageway roads, where slower traffic is excluded, are 50 per cent lower than on other single carriageway roads.

In Sweden

- Rates on national 'A' roads are about three times those on Swedish motorways.
- Flows on Swedish roads are much lower than flows on equivalent road types in Britain and the Netherlands.
- Rates on divided roads with grade-separated junctions are only 50 per cent higher than rates on motorways.
- Rates on single carriageway (2-lane) roads are about 3 times those of motorways. Rates on multilane roads are similar to those on wide single carriageways.

In Catalonia

- Rates on national 'A' roads are less than double the rates on motorways.
- The network examined included a much wider range of regional roads than in the other countries.
- In all four areas (Britain, the Netherlands, Sweden, and Catalonia), the general pattern of rates between different parts of the road system is relatively similar. Further investigation is needed in the next stage of the project to assess whether the differences that do exist reflect design differences within the various general road types. After adjusting for reporting differences, the motorway rates for Britain, the Netherlands and Sweden are roughly similar, but rates for Catalonian motorways are much higher. Rates for each road type are higher in Catalonia reflecting, in part, different driving behaviour. Rates for single carriageway roads in Britain are almost 50 per cent higher than in Sweden, probably reflecting the greater density of small populated areas along the British routes.

7.3 Identifying road sections with high and low fatal and serious accident rates

- The three significantly different flow groups should, therefore, be analysed separately when considering the implications of road sections with relatively high or low fatal and serious accident rates. Sections can be investigated both in relation to the average rates for their flow group, and the potential number of accidents that could be saved if rates on higher risk sections were reduced to this group average.
- Fatal and serious accident rates for the short road sections are substantially different from the group averages. For motorways and dual carriageways, these differences are significant up to section lengths of 10kms. It is proposed, therefore, that when assessing whether individual sections are above or below average, rates for sections up to 10kms for motorways, and 5kms for 'A' roads, should be treated cautiously. Only 7 per cent of the motorway veh-kms and 2 per cent of the A-road veh-kms travel over these short sections.
- 'A' road sections with higher than average fatal and serious accident rates are distributed throughout the national and regional networks. About 55 per cent of the network of both regional and national roads have rates above the average for each network. About 10 per cent of the

national road length and 30 per cent of the regional road network have a rate at least twice the overall average rate for the combined network. Over 100kms of motorway sections have rates about twice the average rate for motorways, representing 4 per cent of the motorway network.

7.4 Looking at local variation and shorter (high risk) lengths of road

- EuroRAP is concerned with identifying stretches of road with poor safety performance resulting in significant death and serious injury. The data does, however, provide scope to investigate road sections of much smaller length. Rates for these sections have been shown to be higher than the group average, and the smaller accident numbers may give rise to greater variability, but short sections with fatal and serious accident rates much higher than average could usefully be investigated further. Variability of fatal and serious accident rates within routes could also be examined to highlight the types of short road section needing special treatment.

7.5 Setting standards for hierarchies and links with appropriate speed

- Speed limits have been recorded for the road sections within the database. Analysis of fatal and serious accident rates in relation to these limits may indicate the extent to which differences in the choice of speed limits for similar types of road have affected overall accident rates.
- The protocol developed for the drive-through route inspections proposes an assessment system that classifies routes into 4 basic groups according to the standard of the road infrastructure safety features, although intermediate scores can also be achieved where standards vary along the section or fall between two categories. The rating of the infrastructure can be directly related to the speed of the traffic on the route. Roads where traffic travels at higher speeds need to operate to a higher standard.

7.6 Assessing potential for death and serious injury reduction

- The analysis provides extensive information on the variation in fatal and serious accident rate in different parts of the main road network, outside urban areas. The network addressed in Britain had an average annual total of about 8500 fatal and serious accidents during the period 1997 to 1999 (ie 22 per cent of the national total of fatal and serious accidents). The network included about 40 per cent of the national total of fatal accidents. If only those road sections with fatal and serious accident rates above the group average rate were improved to the group average, an annual total of some 1700 fatal and serious accidents (ie 20 per cent of the accidents on this network) would be saved.

7.7 Development of analysis through modelling

- Elements of the data sets being assembled may be interrogated at a later stage using modelling techniques to develop the analysis of the extent to which individual high-level design factors are associated with accident risk.

8 REFERENCES

AA (1999). *What goes wrong in highway design*. TMS Consultancy for the AA.

Barker J, S Farmer and M Taylor (1999). *The development of accident-remedial intervention levels for rural roads.* TRL Report 425. Crowthorne: Transport Research Laboratory.

Elsner A, S Reichwein and A Schepers (2000). *Verkehrssicherheit auf Europaischen Autobahnen* Strassenverkehrstechnik 1/2000.

McGuigan D R D (1982). *Non-junction accident rates and their use in black-spot identification*. In: Traffic Engineering and Control, February, pg. 60-65.

OECD (1999). *Safety Strategies for Rural Roads.* Road transport and Intermodal research report. Organisation for Economic Co-operation and Development. Paris.

9 ACKNOWLEDGEMENTS

The authors acknowledge the collaboration of the Swedish National Road Administration and the Dutch Ministry of Transport Research Centre (Adviesdienst Verkeer en Vervoer) which is essential to the success of this programme, not only in the provision of data, but in offering wide experience of the interpretation of the results. Thanks are due in particular to Hans Wahlström, Bo Lönegren and Peter M Mak. They also acknowledge the collaboration of Leif Thorson Bofarull of the Catalan Traffic Service, and Pere Sauret and Lluis Puerto of the motoring club RACC, who provided and analysed the data for an extensive network of roads in Catalonia. Jayne Dando-Budgen of TRL carried out the road inspections in all four countries surveyed.

John Dawson of the AA Foundation, and Rod Kimber as Advisor to the Foundation, have made major contributions to the development of the philosophy behind the programme, the procedures being used, and the interpretation of the data, as well as overseeing the management of study.

The early programme has been strongly supported by the enthusiasm and broad European experience of the leading motoring organisations' (initially through their EuroTest programme, administered by the AIT/FIA Brussels office), who contribute to the Technical Steering Group. Mike Garnham of the Highways Agency, and Hugh McCafferty of Scottish Executive (Roads) have also given useful input to that Steering Group.

EuroRAP is currently supported by the European Commission, the FIA Foundation for the Automobile and Society, by Toyota Motor Europe, and by the AA Foundation for Road Safety Research.

Corresponding author: Dr Steve Lawson can be contacted by email at steve.lawson@theaa.com

Appendix A LIST OF DATA ITEMS USED FOR ROAD SECTION COMPARISONS

Essential data for the calculation of individual risk

1. Section identifier (probably four digit)
2. Road number (and class if appropriate) eg A34
3. Section description (ie between point A and point B; A and B might be uniquely numbered intersections, or administrative boundaries)
4. Reference for Start of section (this should be unique map grid reference or GIS reference, from which the section can be clearly identified on a map)
5. Reference for End of section (as 4)
6. Name of road authority (this might be simply road authority type eg national or regional, or where appropriate motorway operating company or State or named Regional authority)
7. Section length (in kms to nearest 0.1km)
8. Annual number of fatal and serious accidents (period averaged over to be shown)
9. Annual number of fatalities (assumed time to die to be stated for definition of fatality)
10. Annual number of serious injuries (some indication of definition of serious injury would be useful)
11. Average annual daily traffic flow (vehicles per day in both directions)
12. Number of lanes (eg 2 + 2 where road is physically divided, 4 where undivided)
13. Road width (approximate eg 7m, 9m, 10m, 13m according to typical design conventions within the country)
14. Speed limit (kms per hour)
15. Whether roadway is physically divided (Yes/No)

Additional information (if available)

16. Annual number of all injuries (averaged as in 8 and 9 above)
17. Proportion of large goods vehicles
18. Type of intersection design (grade-separated, or at same level)
19. Type of central road treatment (safety fence, unfenced median, hatching)
20. Type of edge of road treatment (hard shoulder, hard edge strip, no hard area outside running lanes)
21. Level of cyclist and pedestrian traffic (low, medium, or high compared to other routes of this type)

Appendix B. FURTHER ANALYSIS OF BRITISH DATA

B.1 Comparative networks within Great Britain

The database developed above was used to investigate variations in the fatal and serious accident rate within the motorway and 'A' road networks in Great Britain. Figure AB.1 summarises the accident rates on the three main networks.

The charts in this and subsequent sections show error bars, which indicate twice the standard error either side of the mean. The standard errors are based on rates weighted by the proportion of veh-kms using each road section. Where these error bars are not overlapping, we can be highly confident that the group averages genuinely differ, and that the difference has not arisen by chance.

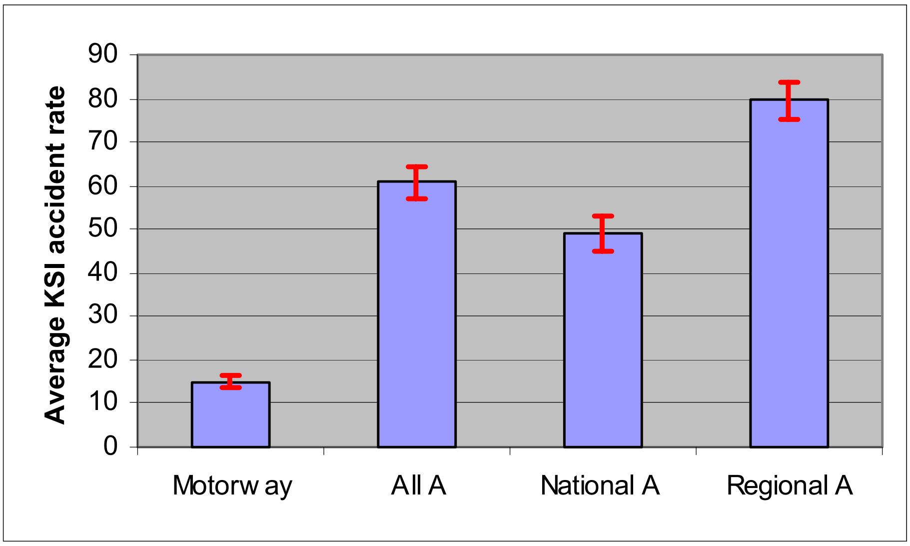

Figure AB.1 Fatal and serious accident rates of motorways and 'A' roads

The average fatal and serious accident rate for the 'A' road network is about four times higher than that for the national motorway network. The average fatal and serious accident rates on the national and regional 'A' road networks are significantly different from each other. The lower rate for the national network is strongly influenced by the higher proportion of higher flow roads in the national networks, and the greater incidence of villages and small towns on the regional roads.

The 'A' road network is made up of roads of varying design, with both dual carriageway and single carriageway sections. Part of the dual carriageway network has grade-separated junctions, and part has at-grade junctions. Although the process of combination of links into road sections sought to maintain consistency of design as far as possible, a substantial proportion of sections contained both dual and single carriageway links. In some cases, this was a basic feature of route design; in other cases, it resulted from the need to develop sufficiently long sections to have repeatable accident numbers. The 'A' road network sections were divided into three groups (predominantly dual, mixed dual and single, and predominantly single); similar categories were developed for junction type.

The chart shows the variation in fatal and serious accident rate on roads of different designs, for those roads for which design detail is known.

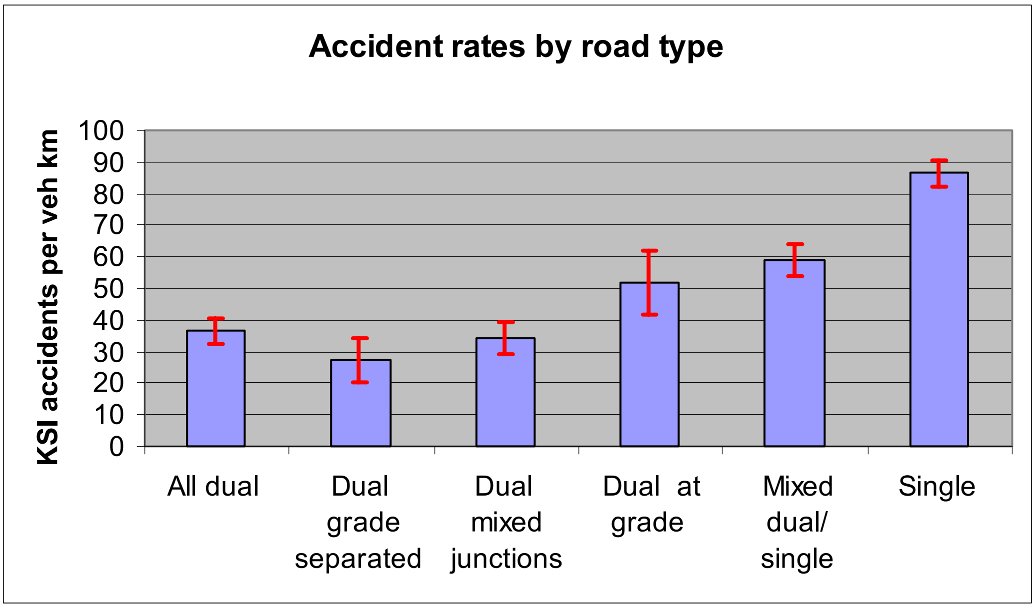

Figure AB.2 Fatal and serious accident rates by road type

There is significant difference between the fatal and serious accident rates for dual, single and mixed dual/single road sections, with the dual carriageway rates averaging less than half that for the single carriageways, and the mixed category averaging rates about 70 per cent of the single carriageway rate. Within the dual carriageway group, sections with grade-separated junctions have rates averaging about half the rate for sections with at-grade junctions, and this difference is significant.

The rates from these analyses can be compared with previous studies (Barker *et al*, 1999) for rural roads in 1994/5, which showed a motorway fatal and serious accident rate of 16, and rates for single and dual carriageway 'A' roads of 84 and 48 respectively.

B.2 Distribution of fatal and serious rates with flow

The variation of fatal and serious accident rate with traffic flow has already been discussed in section 3.4. The data show very little variation in fatal and serious accident rate with flow for motorway sections but considerably greater variation within the 'A' road network.

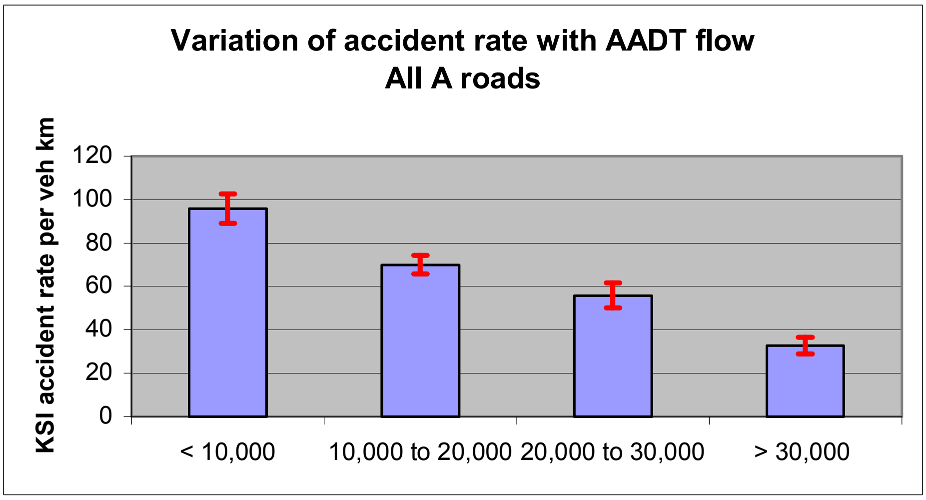

Figure AB.3 Variation of fatal and serious accident rate with flow, 'A' roads

This suggests that there are significant differences in fatal and serious accident rate between roads with less than 10,000 AADT, roads with 10,000 to 20,000 AADT, roads with 20,000 to 30,000 AADT, and roads with more than 30,000 AADT. Different flow groups should, therefore, be considered separately when identifying sections with relatively high or low fatal and serious accident rates for their group, so that roads are judged against a common flow criteria.

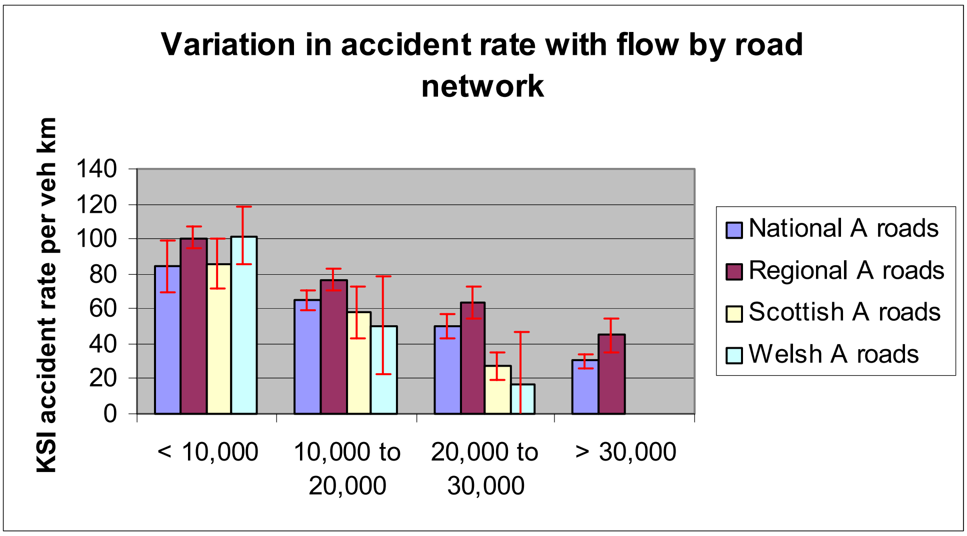

Figure AB.4 Variation of fatal and serious accident rate with flow on national and regional 'A' roads separately.

Figure AB.4 suggests that, although there are differences in group rates, with Scottish roads appearing, for example, to have lower rates than English regional roads, the confidence limits are, in general, so large that it is difficult to identify real differences.

B.3 Effect of section length

The possibility of relatively higher fatal and serious accident rates being associated with short road section lengths was raised in section 3.5. Figure AB.5 shows the variation in accident rate per veh-km with section length for the different designs of road.

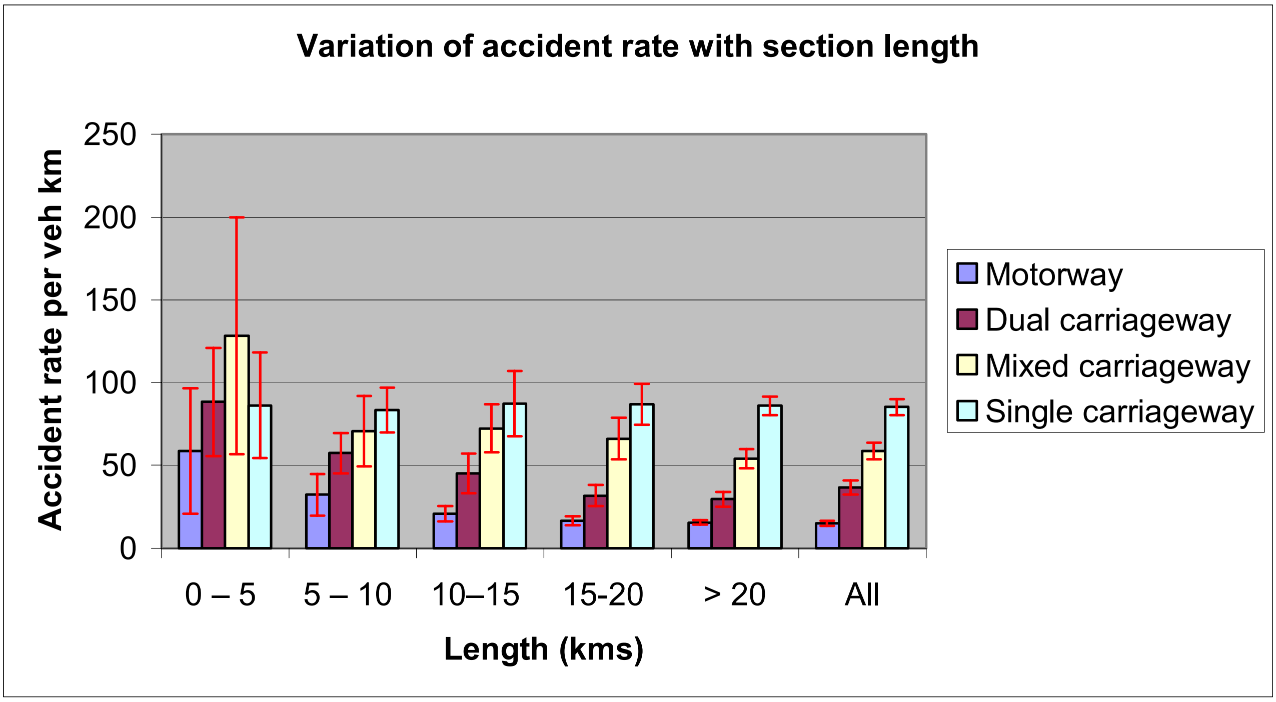

Figure AB.5 Variation in fatal and serious accident rate with section length

This chart shows that the fatal and serious accident rates for the shorter sections are substantially different from the group averages. For motorways and dual carriageways, these differences are significant up to section lengths of 10kms. Where these type of sections cannot be combined to make longer lengths, it suggests that the section is an isolated short link where stable conditions may not be established, or a section linking two other parts of the network, which may give rise to high levels of merging and weaving. These factors may explain the higher rates. It is proposed, therefore, that when assessing whether individual sections have fatal and serious accident rates that are above or below average, sections up to 10kms for motorways, and 5kms for 'A' roads are treated separately. Only 7 per cent of the motorway veh-kms and 2 per cent of the 'A' road veh-kms travel over these short sections.

Appendix C. PRELIMINARY PROTOCOLS USED DURING PILOT YEAR TO DEVELOP A ROAD PROTECTION SCORE

Section 6.3 describes the philosophy behind the Road Protection Score. The aim is to develop this procedure further and develop detailed scoring systems that can be linked to well established changes in safety performance. However, the data source used to assess safety performance is dependent on aspects of road design that can be seen and easily evaluated during inspection drives over long routes.

Pending the development of better criteria, a simple system was used during the pilot year, based loosely on grading designs into the following sets of four bands for each design element.

C.1 Median treatment

Score	Median design
4	Median width > 3m with barrier
3	Median width > 1m with barrier or > 10m without barrier
2	Wide (>9m) road without physical barrier but with marked separation of directional flow
1	Single width <9m

C.2 Edge of road protection

Score	Edge of carriageway	Barrier protection	Bends and hilliness
4	3.5m hard shoulder	Continuous safety barriers or 10m safety zone	Generally straight and flat
3	> 1m hard shoulder	Safety barriers for all hard obstacles or steep slopes within 6m	Curves and gently undulating
2	1m hard edge	Safety barriers for more than half of hard obstacles or steep slopes within 3m	Low frequency of sharp bends and hills
1	No added hard edge	Barriers not generally used (only at most severe sites)	High frequency of sharp bends, crests and dips

C.3 Intersections

The rating of major intersections is based on the potential speed at which conflicts are likely to occur. The highest rating is given to merging conflicts. Roundabouts which require traffic to negotiate them at relatively slow speeds are given a higher rating than traffic signals.

Score	Design of major intersections	Frequency of minor intersections
4	Merging traffic only	No X roads, <1.0/km T intersections
3	Roundabouts with high deflection on entry	No X roads, >1.0/km T intersections
2	Traffic signals or roundabouts with low deflection	<0.5/km X roads, <1.25/km T intersections
1	Priority to main road only protected by give way	>0.5/km X roads, >1.25/km T intersections

C.4 Pedestrians and cyclists

Score	Pedestrians		Cyclists
	Crossing	Along roadside	
4	Protected crossing which drivers negotiate at low speed	Wide segregated footway	Segregated cycleway, and designated space at crossings
3	Signalised crossing	Unsegregated footway	Cycle lane on road
2	Non signalised marked crossing	Hardened roadside area	Hardened roadside area
1	No provision	No provision	No provision

Routes would also score 4 where pedestrians and/or cyclists are restricted from using them, providing this is consistent with the route's agreed function.

Comparison with standard safety audit assessments

The typical problems identified by standard road safety audit (in for example AA, 1999)) include:

- lack of deflection or too many entry lanes at roundabouts;
- actual speeds greater than design speeds;
- unprotected signs or columns;
- signs obscured or poorly sited;
- lack of continuity in provision for cyclists;
- poorly sited pedestrian crossing facilities;
- embankments unprotected;
- short gaps in safety fencing;
- poor design of nosing protection at exits.

Although these generally refer to individual sites, the road protection score is designed to take account of such deficiencies if they occur regularly along the route.

Appendix D. SUMMARY OF DATA USED FOR NETWORKS WITHIN GREAT BRITAIN (See section 5.5)

Table AD.1 Accident rates of motorways and 'A' roads

	Length Kms	Annual F&S accidents	Vehicle kms	Accidents per veh km	s.e
Motorway	3119	1099	77,300	14.2	0.79
All 'A' roads	19283	6246	103,800	60.2	1.27
National 'A' roads	8569	3092	63,200	48.9	1.32
Non-national 'A' roads (Regional)	10714	3154	40,500	77.8	1.97

Table AD.2 Accident rates by road type

	Length Kms	Annual F&S accidents	Vehicle kms	Accidents per veh km	s.e
All dual carriageway	3090	1382	38090	35.9	1.96
Dual c'way with grade-separated junctions	631	229	8658	26.4	2.66
Dual c'way with mixed junctions	1237	636	17360	36.6	2.78
Dual c'way with at-grade junctions	923	443	9195	48.2	4.95
Mixed dual and single carriageway	4120	1385	28214	49.1	2.56
Single carriageway	12380	2729	40106	68.0	2.26

Table AD.3 Variation of accident rate with flow:'A' roads

Flow AADT	Length (km)	Annual F&S accidents	Vehicle kms	Accident rate per veh km	s.e.
< 10,000	8348	1412	17970	78.6	3.07
10,000 to 20,000	6583	1989	34958	56.9	1.82
> 20,000	4173	1808	49400	36.6	1.62
20,000 to 30,000	2285	850	20374	41.7	2.72
> 30,000	1888	958	29026	33.0	1.97

Table AD.4 Variation of accident rate with flow on national and regional 'A' roads separately.

Flow AADT	**Length %**	**Annual F&S accidents**	**Vehicle kms %**	**Accident rate per veh km**	**s.e.**
All National 'A' roads					
< 10,000	21	489	7	83.1	8.58
10,000 to 20,000	42	1255	31	64.3	2.76
20,000 to 30,000	18	505	22	42.4	3.82
> 30,000	19	843	39	32.9	2.24
All Regional 'A' roads					
< 10,000	60	1295	32	77.0	3.46
10,000 to 20,000	29	1252	39	48.5	2.04
20,000 to 30,000	8	394	17	44.3	3.15
> 30,000	3	213	12	35.8	3.42
All Scottish 'A' roads					
< 10,000	79	395	36	63.4	6.37
10,000 to 20,000	18	175	31	36.9	4.84
> 20,000	3	114	35	27.1	5.22
All Welsh 'A' roads					
<10,000	75	224	30	79.4	7.83
10,000 to 20,000	10	60	12	57.2	9.68
> 20,000	15	51	58	31.1	9.61

Table AD.5. Variation in group accident rate with section length (standard error shown in brackets)

Length km	**0 – 5**	**5 – 10**	**10–15**	**15-20**	**> 20**	**All**
Motorway	43.2 (1.88)	27.5 (3.05)	18.4 (2.12)	16.6 (1.50)	11.0 (0.68)	13.4 (0.92)
'A' road Dual	99.6 (20.8)	59.8 (7.43)	43.2 (5.98)	31.4 (2.67)	27.9 (1.98)	36.3 (3.90)
'A' road Mixed	115.9 (41.3)	57.4 (7.43)	56.2 (32.0)	57.3 (6.7)	45.3 (2.92)	49.1 (3.01)
'A' road Single	61.5 (10.4)	58.4 (9.29)	77.0 (12.8)	70.0 (7.3)	68.0 (2.80)	68.0 (2.64)

European Road Assessment Programme, c/o AA Foundation for Road Safety Research
Southwood East, Apollo Rise, Farnborough, Hampshire GU14 OJW