The Impact of Localized Road Accident Information on Road Safety Awareness

Yunan Zheng

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Abstract

The World Health Organization (WHO) estimate that road traffic accidents represent the third leading cause of 'death and disease' worldwide. Many countries have, therefore, launched safety campaigns that are intended to reduce road traffic accidents by increasing public awareness. In almost every case, however, a reduction in the total number of fatalities has not been matched by a comparable fall in the total frequency of road traffic accidents. Low severity incidents remain a significant problem. One possible explanation is that these road safety campaigns have had less effect than design changes. Active safety devices, such as anti-lock braking, and passive measures, such as side impact protection, serve to mitigate the consequences of those accidents that do occur. A number of psychological phenomena, such as attribution error, explain the mixed success of road safety campaigns. Most drivers believe that they are less likely to be involved in an accident than other motorists. Existing road safety campaigns do little to address this problem; they focus on national and regional statistics that often seem remote from the local experiences of road users. Our argument is that localized road accident information would have better impact on people's safety awareness. This thesis, therefore, describes the design and development of a software tool to provide the general public with access to information on the location and circumstances of road accidents in a Scottish city. We also present the results of an evaluation to determine whether the information provided by this software has any impact on individual risk perception. A route planning experiment was also carried out. The results from the experiment gives more positive feedback that road users would consider accident information if such information was available for them.

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Chapter 1 Introduction

1.1 An Introduction to Road Traffic Accidents

In 1896, a 44 years old woman was hit by a car travelling at "tremendous speed" (4 mph) and died minutes later of head injuries. This is the first recorded road traffic death in the world [102]. The coroner said, "This must never happen again". More than a century later, road traffic accidents are a serious problem for almost every country.

In the UK, road traffic accidents are the leading injury-related cause of death among people aged 15-44 years. Table 1.1 shows accidental death statistics from 1971 to 1998 in Great Britain.

Accidental deaths: by cause				
United Kingdom	Numbers			
	1971	1981	1991	1998
Road accident	8,302	5,133	5,276	3,421
Railway accident	213	97	90	47
Other transport accident	235	146	115	87
Other accident				
At home or in communal				
establishments	7,224	..	4,865	3,763
Elsewhere	3,930	..	2,569	4,319
All other accidents	11,207	10,414	7,493	8,519

All accidental deaths	19,957	15,790	12,974	12,154

Table 1.1 Accidental deaths: by cause 1971-1998 (from National Statistics[65])

As we can see from the table, road accidents caused about 40 percent of accidental deaths in 1971 and around 30 percent of accidental deaths in 1998. In the last decade, around 3,500 people were killed on Britain's roads and 40,000 were seriously injured every year (See Table 1.2). The direct cost of road accidents involving death or injury is thought to be in the region of £3billion a year. This does not include consequential losses in terms of employment, etc.

Road accident casualties : by road user type and severity										
Great Britain										Numbers
Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Killed	3814	3,650	3,621	3,598	3,599	3,421	3,423	3,409	3,450	3,431
Killed or seriously injured	48,834	50,190	49,154	48,097	46,583	44,255	42,545	41,564	40,560	39,407
All severities	306,135	315,359	310,687	320,578	327,803	325,212	320,310	320,283	313,309	302,605

Table 1.2 Road accident casualties: by road user type and severity 1993-2002 (From National Statistics)

From table 1.2, we can see that the number of people killed in road accidents has been decreasing. From 1994 to 1997, there were about 3,600 people killed every year. From 1998 to 2002, this number was down to 3,400. At the same time, the number of people killed or seriously injured was falling every year from 50,190 in 1994 to 39, 407 in 2002. That is a fall of 21.5 percent during the 9 years. The improvement of road infrastructure and of car design and government's safety campaign are helping to achieve this. However, the reduction in the total number of fatalities has not been matched by a comparable fall in the total number of all severities. From 1993 to 2002, the number of all severities remains high, over 30,000 every year.

Road traffic accidents also have significant impact on world economics. According to the WHO's (World Health Organization) "World report on road traffic injury prevention in 2004", the cost of road crash injuries is estimated at roughly 1% of gross national product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries. The direct economic costs of global road crashes were estimated at US$ 518 billion in 2004. The estimated annual economic cost of injury sustained in road accidents in China is equivalent to US$12.5 billion --- almost four times the total public health services budget for the county.

1.2 An Introduction to Road Safety Research

Since road traffic accidents are a serious problem for all countries in the world, the question of how to effectively reduce road accidents has become a more and more important issue considered by a large range of scientists.

After an individual road accident, there is a concern to find out what the cause was and who was to blame. Sometimes people blame alcohol [4, 54], speed [20, 13], bad weather [32], poor road surface conditions [75], inadequate traffic signs [27], vehicle defects [21]..., and so on. These accidents cannot therefore be addressed by any single solution. They are caused by a combination of lots of factors [72, 45]. This is why different disciplines are engaged in the search for a solution.

The main aim of road safety research is to use scientific ways to study the road and traffic system in any of its aspects to find suitable solutions for reducing the number of road accidents or their severity. Assessing the effectiveness of these solutions is another research purpose. However, road traffic accidents are a dynamic phenomenon. An advance in one direction can raise new problems. 'Risk Homeostasis' is the theory that humans behave in such a way that if a risk is identified in a given system, and is reduced by design, then a compensatory increase in risk-taking will occur somewhere else in the system [98]. Therefore, solutions are changing all the time and road safety research involves a very large scientific area. It can be divided into the following four fields [72]:

1.) the study of occurrence of accidents (statistics);
2.) the detailed study of any aspect of the accident process which may be a factor in accident production;
3.) the consequences of accidents, i.e. injury and damage;
4.) the economic aspects of accidents and safety measures;

Detailed information about research in these areas can be found in Appendix A: A brief review of road safety research.

According to the research work by Sabey in 1975 [80], the accident process can be divided into three categories: vehicle, road environment and road users, and **road users make the greatest contribution to road accidents.** He attempted to identify the "main contributory factors" responsible for

2130 accidents which were investigated in great detail. Evidence was obtained by observations of roads, vehicles and road users, by interviews, and by assessing errors which were made by the road users, by examining defects in vehicles, and by noting adverse features of vehicle and road. The research team formed certain opinions. They categorized these contributory factors into 3 areas (road environment, road user, vehicle), some accidents being caused by a single factor, some caused by multiple factors. The result shows that 8.5 percent of the causes could be assigned to vehicles, 28 percent to the road environment, and 95 percent to road users; these add up to more than 100 percent because many accidents were considered to be the result of more than one contributory factor. Figure 1.1 shows this result.

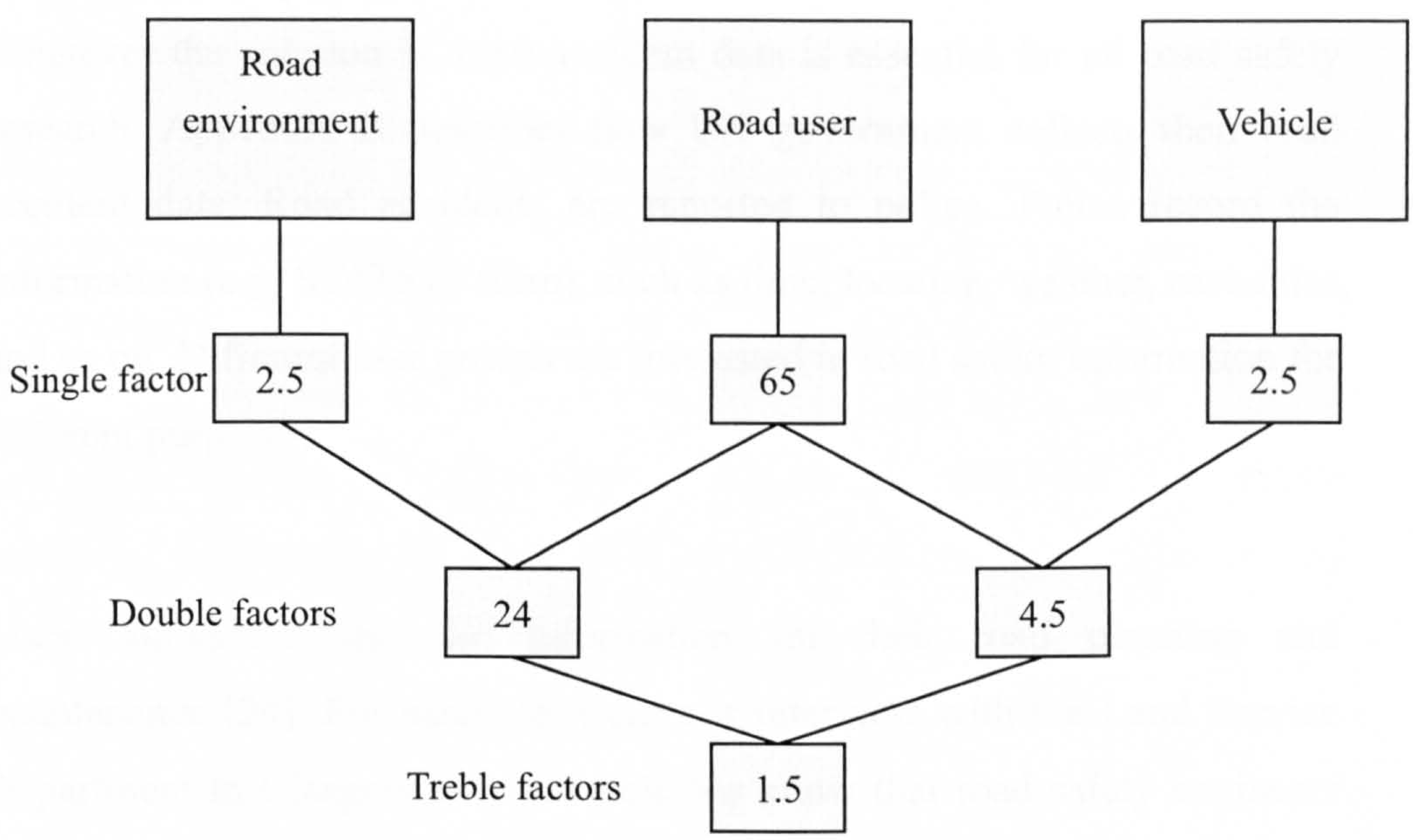


Figure 1.1 Percentage contributions to road accidents

Finding solutions for accidents caused by road users is much more difficult than for those accidents caused by vehicle or road environment defects. Changing road users' attitudes toward safety is a common response to accidents caused by road users. Road safety campaigns, education and law enforcement are ways to influence people's safety awareness. Chapter 2 will discuss more human factors involved in road accidents.

With the development of computer technology, there are more and more road accident related systems available for people to analyze massive accident information. These systems provide a lot of help for experts to find the solutions for accidents caused by vehicle or road environment defects. Chapter 3 will discuss some of these systems.

1.3 Potential Users of Accident Data

Whatever the solution is, road accident data is essential for all road safety research. Appendix B describes how UK government collects their road accident data. Road accidents are reported to police. Police record the information (e.g. STATS19 form), such as time, location, weather, casualties, and so on. Different user groups are interested in road safety information for different purposes.

Local authorities use the information for their road planning and maintenance [24]. For example, from our interview with the Land Service Department in Glasgow City Council, we know that road safety engineers need historical data to identify accident black spots in local areas. They then look into the data in detail so that they can find out the causes for these black spots and take some countermeasures.

Vehicle engineers are interested in accident data because they can find vehicle defects and ideas for improvements from accidents. For example, research found that head related injuries accounted for most of the injury cases, therefore, helmets for moto cyclists and seat belts for car drivers are designed for protecting people from injury [64].

Insurance companies also care about road accidents [85]. Their accident data sometimes are more complete than the police's because people report non-injury accidents to their insurance company to claim compensation rather than report them to the police. Insurance companies also carry out many surveys about traffic accidents to collect relevant information. They use the information to determine their insurance premiums.

Road safety campaigns which are launched by governments need the information to support their aims and remind people of the potential dangers on the road. Meanwhile, local governments and schools can use the information to educate pupils and students in the right attitude and behaviour towards road safety [67, 31].

The general public is also interested in road accident information for their own safety during their travel. However, unlike the above user groups, the general public doesn't have much of this information. Governments show them tables, figures, and diagrams which are highly aggregated statistics. From real time accident report systems, the general public can know where accidents are happening now. But they don't have any access to the historical and local road accident information. However, we think this information can be helpful for changing people's safety awareness.

1.4 Research Objectives

From the previous sections, we can see that research on historical accident data can find injury patterns of victims and propose protective measures in the light of these patterns, therefore can reduce the number of people killed or seriously injured. Furthermore, historical accident data can show defects of vehicles and identify accident hot zones. But the statistics show that although the number of people killed or seriously injured in accidents is falling, the total number of accidents still remains high (See table1.2). Increase road users' safety awareness and attitude has been a popular way to improve road safety for many years. There are three most common ways to influence road users' attitudes, 1) Driver training, school programs or education; 2) Road safety campaign; 3) Legislation and enforcement. These methods will be discussed in detail in chapter 2. Our research, however, is related to localized accident information.

Our research focuses on how the historical accident information can affect the general public's safety awareness. We believe that information which is customized to a person's characteristics and situation is more likely to affect risk perception or safety awareness. Therefore, localized accident information would have a better impact than high level national statistics.

Using localized information to find out certain patterns which can't be obtained from high level statistics is not a new idea. Figure 1.2 is a snapshot from Donald Brown's Regional Crime Analysis Program (RECAP). He believes analyzing regional crime data at the level of individual districts or even blocks is increasingly important when police initiatives to address criminal activities in one area or district can displace those activities to other areas.

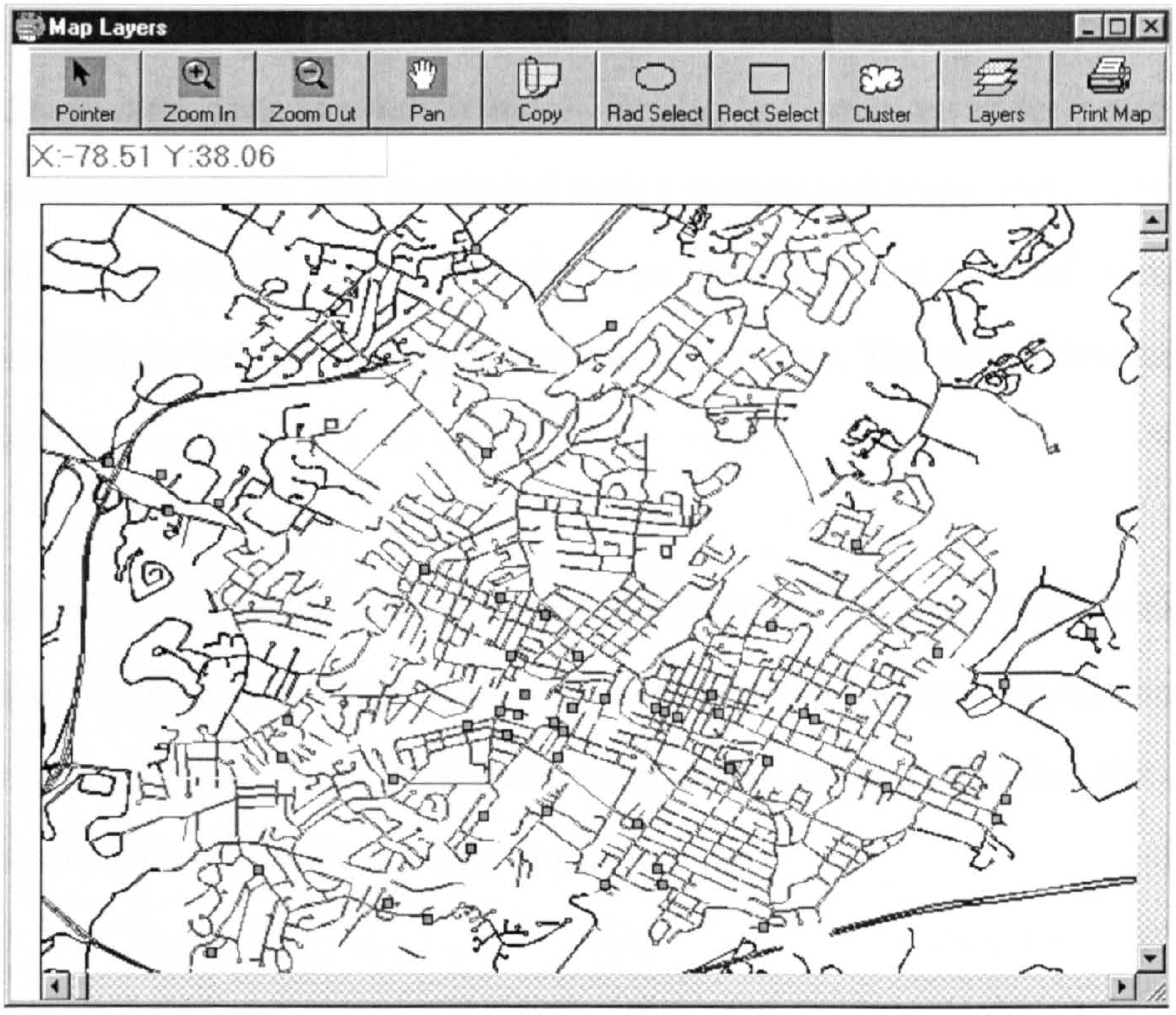


Figure 1.2 Snapshot of ReCap system

Therefore the research objective is to find out how to affect the general public's safety awareness by using localized historical road accident information. The thesis will start with evaluating the existing road safety campaign websites in order to see whether they have a significant impact on people's safety awareness. Then it will describe our own localized road accident information system and evaluate it. A route planning experiment is also described to see whether such localized accident information would affect people's route choices. Positive results from the experiment would suggest such information does have an impact on people's safety awareness.

1.5 Structure of the Thesis

As we said in previous sections, most contributions to road accidents are from road users. Therefore, how to improve the general public's safety awareness and their behaviour become more and more important. However, as we found, there is no such road accident analysis system for general public so that they can know more detailed information about accidents happening near them. We developed such a system and compared it with the existing road safety campaign website to find out what kind of accident information is helpful for improving their awareness. The thesis structure is as follows.

Chapter 2 discusses the relationship between human error and road accident. It also analyzes some problems of current road safety measurements, education, legislation and road safety campaigns. Then it describes the user group of our study and our research methodology.

Chapter 3 evaluates of existing road safety information system ('Think' and Scottish road safety campaign websites) and their effect on general public's safety awareness by using psychometric questionnaire. At the end of the chapter, the reasons why our results do not show a consensus are discussed.

In order to build our localized accident information system, chapter 4 discusses the available road traffic accident data and their structure. It also describes our requirements elicitation and analysis. A full list of functional and non-functional requirements is provided.

Chapter 5 discusses some statistical graphics for visualizing multivariate data, their advantages and disadvantages. It also explains why we chose map-based visualization technique. In order to enhance our system's effect, interactive information display theories, their advantages and disadvantages are also discussed.

Based on the requirements listed in chapter 4, chapter 6 discusses the interface design, system structure design, class classification and the system implementation.

Chapter 7 discusses the system usability evaluation. The same psychometric questionnaire as in chapter 3 was used to find the impact of our system on people's safety awareness. In addition, a focus group discussion is used as an alternative measure for accessing such impact.

In chapter 8, we describe how we designed a route planning experiment. In this experiment, we provided taxi drivers with local accident information. We wanted to find out that whether accident information would change their route planning. The Sign test was used to test our hypothesis. At the end of this chapter, we discuss the findings from this experiment and possible application areas.

In chapter 9, we carried out the similar route planning experiment with university staff and students.

Chapter 10 discusses the future work on the impact of localized accident information and its applications. Conclusions will be offered as well.

Chapter 2

Problems Identified and Research methodology

2.1 Human Error and Road accidents

As mentioned in Appendix A: A brief review of road safety research, perception, decision and action are the three main aspects involved in driving. Any error in these phases may cause an accident. For example, the following accident happened on Saturday, October 13, 2001 (NTSB Number HAR-04/01, NTIS Number PB2004-916201). A school bus entered a work zone and struck road side barriers. It then rode up onto a bridge's sidewall, and rolled 270 degrees clockwise as it fell about 49 feet. It landed on its left side in a 1-foot-deep creek below the bridge. The NTSB determined that the probable cause of this accident was "the failure of the Nebraska Department of Roads to recognize and correct the hazardous condition in the work zone created by the irregular geometry of the roadway, the narrow lane widths, and the speed limit. Contributing to the accident was the accident bus driver's inability to maintain the bus within the lane due to the perceived or actual threat of a frontal collision with the approaching eastbound motorcoach and the accident bus driver's unfamiliarity with the accident vehicle". In this accident, the bus driver had to perceive the hazardous condition in the work zone and the threat of a collision with the approaching coach. The bus driver's inability to maintain the bus within the lane and unfamiliarity with the accident vehicle could indicate errors in decision and actions.

Rasmussen [44] thinks that the whole of human behavioural control can be categorised into three levels, skill-, rule- and knowledge-based behaviour. Skill-based behaviours are auto-mated routine actions during familiar work situations, such as make a 'U' turn or take a right (left) turn. At the level of rule-based behaviour, people act on a stored rule which is the integration of a sequence of subroutines, such as overtake a vehicle. The rule or control is selected on the basis of previous successful experiences. Knowledge-based behaviour focuses on problem solving when there is no suitable rule available for the unfamiliar situation, such as handing emergency situations. James Reason's Generic Error-Modelling System analyzes common human error forms based on Rasmussen's framework. Figure 2.1 shows the dynamics of this system. Reason also gives error-shaping factors for each of these levels. Table 2.1 shows these factors. According to the NTSB report, the above road accident involves errors in all these three levels. First, the Nebraska Department of Roads failed to recognize and correct the hazardous condition in the work zone. This error may because they thought the work zone was safe as others for the traffic, which is an example of rule-based error-shaping factor No.1 'mind set' or No. 5 'over-confidence'; or because they unable to analyze the danger based on the available data, which is an example of knowledge-based error-shaping factor No. 7 'Incorrect/incomplete mental model'. When bus driver saw the approaching motorcoach, he may not have thought that would be a problem for him, which is an example of the skill-based error-shaping factor No. 2: fail to recognize 'environmental control signals'; or he may have been thinking about something else, which is an example of skill-based error-shaping factor No. 4 'concurrent plans'; or he trusted his driving skills, which is an example of rule-based error-shaping factor No. 5 'over-confidence'. Then, when collision happened, he was unable to maintain the bus within the lane because of his unfamiliarity with the accident vehicle. This should be an example of knowledge-based error-shaping factor No.5 'Incomplete/incorrect knowledge' because the driver may have the required skill to control the bus. But his knowledge (unfamiliarity with the accident vehicle) prevents him from performing the correct skills.

PERFORMANCE LEVEL	ERROR-SHAPING FACTORS
SKILL-BASED	1. Recency and frequency of previous use 2. Environment control signals 3. Shared schema properties 4. Concurrent plans
RULE-BASED	1. Mind set ('It's always worked before') 2. Availability ('First come best preferred') 3. Matching bias ('like relates to like') 4. Over-simplification 5. Over-confidence ('I'm sure I'm right')
KNOWLEDGE-BASE	1. Selectivity 2. Working memory overload 3. Out of sight out of mind 4. Thematic 'vagabonding' (Flitting from issue to issue quickly, treating each one. superficially) and 'encysting' (Can't see wood for the trees) 5. Memory cueing/reasoning by analogy 6. Matching bias revisited 7. Incomplete/incorrect mental model

Table 2.1 The major error-shaping factors at each level of performance [44]

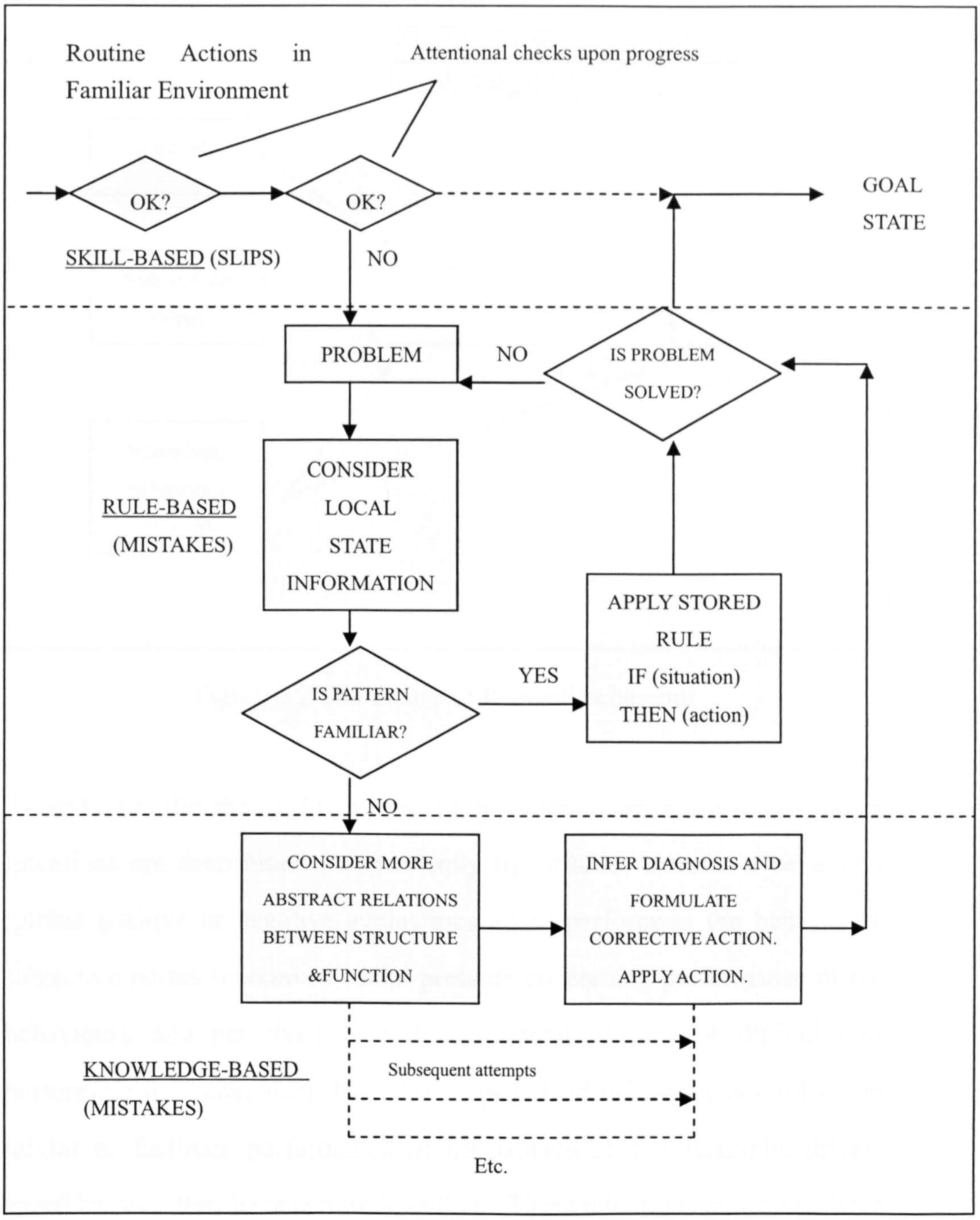


Figure 2.1 Dynamics of generic error-modelling system (GEMS)

Other branches of psychology have also been used in analysing human errors and road accidents. Rothengatter [79] defined the study of the behaviour of road users and the psychological processes underlying that behaviour as traffic psychology. The basic psychological theory used in road safety research is the theory of planned behaviour, which was originally proposed by Ajzen [3]. The diagram in Figure 2.2 shows a simplified version of the theory.

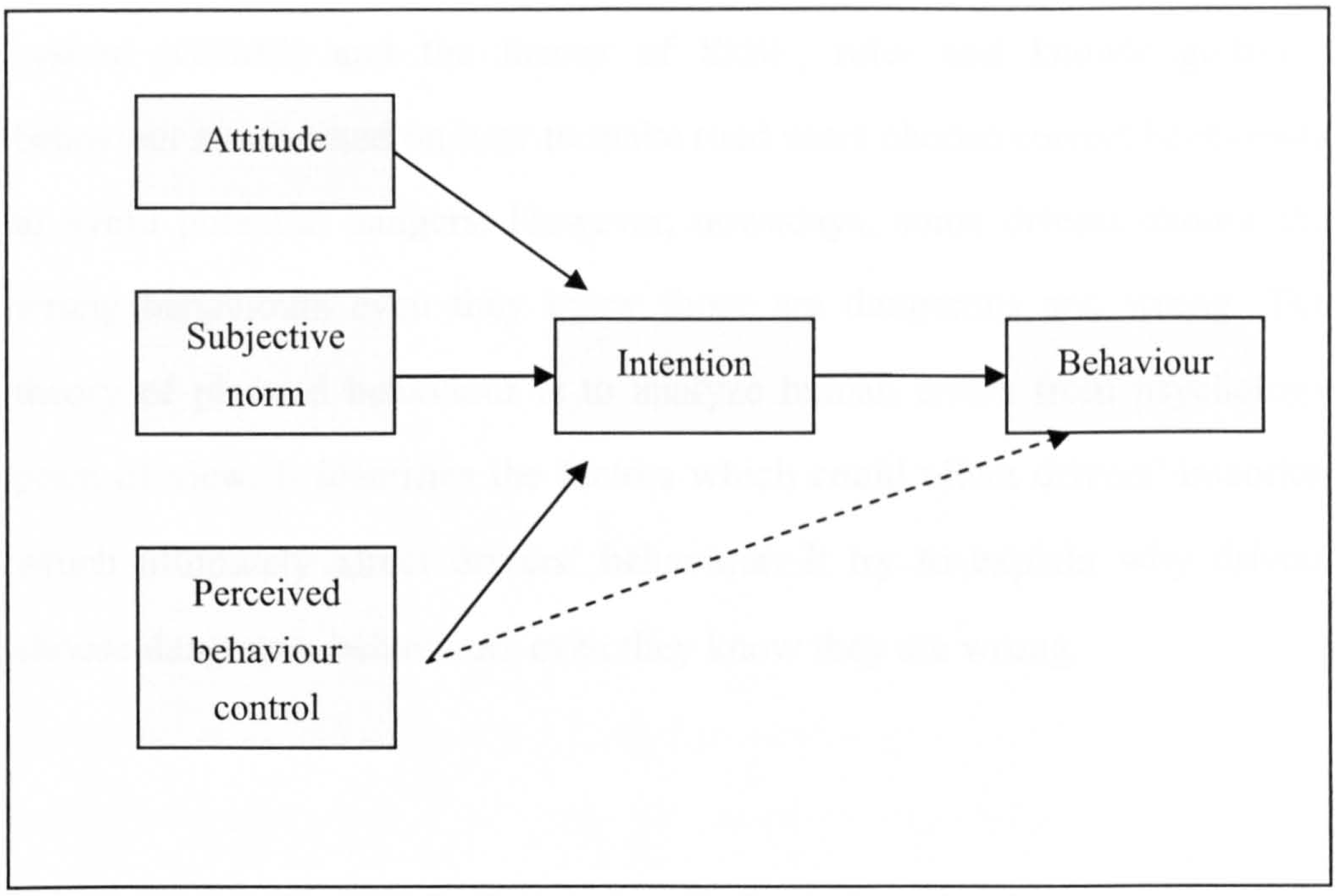


Figure 2.2 The theory of Planned behaviour

According to this theory, intentions are the main determinants of behaviour. Intentions are determined independently by attitudes towards a behaviour (global positive or negative evaluations about performing the behaviour), subjective norms (perceived social pressure concerning performance of the behaviour), and perceived control (the perceived ease or difficulty of performing the behaviour). In addition, perceived behaviour control might inhibit or facilitate performance of the behaviour. For example, drivers speed because they have certain intentions. These intentions may come from the following judgments: "Speeding can really save my time and I can bear the consequences (getting a ticket from the police)" (attitude); "Everyone speeds" (subjective norm); "If there is a danger, I can control my car under that speed. I did it many times and it is difficult for me to keep the speed under the limit on such quiet road" (Perceived behaviour control).

The common feature from the above theories is that they are all trying to analyze the relationships between human being's behaviour (errors) and road accident. The differences are Dynamics of Generic error-modelling system (GEMS) and the theory of Skill-, rule- and knowledge-based behaviour are focused on how to make road users choose correct behaviours to avoid potential dangers. However, nowadays, some drivers choose the wrong behaviours even they know those are dangerous and wrong. The theory of planned behaviour is to analyze human errors from psychology point of view. It identifies the factors which could affect drivers' intention which ultimately affect drivers' behaviour. It try to explain why drivers choose dangerous behaviours even they know they are wrong.

2.2 Practices in Influencing Drivers' Attitude

Attitude plays an important role in the theory of planned behaviour. There is evidence to suggest that 'people drive as they live' [90]. The term "attitude" is a key concept in social psychology, referring to a hypothetical mental structure which determines actions or prepares a person to act in a certain way [41]. It is generally used to characterize a person's convictions or beliefs about objects regarded as good or bad, acceptable or unacceptable, and with which the person feels in compliance or not, as manifested in various kinds of behaviour. Here is an example from Fildes' study "Speed Behaviour and Drivers' Attitudes to Speeding" [9]. The study found "A surprisingly high number of motorists at all speed levels did not believe it to be dangerous to travel 30km/h above the posted speed limits and most thought the chance of being stopped by the police for speeding at these sites to be low". These drivers think travelling over 30km/h is acceptable, even when that is above the speed limit.

There is still little practical experience of how to identify, measure and modify attitudes. As mentioned in the previous chapter, driver training, school programmes or education [67, 31], road safety campaign [87, 70], legislation, enforcement [22] are all used to influence behaviour and attitude. Driver training and school programmes are aiming at establishing new kinds of traffic safety behaviour and attitudes. The other methods are targeting at behavioral or attitude change for existing drivers.

Driver training and examination can provide necessary driving skills. It can also influence driving behaviour and attitude. For example, the UK driving test includes both a theory test and a practical test. The theory test has multiple choice questions and a hazard perception test. In hazard perception, participants are required to view 14 hazard video clips on the computer screen for approximately one minute each. There are 15 hazards to find. The practical test covers a wide variety of different road conditions, from quiet low speed roads to busy high-speed roads and town or city centre driving. Drivers are also required to undertake several set maneuvers. These tests provide drivers with information about dangerous environments and situations on the road. At the same time, they learn how to cope with those situations, using the skills received from training.

Finland and Norway have carried out evaluations of a new driver training course. The course has two phases. Skid training is one component of the second phase. The result shows that the drivers trained by the new curriculum were less afraid of driving on a slippery road. However, young drivers trained by the new curriculum had a greater proportion of accidents on a slippery road than the older ones and those trained by the old curriculum. **It was recommended that exercises in skid training should be developed so that the perception of risks and anticipation are stressed more than training of skilled performance** [49].

Traffic education in schools has helped pupils to learn basic rules, understand traffic processes and provides basic instructions on behaviour. It is intended to establish positive attitudes towards safety standards. But the effectiveness of the education can decline over time when the course is finished. Establishing long-lasting good attitudes needs help from other sources.

Road safety campaigns remind people of the dangers of road traffic accidents, what kinds of situations they should pay attention to and what skills could be used to cope with such situations. A variety of techniques have been used to provide information to the general public about the dangers associated with road use. These include media broadcast, leaflet campaigns, community-based schemes, and so on. The key point in the success of a campaign is that the information provided must catch the attention of the target audience. They must also be willing to listen to the information. Another problem is that safety campaigns involve significant costs to the agencies that use them. The production costs associated with leaflet production must be added to the logistics involved in disseminating the publications to the general public. Even when these leaflets are delivered to individual households a significant proportion of them will be discarded before they are read [91].

Legislation and enforcement are other means to influence road users' behaviour and attitude. Legislation dictates behaviour and in theory makes the behaviour of all road users predictable and safe. However, when the goals of legislation appear to be unreasonable, people may be less willing to adapt their behaviour, or change their attitudes.

In many cases, legislation and regulation are not enough to change behaviour. Police enforcement is necessary. But enforcement is an external motivator for behaviour. It makes certain behaviour disadvantageous so that drivers or riders may consider the consequence of their decisions and hopefully do not take any dangerous actions. Enforcement often leads to a change in behaviour, but in many cases only for as long as the perceived chance of being caught is high enough. Changes in attitudes do not always result from enforcement. A combination of enforcement and information provides better support for lasting behaviour change [41].

2.3 Identified Problems

As discussed above, efforts have been made to change the attitudes of road users, e.g. by public information campaigns and driver education. Such measures have so far had limited success in terms of reducing accidents [17, 37, and 68]. Charles Goldenbeld, Peter Bernadus, and Jelle Heidstra [16] suggest possible reasons for this situation. They believe attitude change does not necessarily lead to behaviour change because:

1) A person may not have the skills or knowledge to behave in accordance with his/her attitude;

2) Situational factors hamper the showing of attitude-compatible behaviour;

3) At a particular moment, other attitudes or preferences are stronger.

However, this doesn't mean influencing attitude is not important. A negative attitude towards particular behaviour can act as a barrier to performing that behaviour. It is always important to remove such barriers, even if it does not immediately lead to a behaviour change. **In fact, they believe changing attitudes towards traffic behaviours by providing road users with attitude-relevant information is an important tactic to achieve behavioural change. They also provide some recommendations:**

1) The information should address the needs of road users in order to increase the probability that the information will be noticed and used;

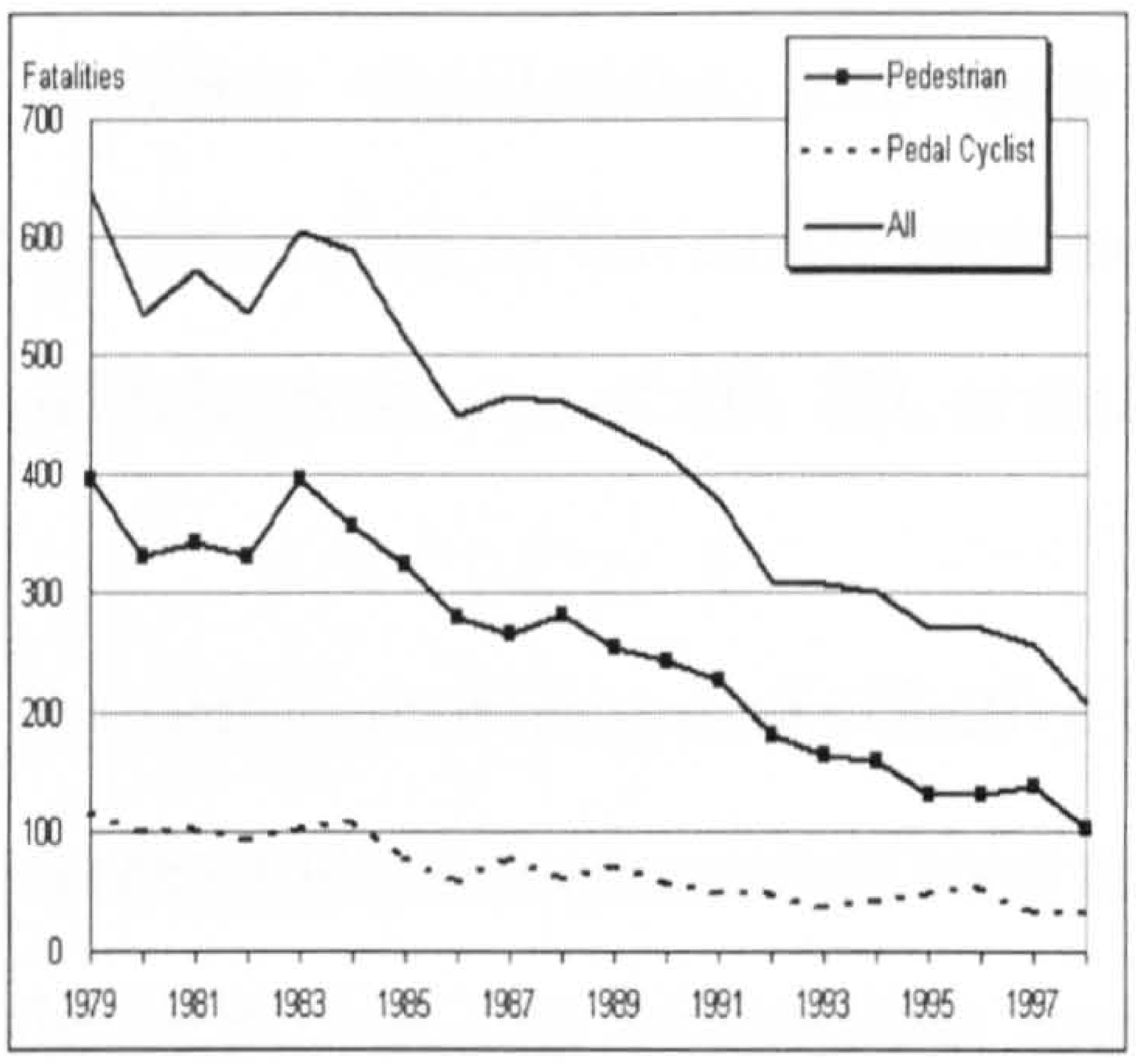
2) "We should be precise as to the distinct character of the traffic behaviour we aim to change and the context of the behaviour." For example, researches about speeding [2] showed that the importance of attitude and social norm can differ depending on the type of road considered. Therefore, road safety campaign information about driving speed should make a distinction between the different categories of road, inside and outside built-up areas.

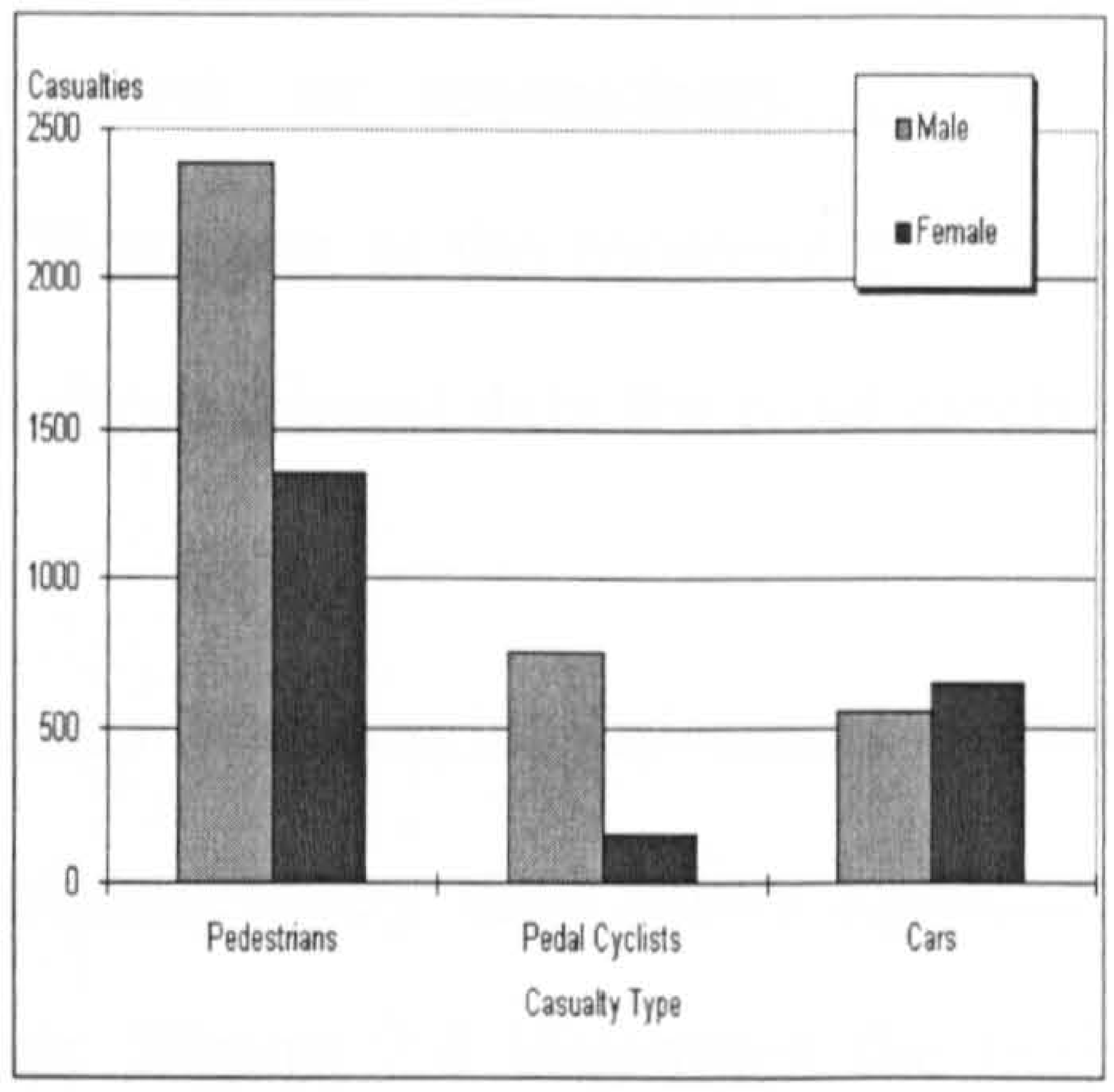
From the above recommendations and previous road safety practises, we can see that road accident related information can play a role in reducing road accidents. Driver training courses need this information to identify potential risks and provide appropriate advice or instructions. School education needs this information to inform pupils. Road safety campaigns need this information to support their plans and show evidence to the general public. Legislation and enforcement need this information to help people understand the rules and therefore obey the laws.

Road accident information is presented in various format including text, images and video. The presentation of this information can be divided into 1-dimensional, 2-dimensional and multi-dimensional representations. Figure 2.3 shows some examples of different dimensional road accident information data.

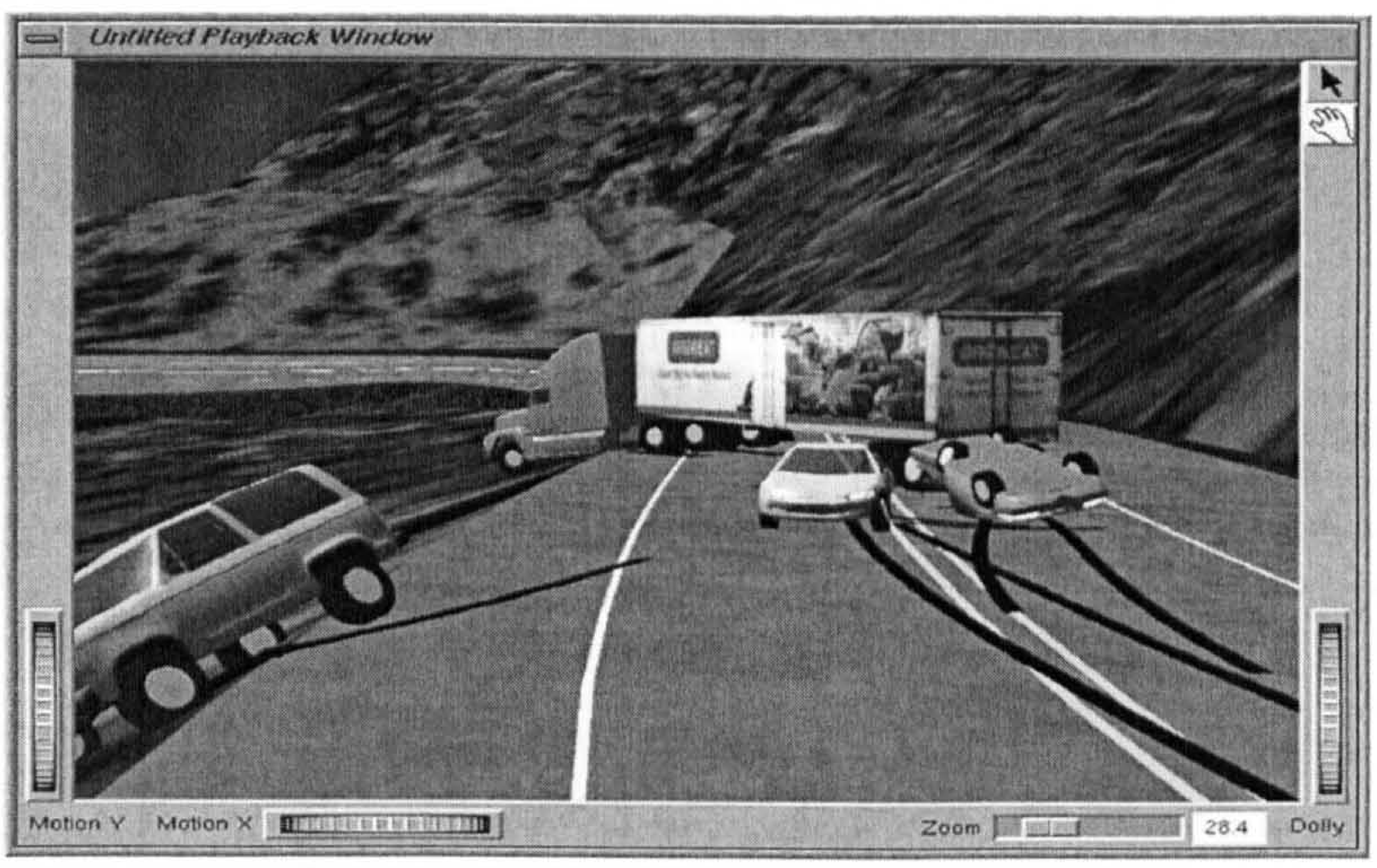
> Road Incident:
>
> A4148: Lane(s) closed between West Bromwich Road: Fullbrook and Birmingham Road in Anti-clockwise direction.

One dimensional (text)





Two dimensional (charts, images, graphs, et.)



Multi dimensional (video)

Figure 2.3 different kinds of road accident information

1-dimensional information provides a literal description of the accident. Those information are usually come from traffic police. They recorded the accident process according to the description of witnesses. 2-dimensional information, such as charts and graphs, can show trends in accidents. Those information are usually generated by road safety experts or researchers. They use such information to identify potential accident patterns so that they may find countermeasures. Multi-dimensional information, such as accidents simulations, can help experts or researchers get a better understanding of the single accident. However, at the moment there are few guidelines for use of 1D, 2D, or multi-dimensional data for road safety.

In order to provide a cost effective means of accessing information about the causes and consequences of road accidents, many road safety agencies have developed on-line information sources. Figure 2.4 illustrates the main UK Department of Transport portal for road safety information. As can be seen, this web site provides access to information about a range of issues including the use of speed cameras, child safety and alcohol limits. National level statistical information is also provided.

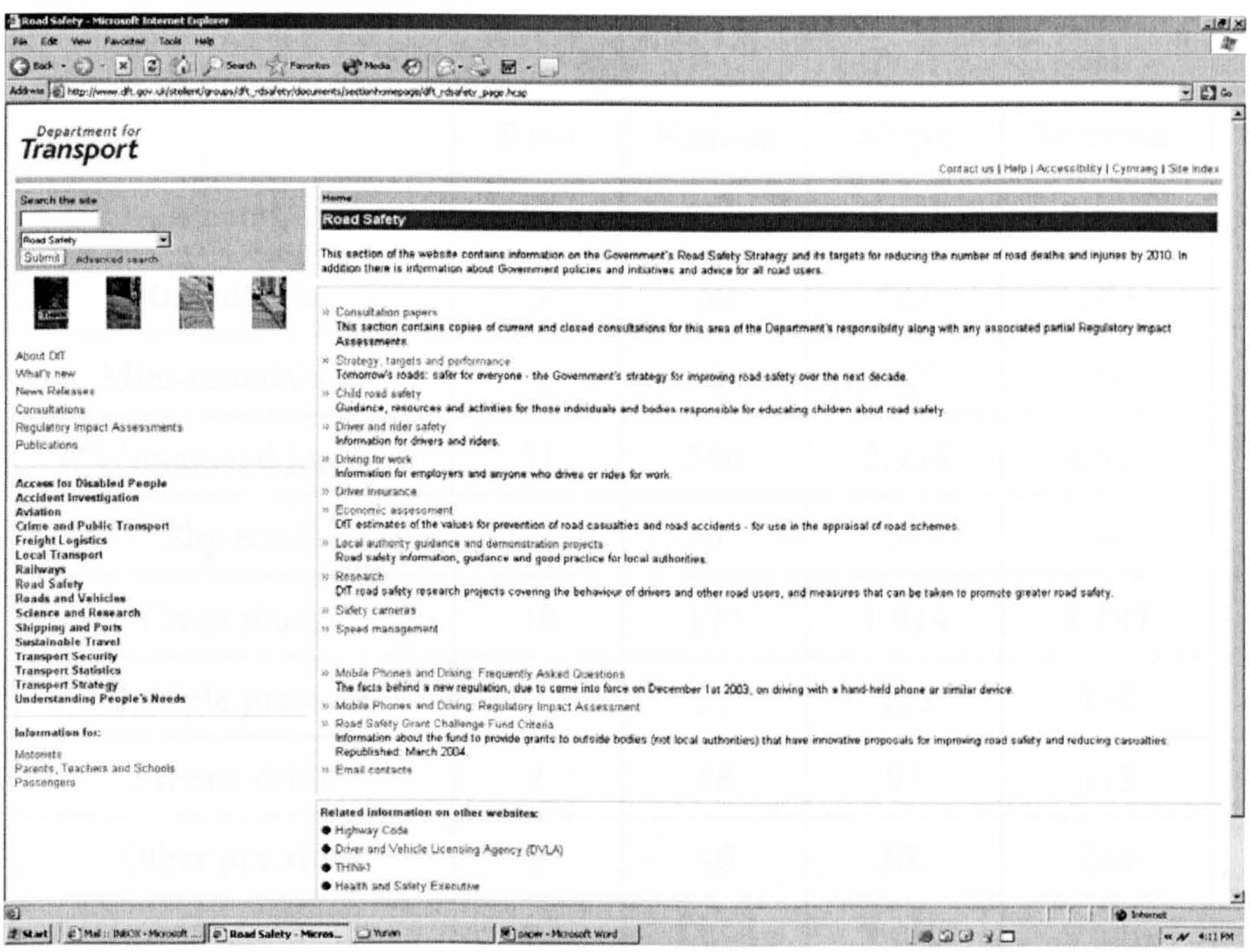


Figure 2.4: UK Department of Transport Road Safety Site

Within Scotland, it is possible to access local accident data published by the Scottish office. There are, however, a number of usability issues associated with this information source. Members of the public must use a series of interlinked Excel workbooks to navigate between different views of the regional statistics (there are html and pdf versions available now for the users). This data has the benefit of providing detailed information about the frequency of accidents in particular, generic types of road geometry. Table 2.2 illustrates the Scottish Executive data from mean accident frequencies at different severity levels for built-up (urban) junctions between 1998 and 2002.

	Fatal	Serious	Slight	All Severities
Junction	45	772	2,995	3,812
Roundabout	3	60	521	583
Mini-roundabout	-	6	42	48
T/Y/staggered junction	31	596	2,994	3,621
Slip road	-	9	55	64
Cross roads	10	172	1,014	1,197
Multiple junction	-	22	115	138
Private drive	1	18	93	112
Other junction	2	40	202	244
Total	93	1,695	8,032	9,820

Table 2.2: Scottish Executive Accident Frequencies for Urban Junctions (1998-2002).

At a local level, individual city and municipal organizations will also issue information about road safety issues. For example, Glasgow City Council developed a road safety action plan. This publicized the various direct steps that they were taking to reduce the accident rate within the areas under their control. This argued "In 1997, 22 people were killed, 496 were seriously injured and 2597 were slightly inured on the roads in Glasgow. Although, this was the lowest total of casualties in modern times, it is 22 deaths too many". Figure 2.5 shows how the review of their strategy presented aggregate local accident statistics to members of the public.

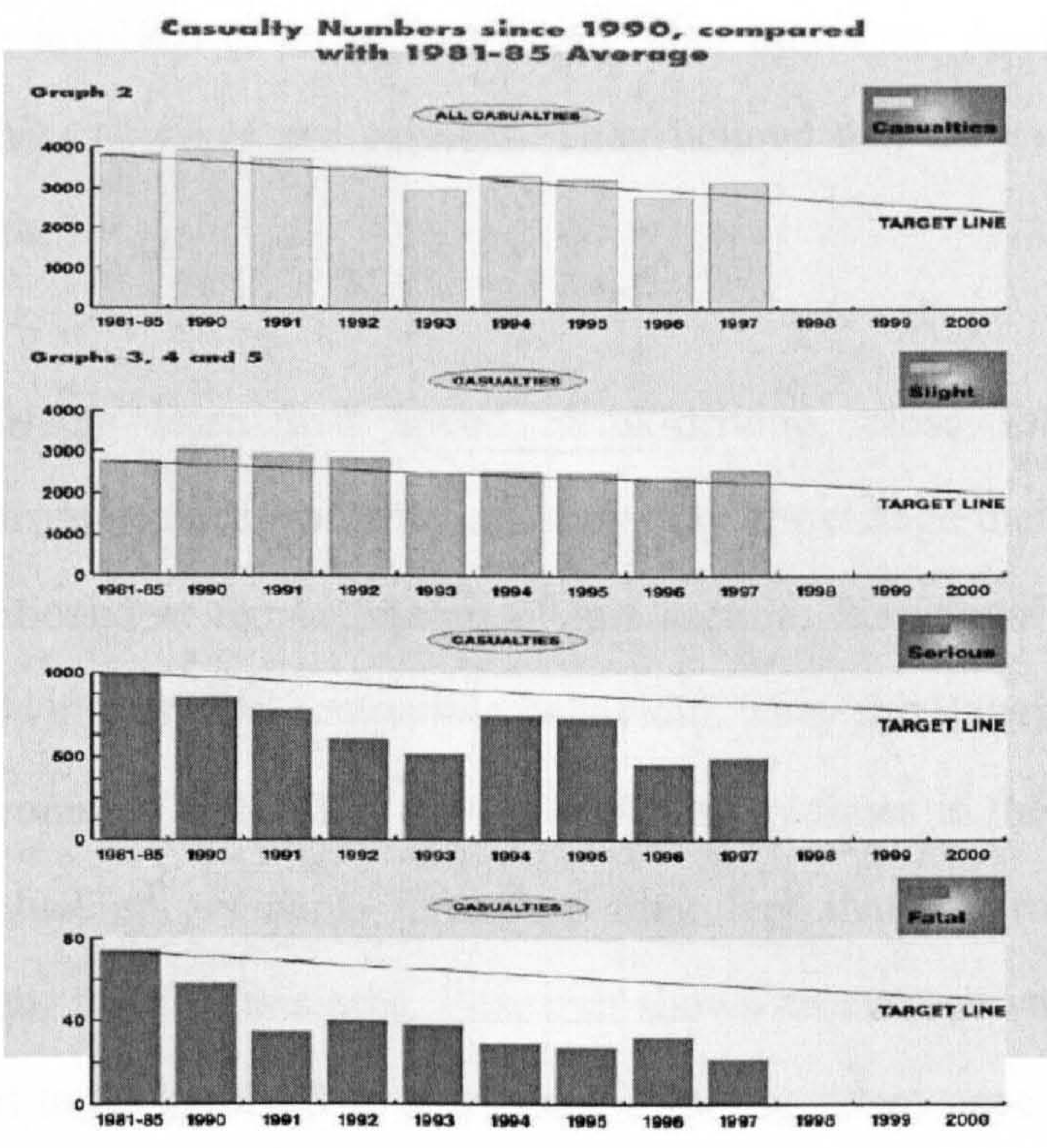


Figure 2.5: Excerpt from Glasgow City Council's Review of Road Safety Strategy

From the previous examples, we can see these on-line information sources only provide high level aggregate national or regional statistics. These statistics provide an overview of road accidents and certain relationships between accidents and factors, such as road geometry, accident locations, accident times. But this kind of information does little to cope with the problem of fundamental attribution error.

Fundamental Attribution Error (FAE) is a psychological phenomenon. This refers to the fact that whenever people are making attributions about an action, they tend to over-emphasize dispositional factors about the actor, and under-emphasize situational factors [77]. Because it appears as if people generalize from the actor's behavior and ignore the situational context in which behavior occurs, the FAE is often described as a tendency to underattribute the cause of behavior to situations and overattribute it to dispositional traits [77]. For example, most drivers believe that they are less likely to be involved in an accident than other motorists. Accidents occur because other motorists are careless. They believe that they would never drive like that.

Even if drivers learn that speed, drink-driving, close following are dangerous from accident information, they may not change their behaviour. As we mentioned at the beginning of this section, Situational factors can hamper showing attitude-compatible behaviour. They think they know their traffic environment well. They have traveled many times in their local area and never had an accident. Therefore they feel that the rules are not applicable for them in this area. Research shows an average car driver can be expected to be involved in a personal-injury accident once in about 60 years [29]. So it is normal for a driver not to have an accident for long periods of time. But if drivers drive dangerously 10 times without an accident, this doesn't mean they won't get hurt the next time. If they know someone in their area who has had an accident with the same situation they had, they may be more alert to that situation.

2.4 Research Methodology

From previous sections, we can see increase road users' safety awareness and attitude has been a popular way to improve road safety for many years. However, the existing methods have their limitations. Driver training, school programs or education only have short term impacts on road users' safety awarness. Road safety campaign could be affected by Fundamental Attribution Error (FAE). Enforcement often leads to a change in behaviour, but in many cases only for as long as the perceived chance of being caught is high enough. Our research focuses on different aspects of accidents information. We argued that more localized precise road accidents information may have a significant impact on the general public's safety attitudes. In order to test our hypothesis, we decided to develop a software application, which will provide a map-based road accident information system for the Glasgow area. Using localized information is not a new idea. For example, Don Brown's group at the University of Virginia has recently implemented a Regional Crime Analysis Program (ReCAP) for use in small cities and towns. This system uses a client-server architecture so that local officers can monitor patterns in crime reports across time and geographical locations. This tool enables law enforcement agencies to analyze crime data down to the level of individual districts. This is increasingly important when police initiatives to address criminal activities in one area or district can displace those activities to other areas. As with ReCAP and unlike route planning systems, such as the AA navigation tool, our proposed application will provide localized historic accident information for the general public.

Our research had three main stages. First, we used risk perception assessment techniques to find out how existing on-line road accidents information affects the general public's safety attitudes. This is discussed in detail in Chapter 3. Secondly, we developed a map-based road accident information system for the Glasgow area. Through our system users can find out detailed information about every accident that has happened over the last few years. Additional tools will also be provided so that users can find accident patterns in the area. We then used the same psychometric techniques to assess the impact of our system on people's safety attitude.

By comparing existing on-line information system and our system, we hoped we could identify which information and information presentation tools are critical in changing the general public's attitudes to road safety.

Chapter 3

Evaluation of Existing Road Safety Websites

3.1 Existing Road Accident Related Information Systems

3.1.1 Simulating Individual Road Accidents

The simulation of individual road accidents is an important aspect in road safety research. It can show the interactions between humans, vehicles and the environment based on data collected at the scene of an accident or incident. The Human Vehicle Environment (HVE) is such a system, developed by the Engineering Dynamics Corporation. This system can simulate the response of multiple occupants during a rollover collision including contact between the occupants. It can simulate a crash sequence and change the initial conditions to study avoidability. It can route the results directly to a video showing multiple views including those of the driver of each vehicle, use virtual thermocouples to monitor brake lining temperatures on a downhill grade, create a complex 3-D terrain mesh and drive a vehicle on it, and so on [39]. Figure 3.1 shows some screen shots from the system. The left hand side figure simulates a van driver's view before this van collides with the coming truck. The whole accident process can be seen from the simulation with HVE's virtual camera attached to the witnesses and driver of each vehicle. The right hand side figure shows another simulation of two car crash. From the simulation, we can see, during the accident, not only did the occupants strike the vehicle interior, they also struck each other. This kind of information could help experts to explain the injury patterns of the victims. However, this software has limitations. Such simulations only help researchers understand individual road accidents or generic scenarios based on particular types of common accidents. It is difficult for researchers to see the relationships between accidents. For example, from one accident simulation, researchers might find that the car speed is too high. If this car can be driven under 60 mph, the accident will not happen. But if conditions change a little, the conclusion may not be right. For instance, another car, which is driven under 60 mph at the same place, may still have an accident because it is raining. Therefore, the information that comes from individual accidents is not enough for road safety research. However, statistical tools can be used to help identify relationship between different individual accidents.

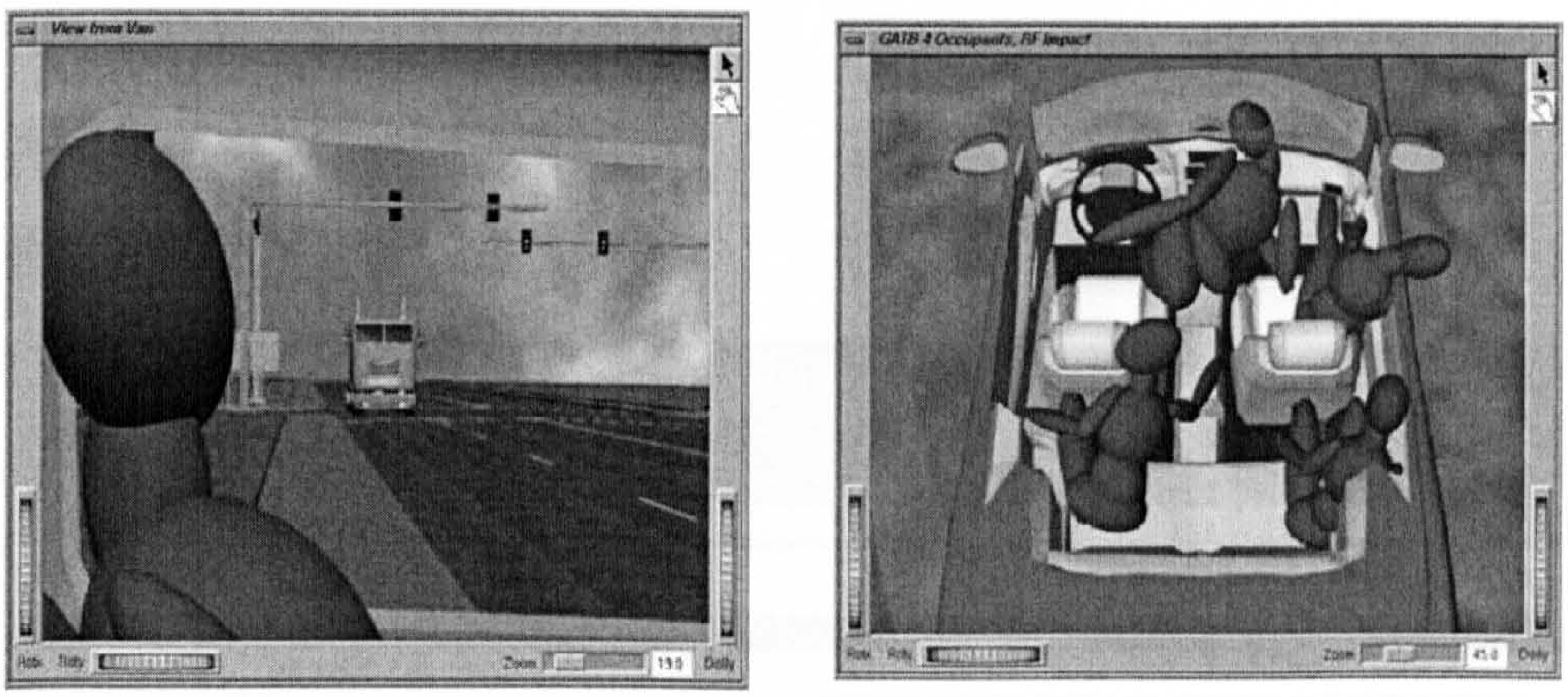


Figure 3.1 Screenshots of HVE

CarSim (http://www.carsim.com/) and Pam-Crash (http://www.esi-group.com) provide further examples of single accident simulation tools.

3.1.2 Real-time Road Traffic Accidents Reporting System

At present, many commercial websites provide real-time road traffic accident information using their own visualization tools. This information is updated every hour or even every minute. People browsing these websites can find out where and when accidents have happened. Using the information, people can plan to avoid traffic before they go out. The following are typical of these websites.

3.1.2.1 TxDOT Expressway

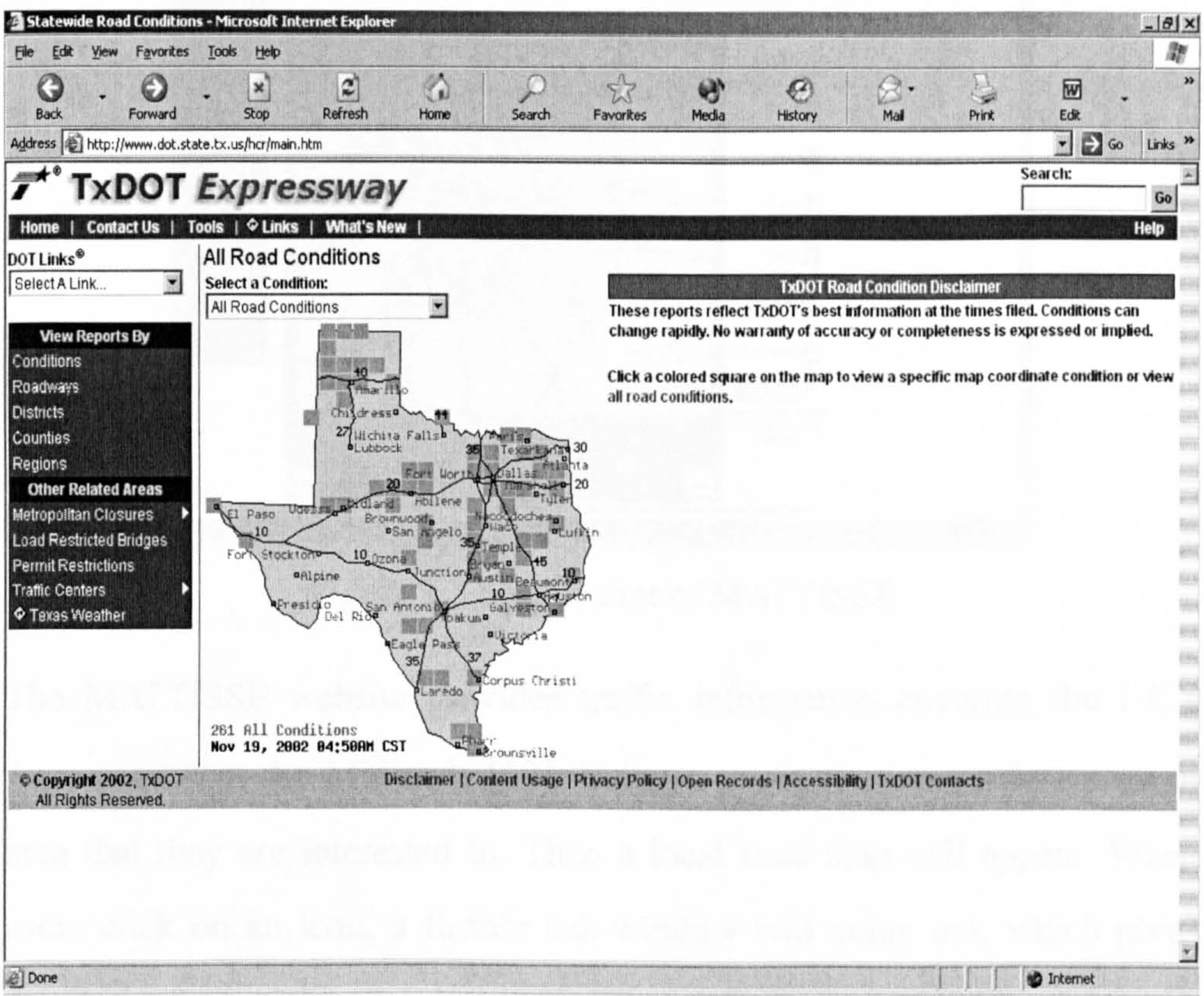


Figure 3.2 screen shot of TxDOT

The TxDOT Expressway website provides road condition information for Texas State [95]. The map is divided into many squares. Those that are colored blue have road traffic problems. Users can select an area by clicking the corresponding blue square. Then a new page with detailed road condition information is displayed. Users can also use a combo box above the map to select a specific condition, such as construction, bridge-out, damage, and so on. Figure 3.2 shows a screen shot of TxDoT system. With the information provided from this system, road users can be informed by the current road conditions on every road in Texas State so that they can plan their journey more efficiently.

3.1.2.2 MATTISSE

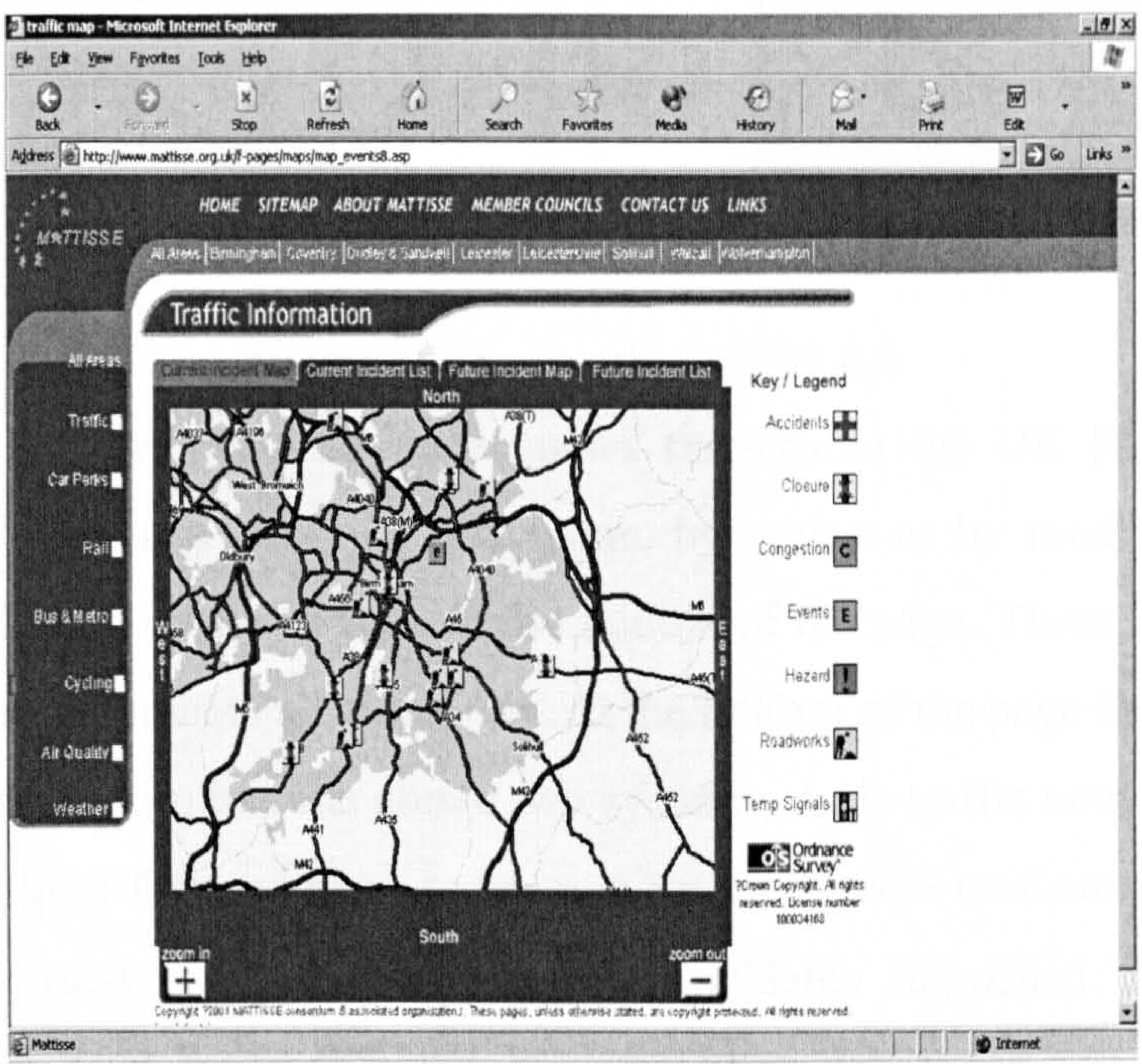


Figure 3.3 Screen shot of MATTISSE

The MATTISSE website provides traffic information covering the UK's "crossroads" in the Midlands [59]. Using a map, users can select a small area that they are interested in. Then a local road map will appear. When users click on an icon, a further sub-window will come out, which gives detailed information. An icon list is always at the right-hand side of the web page, which gives users an explanation of each icon. This website also provides an incidents list. Figure 3.3 shows a screen shot of MATTISSE. Like the TxDoT system above, the information provided by MATTISSE could help road users plan their journey more efficiently and safer.

3.1.2.3 AA

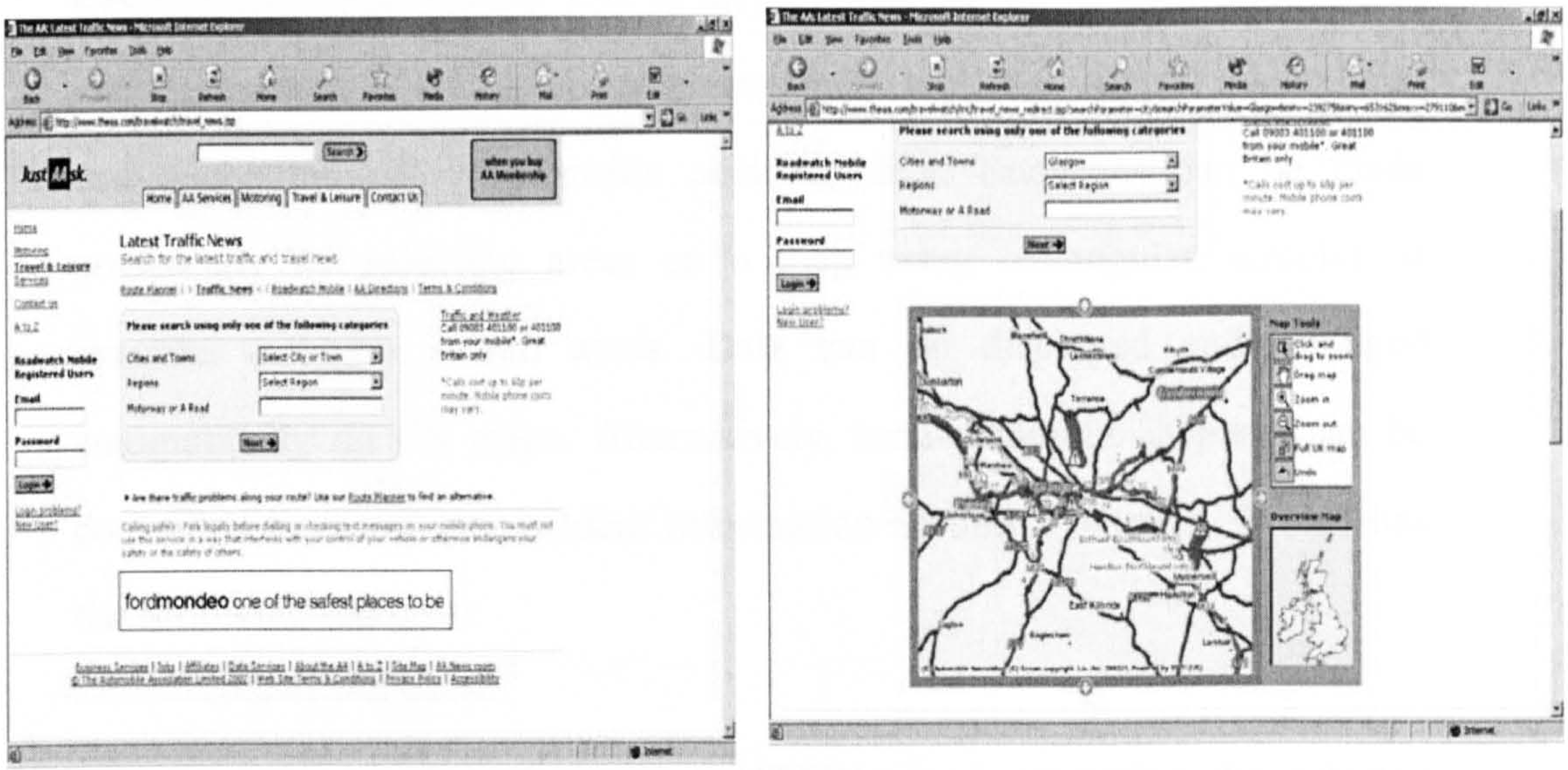


Figure 3.4 screen shot of the AA

The 'AA' website provides traffic news throughout the UK [88]. Users must firstly fill in a query by city name, by region or by road name. The system will then display a map in the middle of the page. There is only one kind of icon to indicate all situations. At the bottom of the page there is a list of incidents. Again, like the above two systems, AA's traffic news and maps are very helpful for road users to know what the current road conditions are, where the road works are, where the incidents happened. With such information, road congestion can be reduced around those areas and road uses can save a lot of time.

Real time accident information system can give road users ideas about which road to avoid so that people can choose another better route. However, such systems do not provide historic accident data. People can't know which area is an accident hot spot and which route is safer. The next section will talk about accident analysis system which could provide such information.

3.1.3 Road Traffic Accident Analysis Systems

3.1.3.1 KeyAccident

KeyAccident (See Figure 3.5) is an AutoCAD® based GIS application, including a standalone database management tool, for storing, maintaining and analyzing UK road traffic accident data. Enquiries can be made graphically by selecting areas on a map using rectangular, circular or irregular polygon search areas. Data can be displayed and arranged automatically on OS maps. Alternatively, semi-automatic displays can be controlled to distribute accident information around a junction. It also has the following features:

- Setting up the SEARCH CRITERIA and extracting the selected accidents
- Creating a FILE from the selected accidents for future use.
- Creating and drawing the STICK DIAGRAMS and sorting them.
- Creating and drawing the HISTOGRAMS.
- Creating and drawing the PIE CHARTS.
- Creating and printing out the TEXT SUMMARY.
- Ability to perform GIS searches quickly with ease and present RTA data in a graphical format
- Generate accurate Cluster Site lists using recognised algorithms
- Maintain RTA data effortlessly using comprehensive data management tools
- Create statistical, narrative, comprehensive or user defined reports
- Facility to monitor sites with the automatic extraction of RTA data to the DfT Safety Camera Partnership database

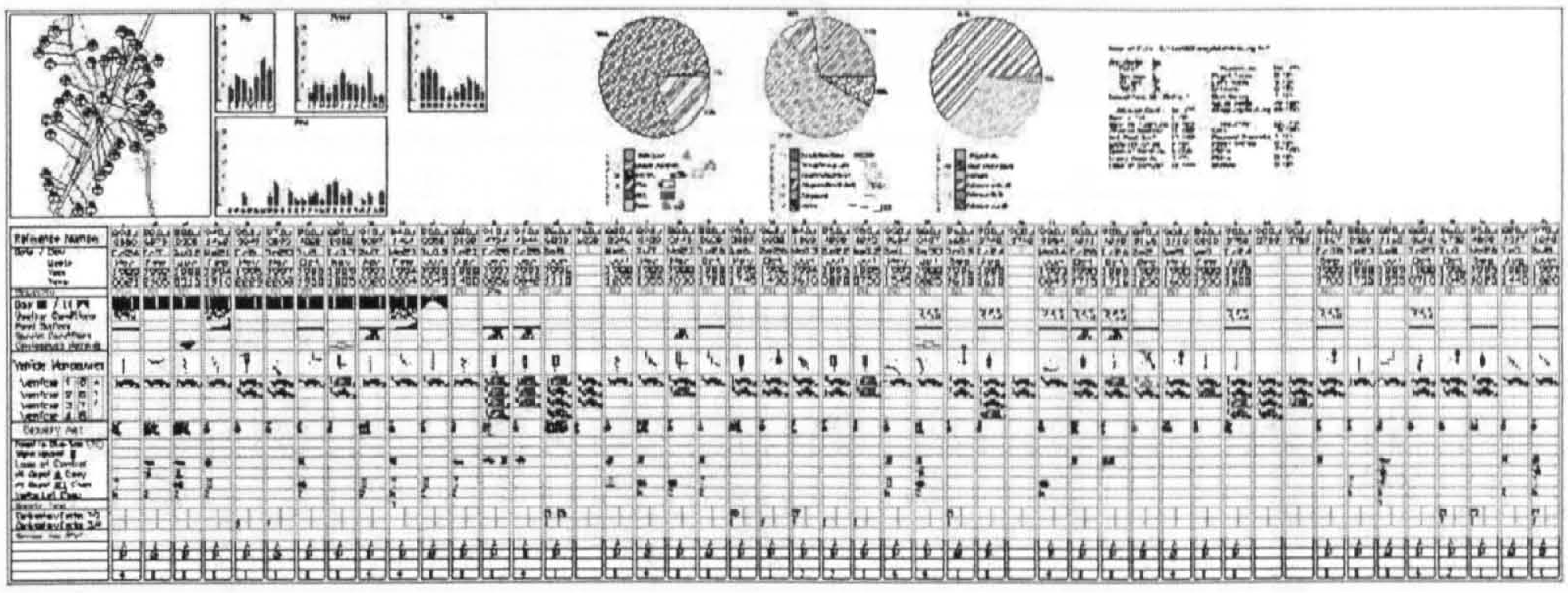
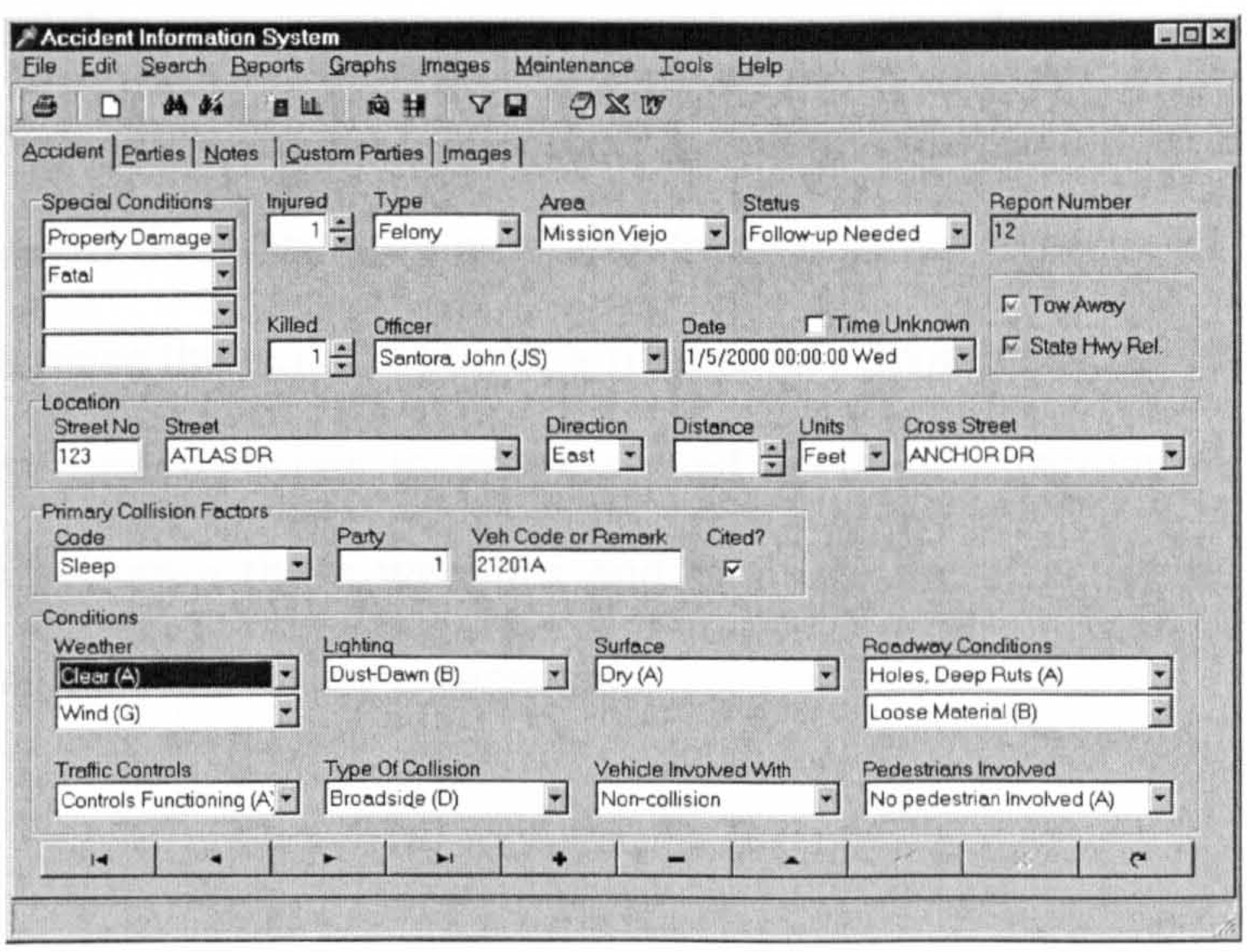


Figure 3.5 An example result of KeyAccident system

As we shall see, the KeyAccident system is used by several local authorities to guide road planning.

3.1.3.2 AIS (Accident Information System)

AIS was developed for police departments in California. It is a comprehensive accident data reporting and tracking system, for traffic enforcement personnel. In use since 1993, AIS can view, edit, compare and combine visual representations of accident scenes (photos). And it can generate many reports customized by users. Figure 3.6 shows some snapshots of the system.



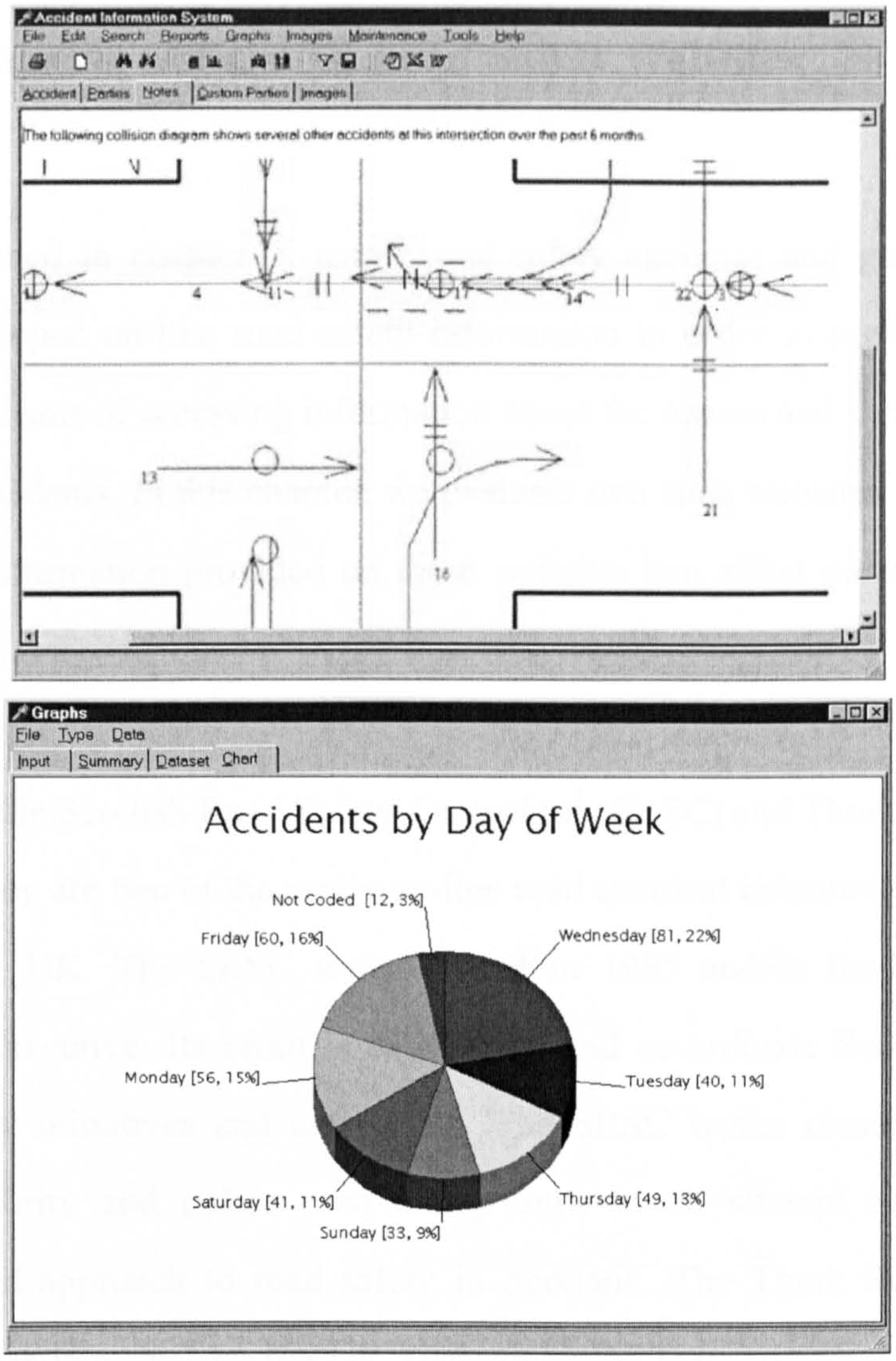


Figure 3.6 Snapshots of AIS

Although all the above systems can provide great insight into road accidents, none of them provides historical road accident information to the general public. Most of them are only available to road safety experts. In the UK, in order to increase the general public's road safety awareness, government has launched several websites to provide road accident information. The next section will discuss these websites and evaluate the effectiveness of these websites on people's safety awareness.

3.2 Evaluation of Existing Road Safety Websites

As mentioned in chapter 2, many road safety agencies and governments have developed on-line road safety information in order to provide a cost effective means of accessing information about the causes and consequences of road accidents. In this chapter, we evaluate two such websites to find out how the information provided on these websites can affect people's safety awareness.

We chose the Scottish Road Safety Campaign[1] (SRSC) and Think![2] websites because they are two of the major on-line road accident information systems within the UK. The SRSC was founded in 1985 and is funded by the Scottish Executive. Its remit is to develop and co-ordinate Scotland-wide road safety initiatives and campaigns. The SRSC works closely with all local authority and police road safety units in an attempt to ensure a coordinated approach to road safety in Scotland. The Think Road Safety Website was launched by the UK Department of Transportation to provide the news of latest campaigns and road safety advice to keep everyone safer on the UK's roads.

[1] http://www.srsc.org.uk/

[2] http://www.thinkroadsafety.gov.uk/index.htm

3.3 Information on the Websites

A variety of road safety related information can be found on these two websites. It can be divided into four categories: road traffic accident statistics, tips and advice on road safety, interactive multimedia information on road safety, and road traffic safety research outcomes and publications. The websites focus on several different kinds of road users, from young teenagers to old persons, from road safety engineers to traffic police, and from pedestrians to drivers and cyclists.

A number of different techniques are used to present information on these websites. First are statistics, facts and figures. The information covers all important aspects of road safety, such as facts about drinking and driving, seatbelt usage, motorcycle accidents and casualties, and so on.

Figure 3.7 shows some facts and figures from the Think website.

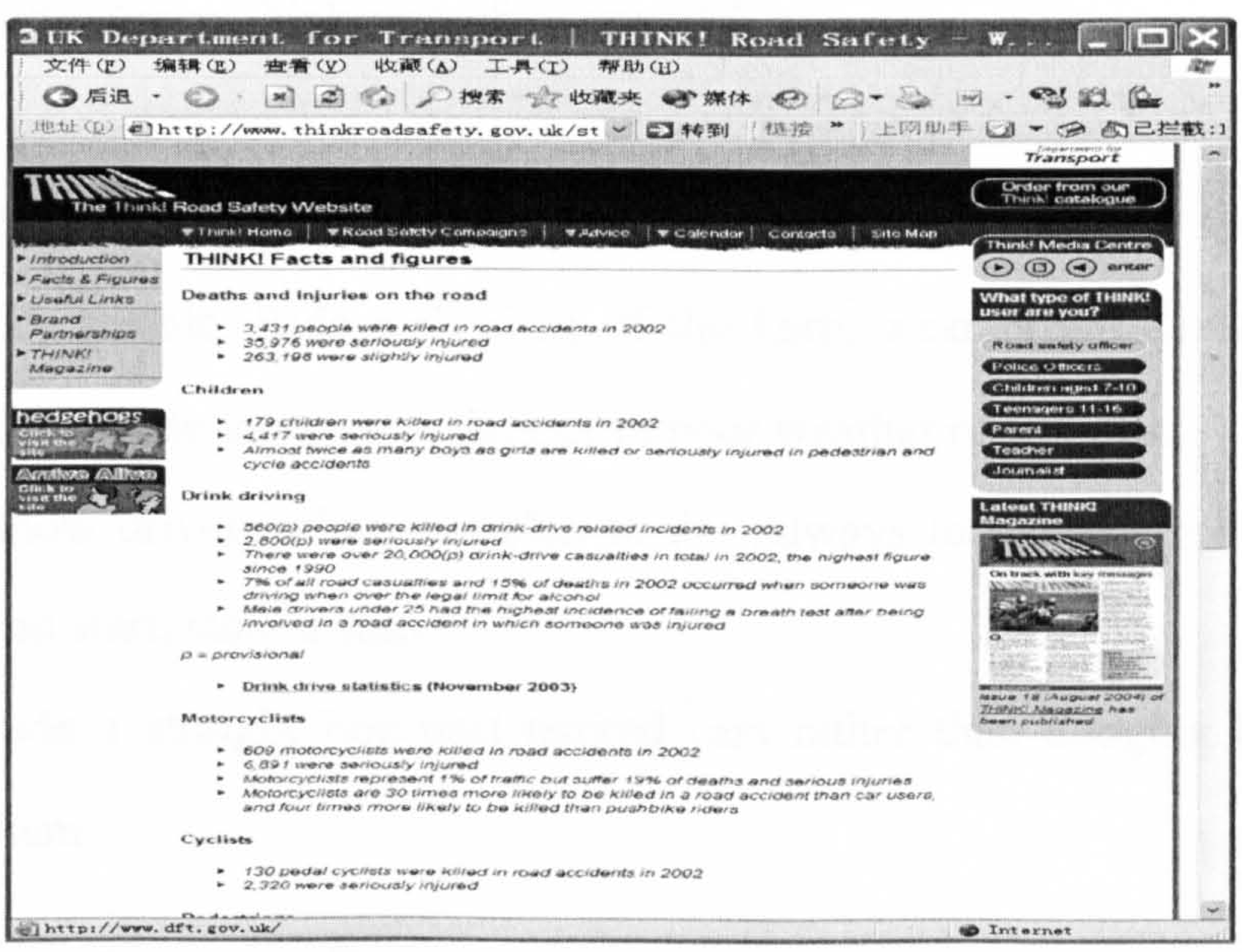


Figure 3.7 Facts and Figures from Think Road Safety Website

These websites also provide tips and advice on road safety. This information focuses on specific user groups, like drivers, pedestrians, cyclists, school pupils. For example, SRSC give some tips for older pedestrians:

- "Try to plan your day to avoid rush hour traffic. In this way you can reduce the risk of being involved in a road accident.
- Allow extra time for journeys. When in a hurry or running late, people tend to become careless and overlook safety
- Try to keep yourself fit and healthy. Have regular check-ups, especially for your eyesight and hearing. It is important for all pedestrians to be able to see and hear the oncoming traffic.
- If you need to wear glasses or a hearing aid, make sure you wear them every time you are out.
- Try to use safer crossing places such as zebra and pelican crossings whenever possible. Many accidents involving pedestrians happen near or on Pedestrian Crossings. These crossings are only safe when used properly
- If you ever need help to cross the road don't be afraid to ask." (http://www.thinkroadsafety.gov.uk/)

The Think website provides the following advice for cyclists.

- "Be visible. Ride well clear of the kerb, wear bright clothing and always use lights after dark or in poor weather conditions.
- Show drivers what you plan to do. Always look and signal before you start, stop or turn.
- Ride a straight line past parked cars rather than dodging between them.
- Don't jump red lights.
- Don't ride on pavements.

- Don't ride the wrong way up one-way streets, unless there's a sign saying cyclists can.
- Don't ride across pedestrian crossings." (http://www.thinkroadsafety.gov.uk/)

However, it is difficult to determine whether such advice has been shown to have an effect on behaviour.

In order to attract young road users, interactive multimedia information is available on the sites. These includes video (TV road safety campaign), audio, games and screensavers. Through the interaction, it is hoped that young road users may understand and assimilate some important safety concept and rules.

Lists of related research results and publications are also a part of these sites. They may use these for publicity, education and further research.

The information on both websites is intended to help road users realize the risks on the road, provide information about what they should and should not do for their own safety, how they can reduce potential risks during the journey. "THINK! is about saving lives. We campaign all year round to get people to think more about road safety, whether you walk, drive or ride. As part of the Government's strategy, our aim is to cut the number of deaths and serious injuries from road accidents by 40% by 2010." (http://www.thinkroadsafety.gov.uk/)

These two websites provide lots of different kinds of accident information for different road users. In order to improve safety awareness and attitudes, the most important factor for the two websites is that they can attract people to visit them. People should be interested in the information provided by the websites. From our focus group discussion, which is described in detail in chapter 7, people are not interested in these aggregated statistics and advices. People are only interested in the information that relates to them. For example, one student said "when I go to a new town, the accident information would help me decide where I should drive carefully".

For those who did visit the websites, we need means of assessing risk perception to find out whether the information provided by the websites has impact on their safety awareness.

3.4 Risk Perception Evaluation

Risk perception is "one's opinion of the likelihood of risk associated with performing a certain activity or choosing a certain lifestyle" [83]. Our evaluation used a questionnaire that amalgamated elements of three existing road accidents risk perception forms [92, 69, and 57].

A campaign to promote safe driving behaviour has been carried out among adolescents in two Nordic counties since 1998. It focused on traffic accident risk perception. Rundmo and Iversen present the results of the evaluation of the effect of the campaign. They use this to examine the association between risk perception and traffic behaviour [92]. The respondents perceived the risk to be higher after the campaign than before. The respondents of the post-sample of the experimental group also reported less 'risky behaviour' in traffic. The questionnaire measured cognition-based as well as emotion-based risk perception. Cognition-based risk perception is about personal belief, such as assessment of the probability of an accident. Emotion-based risk perception is about the sense of feelings, such as worry and insecurity. Model tests showed that assessments of the probability of traffic accidents and concern were non-significant predictors for self-report risk behaviour. In contrast, worry and other emotional reactions related to traffic hazards significantly predicted behaviour.

A similar study was carried out by Rundmo and tried to integrate two research traditions, the personality trait approach and the social cognition approach, to explain individual differences in risky driving behaviour and traffic accident involvement [69]. The cognition approach studied variables such as management of attention and information processing capabilities. Personality approach has focused upon the predictive value of personality traits, such as aggression, anxiety. The study was based on a self-completion questionnaire survey. The questionnaire included measures of risk perception, attitudes towards traffic safety and self-reported risk-taking in traffic. The results suggested that the relation between the personality traits and risky driving behaviour was mediated through attitudes. On this basis it was concluded that personality primarily influences risky driving behaviour indirectly through affecting the attitudinal determinants of the behaviour.

3.4.1 Evaluation Method

Based on the above research, our resulting instrument asked a total of nine questions. These questions relate to both cognition-based and emotion-based risk perception. We did not include any personality questions because our research purpose is to find out the relationship between accident information and risk perception, not the relationship between personality and risk perception. A ten-point bipolar evaluation scale was applied for measuring all types of risk perception. The questions are shown below.

1 Do you feel unsafe that you yourself could be injured in a

traffic accident? Answers are scales from 1 to 10.

Safe 1 2 3 4 5 6 7 8 9 10 unsafe

2 Are you worried for yourself being injured in a traffic accident? Answers are scales from 1 to 10.

Not worried 1 2 3 4 5 6 7 8 9 10 worried

3 How probable do you think it is for yourself to be injured in a traffic accident? Answers are scales from 1 to 10.

Unlikely 1 2 3 4 5 6 7 8 9 10 likely

4 How concerned are you about traffic risks and are thinking that you yourself could be victimized? Answers are scales from 1 to 10.

Not concerned 1 2 3 4 5 6 7 8 9 10 concerned

5 Please rate the equity of this risk, in terms of whether those who receive the benefits are the same people who carry the risks. Answers are scales from 1 to 10.

Not equitable 1 2 3 4 5 6 7 8 9 10 equitable

6 Please rate how much the risk of being in a road traffic accident affects you. Answers are scales from 1to 10.

Not affect me 1 2 3 4 5 6 7 8 9 10 affect me

7 Please rate the extent to which this risk is chosen voluntarily by the people affected. Answers are scales from 1 to 10.

Involuntary 1 2 3 4 5 6 7 8 9 10 voluntary

8 Please rate the immediacy of this risk, in terms of how soon possible harmful effects may occur. Answers are scales from 1 to 10.

Delayed 1 2 3 4 5 6 7 8 9 10 immediate

9 Please rate how controllable this risk is. Answers are scales from 1 to 10.

Uncontrollable 1 2 3 4 5 6 7 8 9 10 controllable

The first four questions are about participants' general attitude and concern for road traffic accidents. Question five can be used to find out whether people think those who carry the risks also benefit most from the road use behaviour. Question seven asks whether people take risks voluntarily. Similarly, question nine asks if this kind of risk is controllable.

Evaluation Goal:

To determine whether road safety websites have a big impact on people's safety awareness?

Evaluation Method:

Risk perception questionnaire (above)

Evaluation Participants and the procedure:

The participants were drawn from a sample of road users in and around the Glasgow area. They included drivers, pedestrians and cyclists. 26 participants did the evaluation in three stages. First, participants were asked to fill in the risk perception questionnaire. Then they were encouraged to browse two road safety web sites for about 10 to 15 minutes. These were the 'Think!' campaign site coordinated by the UK Department of Transport and the web site for the Scottish Road Safety Campaign, mentioned in previous paragraphs. During these 15 minutes, they can choose the information whatever they like to see. There has no specific task. We then ask them to fill out the risk perception questionnaire again and using T test to analysis the results to find out whether their exposure to this information had any short-term impact on their expressed attitudes towards the risks associated with road use. We decided not to assess the relative strengths and weaknesses of these two sites because they arguably present complementary information. We also restricted our evaluation to a relatively small sample because this base-line study was partly intended to identify any potential problems with the existing web sites and partly also to establish the utility of psychometric techniques as means of assessing the impact of these information sources.

3.4.2 Evaluation Results and Discussion

Table 3.1 shows the summary of statistical analysis (t-test) of all the questions. The results show some interesting points. First, the sites seem to have a very small impact on people's safety awareness. Many participants did not alter their assessment of road accident risks. Those who have different answers before and after exploring the websites only changed their ratings by 1 or 2 points. Secondly, the results show there are strong individual differences in the manner in which we perceive the risks of involvement in road traffic accidents. Some people think that the risks of road traffic are controllable, others think the opposite. Thirdly, some participants have difficulty in interpreting some of the questions. They felt it was hard to apply them to their own experience of road usage. We decided to use existing psychometric instruments to minimize the possibility of such influences.

Questions	Mean (before)	Mean (after)	Sdev (before)	Sdev (after)	P value (the two group have no difference)
Feel Safe/unsafe	5.46	5.96	2.50	2.44	0.96
Worried/not worried	5.54	6.15	2.61	2.44	0.99
Unlikely/likely injured	4.85	5.23	2.62	2.3	0.775
Not concerned/Concerned	5.5	6.03	2.23	2.36	0.94
Equity of road risk/benefits	5.27	6.08	2.43	2.30	0.929
Not affect me/Affect me	6.38	6.73	2.77	2.42	0.8
Involuntary/voluntary	6.69	6.35	2.36	2.01	0.655
Immediacy	6.96	7.12	1.59	1.58	0.56
Controllable/uncontrollable	6.15	5.92	2.46	2.51	0.52

Table 3.1 Statistical analysis of the evaluation questions

Figure 3.8 gives the results from question 1, how safe do you feel in terms of the likelihood that you could be injured in a road traffic accident? Before exploring the websites, there are 12 answers are higher than 6. After seeing the websites, 11 people have answers higher than 6. Nearly half of the participants (12 out of 26) felt less safe after accessing the web sites. 3 participants felt safer. From the mean, we can see there is a very little change in their feeling about road risks. Similar results can be found in Figure 3.9, Figure 3.10 and Figure 3.11.

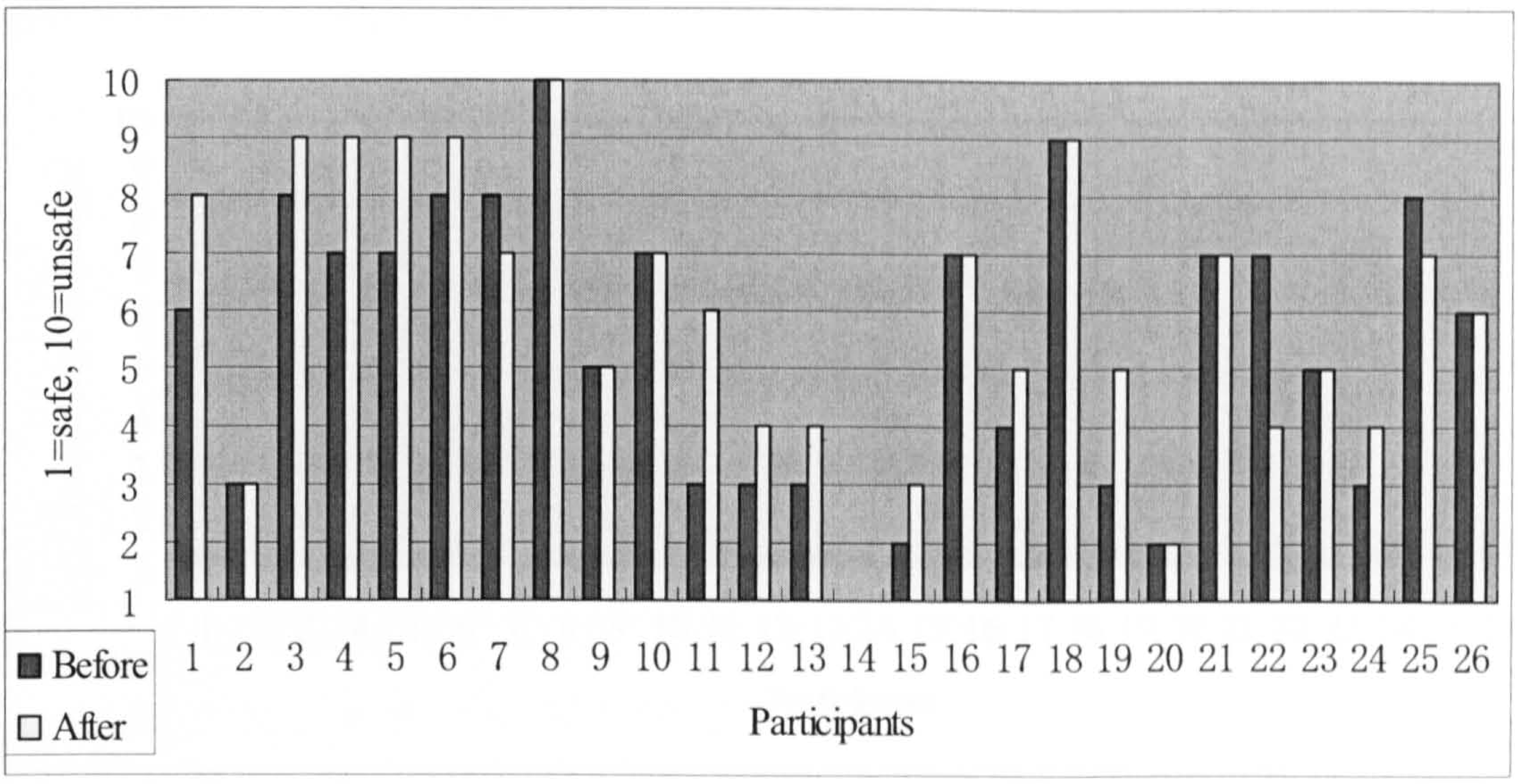


Figure 3.8 Question1: How safe do you feel in terms of the likelihood that you could be injured in a road traffic accident?

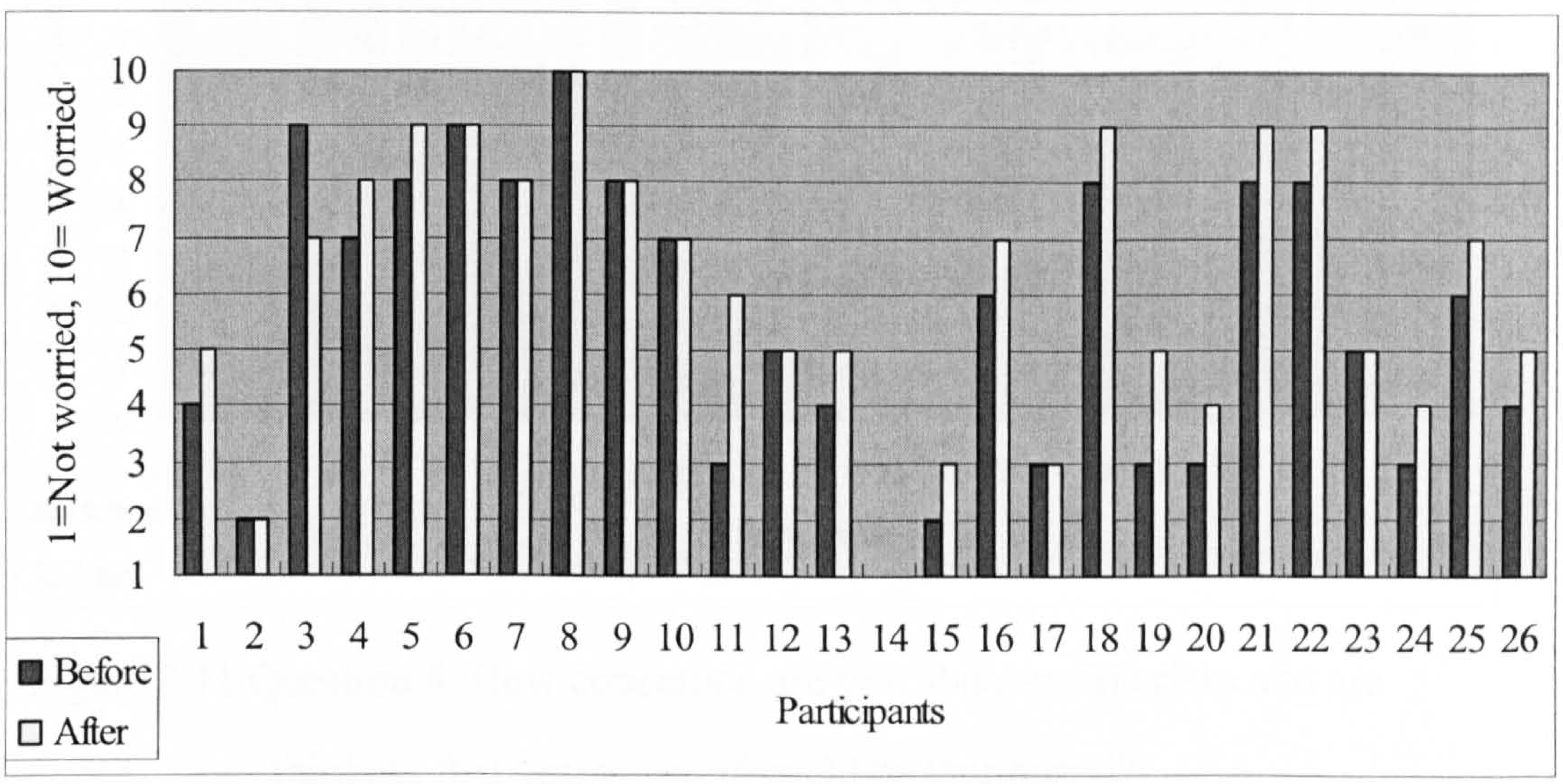


Figure 3.9 Question 2: Are you worried about yourself being injured in a traffic accident?

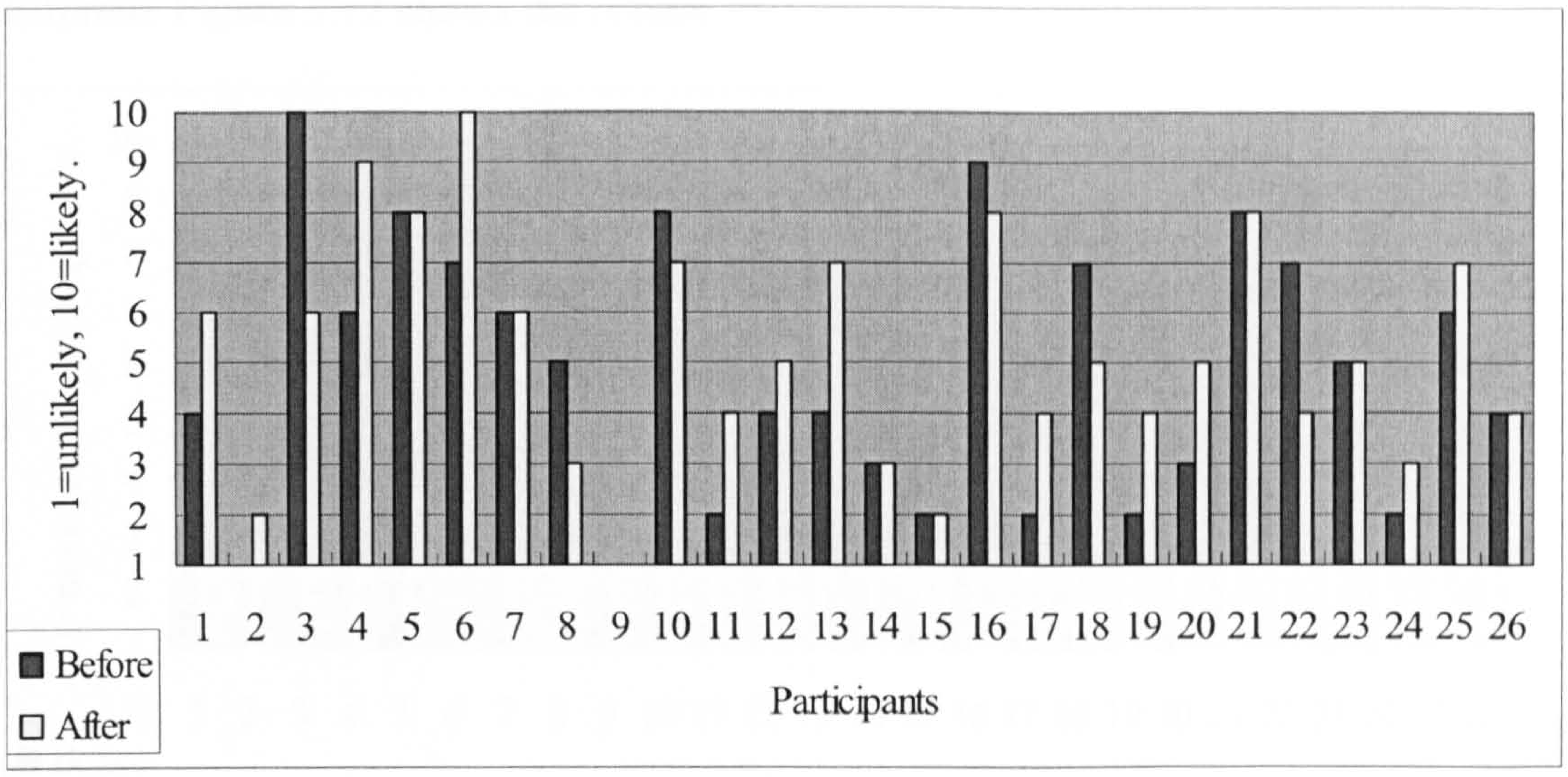


Figure 3.10 Question 3: How probable do you think it is for yourself to be injured in a traffic accident?

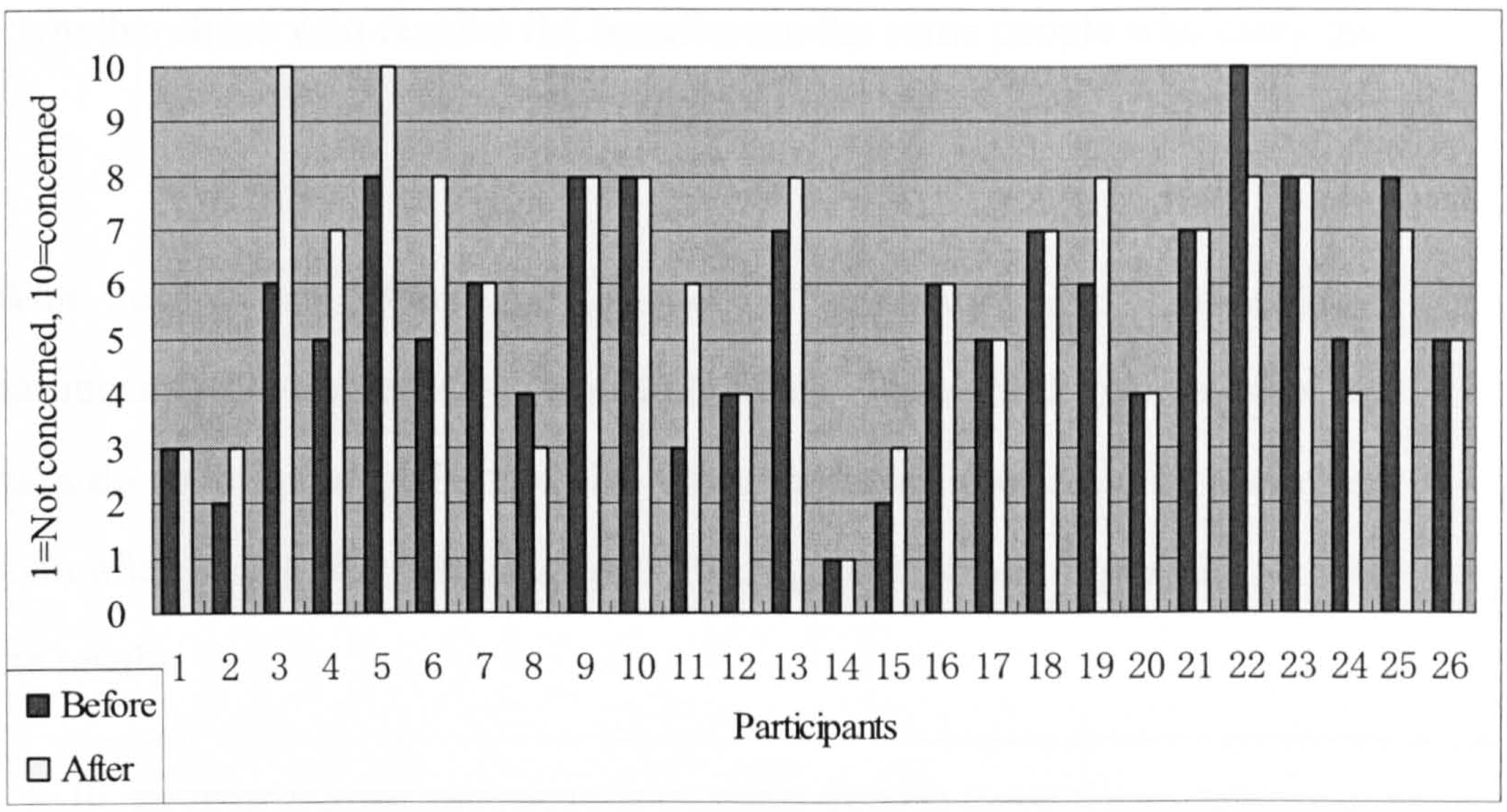


Figure 3.11 Question 4: How concerned are you about traffic risks and are thinking that you yourself could be victimized?

Question 5 is trying to find out whether people think the person or group who creates the risk of a road traffic accident is also the most likely to suffer any adverse consequences. For example, a speeding motorist may increase the risk of an accident to a pedestrian. Most participants found this question hard to answer. They had to think of what 'equitable' means. They never use this concept to compare such activities. Therefore, our responses were very different. Figure 3.12 shows the results.

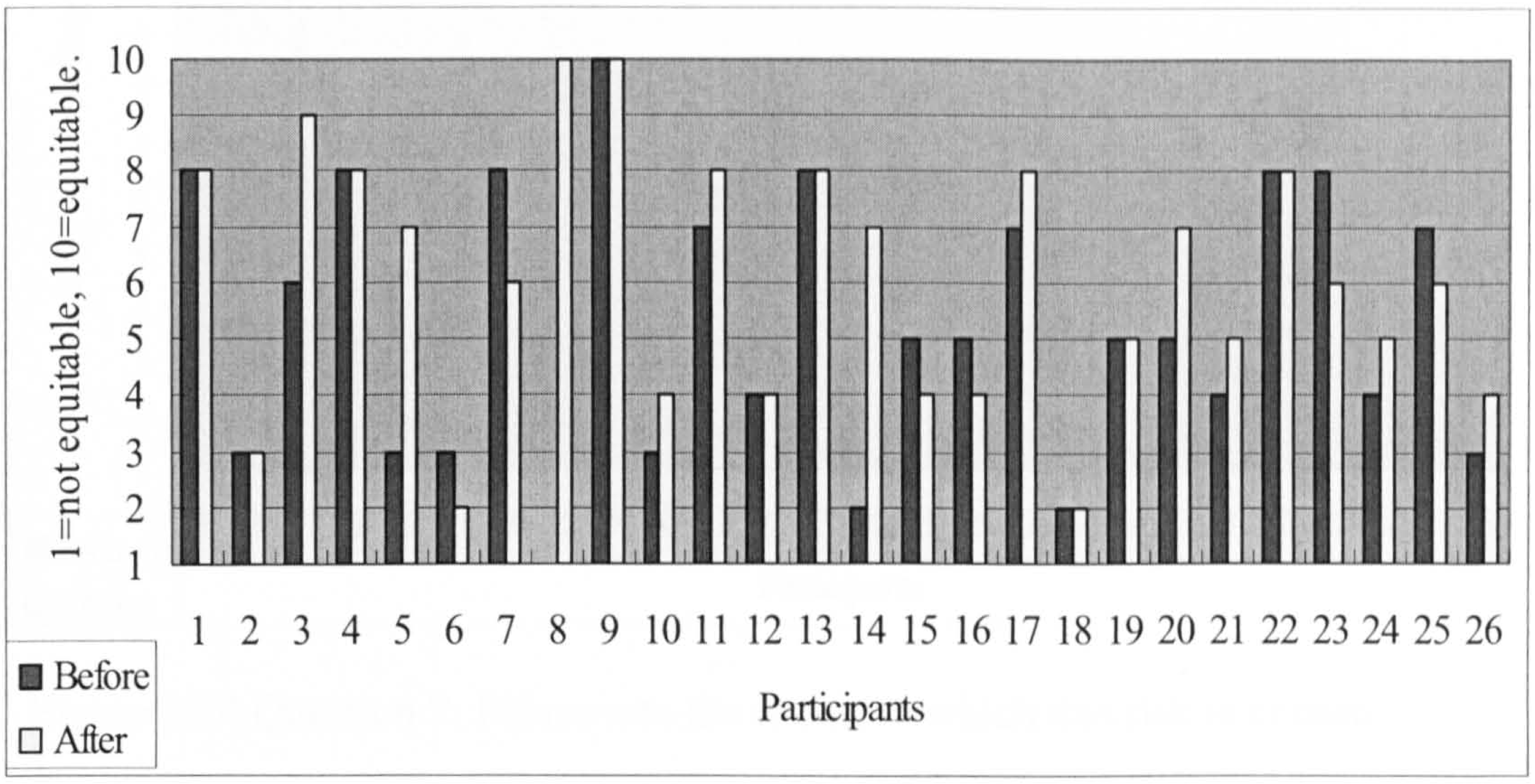


Figure 3.12 Question 5: Please rate the equity of this risk, in terms of whether those who receive the benefits are the same people who carry the risks.

With regard to "affect me or not", "voluntary" and "immediacy", participants have relatively same judgments. They think people who take risks do so voluntarily. People also think the harmful effect may occur very soon after taking the risks. Figure 3.13, Figure 3.14 and Figure 3.15 shows the results.

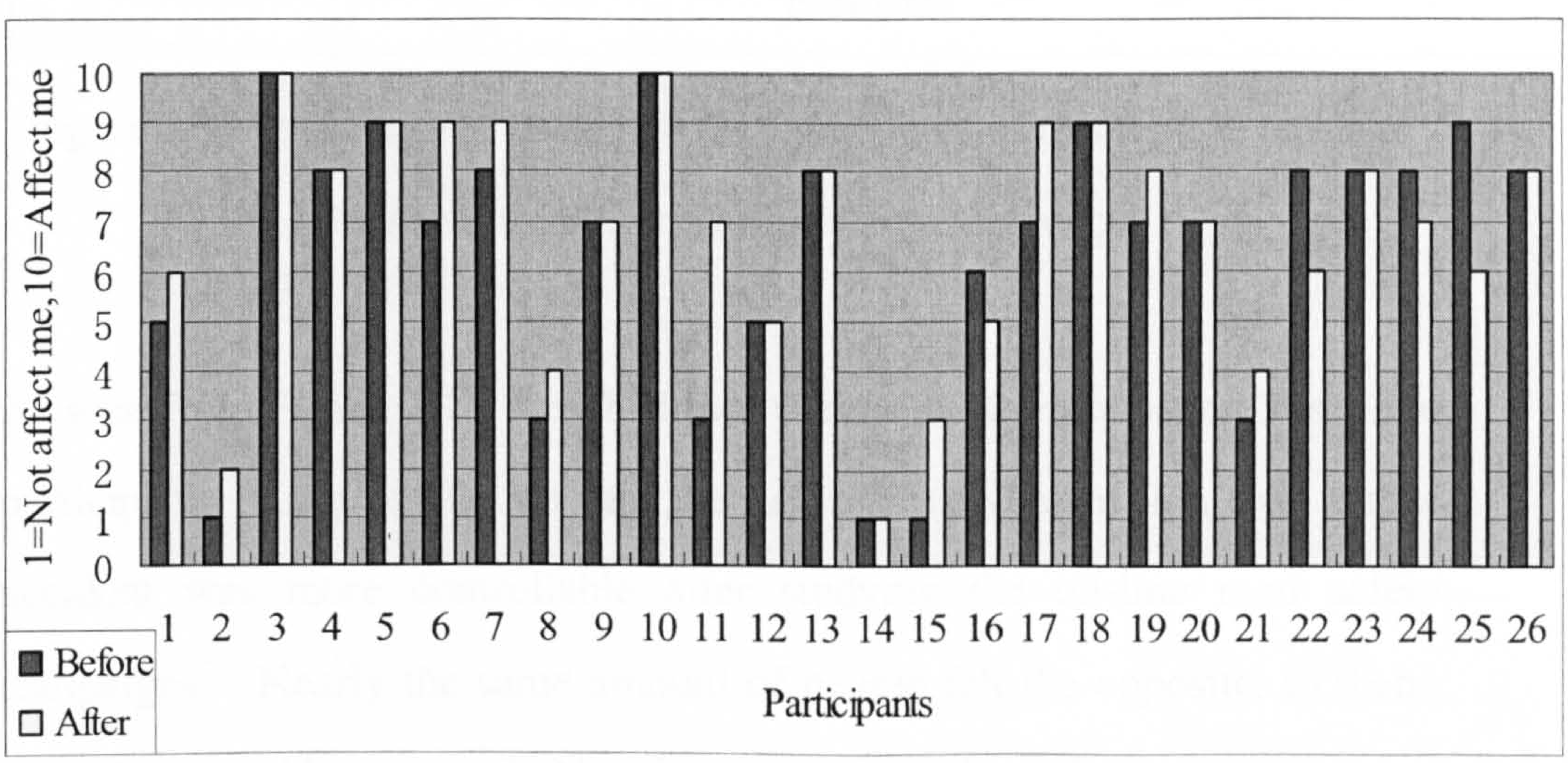


Figure 3.13 Question 6: Please rate how much the risk of being in a road traffic accident affects you.

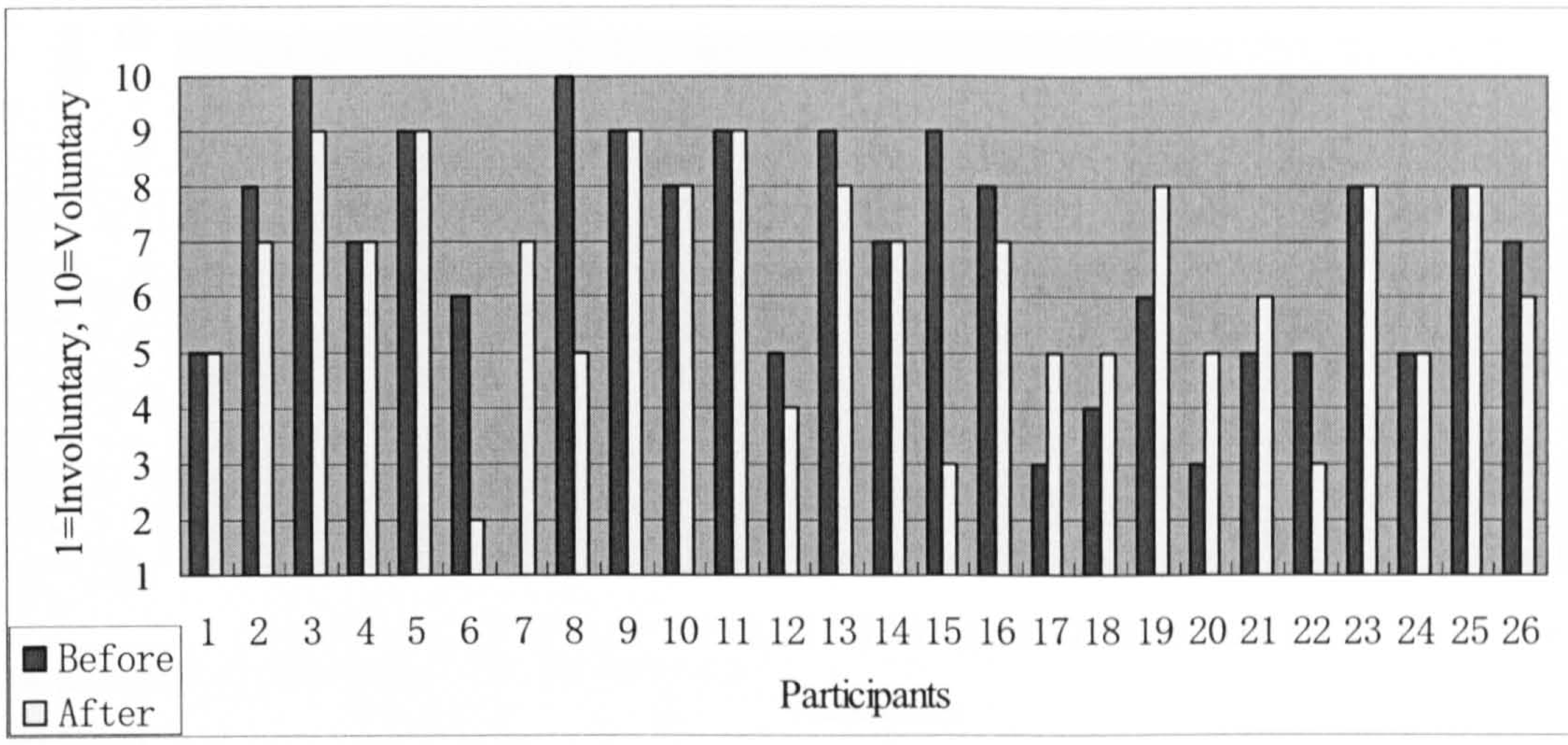


Figure 3.14 Question 7: Please rate the extent to which this risk is chosen voluntarily by the people affected.

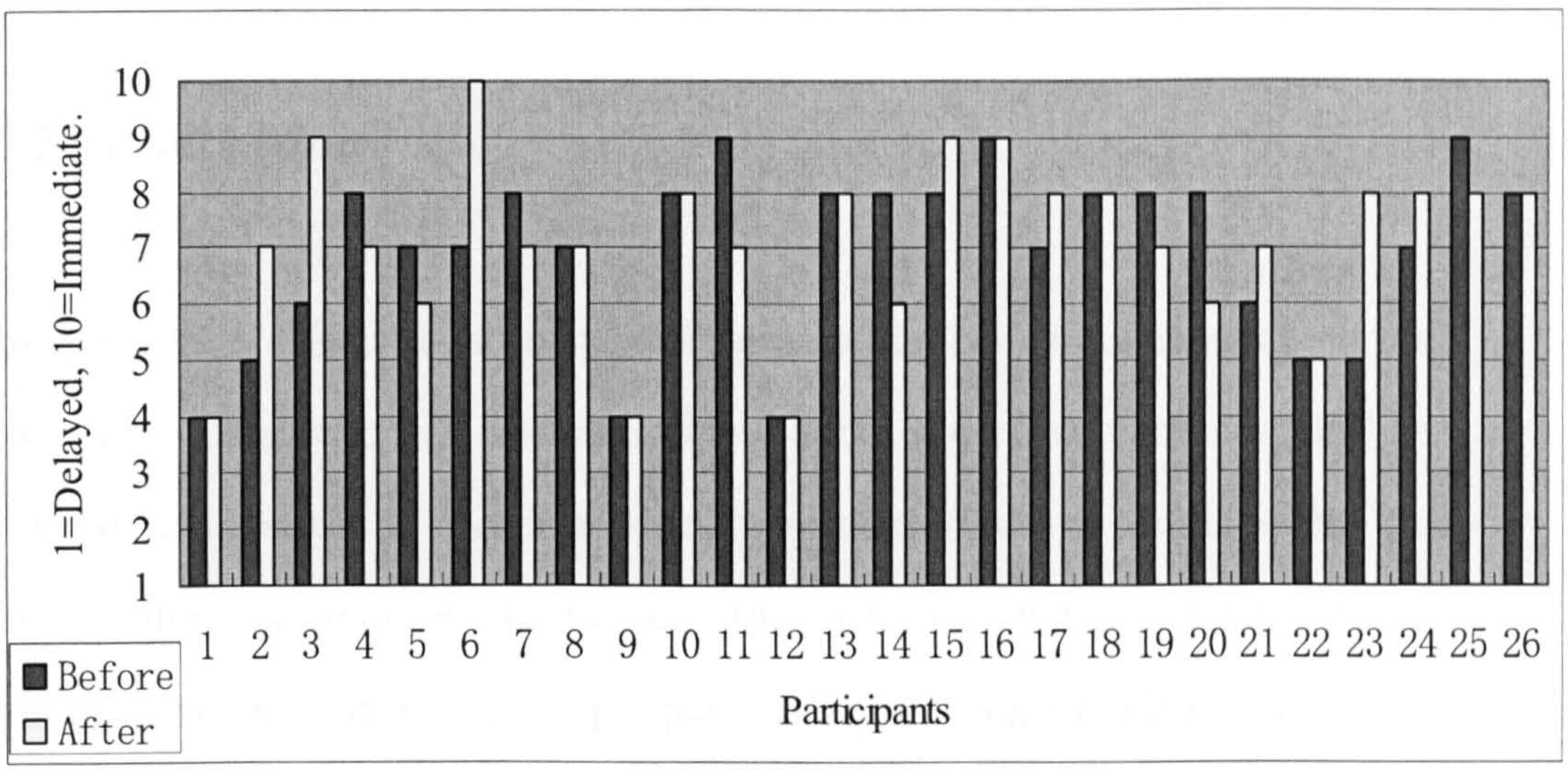


Figure 3.15 Question 8: Please rate the immediacy of this risk, in terms of how soon possible harmful effects may occur

As seen from Figure 3.16, which shows the results from question 9, several participants (9 out of 26) felt that the risk of involvement in a road traffic accident was more controllable after studying the on-line road safety campaigns. Nearly the same amount of people felt the opposite; to them, the risk seemed less controllable after exposure to the web sites.

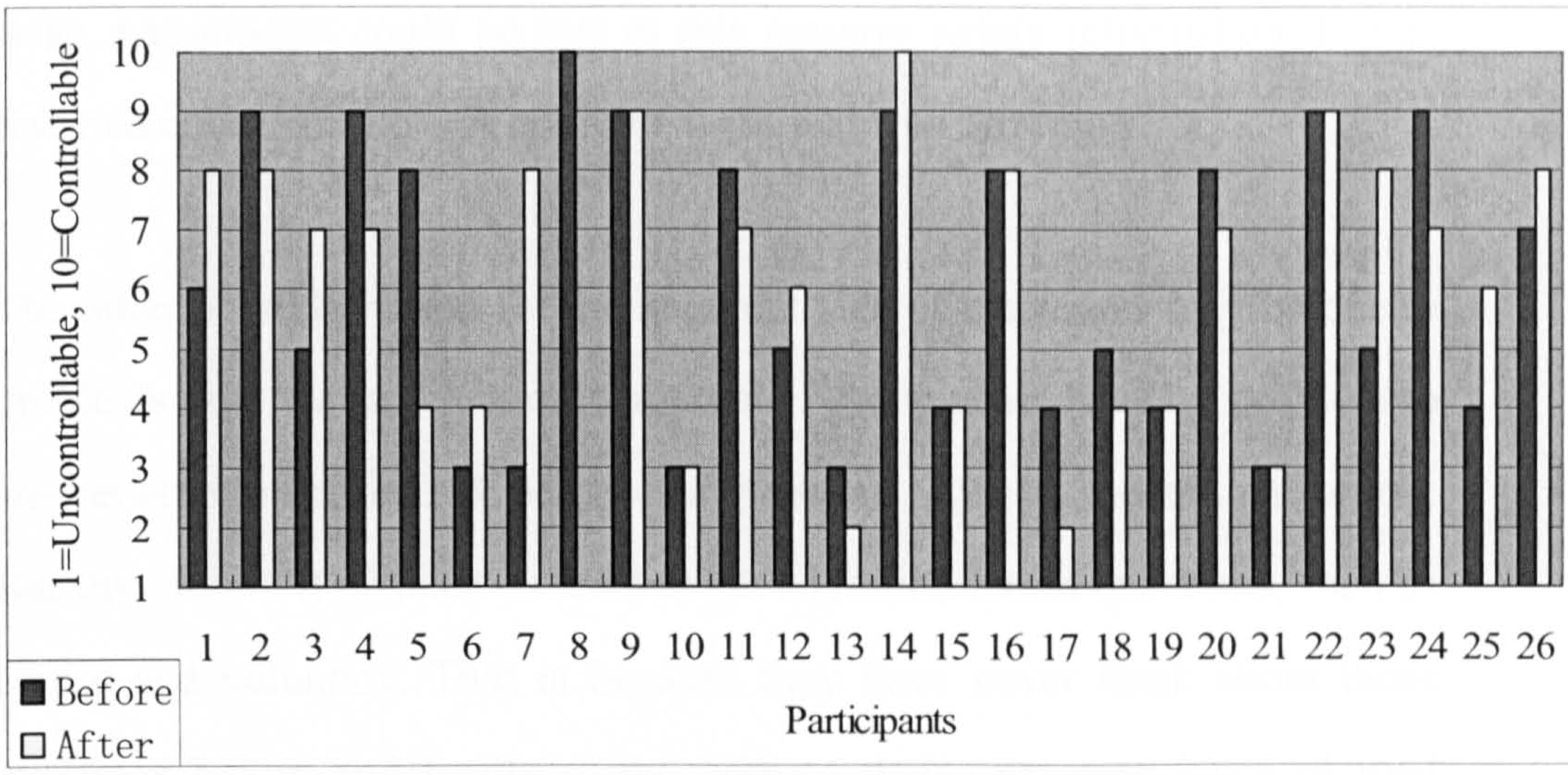


Figure 3.16 Question 9: Please rate how controllable this risk is.

3.5 Conclusion

In conclusion, this lack of consensus raises a number of concerns about the use of psychometric risk assessment and about the effectiveness of on-line information sources in this area. One interpretation of our results is that the information and representation of the information on these two websites do not have significant impact on people's safety awareness. Therefore, as we indicated before, we devised an alternative accident information system which provides localized accident information to the general public. This is described in chapter 4 and chapter 5.

Another possible reason is, during the evaluation, we did not provide specific tasks for participants to do. At first, we thought that different road users may care about different road safety information. If we provide tasks which are not interested by participants, they would ignore what they saw. Therefore, we give them freedom to browse whatever they like to know about these websites. But this method is not ideal either. Without specific tasks, participants could be lost in this massive safety information. Future research could use the way combine tasks and free browsing.

The other possible reason for the apparent lack of consensus may be due to problems with the psychometric approach. Participants have no problem to answer emotion-based risk perception questions, such as concern and worry. But they found it difficult to answer the cognition-based questions, such as equity and voluntary. That is because they have never think about those questions before and hardly apply them to their own experience of road usage. We did not expect this because all the questions come from other researches which they use these questions successfully to monitor the changes of safety awareness. In chapter 7 and 8, we discuss alternative evaluation techniques which could help us to measure more accurately the effect of accident information on people's safety awareness. Those alternatives include focus group discussion and road planning experiments.

Chapter 4

Data Sources and Requirement Analysis

This chapter is based on a joint paper [103] with C.W Johnson and all sections here are based on my contribution.

4.1 Data Sources for Road Accident Information System

The opening sections of this thesis argued that 'attribution error' is a significant problem for road safety campaigns. Individuals feel that adverse events are less likely to occur to them than they are to their peers. One way of addressing this bias is to provide information about those accidents and incidents that occur in their neighborhood rather than simply providing access to national and regional aggregate statistics. The UK Data Archives provide an important source for information about individual road accidents [96]. In contrast, to the UK Department of Transport and Scottish Executive sites this source is not primarily intended to support public access to road safety information. It provides a more focused resource for 'raw' data on road accidents from 1991 to 2004. Each entry in the UK Data Archive has three sections. The first acts as a meta-record for information about each accident. The other records can be used to store information about the vehicles involved and any casualties. The resulting data structures are capable of storing a wide range of incident data. For example, there are 30 fields in the meta-level accident record. These include timing information, a police force reference code, and general information about the vehicles and whether or not pedestrians were involved. Figure 4.1 provides an overview of the accident fields.

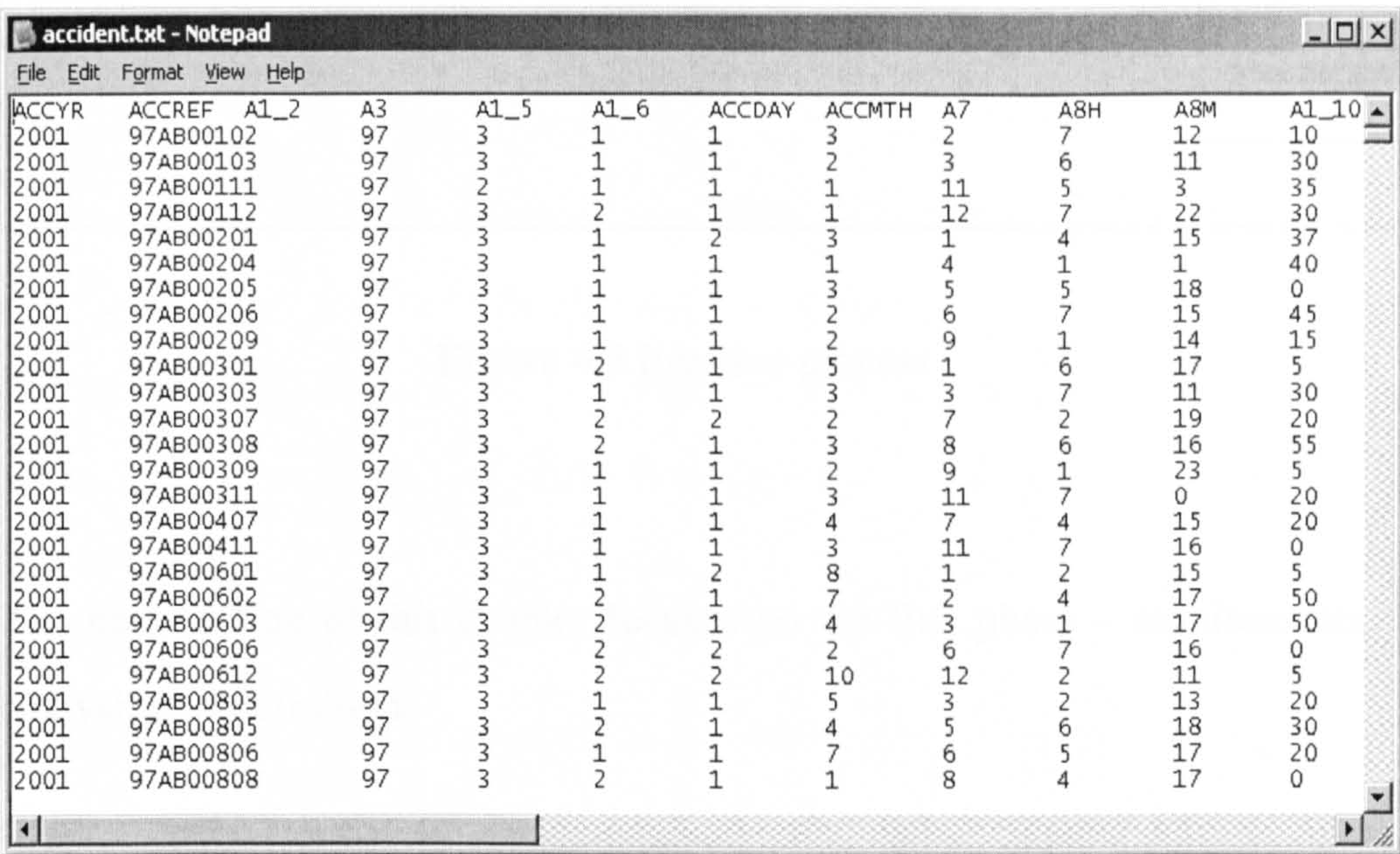
Accident Records

Variable	Character Position	Integer /Alpha	Variable Label
ACCYR	1 - 4	(I)	Accident Year (YYYY)
ACCREF	5 - 13	(A)	Accident Ref. No.
1.2	20 - 21	(I)	Police Force Code
A3	22	(I)	Accident Severity
1.5	23 - 25	(I)	No. of Vehicles
1.6	26 - 28	(I)	No. of Casualties
ACCDAY	29 - 30	(I)	Accident Day
ACCMTH	31 - 32	(I)	Accident Month
A7	33	(I)	Day of Week
A8H	34 - 35	(I)	Hour of Accident
A8M	36 - 37	(I)	Minute of Accident
1.10	38 - 40	(I)	Local Authority
A10	41 - 45	(I)	Location - Easting
A11	46 - 50	(I)	Location - Northing
1.12	51	(I)	1st Road Class
1.13	52 - 55	(I)	1st Road Number
1.14	56	(I)	Road Type
1.15	57 - 59	(I)	Speed Limit
1.16	60 - 61	(I)	Junction Detail
1.17	62	(I)	Junction Control
1.18	63	(I)	2nd Road Class
1.19	64 - 67	(I)	2nd Road Number
1.20A	68	(I)	Pedestrian Crossing - Human Control
1.20B	69	(I)	Pedestrian Crossing- Physical Facilities
1.21	70	(I)	Light Conditions
1.22	71	(I)	Weather Conditions
1.23	72	(I)	Road Surface Conditions
1.24	73	(I)	Special Conditions at Site
1.25	74	(I)	Carriageway Hazards
1.26	75	(I)	Place Accident Reported

Figure 4.1 Format for Accident Records in UK Road Traffic Accident Data

The vehicle and casualty record sections can be used to provide additional information about each road traffic accident. 24 fields are provided for vehicle specific data. These include information about whether the vehicle skidded or overturned. It can also record whether it was towing anything at the time of the incident. This section also provides means of denoting the compass direction from which the vehicle was coming and to which it moved during the adverse event. Vehicle data includes the age and sex of the driver. It also records whether it was a 'hit and run' incident and whether or not a breath test was conducted to detect alcohol consumption. Similarly, the casualty record provides 16 fields that capture the 'severity' of the casualty, whether they were a pedestrian or a passenger on a bus or coach, whether they were wearing a safety belt etc.

Figure 4.2 illustrates the raw format used by the UK Data Archive. The first field represents the year of the accident. The second provides the accident reference number that acts as a key to the associated vehicle and casualty records and so on. The key issue here is that the archive provides a valuable resource for researchers and for road safety managers in local government. However, additional tools must be used to analyze this data before it can inform the work of these professionals far less provide usable information to the general public.


accident.txt - Notepad

File Edit Format View Help

ACCYR	ACCREF	A1_2	A3	A1_5	A1_6	ACCDAY	ACCMTH	A7	A8H	A8M	A1_10
2001	97AB00102		97	3	1	1	3	2	7	12	10
2001	97AB00103		97	3	1	1	2	3	6	11	30
2001	97AB00111		97	2	1	1	1	11	5	3	35
2001	97AB00112		97	3	2	1	1	12	7	22	30
2001	97AB00201		97	3	1	2	3	1	4	15	37
2001	97AB00204		97	3	1	1	1	4	1	1	40
2001	97AB00205		97	3	1	1	3	5	5	18	0
2001	97AB00206		97	3	1	1	2	6	7	15	45
2001	97AB00209		97	3	1	1	2	9	1	14	15
2001	97AB00301		97	3	2	1	5	1	6	17	5
2001	97AB00303		97	3	1	1	3	3	7	11	30
2001	97AB00307		97	3	2	2	2	7	2	19	20
2001	97AB00308		97	3	2	1	3	8	6	16	55
2001	97AB00309		97	3	1	1	2	9	1	23	5
2001	97AB00311		97	3	1	1	3	11	7	0	20
2001	97AB00407		97	3	1	1	4	7	4	15	20
2001	97AB00411		97	3	1	1	3	11	7	16	0
2001	97AB00601		97	3	1	2	8	1	2	15	5
2001	97AB00602		97	2	2	1	7	2	4	17	50
2001	97AB00603		97	3	2	1	4	3	1	17	50
2001	97AB00606		97	3	2	2	2	6	7	16	0
2001	97AB00612		97	3	2	2	10	12	2	11	5
2001	97AB00803		97	3	1	1	5	3	2	13	20
2001	97AB00805		97	3	2	1	4	5	6	18	30
2001	97AB00806		97	3	1	1	7	6	5	17	20
2001	97AB00808		97	3	2	1	1	8	4	17	0

Figure 4.2 Sample Accident Information from the UK Data Archive

4.2 System Development Process

The UK data archive was used to drive our information system. The development process which followed the iterative process is shown in the following figure.

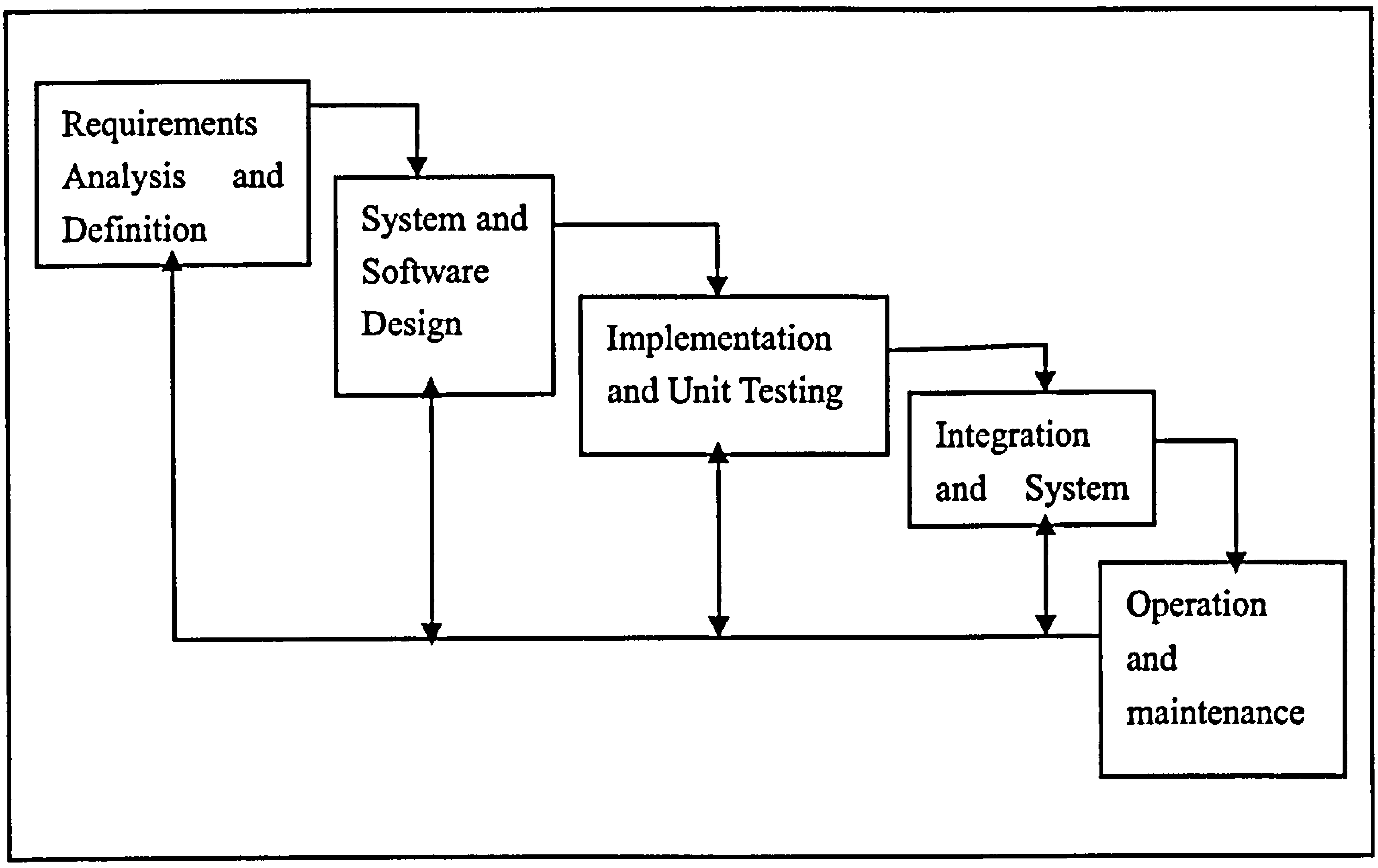


Figure 4.3 Iterative process

The next section of this chapter focuses on the first phase – requirements analysis and definition.

4.3 Requirement Analysis

"The process of establishing the services the system should provide and the constraints under which it must operate is called Requirements Engineering."[40]

As the first stage, capturing accurate requirements is highly critical for the whole process. Since developing software systems can be both complex and time-consuming, if developers, at the end of the process, find what they have done is not the product the customer actually wants or needs, they have to spend more time and money in rebuilding the system.

For future development, a document which explains clearly all of the requirements that have to be fulfilled by the system is needed. This stage consists of three major steps: requirements capture and analysis, requirements definition, and requirements specification. These requirements can be either functional ("It describes a system service or function" [40]) or non-functional ("It is a constraint placed on the system or on the development process" [40]).

A requirements definition normally uses natural language plus diagrams to describe "what services the system is expected to provide and the constraints under which it must operate."[40] A requirements specification is usually a structured list which describes the services of the system in detail.

A key aim of the final system was to increase awareness about the causes of road traffic accidents. Therefore, a two-step approach was adopted. In the first step, we contacted existing road traffic 'experts' since they have more knowledge about what constitutes more important accident information. After developing a system prototype according to these experts' advice, in the second step, we validated key design issues with a wider audience, gathered more requirements from them and redesigned the system (See chapter 6.1.2 and chapter 7.2).

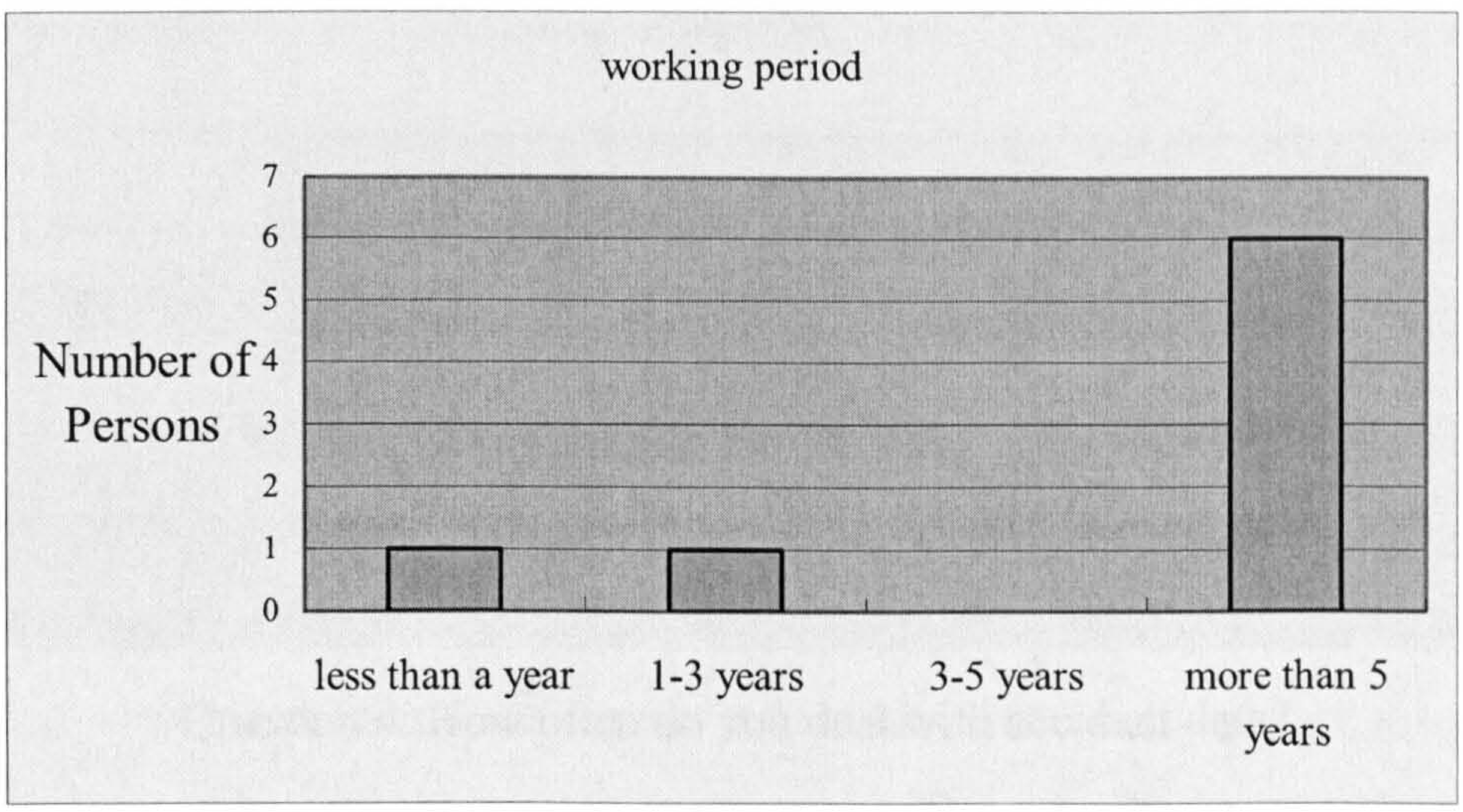
The initial requirements elicitation focused on the local police force. They provide the immediate response in the aftermath of a road traffic accident. The formal elicitation also focused on two agencies with a longer term responsibility for road traffic safety: the Land Service Department in Glasgow City Council and Amey Highways Ltd. These two organizations have responsibility for safety on minor and major roads respectively. They also have experience of using existing geographical information tools to review road traffic accident data. This is important because one of the key concerns that we had at this early stage in the project was that the existing forms of interaction with map-based systems were largely through SQL interfaces or through a form of spreadsheet interaction. Neither of these was considered suitable for our more general user group.

We, therefore, developed a system prototype using direct manipulation techniques to access incident information from the UK Data Archive through a local map based interface. This design is described in more detail in subsequent sections. For now, it is sufficient to observe that we based our requirements analysis around a two-part questionnaire (See Appendix D). Section 1 elicited background information about the participants. Section 2 focused on requirements for the system. We were particularly concerned to identify the causal information that they felt was more important for the potential end-users of the system. Also, based on the observation of existing road safety information system (in chapter 3), we were interested in functions and features which can be used to present the information effectively. As mentioned, this use of 'expert' advice represents an initial compromise before subsequent validation with a wider class of potential end-users. We also conducted an initial study of existing web based systems, which is mentioned in chapter 3.

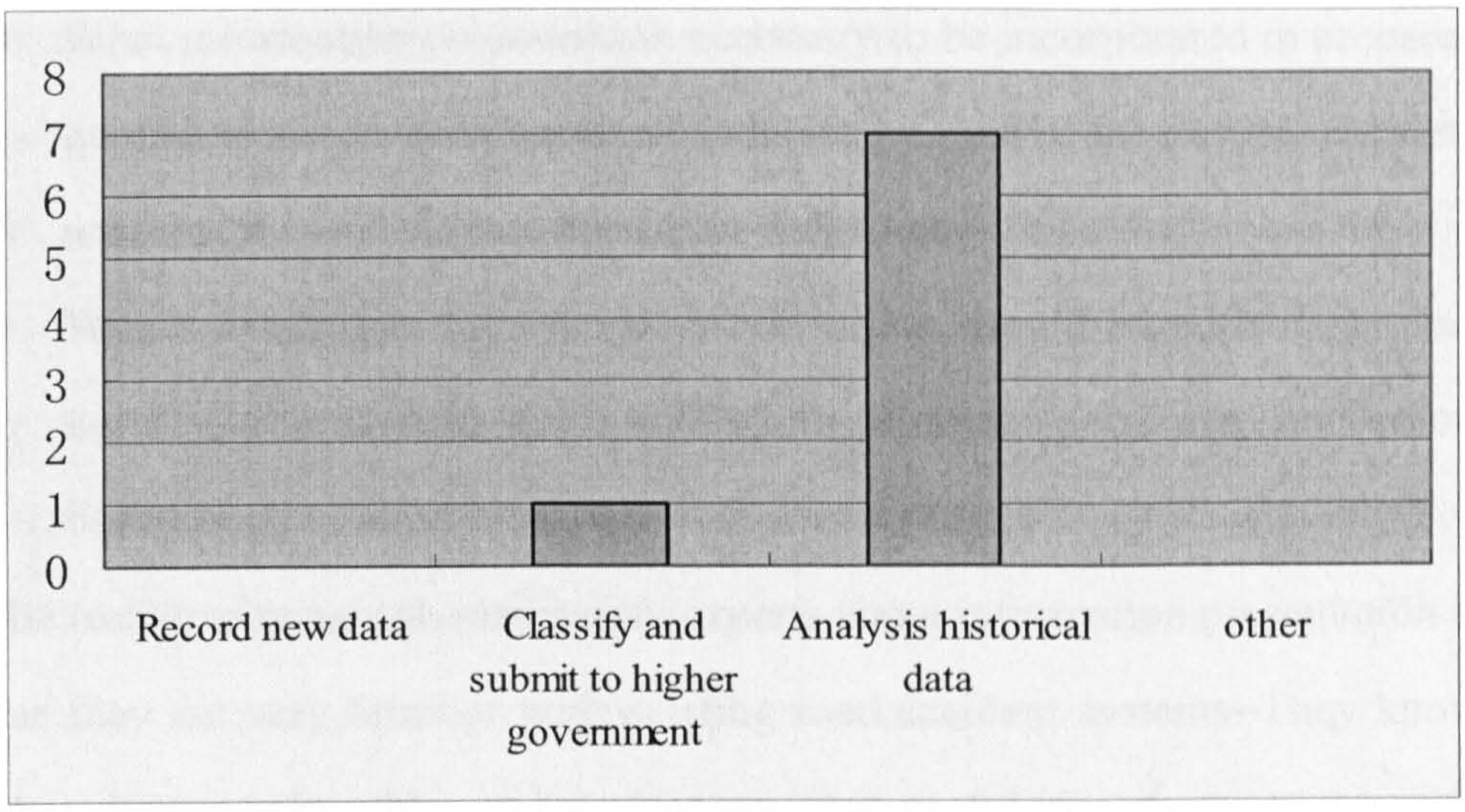
The initial part of the questionnaire revealed the depth of the respondents' expertise. There are 8 experts that answered the questionnaire. Six of the analysts had spent more than five years working with road traffic data. One had less than a year experience and another had between one and three years. All of them used a computer in their everyday activities. Seven respondents stated that their main task was the analysis of historical data about road traffic accidents. One respondent reported that their occupation was centered on preparing reports for higher (regional) government so that it could perform further analysis of the data. Question 1 asked about their job title, the results are as follows.

- Accident Investigation & Protection (A.I.P) Officer
- Project Manager--- A.I.P & Development Control
- Road Safety Engineer (3 persons)
- Road Planning Engineer (2 persons)
- Technician

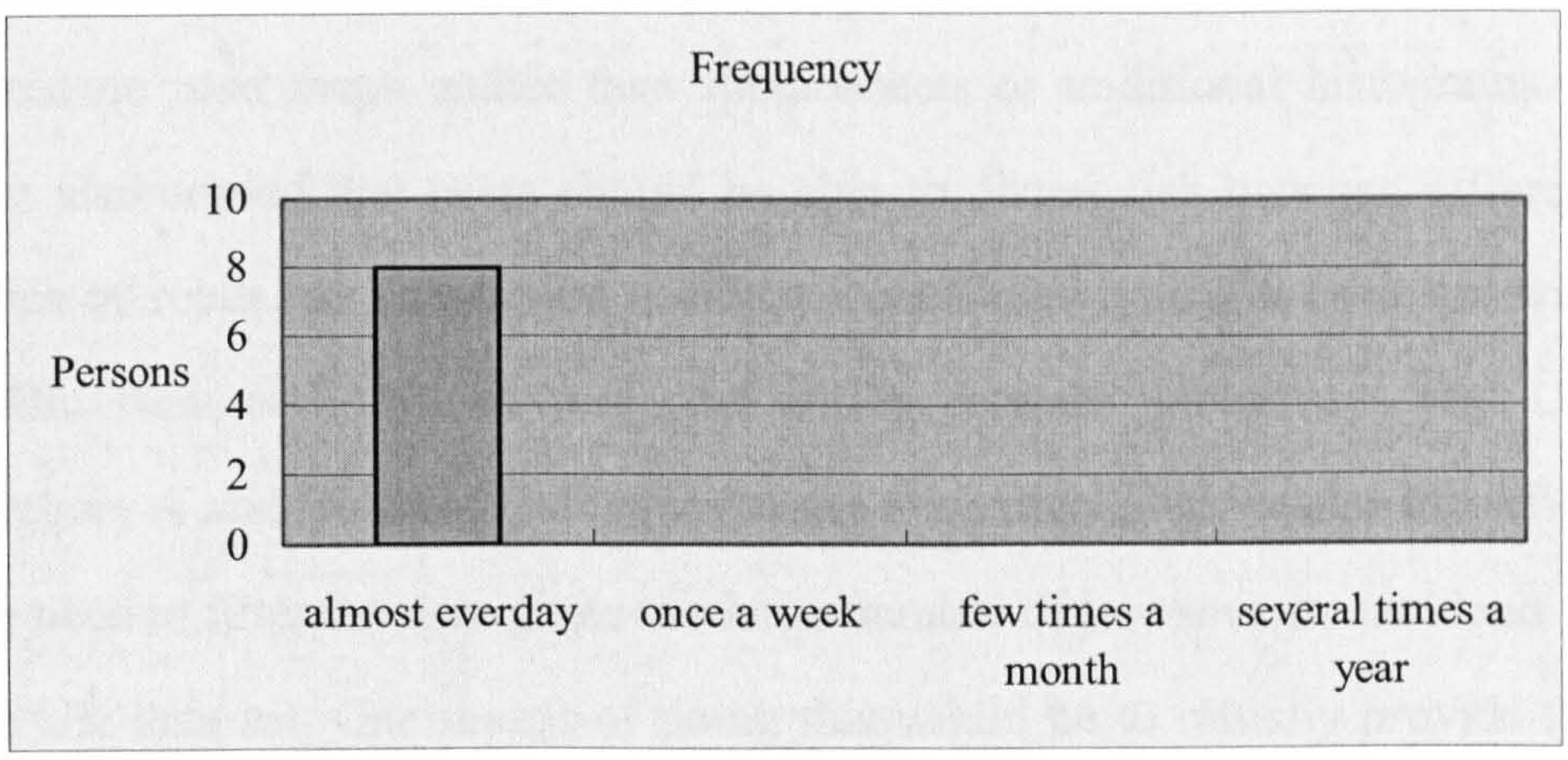
Figure 4.4 shows results from other questions in this section.



Question 2: How long have you worked at this job?



Question 3: How do you deal with accident data?



Question 4: How often do you deal with accident data?

Figure 4.4 Some results of experts background

The second part of the questionnaire revealed a number of requirements that the road safety professionals felt to be important in the success of any tool that would provide local accident information to a wider audience. Three main types of questions are asked in this part, which are:

- What kinds of accident information do you think are important and should be displayed in the map-based system? (choose top 5 answers from all the columns in the accident information)

- What information do you think necessary to be incorporated in prepared queries to access accident data? (such as by time of the day, by accident severity, by road surface condition, and so on)
- Which features in the system do you think should be editable by end users? (such as road color and width, accident point size and color, background color, and so on)

The reason why we ask road safety experts about information presentation is that they are very familiar with existing road accident systems. They know what feature they like, what features are useful for them to identify information quickly. Through the questionnaire and discussion, we found out that firstly, their experience with the existing information sources made them advocate the use of geographical interaction techniques, for instance based on road maps, rather than spreadsheets or traditional histograms. It was also argued that users should be able to distinguish between different types of roads. As mentioned accident frequencies typically correlate with traffic flow and this, in turn, can differ between motorways and UK category A and B roads. The requirements elicitation exercise also identified the need to filter the data given the large number of low severity incidents in the UK data set. One means of doing this would be to initially provide the users with access to the most recent data but with the option to provide additional years as required.

The open-ended questions, such as "If you have already used some similar system, could you point out some limitations of that system or the features that you wish to improved?", failed to identify specific information requirements from among the mass of data provided by the UK archives. Instead it was felt that potential end users should have some means of accessing all of the available information in the three records described in the previous section. As we shall see, however, initial field trials later identified the need to tailor this mass of data to support particular groups of end users. The road safety professionals also advocated the use of prepared queries. They argued that it can be difficult for many users of existing systems to form their own information requests until they have gained a significant degree of expertise with an application. They said "Prepared queries can make their tasks easy and quick". This requirement raised the difficulty of determining what queries to provide for novice users. Some seemed relatively uncontroversial, such as a request to display all fatal accidents. Beyond this, it was less clear whether the general public might want, for example, to display all accidents that happened on a Monday or those adverse events involving casualties over 60 years old. Initial focus group discussions revealed that these queries were important to particular individuals but it is less clear that they will have a wider significance for the potential user population.

The following is a list of requirements identified from the questionnaire and discussion.

Functional requirements:

1) Users can see a Glasgow local road map
2) Users can distinguish different types of road (motorway, A, B...)
3) Users can see accidents on the road map
4) Users can get brief information for each selected accident
5) Users can see all detailed information for each selected accident
6) Users can search for specific accidents by using prepared queries
7) Users can manipulate the map, such as zoom in and out, move, reset, and so on
8) Users can get a list of accidents according to query results
9) Users can see tooltips for road and accident to show basic information, such as road name and accident reference
10) Users can choose which type of road they want to see
11) User selected road section or accident will be highlighted.

12) Users can set up which information they want to see for each selected accident

Non-functional requirements:

1) The system should be web based application so that users could easily access.
2) Using sensible words to describe the filter function or prepared queries so that users should easily understand them without having the knowledge of SQL language.
3) The query should be quick and without too much delay, otherwise, users should get feedback of the query progress.
4) Use reasonable fonts and layout to avoid information overlapping.
5) Show the accident information in sensible words other than predefined codes and types.
6) Users should always know where they are and can go back to previous step.

4.4 Conclusion

In chapter 3, we evaluated the existing road safety websites. We found that the information and the representation of the information in those sites have little influence on the public's safety awareness. In this chapter, I described our concept a localized road accident information system which might have better effects. Three things have been done. First, we gathered 'raw' data on road accidents from UK Data Archive which is essential for our system development. Secondly, we consulted and discussed with several road safety experts. They provided useful advices on the accident information and their experiences about the usage of existing road accident information system.

Thirdly, we elicited a list of requirements which would guide us to develop the system. We finally chose the map-based interaction system to represent the massive accident data because we believe this is an easy way for the general public to understand such information. Actually, there are many different ways to represent accident data, and the next chapter discusses some of them. In addition, the next chapter discusses information visualization techniques which could be used in our system.

Chapter 5

Theories of Visualizing Multivariate Data

As we argued in previous chapters, we were trying to find an easy way for the general public to understand a mass of road accident information so that this information would influence their safety awareness. Information visualization is a good way to meet our requirement. Although we finally chose map based visualization, there are many other ways to visualize such information. In this chapter I discuss these methods and explain why we did not consider them in our system. The second part of this chapter talks about techniques which can be used in the system.

As William S. Cleveland mentions [100], "Visualization is an approach to data analysis that stresses a penetrating look at the structure of data". Robert Spence also points out that information visualization is a cognitive activity which can help people get insight into data [76]. There are many different tools for and theories about visualizing information. Normally, these tools are categorized by type of data. Spence argues that the difficulty of designing an interactive display is strongly influenced by the number of attributes or variables.

Univariate data deals with a single attribute, such as people's height or weight. Bivariate data and trivariate data are data with two attributes and three attributes respectively. For example, we would need a bivariate representation to analyze the relationship between people's height and weight. In our research, we were concerned with multivariate data. Traffic accident data include weather, speed, road geometry features, and so on. The following pages, therefore, focus on theories and tools for visualizing multivariate data.

5.1 Statistical Graphics for Visualizing Multivariate Data

Statistical graphics is a major way to represent multivariate data. Such graphics can contain a lot of information. They also can be used to analyse the relationships between different attributes. These static representations of multivariate data can be used to carry out further analysis of a group of road accidents which generated from predefined queries. They can also be used to generate summary reports on certain types of road accident data. The following are several typical statistical graphics.

5.1.1 Multiple-code Plotting Symbols

The problem with visualizing multivariate data is they require multi-dimensions to fully represent all of the variables. One strategy for dealing with this is to represent the data objects with symbols or icons that contain multiple components. Information is then encoded into the features of the icons themselves. Multiple-code plotting symbols can be used to obtain graphical representations of multivariate data. For example, we use color to code accident time (e.g. green for morning, orange for noon, black for night), use shape to code accident severity (e.g. round for slight accident, square for serious, diamond for fatal accidents), and so on. For example, figure 5.1 shows two icons to represent two accidents. The first one (a) is a green diamond shaped icon and it means this is a fatal accident which happened in the morning. The second one (b) is a black square shaped icon and it means this is a serious accident which happened at night.

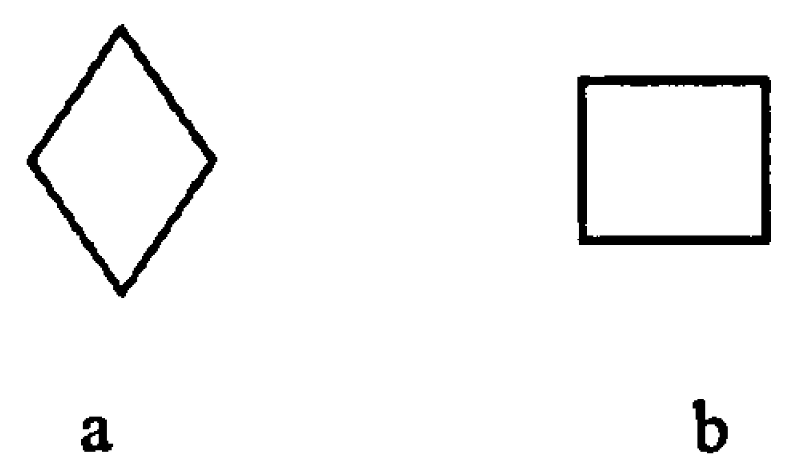


Figure 5.1 Multi-code plotting symbols

However, there are also some potential weaknesses. One is that when variables divide the data into a larger number of discrete subgroups, it is difficult to use different symbols to represent all the categories in a single display, for example, one accident data item contains about 70 data fields (30 in accident record, 24 in vehicle record, and 16 in casualty record, see chapter 4). It is very difficult to find symbols which can represent all these variables. Another difficulty is severe overplotting will inhibit the visual resolution of the multivariate information. That means that even if we find suitable symbols to represent all accident variables, it is very difficult for users to remember all the meanings of attributes in the symbols. Therefore, this is not an easy way for the general public to understand accident information and it does not meet our requirements. But we can use this technique for displaying certain features of accidents in our system. For example, we used different shapes to represent different accident severity levels.

5.1.2 Histogram Plots

A histogram plot represents each observation as a set of k concatenated vertical bars [28]. Each bar corresponds to one of the k variables in the profile. For example, we want to find out whether overloaded vehicles will have more casualties than non-overloaded vehicles in accidents. We can draw a histogram plots (Figure 5.2), which includes the number of casualties (c), the number of passengers in the vehicle which had the accident (p), the maximum number of passengers allowed in the vehicle (mp).

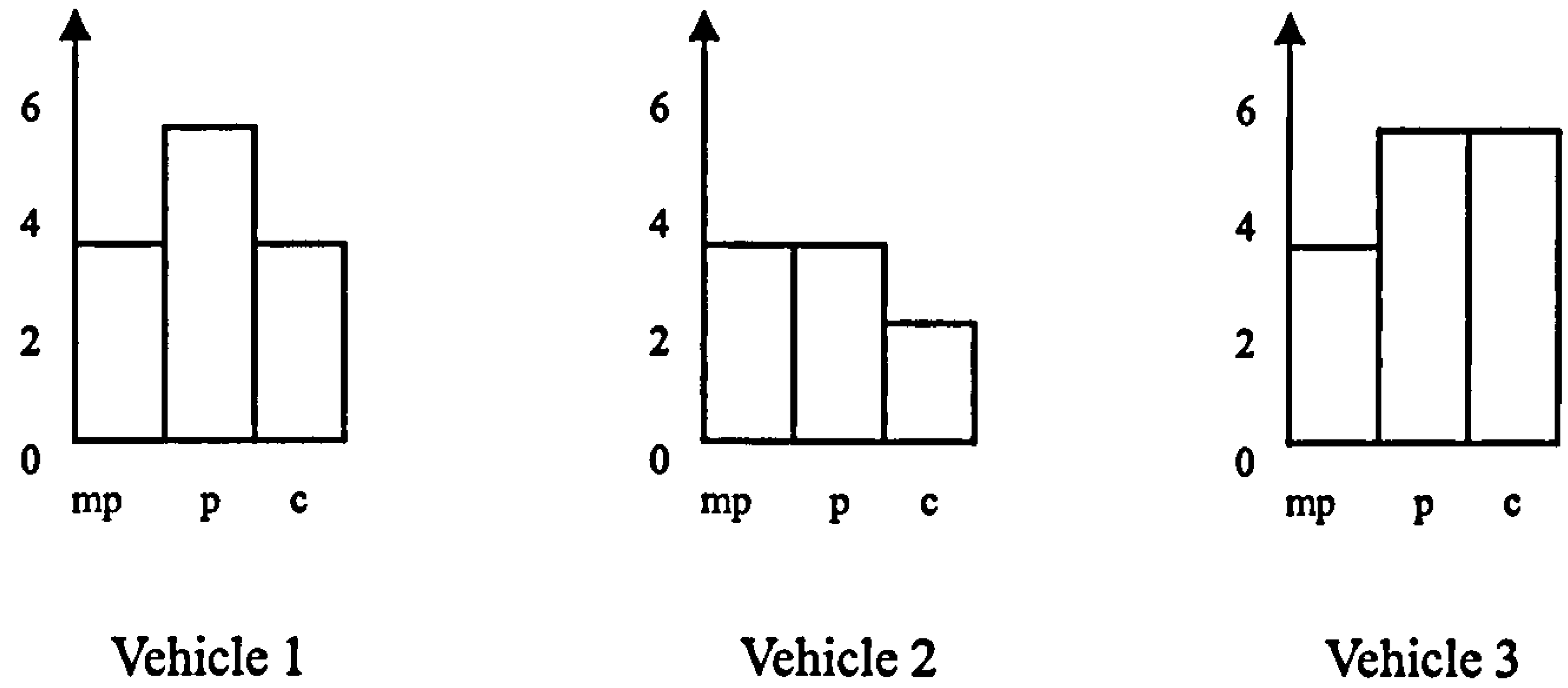


Figure 5.2 Examples of Histogram Plots

Histogram plots can help people to find out certain relationships between variables. However, histogram plots are not suitable for visualizing large amounts of information, especially location based information. Each road accident has several kinds of data, and they can not be drawn on one single graphic. But we can use Histogram plots to do some further analysis only on certain types of road accident data, for example, use histogram plots to compare accident rate on each day of a week to find out which day is the most dangerous in this area.

5.1.3 Star Plots

In a star plot, each observation is shown as "a collection of k rays emanating from a central point. These rays are equally spaced around the point; the angle between any pair of adjacent rays is therefore 360/k degrees. Each ray is assigned to a particular variable, and the length of the ray is proportional to the value of the variable for that observation" [15]. Star plots are more suitable for large profiles than histogram because those icons are restricted to a fairly narrow width so that all n icons can be included within a single display. Figure 5.3 shows an example of star plots. It is about automobile analysis in 1979 in the US. The following are definitions of the 9 rays. 1 Price, 2 Mileage (MPG), 3 1978 Repair Record (1 = Worst, 5 = Best), 4 1977 Repair Record (1 = Worst, 5 = Best), 5 Headroom, 6 Rear Seat Room, 7 Trunk Space, 8 Weight, 9 Length. [66]

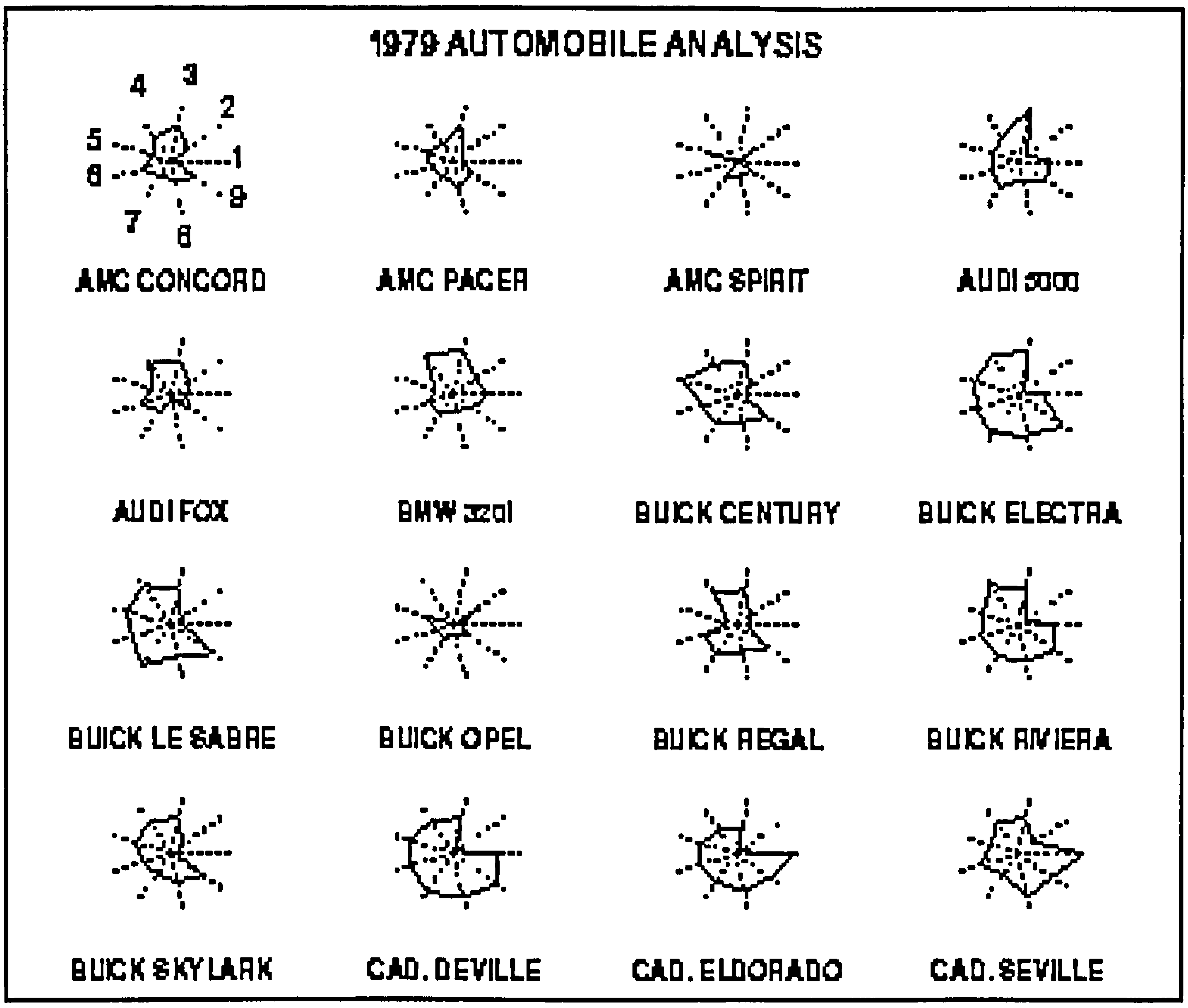


Figure 5.3 Example of Star Plots

Star plots can represent more variables than histogram plots. They are useful tools to make a comparison between certain types of road accident. Users could get more information about the relationships between these variables. Therefore star plots are suitable for further analyzing after users filtered out a group of road accidents. For example, users can use star plots to compare accident patterns on different roads or areas. Each star represents a road or area. Different rays will represent different accident information, such as average age of the driver, average traffic volume, and so on.

5.1.4 The Scatterplot Matrix

A scatterplot matrix is defined as a square, symmetric table or "matrix" of bivariate scatterplots [18]. This table has k rows and columns, with each one corresponding to a different variable. Each of the table's cells formed by the intersection of row i and column j contains a scatterplot showing X_i as the vertical axis variable and X_j as the horizontal axis variable. Because the scatterplot matrix is symmetric about its diagonal, these named variables also appear in panel ji, with their vertical and horizontal positions reversed. The most important feature of the scatterplot matrix is that its panels show all possible bivariate relationships that exist within the multivariate data [99]. Figure 5.4 shows an example of the scatterplot matrix. Three variables are chosen, speed (mph), driver's age (years), and driver's drink frequency (drinks per week). From this figure, we can see the younger drivers are, the faster they drive. The younger drivers are, the more frequently they drink.

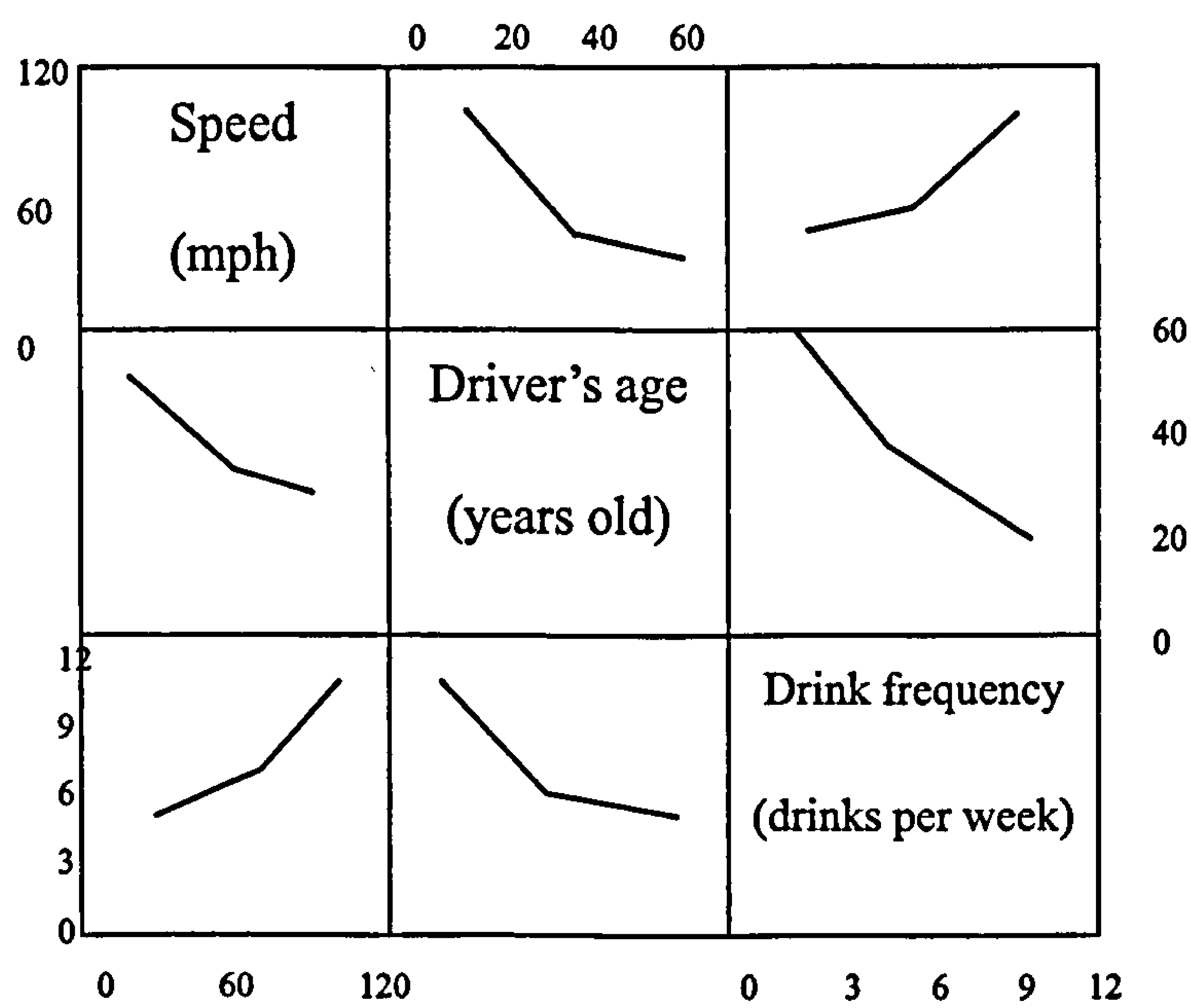


Figure 5.4 Example of Scatterplot Matrix for Accident data.

The scatterplot matrix does have two potential disadvantages. One is the limitation of the number of variables. That means it is not suitable for displaying a large number of variables otherwise the table would be too huge to look at. The other one is it cannot really show a multivariate structure, because the scatterplot within each panel is constructed completely independently of the information in any other panel. Figure 5.4 shows all possible bivariate relationships among speed, driver's age and drink frequency, each panel was drawn without the information in the other panel. Therefore, Scatterplot Matrix can be used to analyze relationships between certain accident data.

5.1.5 Conditioning Plots

The conditioning plot can show how a dependent variable is affected by several other variables, simultaneously. The values of each conditioning variable are divided into a series of m intervals. Then, each interval of the conditioning variable is allocated to one of m separate panels in the conditioning plot. There are two other variables in each panel which shows the bivariate scatterplot for them. Each panel only includes the data points that fall within the interval corresponding to that panel [99]. The variable that corresponds to the vertical axis in each display panel is called "dependent variable". The variable that is shown on the horizontal axis of each panel is called the "panel variable" [100]. Figure 5.5 shows an example of using conditioning plots to analyze accident information. The table is divided into different age groups. Then table shows relationships between the number of years holding licence (years) and driving speed (mph). The data for this table are not real. This is merely to demonstrate how to use a conditioning plot to analyze accident information. From the figure, we can see that although the younger drivers (age<20) have fewer years of holding a licence than the older drivers (age>60), they more likely drive faster than old drivers. However, in each age group, those who have more experience (more years of holding a driving licence) are among the people who like to drive fast.

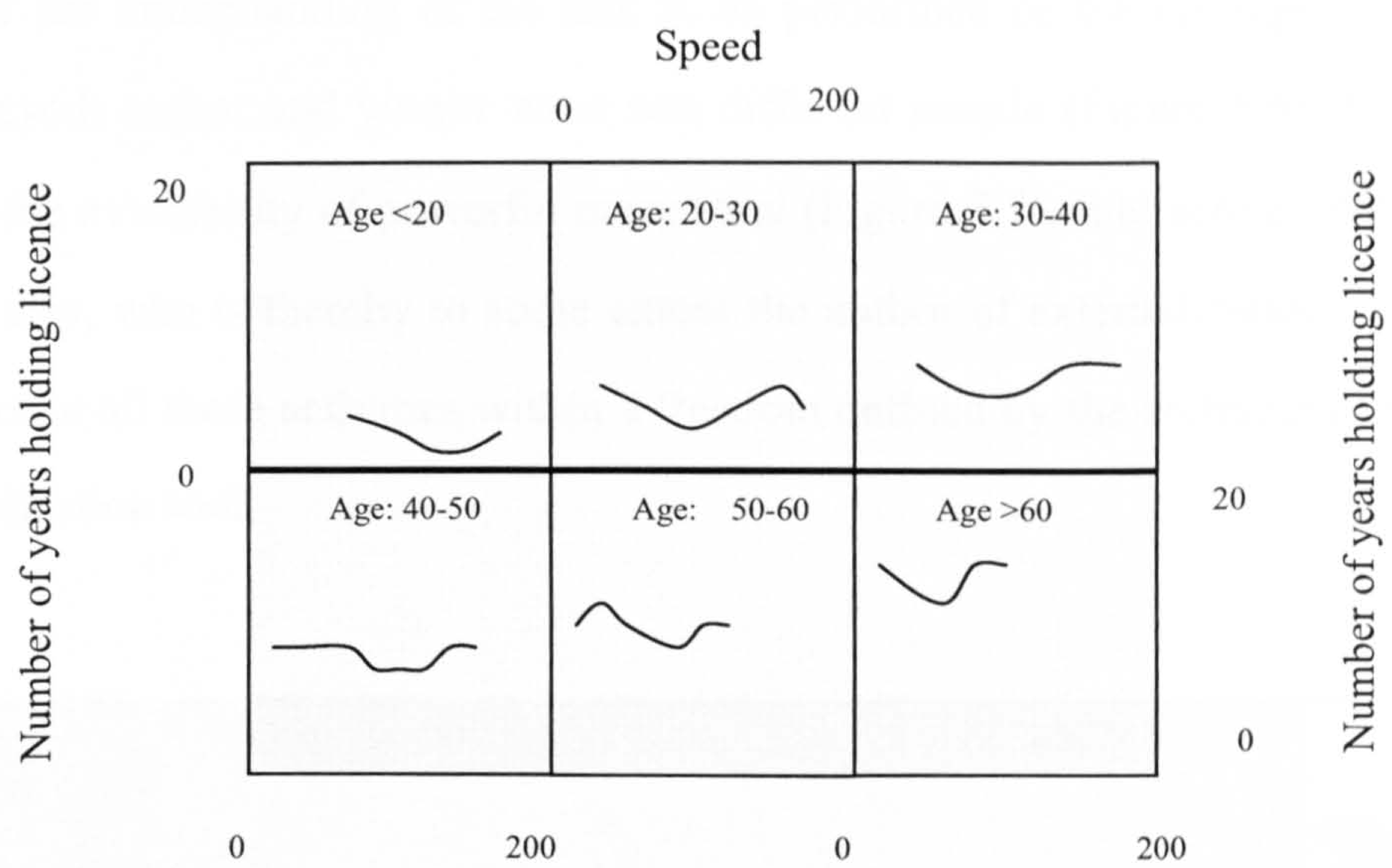


Figure 5.5 Example of conditioning plot for accident information

The most important feature of a conditioning plot is that it shows multivariate data in a form that is highly organized through visual inspection. "They enable a researcher to discern patterns within a complex dataset without requiring stringent assumptions about the nature and details of any underlying structure that may exist among the data points". [99] Conditioning plot is suitable for analyzing accident patterns. Our system could use this function to provide users better understanding of the relationships between different accident information, such as above figure.

5.2 Interactive Information Display Theories

Robert Spence argues that [76], in the pre-computer age, the author of an image had to perform selection, representation and presentation according to his or her understanding of the task to be performed or the message to be conveyed: author and viewer were two different people (Figure 5.6). Now, with the availability of powerful computers (Figure 5.7), interactive control by a user, who is thereby to some extent the author of externalizations, can influence all these activities within a freedom defined by the architect of the visualization tool.

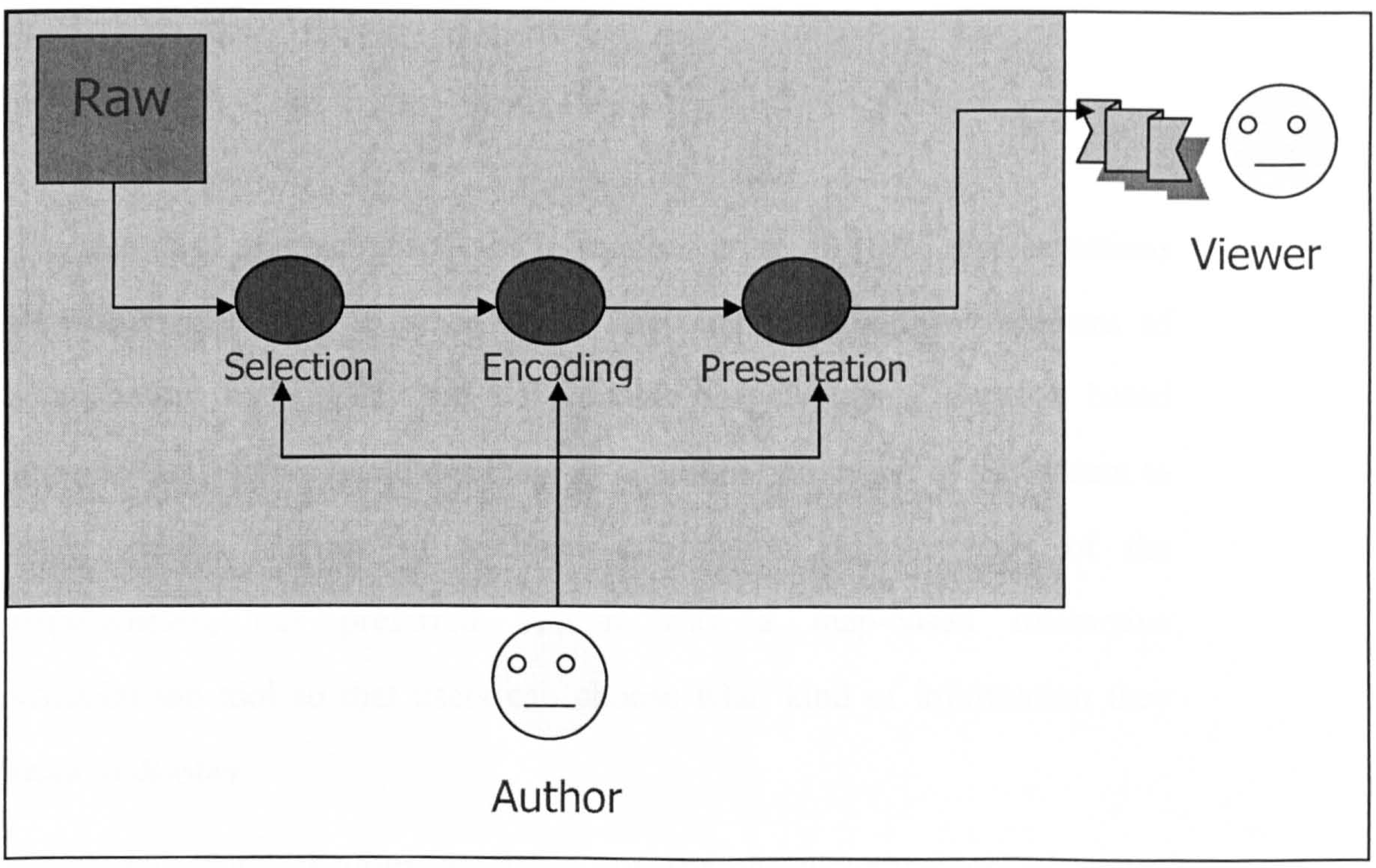


Figure 5.6 Pre-computer creation of a visualization tool

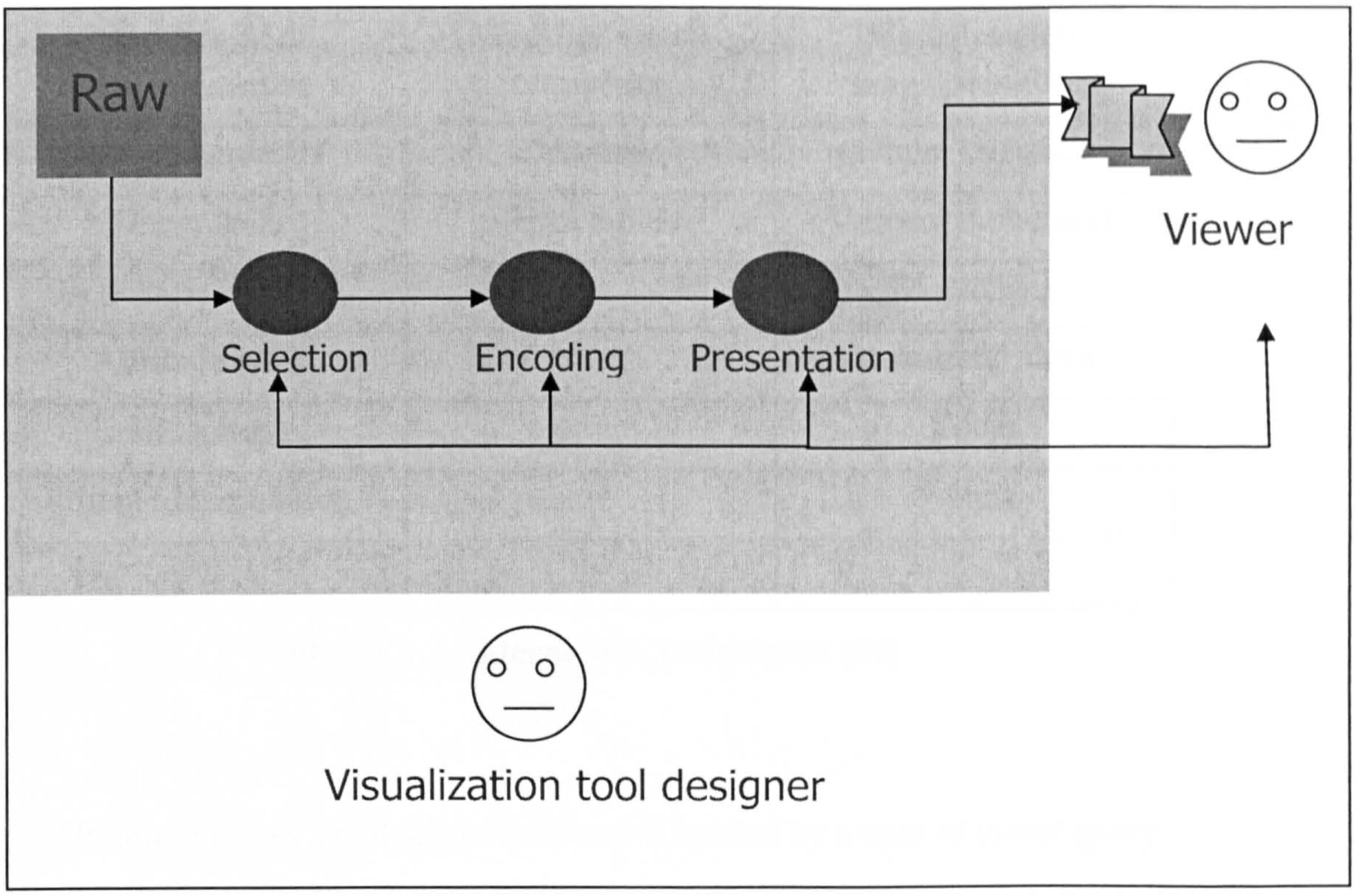


Figure 5.7 The creation and use of a computer-based visualization tool

The statistical graphics discussed in section5.1 are all static representations of multivariate data. In other words, they are pre-computer creations of visualization tools. They are not suitable for displaying location based information. But we could use them as additional functions of the system to show certain features of accident information. In the light of the requirements, our preferred system was a map-based interactive visualization tool so that users can choose what kind of information they want to display.

There are many theories available for the visualization tool designer. Generally, interaction techniques can be divided into three categories: interacting with data transformations; interacting with visual mappings; interacting with view transformations. Each category makes use of several techniques. Table 5.1 lists these techniques.

Modifies data transformation	Modifies visual mappings	Modifies view transformation
Dynamic queries	Dataflow	Direct selection
Direct walk	Pivot tables	Camera movement
Details-on-demand	etc.	Magic lens
Attribute walk		Overview + detail
Brushing		Zoom
Direct Manipulation		etc.
etc.		

Table 5.1 Interaction Techniques [86]

"A **dynamic query** involves the interactive control by a user of visual query parameters that generate a rapid (100 ms update), animated, visual display of database search results" [86]. In particular, sliders or radio buttons are used to select value ranges for variables in the Data Table. The cases for which all the variables fall within the specified ranges are displayed. The other cases are hidden. For example, in road accident analysis, this technique could help users to limit the display of accidents according to specified conditions which are set up in dynamic queries.

Direct walk proceeds by a set of linkages from case to case [14]. A web browser is an example of direct walk. Users can link from page to page. Through a series of clicks on visualizations, users can search for information or modify it. In our system, we could use direct walk to link accidents which are displayed in the map to the detailed information about each accident. That means when users click one accident spot on the map, the system can show them relevant information.

Details-on-demand expands a small set of objects to reveal more of their variables. It allows more of the variables of the case to be mapped to the visualization. This technique is similar to direct walk. Users' request for detailed information of a particular accident can be considered as a details-on-demand.

Attribute walk is where users select some case and then search for other cases with similar attributes. The technique was developed in a system called Rabbit for searching databases [93]. When analyzing accidents, users can use attribute walk to find certain accident patterns. But this technique is not suitable for our system because the general public, our targeted end users, don't have enough knowledge to pick up useful attributes. Therefore, the pattern which they find out would not be meaningful for them.

Brushing is used with multiple visualizations of the same objects [19]. Highlighting a case from the Data Table in one view selects the same case in the other views. For the same reason discussed above, this technique is not suitable for our system.

Direct manipulation can be used to modify transformations. For example, Hendon and Myer at Brown University [36] have developed 3D widgets that can be embedded in visualizations, allowing multiple parameters to be adjusted. In our system, this technique can be used to set up the display of accidents and roads. For example, users can set up the color and the width of roads in order to see them clearly.

Dataflow is a common technique used by commercial visualization systems to map data to visual form. The basic idea is to use an explicit representation such as node-link diagrams to represent the mapping. Our system is to display accidents on a local road map. Dataflow is not suitable for such a system.

A **pivot table** is a technique found in modern spreadsheet programs that lets the user rapidly manipulate the mapping of data to the rows and columns of a spreadsheet. They represent a domain-specific example of interacting with visual mappings. Our system is not a spreadsheet based system. Therefore, we rejected this technique.

Direct selection refers to the set of schemes that have evolved for selecting and highlighting objects and groups of objects. They enhance the appearance of a Visual Structure in some way, often to identify the set of objects that will be the arguments to some action. This technique is similar to direct walk and detail-on-demand. We can use this technique to display accident information when users select their target accident(s).

Camera movement is the change of position of the observer, especially in 3D space. For example, information landscapes may sometimes benefit from allowing the user to view them from another angle, avoiding occlusions. Swinging the camera around could reveal parts of the visualization not otherwise visible. We rejected this technique since our system is not a 3D representation of accidents.

Magic lenses select objects according to the X, Y position of their marks, and then apply further selection techniques, such as dynamic queries [10]. In addition, they can apply data or view transformations to the items selected. Because multiple lenses can be placed atop each other, they can be used to create more complex Boolean queries.

Overview + detail use two or more levels of linked visualizations [71]. One visualization displays either all of the objects or at least some visual framework that spans all of the objects, such as a map of the world or key nodes in a tree. Another window shows a more detailed view of the object. The nodes in the detail view are marked as a region that can be moved in the overview. This technique is useful for a map-based system, especially when the map is very large and users may feel lost while they look into small areas.

Zooming involves reducing the number of objects that are visible, but possibly increasing the number of variables per object that are shown. In addition, less compressed techniques may be used to view the objects. When analyzing accidents, this technique can help users to focus on a particular area on the map, such as a junction or city center. Especially when the area involves many accidents, zoom in can help users to identify each accident.

5.3 Conclusion

This chapter reviews two major categories of information representation, static statistical graphics and interactive information presentation techniques. Both can provide us with insights into the road accidents. Interactive techniques could help users to find certain types of accidents quickly and statistical graphics can help users to analyze the data and find the relationships between different variables in multivariate data. However, since the general publics are our end users, they may find it difficult to interpret statistical graphics since they don't have much professional knowledge about statistics. Moreover, the requirements from chapter 4 suggest that our system does not need complex statistical tools. Therefore, interactive techniques are the main tools in our system. What we are trying to do is to provide the general public with a tool which can allow them to access local road accident information easily and efficiently. Based on the requirements from chapter 4 and the available techniques which discussed in this chapter, next chapter will discuss the system design and implementation process.

Chapter 6

System Design and Implementation

In chapter 4, a number of key observations emerged from the results of our initial requirements elicitation with road safety professionals. In particular, it was clear that the mass of data available about road traffic incidents within a single city centre created considerable problems. For example, as described in Chapter 4, each traffic accident record has three separate sections. The first acts as a meta-record for information about each accident. The other records can be used to store information about the vehicles involved and any casualties. There are 30 fields in the meta-level accident record, 24 fields are provided for vehicle specific data and 16 fields for casualty record. Thus, it is very difficult for users to find out the information they need. Furthermore, even if they find the information, most of it is coded by police and users need a check list to interpret it. In consequence, many public information campaigns only provide access to highly aggregated regional and national statistics. In chapter 5, we analysed several different ways of representing such multivariate data. We concluded that static statistical graphics are not suitable for our system. We decided to use computer-based visualisation techniques to provide users with means of interactively exploring more detailed information about adverse road events in their local area. The impact of localized accident information on people's risk perception is the main purpose of this research. Therefore, as long as a user interface meets our requirements in chapter 4, such as can display maps and accidents, and provide predefined queries, it is what we need. Although it may be not the best, the following evaluation in the chapter 7 shows that the usability of this system is quite good.

I now turn to the issues of system design and implementation.

6.1 Interface Design

Many different approaches to information visualization were mentioned in Chapter 5. Both Tufte [25] and Spence [76] have developed theories that support the visual display of quantitative information. However, we chose to focus on the more general guidelines provided by Shneiderman's TTT (Task by Data Type Taxonomy for Information Visualizations) theory [8]. According to the TTT theory, seven broad categories can be used to distinguish between the various tasks that users perform with information visualization systems. Table 6.1 shows the relationships among those task categories, our system requirements (See chapter 4) and available techniques.

System Requirements	Task Categories	Techniques/Functions
Display Glasgow local road map and road accidents	Overview	Zoom out, reset map
Manipulate the map	Zoom	Zoom in
Users can search for specific accidents	Filter	Queries, check box, radio box
Users can see all detailed information for each selected accident	Details-on-demand	Click an accident spot, users will get all the information about this accident
n/a	Relate	n/a
Users should always know where they are and can go back to	History	Undo

previous step.		
n/a	Extract	Save, print

Table 6.1 Relationships between task categories, requirements and techniques

The first task is to an overview of the entire collection. Overview strategies include 'zoomed-out' views of each data type to see the entire collection plus an adjoining detail view. The second set of common tasks with any visualization involves 'zooming-in' on items of interest. Users typically have an interest in some portion of a collection. They need tools to enable them to control the zoom focus. Smooth zooming can helps users preserve their sense of position and context. A third class of tasks is to filter out irrelevant information. Our initial requirements elicitation also confirmed this as an important attribute of any implementation. The fourth of Shneiderman's items describes tasks that enable users to access additional details on demand. Once a collection has been trimmed to a few dozen items it should be easy to browse the details about the group or individual items. A fifth set of tasks should help users to view relationships between the items in a data set. The sixth focuses on the maintenance of a history or log to support undo, replay, and progressive refinement. Information exploration can involve iterative refinement of an initial search, retaining the history of actions and allowing users to retrace their steps is important. The final class of tasks focuses on the extraction of sub-collections and of the query parameters. Once users have obtained the item or set of items they desire, it would be useful to be able to extract that set and save it to a file in a format that would facilitate other uses such as sending by email, printing, graphing, or insertion into a statistical or presentation package.

These guidelines together with the initial requirements elicitation helped to inform the interface design of our visualization system. Our first version design was based on a number of recent software tools that have been developed by professional road accident investigators where each incident is displayed on a map by the location in which it occurred. For example, as discussed in chapter 1, KeyAccident (See Figure 6.1) is an AutoCAD® based GIS application. Users use AutoCAD to show the map and use KeyAccident to select, display and analyse accidents. However, KeyAccident is only available for road safety experts and engineers. This system is not intended to be used by the general public.

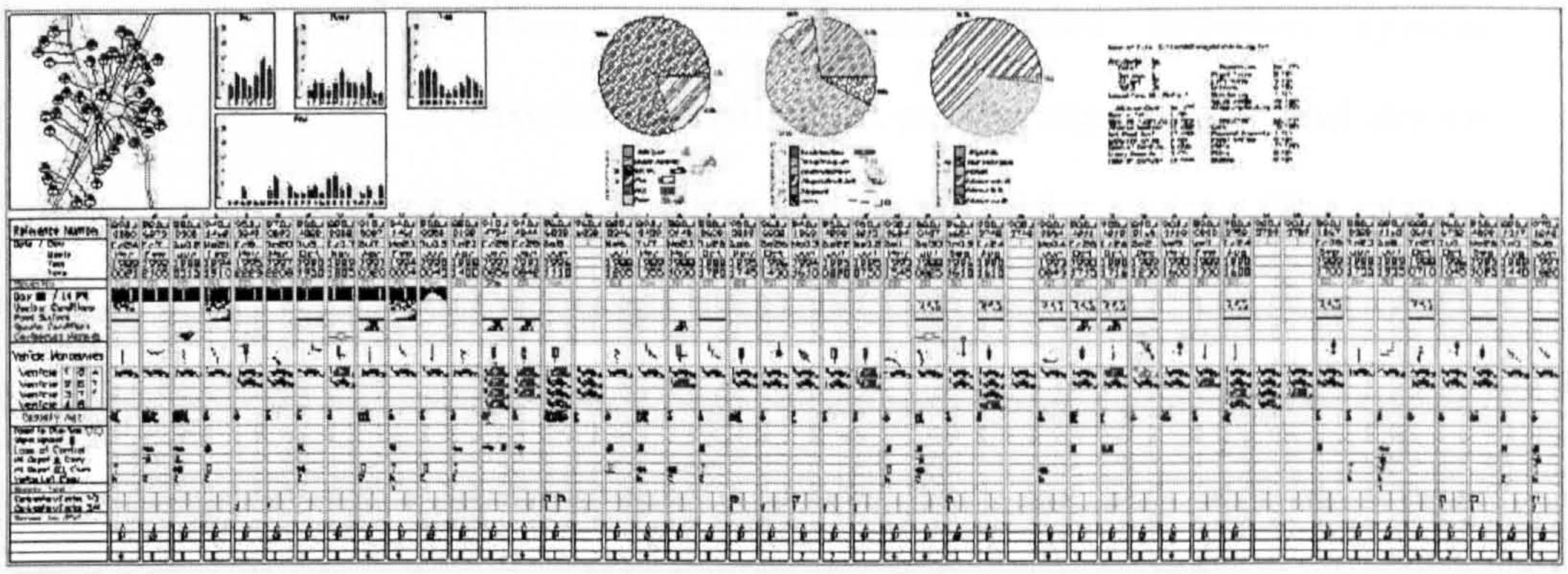


Figure 6.1 An example result of KeyAccident system

In chapter 1, I mentioned how real time accident report systems also show accidents on the map and are available for the general public, such as The AA website, The MATTISSE websites, and the TxDOT Expressway website. Such a system helps people to know what happened in the immediate past. For example, in the TxDoT, highway conditions expected to exist for more than two hours and create unsafe driving conditions (i.e. major accidents) are posted.

However, this makes it difficult to access the risks of a future journey. When conditions are changed, such information will not be useful. But historical accident data can provide an insight into certain risk patterns. For instance, if drivers know how many accidents happened in fog in the past two years and where, they would raise their attention when they encounter these conditions. Therefore, in the light of our requirements, we needed a system which can provide historical accident data and techniques which allow users to manipulate the display of accident information freely.

6.1.1 Initial Design

Based on the observation on the existing road accident system (KeyAccident) and the discussion with road safety experts, we had drawn several simple pictures as our very first prototype of the system. The system will be a map based road accident information system. On the center of the interface will be a Glasgow roads map. Once users made queries, the system will display accidents from the query results. Each accident will have brief information displayed on the right hand side of the system. When users click an accident, another window will be shown with all detailed information of this accident. This raised a number of important issues; in particular we were concerned to ensure that we could log the position of each accident as accurately as possible, based on the data provided in the national archive. We, therefore, engineered the system using the 10-meter Ordnance Survey Grid Reference (OSGR) reference format rather than the more familiar concepts of Longitude and Latitude. OSGR can be thought of as a flat grid overlaid on Britain. The grid is measured in meters and the point of origin is defined to be south west of the Isles of Scilly. Points on a map are given Easting and Northing values. These co-ordinates denote the distance between a location and the origin. For example, the centre of Manchester city is approximately 383,000 meters east and 398,000 meters north of the origin. This reference format acts as a means of moving between the location data provided in the national accident archive and the position of the Geographical Information System that we developed for the centre of Glasgow.

We decided to focus the development of the system around the area of Glasgow that falls between the middle of national grid references (OSGR) NS56 and the middle of NS66. This decision was partly determined by pragmatics. We wanted to focus our initial evaluation within a precise geographical location where we had access to a wide range of potential end users and to road safety professionals who can validate our findings. Linking this geographical area back to the national data archive using the OSGR indexing system yielded a total of 1486 incidents for 2001 and 1471 incidents for 2000. In 2001, those incidents resulted in 3568 vehicle records and 2731 casualty records; recall that each incident can involve several vehicles and casualties. In 2000, those incidents resulted in 3649 vehicle records and 2724 casualty records. The widespread problem of underreporting led us to exclude damage-only incidents. However, the available data could be included in subsequent versions of the system given the relatively modest size of the data files that we have compiled from the national data sources. In the first version of our system, we created a database by using MySql to store the accident data. When users make a query, the system needs to connect to the database and retrieve results of the query. Because of this design, our system runs slow when users use the query function. Therefore, in the revised design, we stored all the accident information in separate Java Object files. These files are generated by a small Java application. This application can read one year's accident data from the database. Then it will create objects from these data. Finally, it writes these objects into a file. Each time, when the system is loaded, all the accident information will be loaded into the memory as well from these files. By doing this, we increase the query response speed.

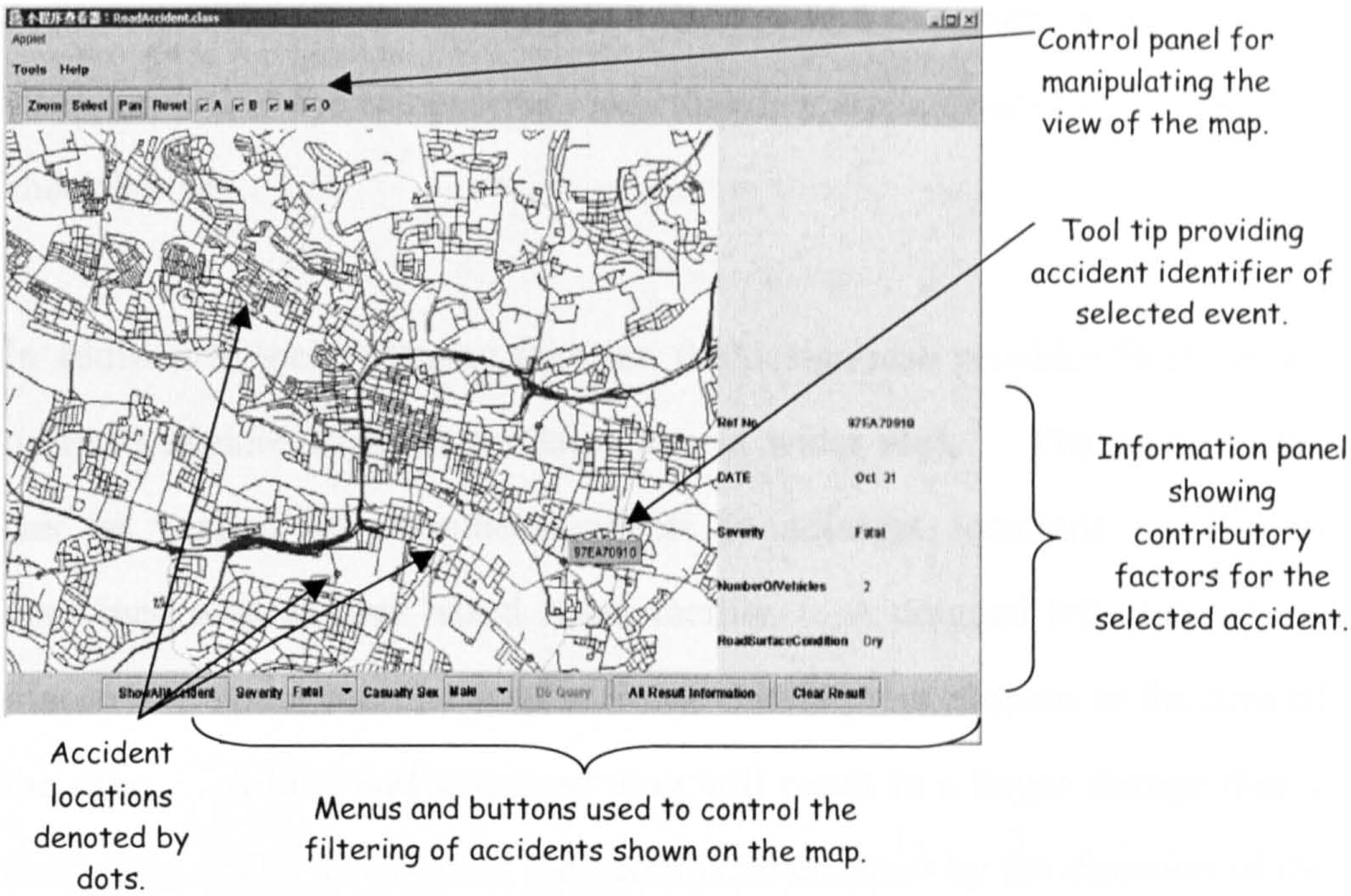


Figure 6.2: Overview of the first version Map-Based Interface

Figure 6.2 illustrates the resulting interface. Accidents are shown by the dots. In the interface, these dots are coloured red. The user can select an individual incident by moving the mouse over one of these dots. A tool tip then appears with the individual incident identifier to provide feedback on their selection. If there is no record of an incident under the mouse location then the tool tip provides contextual information by giving the name of the nearest road. The system uses these techniques to enable the user to access 'details on demand'. A summary of the accident information about each selected incident is presented in a panel on the right hand side of the screen.

The system enables the user to filter information by selecting a number of preformed queries through the menus and buttons at the bottom of the screen. In particular, it is possible to specify the severity of the incidents to be displayed. This filters the mass of red dots that would otherwise overwhelm the user. Our initial requirements analysis with road safety professionals also identified the need to distinguish between incidents that occur on different categories of roads: A and B roads or motorways. Users can select the category of roads that they are interested in by selecting check boxes.

In addition to these filtering features, the design also provides facilities for users to explore accident statistics over a wider area. The map display can be panned to examine incidents in adjacent locations. This is combined with an area based zoom facility. A dragged left-click on the mouse will zoom into the map at a rate that is proportionate to the area of the drag. A long and sustained drag will result in a larger change than a short drag. The direction of the zoom is determined by the direction of the drag. A movement from bottom left to top right zooms into the map while the opposite movement will zoom out. We have also included a reset facility so that any actions should be easily reversible back to a known initial state.

As mentioned, users can exploit the menu options and checkboxes provided by the system to filter the mass of incident data held about road accidents in the Glasgow area. However, even the successive refinement of these queries can still yield a significant number of 'hits'. It would be extremely laborious if users had to manually view each set of contributory factors using the tool tip and panel combination illustrated in Figure 6.2. For this reason we have implemented a facility to review all of the information that is associated with the currently highlighted set of incidents. Figure 6.3 illustrates how the user can gradually read through accident, vehicle and casualty information with each incident presented on a different 'page'.

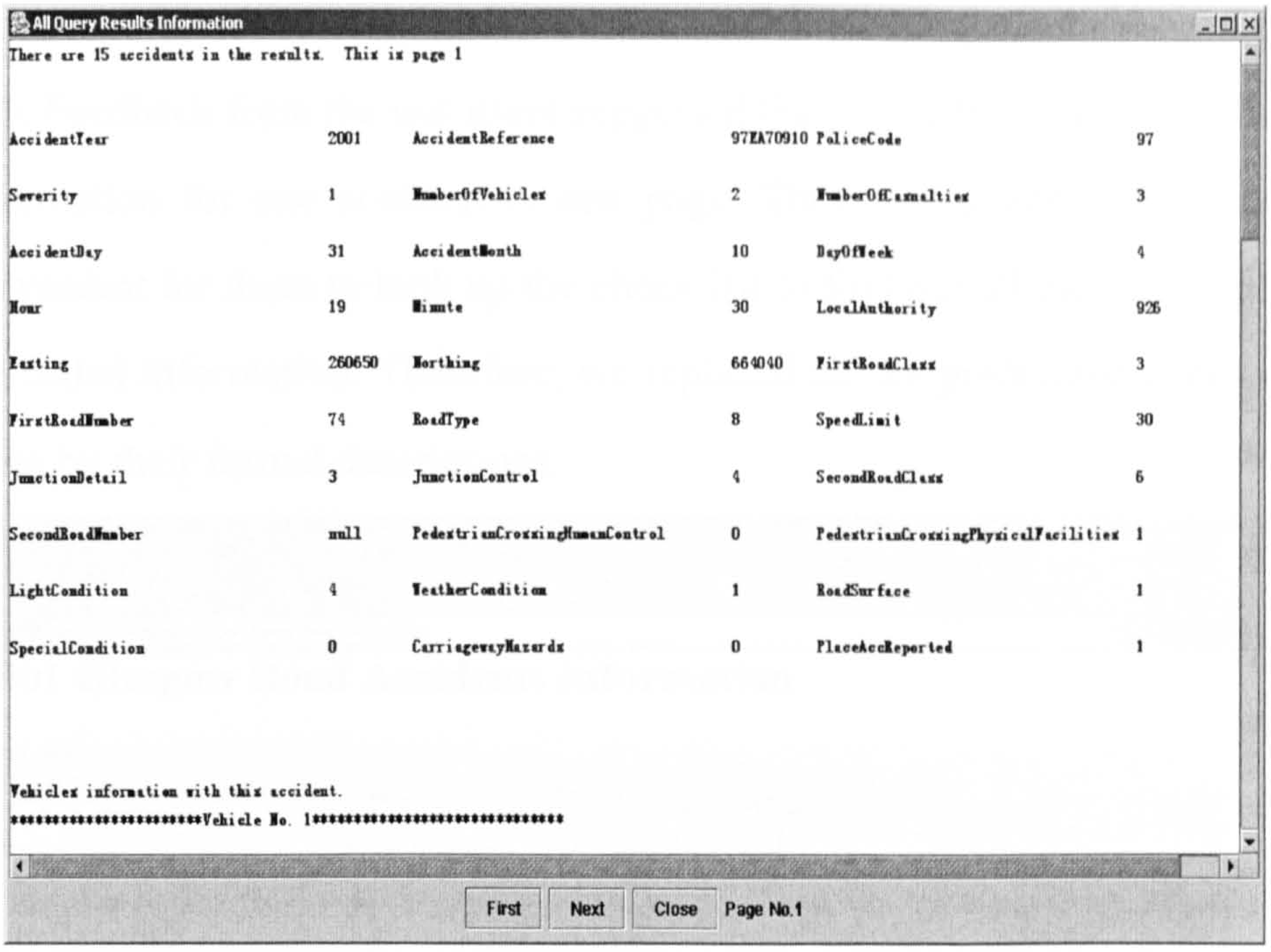


Figure 6.3: Reviewing Details for Several Selected Incidents

6.1.2 Revised Design

After the system evaluation which is discussed in detail in the next chapter, we redesigned the system according to the feedback from end users. Figure 6.4 shows the second version of the interface. We made several changes to the system. First, the new system uses different shapes to represent different levels of accident severity. For example, round means slight, square means serious, diamond means fatal (the level of accident severity comes from accident data directly). Other changes include additional filtering controls. In the filtering control panel there are two buttons, 'Do query' and 'All result information'. When users clicked the 'Do query' button, a new filtering control dialog appears (See figure 6.5). The system now provides more filtering functions in the option panel (See figure 6.6). Users can choose which one or more they want to use.

The second version of the interface design also changed the layout and content of the detailed information for each selected accident (See figure 6.7). Feedback from the end users suggested that it is better to display all the information for one accident in one page. They also stated that it is not convenient for them to look up the check list to find out all the meanings of the coded information. Therefore, we replaced all the predefined codes and types by their formal descriptions.

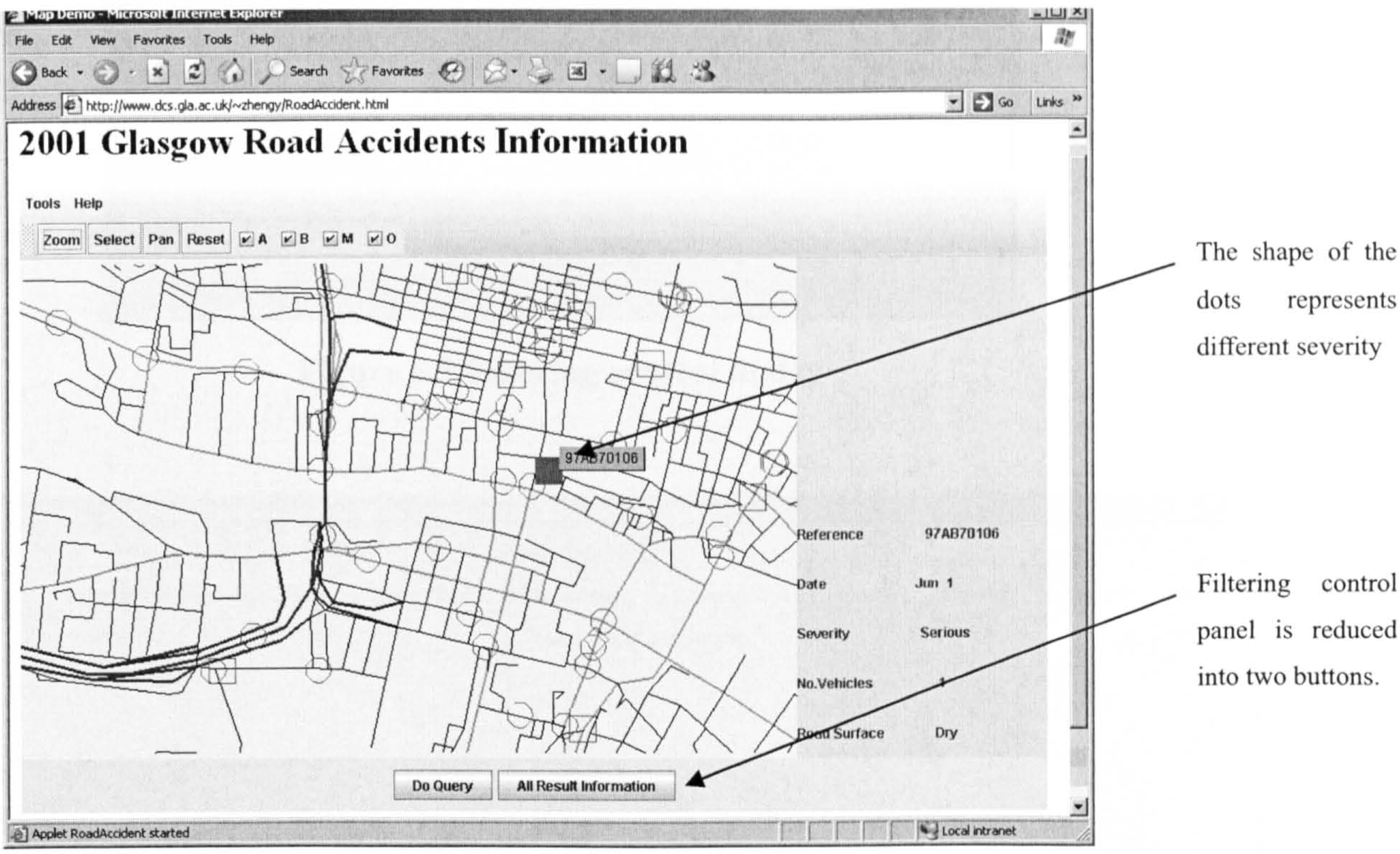


Figure 6.4 Second version of the User Interfaces

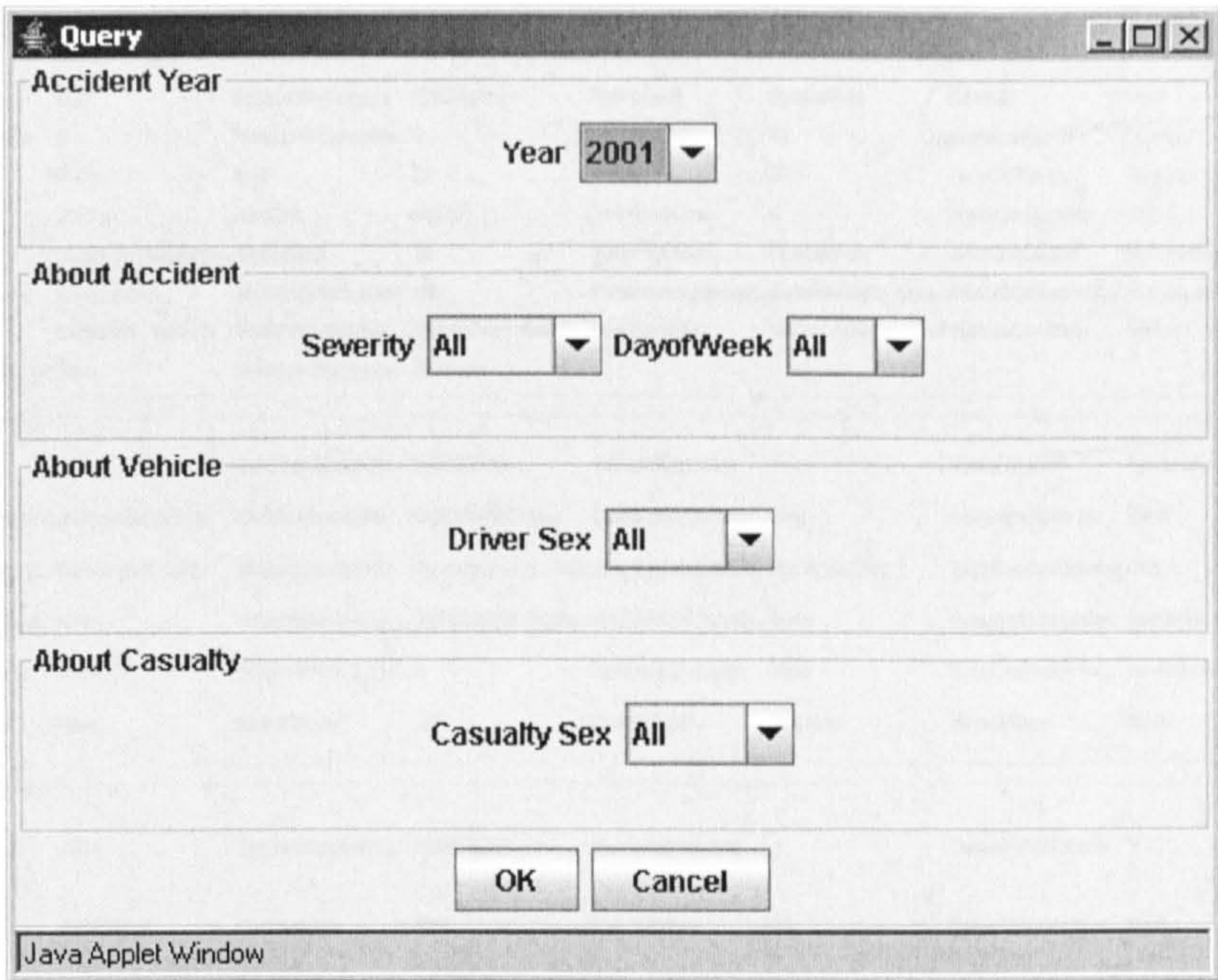


Figure 6.5 Filtering control dialog

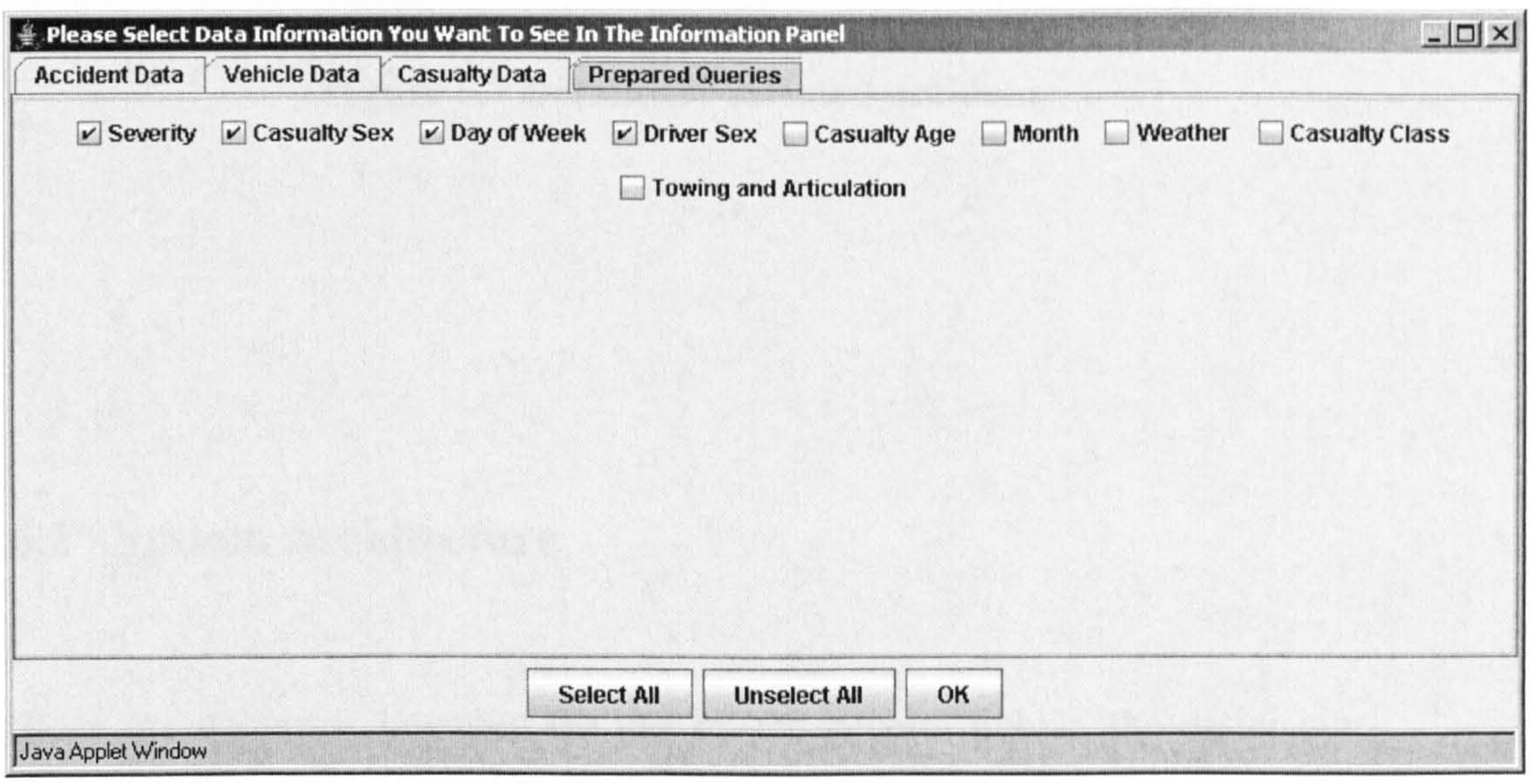


Figure 6.6 Option panel for more filtering functions

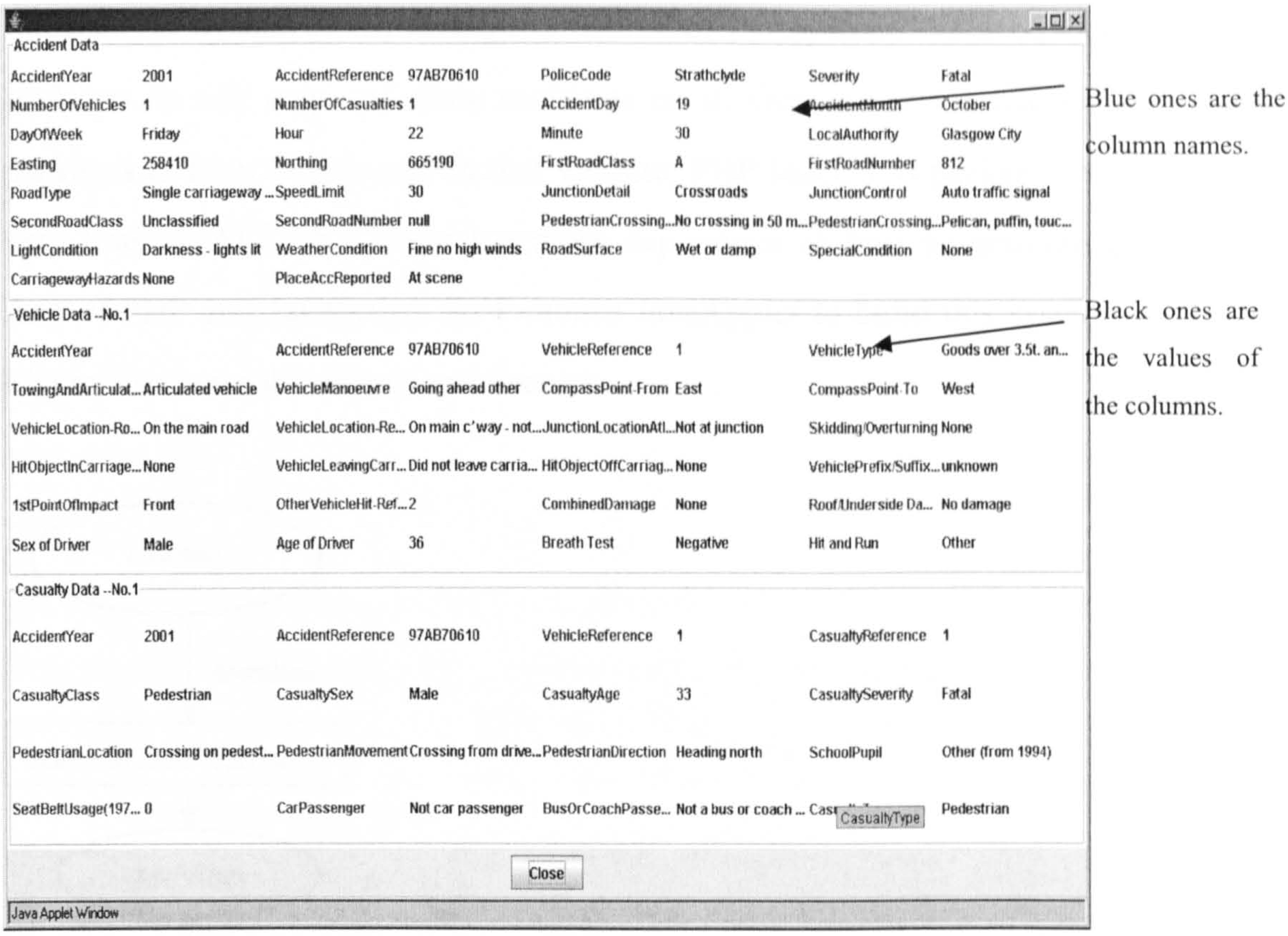


Figure 6.7 Details for selected accident

6.2 System Architecture

Since the system is intended for use by the general public, the easier our system can be accessed, the more impact it can make. Also system help function or tutorials should provide enough demonstration about system usage so that users don't need face to face training. Therefore, an Internet based system would be a good design choice. There are several techniques can be used to build such a system, such as PHP, JavaScript, JavaApplet. However, PHP and JavaScript are scripting language, especially server-side scripting, which mainly is used for collecting form data, to generate dynamic page content, or to send and receive cookies. Geographical

Information System (GIS) is another feature of our system. We need Geo packages to edit map and draw accidents on it. Our source for free GIS packages is from freegis.org. In that website, PHP based geo packages are very limited. Also, the author has more experience of Java programming than of PHP and JavaScript. So I choose JavaApplet to build this system. Figure 6.8 shows the overall architecture.

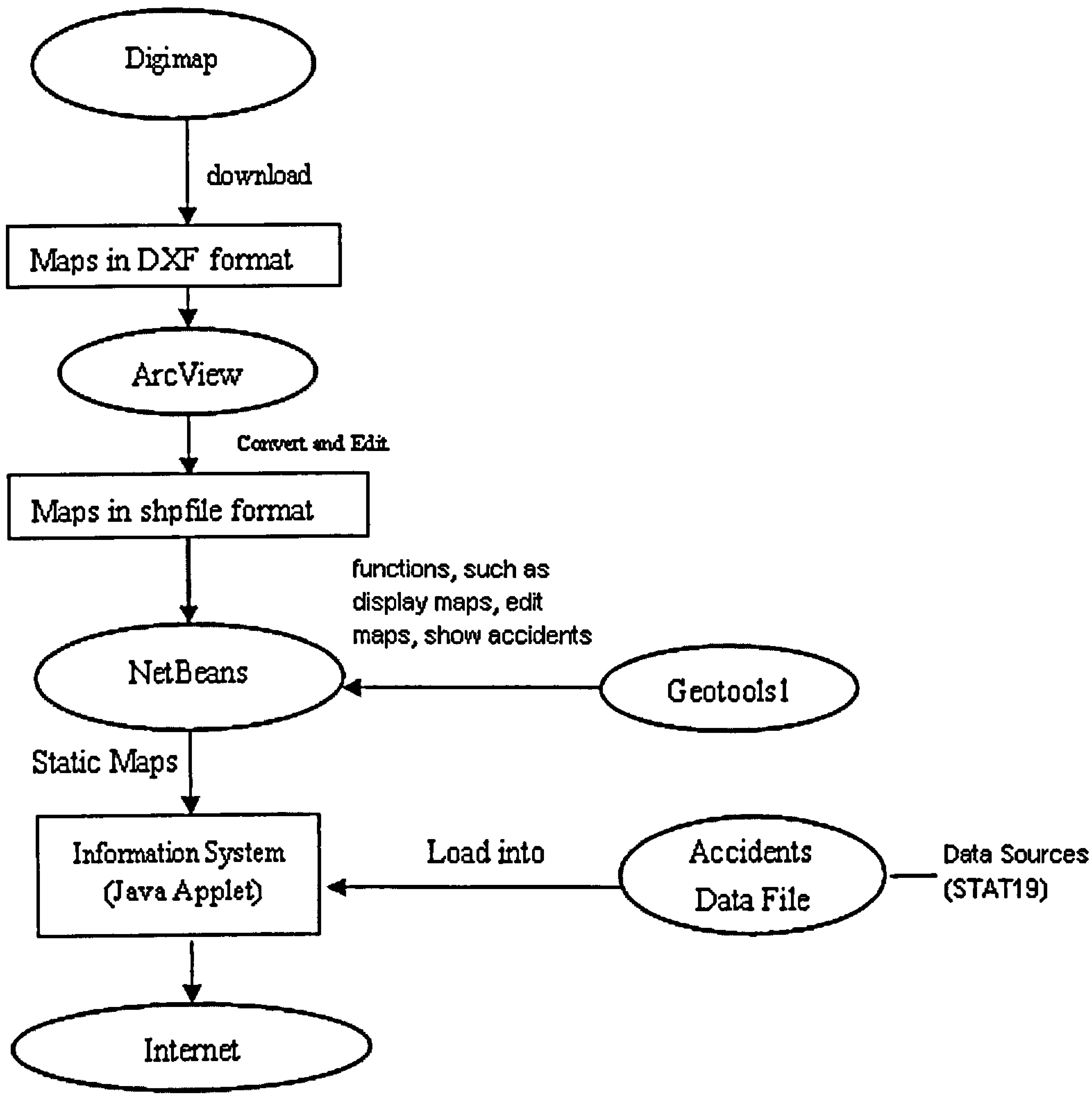


Figure 6.8 System architecture

GIS applications link locations to information, such as people to addresses, buildings to parcels, or streets within a network. They layer that information to give you a better understanding of how it all interrelates [82]. GIS systems have the following features: interactive (requests and feedback), large information (database), map-based GUI (Graphical User Interface), regular information update (including data structure). The Glasgow Road Accident Information System is such a system. It will store data on several thousands of accidents. Users can browse the map of Glasgow, set up queries and retrieve accident information. Since the accident records are based on STAT 19 forms, if the police or government change the structure of the STAT19, then our system needs to be able to update the information with minimum effort and cost.

Object-oriented design (OOD) and programming provide a suitable framework for developing such a system. OOD models the real world into the software objects and operations. Sanjiv [30] argues in his book that OOD has the following benefits: 1) Better mapping between the business and software (easy to understand); 2) Coping with change (easy to maintain); 3) Improved productivity and quality through the reuse of existing components (reusability). These features are all useful in our system. For example, when we map the vehicle data into an object in the system, all the items would become attributes of the object. If the structure of STAT19 is changed, say they add one item into the vehicle data, we don't need to rewrite the whole program. There is an attribution list for each record. We just need to add one attribute to the list and leave the rest of the attributes and methods unchanged. The detailed classification of all objects in the system will be discussed in the following section.

6.3 Class Classification and Implementation

There are a number of proven approaches for identifying objects in the system [11], such as classical approaches, behaviour analysis, domain analysis, Use-case analysis, CRC (Class, Responsibilities, and Collaborators) cards, informal English Description, and structured analysis. We use classical approaches plus use-case analysis to identify classes in our system.

Classical approaches derive primarily from the principles of classical categorization. From the perspective of database modelling, Ross offers a list [78]: people, places, things, organizations, concepts and events. In our GIS system, things (information) include accident data, vehicle data, and casualty data. Events include map drawing and queries. The result of a query may generate a list of accident data, vehicle data or casualty data. Maps include both the road map layer and the accident layer.

Use-case analysis was first formalized by Jacobson. He defines a use case as "a particular form or pattern or example of usage, a scenario that begins with some user of the system initiating some transaction or sequence of interrelated events" [42]. Figure 6.9 shows a use case diagram of our system.

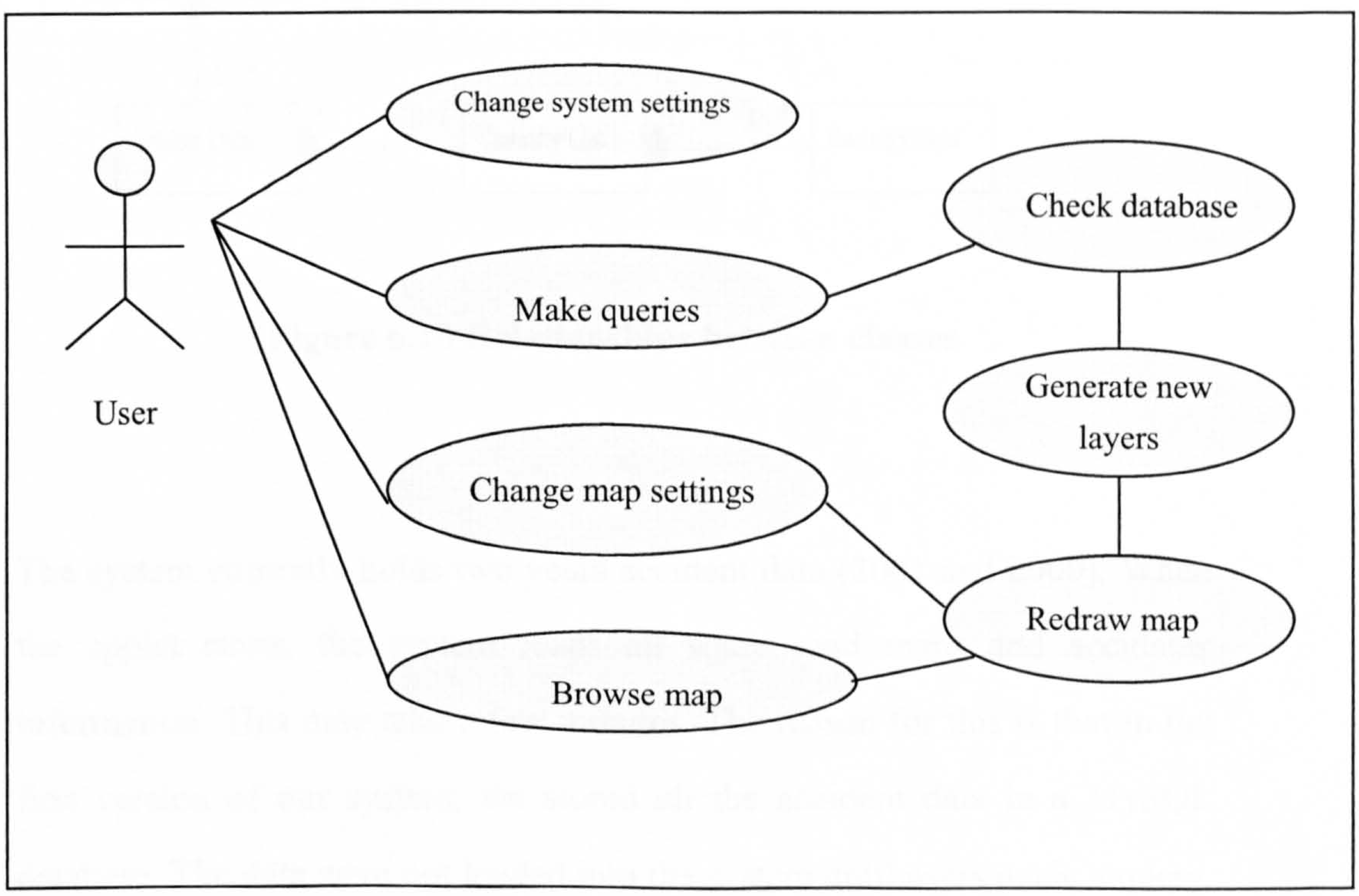


Figure 6.9 Use Case diagram

Using the combined classical approach and use-case analysis, we identified the following classes: Accident Data, Vehicle Data, Casualty Data, Accident List, Vehicle List, Casualty List, My Layer, My Theme, Result Theme, Road Accident, Application Manager, and Information Frame. Their relationships are show in figure 6.10

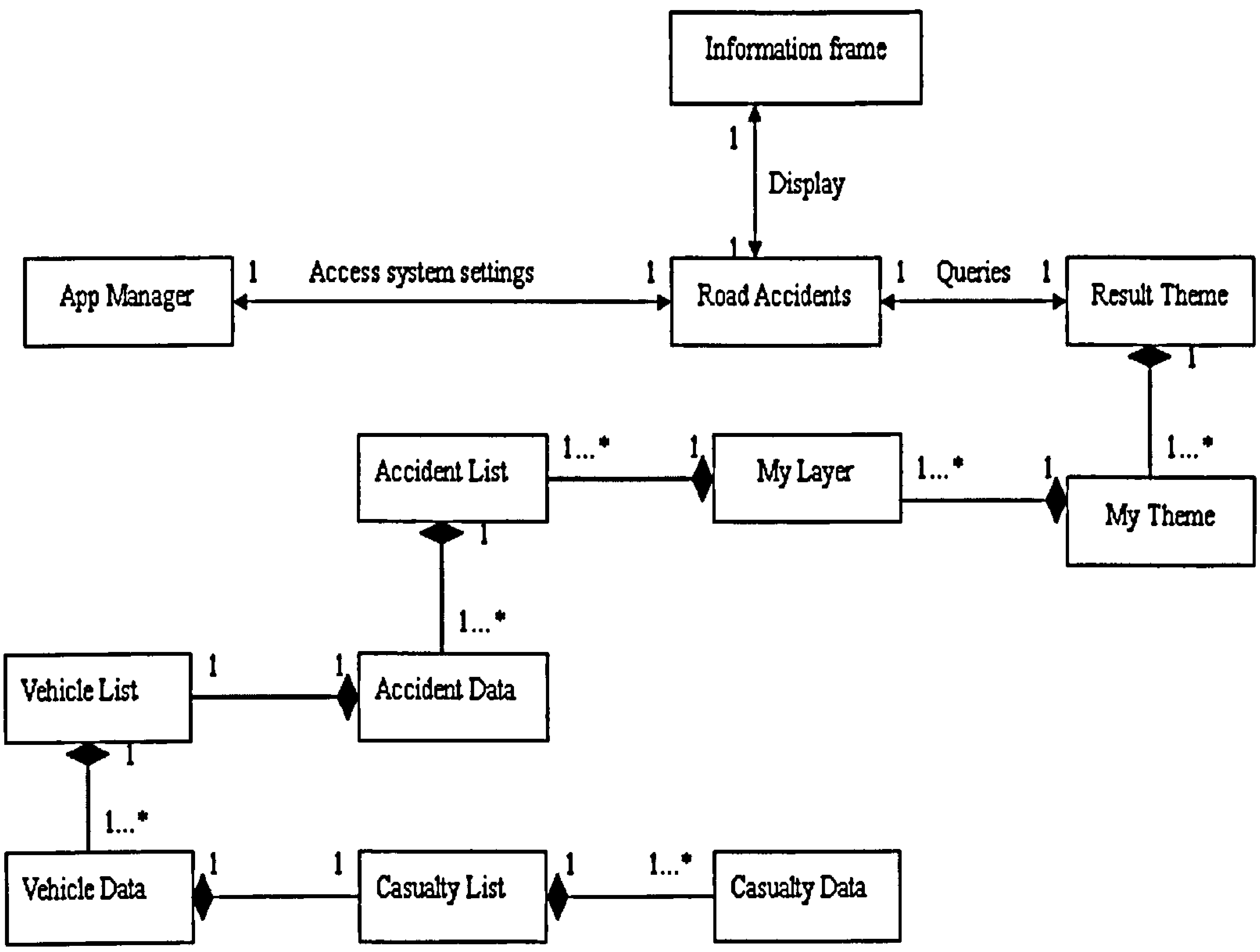


Figure 6.10 Relationships between classes

The system currently holds two years accident data (2001 and 2000). When the applet starts, the system loads all static road maps and accidents information. This may take a few minutes. The reason for this is that in the first version of our system, we stored all the accident data in a MySQL database. The data were not loaded into the system until users made a query. However, the evaluation shows users feel the system is too slow. Therefore, in the second version of our system, we stored all the accident data in separate Java Object files. Each file has one year's accident data. Although it takes a few minutes to load all the information, after loading, queries are very fast. In the future, if we need to include more years' accident data or need a much large geographical area, we need to consider other ways to balance the system memory limit and the system speed. Figure 6.11 shows an example of the system flow chart.

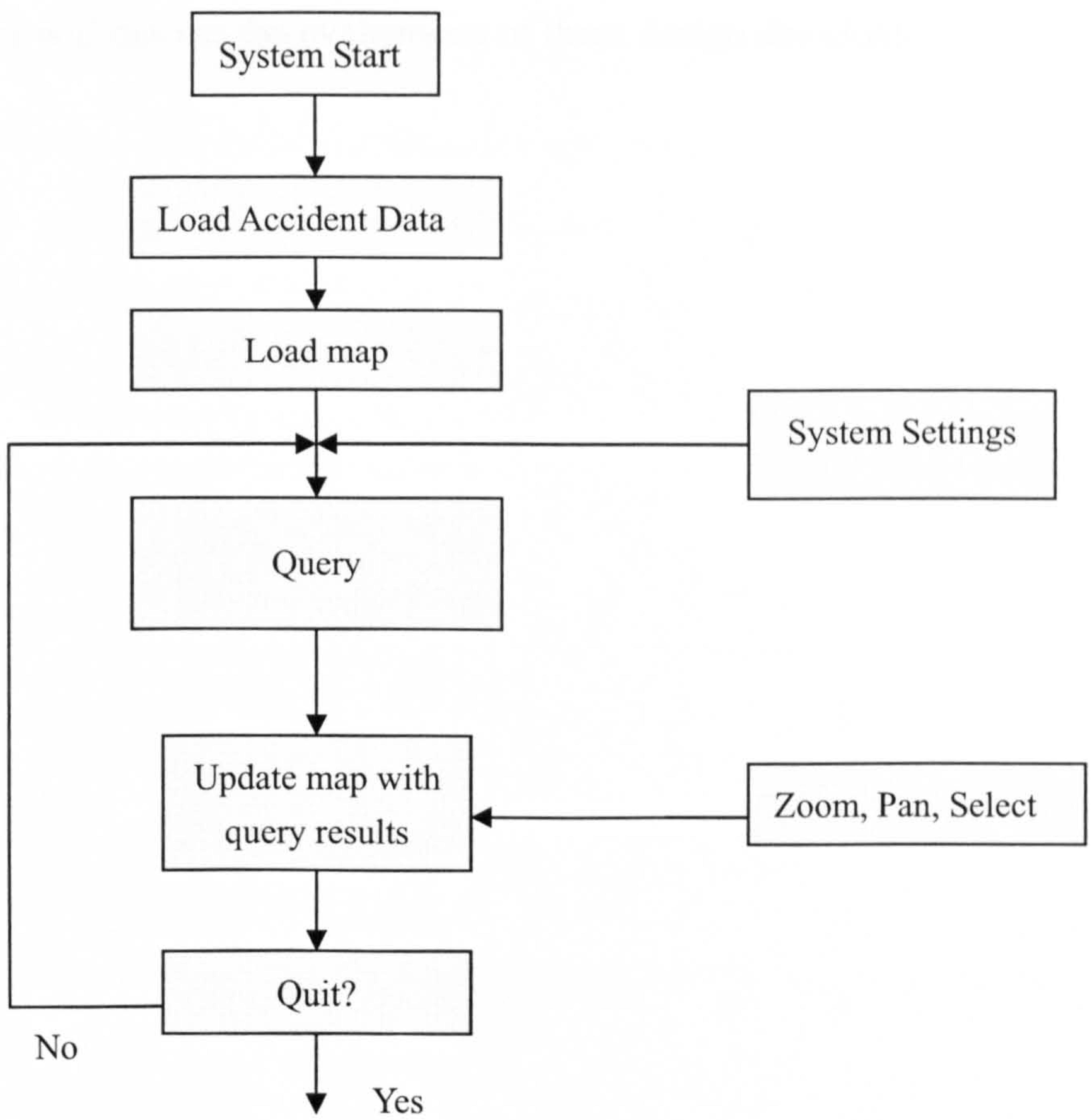


Figure 6.11 an example of the system flow chart

6.4 Conclusion

Having in mind the requirements listed in chapter 4, we designed and developed two versions of our system. After completing the first version, we carried out an initial evaluation and made several changes to the system, such as using different shapes to represent different accident severity, replacing the bottom panel by a more simplified query control panel, replacing accident codes by the formal descriptions, and so on. The system was designed based on object-oriented principles which make it easy to understand and maintain. Through our system, users can see the local accident information in Glasgow area, can find specific kinds of road accidents, and can read the detailed accident records for every accident. The next chapter will discuss the evaluations of these design decisions.

Chapter 7 System Evaluation

Previous chapter have argued that several biases, including attribution error, result in drivers underestimating the likelihood that they will be involved in a road traffic accident. It has also been argued that previous initiatives to improve road safety might be supported if drivers were provided with more direct information about the frequency of accidents within their local area rather than through regional or national aggregate statistics. We are, therefore, concerned to determine whether using our application would have any measurable effect on an individual's perception of their likelihood of being involved in a road accident.

7.1 Method

Major evaluation goal:

Evaluate whether our system has a significant impact on people's safety awareness.

Minor evaluation goal:

Evaluate the usability of the system.

Evaluation Methods:

Usability questionnaire and risk perception questionnaire

Evaluation participants and process:

The formal evaluation was conducted in three stages. First, each participant completed a benchmark risk perception questionnaire. This was based on three existing general road accidents risk perception forms, described in the chapter 3 [92, 69, 57]. The second stage provided users with an opportunity to interact with the system described in the previous section. We offered a scripted introduction to the functions offered by the application and then left them to browse the accidents. Each user was told that they could use the system for less than half an hour. After they had finished using the system they were again requested to complete the same risk perception questionnaire. They were also asked to provide feedback on the user interface to the tool (See Appendix E). We did not provide specific tasks for participants to do. At first, we thought that different road users may care about different road safety information. If we provide tasks which are not interested by participants, they would ignore what they saw. Therefore, we give them freedom to browse whatever they like to know about our system.

We started with a sample of 25 potential users, although 29 users did the usability evaluation (4 users had difficulty completing the risk perception questionnaire). We did not want to place undue time constraints on the familiarization period that was available for users as they learned how to use the system. Therefore, we used a different sample from that involved in our risk perception study of existing web sites which was described in chapter 3.

7.2 Results of Usability Questionnaire

The feedback from open-ended questions about the usability of the software included several negative comments. These have formed the focus for our redevelopment efforts that resulted in the revised interface design described in chapter 6. In retrospect, we realize that we should have anticipated some of their criticisms earlier in the development cycle. For example, accident records in the UK archive use a number of predefined types to represent certain values. These types have a relatively clear meaning to safety professionals. For example, in the severity column, '1' means fatal accident, '2' means serious accident, and '3' means slight accident. Our more general users were not, however, familiar with these distinctions between road types and local authority codes. In consequence, many of our participants reported high levels of frustration whenever they had to crosscheck the codes in the accident records with an explanatory table. For example, one participant wrote "It is very difficult to always refer to the manual to interpret codes". Our first design of user interface was served as a heuristic prototype to help us to identify the potential problems. The above problem was identified in the first user interface evaluation and has been fixed in our revised design of user interface.

A number of further criticisms related to significant details in the presentation of the user interface. For instance, several users complained that the font used to display the detailed information about each accident was too small. Others complained that it was difficult to distinguish between incidents because the associated location markers on the map began to overlap when they viewed the system at a low level of 'magnification' or 'zoom' (See figure 7.1). Other common criticisms echo previous studies of the usability of geographical information systems by a relatively wide user population. Several people found it difficult to distinguish between the pan and zoom actions. Others became lost as they traversed the map and requested the provision of additional landmarks.

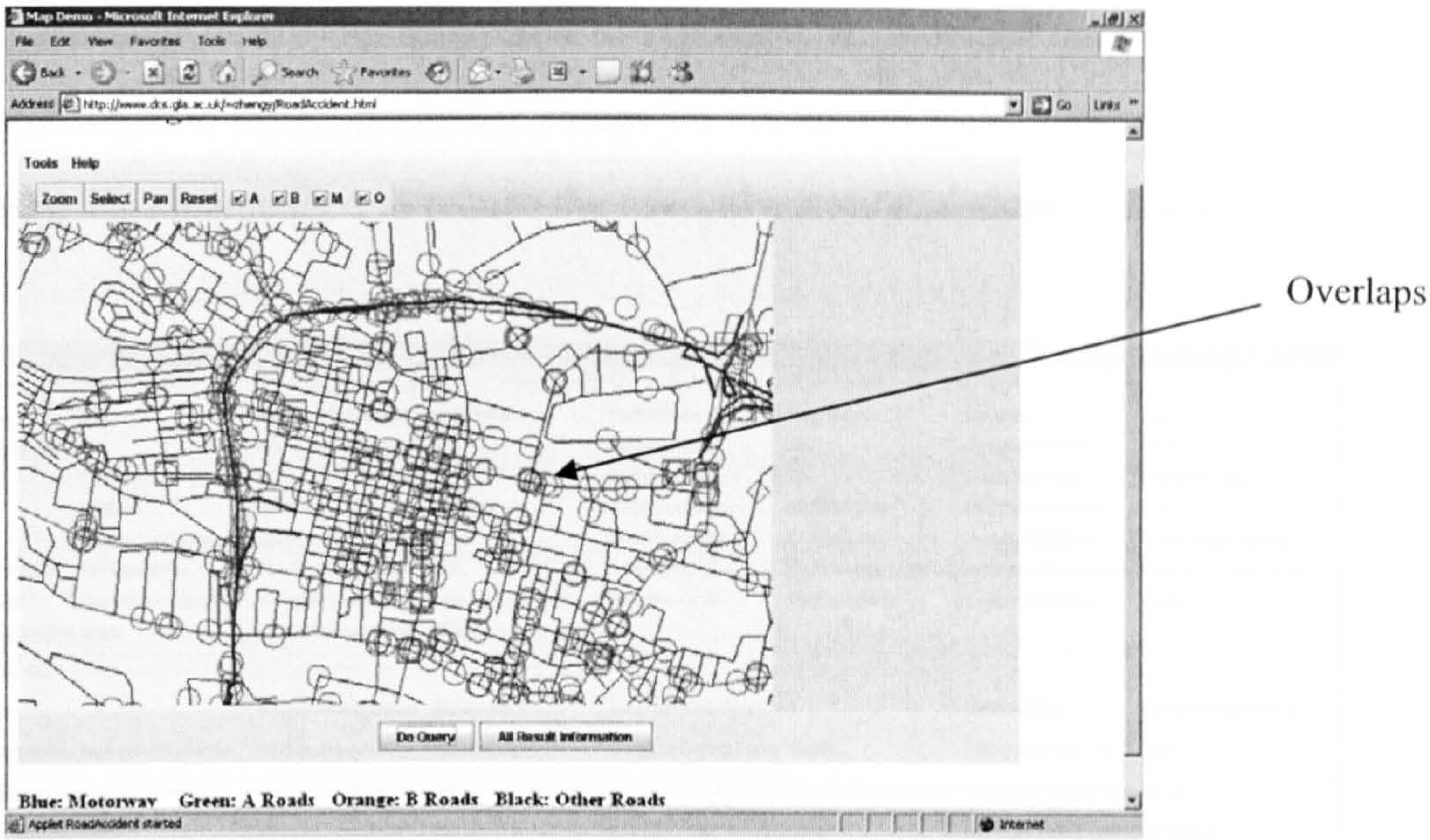


Figure 7.1 Overlaps on the map

A final cluster of adverse comments focused more on the information content that was provided by the system. One participant wrote "The cause of accidents is not clear". This is a key observation and there are several explanations. It is important to stress that the national archive does not directly record the cause of each adverse event. This is justified both for legal and ethical reasons. The police's view of the potential causes might be used in legislation. Hence it is not described in the data archive. Instead, the data focuses on contextual details such as the prevailing weather conditions and whether or not alcohol was involved. Some police agencies do retain causal information in a format that can be linked to the national archive data. However, we could not obtain public access to these data sources during the initial development of the prototype interface. Several other factors can explain end-user criticisms about the presentation of causal information. In order to track the geographical distribution of common contextual factors users must first select the incidents that they are interested in, using the map-based display, and then access the individual records associated with each accident, using the text-based pages illustrated in Figure 7.2. Post-evaluation debriefs helped to identify the basis for current redesign where the icon used to represent an incident on the map will be changed to reflect particular values for contextual factors selected by each user. This is intended to reduce the need to access this mass of detailed text.

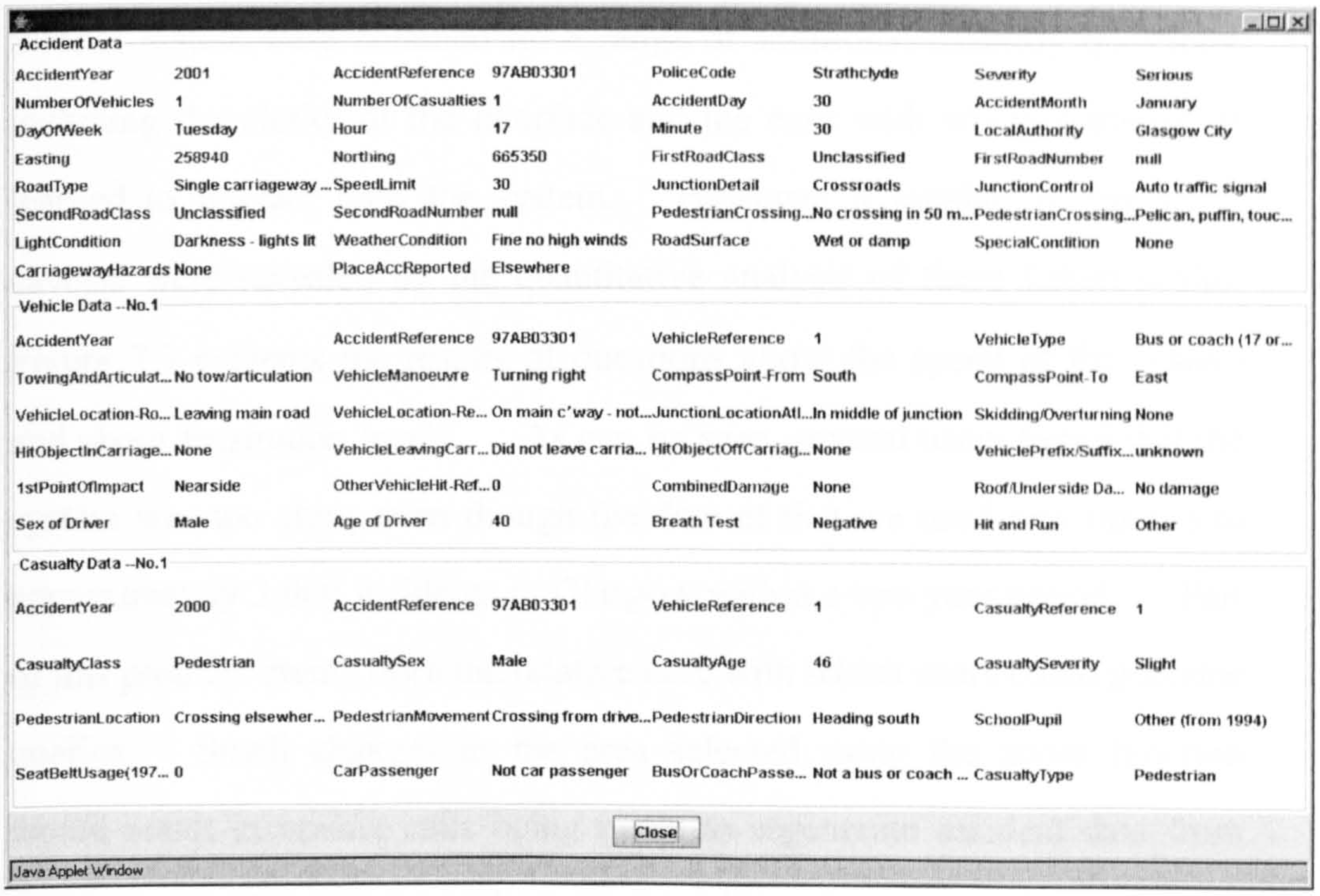


Figure 7.2 Detailed accident information

The evaluation also helped to elicit criticisms that the prepared queries were too restrictive and that the data provided by the national archive was too limited. In particular, one participant wrote "(The system) should add more data regarding the details of accidents, e.g. the mental, physical conditions of the driver who causes the accident". This last point raises a number of important issues. It can be difficult for investigators to elicit personal information, for instance about the mental state of a driver, in the aftermath of an adverse event. Informal comments made by the participants indicated that these sorts of details would have a profound impact on any personal assessment about how likely they were to find themselves in a similar situation in the future.

Likert scales were used to assess the overall 'usability' of the prototype.

In an initial sample of 29 potential users, nineteen ranked the overall usability at 4 on a scale from 1, denoting that the system was 'terrible' to 5, denoting that the system was 'wonderful'. Six users scored the system as 3 on this scale while four users ranked the system in the highest category. Similar results were obtained for a range of additional usability questions, including the clarity of the interface and the ease with which participants learned to interact with the system. However, a number of important caveats were revealed by the quantitative analysis of these Likert scales. Figure 7.3 presents the results of questions about the speed of the system and about frustration levels. As can be seen, several users found that the system was too slow, even though the dataset that we used was limited to approximately 3,000 incidents in Glasgow within a two year period. Part of this problem stems from the relative ease with which users could generate queries. Small changes in the area selected using the zoom function would result in update calls being made to regenerate incident data from within a MySQL database. In our second version system, we load the accident information from stored files rather than from the MySQL database. Although this increase the loading time since when users open the system, it will load all available data into the system, the query times are reduced and the system is more stable than in the previous version. The right hand side figure shows most people are satisfied with the application. But there is one participant feel frustrating about the system. The system was crashed after this participant executed several queries. Same reason as above caused this problem. Frequently query the database caused the system unstable. After we redesigned our system, it has not been crashed anymore.

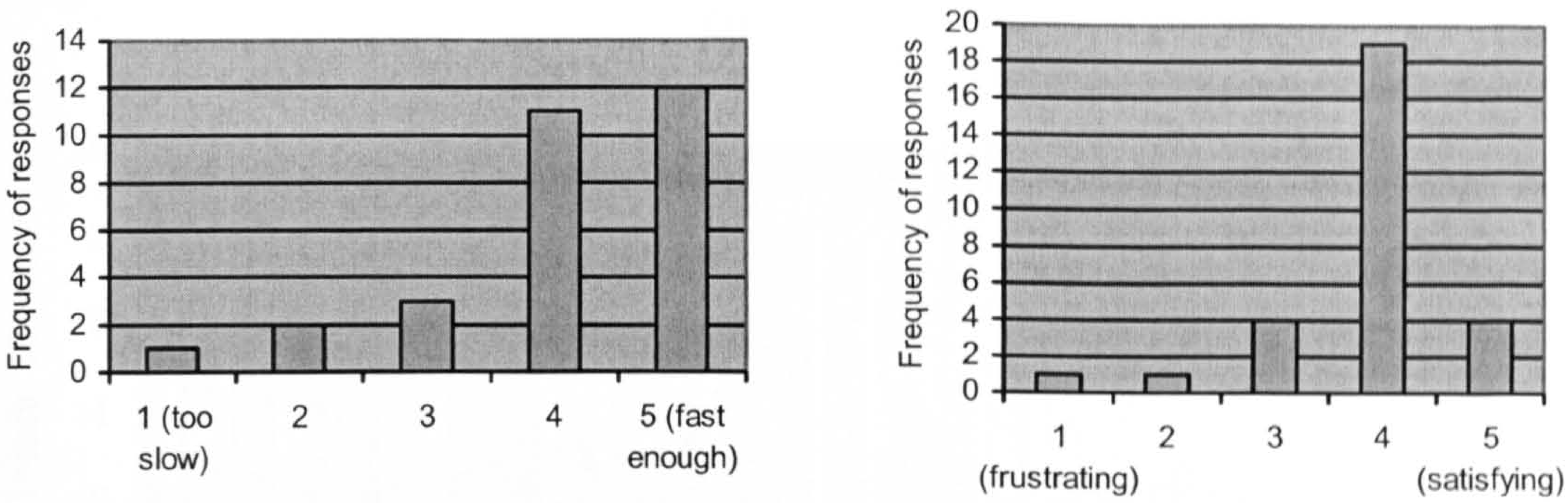


Figure 7.3: Quantitative Results from the Usability Evaluation

7.3 Results of Psychometric Study

The following figures present a sample from the results that were obtained from the second stage of our evaluation. This was based on the same procedure that had been initially used to sketch the impact that existing road safety web sites might have upon the potential users which was described in chapter 3. In this instance, the participants were given a questionnaire that was based on three previous psychometric studies of road accident risk perception before they interacted with our map-based visualisation systems. They were then encouraged to use the prototype for as long as they wanted. After they completed the more general interface evaluation questions, described above, they were then asked to repeat the risk perception questions. As in the previous examination of national and regional web sites, the intention was to determine whether interaction with our information source had any measurable effect on their risk perception scores. Figure 7.4 and figure 7.5 present the results from two of the nine questions before and after using the system.

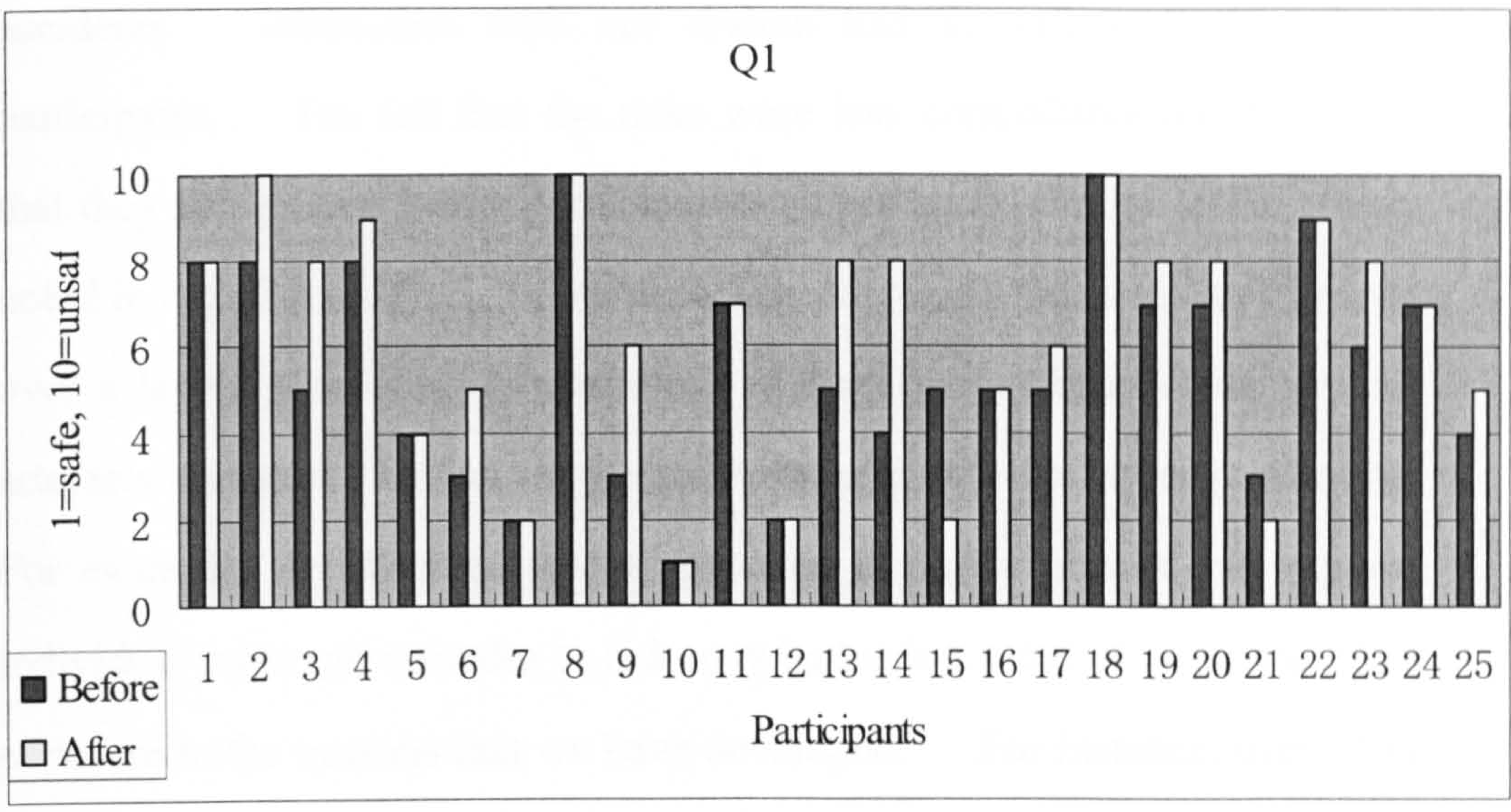


Figure 7.4 How safe do you feel in terms of the likelihood that you could be injured in a road traffic accident? (p = 0.98)

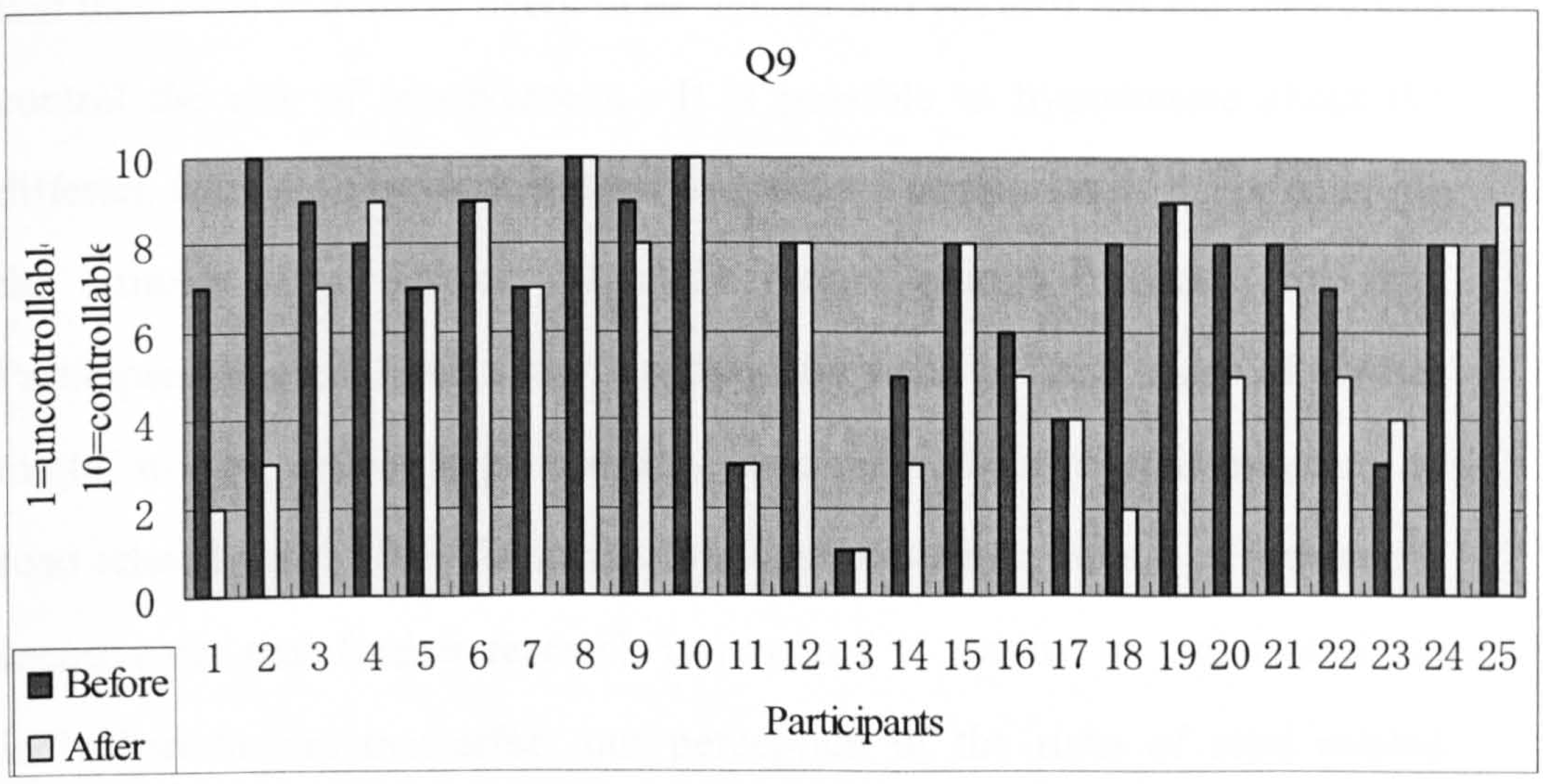


Figure 7.5 How controllable is the risk of involvement in a road traffic accident? (p = 0.98)

Interaction with the new system increased the perception of the likelihood of an accident in 12 of the participants. In two participants it and the remainder showed no change in their expressed perception. However, the magnitude and frequency of this effect is broadly similar to that observed with the existing on-line resources. The graph on figure 7.5 shows the responses to a question about the controllability of risk in road traffic accidents. Interaction with our system had no effect on 12 of the participants. Ten felt that the risks were less controllable and three felt that they had greater control. This diversity is again similar to the effects noted in the pilot study. In both cases, however, further tests are required over a larger population to determine whether these observations are not artefacts that stem from an inappropriate sample of a far larger population. For example, we observed several patterns in our responses that suggest individual traits and attitudes to risk may be having more of an impact than exposure to the systems that we have developed. For instance, user 10 in Figure 7.4 felt that there was no likelihood that they would be involved in a road accident even after they had used our system. They also felt completely in control of the associated risks. Conversely, participant 8 felt that they were extremely likely to be injured and yet also felt that they could control the risk of involvement. It is possible to hypothesise about the different attitudes that motivate such expressed perceptions. For example, the attitude of participant 10 might reflect a high tolerance for risk. Participant 8 might have a low threshold for risk. Their sense of control might, in part, reflect steps that they have taken to limit their exposure to road related risks. It is difficult to validate these assertions. However, it seems clear that further research is required if we are to understand the individual factors that affect our perception of the risks of road related incidents. For instance, none of the previous psychometric tests that we adopted account for the strong effects that must be introduced when individuals have recently been involved in an adverse event. Similarly, they fail to account for the different risk profiles that are associated with different forms of road use. Individuals who never drive may have different attitudes towards the risks of road accidents than individuals who regularly use high-powered motorcycles.

7.4 Focus Group Discussion

Our consultations after this evaluation led us to consider a greater use of focus groups to supplement psychometric techniques. Unlike one to one interviews, "focus groups generate data through the give and take of group discussion. Listening as people share and compare their different points of view provides a wealth of information—not just about what they think, but why they think the way they do" [97].

We selected 8 undergraduates in Glasgow University to form the focus group about road traffic accidents. The reasons why we chose them are, first, according to the statistics young people (17 to 22 years old) are most likely to be involved in traffic accidents [74], and secondly, they are familiar with traffic conditions and the local environment in Glasgow city. Several questions were discussed. We choose these questions because we thought they are useful for us to identify how road users think about road accidents and accident information.

1. Do you think the modern road traffic system is safer than in the past?
2. What do you think are the main causes of road accidents?
3. How controllable are these risks?
4. From a road users' point of view, what kind of means can affect people's safety awareness or their behaviour?
5. What are the advantages and disadvantages of national accident statistics and the information provided on websites?
6. Do you think local accident information is more important or helpful than high level statistics?
7. When you plan your journey, would you consider accident information in addition to distance and road type information?

They believe that the modern road traffic system is safer than the past since the total number of accidents is less than decades ago. However, with more traffic, more powerful cars, they are still concerned about road safety. Drink-driving and speed are blamed for most road accidents, although someone mentioned poor road and car maintenance, and one overseas student said "roads in Glasgow are too narrow". They all think these main risk factors are hard to control. One student argued "We have to build a safety culture by education or law enforcement to change people's attitude towards these risks". When they are asked about useful ways to affect people's attitude, more severe punishment and showing people the consequences of accidents were the most popular answers. They think one of the TV road safety campaigns is very helpful, which showed four young students driving a car after they have had a drink, when they are hit by another car. The advert actually showed the injuries of every one in the car. They believe if people know they cannot afford or bear the consequences of accidents, they won't risk them.

When we talked about national statistics and their safety campaign websites, they thought that although the information is useful, "people just don't go to these websites". People don't care how many casualties there are on the road last year. They are not interested in what the main reason for road accidents is. They think "I never have an accident and I live in a safe area". People are only interested in the information that relates to them. For example, one student said "when I go to a new town, the accident information would help me decide where I should drive carefully". After seeing our system, they said this kind of specific, localized information would definitely be helpful for road safety, "People are interested in this information". They would like to find out what happened in their neighbourhood. Once they realize the area is not as safe as they thought, they might change dangerous driving behaviours. When talking about the impact of accident information on journey planning, they thought this really depends on a lot of factors. One said "If a safer road will cost an extra half an hour or more, I would rather choose the dangerous one". It is hard to compare different situations just by talking. But they said if such information was available, they would consider this when they plan a journey.

In the next chapter, I describe an experiment we did which helped us to find out whether accident information would affect people's journey planning.

7.5 Discussion and Conclusion

Since conducting our evaluation, we have endeavored to identify other metrics that we might use to support the validation of our localized approach to the provision of accident information. In particular, we are looking for techniques that might both demonstrate the utility of the approach to sponsoring organizations and also produce results that can drive subsequent iterations in the development cycle of our tools. This search has involved discussions with a number of cognitive psychologists and safety engineers. These discussions have raised questions about the utility of the psychometric approach in this context. Asking users about the costs and benefits associated with the risks of road usage is like 'asking someone whether they would like a swimming pool on the moon, it has simply never occurred to them before'. Many people find it hard to answer our questions because they have never thought explicitly about the risks of road use.

The experience gained from the development of the software tools showed that general public has great interests in the localized information. However, we have learned valuable lessons about the criteria that might be used to validate these systems. We cannot simply take metrics from cognitive science and hope that they can be directly applied to support software design and interface development. In retrospect we realize that we may have been naïve in ever expecting that this would be straightforward.

This area raises considerable practical and ethical problems. The ultimate measure of success might be to demonstrate that those who had access to this localized information were statistically less likely to be involved in road traffic accidents. Ethical and practical considerations make it unlikely that we will be able to conduct such tests. However, we continue to look for alternative measures.

We are also increasingly aware that many of these metrics may be inappropriate for such software. In particular, the popularity of the system has come as a considerable surprise. Many of the participants in the study wanted longer-term access so that they could monitor the impact of road planning policy and lobby for changes in traffic management within their neighborhood. It might, therefore, be argued that this increased sense of engagement with road safety issues is a greater benefit for this type of software than any transient changes in risk perception.

Overall, the main contributions of this chapter are, firstly, usability evaluation showed that participants are satisfied with the system and the system met our requirements. Secondly, the psychometric questionnaire revealed that people's response before and after they saw the detailed local road accident information showed little change. Thirdly, the focus group discussion shows road users have great interests in localized accident information.

Chapter 8

Route Planning Experiment with Taxi Drivers

8.1 Motivation and Goals

Previous chapters argued that high-level national road accident statistic can have little impact on people's safety awareness and their behaviour. The possible reason for this is attribution error: most drivers believe that they are less likely to be involved in an accident than other motorists. Previous chapters have argued that local accident information may have more impact on people's awareness and their behaviours than aggregate national statistics. However, our questionnaire revealed that people's response before and after they saw the detailed local road accident information showed little change either. As discussed before, this could have several explanations. One is that our psychometric questionnaire forced people to answer questions they had not considered before.

We needed to find another way to assess the impact of local accident information on people's safety awareness and their behaviours. Route planning is one of the activities drivers perform almost every day. From the route planning function on the AA's website, we can see, traditionally, people choose their route by the type of road (e.g. avoiding motorways), by traffic condition and by cost. The website does not include accident factors, such as 'avoid high accident rate area'. That may not be because they don't care about accident information, but they don't have ways of accessing such information. We designed an experiment to find out whether, once people know about local road accident information, they would change their route choice. If the experiment showed there is some link between people's route planning and their local safety knowledge, it would support our hypothesis which is that localized accident information can affect people's safety awareness and we can use local accident information to influence people's behaviour.

We chose to adopt a within subject design and decided to focus on two sets of user groups, taxi drivers and university staff and students. We choose to focus on this group because they were really accessible for our study. They can also be a base case for further comparisons. The next chapter will discuss the experiment with university staff and students. The decision to choose taxi drivers was justified by the observation that this group has an extremely high-risk exposure and hence has both a commercial and personal motivation to consider localised accident information systems. The decision to focus on this user group introduced a number of additional complications into our experimental design. In particular, we were forced to consider the other types of local knowledge that might help to shape the taxi driver's route planning. We were concerned that their experience of delays on certain routes or particular environmental aspects including road layout might have a greater impact on route selection than any information about average journey times or even localized accident information. We, therefore, decided to repeat the test using two different route-planning tasks. One was based in the centre of Glasgow and hence was familiar to the drivers. The other was set in central Manchester. We ensured that none of the participants had ever driven in this area before starting the evaluation. This method was, therefore, intended to support two different but complementary hypotheses*.

* This chapter describes joint work with Chris Johnson, Phil Gray and Marilyn Mcgee-Lennon. I conducted the experimental work and analysis. The study design was the result of joint discussions.

8.2 Experiment Design

Hypotheses

Hypothesis 1: Local road accident information would affect people's choice in the rankings of the candidate routes.

Hypothesis 2: People's own local experience would affect their choice in the rankings of the candidate routes.

Independent Variable:

Road accident information

Dependent Variable:

The rankings of the candidate routes and locations

This was a within subject design. Two scenarios were involved in this experiment. The first one provided users with time information, which indicated how much time drivers may spend on each road section. The task was to drive from point A to point O (See Figure 8.1 and Figure 8.2). Participants needed to rank 7 candidate routes. The second condition provided users with both time and accident information. This told participants how many accidents happened on each road section last year. The task remained the same.

Participants had to do the experiment on two different maps. One was a Glasgow city map, the other was a Manchester city map. The reason we did this is because we wanted to see when drivers made their choices on the routes, whether they used their own experiences rather than the information we provided. Therefore, we had to make sure all the participants had never or very rarely driven through the centre of Manchester, so that we could make comparisons.

The participants we focused on are taxi drivers. Their daily job is driving through Glasgow. They are frequently making route decisions based on road traffic conditions and time of the day. Also they have plenty of local experiences. Therefore they are the ideal participants for our experiments. 20 drivers in total did the experiment.

8.3 Measurement and Tests

Since we use rankings to measure people's choices on routes, it is a non-parametric test. This means that it does not rely on assumptions about underlying population parameters (mean, variance). Therefore, we cannot use t-test or other parametric tests to test our experiment results. After consulting with other researches in the department, we choose the Sign test. The Sign test is one of the non-parametric tests and it can be used to test rankings. The Sign test is generally less powerful than the Wilcoxon test. It is, however, simple and easy to use. The general procedure is as follows.

1. Inspect the difference between each pair of scores. Put a plus sign (+) next to the differences in one direction, and a minus sign (-) next to the differences in the other direction.
2. Find the total number of either +s or –s, whichever occurs less frequently. Let this number be x.
3. Find the critical value of x for the desired level of significance using the following table. This value will depend upon (1) N, the total number of pairs, and (2) whether the prediction is directional.
4. If x is less than or equal to the critical value, reject the null hypothesis in favour of the alternative hypothesis that the independent variable has had an effect on behaviour.

If a pair of scores are equal they should be dropped from the analysis, and the value of N reduced accordingly [12].

8.4 Results and Analysis

Figure 8.1 shows the experiment map with time and accident information for Glasgow.

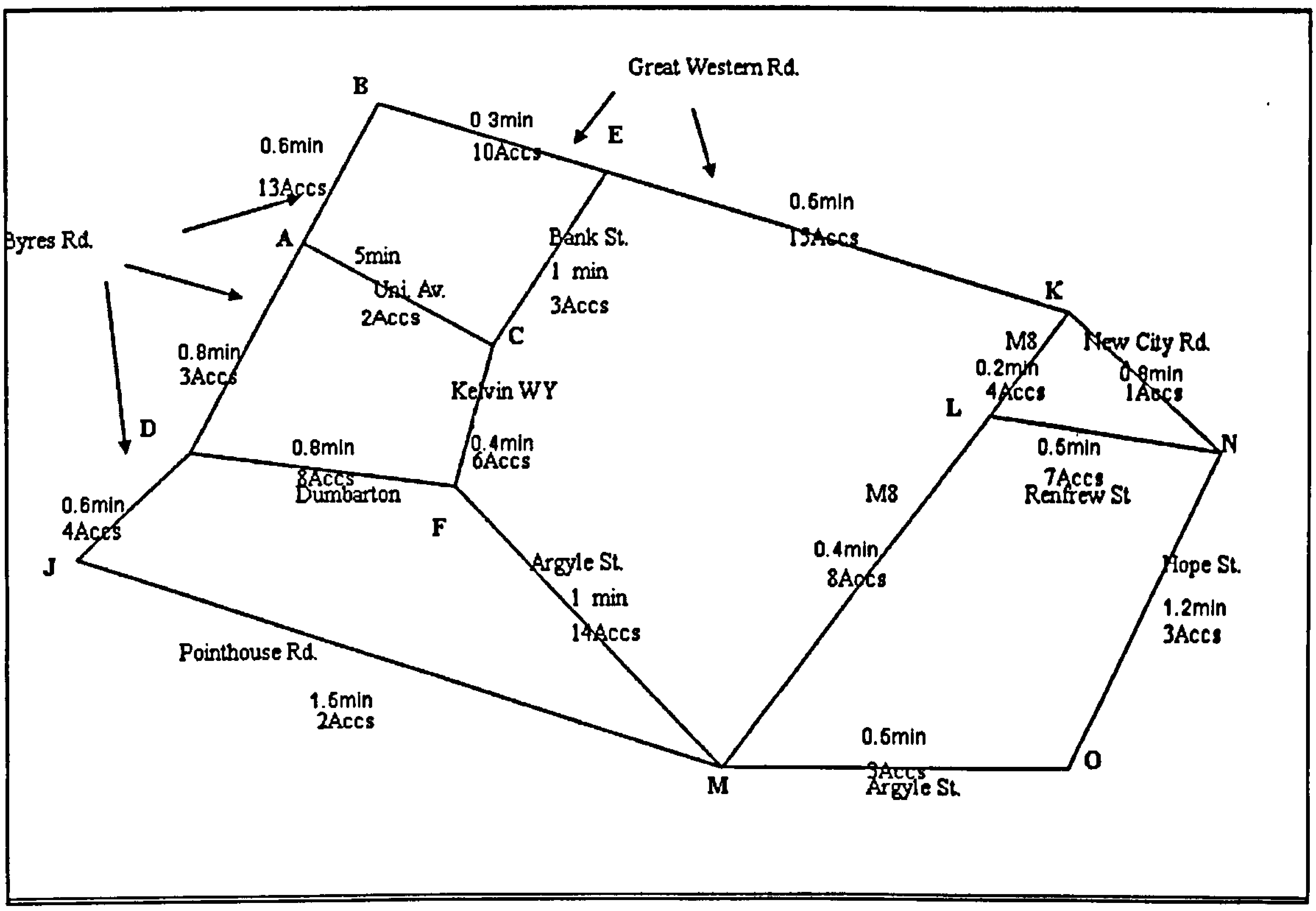


Figure 8.1 Glasgow road map with time and accident information

Our initial experiment focussed on 10 taxi drivers working in the centre of Glasgow, the largest city in Scotland. Table 8.1 presents the results that were obtained when these potential users were asked to rank different routes across the city where they worked. The left-hand section of the table documents the order of preference for routes before accident information was provided. For instance, the row labelled S1 represents the first subject's preference for route R5 above R7, which was preferred over R4 and so on. The right-hand section of Table 8.1 illustrates the changes in preference after the subjects were provided with the map that included information about previous accidents on those routes.

	Route Ranking (no accident information)							Route Ranking (local accident information)						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
S1	R5	R7	R4	R6	R3	R2	R1	R7	R5	R1	R3	R4	R2	R6
S2	R5	R6	R7	R4	R3	R2	R1	R5	R6	R7	R4	R3	R2	R1
S3	R5	R6	R7	R1	R2	R3	R4	R7	R5	R1	R4	R3	R2	R6
S4	R5	R6	R7	R4	R3	R2	R1	R7	R5	R1	R3	R4	R2	R6
S5	R5	R7	R6	R3	R4	R2	R1	R7	R5	R4	R3	R6	R1	R2
S6	R5	R6	R7	R4	R3	R2	R1	R7	R5	R1	R4	R6	R3	R2
S7	R5	R7	R6	R4	R3	R2	R1	R7	R5	R4	R1	R3	R6	R2
S8	R5	R7	R6	R3	R4	R2	R1	R7	R5	R4	R3	R6	R1	R2
S9	R5	R7	R6	R4	R3	R2	R1	R7	R5	R1	R3	R4	R6	R2
S10	R5	R6	R7	R4	R3	R2	R1	R7	R5	R1	R4	R3	R2	R6

Table 8.1 Preferences for the Glasgow route finding task

The Appendix F shows an example of calculating sign test for route 1 (R1).

Table 8.2 shows sign test result on these 7 candidate routes on Glasgow map.

	Number of '+'s	Number of '—'s	Number unchanged	P value
R1	9	0	1	0.004
R2	0	6	4	0.031
R3	4	1	5	0.375
R4	4	3	3	1
R5	0	9	1	0.004
R6	0	9	1	0.004
R7	9	0	1	0.004

Table 8.2 Sign test result for the Glasgow route finding task

Table 8.2 provides the results obtained from applying the Sign test in the manner described in previous sections. The results show that the provision of local road accident information did affect the rankings of all routes. If we choose the 0.05 level of significance then the P-values obtained from a two-tailed sign test show that the provision of this information had a significant impact on the ranking for routes R1, R2, R5, R6 and R7. A two-tailed sign test is appropriate here because we are interested in whether the provision of local accident information increases the ranking of some routes and correspondingly leads to a decrease in the ranking of other routes.

Figure 8.2 shows the experiment map with time and accident information for Manchester.

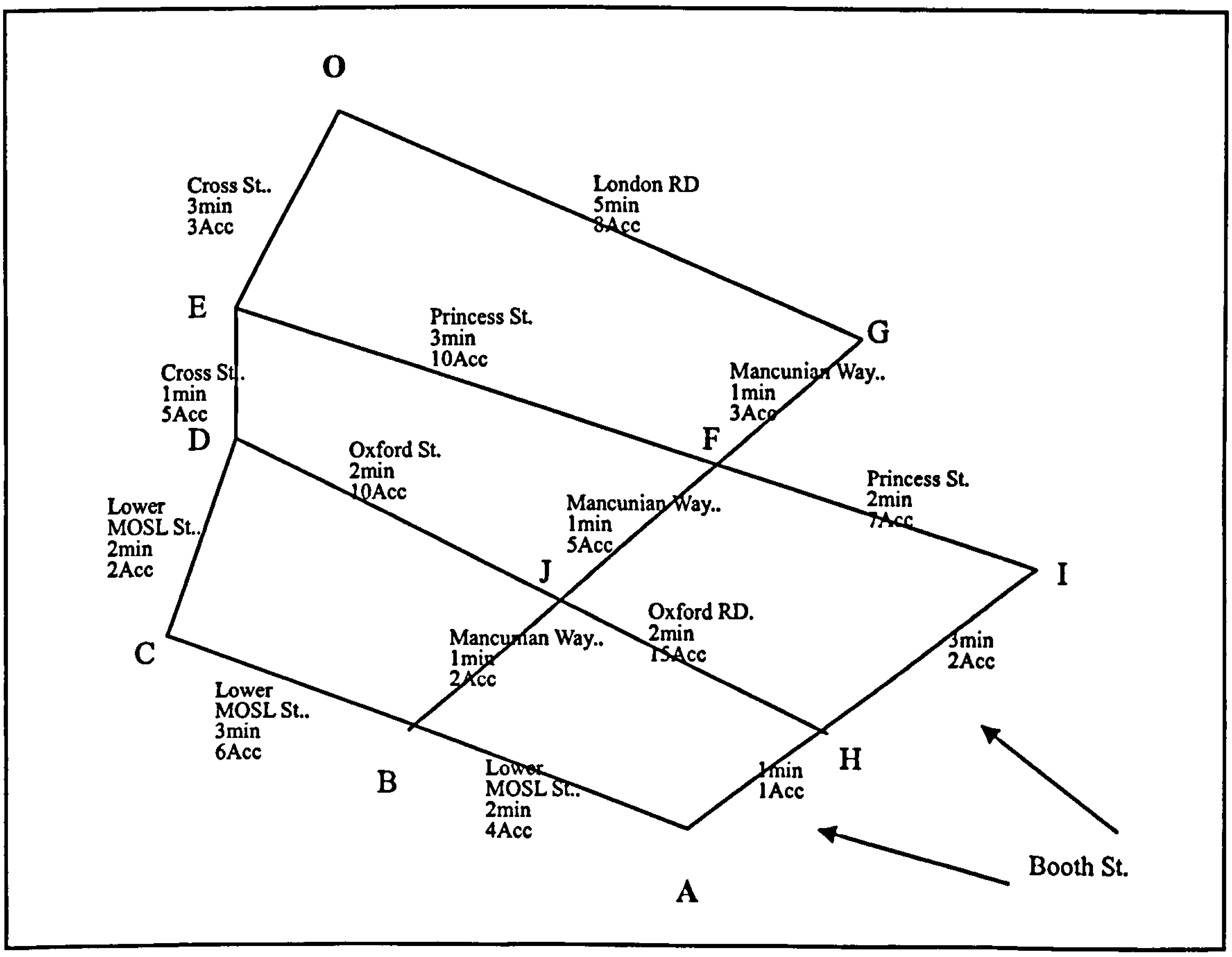


Figure 8.2 The experiment map of Manchester

Table 8.3 provides an overview of the results from the route preference task obtained when the Glasgow taxi drivers were asked to navigate across part of Manchester. Recall that none of the drivers were familiar with the road layout of this city in the North of England. As before, the left hand section of table provides the rankings for the task when the drivers only had access to the information available from existing route finding systems. The right-hand section of the table, in contrast, illustrates the impact on their preferences from providing information about previous accidents on the routes. In order to counter balancing the experiment, half the participants were asked to rank the Manchester City road map first and then rank the Glasgow road map. The other half did the other way around. The reason we did this is because we don't want the order of the experiment affect taxi drivers' judgements. However, in the experiment, all the participants always saw the map with accident information after the map without accident information. The obvious reason is when participants saw the map with accident information first. They would not forget accident information when they saw the map without accident information. Therefore, it will make no difference whether the map with or without such information.

	Route Ranking (no accident information)							Route Ranking (local accident information)						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
S1	R9	R10	R13	R14	R8	R11	R12	R8	R11	R12	R9	R14	R10	R13
S2	R9	R10	R13	R14	R8	R11	R12	R8	R12	R11	R9	R14	R10	R13
S3	R9	R10	R14	R13	R8	R12	R11	R8	R12	R11	R9	R14	R10	R13
S4	R10	R9	R13	R14	R12	R8	R11	R12	R8	R11	R9	R14	R10	R13
S5	R9	R11	R12	R10	R8	R13	R14	R8	R11	R12	R9	R14	R10	R13
S6	R9	R10	R14	R13	R8	R12	R11	R8	R11	R12	R9	R14	R10	R13
S7	R10	R9	R13	R14	R12	R8	R11	R12	R8	R11	R9	R14	R10	R13
S8	R9	R10	R14	R13	R8	R12	R11	R8	R11	R9	R12	R14	R13	R10
S9	R9	R11	R12	R10	R8	R13	R14	R8	R12	R11	R9	R13	R10	R14
S10	R9	R11	R12	R10	R8	R13	R14	R8	R11	R9	R12	R10	R13	R14

Table 8.3 Preferences for the Manchester route finding task

Before looking in more detail at the results of the Sign test, it is worth noting that several pairs of routes were chosen to take the same time. These were (R9, R10), (R11, R12), (R13, R14). However, each element of these pairs was chosen to have a different historic number of accidents. The results in Table 8.4 show that taxi drivers do consider accident information when two routes are shown to require the same time in an unknown location. For instance, subject S1 initially preferred R13 to route R14. After they were provided with the accident information this ranking was reversed. Subjects S2, S4, S5 and S7 reveal a similar pattern while subjects S3 and S6 did not change their initial ranking that placed route R14 before R13. Such descriptive analysis can be supported by the statistical measures of the Sign test in Table 8.4.

	Number of '+'s	Number of '—'s	Number unchanged	P value
R8	10	0	0	0.002
R9	0	10	0	0.002
R10	0	10	0	0.002
R11	7	1	2	0.070
R12	8	1	1	0.040
R13	0	9	1	0.004
R14	1	7	2	0.070

Table 8.4 Sign test result for the Manchester route finding task

Table 8.4 summarizes the results of the Sign test for the Manchester route finding task. As before, the provision of local accident information has an effect on the ranking of all routes. However, the P-values indicate that the effects on the position of routes R8, R9, R10, R12 and R13 were statistically significant. We cannot conclude that the change in ranking of R11 and R14 were due to the provision of accident information and may simply have been due to change experimental effects.

It seems clear that both hypothesis 1 and hypothesis 2 are supported by the results that are summarized in Tables 8.2 and 8.4. The provision of local accident information did have an effect on the ranking of routes for a town that was not well known to the taxi drivers. Access to this information also had an impact on the rankings associated with routes across a city that were used by the taxi drivers every day of their working lives.

Our results showed significant differences for the rankings associated with five of the seven routes in both experimental conditions. This raised questions about the nature of those routes that were unaffected by the provision of information. One possibility is that these were routes that were never actively considered by the drivers, they appeared to be so undesirable that the provision of accident information was largely irrelevant. Debriefing sessions also raised further concerns about the conduct of this initial run. We used a prepared script to ensure that all of the taxi drivers received the same set of instructions. These asked them to "Please rank the following seven routes by order of preference. (From 1, which you think is the best route, to 7 which is your least favourite)." A small number of the drivers in this study were confused by this instruction and asked whether they were being asked to base their selection on speed or cost. We deliberately did not want to bias the criteria that they might use in their ranking. We, therefore, decided to conduct a second study using the same method but with ten more taxi drivers. The experimental instructions were changed to "From the point of view of your work as a taxi driver, please rank the following routes in order of preference from 1 to 7 where the first is the route that you would definitely use and the last is the route that you would be least likely to use."

We also decided to simplify the experiment slightly by marking the total time and cumulative number of accidents next to each route. Table 8.5 illustrates the results for this second cohort of taxi drivers on the routes across Glasgow city centre. Table 8.6 presents the results from the Sign test applied to this second set of route preferences in an area that is already familiar to the drivers.

	Route Ranking (no accident information)							Route Ranking (local accident information)						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
S11	R5	R6	R7	R3	R4	R2	R1	R7	R5	R4	R6	R3	R1	R2
S12	R5	R6	R7	R3	R4	R2	R1	R7	R5	R6	R4	R3	R2	R1
S13	R5	R6	R7	R4	R3	R2	R1	R7	R5	R4	R6	R3	R1	R2
S14	R5	R6	R7	R4	R3	R2	R1	R7	R5	R4	R6	R3	R1	R2
S15	R5	R7	R6	R4	R3	R2	R1	R7	R5	R4	R1	R3	R6	R2
S16	R5	R6	R7	R3	R4	R2	R1	R7	R5	R6	R4	R3	R2	R1
S17	R5	R6	R7	R4	R3	R2	R1	R7	R5	R4	R6	R3	R1	R2
S18	R5	R7	R6	R3	R4	R2	R1	R7	R5	R6	R4	R3	R1	R2
S19	R5	R7	R6	R4	R3	R2	R1	R7	R5	R6	R4	R3	R1	R2
S20	R5	R6	R7	R3	R4	R2	R1	R7	R5	R4	R6	R3	R1	R2

Table 8.5 Second Group of Taxi Drivers' Preferences on Glasgow route finding task

	Number of '+'s	Number of '—'s	Number unchanged	P value
R1	8	0	2	0.008
R2	0	8	2	0.008
R3	0	5	5	0.063
R4	9	0	1	0.004
R5	0	10	0	0.002
R6	0	8	2	0.008
R7	10	0	0	0.002

Table 8.6 Sign test result for the Second Group's Glasgow route finding task

As can be seen, the addition of localised accident information had a statistically significant impact on the ranking of all routes except for R3. It can be argued that by clarifying the experimental briefing and by providing cumulative totals for expected delays and raw accident frequencies, the provision of this additional safety information has had a clear effect on the taxi drivers' rankings for the routes across the roads of a city where they work. Table 8.7 goes on to summarise the rankings associated with the Manchester routes for this second cohort of taxi drivers.

	Route Ranking (no accident information) 1	2	3	4	5	6	7	**Route Ranking (local accident information)** 1	2	3	4	5	6	7
S11	R9	R10	R13	R14	R8	R11	R12	R8	R12	R9	R11	R14	R10	R13
S12	R9	R10	R13	R14	R8	R11	R12	R8	R12	R9	R11	R10	R14	R13
S13	R9	R10	R14	R13	R8	R11	R12	R8	R12	R11	R9	R14	R10	R13
S14	R10	R9	R13	R14	R12	R8	R11	R8	R12	R9	R11	R10	R14	R13
S15	R9	R10	R14	R13	R8	R11	R12	R8	R12	R9	R11	R10	R14	R13
S16	R9	R10	R14	R13	R8	R11	R12	R8	R12	R9	R11	R14	R10	R13
S17	R10	R9	R13	R14	R12	R8	R11	R8	R12	R9	R11	R10	R14	R13
S18	R9	R10	R14	R13	R8	R11	R12	R8	R12	R9	R11	R10	R14	R13
S19	R9	R10	R14	R13	R8	R12	R11	R8	R12	R11	R9	R14	R10	R13
S20	R9	R10	R13	R14	R8	R11	R12	R8	R12	R11	R9	R10	R13	R14

Table 8.7 Second Group's Preferences on Manchester route finding task

Table 8.8 presents the results of the Sign test on this second cohort of preferences from the Manchester study. As can be seen, the provision of localised accident information had a significant impact on the rankings associated with every route across this 'unfamiliar' road system. It is important to stress that the sign test does not provide a quantitative assessment of the strength of any effect. If a particular route were to be downgraded from first to seventh place then this would be registered as a single '-' value in the Sign test. However, the unequivocal results from this stage of our study in Table 8.8 illustrate the impact of localized accident information on the taxi drivers in our study.

	Number of '+'s	Number of '—'s	Number unchanged	P value
R8	10	0	0	0.002
R9	0	10	0	0.002
R10	0	10	0	0.002
R11	10	0	0	0.002
R12	10	0	0	0.002
R13	0	10	0	0.002
R14	0	10	0	0.002

Table 8.8 Sign test result for the Second Group's Manchester route finding task

The results from this second group show that the rankings for six of the seven Glasgow routes support hypothesis 1. In other words, the ten taxi drivers changed their initial route preferences once they had been provided with information about previous accidents on those routes. In the case of the

Manchester routes, that were not previously familiar to the taxi drivers, all of the route preferences changed as a result of the accident information. Of course, neither of these findings implies any consequent change in behaviour. There is no guarantee that the taxi drivers will use the accident information during their work, just as there is no guarantee that a driver will follow the fastest or cheapest route recommended by conventional planning software. Route planning depends on the knowledge and skill of the navigator. Our studies have, however, shown that the provision of localised accident information can have an impact on these complex, problem solving tasks. It is important to acknowledge, however, that our results do not provide anything like a complete theoretical understanding of the cognitive processes that are involved in the exploitation of local, historical accident information. For instance, some drivers may rate safety information more highly than their peers. Only driver S2 from the first group of the Glasgow users did not change any of his rankings after being presented with the accident information summarised in Table 8.9. As mentioned, however, this may have been due to the way in which the task was presented. However, further studies are required to determine whether the revised procedure with the second group would entirely eliminate this observed behaviour or whether S2 is typical of a persistent group of road users who would not be influenced by the previous number of accidents over the routes that they use every day.

Identifier	Nodes	Total estimate time (seconds)	Cumulative number of accidents
R1	ABEKNO	204	42
R2	ABEKLNO	198	52
R3	ACEKLNO	234	34
R4	ACEKNO	240	24
R5	ACFMO	144	25
R6	ADFMO	186	28
R7	ADJMO	204	12

Table 8.9 Summary of Routes in the Glasgow Map

Table 8.9 summarises the routes from the Glasgow map that was used in both groups of this study. As mentioned, there were 20 taxi drivers in both groups. If accident related information had been the main determinant in route planning then we might have expected that most would have chosen the order R7, R4, R5, R6, R3, R1 and R2. However, none of the drivers in the first or second cohorts chose this ordering. Instead, five chose a single permutation of R5 and R4. In other words, they chose: R7, R5, R4, R6, R3, R1 and R2. This apparent inconsistency can be explained in terms of the similarity between R4, with 24 accidents, and R5 with 25. It seems likely that they were trading the single additional accident against a larger time saving with R5's estimated 144 seconds being preferred to R4's 240 seconds.

At one level it can be argued that the taxi drivers were employing a relatively simple form of satisfying. In other words, they were willing to trade a certain degree of speed against a higher number of accidents and vice versa. For example, R6 (28) has had more accidents than R4 (24). However, R6 has an estimated journey time of only 186 seconds compared to 240 seconds for R4. In the second cohort, four drivers ranked R6 above R4. Six taxi drivers rated R4 above R6. It might, therefore, be argued that such differences illustrate a degree of risk preference and aversion when faced with similar routes. However, there is also evidence of more complex forms of constraint satisfaction that go beyond simple trade-offs between time and safety. R1 was the least preferred route on the Glasgow map even though it was not the route with the highest average journey time. 19 out of the 20 drivers put it in last place in their ranking. This would seem to indicate that the drivers relied upon outside knowledge that was not fully being captured in the simple timings that we presented. However, when additional information was provided about the number of local accidents most drivers revised their choice. Recall that R2 had 52 accidents compared to 42 for R1 and that the difference in estimated journey time was only six seconds. In consequence, thirteen of the twenty drivers revised their ranking to put R2 in last place.

Identifier	Nodes	Total estimate time (seconds)	Cumulative number of accidents
R8	ABCDEO	660	20
R9	ABJDEO	540	24
R10	AHJDEO	540	34
R11	AHIFEO	720	23
R12	AHIFGO	720	21
R13	AHJFEO	600	34
R14	AHJFGO	600	32

Table 8.10 Summary of Routes in the Manchester Map

Table 8.10 provides a summary of the cumulative accident frequencies and estimated journey times for the Manchester routes, which were not familiar to either group of taxi drivers. The pattern of results for both individual subjects and for particular routes is broadly similar to that for the Glasgow journeys. There are, however, some important differences. Unlike the local route-planning task, there is no individual who retained his or her original preference list after being shown the accident information. This tends to confirm our suggestion that the individual from the first cohort of the Glasgow study may have shown an inelastic preferences for routes with which they were very familiar. However, that same individual appears more willing to revise their preferences for routes that they do not drive every day. This is an important finding because it implies that there will be some value added from the provision of accident information given that individuals are less likely to use route-planning software for routes that they already know very well. However, as mentioned in previous paragraphs, further work is required to support this additional hypothesis.

If taxi drivers' preferences were being determined by the number of accidents alone then one might have expected most participants to opt for the sequence R8, R12, R11, R9, R14, R10, R13. As with the Glasgow study, things were not this straightforward. Only four of the taxi drivers chose this ranking after being presented with the accident information. The remaining drivers seemed to exhibit the same satisfying behaviour that was observed in the previous paragraphs. Trade-offs are being made between journey time and accidents. It can, however, be argued that the interpretation of these results is simpler because the drivers did not have any previous experience of navigating in Manchester city centre.

8.5 Conclusion

The main contribution of this chapter is that we carried out route planning experiments on taxi drivers and find that road accident information has some impact on their route planning decisions. However, the design of this experiment does not consider other factors that may affect drivers' decision on route choices. The sign test suggests the extra information (accident information) may have influence on drivers' decision. But we can not conclude that local accident information will affect drivers' safety awareness. Further researches can be done to perform some stronger tests which compare road accident information against other form of information, such as news agent locations, or pub locations. Once we find out that road accident information have stronger impacts on drivers' route planning decision than other form of information. We can say local accident information will affect drivers' safety awareness.

Chapter 9

Route Planning Experiment with University Staff and Students

From the above study, we can see localized accident information has a significant impact on taxi drivers' route planning. In other words, they considered safety as one factor when planning their journey during our experiment. The use of taxi drivers in the experiment has advantages and disadvantages. It is certainly true that this subset of drivers has a commercial and personal motivation to consider accident information. This subset provides an interesting cross-section of participants who are very familiar with many routes, and thus the population seems a reasonable choice. However, taxi drivers are a special group. Few drivers would have same knowledge of local roads as taxi drivers. Few other drivers have the same high-risk exposure as taxi drivers. Research [1] shows, "Buses, taxis and emergency vehicles were found to be over-represented in accidents on urban roads of all classifications. Those driving buses, taxis and emergency vehicles, suffered more accidents primarily caused by other road users. Their problem was therefore predominantly one of exposure to dangerous environments."

In order to see whether localized accident information has a significant impact on other drivers, we repeated our experiment with university staff and students. This group typically do not live on driving. They don't have the same high-risk exposure as taxi drivers. They don't consider route planning often as taxi drivers. This group usually have a higher level of education than taxi drivers.

9.1 Experiment Design

Hypotheses

Hypothesis 1: Local road accident information would affect people's choice in the rankings of the candidate routes.

Hypothesis 2: People's own local experience would affect their choice in the rankings of the candidate routes.

Independent Variable:

Road accident information

Dependent Variable:

The rankings of the candidate routes and locations

This was a within subject design. Two scenarios were involved in this experiment. The first one provided users with time information, which indicated how much time drivers may spend on each road section. The task was to drive from point A to point O (See Figure 9.1 and Figure 9.2). Participants needed to rank 7 candidate routes. The second condition provided users with both time and accident information. This told participants how many accidents happened on each road section last year. The task remained the same. Participants had to do the experiment on two different maps. One was a Glasgow city map, the other was a Manchester city map. We chose 10 staffs and 10 students from University of Glasgow to do the experiment.

9.2 Measurement and Tests

Same as chapter 8, we use Sign test to analyse the experiment.

9.3 Results and Analysis

Figure 9.1 shows the experiment map with time and accident information for Glasgow.

This is the same as before but we repeat it here to help readers follow the analysis in this chapter.

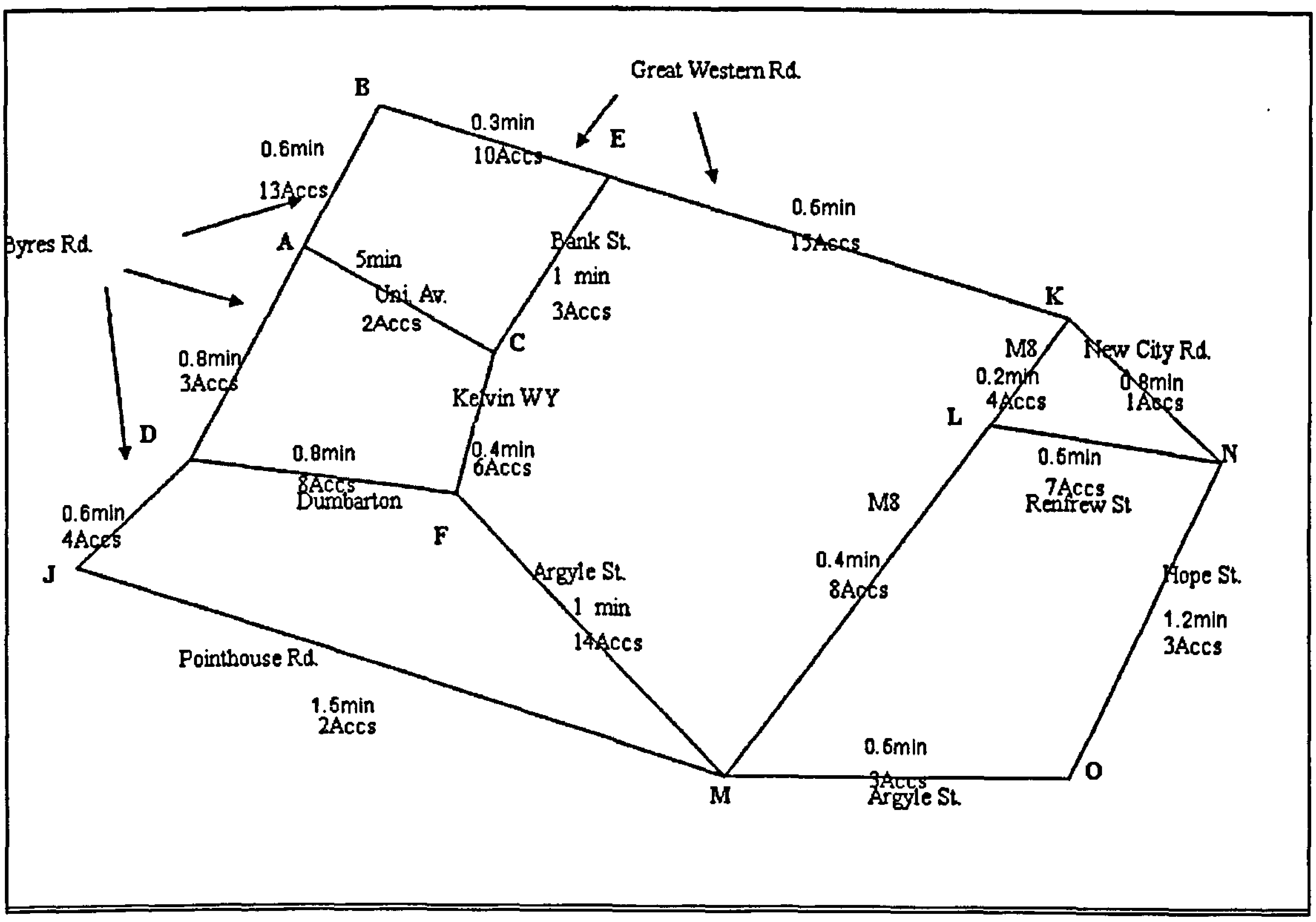


Figure 9.1 Glasgow road map with time and accident information

Table 9.1 presents the results that were obtained from 10 university staff.

The left-hand section of the table documents the order of preference for routes before accident information was provided. The right-hand section of Table 8.1 illustrates the changes in preference after the subjects were provided with the map that included information about previous accidents on those routes.

	Route Ranking														
	(no accident information)								(local accident information)						
	1	2	3	4	5	6	7		1	2	3	4	5	6	7
S1	R5	R6	R7	R3	R4	R2	R1		R7	R5	R4	R6	R3	R1	R2
S2	R5	R6	R7	R4	R3	R2	R1		R7	R5	R6	R4	R3	R2	R1
S3	R5	R6	R7	R3	R4	R2	R1		R7	R5	R6	R4	R3	R1	R2
S4	R5	R6	R7	R3	R4	R2	R1		R7	R5	R6	R4	R3	R1	R2
S5	R5	R6	R7	R3	R4	R2	R1		R7	R5	R4	R6	R3	R1	R2
S6	R5	R6	R7	R3	R4	R2	R1		R7	R5	R4	R6	R3	R1	R2
S7	R5	R6	R7	R3	R4	R2	R1		R7	R5	R6	R4	R3	R2	R1
S8	R5	R6	R7	R3	R4	R2	R1		R7	R5	R6	R4	R3	R2	R1
S9	R5	R6	R7	R3	R4	R2	R1		R7	R5	R6	R4	R3	R1	R2
S10	R5	R6	R7	R3	R4	R2	R1		R7	R5	R6	R4	R3	R1	R2

Table 9.1 10 university staff's preferences on Glasgow route finding task

Table 9.2 shows sign test result on these 7 candidate routes on Glasgow map.

	Number of '+'s	Number of '—'s	Number unchanged	p value
R1	7	0	3	0.016
R2	0	7	3	0.016
R3	0	9	1	0.004
R4	9	0	1	0.004
R5	0	10	0	0.002
R6	0	10	0	0.002
R7	10	0	0	0.002

Table 9.2 Sign test result for the Glasgow route finding task (university staff)

The results show that the provision of local road accident information did affect the rankings of all routes. If we choose the 0.05 level of significance then the P-values obtained from a two-tailed sign test show that the provision of this information had a significant impact on the ranking for all routes.

Figure 9.2 shows the experiment map with time and accident information for Manchester.

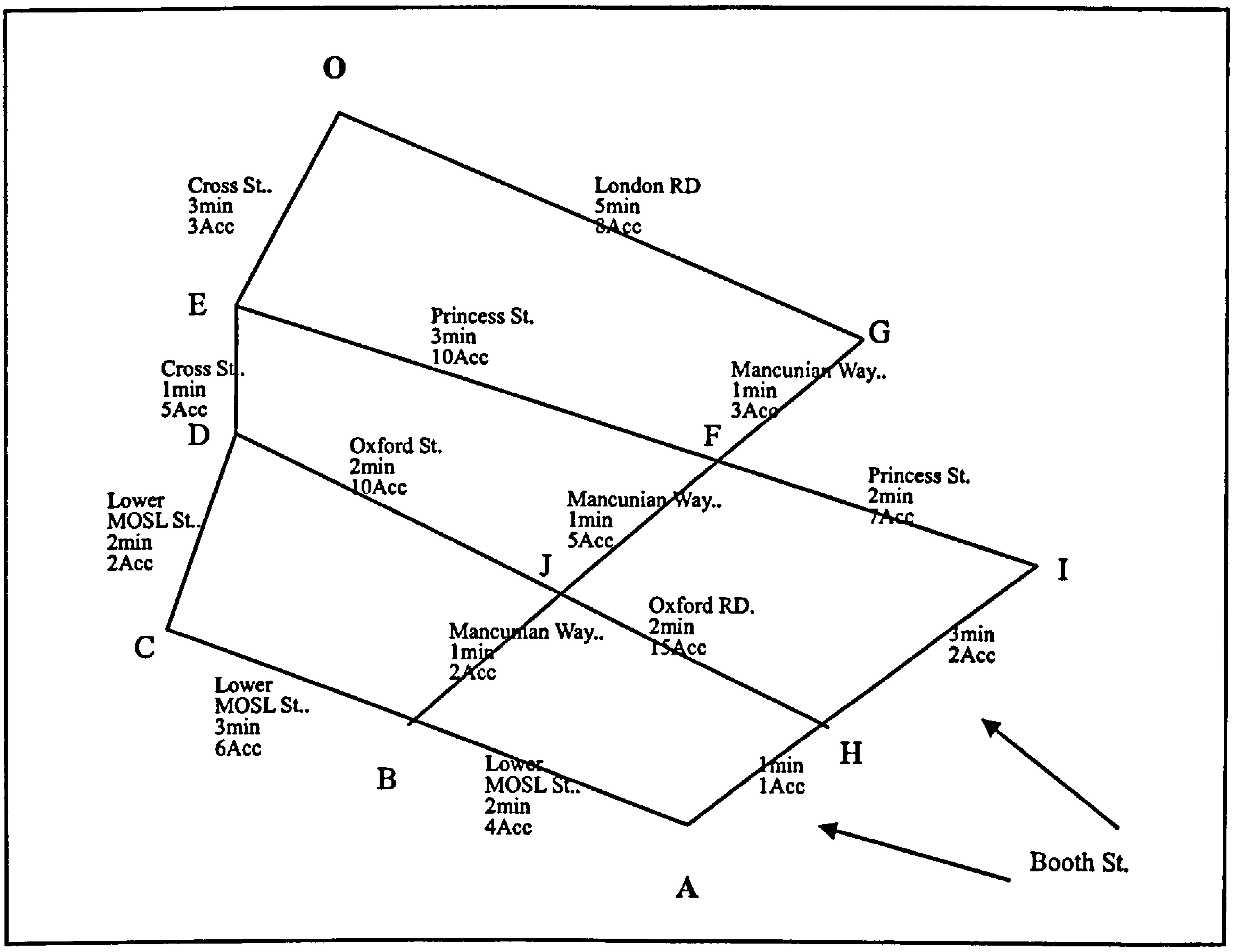


Figure 9.2 The experiment map of Manchester

Table 9.3 provides an overview of the results from the route preference task obtained when 10 members of university staff were asked to navigate across part of Manchester. None of them were familiar with the road layout of Manchester. As before, the left hand section of table provides the rankings for the task when the drivers only had access to the information available from existing route finding systems. The right-hand section of the table, in contrast, illustrates the impact on their preferences from providing information about previous accidents on the routes. Same as taxi drivers' experiment, half the participants were asked to rank the Manchester City road map first and half the participants were asked to rank the Glasgow road map first.

	Route Ranking														
	(no accident information)								(local accident information)						
	1	2	3	4	5	6	7		1	2	3	4	5	6	7
S1	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S2	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S3	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R14	R10	R13
S4	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S5	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S6	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S7	R9	R10	R14	R13	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S8	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R14	R10	R13
S9	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S10	R9	R10	R14	R13	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13

Table 9.3 Preferences for the Manchester route finding task (university staff)

As we mentioned in Chapter 8, several pairs of routes were chosen to take the same time. These were (R9, R10), (R11, R12), (R13, R14). However, each element of these pairs was chosen to have a different historic number of accidents. The results in Table 9.3 show that university staff do consider accident information when two routes are shown to require the same time in an unknown location. For instance, subject S1 initially preferred R13 to route R14. After they were provided with the accident information this ranking was reversed. Subjects S2, S3, S4, S5, S6, S8 and S9 reveal a similar pattern while subjects S7 and S10 did not change their initial ranking that placed route R14 before R13. Such descriptive analysis can be supported by the statistical measures of the Sign test in Table 9.4

	Number of '+'s	Number of '—'s	Number unchanged	P value
R8	10	0	0	0.002
R9	0	10	0	0.002
R10	0	10	0	0.002
R11	10	0	0	0.002
R12	10	0	0	0.002
R13	0	10	0	0.002
R14	0	10	0	0.002

Table 9.4 Sign test result for the Manchester route finding task (university staff)

Table 9.4 summarizes the results of the Sign test for the Manchester route finding task. As before, the provision of local accident information has an effect on the ranking of all routes. In the case of the Manchester routes, that were not previously familiar to the university staff, all of the route preferences changed as a result of the accident information.

It seems clear that both hypothesis 1 and hypothesis 2 are supported by the results that are summarized in Tables 9.2 and 9.4. The provision of local accident information did have an effect on the ranking of routes for a town that was not well known to the university staff. Access to this information also had an impact on the rankings associated with routes across a city that were used by the university staffs every day.

Table 9.5 presents the results that were obtained from 10 university students. Table 9.6 presents the results from the Sign test applied to this set of route preference.

	Route Ranking (no accident information)								(local accident information)						
	1	2	3	4	5	6	7		1	2	3	4	5	6	7
S1	R5	R6	R7	R2	R1	R3	R4		R7	R5	R6	R4	R3	R1	R2
S2	R5	R6	R7	R2	R1	R3	R4		R7	R5	R6	R4	R3	R1	R2
S3	R5	R6	R7	R2	R1	R3	R4		R7	R5	R6	R4	R3	R1	R2
S4	R5	R6	R7	R2	R1	R3	R4		R7	R5	R6	R4	R3	R1	R2
S5	R5	R6	R7	R3	R4	R2	R1		R7	R5	R6	R4	R3	R2	R1
S6	R5	R6	R7	R2	R1	R3	R4		R7	R5	R6	R4	R3	R1	R2
S7	R5	R6	R7	R2	R1	R3	R4		R7	R5	R6	R4	R3	R2	R1
S8	R5	R6	R7	R2	R1	R3	R4		R7	R5	R6	R4	R3	R1	R2
S9	R5	R6	R7	R2	R1	R3	R4		R7	R5	R6	R4	R3	R1	R2
S10	R5	R6	R7	R2	R1	R3	R4		R7	R5	R6	R4	R3	R2	R1

Table 9.5 Preferences for the Manchester route finding task (university students)

	Number of '+'s	Number of '—'s	Number unchanged	P value
R1	0	9	1	0.004
R2	0	9	1	0.004
R3	9	1	0	0.004
R4	10	0	0	0.002
R5	0	10	0	0.002
R6	0	10	0	0.002
R7	10	0	0	0.002

Table 9.6 Sign test result for the Glasgow route finding task (university students)

Results show that the provision of accident information had a significant impact on the ranking for all routes. The same results can be found in the Manchester map in Table 9.7 and 9.8.

	Route Ranking (no accident information)								Route Ranking (local accident information)						
	1	2	3	4	5	6	7		1	2	3	4	5	6	7
S1	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R14	R10	R13
S2	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S3	R9	R10	R14	R13	R8	R11	R12		R8	R12	R9	R11	R14	R10	R13
S4	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S5	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S6	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S7	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R14	R10	R13
S8	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S9	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13
S10	R9	R10	R13	R14	R8	R11	R12		R8	R12	R9	R11	R10	R14	R13

Table 9.7 Preferences for the Manchester route finding task (university students)

	Number of '+'s	Number of '—'s	Number unchanged	P value
R8	10	0	0	0.002
R9	0	10	0	0.002
R10	0	10	0	0.002
R11	10	0	0	0.002
R12	10	0	0	0.002
R13	0	10	0	0.002
R14	0	10	0	0.002

Table 9.8 Sign test result for the Manchester route finding task (university students)

As mentioned in Chapter 8, none of these findings implies any consequent change in behaviour. Our studies have, however, shown that the provision of localised accident information can have an impact on these complex, problem solving tasks. It is important to acknowledge, however, that our results do not provide anything like a complete theoretical understanding of the cognitive processes that are involved in the exploitation of local, historical accident information.

9.4 Conclusion

Route planning is an activity in which people use their own knowledge and experience to perform. Our experiment chose route planning to assess people's safety awareness: in other words, do they consider road accident information when they plan their journey? We believe the result from the experiment supports our argument that detailed local traffic accident information has an impact on people's safety awareness and behaviour since the national statistics on this problem appear to have had little impact.

From the experiment, we have gathered support for our two hypotheses. Firstly, the provision of local accident information does have an impact on the routes that drivers select in areas that they are already familiar with. Secondly, this effect can also be seen when drivers have access to information about towns that they are less familiar with. Our results were obtained from studies with a group of taxi drivers because these users typically have the greatest exposure to risk, illustrated by correspondingly high insurance premiums. We also obtained results from studies with a group of university staff and students.

As mentioned, we have already developed a web-based system for presenting localised accident information. As we developed this tool to provide route-planning functionality, a number of additional problems have arisen. Many of these were not directly considered within our study. In particular, the journeys in our system are over relatively short distances within two city centres. Hence, we have a relatively low number of accidents for each route within our data set and it is possible to provide the drivers with raw accident frequencies over a five or ten year window. As we expand the length of a route then these frequencies become increasingly problematic, as there may be several thousand accidents on a journey of an hour or more over busy local roads. Previous sections have also argued that raw cumulative accident frequencies ignore the different traffic volumes that pass over each route. It is relatively straightforward to factor traffic flows into the calculation of accident rates rather than frequencies. However, it can be difficult to explain the resulting cumulative rates to a broad group of end users. For example, comparable risk exposures can be derived from a prolonged period of driving on a road with a medium accident rate or from a short period driving on a road with a high accident rate followed by a longer period driving on a 'low risk' road.

If we are to move from raw accident frequencies to consider issues of risk exposure then there seems to be considerable scope for the development of appropriate interfaces that might mask some of the underlying complexity from end-users, such as our taxi drivers, who have a significant interest in using this data. We are currently experimenting with extensions to existing route planning systems. These already offer users planning criteria such as 'avoid motorways' or 'avoid toll roads and congestion charging'. Further work is required to determine whether this supports the more complex trade-offs between time and risk that seem to be emerging from our study of route planning behaviour by the two groups of drivers.

A natural extension of many of the ideas in this thesis would be to integrate local accident information into an in-car GPS navigation system. This would be relatively straightforward with accident frequency updates being supplied with each map upgrade. The existing web-based accident information system draws its updates directly from the national accident records supplied indirectly to the public by regional police forces. Local accident information might be used by in-car systems in the manner described above for more conventional route planning software. The provision of GPS also enables the use of visual or audio warnings to inform drivers when they enter an accident 'hotspot'. It is important not to underestimate the importance of such potential applications. However, the problem for such warning system is it may cause distraction to drivers. Moreover, displayed accident information should be detailed but brief so that drivers don't need much time to read it during the driving. Therefore, different user interfaces may be required for different user groups, such as taxi drivers and university staff and students. All these questions are all need further research work to find out the best solutions.

Overall, the main contribution of this chapter is that we carried out route planning experiments on university students and staffs and find that road accident information has some impact on their route planning decisions. However, as mentioned in chapter 8, the design of this experiment does not consider other factors that may affect drivers' decision on route choices. The sign test suggests the extra information (accident information) may have influence on drivers' decision. But we can not conclude that local accident information will affect drivers' safety awareness. Further researches can be done to perform some stronger tests which compare road accident information against other form of information, such as news agent locations, or pub locations. Once we find out that road accident information have stronger impacts on drivers' route planning decision than other form of information. We can say local accident information will affect drivers' safety awareness.

Chapter 10
Conclusions and Future Work

10.1 Conclusions

Our study was based on the hypothesis that existing road safety advice depends too much on the use of national statistics and localized information may have more impact on people's safety awareness. We carried out an evaluation on existing road safety campaign websites which provide mainly high level national statistics. The result shows that the information on the websites made little impact.

Then with advice from experts in Glasgow City Council and the Highway Agency, we developed a localized accident information system. The same evaluation method for government websites was carried out. The result showed some impact on people's awareness, but it was not as big as we had anticipated. We therefore used other methods to assess the impact of local accident information on people's safety awareness. These included focus group discussion and a route planning experiment.

The result from these two methods gave us more positive feedback and the experiment shows that taxi drivers do consider accident information when two routes are shown to require the same time in an unknown location. Access to such information also had an impact on the rankings associated with routes across a city that were used by the taxi drivers every day of their working lives. But it is still early to say which is better, a high level national safety campaign or local accident information system since as I pointed out in chapter 7, the local accident information system has much room for improvement. It seems unlikely, furthermore, that many of the effects that we observed for our taxi drivers will be equally apparent for all drivers.

10.2 Future Work

The study has found that road users are interested in local accident information and such information may affect people's safety awareness. However, in order to find out whether local accident information has more impact on people's safety awareness than high level accident statistics, we need to include more kinds of road users in the study. We may also need to divide these people into several sub groups, such as drivers, cyclists, pedestrians, and so on. This is because different road user groups may have different requirements in accident information. For example, pedestrians may only care about pedestrian-involved accident information. Other information would have little impact on their safety awareness. Moreover, we need more experiments to find out ways to improve the impact of localized road accident information on people's safety awareness.

I now discuss possible future research from following three aspects: information, interaction and prediction.

a) Information

Local accident information can help people to assess the safety of their environment. However, each accident record holds lots of detailed information. Some users may not need all of this, different road users may be interested in some specific information. In the future, experiments are needed to identify the information most important to road users.

Brief description. In the early stage of the study, experts from Glasgow city council suggested to giving a brief description of each accident. Currently, I directly display all the columns from the database. It is not clear if users can obtain a coherent overview from all of the values and codes. An experiment is needed to decide whether 'brief description' is a good idea and what kind of information should be included in this description.

Advice from experts. Our study shows that since people are less interested in high level national statistics on government road safety campaign websites, they won't go there voluntarily. However, they think that advice and guidelines on the websites are useful. Figure 10.1 shows advice from the "Think!" website. Therefore, adding advice to a localized accident information system could be more effective than those websites. Moreover, advice normally focuses on specific road user groups or locations (road type) or special conditions (winter driving, driving when tired). When users search for specific kinds of accidents, they could also be given advice on how to avoid this type of accident.

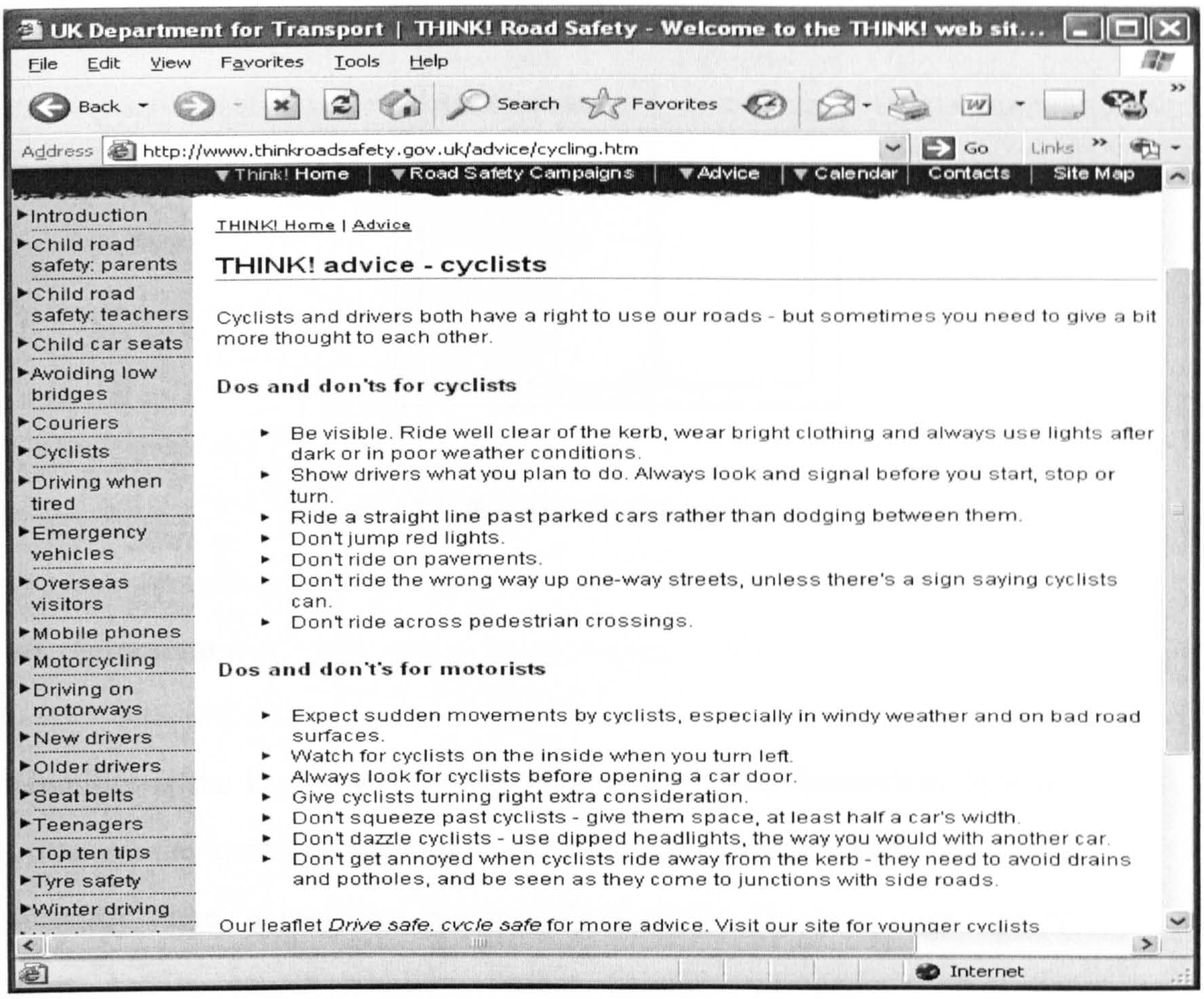


Figure 10.1 Advices on "Think!" website

Pictures. From our focus group discussion, some people feel that shocking images could have a big impact on people's safety awareness. These have already been used in a UK government TV campaign showing the consequences of cars colliding. If pictures from accident scenes can be seen in our system, this might be also alert people about safety issues. Pictures from an accident location will show geometry features of that area. The pictures can be added to the full accident information panel (see figure 10.2). However, this raises a lot of ethical issues and requires careful consideration. It may be very disturbing to the relatives of anyone killed in such an accident, even if graphical reconstructions were used rather than actual photographs.

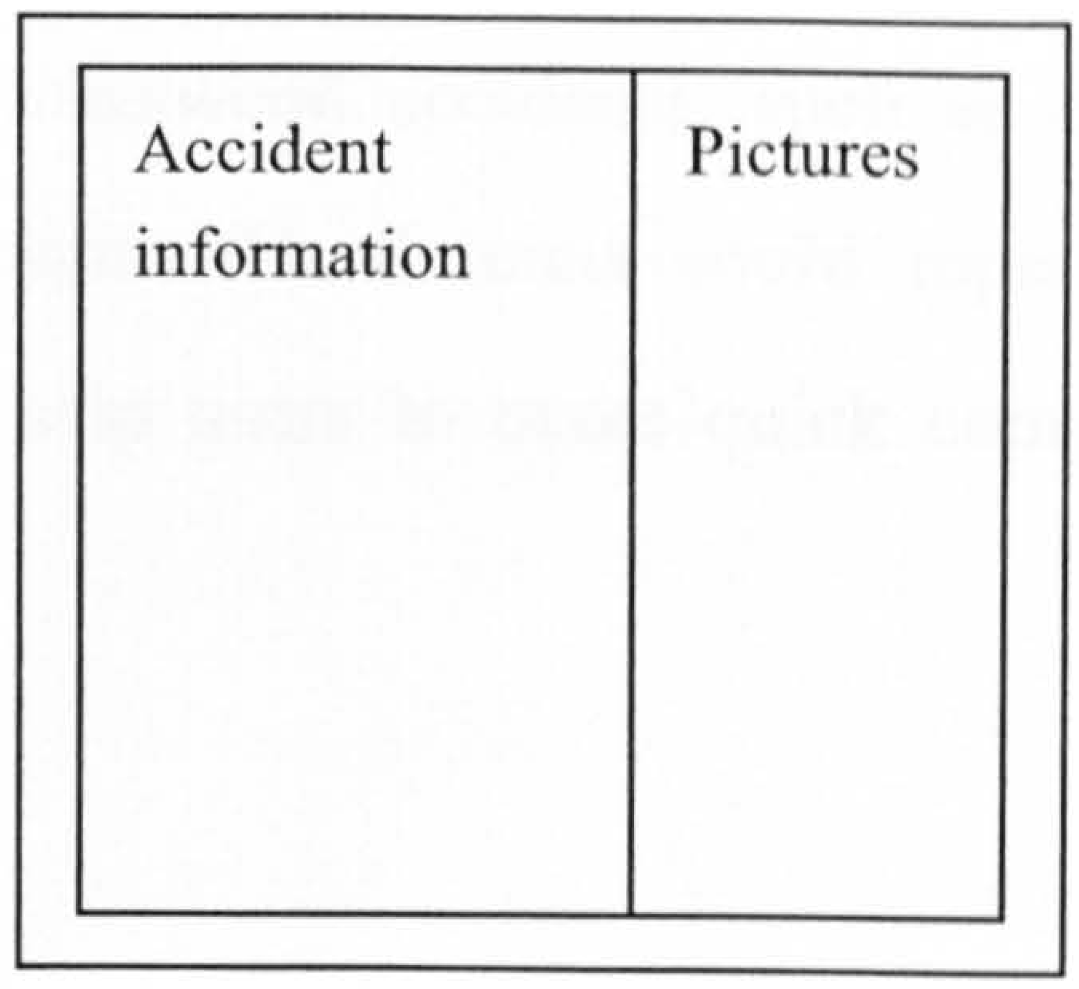


Figure 10.2 Pictures in the system.

b) Interaction

Usability is the key issue of every Human Computer Interaction System. Although the system evaluation shows people are satisfied with the current interface, there are problems. Some symbols overlap, the query speed can be slow, and so on. In addition, further development might support the following:

Display accidents by area or roads. When users want to see the situation in a specific area, such as a junction, they could use a mouse to drag a circle and then information about all the accidents in this area would be displayed. Similarly, if users click on a road or select a road name from a drop down list, accidents on that road would show up.

Fish eye function. Although I provide zoom in and out, users sometimes want to see detailed information on a large scale background. Providing functions like a magnifier, users could quickly browse the whole map with more accurate information.

Self defined icons. Currently, I use different shapes to code accidents by their severity. In the future, users could define their own icon groups to identify other relationships between accidents, such as different weather conditions, different car type. Mixed icons could represent multi level information. These might help users to make quick comparisons and get more information directly.

c) Prediction

As mentioned in chapter 1, Prediction is another way to reduce accidents by identifying potential problem areas. If we add prediction into our system, people can see what may happen in the future. But first, we need to do research to see whether people are interested in prediction. The experiment may be similar to the one in this study. If the prediction can affect people's decisions, then the study can carry on to build a prediction model.

Research into prediction of road traffic accidents has been carried out for many years. There are many approaches to prediction. The first is accident observation or a 'before and after' study. Accident totals or rates can be compared at treated sites in the periods before and after an implementation; sites can be ranked according to their observed accident totals and/or rates [53]. But accident counts are prone to sources of error [33, 56, 43]. Accident rates are normally used to allow for variations in exposure to compare safety levels at different locations or times on the assumption that a lower accident rate indicates a safer site. However, if the relationship between accidents and exposure is non-linear, accident rates will vary with exposure so that a lower accident rate would not necessarily imply a safer site [34].

Then researchers have tried to find suitable prediction models which relate accident occurrence to traffic volume and a range of attributes such as road geometry features, traffic control features, and so on. In the early years, people used multiple linear regression modelling, with its assumption that accident counts follow a normal distribution. Then people found it is far better to model the process using the Poisson distribution for the frequency of accidents in a given period of time at any one site. Examples of this model can be found in Jovanis and Chang's research [48]. Since people realized the advantages of the Poisson model over the standard regression model, generalized linear models have become popular to develop the desired forms of relationships using a Poisson model [47, 101].

Although the Poisson model offers significant advances in accurate and reliable modelling, it has some weaknesses. One is called the "overdispersion" phenomenon. In the pure Poisson model, the variance is equal to its mean. But in practice, actual accident variance has been found to be greater than the mean. Recent studies have proved that the negative binomial distribution might be more appropriate because it allows greater variance in the data and thereby deals with the overdispersion [63, 1].

There are other models for prediction, like Andrew and Stig's multilevel model [5] and Matthew and Ioannis's hierarchical tree-based regression model (HTBR) [58]. Andrew and Stig think their multilevel model helps to quantify the various influences on casualty outcomes. HTBR model is a non-parametric statistical method.

After comparing these prediction models, in the future, we would use generalised linear modelling techniques. The distributions of accident counts will be assumed to follow a Poisson distribution. The main advantage of the Poisson distribution is its simplicity. Although the overdispersion phenomenon is one of the weaknesses of Poisson distribution, overdispersion does not affect the coefficient estimates but does cause their standard errors to be underestimated [61]. Some studies show that the values of the model parameters were almost the same regardless of the distribution assumption [51].

The model structure is:

$$Y = aN^{p}\exp\sum\beta_j X_{ij}$$

Y is the expected number of accidents, N normally is the traffic flow (AADT), x variables describing road geometry or environment of the road, a,p, β are estimated parameters.

The development of our prediction model would have four major steps using the Generalized Linear Model.

1 Identify potential parameters in the prediction model. We will consider two different ways to do this. We prepared a questionnaire for people in the Land Service Department of Glasgow City Council. In the questionnaire (see Appendix C), we list many different parameters that could be used for prediction, most of them from existing prediction papers mentioned above. We then asked them to scale the parameters from 1 to 10. 10 means the most important. Alternatively, we have considered Locally Linear Embedding. This can help us to find useful parameters for prediction. Locally linear embedding (LLE) is an unsupervised learning algorithm that computes low dimensional, neighborhood preserving embeddings of high dimensional data. LLE attempts to discover nonlinear structure in high dimensional data by exploiting the local symmetries of linear reconstructions (16). We could also combine the results from these two methods to pick potential parameters.

2 Data Collection. We contacted the Department of Transportation, and they provided us with 10 years (1993-2002) traffic volume data and major road network information in Glasgow, such as road type, speed limit, number of lanes, width, length, and so on. We have already obtained 11 years accident data (1991-2001). Figure 10.3 shows an example of traffic volume data and major road network information.

Microsoft Excel - Glasgow AADFs 1993 to 2002.xls

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	LACode	MAJOR ROADS1.CP	dOpened	dClosed	R ROADS	Road	RdSeq	RCat	d Name at	P Locatio	A-Junction	B-Junction	S Ref E	S Ref N
2	9260	1000	01/01/1982		NM	M8	220	TM	N/A		11	10	266200	666110
3	9260	1001	01/01/1982		NM	M8	170	TM	N/A		16	15	259700	666300
4	9260	1009	01/01/1982		NM	A8	150	PU	Street		Paisley	A77	258500	664500
5	9260	1010	01/01/1982		NM	A8	5140	PU	Street		Morrison	A77	258500	664640
6	9260	1011	01/01/1982		NM	A8	220	PU	t		Bridgegat	A89/A749	259560	664750
7	9260	1027	01/01/1982		NM	A77	320	PU	e Street		A8	A814	258640	664720
8	9260	1029	01/01/1982		NM	A80	10	PU	uld Road		A8	M8	262900	666000
9	9260	1033	01/01/1982		NM	A82	10	PU	Western		A804	A804	258100	666500
10	9260	1038	01/01/1982		NM	A89	10	PU	e		A8	Millerston	260500	664770
11	9260	1090	01/01/1982		NM	A730	20	PU	Street		A728	A8	259000	664200
12	9260	1091	01/01/1982		NM	A736	100	PU	Road		A726	Barrhead	251900	661200
13	9260	1094	01/01/1982		NM	A739	40	PU	Road		A814	A82	254600	668000
14	9260	1097	01/01/1982		NM	A749	40	PU	ck Road		Boundary	A74	261220	663320
15	9260	1106	01/01/1982		NM	A804	20	PU	George's		A814	A82	258000	666300
16	9260	1112	01/01/1982		NM	A814	120	PU	Watt		M8/A804	Bromiela	258400	665100
17	9260	1143	01/01/1982		NM	A879	10	PU	Street		M8	Hayston	259100	667800
18	9260	10813	01/01/1982		NM	M8	200	TM	N/A		13	12	263000	666600
19	9260	10814	01/01/1982		NM	M8	120	TM	N/A	Jcts 22 -	23	22	256000	664200
20	9260	10819	01/01/1982		NM	A8	100	PU	Road		A736	A739	252650	666000
21	9260	10820	01/01/1982		NM	A8	170	PU	Street		A730	A814	259200	664600
22	9260	10821	01/01/1982		NM	A8	230	PU	Street	of	A89	A803	260000	665330
23	9260	10836	01/01/1982		NM	A74	321	PR	Road		M74	Mount	267500	662500
24	9260	10918	01/01/1982		NM	A804	40	PU	Road		M8/A81	M8/A879	258800	666374
25	9260	10923	01/01/1982		NM	A814	90	PU	Park Drive		Kingsway	A739	254000	667100
26	9260	10924	01/01/1982		NM	A814	150	PU	w		James	A77	258500	664930
27	9260	11020	01/01/1982		NM	A739	20	PU	od Road		M8	A8	253600	665000
28	9260	20809	01/01/1982		NM	M8	180	TM	N/A		15	14	261000	665900
29	9260	20811	01/01/1982		NM	M8	100	TM	N/A		25	24	254000	664600
30	9260	20815	01/01/1982		NM	A8	120	PU	Drive	B768	B768	A761	255500	664550
31	9260	20816	01/01/1982		NM	A8	180	PU	e		A814	Saltmarke	259400	664700
32	9260	20817	01/01/1982		NM	A8	240	PU	Street		Springbur	Castle St	260200	665850

1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 Sheet9

Figure 10.3 Annual Average Daily Flows and Major Road Network Information in Glasgow

3 Using statistical software (R project, which is an open source statistical package. http://www.r-project.org/), it is relatively straightforward to do regression analyses, then withdraw those parameters that are not statistically significant to prediction.

4 Calculate all the coefficients by using R project. Both step 3 and step 4

will use 5 years accident data, and the data of the remaining years will be used to test these coefficients.

This section has sketched a possible research agenda to extend our work on accident information from purely historical data to include accident prediction. As mentioned at the beginning of this section, once research suggests the general public are interested in prediction, this function can be added into our localized road accident information system. Then experiments are needed to determine whether possible accident information about the future would affect people's safety awareness.

Above all, human beings are the most important factor in road accidents. This thesis is concerned with trying to use localized road accident information to increase people's road safety awareness. The key contributions of this thesis are, firstly, from risk perception questionnaire and focus group discussion, we find that current road safety campaign websites don't have great impact on road users' safety awareness. People are not very interested in the information presented by those websites. Secondly, through our road planning experiments, we find that localized road accident information will affect road users' route planning decisions if they have access to such information, which means road users will consider local accident information before they plan their journey and this could potentially increase their safety awareness. Although we made some progress, there is a great deal of work to be in this area in the future.

Appendix A: A brief Review of road safety research

1 Statistical Models

Statisticians, engineers (road and car), psychologist, economists, sociologists, politicians all work in this area. The study of occurrence of accidents is mainly done by statisticians because road accidents are regarded as chance processes. Statistics can be used to find out certain patterns of accidents. For example the relationship between the number of road fatalities and a given number of motor vehicles and a given population is called Smeed's Law [45]. This law, in its most general form is described by an equation:

$$D/N = a(N/P)^{-b}$$

D represents the number of road accident deaths in a country, N is the number of registered motor vehicles, and P is the population. Smeed fitted this function to 1938 data for 20 countries, and got a value for a of 0.0003 and a value for b of 0.667. This law has been retested in 1968 against data from 16 countries for the years 1957-1966 and once more in 1970 against data from 68 countries for the period 1960-67 and it was found that it still performed well with the same coefficients. This example shows, although some people have argued that road accidents are chance processes, there are certain statistical rules which may apply to all accident situations.

Statistical models can also be used to support accident prediction. There are two main topics in prediction. One is to find an ideal prediction model (algorithm). The other is to identify suitable parameters for the model. Generalized linear models [47, 60] and Negative binomial regression models [63, 1] are the two most popular models for prediction. There are many others, such as Andrew and Stig's multilevel model [5] and Matthew and Ioannis's hierarchical tree-based regression model (HTBR) [58]. But all these models have their own strengths and weakness. For example, generalized linear models suffered an "overdispersion" phenomenon. According to the pure Poisson model, the variance is equal to its mean. But in practice, people found actual accident variance is greater than the mean. Different models will have different sets of parameters and even the same model may have different sets of parameters for different areas which have their own characteristics. Expert judgment, statistical analysis tools and research experience all could help to identify those parameters.

2 Accident Process

Research into the accident process can be divided into three categories: vehicle, road environment and road users.

Vehicle defects cause accidents. The layout of seats and controls, tyre condition, vehicle lighting, braking performance, and steering all affect driving safety. Therefore, vehicles can be made safer to drive in two ways (1) by improving their design and (2) by keeping them in better condition throughout their lives. Through research on individual car accidents, manufacturers, their engineers and designers can find existing defects and then improve design features and manufacturing techniques. For example, in December 2000, Ford recalled their 2001 Ford Focus because of a defect in the seats. According to the report, "the subject vehicles have a folding 60/40 second seat that becomes a load floor in the folded position. When the 60% portion of the seat is folded down and a load is applied to the front edge of the load floor, the outboard hinge pivot could disengage from the hinge. If the seat is then returned to the upright position without re-engaging the hinge pivot, the seat and seat belts may not provide the intended level of performance in the event of crash" (www.automotive.com).

The road environment plays another very important role in road safety research. The following are features which may influence the risk of accidents [29]:

a) Road geometry, such as road and lane width, shoulders and medians, horizontal and vertical curves, vertical alignment, the layout of junctions, and roundabouts.

b) Road delineation and marking, such as lane markers, pedestrian crossing markers, and the marking of the entrances to and the exits from motorways.

c) Traffic signs and traffic signals, such as direction signs, warning signs and mandatory signs.

d) Road surfaces, such as surface texture, spray problem in wet weather, surfaces of verges, shoulders and central reservations.

e) Lighting, such as street lighting and anti-dazzle screens.

f) Obstructions on and off the carriageways, such as street furniture (lamp posts, trees, telegraph poles, traffic signs...), crash barriers, kerbs, obstructions in the road, parked vehicles.

g) Weather, such as rain, snow, wind.

Research on these features can help people to find and build safer roads. For instance, for two-lane roads, 12 foot (3.7m) lanes have been found to be safer than 9 or 10 foot (2.7 or 3m) lanes [35]. Research also found that roads with long straights and few bends, particularly if they are sharp bends, may have higher accident rates than roads with more bends [73].

According to the research work by Sabey in 1975 [80], road users make the most important contributions. He attempted to identify the "main contributory factors" responsible for 2130 accidents which were investigated in great detail. Evidence was obtained by observations of roads, vehicles and road users, by interviews, and by assessing errors which were made by the road users, by defects in vehicles, and by adverse features of vehicle and road. The answers depended on opinions which are formed by members of the research team. They categorized those contributory factors into 3 areas (road environment, road user, vehicle), some accidents being caused by a single factor, some caused by multiple factors. The result shows 8.5 percent of the causes could be assigned to vehicles, 28 percent to the road environment, and 95 percent to road users; these add up to more than 100 percent because many accidents were considered to be the result of more than one contributory factor. Figure A.1 shows this result briefly.

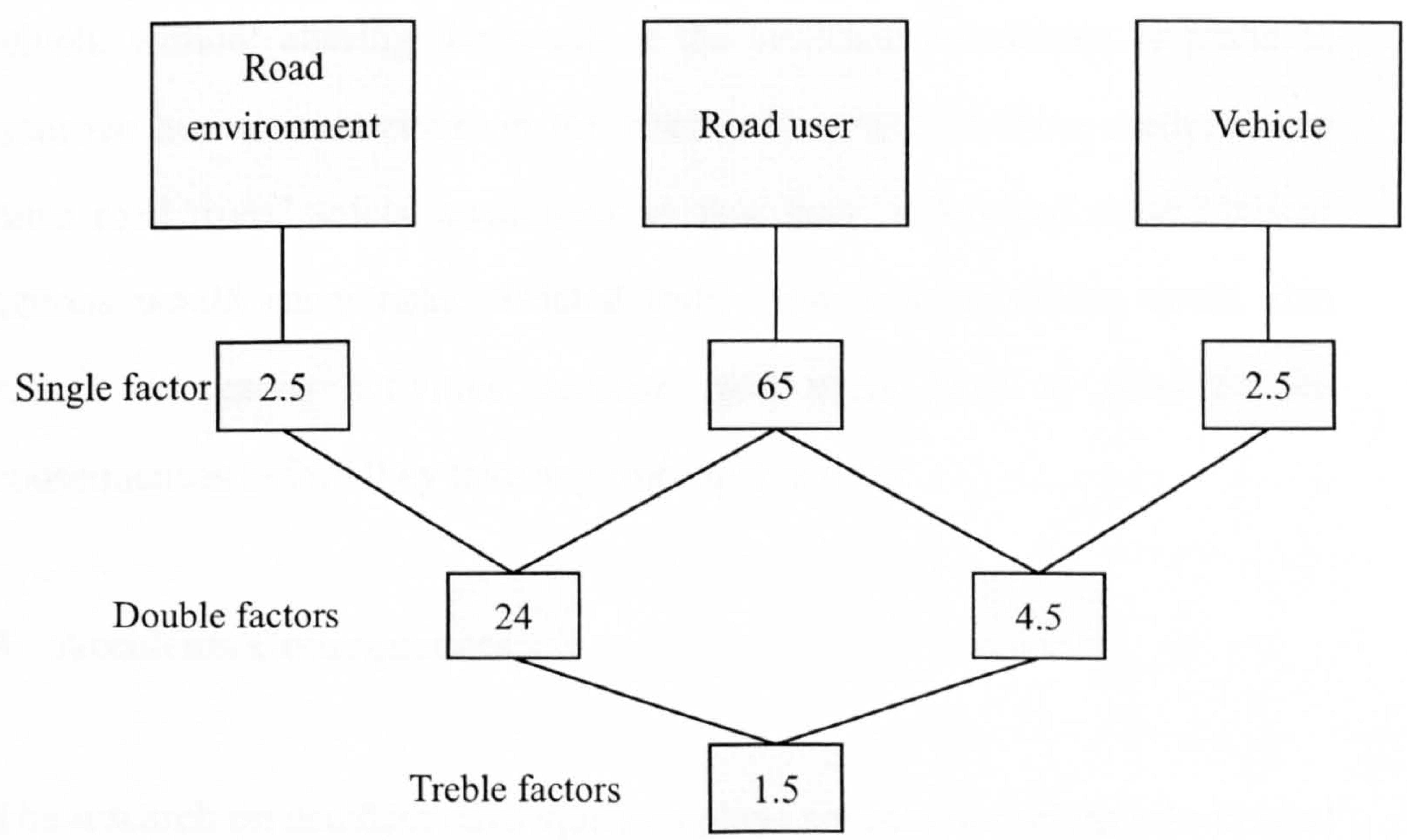


Figure 1.1 Percentage contributions to road accidents

Much recent research focuses on driver behaviours to find potential dangerous actions or bad habits which may cause accidents.

The driving task has three main aspects: the intake of information, the making of decisions and the control of the vehicle. Any error in these aspects could be dangerous. Drink driving, drug-driving, speeding and driver distraction are typical problems which could affect drivers' behaviour. According to the "Think!" website[89], on average 3,000 people are killed or seriously injured each year in drink drive collisions and nearly one in seven of all deaths on the road involve drivers who are over the legal limit. Research has shown that speed and speed related causes are major factors in about one-third of all road accidents. Surveys show that almost all drivers and riders exceed speed limits at some time. Observation of vehicle speeds in Great Britain in *1998 showed that 69% of cars* exceeded the 30mph limit and 29% exceeded the 40mph limit in free flowing traffic [94].

Education, training, propaganda and enforcement are some of the ways in which, without altering the roads or the vehicles, an attempt is made to improve human behaviour on the road [27]. The first three methods can raise road users' safety awareness so that they understand what kind of actions would carry risks. Related traffic law and legislation could also reduce dangerous activities because road users have to consider the consequences before they take any improper actions.

3 Accidents Consequences

The research on accident consequences plays another important role in road accidents investigation and research. Injury to road users is one of the most important consequences from accident. In order to save lives, much attention has been paid to the causes of injuries. Alan formed a hypothesis in 1967 [94] that "many accidents cannot be prevented, but most traffic deaths and injuries can be". Although I don't agree with the first part of his hypothesis, from figure in table 1.2, we can see there is a big reduction in the number of killed or seriously injured from 1993 to 2002.

According to the research [29(p121)], there are two most important factors in injury production. First is the velocity change of the vehicle, the other is the duration of the impact. Alan believed there are 5 factors which can affect the severity of the injuries:

1) "the magnitude of the force
2) the area of the body that is struck
3) the rate of onset of the force
4) the duration that the force must be withstood
5) the total area of the body over which the force is distributed" [94]

The injury research in 1963 [72(p462-p466)] showed that the head related injuries accounted for most of the injury cases. In Alan's research [94], similar results were found. His data were collected in an analysis of 150 accidents which were selected from a total of 3,308 accidents that occurred in 1965 in California. The data showed that there were 32 percent face injury, 19 percent head injury and 2 percent neck injury.

After analysing injuries, two kinds of protective measures can be taken to minimise the injury when an accident has occurred. The first kind is the protective devices which can restrain and control the movement of the occupant and prevent impacts with the interior of the car. The second kind is alterations to the construction of the car. The seat belt is a typical device of the first kind. The most important function of seat belts is to protect heads and bodies of the wearers in frontal impacts. Table 1.4 compares that the injuries to the occupants of the front seats of cars wearing and not wearing seat belts [38]. The data were based on 1163 unbelted and 490 belted front-seat occupants of cars.

Region	Unbelted (percentages injured)	Belted (percentages injured)
Head	23.7	10.6
Neck	1.2	1.6
Shoulders	2.1	1.4
Chest	5.2	3.9
Spine	1.5	0.6
Abdomen	2.0	1.2
Pelvis	0.7	0.4
Hip joints	0.6	0
Thighs	2.1	0.6
Knees	2.2	1.8
Lower legs	1.5	0.6
Feet/ankles	1.5	2.4
Arms	3.7	2.0

Table A.1 Injuries comparison between unbelted and belted occupants

From the above table, we can see, apart from neck injuries, seat belts do help to reduce injuries. When all types of accident are included, seat belts reduce the probability of serious injury by about 42 per cent.

In the second kind of protective measures, an example is the design of the steering assembly so that even when the front of the car is heavily deformed, the steering wheel is not forced back on the driver. Another example is safety glass for windscreens. The objective of safety glass is that when occupants hit the windscreen, fragments are less liable to cause severe cuts. There are two types of safety glass in Britain, laminated and toughened glass. After fracture, fragments of toughened glass are less sharp than laminated glass. But laminated glass has better visibility than toughened glass.

4 Economic Impacts of Road Accidents

Road accidents have a big impact on national and regional economics. According to WHO's (World Health Organization) "World report on road traffic injury prevention in 2004", the cost of road crash injuries is estimated at roughly 1% of gross national product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries. The direct economic costs of global road crashes have been estimated at US$ 518 billion in 2004. The estimated annual economic cost of injury in China is equivalent to US$12.5 billion --- almost four times the total public health services budget for the county.

Road accidents also affect the economy indirectly. People aged between 15 and 44 years are the most productive age group. But they are also the majority group in road traffic injuries. The economic impacts of injuries in this age group are therefore especially damaging. According to the WHO, people in this group, "tend to affect productivity severely, particularly among the lowest-income groups whose exposure to risk is greatest and whose earning capacity is most likely to rely on physical activity".

Although governments are paying more and more attention to road traffic safety, the WHO believe "current road safety efforts fail to match the severity of the problem. Road travel brings society benefits, but the price society is paying for it is very high."

Appendix B: Collection of Road Accident Information

Accurate, adequate and reliable road accident data are crucial to any systematic, scientifically-based analysis of the road accident situation and the development of rational countermeasures. In this section, I describe how accident data are collected in Great Britain and what kind of data are needed.

In the UK, the collection process and accident data collected vary across local authority and police force areas. They reflect local road safety requirements and circumstances. However, each local area is asked to report the same set of accident records for national purposes and to transmit them to central government. This is the 'STATS19' collection system, which was established in 1949. STATS19 is a standardised form used by police to record road traffic accidents.

Recorded accidents only consist of those in which someone was injured. Damage-only accidents do not appear in the collected accident information. Injuries are classified according to the following criteria [29]:

a) Slight injury. An injury of a minor character such as a sprain, bruise or a cut or laceration not judged to be severe.

b) Serious injury. An injury for which a person is detained in hospital as an in-patient, or any of the following injuries regardless of whether he is detained in hospital: fractures, concussion, internal injuries, crushings, severe cuts and lacerations, severe general shock requiring medical treatment.

c) Death. Death within 30 days.

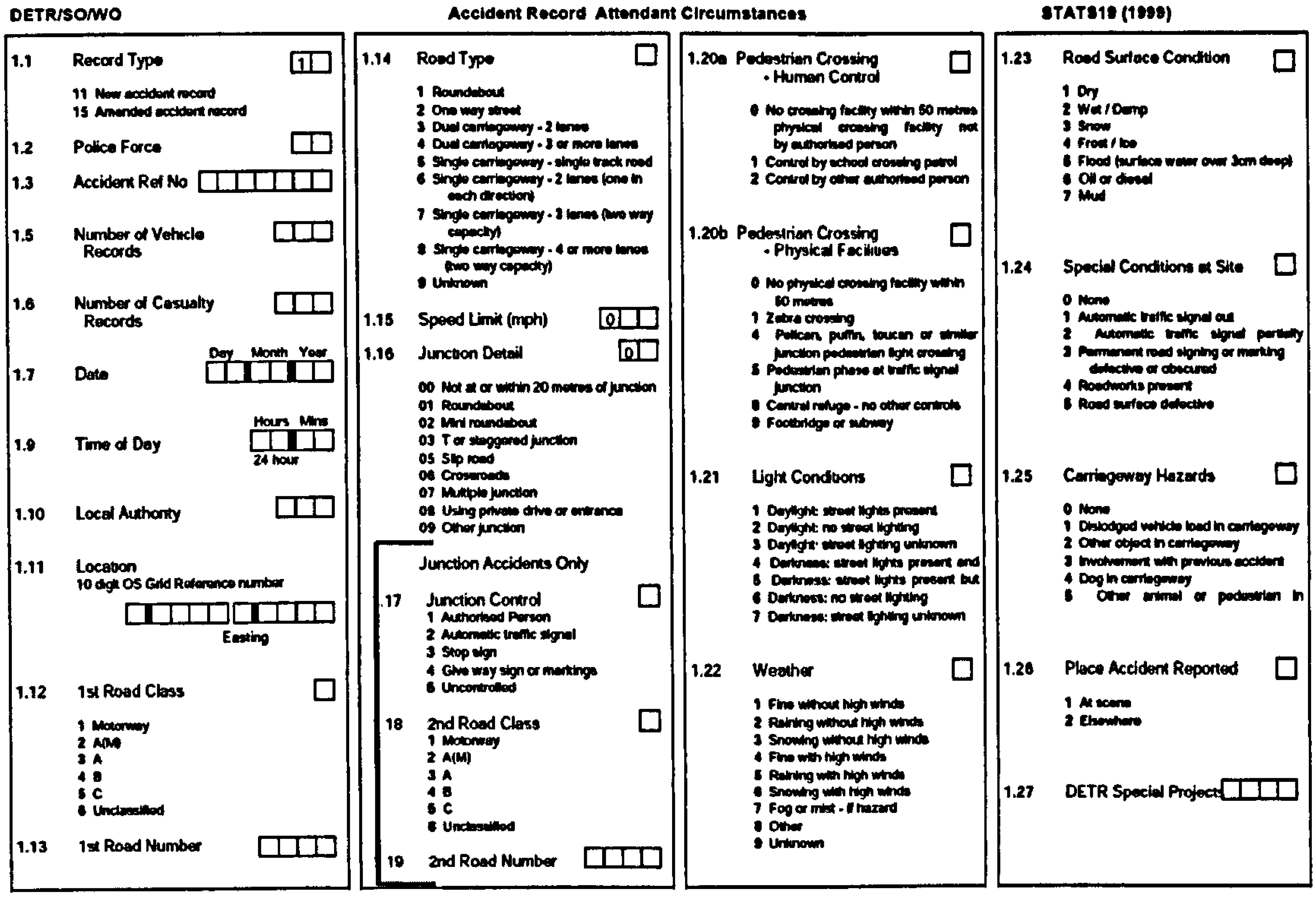
The STATS19 report form consists of an accident record, a vehicle record to be completed for each vehicle, and a casualty record for each casualty arising from the accident.

The accident record includes the severity of the accident, the number of vehicles and casualties involved, time and location, road class and number, speed limit, weather and road conditions, and carriageway hazards.

The vehicle record includes type, location and manoeuvre at time of accident, and details of the driver (age, sex and breath test results);

The casualty record includes casualty age, sex, injury severity and whether a driver, passenger or pedestrian.

Figure 1 is an image of an accident record in a STATS19 form. Figure 2 shows a vehicle record in a STATS19 form. Figure 3 shows a casualty record in a STATS19 form.



DETR/SO/WO — Accident Record Attendant Circumstances — STATS19 (1999)

1.1 Record Type [1]
11 New accident record
15 Amended accident record

1.2 Police Force

1.3 Accident Ref No

1.5 Number of Vehicle Records

1.6 Number of Casualty Records

1.7 Date (Day Month Year)

1.9 Time of Day (Hours Mins) 24 hour

1.10 Local Authority

1.11 Location
10 digit OS Grid Reference number
Easting

1.12 1st Road Class
1 Motorway
2 A(M)
3 A
4 B
5 C
6 Unclassified

1.13 1st Road Number

1.14 Road Type
1 Roundabout
2 One way street
3 Dual carriageway - 2 lanes
4 Dual carriageway - 3 or more lanes
5 Single carriageway - single track road
6 Single carriageway - 2 lanes (one in each direction)
7 Single carriageway - 3 lanes (two way capacity)
8 Single carriageway - 4 or more lanes (two way capacity)
9 Unknown

1.15 Speed Limit (mph) [0]

1.16 Junction Detail [0]
00 Not at or within 20 metres of junction
01 Roundabout
02 Mini roundabout
03 T or staggered junction
05 Slip road
06 Crossroads
07 Multiple junction
08 Using private drive or entrance
09 Other junction

Junction Accidents Only

.17 Junction Control
1 Authorised Person
2 Automatic traffic signal
3 Stop sign
4 Give way sign or markings
6 Uncontrolled

18 2nd Road Class
1 Motorway
2 A(M)
3 A
4 B
5 C
6 Unclassified

19 2nd Road Number

1.20a Pedestrian Crossing - Human Control
0 No crossing facility within 50 metres physical crossing facility not by authorised person
1 Control by school crossing patrol
2 Control by other authorised person

1.20b Pedestrian Crossing - Physical Facilities
0 No physical crossing facility within 50 metres
1 Zebra crossing
4 Pelican, puffin, toucan or similar junction pedestrian light crossing
5 Pedestrian phase at traffic signal junction
8 Central refuge - no other controls
9 Footbridge or subway

1.21 Light Conditions
1 Daylight: street lights present
2 Daylight: no street lighting
3 Daylight: street lighting unknown
4 Darkness: street lights present and
5 Darkness: street lights present but
6 Darkness: no street lighting
7 Darkness: street lighting unknown

1.22 Weather
1 Fine without high winds
2 Raining without high winds
3 Snowing without high winds
4 Fine with high winds
5 Raining with high winds
6 Snowing with high winds
7 Fog or mist - if hazard
8 Other
9 Unknown

1.23 Road Surface Condition
1 Dry
2 Wet / Damp
3 Snow
4 Frost / Ice
5 Flood (surface water over 3cm deep)
6 Oil or diesel
7 Mud

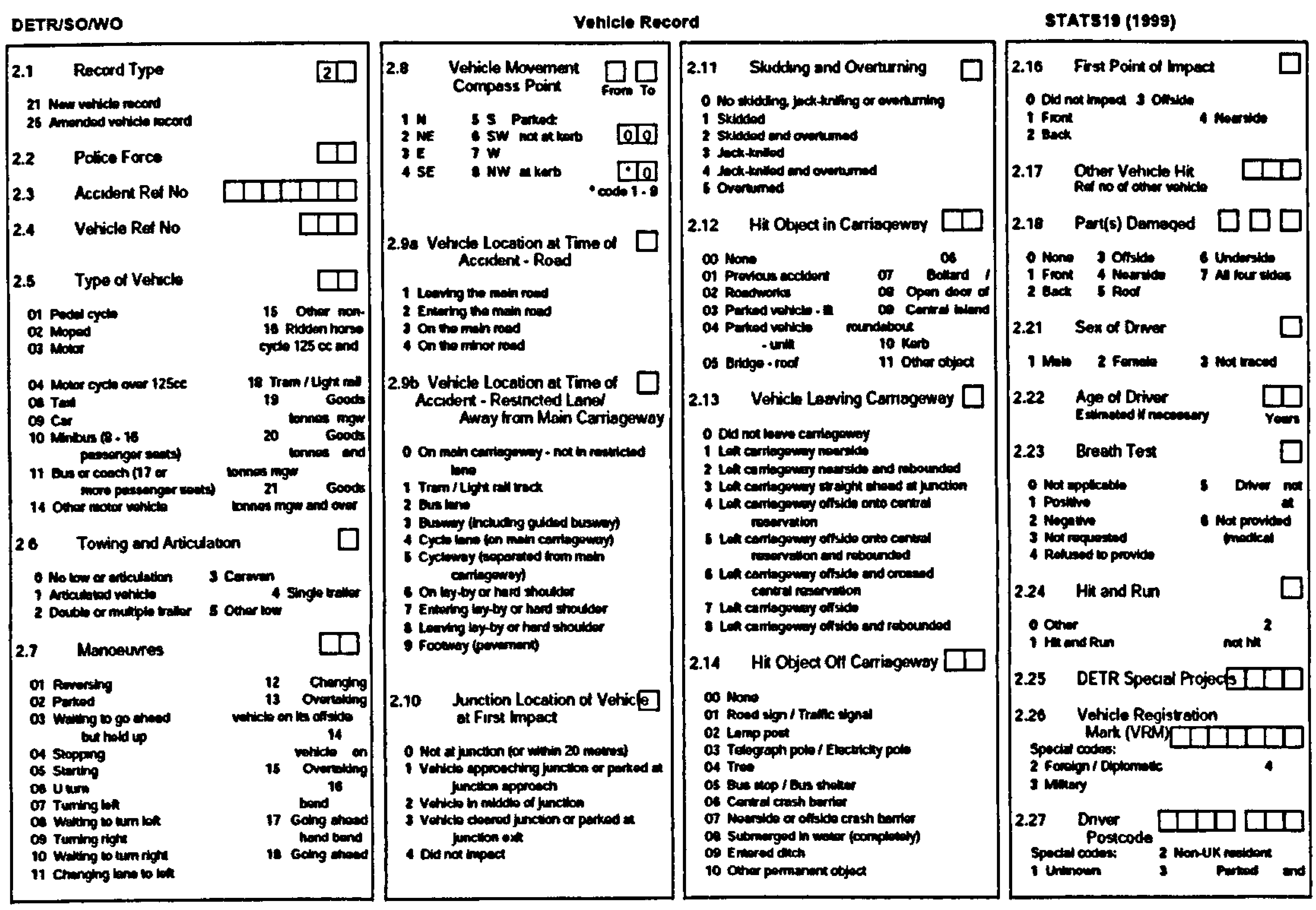
1.24 Special Conditions at Site
0 None
1 Automatic traffic signal out
2 Automatic traffic signal partially
3 Permanent road signing or marking defective or obscured
4 Roadworks present
5 Road surface defective

1.25 Carriageway Hazards
0 None
1 Dislodged vehicle load in carriageway
2 Other object in carriageway
3 Involvement with previous accident
4 Dog in carriageway
5 Other animal or pedestrian in

1.26 Place Accident Reported
1 At scene
2 Elsewhere

1.27 DETR Special Projects

Figure B.1 STATS19 — Accident Record



DETR/SO/WO — Vehicle Record — STATS19 (1999)

2.1 Record Type [2]
21 New vehicle record
25 Amended vehicle record

2.2 Police Force

2.3 Accident Ref No

2.4 Vehicle Ref No

2.5 Type of Vehicle
01 Pedal cycle
02 Moped
03 Motor
04 Motor cycle over 125cc
08 Taxi
09 Car
10 Minibus (8 - 16 passenger seats)
11 Bus or coach (17 or more passenger seats)
14 Other motor vehicle
15 Other non-
16 Ridden horse
cycle 125 cc and
18 Tram / Light rail
19 Goods tonnes mgw
20 Goods tonnes and tonnes mgw
21 Goods tonnes mgw and over

2.6 Towing and Articulation
0 No tow or articulation
1 Articulated vehicle
2 Double or multiple trailer
3 Caravan
4 Single trailer
5 Other tow

2.7 Manoeuvres
01 Reversing
02 Parked
03 Waiting to go ahead but held up
04 Stopping
05 Starting
06 U turn
07 Turning left
08 Waiting to turn left
09 Turning right
10 Waiting to turn right
11 Changing lane to left
12 Changing
13 Overtaking vehicle on its offside
14 vehicle on
15 Overtaking
16 bend
17 Going ahead hand bend
18 Going ahead

2.8 Vehicle Movement Compass Point (From To)
1 N
2 NE
3 E
4 SE
5 S
6 SW
7 W
8 NW
Parked: not at kerb [0][0]
at kerb [*][0]
* code 1 - 8

2.9a Vehicle Location at Time of Accident - Road
1 Leaving the main road
2 Entering the main road
3 On the main road
4 On the minor road

2.9b Vehicle Location at Time of Accident - Restricted Lane/ Away from Main Carriageway
0 On main carriageway - not in restricted lane
1 Tram / Light rail track
2 Bus lane
3 Busway (including guided busway)
4 Cycle lane (on main carriageway)
5 Cycleway (separated from main carriageway)
6 On lay-by or hard shoulder
7 Entering lay-by or hard shoulder
8 Leaving lay-by or hard shoulder
9 Footway (pavement)

2.10 Junction Location of Vehicle at First Impact
0 Not at junction (or within 20 metres)
1 Vehicle approaching junction or parked at junction approach
2 Vehicle in middle of junction
3 Vehicle cleared junction or parked at junction exit
4 Did not impact

2.11 Skidding and Overturning
0 No skidding, jack-knifing or overturning
1 Skidded
2 Skidded and overturned
3 Jack-knifed
4 Jack-knifed and overturned
5 Overturned

2.12 Hit Object in Carriageway
00 None
01 Previous accident
02 Roadworks
03 Parked vehicle - lit
04 Parked vehicle - unlit
05 Bridge - roof
06
07 Bollard /
08 Open door of
09 Central island roundabout
10 Kerb
11 Other object

2.13 Vehicle Leaving Carriageway
0 Did not leave carriageway
1 Left carriageway nearside
2 Left carriageway nearside and rebounded
3 Left carriageway straight ahead at junction
4 Left carriageway offside onto central reservation
5 Left carriageway offside onto central reservation and rebounded
6 Left carriageway offside and crossed central reservation
7 Left carriageway offside
8 Left carriageway offside and rebounded

2.14 Hit Object Off Carriageway
00 None
01 Road sign / Traffic signal
02 Lamp post
03 Telegraph pole / Electricity pole
04 Tree
05 Bus stop / Bus shelter
06 Central crash barrier
07 Nearside or offside crash barrier
08 Submerged in water (completely)
09 Entered ditch
10 Other permanent object

2.16 First Point of Impact
0 Did not impact
1 Front
2 Back
3 Offside
4 Nearside

2.17 Other Vehicle Hit
Ref no of other vehicle

2.18 Part(s) Damaged
0 None
1 Front
2 Back
3 Offside
4 Nearside
5 Roof
6 Underside
7 All four sides

2.21 Sex of Driver
1 Male
2 Female
3 Not traced

2.22 Age of Driver
Estimated if necessary
Years

2.23 Breath Test
0 Not applicable
1 Positive
2 Negative
3 Not requested
4 Refused to provide
5 Driver not at
6 Not provided (medical

2.24 Hit and Run
0 Other
1 Hit and Run
2 not hit

2.25 DETR Special Projects

2.26 Vehicle Registration Mark (VRM)
Special codes:
2 Foreign / Diplomatic
3 Military
4

2.27 Driver Postcode
Special codes:
1 Unknown
2 Non-UK resident
3 Parked and

Figure B.2 STATS19 — Vehicle Record

DETR/SO/WO | Casualty Record | STATS19 (1999)

3.1 Record Type [3][ ]

31 New casualty record
35 Amended casualty record

3.2 Police Force [ ][ ]

3.3 Accident Ref No [ ][ ][ ][ ][ ][ ][ ]

3.4 Vehicle Ref No [ ][ ][ ]

3.5 Casualty Ref No [ ][ ][ ]

3.6 Casualty Class [ ]

1 Driver or rider
2 Vehicle or pillon passenger
3 Pedestrian

3.7 Sex of Casualty [ ]

1 Male
2 Female

3.8 Age of Casualty [ ][ ] Years
Estimated if necessary

3.9 Severity of Casualty [ ]

1 Fatal
2 Serious
3 Slight

3.10 Pedestrian Location [ ][ ]

00 Not a pedestrian
01 In carriageway, crossing on crossing facility
02 In carriageway, crossing within zig-lines at crossing approach
03 In carriageway, crossing within zig-lines at crossing exit
04 In carriageway, crossing elsewhere within 50 metres of pedestrian
05 In carriageway, crossing elsewhere
06 On footway or verge
07 On refuge, central island or central reservation
08 In centre of carriageway, not on central island or central
09 In carriageway, not crossing
10 Unknown or other

3.11 Pedestrian Movement [ ]

0 Not a pedestrian
1 Crossing from driver's nearside
2 Crossing from driver's nearside - by parked or stationary vehicle
3 Crossing from driver's offside
4 Crossing from driver's offside - by parked or stationary vehicle
5 In carriageway, stationary - not (standing or playing)
6 In carriageway, stationary - not (standing or playing), masked by parked or stationary vehicle
7 Walking along in carriageway - facing traffic
8 Walking along in carriageway - back traffic
9 Unknown or other

3.12 Pedestrian Direction [ ]

Compass point bound

1 N
2 NE
3 E
4 SE
5 S
6 SW
7 W
8 NW
9 Unknown
0 Standing still

3.13 School Pupil Casualty [ ]

1 School pupil on journey to or from school
0 Other

3.15 Car Passenger [ ]

0 Not a car passenger
1 Front seat passenger
2 Rear seat passenger

3.16 Bus or Coach Passenger [ ]

0 Not a bus or coach passenger
1 Boarding
2 Alighting
3 Standing passenger
4 Seated passenger

3.17 DETR Special Projects [ ][ ][ ][ ]

3.18 Casualty Postcode [ ][ ][ ][ ] [ ][ ][ ]

Special codes:
1 Unknown
2 Non-UK resident

Figure B.3 STATS19 — Casualty Record

Appendix C

Questionnaire for Road Accident Prediction

1. What kinds of accident prediction model are useful to your job?

a. all accidents
b. all injury accidents
c. certain types of accidents (single accidents, rear-end accidents, crossing accidents, turning accidents...), or on certain type of roads (Motorway, A, B, other)
d. other, please specify______________________________

____

____

1. Normally, every prediction model has algorithm for road links and junctions. In order to predict your chosen accident type, please scale the following data based on importance to the prediction. (from 1 to 10, 10 the most important)

Road Links:

a) traffic flow	1	2	3	4	5	6	7	8	9	10
b) length of road section	1	2	3	4	5	6	7	8	9	10
c) speed limit	1	2	3	4	5	6	7	8	9	10
d) one/two-way traffic	1	2	3	4	5	6	7	8	9	10
e) number of lanes	1	2	3	4	5	6	7	8	9	10
f) road width	1	2	3	4	5	6	7	8	9	10
g) speed reducing measures	1	2	3	4	5	6	7	8	9	10
h) cyclist facilities	1	2	3	4	5	6	7	8	9	10
i) footway	1	2	3	4	5	6	7	8	9	10
j) central island	1	2	3	4	5	6	7	8	9	10
k) parking facilities	1	2	3	4	5	6	7	8	9	10
l) bus stop	1	2	3	4	5	6	7	8	9	10

m) other parameters in STAT 19

____

____

____

____

Junctions

a)	traffic flows	1	2	3	4	5	6	7	8	9	10
b)	number of lanes	1	2	3	4	5	6	7	8	9	10
c)	traffic island	1	2	3	4	5	6	7	8	9	10
d)	turning lane	1	2	3	4	5	6	7	8	9	10
e)	bicycle facilities	1	2	3	4	5	6	7	8	9	10
f)	signalised/non-signalised	1	2	3	4	5	6	7	8	9	10
g)	number of arms	1	2	3	4	5	6	7	8	9	10
h)	other parameters in STAT 19										

____

____

____

____

____

Appendix D

Questionnaire for gathering experts information and initial system requirements

The Road Traffic Accident Information System help people find out about accidents detail in Glasgow. Currently, the Road Traffic Accident Information Management System is only prototype. To build a functional system, we need to get more requirements from potential users. Traffic police and people in the Glasgow city council who deal with road traffic are selected to answer this questionnaire.

1 What is your job title?

a) traffic police b) road planning engineer c) road accident researcher
a) other, please specify ________________

2 How long have you worked as this job?

a) less than a year b) 1-3 years c) 3-5 years d) more than 5 years

3 How do you deal with accident data?

a) record new data b) classify and submit to higher government
c) analysis historical data d) other, please specify ___________

4 How often do you deal with accident data?

a) almost everyday b) once a week c) few times a month d) several times a year

5 How often do you use a computer?

a) almost everyday b) once a week c) few times a month d) several times a year

6 How do you rate your computer knowledge?

Novice (1) 2 3 4
5 Expert

7 Are statistical analysis methods involved in your daily work?

a) Yes b) No

8 How do you rate your statistical knowledge?

Novice 1 2 3 4
5 Expert

If you have ever received training on statistical techniques, please state the level (e.g. school, college, university...)

____

____

____

9 We have already got accident data for the Glasgow area. What kinds of accident information do you want to be displayed in the map-based system? Please tick the top 5 you think are more important.

a) Year of Accident ☐
b) Accident Reference Number ☐
c) Police Force Code ☐
d) Accident Severity ☐
e) Number of Vehicles ☐
f) Accident Day ☐
g) Accident Month ☐
h) Day of week ☐
i) Time of Day (Hour, Minute) ☐
j) Location (Easting, Northing) ☐
k) 1st Road Class and 1st Road Number ☐
l) Road Type ☐
m) Speed Limit ☐
n) Junction Detail and Junction Control ☐
o) 2nd Road Class and 2nd Road Number ☐
p) Pedestrian Crossing-Human Control and Pedestrian Crossing-Physical Facilities ☐
q) Light Condition, Weather Conditions, Road Surface Conditions ☐
r) Special Condition at Site ☐
s) Carriageway Hazards ☐

10 The following are some potential ways to display accident data. Please tick the top 5 of your choice.

a) by year
b) by road
c) by road type
d) by time of the day
e) by day of the week
f) by month
g) by light condition
h) by weather condition
i) by road surface condition
j) others, please specify ____________________

11 Some elements of the system display can be changed by the users. Which of the following features do you think are better if they are editable by users? Tick top 5. If you are unclear what this means, please ask.

a) Road color
b) Road width
c) Accident point size
d) Accident point color
e) Information to be displayed on the right hand side text area
f) Information to be displayed on the tooltip
g) Background color
h) Font (e.g. style of text)

12 In addition to accidents data, we also have casualties' data and vehicle data which currently are not displayed in the system. Do you think it is necessary to display this information with the accident data?

a) yes b) no

If yes, what kind of casualty information do you want to be displayed in the system? Please tick the top 5.

a) Casualty Class. (Driver or rider, Passenger, Pedestrian)
b) Sex of Casualty
c) Age of Casualty
d) Severity of Casualty
e) Pedestrian Location
f) Pedestrian Movement
g) Pedestrian Direction

h) Car Passenger
i) Bus or Coach Passenger
j) Casualty Type
k) Seat Belt Usage

13 On the above list, which ones do you think are necessary to be made as prepared queries to display accident data? Please also tick top 5.

a) by Casualty Class. (Driver or rider, Passenger, Pedestrian)
b) by Sex of Casualty
c) by Age of Casualty
d) by Severity of Casualty
e) by Pedestrian Location
f) by Pedestrian Movement
g) by Pedestrian Direction
h) by Car Passenger
i) by Bus or Coach Passenger
j) by Casualty Type
k) by Seat Belt Usage

14 For the vehicle data, what kind of information you want to be displayed with accident data? Please tick top 5?

a) Vehicle Type
b) Towing and Articulation
c) Vehicle Manoeuvre
d) Vehicle Movement Compass Point
e) Vehicle Location
f) Junction Location at Impact
g) Skidding/Overturning
h) Hit Object In Carriageway
i) Vehicle Leaving Carriageway
j) Hit Object Off Carriageway
k) 1st point of Impact
l) Driver Breath Test
m) Driver Hit and Run
n) Damage
o) Vehicle Prefix/Suffix Letter

15 On the above list, which ones do you think are necessary to be made as prepared queries to display accident data? Please also tick top 5.

a) by Vehicle Type
b) by Towing and Articulation

c) by Vehicle Manoeuvre
d) by Vehicle Movement Compass Point
e) by Vehicle Location
f) by Junction Location at Impact
g) by Skidding/Overturning
h) by Hit Object In Carriageway
i) by Vehicle Leaving Carriageway
j) by Hit Object Off Carriageway
k) by 1st point of Impact
l) by Driver Breath Test
m) by Driver Hit and Run
n) by Damage
o) by Vehicle Prefix/Suffix Letter

16 When you find all the data you need, which of the following tools are necessary or useful. Please tick all you want.

a) display these data by using numerical table
b) display these data by using different kinds of charts, such as line chart, bar chart.
c) Extract these data out of the system, such as print, save as another format (text, graphical)
d) What else____________________

17 If you have already used some similar system, could you point out some limitations of that system or the features that you wish to improved?

____
____
____
____
____
____

18 Any other comments on this work?

____
____
____
____
____
____
____

Appendix E

User Interface Evaluation Form

User Interface and Navigation:

1. Was the presentation of content **clear?**

   (no) 1 2 3 4 5 (yes)

2. Was the user interface **attractive** and **appealing?**

   (Bad) 1 2 3 4 5 (Good)

3. Is the sequence of the screens **clear?**

   (Confusing) 1 2 3 4 5 (very clear)

4. Is reading character on the screen easy?

   (hard) 1 2 3 4 5 (easy)

5. Was **user orientation** ("Where am I?") within the Applet easy and intuitive?

   (Bad) 1 2 3 4 5 (Good)

6. Was **navigation** of the Applet ("Can I go where I want to go?") easy and intuitive?

   (Bad) 1 2 3 4 5 (Good)

7. Was the layout of the Applet **appropriate?**

   (Bad) 1 2 3 4 5 (Good)

8. How well did the use of color, graphics, images and fonts **enhance** the user's experience of the site?

   (Bad) 1 2 3 4 5 (Good)

9. Can user control pace and sequence easily?

   (Difficult) 1 2 3 4 5 (Easy)

10. Is system speed fast enough?

(Too slow) 1 2 3 4 5 (fast enough)

Terminology and System Information

1. Is use of terms throughout system consistent?

   (Inconsistent) 1 2 3 4 5 (consistent)

2. Is position of messages on screen consistent?

   (Inconsistent) 1 2 3 4 5 (consistent)

3. Is remembering names and use of commands difficult?

   (Difficult) 1 2 3 4 5 (Easy)

4. Is the terminology always related to the task?

   (never) 1 2 3 4 5 (always)

5. Does computer always informs about its progress?

   (never) 1 2 3 4 5 (always)

6. Is text clear and easy to read?

   (Bad) 1 2 3 4 5 (Good)

7. Does the highlighting simplify the task?

   (not at all) 1 2 3 4 5 (very much)

8. Is the organization of information clear?

   (confusing) 1 2 3 4 5 (very clear)

9. Under normal conditions, does the program run consistently?

   (Inconsistent) 1 2 3 4 5 (consistent)

Overall reaction to the software

How do you think the software?

(terrible) 1 2 3 4 5 (wonderful)

(frustrating) 1 2 3 4 5 (satisfying)

(inadequate power) 1 2 3 4 5 (adequate power)

List the most **negative** aspect(s):

1. ______________________________

2. ______________________________

3. ______________________________

List the most **positive** aspect(s):

1. ______________________________

2. ______________________________

3. ______________________________

User Interface Evaluation Data

Q1 Was the presentation of content clear?	No.	1	2	3	4	5	Yes
			1	3	11	14	

Q2 Was the user interface attractive and appealing?	Bad	1	2	3	4	5	Good
				7	12	10	

Q3 Is the sequence of the screen clear?	Confusing	1	2	3	4	5	Very Clear
				7	14	8	

Q4 Is reading character on the screen easy?	Hard	1	2	3	4	5	Easy
			3	6	14	6	
Q5 Was user orientation within the Applet easy and intuitive?	Bad	1	2	3	4	5	Good
			3	7	10	9	
Q6 Was navigation of the Applet easy and intuitive?	Bad	1	2	3	4	5	Good
		1	3	5	17	4	
Q7 Was the layout of the Applet appropriate?	Bad	1	2	3	4	5	Good
				1	19	9	
Q8 How well did the use of color, graphics, images and fonts enhance the use's experience of the system?	Bad	1	2	3	4	5	Good
			4	7	12	6	
Q9 Can user control pace and sequence easily?	Difficult	1	2	3	4	5	Easy
			1	3	16	9	
Q10 Is system speed fast enough?	Too slow	1	2	3	4	5	Fast enough
		1	2	3	11	12	
Q11Is use of terms	Inconsistent	1	2	3	4	5	Consistent

Question		1	2	3	4	5	
throughout system consistent?							
				1	12	16	
Q12 Is position of messages on screen consistent?	Inconsistent	1	2	3	4	5	Consistent
			1	1	11	16	
Q13 Is remembering names and use of commands difficult?	Difficult	1	2	3	4	5	Easy
			2	3	13	11	
Q14 Is the terminology always related to the task?	Never	1	2	3	4	5	Always
				4	17	8	
Q15 Does computer always informs about its progress?	Never	1	2	3	4	5	Always
		3	5	12	3	6	
Q16 Is text clear and easy to read?	Bad	1	2	3	4	5	Good
			5	4	13	7	
Q17 Does the highlighting simplify the task?	Not at all	1	2	3	4	5	very much
		1	2	3	17	6	
Q18 Is the organization of information clear?	Confusing	1	2	3	4	5	Very Clear
			2	3	17	7	
Q19 Under normal conditions, does the program run consistently?	Inconsistent	1	2	3	4	5	Consistent

		1		2	14	12	
Q20 How do you think the software?	terrible	1	2	3	4	5	wonderful
				6	19	4	
	frustrating	1	2	3	4	5	satisfying
		1	1	4	19	4	
	inadequate power	1	2	3	4	5	adequate power
		1	8	6	10	4	

Appendix F

An example of calculating sign test

R1

Subjects	Ranking (no acc)	Ranking (acc)	Direction of difference
S1	7	3	+
S2	7	7	0 (omitted)
S3	4	3	+
S4	7	3	+
S5	7	6	+
S6	7	3	+
S7	7	4	+
S8	7	6	+
S9	7	3	+
S10	7	3	+

Less frequent symbol is '—', the number of '—'s is 0.

The critical value for 5 per cent is 1 (N=9). Therefore, sign test suggest the dependent variable (accident information) has had an effect on behaviour (route planning).

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