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An accident centred approach to primary safety strategy development for vehicles.

by

William Simon Fletcher

A Doctoral Thesis
Submitted in partial fulfilment of the requirements for the award of
Doctor of Philosophy
of Loughborough University

March 2000

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Abstract.

This thesis addresses the development of a methodology to determine primary safety strategy with respect to the choice of appropriate technological solutions to the problem of accidents in cars.

In motorised societies in the 1990s, road accidents are a major cause of loss of life, injury and property damage. Motor manufacturers have increasingly been concerned with reducing the effects of accidents and have recently been developing technologies to attempt to reduce the number of accidents on the roads. Traditionally, these technologies have been transferred from other domains into vehicles, (principally from aerospace). Two problems however exist with this approach.

Firstly, developing solutions on the basis of what is technologically feasible may ignore the requirements of the drivers in terms of systems that would actually be of benefit whilst driving. In part, this is due to an incomplete understanding of the reasons why drivers have accidents in cars.

Secondly, motor manufacturers are faced with an ever increasing number of potential systems that they may develop and eventually implement in cars. Currently, they have no methodology to determine which of these systems, if any, should be researched or developed further.

This thesis addresses both of these issues. Firstly, a large scale questionnaire survey was conducted using a population of recently accident involved drivers drawn from the insurance group of a major motor manufacturer. The survey was designed to obtain information from drivers pertaining to the reasons for the occurrence of their accident. This information was more detailed than had previously been gained from drivers after they have been involved in accidents in cars.

This data was built upon in the second study of the thesis, which used real life accident data to develop a methodology to determine safety strategy for a motor manufacturer. Focus groups using a variety of employees of the motor manufacturer were employed to correlate accident scenarios with a series of functionally defined accident countermeasures. When combined with quantitative data from the questionnaire survey, assessments of the overall efficacy of the countermeasures
Abstract.

could be deduced. From this, an outline strategy for primary safety system development was deduced.
Acknowledgements.

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I would like to thank my supervisor, Professor Margaret Galer Flyte for her support and guidance throughout this research project. Grateful thanks are also due to John Green from Rover Group, and the staff at the Rover Group Fleet Insurance Department, Uxbridge.

I would like to thank all the staff and postgraduate students from the Department of Human Sciences for their valued support and friendship throughout the course of this work. It would be unfair of me to mention any in particular lest I forget others. However, I owe Lynda a debt of thanks for submitting this for me whilst I was unable to.

To Rich for valuable comments over the odd pint, (Ya mate, I did finish) and to Rich, Andy and Jo for encouragement and rearranging their home to put up with me in the final weeks. To my family, whom I’ve hardly seen in this last year or so, and whom I hope to see more of now this is finally done.

Last, but most importantly, to Clare, what can I say? *Ein Tag ohne Dich, ist wie ein Tag ohne Sonne.*
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Throughout the course of this thesis, a number of closely related terms will be used and are explicitly defined below.

**Accident:** An accident is an unexpected and unintentional series of events, that occurs through a combination of contributory and causal factors. It may result in one or more of a number of possible outcomes, including physical harm to an individual, damage to property, or merely a significant deviation from safe system operation, (adapted from Bentley 1998).

**Road Traffic Accident, (RTA):** RTAs are a subset of accidents that occur in the road traffic environment and are concerned with failures in the safe operation of motorised transportation. These failures may result in physical harm to either the operator of the transportation system, (the driver), harm to other road users, or may result in damage to either the vehicles concerned or to other property. In addition, RTAs may result in neither harm to individuals or property, but may result only in significant departures from safe system use, (for example in the case of a vehicle running off the roadway but not colliding with any roadway or roadside objects). The focus of this thesis is on RTAs involving cars, and as such this term will only be used when at least one of the vehicles involved is a car.

**Causal Factor:** Any identified factor which directly causes an accident and without which the accident would not have occurred. Examples of such factors would be a sudden and catastrophic mechanical failure whilst driving at speed, such as a tyre blowout on a motorway. It is highly likely that given this factor, an accident will occur, (from Broughton and Markey 1996).

**Contributory Factor:** Any identified factor that contributes to an accident, but does not in isolation cause it. An example of this would be a driver who is in excess of the legal limit of blood alcohol concentration. Whilst this driver is more likely to be involved in an accident, drivers may frequently drive with excess alcohol in their blood and not have an accident and thus this factor cannot be described as causal, (from Broughton and Markey 1996).

**Accident Prevention Measures/Accident Countermeasures:** Any intervention that may serve to reduce the likelihood of an accident occurring. It is implicit in this
Definitions.

definition that these interventions will only have potential to prevent some forms of accidents and that these interventions may be based on the driver, the vehicle, or the environment through which driving occurs.

**DRIVE,** (Dedicated Road Infrastructure for Vehicle safety in Europe): European based research programme in transport Telematics and intelligent transport systems. Two such programmes have been undertaken, DRIVE I (running from 1989-1991) and DRIVE II, (1992-1995), both funded by DG XIII of the European Commission. Unless specifically required, both research programmes will be referred to in this thesis as DRIVE.

**PROMETHEUS,** (PROgraMme for European Traffic with Highest Efficiency and Unprecedented Safety): A research programme carried out in parallel to the DRIVE programme, (1986 to 1994), funded by Eureka. In contrast to DRIVE, the PROMETHEUS programme was funded primarily by industry and was headed by European based motor manufacturers.

**ATT/IVHS:** ATT, (Advanced road Transport Telematics) and IVHS (In-Vehicle Highway Systems), are sub-classes of accident prevention measures that are focused primarily at the vehicles concerned. They may be systems based exclusively in the vehicles themselves, (such as Anti-lock Braking Systems), or may be systems that interact with the vehicle and environment, or other vehicles within the environment, (such as Variable Message Signs on motorways). These are systems that are either currently in production in vehicles, or are in prototype or simulation form. Technologies described in the academic literature, (for example in literature undertaken throughout the DRIVE or PROMETHEUS programmes) will be described as either ATT or IVHS.

**Potential Technological Solutions:** These are a subset of Accident Prevention Measures or Accident Countermeasures that are focused exclusively on technological systems that a motor manufacturer would have direct input in designing or implementing in their vehicles. Two distinctions are drawn between these systems and those described in the DRIVE or PROMETHEUS work. Firstly, these systems are not yet in production or prototype form, but are suggested as a result of the implications of the methodologies developed in this thesis and the strategy for primary safety system development. Secondly, these systems will be functionally described; in relation to the actions these systems will carry out they will be described in terms of the function that the system performs for the driver.
Definitions.

rather than the technological action per se. For example, antilock braking systems, (ABS) would be described as either a system that allows constant efficient braking under poor road conditions, or one that allows a driver to steer and brake effectively, rather than one that maintains optimum traction for braking through rapidly applying and releasing the brakes so as to prevent skidding.

These systems although having significant components based in vehicles are not exclusively based on in vehicle systems. They may for example rely on information transmitted to the vehicle and presented to the driver by an on-board system, for example information from road side beacons relating to hazardous roadway situations ahead. Systems with no vehicular component, for example Variable Message Signs, (VMS), currently seen along some stretches of motorway in the United Kingdom are excluded from this category.

Our Driver: In the context of the current work, 'our driver' will refer to the driver completing the RTA causation questionnaire.

Other Driver: In the case of an RTA involving more than one vehicles, 'other driver' will refer to the driver of the vehicle most proximal to that of our driver. Discussion of an additional driver will not be undertaken except where pertinent.

Functionality Matrix: A functionality matrix is a method described within the HUFIT toolset that allows large amounts of information relating to user requirements and system functionalities to be cross referenced. The matrices are completed by groups, using a non numerical coding scheme indicating the required system functionalities for each system.

Solutions Matrices: A Solutions Matrix is modification of the Functionality Matrix concept in which RTA scenarios are cross referenced with Potential Accident Countermeasures. In addition, information relating to the development efforts required are contained within the Solutions Matrix which is used to determine the relative efficacy of a number of Potential Accident Countermeasures for the purposes of defining safety strategy.
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1.0 Introduction.

1.1 Chapter summary.

This chapter introduces the thesis as a whole and the area of research in which these studies were conducted. Specifically, this chapter outlines the requirements for this work and describes some of the issues allied with work in this area. Finally, the chapter then describes the structure of the thesis and the studies described herein.

1.2 General introduction to the thesis.

In motorised societies in the 1990s, road accidents are a major cause of loss of life, injury and property damage. The motor industry as a whole has increasingly been concerned with reducing the effects of accidents and has accordingly been introducing technologies aimed primarily at reducing the injuries sustained by those involved. Efforts have also been directed towards transferring technology from other domains into vehicles, (principally from aerospace), as well as at developing novel technologies to aid and assist drivers. Traditionally, these technologies have been directed simultaneously at many aspects of improving driving (for example efficiency or comfort). Only one of these aims is the safety of those travelling.

However, it can be seen that two problems exist with respect to the introduction of new driver information and support technologies into vehicles in this manner. Firstly, the emphasis of much of the research and development has been from a technological perspective. In essence, much of the efforts have been directed towards developing and implementing systems that are technologically feasible rather than systems that are actually required by the drivers to assist their driving. Some of these systems may effect a reduction in the number of accidents occurring on roadways by directly improving the safety of those travelling on the roads,
Introduction.

example traction control or anti-lock braking systems). However, the new technologies are for the most part not specifically designed for this purpose and consequently technologies aimed primarily at reducing the likelihood of accidents occurring are rare.

Secondly, given the number of technological products that are being developed and tested, motor manufacturers are faced with the decision of which if any of these potential accident countermeasures should be further researched or implemented into their production vehicles. With respect to accident prevention, currently no methodology exists to allow a motor manufacturer to decide upon which technologies should be further researched or manufactured to effect a reduction in the number of accidents. The development of a methodology to allow a motor manufacturer to make strategic decisions regarding potential technological solutions for accident prevention is the primary aim of this thesis. Since this research is aimed at the development of a methodology from which to produce a strategic plan, it was not expected to result in precisely quantifiable results. It is a means to an end.

1.3 Background to the research.

Despite recent efforts directed towards increasing the safety of those travelling on the roads, in motorised societies, the number one public health problem in the 1990s has been argued to be due to road traffic accidents, (Deering and Viano 1994). In the West, more pre-retirement deaths are due to traffic crashes than to the combined effects of the two leading diseases, cancer and coronary heart disease, (Evans 1991). Road deaths are not just of consequence to the middle aged however. In the US alone, almost half of the 19 year olds dying annually do so due to traffic accidents. The ever increasing reliance on the road as a means of transportation will continue to place increasing demands on roads, vehicles and the drivers utilising them. With the numbers of motor vehicles constantly increasing, the issue of the safety of those on the roads has become of more importance in the past 10 years.
Introduction.

Currently, although the number of licensed drivers in the UK has risen by a little over a third in the last 15 years, the numbers dying on the roads annually are actually falling slightly, (DoETR 1997). This is due to a number of factors, not least of which is the increasing number and efficiency of occupant protection technologies that have been developed and are currently in vehicles. The efficacy of measures such as equipping the vehicle with seat belts has become greatly enhanced by recent advances in electronics, sensor technology and computing, in addition to vehicle design as a whole. Vehicles are now commonly equipped with seat belt pretensioners and air bags, and may soon be equipped with more advanced occupant protection devices such as smart air bags that are timed to activate according to the size and weight of the occupants so as to maximally enhance the survivability of an accident, (Grafton, Galer Flyte, King, & Jackson 1995; King, Jackson, Galer Flyte, & Grafton 1995).

These advances in technology have also facilitated the research and development of novel high technology systems such as collision warning systems and intelligent cruise control into vehicles, (see Figure 1.1). As can be seen however, in addition to modifying vehicles, changes in the nature of driving may be effected by introducing modifications to the environment, (for example with roadway layout modifications), or changing the way the driver behaves, (for example by changing the nature of the training a driver undertakes before being licensed). Not all of the changes in driving that may be produced by modifying elements in the driver - vehicle - environment systems are therefore technological in nature. The changes that a motor manufacturer would have most influence on however are mostly those concerning the vehicles themselves. In general, any changes in driving brought about by the influence of a motor manufacturer’s direct input will by necessity be due to the implementation of technology in some form.
Introduction.

Driver Solutions
- Education/training, Licensing.

Vehicle Solutions (May include IVHS and ATT)
- Improved performance, and reliability.
- Intelligent vehicle solutions, (e.g. Collision avoidance systems, Intelligent cruise control).
- Enhanced occupant protection, (e.g. Air bags, Seat

IVHS).
- Speed limiting measures.
- Traffic management systems
- VMS, Improved crash barriers.

Driver

Environment

Vehicle

Figure 1.1 A schematic outline of the subsystems involved in driving illustrating potential solutions to the problem of vehicle accidents, (adapted from Zimmer 1990).

This thesis is concerned with changes in the nature of driving that a motor manufacturer may have an active role in effecting. The emphasis is therefore primarily concerned with the nature of the process through which a motor manufacturer develops and implements technologies into vehicles. Specifically, this thesis will address systems that are characterised by being technologically advanced, and may be introduced into vehicles in the near future. The focus of this thesis is those systems that are designed to effect a reduction in the number of accidents currently occurring on the roads and such systems will be described as potential technological solutions. (Accident prevention measures out of the direct influence of a motor manufacturer will be discussed where pertinent however).
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1.4 The development of advanced technologies in vehicles.

Some potential advanced technologies solutions have progressed sufficiently in their development and are now in production in vehicles, an example being route guidance systems that allow the driver to select and be directed to a destination. More advanced route guidance systems that actively take into account the current traffic environment, (for example circumventing sections of the route that a given driver may wish to avoid or directing the driver around an unexpected hold-up in the intended route), are being developed and are expected in the marketplace in the near future. Other technologies which may have a more obvious primary safety application, for example collision avoidance systems or intelligent cruise control, are currently being developed and are expected to enter the marketplace within the next 5 years.

Whilst efforts are being made to ensure that such technologies conform to basic ergonomic criteria, in that for example they are not distracting, and do not put unnecessary cognitive burdens on the driver, (for example Galer and Simmonds, 1984, Galer 1985, Robertson and Southall 1992), the majority of development efforts have been directed at perfecting the technological aspects of the systems. Little concern has been directed to the potential for such systems to perform what must be a basic system action, that of effecting some reduction in the number of road accidents, and by implication the number of casualties currently experienced. Largely this is due to the development history of such technologies as they have for the most part been technologies transferred from other domains, (notably aviation and military applications), and subsequently applied to the driving scenario.

It can be seen therefore that whilst the systems currently under development, (and to some extent those in production now), technologically function well, and are for the most part ergonomically appropriate, (or are under development to improve their usability), little attention has been given towards effecting a reduction in the number
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of accidents currently experienced on the roads that appropriate implementation may produce. In effect, many systems have been designed on the basis of what is technologically feasible and implemented with the hope that a reduction in accident numbers will result.

Two problems therefore exist for motor manufacturers with respect to the choice of such technologies for implementation. Firstly, the current technologies do not specifically address the problem of accidents in cars. Secondly, motor manufacturers are bombarded with products by their suppliers, (as well as prototype systems being developed in house), and these companies have no way of making informed decisions about the relative merits of any particular system. It is the development of a methodology to determine primary safety strategy with respect to the choice of appropriate technological solutions that this thesis addresses.

1.5 Underpinning thesis hypothesis.

In order to effectively understand priorities for primary safety systems development, one needs to collect data on real life accidents and have a means of evaluating the potential value of technological solutions in reducing the number of accidents.

1.6 Aims and objectives of the thesis.

The aim of the current work is the development of a methodology, the application of which will allow a motor manufacturer to make strategic decisions concerning the priorities for in vehicle primary safety countermeasures development. To accomplish this, the objectives of the thesis are as follows:

1. To perform state of the art literature reviews of the current situation with respect to accident causation, vehicle accidents in specific, and available and prototype technologies that may address primary safety in cars.
2. To collect information on accidents involving cars to determine the nature of the causative factors in more detail.

3. To define a procedure for correlating information on accident causation and potential accident countermeasures.

4. To develop processes within a motor manufacturer whereby they can utilise such a methodology to determine their primary safety strategy. In effect, a process model for implementation of the methodology will be developed.

1.7 The structure of the thesis.

The thesis is partitioned into three main stages of work, state of the art literature reviews, data collection and methodology derivation, and discussion and conclusions of the project as a whole.

Chapter 2 details reviews of literature concerning accident causation in general, accident causation in cars in specific, methodologies of data collection on accident causation and on technological countermeasures.

Chapters 3 and 4 describe the main data collection of the thesis. Specifically, Chapter 3 describes the work undertaken to determine in some detail the nature of the factors impinging on car accidents. Chapter 4 builds on this work with the development and testing of the Solutions Matrices methodology which determines the most effective technological solutions that a motor manufacturer may consider in their safety strategy.

Chapter 5 discusses the project as a whole and describes a process model wherein a motor manufacturer may integrate the information described in Chapters 2 to 4 into a structured safety strategy.

Finally Chapter 6 recapitulates the conclusions of the study and discusses the opportunities for further work continuing on from this thesis.
1.8 Chapter conclusions and summary.

This chapter has introduced the scope of the thesis and in particular the need for this research. The underlying hypothesis in this work has been outlined and the aims and objectives of the study and the structure of the thesis overall have been described.
2.0 Literature reviews.

2.1 Chapter summary.

This chapter introduces the background to the thesis by describing the literature underlying the work undertaken. The review will describe accident causation in general, followed by accidents in cars in specific. This includes details of in-depth accident studies and methodological limitations of these studies. Following this, the nature of technologies being introduced into vehicles and how in-depth studies may be used to better determine these are described.

2.2 Background to the research.

One of the major public health problems in motorised societies is road traffic accidents, (RTAs). Considerable costs to society as a whole occur due to those killed and injured as well as the very much more frequent non-injury RTAs, (Deering and Viano 1994). Safety science describes the possible remedial actions that may be taken to reduce the toll of vehicle accidents in three domains, (Forum of European Road Safety Research Institutes 1994, Tingvall 1997);

- Primary safety: concerns the prevention of accidents and relates to improving the skill of the driver or the performance of vehicles (by introducing for example anti-lock braking systems).

- Secondary safety: concerns the prevention and reduction of injury once an accident has occurred and relates to the crashworthiness of vehicles (such as air bags or seat belt pre-tensioning systems).
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- Tertiary safety: concerns the minimising of the consequences of injury and preventing these injuries from worsening given that they have occurred. This relates most often to the speed and quality of post incident trauma care that the victims receive.

At least to some extent however, the costs are preventable by implementation of suitable accident prevention measures and as such a number are currently being employed or developed. In terms of the activities of a motor manufacturer, only primary and secondary safety interventions are of direct relevance.

Unlike secondary safety countermeasures which are exclusively technological in nature, primary safety countermeasures may be either a technological intervention, (such as anti-lock braking systems or traction control systems), or a social intervention, (such as driver training or safety education). From the perspectives of a motor manufacturer, only technological interventions are of primary interest.

Vehicle design considerations and the implementation of new technology into vehicles for the express purpose of accident prevention are an important, and currently under researched area of activity. There are three main reasons for research in this specific application area. Firstly, whilst secondary safety measures are becoming increasingly efficient at saving lives and reducing injuries, some accidents that occur are simply not survivable given the nature of the accidents themselves, (notably multiple vehicle, high speed impacts). This is linked to the second issue, namely that secondary safety is arguably rapidly approaching a plateaux in terms of the number of fatalities and injuries preventable, (Deering and Viano 1994). Finally, a third issue is that whilst injuries and fatalities are preventable to some extent given that an accident has occurred, a logical approach would be to attempt to prevent the accident from occurring in the first instance, thus reducing or eliminating the costly requirements of injury rehabilitation. Sanders and McCormick (1992), stated that one of the main objectives of human factors is to reduce accidents, and in the current context, it can hardly be argued that prevention is indeed better than cure.
The hypothesis underpinning this thesis is as follows; in order to effectively understand priorities for primary safety systems development, one needs to collect data on the causes of real life RTAs and have a means of evaluating the potential value of technological solutions in reducing the number of accidents. It is thus argued that by understanding why these RTAs occur, appropriate actions may be undertaken to prevent these RTAs. An Ergonomics or Epistemological approach is therefore being taken, (Bentley 1998).

Driving can be viewed from a systems perspective, the systems concerned being the driver, the vehicle, the environment in which the driver and vehicle move through, and the interfaces between these subsystems, (Figure 1.1). From this perspective, RTAs are viewed as a product of mismatch between the driver, the vehicle and environment. By identifying the factors and interactions impinging on RTA causation, and hence identifying these mismatches, an understanding of the nature of their causation may be derived. Following this, appropriate accident countermeasures may be designed and eventually introduced. However, no method exists to determine which potential technologies should be implemented or researched further.

The emphasis of this work is from the perspectives of a motor manufacturer and what such a manufacturer may do to effect a reduction in the number of RTAs. This project is thus to develop a methodology to identify the human-vehicle interactions impinging on accident causation with a view to improving safety through vehicle design improvements and the appropriate implementation of advanced technology into vehicles.

2.3 Aims and objectives.

This chapter has two aims; to demonstrate the need for this research by reviewing the literature and highlighting the omissions in the research, and to use this review to outline the work undertaken and described in the thesis. There are three objectives;
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- To describe the scope of the problem by reviewing the literature relating to accidents in general and in cars in specific.

- To describe the details of in-depth accident studies relating to accidents in cars and to outline the methodological limitations of these studies.

- To describe the in-depth studies that have related the cause of the RTAs to possible RTA countermeasures, and outline the limitations of these studies.

2.4 An Introduction to accident causation.

2.4.1 The nature of accidents and of the accident process.

Most dictionary definitions and many scientific approaches to accidents include some references both to the consequence of the incident and the chance nature of the event. For example, an accident may be defined as 'an event that is without apparent cause, or is unexpected; an unfortunate event, especially one causing physical harm or damage', (Concise Oxford Dictionary 1996). In scientific literature, similar definitions abound. Meister (1987) for example defined an accident, as 'an unanticipated event which damages the system and/or the individual or affects the accomplishment of the system mission or the individual's task'.

Suchman (1961) produced a list of indicators of the 'accidental nature of an event', the more of which are present the more likely the incident is to be called an accident. The indicators are:

- Low degree of expectedness.

- Low degree of avoidability.

- Low degree of intention.
A frequent characteristic of the majority of accident investigations, (notably those within the domain of aviation), is to find a single cause, or a small number of causative factors on which to assign blame. Thus the emphasis tends, especially within a legal framework, to assign blame to an individual or company often for the purposes of litigation.

However, in almost all cases, an accident results, not from a single factor, such as a pilot making an error, but due to a multitude of factors, many of which are unrelated in their aetiology, (Figure 2.1). An illustrative example is the fire, started by Nero that destroyed the city of Rome in AD 64 (Dixon 1994). The devastation caused by this fire was greatly enhanced by several factors; the location of the original act of arson, the prolonged period of drought immediately prior to the fire and the strong winds blowing towards the centre of the city from the direction of the start of the fire. Had the fire been started in a different part of the city, or had there not been a water shortage caused by a prolonged drought, or had the prevailing winds not been blowing in the direction that they were, the devastation caused would have been considerably reduced.
Many authors have emphasised the multifactorial nature of accidents, even those advocating the theory of accident proneness, that in its original conception postulated that the main cause of accidents was a single, unwavering personal disposition, (Shaw and Sichel 1971).

A distinction may be drawn between factors that make the likelihood of an accident occurring higher, and those that actually cause and accident. These are contributory and causal factors respectively. In Figure 2.1 a contributory factor is defined as an identified factor that when present significantly increases the probability of an accident, but does not in isolation cause it. An example of this would be a driver who is in excess of the legal limit of blood alcohol concentration. Whilst this driver is more likely to be involved in an accident, not every driver who drives with excess alcohol in their blood will crash, and thus this factor cannot be described as causal. A causal factor however, is defined as a failure of a critical piece of equipment or a human error without which an accident would not have occurred. Examples of such factors would be a sudden and catastrophic failure whilst driving at speed, such as a tyre blow-out on a motorway. It is highly likely that given this factor, an accident will occur and without this causal factor, an accident will not result. Causal factors are thus typically what would be regarded for legal purposes as being the cause of the accident. The danger release phase is the moment of the accident, i.e. the crash or explosion, and is distinct from the harm release phase, which is the phase during which harm to people and property occurs. Dependant on the nature of the systems involved, there may be some delay before the harm release phase occurs, and this phase itself may extend over a very short period of time or many years.

A summary of several dictionary definitions of 'accident' suggests that an accident is 'anything that happens; an unforeseen or unexpected event; a chance or a mishap'. To many, therefore, the term accident implies an act of fate, which is therefore devoid of any predictability. Figure 2.1 is illustrative of the nature of the fallibility of this and of using non technical terms in a technical argument. Accidents are not just 'acts of chance' but are probabilistic events whose causes may be determined and countermeasures prescribed accordingly. The basic definition of an accident
used in the remainder of this thesis, is derived from that of Bentley (1998). The emphasis of this definition is that although an accident is unexpected and unintentional, they occur through the interaction of a series of contributory and causal factors. Additionally, an accident may result in a number of possible outcomes, including physical harm to an individual, damage to property, or a significant deviation from safe system operation.

For simplicity in the remainder of this thesis, the term Road Traffic Accident, (RTA), will be applied to accidents involving motorised transportation. RTAs are a subset of accidents that occur in the road traffic environment and are concerned with failures in the safe operation of motorised transportation. These failures may result in physical harm to either the operator of the transportation system, (the driver), harm to other road users, or may result in damage to either the vehicles concerned or to other property. In addition, RTAs may result in neither harm to individuals or property, but may result only in significant departures from safe system use, (for example in the case of a vehicle running off the roadway but not colliding with any roadway or roadside objects). The focus of this thesis is on RTAs involving cars, and as such this term will only be used when at least one of the vehicles involved is a car.

It should be remembered that the use of accident does not imply that an RTA is a random, unpredictable event, but one that occurs though the interaction of a number of causative and causal factors that may be deduced and thereby effective accident prevention measures designed.

Having described the nature of accidents, the sequence of events in an accident requires consideration. Ramsey described an accident sequence model which may be directly applied to RTAs, (Ramsey 1985). In Ramsey’s model, the information processing stages in an accident sequence are described, and with reference to a specific domain, the factors associated with an accident’s genesis may be determined. Once an individual has been exposed to a hazardous situation, upto 4
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main stages are passed through before safe or unsafe behaviours are exhibited and the accident either occurs or is avoided. The model is presented in Figure 2.2.

![Figure 2.2. A model of an accident sequence, (adapted from Ramsey 1985).](image)

Ramsey's model stresses the importance of hazard perception; many accidents that occur are due to not recognising or to underestimating hazards and risks involved in the situation. Errors associated with driving in particular have been associated with inappropriate information acquisition and processing, (Rumar 1988), failures of which will fit within Ramsey's model. Once a hazard has been identified, the
motivational aspects of hazard avoidance are also implicit in this model. This is of especial importance as drivers have frequently been shown to behave as if it is the responsibility of the other road users involved in an accident to avoid the accident occurring, (Clay 1995, Evans 1991). Ramsey’s model may be criticised however for its apparently linear nature when viewed at face value. Its value in the description of RTAs are the 4 central processes of perception and cognition of the hazard, and the decision and ability to avoid the hazard. This model is limited however as the reasons for an RTA are not explained. The factors underlying specific RTAs are not described explicitly.

2.4.2 Theories of accident causation.

Theories of accident causation will naturally focus on attempts to determine the factors underlying accident occurrence. In an analysis of insurance company data Heinrich (1959) concluded that in 85% of accidents human operator error was the direct cause. It may be possible in any given case to assign the fundamental error to the operator of a system that breaks down and causes an accident, or to the designer of that system. Taking this broad perspective, Petersen (1984) concluded that human error was the fundamental cause behind all accidents. The precise allocation of cause often depends upon the stop rule applied in the accident analysis, (the point at which the accident analyst stops searching for more causal or contributory factors). This in itself will be determined largely by the background of those investigating the accident; psychologists may naturally look for human errors whereas engineers may more inclined to look for engineering system failures.

Accidents may be caused by either unsafe acts of persons, (operator error), or unsafe conditions, (designer error, Heinrich, 1959). The implication of this is that often the injured individual or operator of the system, is blamed, (as exemplified by the Driver / Pilot error scenario). There is therefore a tendency to direct attention at fault, (Alicke 1992, Clay 1995, Shealy 1979). Shealy (1979), noted 4 main underlying reasons for fault attributions;
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- It is human nature to blame what appears to be the active operators for system failures resulting in accidents. This is especially the case when personal injury to third parties results. At least in part these attribution errors may result from processes of social cognition, (Alicke 1992, Hewstone 1988), manifesting itself as an overly optimistic appraisal of one's own driving abilities at the expense of others, (McKenna 1993, McKenna, Stanier and Lewis 1991, Svenson 1981).

- The legal system is geared towards assigning blame or fault often for the purposes of litigation; accident data is often collected merely to fulfil legal requirements, (Sanders and McCormick 1992). By implication, such data are inadequate for post hoc deduction of accident prevention measures as it is often difficult to extrapolate from data collected purely for other purposes, (Frampton 1997).

- From an organisational perspective, it is often easier for management to blame workers than to accept that other, (often more costly), changes are required, (for example workplace improvements or changes in standard operating procedures).

- Accident investigation forms that are to be completed are often modelled on the unsafe act/unsafe condition dichotomy, (e.g. Heinrich 1959).

Early accident investigations noted that some individuals suffered more accidents than others and specifically more than would be expected by chance alone, (e.g. Greenwood and Yule 1920), and this naturally leads to Farmer and Chambers (1926) postulating the theory of 'Accident Proneness'. Simply stated, this theory suggests that the reason for some individuals being involved in multiple accidents is that they possess a permanent characteristic of being accident prone. The theory of accident proneness has a certain amount of face validity and was generally accepted albeit with some modification until the mid 1960s. It was still favoured by some until the 1970s, (for example Shaw and Sichel 1971). At a superficial level, accident proneness seemed to fit accident statistics, however few explanations for this personal disposition were suggested. This may have partly been due to the pervasive acceptance of behaviourism, although one notable exception to this lack of
explanation was the work of Dunbar. Dunbar (1954) suggested that a personality trait of accident proneness was a proven fact and advanced psychoanalytic explanations for the existence of this trait. Later versions of the accident proneness theory were less extreme in outlook than the earliest theories presented. Shaw and Sichel (1971) for example suggested that accident proneness was not an enduring trait, but was modified throughout life in a similar manner to other behavioural changes. The fundamental concept of accident proneness remained however.

There are several reasons for the decline of the accident proneness theory. Firstly, and perhaps most importantly, close examination of the data suggests that the theory is not accurate. Whilst it is undeniable that some individuals are involved in more accidents than others, it can be readily seen that different individuals are involved in different types of accidents, and thus the concept of being generally accident prone cannot be the complete explanation. Additionally, few attempts were made to explain the concept of accident proneness at a behavioural or cognitive level. In essence, the concept of accident proneness is a circular argument; it suggests that some individuals are involved in multiple accidents because they possess some enduring trait which predisposes them to be involved in multiple accidents.

With the decline in the acceptance of the theory of accident proneness, several other theories were suggested. These were summarised by Sanders and McCormick (1992). Arousal theory suggests that performance is related to an individual’s level of arousal, a graph of performance against arousal being an inverted U shape. Too little arousal and an individual performs poorly, performance gradually improves to a peak at the optimum level of arousal. Beyond this optimal level of arousal, performance gradually declines. The same reasoning can be applied to job demands and worker capability. As the demands of a job increase, performance increases, and therefore errors and hence accidents are reduced. Beyond the optimal level of job demands, performance decreases as the worker becomes overloaded and the levels of demands exceed an individual’s ability to cope.
An alternative model proposed that the greater freedom that individuals have to set their own goals the better performance becomes resulting in fewer accidents. This is known as the goals-freedom-alertness theory. Psychoanalytic theories have also been suggested that describe accidents as punitive self acts caused by guilt and aggression. However, perhaps due to its face validity and the idiomatic use of the term 'Accident Prone', the theory of accident proneness has remained popular almost to date.

A modification of the theory of accident proneness, the theory of accident liability, suggests that different individuals are more or less prone to accident involvement and that this trait changes over time. For example, it has been demonstrated that the young are generally involved in more RTAs that middle aged drivers, and that states such as inexperience, inattention, overestimation of personal ability and pride may be related to their increased accident risk. A higher degree of explanation is inherent in this theory than in many other accident causation theories, although McKenna (1983) demonstrated that some individuals may be exposed to more hazards than others and are therefore more likely to be involved in RTAs irrespective of their own accident liability.

A modified differential accident liability theory has been proposed, (McKenna 1983). This theory postulates that people are differently liable to accident involvement due to different personal circumstances. For example, those driving more miles per year would be at greater risk than those driving fewer miles. By implication, further analyses would have to be undertaken in any specific domain in order to deduce the underlying factors causing a differential liability to be involved in an accident. To some extent, this can be argued to be simply a more explicit investigation of the demographic factors underlying accidents in any domain and thus this theory of accident causation is more a demographic descriptive framework. Taking a wider perspective, this framework can be applied to gain a more complete understanding of the nature of drivers who are involved in accidents. It is then necessary to determine why these drivers are being involved in accidents. It can be
argued that human error is at the heart of this question, but definitive analyses of these errors are rare.

2.4.3 Human error and accidents.

'It is virtually impossible to design and operate a perfectly safe human-technological system', (Brown 1990 pp 755); errors are therefore a natural consequence of learning and operating such systems, (Rasmussen 1987). Reports of industrial or transportation accidents are often concluded with the 'blame' for the accident being placed on human error, (Dixon 1994). Typically for example 'pilot error' is blamed for an aviation accident occurring. Arguments abound as to the proportion of accidents that may be attributed to human error, but it is clear that a significant percentage of accidents have some human error component. Due to the pervasive nature of human error in accidents, in order to understand the causes of accidents, an appreciation of human error is required.

Sanders and McCormick (1992), defined error as 'an inappropriate or undesirable human decision or behaviour, that reduces, or has the potential for reducing effectiveness, safety or system performance', (pp 656). Rasmussen (1987) defined error in a more equivocal manner as the effect of human variability in unfriendly environments. Brown (1994) subsequently suggested a framework for accident analysis that focuses not only on the frequency and variability of differences between prescribed task and actual performance, (errors), but explicitly requires a precise understanding of what these discrepancies are so that effective remedial measures may be undertaken.

2.4.4 Error classification schemes.

Whatever the precise definition of error, it can be readily seen that in any domain, a huge variety of error types may be exhibited, and thus taxonomies of error have been
developed in order to more readily facilitate an understanding of the nature of errors, how they are caused and how they may be prevented.

Swain & Guttman (1985) produced one of the simplest and most widely used error classification systems for single, discrete actions. Errors are classed according to one of four types; omission, (failure to do something); commission, (performing an act incorrectly); sequence, (performing a task correctly, but out of the appropriate sequence); or timing, (failure to perform a task within the allotted time). In theory any error can be categorised according to the above scheme, although in order to achieve this in practice, a precise understanding of the nature of the task in hand must be arrived at. Pragmatically, this requires that a task analysis of the operation of the system under consideration must be undertaken. In the case of driving, task analyses have been performed, (for example, McKnight and Adams 1970, Stene 1991), but this error taxonomy is impractical to use in driving, not least because 1500 separate perceptual tasks alone were identified in driving, (McKnight and Adams 1970). In conjunction, this error taxonomy is too simple, and the task analysis too complex to pragmatically determine the causes of RTAs. An additional criticism of this model of error from the perspective of driving, is that it is only directly applicable to single, discrete actions.

An alternative approach is to classify the errors according to the nature of the information processing being undertaken. Rouse & Rouse (1983) devised a scheme that follows the information processing procedures assumed to occur when humans operate controls. The operator first observes the system state, then formulates a hypothesis concerning the state and intended goal state, selects one or more procedures to attain the system goal and finally executes the procedures. This classification scheme is better defined than Swain & Guttman’s (1985), although many errors are placed under a general and somewhat vaguely defined category of ‘execution of procedure’. Both Swain & Guttman’s (1985) and Rouse & Rouse’s (1983) taxonomies thus suffer from vagueness in definition. Whilst these classification systems suffice for simple linear tasks, in the case of driving where
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multiple actions may be correctly undertaken at any given time to avoid an accident, neither classification may be usefully employed.

A number of other theories of human error warrant brief description. Shffrin and Schneider (1977) described a theory of controlled and automatic processing distinguishing between two modes of memory, a long term store, (which is non sensory in modality), and a short term store. The long term store was thought to passively retain information, whilst the short term store provides a cognitive workspace for current tasks and accesses relevant information from the long term store to facilitate this. Whilst this theory highlights the value of information required in any given setting, (information thereby being the reduction of situational uncertainty Rumar 1988, Stene 1991), it is difficult to envisage how this theory may be practically applied.

Broadbent’s (1984) “Maltese Cross” model of memory and information processing distinguishes between representations and processes and as with Shffrin and Schneider (1977) requires that information on an individuals intentions and task knowledge are deduced and compared to their antecedent behaviour. It is arguable as to whether an individual would have access to such cognitive processes in sufficient depth and thus these theories are beyond pragmatic usage.

An alternative approach recognises the need for accident reports to contain information pertaining to the degree of conscious control an individual has over behaviour, (Norman and Shallice 1980). Thus for accident reporting and analysis, individuals have to be aware of cognitive processes and an assessment of the appropriateness of preceding behaviour needs to be arrived at. Motivational factors are also included so that assessments of why actions are performed are required in accident analysis.
Two models of human error have been widely applied to RTAs, that of Rasmussen, (1982, 1987), and that of Parker, Reason and Manstead, (1995, based on earlier work by Reason, 1990).

Rasmussen (1982, 1987), produced a model of behaviour developed to account for more serious errors that can occur in complex, tightly coupled industrial and process control operations. This taxonomy places more emphasis on an accident analyst being an expert on the systems involved and deducing the previous behaviour and errors rather than the individual concerned in the accident accessing cognitions. This taxonomy is thus arguably more useful in accident investigations than those previously described. Additionally, this taxonomy is more explicitly defined than several others and has been applied to road accidents, (for example van Elslande 1997). In this scheme, behaviours are classified as being one of 3 major types, either skill based, rule based or knowledge based. The nature of the behaviours and the errors associated with each behavioural type are as follows:

- Skill based behaviours are subconscious routines and stored patterns of behaviour appropriate for well learnt behaviour in routine situations. Skill based errors are therefore execution errors.

- Rule based behaviours apply to recognised situations in which stored behavioural routine may be applied. Errors in applying rules are caused either by situation recognition failures, or by application of inappropriate rules.

- Knowledge based behaviours are required in unique, unfamiliar situations in which actions are planned in relation to specific goals. Errors involving knowledge based behaviours are due to inadequate analysis of the situation or poor decision making. These errors are generally viewed to be more serious than skill or rule based errors, (Grayson 1991).
One of the implications of this theory is that in the acquisition of skilled performance, there is a gradual progression from skill based behaviour, to rule and eventually knowledge based behaviour. The errors expected would thus progress from skill, to rule then knowledge based errors as ability improves. It has been stated that most errors with respect to driving are knowledge based, in particular, errors associated with driving have been associated with inappropriate information acquisition and processing, (Rumar 1988). Additionally, misinterpretation of information, especially concerning the intent of other road users has frequently been cited as the cause of road accidents. Rasmussen’s error classification fits the domain of driving well, both by describing the errors involved and from the point of matching the acquisition of skilled performance in driving. However, this taxonomy does not address the sequence of the errors or the sequence of the RTA and therefore is limited with respect to its applicability in suggesting appropriate accident countermeasures.

Reason (1990) distinguished between driving errors and deliberate violations of safe driving practices. Errors arise out of information processing problems and may be one of two types, slips and lapses, (actions deviating from an adequate plan), or mistakes, (actions conforming to an incorrect plan). Violations however are deliberate deviations from acceptable behaviour such as speeding or dangerous driving, (Reason 1990, Parker, et al 1995). In contrast to Rasmussen, who stated the majority of driving errors were related to inadequate analysis of the situation or poor decision making, Parker et al, (1995) related the majority of accidents to non malevolent violations. Thus the two theories differ in the degree of intentionality on the part of the accident involved driver, Parker et al, (1995) relating accidents to those drivers who deliberately commit violations of the highway code whilst Rasmussen (1982, 1987) related accidents to errors in information acquisition and processing. Parker et al (1995) do suggest however when considering that nature of drivers involved in accidents, that there may be ‘no systematic link between errors and accidents’, (pp 1037). This may in part be due to an incomplete model of human error and the role of the sequential nature of these errors in accident genesis. It is clear however, that errors do have a link with accident involvement, although the
nature of the link is still not understood. Subsequent in-depth analysis of accidents are frequently designed to elucidate these errors and the role they play in RTA genesis.

2.5 Individual differences in RTAs.

Were RTAs to be randomly distributed spatially and temporally, and all drivers equally likely to be at risk, frequency histograms of these variables would be normally distributed, (i.e. they would fit a Poisson or normal distribution curve). It is clear from an inspection of the statistics that a large proportion of RTAs are clustered at specific sites and times and occur more commonly to different types of drivers. In terms of those involved in RTAs, the obvious conclusion is that some categories of drivers exhibit more RTAs than others. The study of individual differences in RTA liability was originally associated with the concept of accident proneness, (Farmer and Chambers 1926) and is now replaced with concept of differential accident involvement, (McKenna 1983). This section will describe some of the relevant literature concerning individual differences in RTA involvement, but without specific reference to contributory or causal mechanisms.

2.5.1 Gender.

Every measure of involvement in fatal accidents in the USA for the 1980s shows double rates for men over women, despite the fact that double pair comparisons have shown that for the same physical injury, females are 25% more likely to be killed than males, (Evans 1991). Males are therefore involved in more accidents involving a fatality than females. Males do in general drive more than females and thus their increased exposure to risk of an RTA may have some influence on accident statistics, but the degree to which exposure causes higher fatalities in males than females is disputed and unclear, (West, Elander and French 1992). However, some have argued that even with exposure measures accounted for, males are still differentially at more risk of death in accidents than females, (Evans 1991).
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Additionally, the nature of accidents in which males and females are involved typically differs, males are more likely to be involved in RTAs concerned with alcohol, speeding, or single vehicles running off the roadway. Females in contrast are more likely to be involved in RTAs where vehicle handling errors are implicated in the RTA causation, (Evans 1991).

2.5.2 Age.

Young drivers are particularly involved in RTAs which have been described as a plague of the young, (Evans 1991). As with gender differences, there are age differences in the types of RTAs experienced and in the culpability of these drivers with age. Evans (1991) showed young drivers are more likely to be killed in single vehicle run off road or roll over RTAs whereas older drivers more likely to be killed by side impact collisions at intersections.

In general, 17 year olds have 50% more accidents than 25 year olds who themselves have 35% more than do 50 year olds, (Mayhew, Warren, Simpson and Hass 1981, Maycock, Lockwood and Lester 1991). The conclusion, therefore, is that younger drivers, are for some reason overly represented in the population of drivers having RTAs. This is despite the fact that they show generally enhanced perceptual and psychomotor skills over the older driver population, Yanik (1985). Careful analysis however demonstrates that whilst the perceptual abilities of younger drivers are generally superior to older drivers in laboratory type tasks, in terms of real world hazard perception, they are generally much inferior, Mourant and Rockwell (1970, 1972). Additionally, there are data to suggest that younger drivers generally seek more dangerous driving situations as they may perceive the increased risk to be more intrinsically rewarding, and thus may be differentially exposed to more likelihood of an RTA. There is also some evidence to suggest that RTAs per mile increase after 65 years of age, (Evans 1991, Mayhew et al 1981, Maycock et al 1991); these drivers being involved in less accidents than younger drivers, but typically driving considerably fewer miles per year on average. This illustrates one of the potentially confounding effects when considering the effects of age, younger drivers frequently
Literature reviews.

have high mileages per year as compared to elderly drivers, (Adams, 1985, Evans 1991, Grime 1987, Näätänen and Sumalla 1976). Young drivers however, on average drive less than middle aged drivers and when the effects of these mileages are considered, young drivers are still overly represented in RTAs. An additional confounding variable, the effect of experience is more difficult to partial out, but the data suggest that young drivers are still overly represented in RTAs as compared to middle aged inexperienced drivers, (Evans 1991). Even when exposure measures are controlled for, younger drivers are differentially overly involved in RTAs (Jonah 1986).

2.5.3 Driver skill.

Deducing the effects of driver training and driver skill is fraught with methodological problems; the confounding effects of age and driving experience being extremely difficult to partial out, (Evans 1991). In general however, evaluations of driver training programmes have demonstrated negative effects. Lund, Williams and Zador (1986), and Roberston (1980) showed that high school driver education programmes enabled young drivers to attain their licenses earlier than non trained teenagers and the overall accident rate thereby increased as would be expected by having more young drivers on the roads. Considering the issue of driver skill, Williams and O'Neill (1974) demonstrated licensed race car drivers showed more violations related to speeding and accidents than average drivers. It is possible however, that those drivers that drove in a manner likely to involve them in more accidents, and drove in a high risk style sought the special license. The special license would therefore be indicative of the predisposition of the driver to drive in a more risky manner, rather of a higher than average ability per se.

2.5.4 Cognitive ability.

In terms of cognitive abilities, Quimby and Watts (1981) found that potential hazards in a driving simulator were responded to less quickly by drivers under 25 and over 55 as compared to middle aged drivers. Quimby, Maycock, Carter, Dixon
and Wall (1986) examined the relationship between hazard perception and accident rates when taking other factors, (principally age and mileage) into account. No evidence of a relationship between simple reaction time and accident rates was found. Additionally, lower detection of hazards in a simulator correlated with an above average accident rate. (The use of simulators has subsequently been demonstrated to be valid for procedures of this nature, McKenna and Crick 1994).

In a study of subjective and objective risk of specific roadway locations, Watts and Quimby (1980) showed significant agreement between drivers in their ranking of subjective risks of a wide range of road locations. When these locations were ranked on the basis of relative subjective and objective risk levels, a small but significant association was found. There was some evidence however, that hazards at certain locations were misjudged consistently. Table 2.1 describes the locations consistently misperceived with respect to subjective and objective risk.
Table 2.1 Under reported and over reported risk, (from Watts and Quimby 1980).

<table>
<thead>
<tr>
<th>Under rated risks</th>
<th>Over rated risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suburban dual carriageway near pedestrian bridge</td>
<td>Hump bridge on a rural road</td>
</tr>
<tr>
<td>Rural brow on a single carriageway road</td>
<td>Level crossing on a rural road</td>
</tr>
<tr>
<td>Left turn off a rural road</td>
<td>Suburban shopping centre in a 30 mph limit</td>
</tr>
<tr>
<td>De-restricted rural dual carriageway site near a picnic area</td>
<td>Right bend at the end of a rural dual carriageway</td>
</tr>
<tr>
<td>Rural cross roads controlled by traffic lights</td>
<td>Right turn onto a rural dual carriageway</td>
</tr>
</tbody>
</table>

The significant agreement between driver’s rankings of the locations suggests that different drivers are applying essentially the same criterion in estimating risk levels. However, both the systematic errors shown, and the number of accidents exhibited on the roads attributable to risky manoeuvres, show that errors in risk perception do occur.

Mourant and Rockwell (1972) studied the strategies of visual search by novice and experienced drivers and determined that as driving experience increases, fixations focused more and more towards the focus of expansion of the visual world. Inexperienced drivers however, tended to focus their attention towards the front of the vehicle and to the side of the roadway to assist them guide the vehicle. These visual search strategies may serve to explain the poor perception of hazards by inexperienced drivers noted in the work of McKenna and may serve to explain some of the reasons for RTAs as these inexperienced drivers do not search far enough ahead of their vehicle for hazards.

Additionally, Field Independence, (the capacity to overcome embedded contexts in perceptual processing) which has been generally taken as a measure of cognitive style, has been related to accident involvement. The evidence is conflicting, some
have found negative associations between scores on the Embedded Figures Test and accident involvement, (e.g. Avolio et al 1985, McKenna et al 1986), whilst others found positive associations, (e.g. Mihal and Barrett 1976). McKenna et al (1986) also found negative associations between a Dichotic Listening Task and RTA rates in 2 years following drivers earning a Public Service Vehicle License. These findings imply a difficulty in attentional allocation, itself related to information acquisition and processing.

2.5.5 Risk, driving style and personality factors.

2.5.5.1 Risk.

Driving is a self paced activity (Näätänen and Summala 1976), drivers can therefore select their speed, routes and the level of risk they are willing to tolerate to their own preferences. With respect to the risk that a driver is exposed to whilst driving, several models have been proposed to account for driver behaviour.

Näätänen and Summala (1976) proposed that driver’s behaviour is mediated by a subjective risk monitor, the drivers objective being to maintain the level of perceived risk at zero. Compensatory behaviours are therefore initiated when the driver’s subjective level of risk is not zero, for example a driver may slow down when approaching a difficult section in the road so as to lower risk levels. Fuller (1984) however questioned the ability of subjective risk assessments being maintained at zero and yet having a profound effect on behaviour. Fuller (1984) further proposed a theory of driving in which driving is conceptualised as an exercise in threat avoidance. Fuller argued that the potential for risky behaviour whilst driving is very high and that drivers are motivated to avoid or at worst escape risky situations that may occur. Ideally, the level of subjective risk experienced at any time is therefore zero. However, at most instances, the level of subjective risk is above zero, and the driver is behaving accordingly so as to reduce it to zero.

Wilde, (1981, 1994) acknowledged that driving is inherently risky and proposed that drivers act so as to maintain a level of subjective risk that they are comfortable with.
Accordingly, drivers continuously make adjustments to their driving so as to maintain this level of risk. This risk homeostasis theory has been the centre of intense debate, not least because in its earlier forms it implies that traditional approaches to traffic safety are ineffective, (see for example Adams 1985, Evans 1991, Wilde 1994). Whilst the theory of risk homeostasis is relatively new, the idea that traditional approaches to traffic safety improvements may be ineffective was proposed in the 1940s, (Smeed 1949). Supporters of the theory of risk homeostasis have argued strongly for example that the legislation requiring drivers and front seat passengers to wear seat belts not only has no effect on vehicle occupant death rates, but actually worsens the situation by increasing the risks experienced by other, more vulnerable road users, (Adams 1985). Irrespective of the validity of the theory, one implication of the theory is that safety may be improved only when road users, (specifically drivers) are motivated to behave in a safer manner. However, many traditional approaches to traffic safety do not address the motivational aspects of encouraging drivers to drive in a safer manner.

2.5.5.2 Driving style.

The style of driving will obviously be confounded with other factors such as gender, age and experience, (for example young inexperienced drivers have been demonstrated to drive faster than middle aged drivers, Evans 1991). The effects of these confounding variables are extensive, and are sufficient to cause considerable confusion as to the effects of individual differences in preferred driving style.

In terms of the style of driving, perhaps the most obvious characteristic, (and certainly one of the most frequently discussed in the popular press), that may be associated with RTAs is speed. Speed choice is expected to play a critical role in accident involvement, (West et al 1992). Quimby and Watts (1981) produced a 'safety index' (subtracting braking distances chosen in simulator from required stopping distances as evidenced from speed on test track). This measure was found to be correlated significantly with numbers of accidents per mile of the same drivers in previous two years.
There are perhaps two reasons why an individual chooses an unsafe driving style. Drivers exhibiting unsafe driving styles may differ from safe drivers with regard to their attitudes to driving, (including concern over possibility of an accident), or they may differ with regard to their beliefs about what constitutes good and bad driving and their own level of skill and ability. It is well established that most drivers feel themselves to be above average in terms of skill and ability, (Svenson 1981). McKenna (1993) demonstrated that this was due to drivers believing themselves to be in control of their vehicles, rather than being overly optimistic about the chance of being involved in an accident. The general finding is that faster, more deviant styles are associated with being young and male and that these drivers are most likely to believe in their abilities as drivers. Wilde’s work, (Wilde 1994) suggests that only by motivating these drivers to drive in a safer manner will accidents involving these drivers be reduced.

2.5.5.3 Personality factors.

Relationships between personality factors and accident rates have been studied extensively, partly due to the search for an accident proneness personality type. Shaw and Sichel (1971) for example found higher scores for neuroticism and extraversion amongst bus drivers with poor safety records. Few studies have taken into account the possible relationship between extraversion, neuroticism and exposure, and thus there are significant methodological deficiencies in much of this work, (West et al 1992).

Accident involvement has more reliably been associated with Type A personality measures, (this personality pattern typically involves competitiveness, ambitiousness and a sense of time urgency). Perry (1986) found significant bivariate correlations between Type A behaviour, (as measured with the Jenkins Activity Survey), and both numbers of accidents and number of violations. Using a different rating scale, Evans, Palsane and Carrere (1987) found that drivers assessed as Type A had more accidents than those with Type B behaviour patterns, (the 'opposite' behaviour profile). As with much of the work on personality measures, significant methodological inadequacies exist with much of this research. Specifically, the
accident rate of the drivers being assessed was usually known when assessments of personality type were made, (West et al 1992). West et al (1992) suggest that accident risk may be related to overall level of social deviance and thus many of the personality based assessments will naturally be confounded and of limited use. In conclusion, no clear effects of personality irrespective of other variables have been demonstrated.

2.6 RTAs in context: International and national statistics.

Overall, since the 1920s vehicle numbers have increased enormously and to the mid 1960s injuries have increased in line with this. In general vehicle occupant casualties have increased tremendously, whilst death rates per vehicle have declined considerably. Thus it can be seen, that although absolute numbers of casualties have in some cases increased, decreased death rates per registered vehicle are an indication that the vehicles involved in the crashes are somehow safer. A manifestation of the increased safety of individual vehicles is that currently there are no more deaths on the roads than there were in the 1930s, despite vast increases in the numbers of vehicles and road traffic volumes, (Grime 1987).

2.6.1 International statistics.

In Europe, there are an estimated 120 million cars as of 1995, this figure being expected to rise by 3 to 4% per year, (Stevens 1995). Each year, RTAs in Europe kill approximately 50,000, lead to more than 500,000 hospital admissions and cause upwards of 1,500,000 casualties, (European Traffic Safety Council 1993). It has been estimated that for the Swedish population, RTAs cut average life expectancy by 6 months and lead to an average of 2.5 years of significant health deterioration per head of population, (Tingvall 1997).
Literature reviews.

Of all those dying annually, deaths due to RTAs are a relatively low percentage, (slightly over 0.5%, DoETR 1997); road accidents may therefore be viewed to be a relatively minor problem. However, in motorised societies, the number one public health problem in the 1990s has been argued to be due to road traffic accidents, (Evans 1991, Viano, Davis, Bennett, LeFevre, Rasmussen and Scherba 1991, Deering and Viano 1994). More pre-retirement deaths are due to traffic crashes than to the combined effects of the two leading diseases, cancer and coronary heart disease, (Evans 1991). Road accidents are primarily a killer of the young, in the US alone, almost half of the 19 year olds dying annually, do so as a result of traffic accidents. However, these statistics, in terms of deaths caused are not constant across all countries; an impact of a given severity is more likely to be survivable in countries with better healthcare and emergency service infrastructures than in a less well developed country. This may be due to a number of factors such as the speed of the emergency services arriving at the scene, (if they do at all), or the quality of post trauma care. Thus global estimates of the size of the problem are difficult to accurately quantify. It has been estimated, however, that worldwide approximately half a million people annually are killed due to road accidents, Grime (1987). In addition non fatal injuries, which themselves cost society a considerable amount, outnumber fatalities, estimates being by factors of up to 70 to 1, (Hobbes, Grattan and Hobbs 1979).

Such difficulties in estimates are compounded by confusion as to the varying nature of the statistics quoted by different organisations. For example, when considering fatality data, some organisations include within these statistics those people involved in an RTA that die within 30 days, whilst other organisations use a time period of one year, (Evans 1991, Grime 1987). This latter measure not only returns a different absolute number of deaths per given time, but the distribution of deaths within the driver population may differ. The fatality measure may only record that a death has occurred and that the person had previously, within a specified time period, had an RTA. Although usually the data contain only those individuals whose death may be attributable directly to the RTA, in practice this is not always possible. Thus deaths unrelated to the RTA having occurred may be included, and hence a higher
proportion of the elderly will be recorded. This is especially noticeable when considering longer time frames when more elderly people would be expected to die within a given period than younger people. Whilst some statistical manipulations do exist to attempt to correct for factors such as these, in the absence of better recording techniques with respect to causes of death, with cross cultural comparisons, errors will always occur.

However, fatality numbers are the best estimates of the size of the RTA problem as the estimates of absolute number of accidents whilst driving are complicated by three additional factors. Firstly, it is readily seen that not all RTAs that occur are reported and hence included in published statistics. In general, in westernised society, all crashes involving a fatality are reported to the police, fatality statistics are then obtained either directly from this source or from vehicle licensing authorities or government transportation departments. However, in less motorised societies, the infrastructure may not exist for collection and collation of such information. However, secondly, even in motorised societies the likelihood of an accident being reported decreases dramatically as the economic cost of the accident decreases. A very large number of very minor incidents are thought to occur and yet never be reported, for example minor impacts whilst reversing into a parking space, or minor impacts in closely packed, slow moving rush hour traffic, (Hobbes et al 1979, Deering and Viano 1994). Fatality numbers are therefore more likely to be accurate. Finally, the distributions of accidents with respect to the severity of resultant injuries is not constant across all impact severity levels. It can be seen that a considerably larger number are injured than are killed, US estimates are that 95% of all injuries occur at the lowest two levels of the Abbreviated Injury Scale, (AIS), used by the US Department of Transport to collate data, (Evans 1991). (This level of injury is such that only minor injuries, not requiring professional treatment, occur).

In general, the number of fatalities has been used as an indication of the size of the RTA problem globally. The picture is severely complicated by the nature of the statistics quoted for the relative death rates between for example different countries, be it death rate per percentage of the population, per vehicle, or per distance
travelled. These differing figures will give a different indication as to the size of the problem in any given sample, (Adams 1985). Table 2.2 gives a summary of the data presented for the top 5 and bottom 5 of 62 countries ranked in order of their death rate per 100,000 population, (Adams 1985). As a comparison measure, the death rate and rankings derived from this per 100,000 vehicles is given. It can be seen from this that the two rankings do not correlate well, indubitably due in part to the lack of rigour in collecting such data in the economically less well developed countries and those with lower levels of motorisation. However, additional to this are the effects of the nature of the different road traffic environments, (for example the quality of the road infrastructure, the nature of law and law enforcement in the country under question), and the associated consequences on traffic fatalities. As can be seen for example, in countries where low levels of motorisation are found, the death rate per 100,000 population is low, whereas the rank per 100,000 vehicles is comparatively higher. A relationship encompassing these variables, (known as Smeed's Law), has been demonstrated between the absolute number of deaths, the population size and the number of motor vehicles within a given area, (Adams 1985, Evans 1991, Grime 1987, Smeed 1949).

This illustrates a fundamental difficulty in the nature of RTA statistics, namely what the appropriate statistics to use are. Whilst no one statistic is demonstrably better or worse than any other, the most important consideration is that the same statistic is quoted when comparisons between two data sets are required. Radically different conclusions have been drawn by different researchers using the same data sets but quoting different statistics in terms of accident rates, (either by vehicle, by distance driven or by distance driven per time period, see for example Evans 1991, Wilde 1994). For this reason, the remainder of this thesis will concentrate on absolute numbers of RTAs, fatalities, injuries, or damage only accidents. It should be remembered however, that these figures are estimates based on current data collection procedures, and therefore some systematic errors may be in existence.
Table 2.2 Road accident death rates, (by highest and lowest 5 per population and by vehicle rate as comparison, from Adams, 1985).

<table>
<thead>
<tr>
<th>Country</th>
<th>Rank</th>
<th>Rate</th>
<th>Rank</th>
<th>Rate</th>
<th>Vehicles per Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Volta</td>
<td>1</td>
<td>2.27</td>
<td>41.0</td>
<td>3.25</td>
<td>0.007</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>2</td>
<td>3.22</td>
<td>18.84</td>
<td>11</td>
<td>0.002</td>
</tr>
<tr>
<td>India</td>
<td>3</td>
<td>3.38</td>
<td>52.0</td>
<td>5.59</td>
<td>0.007</td>
</tr>
<tr>
<td>Niger</td>
<td>4</td>
<td>3.95</td>
<td>51.0</td>
<td>5.91</td>
<td>0.007</td>
</tr>
<tr>
<td>Pakistan</td>
<td>5</td>
<td>4.65</td>
<td>55.0</td>
<td>9.35</td>
<td>0.005</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>56.5</td>
<td>24.0</td>
<td>13.5</td>
<td>0.43</td>
<td>0.490</td>
</tr>
<tr>
<td>Austria</td>
<td>59.5</td>
<td>26.0</td>
<td>23.0</td>
<td>0.65</td>
<td>0.400</td>
</tr>
<tr>
<td>France</td>
<td>59.5</td>
<td>26.0</td>
<td>20.0</td>
<td>0.53</td>
<td>0.48</td>
</tr>
<tr>
<td>Portugal</td>
<td>61</td>
<td>29.0</td>
<td>36.5</td>
<td>2.50</td>
<td>0.12</td>
</tr>
<tr>
<td>South Africa</td>
<td>62</td>
<td>31.85</td>
<td>34.0</td>
<td>2.0</td>
<td>0.19</td>
</tr>
</tbody>
</table>

2.6.2 UK Statistics - STATS19.

In the United Kingdom, information on RTAs resulting in personal injuries is collected by the police. This data deals only with a limited number of relatively easy to obtain facts concerning details of those individuals involved in the RTAs such as their age, gender and prior motoring histories. Additionally recorded are such data as the nature of the vehicles involved and any damage done to vehicles or other objects as well as details of the RTA itself. In the case of more serious incidents some initial assessment of blame and decisions to proceed with prosecution are made. In the UK, these data are collected by the police on incident report forms known as RT7s and are subsequently collated by local authorities and entered into a database known as STATS19. This database at a local level contains information in a considerable amount of detail concerning the individual incidents and is subsequently collated and entered into the national STATS19 database. At a national level however, less detail is found in the database due partly to the summation of the data, and partly because each individual authority stipulates collection of slightly different data, in
addition to the data required for the national database. This additional data is therefore lost in the summation process.

The statistics quoted in the following section are derived from the STATS19 database from RTAs in 1996, (DoETR 1997). The implications of these data will be outlined following a description of some of the major findings.

In 1996 in the United Kingdom, there were approximately 3600 deaths as a result of RTAs. Additional to these, there were approximately 45,000 serious injuries and 272,000 slight injuries. In comparison with the average figures for 1981-1985, deaths were 36% lower and serious injuries were 40% lower. At the same time, road traffic rose by approximately 3%. The rate of casualties per 100 million vehicle kilometres in 1996 fell by 33.5% over the average from 1981-1985. It should be remembered that these figures are based on accidents reported to the police and collated through STATS19 procedures, thus the size of the RTA problem in the driving population as a whole may be not insignificantly larger.

Table 2.3 Number of RTAs and percentage of total number of RTAs by severity of injuries sustained by type of roads, (from DoETR 1997).

<table>
<thead>
<tr>
<th>Road Class</th>
<th>Severity of Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Killed</td>
</tr>
<tr>
<td>Motorways</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
</tr>
<tr>
<td>Built up</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
</tr>
<tr>
<td>Non built up</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
</tr>
<tr>
<td>All</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
</tr>
</tbody>
</table>
Literature reviews.

RTAs are neither evenly distributed throughout the driving population, nor different road traffic environments. It can be seen that there is a different distribution of accident types by severity across different road types, (tables 2.3 and 2.4).

Thus for example, the popular misconception that motorways are a comparatively dangerous mode of transport is not confirmed by these statistics, the death rate as a percentage of all accidents is nearly ten times higher on built up roads in comparison with motorways. However, given that an accident occurs, the chances of a fatality are increased for motorways over other road types due to the generally higher average speeds seen on motorways, (Grime 1987). Additionally of note from Table 2.4, are that the majority of accidents occur on built up roads, (68.9% of all accidents), and that fatalities account for only 1.1% of all accidents; the most common result of an RTA in 1996 was slight injury, (85.0%).

Table 2.4 illustrates the numbers of RTAs resulting in different injury levels, reported at different junction types.

Table 2.4 Number of RTAs reported by junction types for different severity levels resulting, (from DoETR 1997).

<table>
<thead>
<tr>
<th>Junction type</th>
<th>Fatal</th>
<th>Serious</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roundabout</td>
<td>52</td>
<td>1588</td>
<td>18013</td>
</tr>
<tr>
<td>T or staggered</td>
<td>736</td>
<td>11556</td>
<td>76947</td>
</tr>
<tr>
<td>Y junction</td>
<td>84</td>
<td>920</td>
<td>6414</td>
</tr>
<tr>
<td>Crossroads</td>
<td>204</td>
<td>3625</td>
<td>25629</td>
</tr>
<tr>
<td>Multiple junction</td>
<td>34</td>
<td>484</td>
<td>3311</td>
</tr>
<tr>
<td>Other</td>
<td>56</td>
<td>639</td>
<td>5078</td>
</tr>
<tr>
<td>Private drive or entrance</td>
<td>94</td>
<td>1506</td>
<td>10379</td>
</tr>
<tr>
<td>All Junctions</td>
<td>1262</td>
<td>20318</td>
<td>145771</td>
</tr>
<tr>
<td>Not at or within 20m of a junction</td>
<td>2012</td>
<td>16984</td>
<td>90168</td>
</tr>
</tbody>
</table>

From this, it can be seen that overall 38.5% of all RTAs involving a fatality occur at junctions and of these T junctions account for the largest group, (accounting for 58.3% of accidents at junctions and 22.5% of all fatality RTAs). In terms of all
accidents, it can be seen that T junctions are the single most represented accident scenario with respect to injury of all levels, with cross-roads being the next most represented scenario.

Table 2.5 Distribution of RTAs by day of the week and time of incident, (from DoETR 1997).

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday to Thursday Average</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>00.00 - 03.59</td>
<td>1181</td>
<td>1652</td>
<td>4217</td>
<td>4321</td>
</tr>
<tr>
<td>04.00 - 07.59</td>
<td>2994</td>
<td>2990</td>
<td>1431</td>
<td>1462</td>
</tr>
<tr>
<td>08.00 - 11.59</td>
<td>20553</td>
<td>11087</td>
<td>8712</td>
<td>5471</td>
</tr>
<tr>
<td>12.00 - 15.59</td>
<td>10946</td>
<td>13651</td>
<td>12986</td>
<td>5435</td>
</tr>
<tr>
<td>16.00 - 19.59</td>
<td>13521</td>
<td>15722</td>
<td>11432</td>
<td>10498</td>
</tr>
<tr>
<td>20.00 - 23.59</td>
<td>5943</td>
<td>9133</td>
<td>7219</td>
<td>6221</td>
</tr>
<tr>
<td>Totals</td>
<td>46947</td>
<td>54237</td>
<td>46286</td>
<td>39209</td>
</tr>
</tbody>
</table>

Table 2.5 shows the distribution of RTAs by day of week. From this, several trends can be seen. Firstly, there are peaks of RTAs each weekday at commuting hours, the single largest peak being Friday between 16.00 and 19.59. Outside of normal work hours, there are also peaks associated with Friday and Saturday evenings. Overall, more RTAs occur on Fridays than any other day. As no severity, causation or demographic data are presented, these data are extremely limited in their use with respect to determining the cause of the RTAs. That the pattern of RTAs and of those driving differs from day to day and hour to hour cannot be determined from these data.

Table 2.6 shows the distribution of RTAs of different severities by daylight and roadway conditions. It can be seen that fatal RTAs mostly occur during daylight hours, 55.9% during daylight compared to 44.1% during darkness. Thus although considerably fewer miles are driven during darkness, the risk of being involved in an RTA resulting in a fatality is significantly higher during darkness hours. In terms of the nature of the roadway conditions, it is readily obvious that the majority of all
accidents occur when the roadway is dry and thus the majority of RTAs of all severities occur in daylight and on roadways that are dry.

Table 2.6 Distribution of RTAs by severity, daylight and condition of roadway, (from DoETR 1997).

<table>
<thead>
<tr>
<th>Daylight</th>
<th>Fatal</th>
<th>Serious</th>
<th>Slight</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daylight Dry</td>
<td>1288</td>
<td>17923</td>
<td>100579</td>
<td>119790</td>
</tr>
<tr>
<td>Wet/Flood</td>
<td>485</td>
<td>6244</td>
<td>37537</td>
<td>44266</td>
</tr>
<tr>
<td>Snow/Ice</td>
<td>40</td>
<td>604</td>
<td>4151</td>
<td>4795</td>
</tr>
<tr>
<td>All</td>
<td>1820</td>
<td>24783</td>
<td>142396</td>
<td>168999</td>
</tr>
<tr>
<td>Darkness Dry</td>
<td>798</td>
<td>6593</td>
<td>27011</td>
<td>34402</td>
</tr>
<tr>
<td>Wet/Flood</td>
<td>613</td>
<td>5382</td>
<td>23108</td>
<td>29103</td>
</tr>
<tr>
<td>Snow/Ice</td>
<td>41</td>
<td>532</td>
<td>2798</td>
<td>3371</td>
</tr>
<tr>
<td>All</td>
<td>1454</td>
<td>12519</td>
<td>52966</td>
<td>66939</td>
</tr>
</tbody>
</table>

2.6.3 The use of international and national data for determining accident causation.

The data summarised in sections 2.5 to 2.6.2 illustrate the nature of those involved in RTAs and the typical scenarios in which they occur. These data however, are extremely limited in their use for the purposes of designing potential accident countermeasures, largely because the data were not collected for this purpose. As Frampton (1997) described, it is extremely difficult to utilise data collected via such tightly controlled data collection procedures for any other purpose than which they were designed to collect. In the case of STATS19 data for example, the data are collected by police almost exclusively for the purposes of prosecution.

Whilst the data collected in this manner are very useful for providing a database from which basic accident patterns, national trends and demographic information concerning those injured or killed in RTAs can be deduced, (such as that quoted above), the data has limited use for the purposes of detailed RTA investigation or analysis. This is due to the nature of the time and financial constraints placed upon those collecting the data, namely the police in the UK. However, whilst data can be
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deduced from the police which is of some use in RTA investigation studies, typically the police do not have the time or financial resources to collect sufficient data to be of use in accident investigations without the addition of more data collected from alternative sources. For these reasons, in order to elicit much of the information required that is vital to investigate efficiently the numerous factors involved in RTA causation, detailed, in-depth studies have occasionally been undertaken.

In the case of the data presented to illustrate the demographic trends within RTA patterns, few causative factors may be inferred. The situational data, (section 2.6) are useful for determining some strategic issues pertaining to RTA occurrence as they describe in what circumstances RTAs typically occur. Thus for example, it is readily obvious that a large percentage of RTAs occur at T junctions and thus these junctions may be selected for detailed study.

More detailed understanding of RTAs can only be gained from further analyses of this data set and is not possible using published data. STATS19 for example, cannot readily be used to determine if a specific population of drivers are differentially more likely to be involved in accidents at T junctions, nor for example if there are differences in RTA patterns between those in which an RTA involved driver is crossing a line of moving traffic as compared to one in which they are joining a line of moving traffic.

A large number of studies have isolated specific RTA scenarios and studied these in depth to determine the issues pertaining to these. Examples of such studies include vehicle control during curve driving, (Godthelp 1986), single vehicle accidents, (McKenna 1987), driver behaviour at T junctions in daylight and darkness, (Darzentas, Holms and McDowell 1980) and overtaking manoeuvres, (Bryant 1978, Farber and Silver 1967). These studies have illustrated some of the important causative factors in specific RTA configurations and have in some cases outlined the need for, and possible direction of further research concerning potential countermeasures. However, by their very nature, such studies suffer from a tendency
2.7 In-depth RTA investigation.

In-depth investigations may be characterised as being traditional in approach or case study based, (Clarke, Forsyth and Wright 1995). Traditional studies rely on large scale data collection, typically involving collection and analysis of data on at least 1000 RTAs which are subject to rigorous statistical analyses to determine the relative contributions of various factors in RTA causation, and their prevalence in the driving population as a whole. Case study approaches however, may utilise significantly fewer individual RTAs but focus on a more qualitative approach by grouping clusters of similar RTAs. Rather than describing the dataset as a whole, case study approaches therefore typically describe the results in terms of these clusters. Traditional approaches can be seen as an attempt to quantify the relative proportions of various factors on RTA occurrence, and therefore have limited use in suggesting appropriate accident countermeasures. Case study approaches however, have proved to be more efficacious in suggesting appropriate accident countermeasures. However, due to the nature of the studies, case study approaches tend to focus on a narrow range of RTAs in comparison with traditional approaches.

2.7.1 Introduction to in-depth RTA studies.

Due to a need to understand in more detail the nature and causes of RTAs, in-depth studies of RTAs became popular from the mid 1960s. In-depth studies may be defined generally as any RTA study that investigates RTAs in much more detail than is commonly performed, (OECD 1980). There are two major subsets of such studies, concentrating on either crash avoidance, (primary safety issues, such as Treat 1980), or crash worthiness, (secondary safety for example Frampton 1997). In addition to gathering data pertaining to either the factors impinging on the causation of the
RTAs or the mechanisms producing injury to those affected by the RTA, these studies typically have three additional aims:

- These investigations are used to provide empirical evidence to determine the likely efficacy of potential road safety projects and to suggest new projects and countermeasures.

- These studies are also used to provide and test new research methodologies and to provide pointers towards likely new areas of research.

- Finally these studies are used to provide data essential to the design of safe and efficient roads and vehicles, and subsequently to obtain an empirical and objective measure of the relative risks associated with differing aspects of highway design, road and vehicle condition.

A review of the background to in-depth RTA studies is first presented, followed by consideration of seven studies in specific.

### 2.7.2 Data collected in in-depth studies.

All in-depth investigations use a number of information sources not normally collected in official RTA reporting, (i.e. that normally performed by the police in the UK). One of the first information sources sought in any in-depth study is to approach those involved in the RTA themselves. This is most often done directly by the investigators, either through on the spot interviews or questionnaires or by subsequently obtaining data from those involved. However these types of data have sometimes been obtained indirectly, (by for example securing the assistance of the police attending the scene of an RTA to collect data additional to their normal requirements). An additional method of obtaining information pertaining to an incident is to examine the files kept by the police authorities concerning the RTAs that have been deemed worthy of investigation. Whilst this method does provide some valuable information, there exist legal issues relating to the investigation of RTAs that may subsequently be the subject of criminal proceedings and
prosecutions. Additionally, this sampling frame will naturally result in a biased sample. A final method of obtaining data is through examination of the sites of the RTAs and the vehicles involved for the purposes of reconstruction. This has been most commonly performed immediately after the crash with the vehicles still at the scene, however this approach has been applied at some months after the RTA, (Carsten, Tight and Southwell 1989).

The types of data ideally collected in in-depth RTA investigations have been characterised as follows, (Grime 1987).

Information required in every case:

- Date, time and place.
- Class of road and speed limit.
- State of light and weather and road conditions; class of street lighting (if any).
- A scale plan indicating the scene of the RTA and including gradients, hedges and obstructions. A vital aspect of this diagram is to mark accurately the positions of the vehicles involved when they have come to rest after the RTA in addition to any marks or debris deposits and damage to roadside furniture.
- Photographs of the RTA scene and the approaches to it from the perspective of the drivers involved. Additionally photographs of marks made on the road by for example skidding vehicles, together with any marks to kerbs, verges or other roadside furniture.
- Photographs of the texture of the road surface may sometimes be useful if the road surface is wet due to recent rain or snow. If the road surface is dry, photographs of any skid marks are useful in determining whether any avoiding action was attempted by the drivers prior to a crash.
- Witness statements should be obtained from all RTA participants and from any persons that were not directly involved in the RTA that witnessed it.
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- Particulars of all injuries.

In addition, Grime (1987), notes several other types of information that are required to be obtained by those investigating different types of RTA. For single vehicle, two vehicle or multi-vehicle RTAs involving cars or commercial vehicles, the following should be recorded:

- Particulars of the make, model, year of registration of each vehicle, and of their weights at the time of the RTA. The information concerning the weight of the vehicles is of especial importance since the mass ratios of vehicles involved in RTAs will be of prime importance in determining injury production, (Evans 1991).

- The results of a vehicle examination performed on each vehicle by a qualified vehicle examiner will need to be noted. Depending upon the exact nature of the RTA, differing aspects of the vehicles will need to be examined in specific cases. The condition of the brakes and steering system of the car need to be determined as does the conditions of the tyres which are of especial importance when the road conditions are wet. In the case of RTAs occurring at night, the condition and aim of the head lamps should be determined if still present and functioning. It should be noted, that this data is rarely collected in detail, and so rarely subsequently reported.

- Photographs of the exterior of the involved vehicles should be obtained to determine the extent of damage sustained and to determine the directions of impacts on each vehicle in an attempt to determine the sequence of impacts. Additionally, in the case of some studies, (the purpose of which is to determine the mechanisms of injury causation to those involved in an RTA), photographs of the interiors of each vehicle should be taken to determine the nature of the injury producing events. Finally evidence as to the use of any safety systems such as air bags, seatbelts and seat belt pre tensioners should be sought; the use of such devices will have a considerable effect on the nature of any injuries caused and may well have some relevance to the nature of the causation of the
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RTA itself, since it has been demonstrated that there are some differences in the risk taking behaviour between groups of drivers either wearing or not wearing seat belts, (Evans 1991).

- Finally, in other cases information specific to the type of RTA concerned will need to be elicited. For example in the case of RTAs involving pedal cycles or motor cycles, in addition to the above, special consideration needs to be given to the site at which the RTA occurred. Specifically information concerning the possible effects of rough or slippery roads, and information concerning obstructions in the roadways, for example stationary cars or protruding kerbs needs to be obtained. Additionally in the case of RTAs involving pedestrians the actions of the pedestrians need to be determined, i.e. whether they were crossing the road by but not on a pedestrian crossing, or by walking out between parked cars. For RTAs occurring at night, the pattern of illumination of the road surface needs to be considered.

Due to the costs involved in large scale in-depth studies of RTAs, comparatively few such studies have been undertaken. The following section reviews those most pertinent to the current study.

2.7.3 Traditional in-depth studies.

2.7.3.1 Transport and Road Research Laboratory, UK.

The TRRL study involved a multi-disciplinary team of researchers being on call 24 hours a day for a period of four years between 1970 and 1974 in the area around the Transport and Road Research Laboratory in South East Berkshire, UK. The team were called to RTA scenes by the police authorities immediately they received notification of an incident. At the scene, the investigators recorded brief details of a non-permanent nature, such as skid marks and the position of the vehicles involved after the impacts, and conducted brief interviews with those involved. At a later date some vehicles were examined by a specialist team, partly due to a requirement of an
additional project that required in-depth analysis of the effects of brake defects on RTA causation, (Sabey and Staughton 1975).

Subsequently a verbal reconstruction of the RTA was made by the investigation team, appraising the role of the different factors recorded for each RTA in contributing to it's occurrence. Thus the role of the various factors identified in the investigation was deduced by the RTA investigation teams.

The total sample employed consisted of 2130 RTAs, which can be broken down into 3757 drivers, 147 pedestrians, and 3909 vehicles. 1316 of the RTAs involved injury to one person or more, of which 1993 persons were injured. This represents 60% of all injury RTAs reported to the police in the area and 20% of damage only RTAs reported to the police, (Sabey and Staughton 1975, Sabey and Taylor 1980).

Further analysis showed that the distribution of RTAs within each category, (injury or non injury) were not significantly different between these categories. The survey was regarded as being representative of South East Berkshire, but not of the country as a whole. This was intentional as one of the aims of the study was to determine the efficacy of such a method of obtaining information pertaining to RTA causation rather than to definitively produce a list of the causes of RTAs. The rural nature of the base for the study was expected to demonstrate that specific RTA patterns would be overly and underly represented compared to the population norms. This was subsequently verified through an analysis of the RTA types studied, (Sabey and Staughton 1975, Sabey and Taylor 1980).

The most important outcome of the study was viewed to be the contributory factors assigned to the RTAs studied. This was because this was the first large scale study whose aim was specifically to elicit such information. These factors were concentrated into three main groups corresponding to the three domains of information outlined in Zimmer's (1980) model of driver behaviour and informational exchange (Figure 1.1). These factors were respectively;
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- Those concerned with the road design and environment, (road layout, junction visibility, adequacy of road signs and markings, weather conditions and road surfaces).
- Those concerned with the vehicle, its design and condition.
- Those concerned with human factors, (driver or pedestrian, driver's skill, judgement and perception, fitness to drive).

![Diagram](image)

**Figure 2.3 Percentage contributions to RTAs (from Sabey and Staughton 1975)**

Figure 2.3 illustrates the proportional contribution of such factors in terms of their contribution to the RTA's occurrence as a percentage of overall RTAs. Thus, the road user was assigned to be solely responsible in 65% of all RTAs studied, and importantly partially responsible for 95% of RTAs studied. It can be seen that in comparison with the other factors identified, human factors can be viewed to be the major contribution to RTA causation, (adverse road and environment features accounting for 28% of RTAs studied and vehicle defects for only 8.5% of those studied).
Additionally, the investigation allotted responsibility to the drivers or pedestrians involved in RTAs by assigning each to an at fault or not at fault category, and judged errors made by the drivers according to a series of categories of driver error specific to their RTA. In terms of fault, of the drivers, 40% were judged to be at fault, 19% partially at fault and 39% not at fault.

In all, 23 categories of driver error were chosen (Table 2.7), albeit somewhat arbitrarily, but on the basis of past experience chosen to cover all likely events, (Sabey and Staughton 1975). It was noted that the boundaries between some classifications were not always clearly defined and in many cases several factors were used to describe the driver’s behaviour. Consequently, the factors are not mutually exclusive and as such there are many links between the factors; e.g. there are strong links between lack of care and looked but failed to see, and between lack of attention and following too close.
**Table 2.7 Human errors contributing to RTAs, (from Sabey and Staughton 1975).**

<table>
<thead>
<tr>
<th>Driver Error</th>
<th>Frequency of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of care</td>
<td>905</td>
</tr>
<tr>
<td>Too fast</td>
<td>450</td>
</tr>
<tr>
<td>Looked but failed to see</td>
<td>367</td>
</tr>
<tr>
<td>Distraction</td>
<td>337</td>
</tr>
<tr>
<td>Inexperience</td>
<td>215</td>
</tr>
<tr>
<td>Failed to look</td>
<td>183</td>
</tr>
<tr>
<td>Wrong path</td>
<td>175</td>
</tr>
<tr>
<td>Lack of attention</td>
<td>52</td>
</tr>
<tr>
<td>Improper overtaking</td>
<td>146</td>
</tr>
<tr>
<td>Incorrect interpretation</td>
<td>125</td>
</tr>
<tr>
<td>Lack of judgement</td>
<td>116</td>
</tr>
<tr>
<td>Misjudged speed and distance</td>
<td>109</td>
</tr>
<tr>
<td>Following too close</td>
<td>75</td>
</tr>
<tr>
<td>Difficult manoeuvre</td>
<td>70</td>
</tr>
<tr>
<td>Irresponsible or reckless</td>
<td>61</td>
</tr>
<tr>
<td>Wrong decision or reckless</td>
<td>50</td>
</tr>
<tr>
<td>Lack of education or road craft</td>
<td>48</td>
</tr>
<tr>
<td>Faulty signalling</td>
<td>47</td>
</tr>
<tr>
<td>Lack of skill</td>
<td>33</td>
</tr>
<tr>
<td>Frustration</td>
<td>15</td>
</tr>
<tr>
<td>Bad habit</td>
<td>12</td>
</tr>
<tr>
<td>Wrong position for manoeuvre</td>
<td>7</td>
</tr>
<tr>
<td>Aggressive</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3704</strong></td>
</tr>
</tbody>
</table>

An important aspect of this study is that the majority of factors constituting poor behaviour relate to some deficiency in the driver’s actions rather than deliberate aggressiveness or irresponsibility. This contrasts with later work by Parker et al (1995) wherein deliberate (though non malevolent), violations of safe driving practices are correlated positively with RTAs. However, despite the lack of a comprehensive model of human error in accident causation, the role of error in RTA causation was clearly paramount in one of the first large scale, in-depth RTA
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investigations. It was also evident, that in the majority of cases, more than one error or failure was implicated in the cause of the RTA.

These human errors can be described as fitting into one of four categories, namely errors due to lack of skill, driver impairment, manner of execution, and perceptual error, (Figure 2.4). A notable feature of this is that errors categorised as errors in the manner of execution were regarded to be the major human error associated with RTAs, (accounting for 75%).

The next most frequent errors were perceptual errors which were viewed to account for 44% of road user errors, (Sabey and Stoughton 1975, Sabey and Taylor 1980). Mourant and Rockwell (1970, 1972) have noted that whilst younger drivers are significantly better than their older peers in terms of perceptual skills, they have different visual search patterns compared to more experienced drivers. This may account to some extent for their over involvement in RTAs as a population of drivers. It has subsequently been demonstrated that significant positive correlations exist between in vehicle visual demands and RTA rate, (Wierwillie and Tijerina 1995).

![Figure 2.4 RTA causation mechanisms, (from Sabey and Stoughton 1975).](image-url)
Literature reviews.

The most significant result of this study was the establishment of the relative importance of different factors as the main contributors to the occurrence of RTAs. The majority of RTAs however, whilst having a multiplicity of causes were viewed to have human errors as the causative factors.

2.7.3.2 Indiana.

The Indiana study (Treat 1980) utilised essentially the same methodology as the TRRL study but modified it slightly by using the three level approach to data collection thereby allocating each factor as being a definite, probable or possible factor in the causal chain of events leading to an RTA.

Additionally, Treat (1980) produced a definition of a reasonable driver, this being someone who is at all times alert, sober and attentive to road use, performing to high but not unusual standards of good defensive road use. This definition was used as a standard to judge each road user as a means to determine the factors implicated in each RTA.

The results obtained were essentially similar to those of the TRRL study, indicating that human factors were definite causal factors in 70.7% of RTAs and as definite or probable causal factors in 92.6% of RTAs.

2.7.3.3 Institute of Transport Studies, UK.

The study performed in Leeds in the late 1980s, (Carsten, Tight and Southwell 1989, Southwell, Carsten, Tight and Plows 1990), built on earlier studies in terms of methodologies, but focused more tightly on the human factors implicated in the causation of an RTA. It was therefore the most comprehensive in-depth RTA study to date focusing specifically on the human factors impinging on RTA causation. As such, this is the in-depth study of most relevance to the current study and will be reviewed in detail.

The study employed data from interviews and questionnaires, police report forms and a site visit, which were combined to determine the human factors behind an RTAs occurrence. However, as the main focus of the investigation was to determine
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these human factors, in contrast to other in-depth investigations, the study did not involve an on the scene type investigation requiring the RTA team to be on call 24 hours a day. A site visit was however undertaken at a later time. The reasoning behind this was that the purpose of the site visit was to draw together all the information pertaining to a given RTA, and to come conclusions regarding the human issues pertaining to the RTA’s cause, rather than to measure the outcome of the RTA in terms of the final resting position of the vehicles involved.

The sample employed in the Leeds study was restricted to injury only RTAs. As Sabey and Staughton (1975) and Sabey and Taylor (1980) demonstrated that there was no difference between RTAs resulting in injury, and those that resulted in damage only, and since large under reporting to the police of damage only RTAs has previously been demonstrated, (Hobbes et al 1979), this was not felt to bias the sample. Additionally this simplified the data collection process as potentially sensitive data relating to the cause of an RTA were not required from those that had been injured, or had caused injury to others. A requirement of the study was that 1000 cases were to be investigated and that these cases should fall within the five police subdivisions of the Leeds metropolitan area. This contrasts with the largely rural nature of the Transport and Road Research Laboratories study, (Sabey and Staughton 1975, Sabey and Taylor 1980).

The most important aspect of the Leeds study was the development and use of a hierarchical scheme of 154 contributory factors (outlined schematically in Figure 2.5. A full list of these factors is presented in Appendix 1). These factors were participant based rather than RTA based. In practice, this means that all the contributory factors for each participant were coded for a given RTA, rather than coding factors for the RTA as a whole. This allows different coding factors to be allocated for different participants in the same RTA. For example, one driver in a two vehicle RTA may view the road environment immediately before an RTA scene as ambiguous, whilst the other driver may view the scene as non ambiguous. A coding scheme of this nature which had not been used before in in-depth RTA studies allowed these differences to be noted.
The contributory factors were defined as road user or traffic systems failures without which the RTA would not have happened, (Southwell et al 1990). It was emphasised that this way of defining a factor specifically removes the issue of blame from a participant by implying that there was some system failure rather than fault on behalf of a participant. An example of a commonly assigned factor was 'unable to anticipate', which was assigned when a road user was aware that an RTA was imminent, but had insufficient time to avoid or prevent the RTA from occurring.

The factors were arranged in a hierarchy that allowed a structured approach to the RTA's causes to be deduced. At the top level were failures, the immediate events that precipitated an RTA such as failure to yield when turning right. The next level dealt with the road user behaviours or lack of skills that led to the top level failure, for example looking, but failing to see an oncoming vehicle at a junction. The lowest level of the factors were the explanations for the middle level behaviours or top level failures for example distraction or situational problems such as obstruction due to the weather conditions. Additionally some factors were coded in an intermediary level. These were factors such as driving too fast or following a lead vehicle too closely that were neither direct precipitators of the RTA, or behavioural explanations for the failures but increased the likelihood of an RTAs occurrence.
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Figure 2.5 A schematic contributory factors coding scheme, (from Carsten et al 1989, Southwell et al 1990).

However, there are two caveats to this. The factors were deliberately limited, firstly by using the definition of reasonable driver, (Treat 1980), thereby producing a standard against which to judge each road user's behaviour, and secondly by setting a criterion on how broadly a systems failure could be construed. The standard chosen for the second criterion was that of the existing traffic environment at the time of the crash. For example brake defects were coded when a vehicle had a faulty braking system, whereas an absence of anti-lock brakes was not coded as a factor.

Secondly, following the Indiana study, (Treat 1980), it was noted that whilst a contributory factor may be present, it was not possible to determine with absolute certainty that this factor was responsible for a subsequent crash. Whilst the Indiana
study utilised three levels of certainty, the Leeds study employed just two, failures and their causes that were definite, or that were probable, the third level employed in the Indiana study not having been utilised much was therefore excluded.

Thus using this novel hierarchy of factors, an RTA could be coded from the point of view of all participants involved at two levels, rather than just at one level and for the RTA as a whole. As a result, a much better understanding of the human factors issues underlying RTA causation was arrived at.

The major findings of this study relate to the contributory factors scheme and its applicability to the RTAs studied. This scheme was created especially for the investigation and underwent extensive testing in the field before it was used for the study. Subsequently the scheme underwent minor revisions during the course of the study and was felt by the investigation team to be a substantial improvement over previous methodologies employed in RTA research, in that it allowed a far more detailed examination of the human factors impinging on RTA causation (Southwell et al 1990).

Of the 1254 injury RTAs studied, the largest fraction were between two vehicles, (47.7%), with the next highest category being single vehicle RTAs (35.1%). The RTAs were fairly evenly distributed by day of the week, (ranging from 12% on Sundays to 19% on Fridays). 69% of RTAs occurred in daylight, 79% in fine weather and 59% on dry roads. Of the 2454 participants, 1963 were vehicle drivers, (the remainder being adult or child pedestrians or cyclists). Overall the interview and questionnaire response rate was 49.4%, however some information on non respondents was obtained via police records.

With respect to the location of RTAs, approximately 70% occurred at junctions. Of these RTAs, the vast majority, (72%) occurred at give way signs, the remainders being at controlled junctions or stop signs, (12%), or at uncontrolled junctions, (16%). When asked about their driving behaviour 35% admitted that they quite often exceeded the speed limits in urban areas, though only 4% felt that driving excessively fast may have contributed to their RTA. This may reflect positive self
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biases within the individual driver, (McKenna et al 1991), or may simply reflect that the majority of drivers, when asked to compare themselves to the average driver view themselves to be both more skilful and safer, (Svenson 1981).

With respect to previous RTA involvement, one third had been involved in at least one previous RTA in the previous three years, the majority of these having been involved in only one incident.

The overall numbers of contributory factors, coded by level are given in Table 2.8. The major first level factors, in order of appearance in the data set were unable to anticipate, failure to yield (minor to major) and loss of control, with 29.0%, 9.8% and 7.4% of the sample falling into these categories. Additionally, 13.9% of the sample were coded as no failure at the top level, and 10.8% of the sample were coded as unknown. It was seen that substantial differences were found between ages and genders with respect to these top level factors. An example of this is factors such as failures to anticipate which were coded significantly more for younger drivers, (under 24) as compared to older drivers, perhaps relating to a lack of experience of these drivers, (Southwell et al 1990), or due to perceptual problems such as poor visual search patterns leading to slower perception of hazards ahead, (Mourant and Rockwell 1970, 1972). In terms of gender differences, a higher proportion of males than females suffered from loss of control and manoeuvre problems, whereas a higher proportion of females compared to males were coded as no failure or failures to yield.
Table 2.8 Contributory factors coded by level, (from Carsten et al 1989, Southwell et al 1990).

<table>
<thead>
<tr>
<th>Failures</th>
<th>Definite known</th>
<th>No Failure or Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Level</td>
<td>1846</td>
<td>588</td>
<td>2434</td>
</tr>
<tr>
<td>(Failure)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second Level</td>
<td>350</td>
<td>0</td>
<td>350</td>
</tr>
<tr>
<td>(Failure)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third Level</td>
<td>1214</td>
<td>486</td>
<td>1700</td>
</tr>
<tr>
<td>(Behaviour or Action)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth Level</td>
<td>664</td>
<td>376</td>
<td>1040</td>
</tr>
<tr>
<td>(Reason)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>4074</td>
<td>1450</td>
<td>5524</td>
</tr>
</tbody>
</table>

In terms of second level factors, overall the most common were situational problems, defined as being a site or environmental situation in which any reasonable road user would have difficulty. This concurs with evidence that has been found elsewhere, (Watts and Quimby 1980), to suggest that certain environmental sites are inherently more risky.

The other second level factors, driving too fast for the occasion, and following too close were coded for approximately 30% and 8% of RTAs respectively. This indicates that overall in the population of RTAs, these factors alone account for 5% and 1% of RTAs respectively. However, it is expected that both these factors may be potentially under reported due to the sensitive nature of disclosing such information.

The third level factors were coded as being perceptual failures, misinterpretation, cognitive failures and unable to see, and accounted for 23.8%, 20.8%, 12.5% and 10.45 respectively. In contrast to the TRRL study, (Sabey and Staughton 1975), perceptual errors account for considerably less errors than suggested by Sabey; the TRRL study suggesting 44% of road user errors were perceptual in nature. This discrepancy may however, be largely due to the different coding schemes used in
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each study. No especial differences were noted in terms of the different errors coded by age, however a higher proportion of cognitive errors were found amongst females as compared to males, (15.7% compared to 11.7% of third level factors).

Of the fourth level factors, of note is that only 5 contributory factors out of a total of 1040 coded were vehicle defects. This contrasts with previous RTA studies in which higher proportions of RTAs were attributed to vehicle defects, (for example 2.5% of single factors for the TRRL study, Sabey and Staughton 1975). It should be noted, that of the remaining, human factors, which are in theory explanations of the above behaviours and failures, 34% of the factors coded at the fourth level were unknown. Thus approximately one third of the explanations of the higher level failures and behaviours were not deduced by this analysis and further analysis was therefore precluded. However, it was noted that of the third level perceptual errors that were explained by a fourth level factor, this fourth level factor was most often distraction.

In terms of the interactions between levels of the coding scheme, almost half of the top level failures to yield were explained by perceptual errors, whereas 14% were explained by cognitive errors. However, 27% of these failures to yield could not be explained with the available information. Losses of control by drivers were most frequently explained by driving too fast, (26.7%) and various types of impairment, (13.7%).

In common with the results of subsequent studies, (for example Parker et al 1995), variations in the patterns of links between top level failures and lower level explanations were found between genders and ages. Top level failures explained by driving too fast were more common for males and younger drivers than females and older drivers. Additionally, there is some indication from the data that younger drivers lost control of their vehicles more often than older drivers because of skills errors, this being more common amongst females than males.

In terms of faults however, whilst 41.0% of drivers were considered to be at fault, there were no gender differences between those assigned to be at fault and those not at fault, but the faults themselves differed with more males than females responsible
for culpable faults, (such as driving too fast), whereas females were more responsible for non culpable mistakes type faults. With respect to age, fault decreased to a low at 50-59 years, then rose for those over 60. Since categorisations of fault were performed for all participants, (including those from whom an interview or questionnaire was not obtained), it was possible to determine whether there was a difference between attributions of fault on the basis of whether or not a participant agreed to an interview. As the interview data was used to assign fault in some cases, a higher rate of unknown fault was found amongst those who did not give an interview as compared to those that did. Using the cases with known fault, it was found that of the refusals, 60.4% were deemed to be at fault, compared to 52.9% of non refusals.

Whilst this approach to categorising the human factors impinging on RTA causation has made a significant improvement in methodological terms there are some limitations to this approach, (Southwell et al 1990). Specifically;

- As the study relied upon a case-by-case basis, it cannot assess the extent to which these factors act in the driving population as a whole. An example given, is that without a parallel exposure study, this method cannot account for the increased risk of an RTA due to inexperience or fatigue, (Carsten et al 1989, Southwell et al 1990).

- Due to the above, and the nature of the interaction effects expected between the contributory factors outlined, it is therefore not possible with this method to gauge the effects of the interactions between the contributory factors in the population as a whole. Thus for example, the increased risk due to the interactions of the factors affecting a young, male driver who has been drinking and subsequently drives home on a wet Friday night, in terms of his elevated risk of an RTA compared to a sober, 50 year old female driver who is driving mid week during daylight hours cannot be deduced. It has been suggested elsewhere however, (Evans 1991), that these effects will be multiplicative in nature and that the worst case illustrated above will be resulting in an elevated risk of
approximately 1000 times that of the best case. Whilst this is certainly a very large increase in risk, it would seem from the published RTA data that these risks are not borne in mind by these at risk drivers.

- The study did not go into great detail regarding the psychological factors associated with the fourth level failures. This was partly due to the design of the study; the interview techniques chosen were straightforward and rather factual in nature, (Southwell et al 1990), and as such did not readily allow such data to be elicited. Additionally, it may have been due to the large number of factors that were coded as unknown at this level. Several reasons may exist for this latter element. Due partly to the traumatic nature of RTAs and partly to the fact that something unexpected occurred, (else the driver would have been able to take prior avoiding actions), it may not have been possible for those involved to accurately give an assessment of such contributory factors. Thus, they may be able to state that the situation was visually misleading or distracting, they may not be able to state what was the cause of the distraction or confusion. Additionally, some factors such as inexperience, impairment due to alcohol or drugs may not be readily admitted.

- Finally, the study relied on the judgement of the team in deciding upon the contributory factors for each RTA participant, and upon deciding between conflicting statements of drivers. Both of these effects may lead to errors in the results.

2.7.4 Case study approaches.

2.7.4.1 Institut National de Recherche sur les Transports et leur Sécurité, France.

Between 1980 and 1987, the Department of Accident Mechanisms at the Institut National de Recherche sur les Transports et leur Sécurité, (INRETS), conducted an in-depth investigation of RTAs in the Salon de Provence region of France. Over the course of this study, 400 RTAs were examined in detail. The aim of this study was to reduce the number and severity of RTAs, (Girard 1993) by gathering data relating
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to the causes of accident in an attempt to design appropriate countermeasures. In contrast to other in-depth studies, the INRETS methodology made specific reference to the cognitive functioning of the driver by adopting a model of driver behaviour as a basis for their research, (Girard 1993). The model assumes that as drivers gain experience, they store a catalogue of roadway situations which act as prototypes for categorising subsequent situations. Whilst driving environmental information is filtered, this filtering process becoming gradually more automatic as skill increases. RTAs are viewed to result due to failures at some level in the sequence of information processing. As a consequence of this, the INRETS methodology both paid particular attention to the drivers account of the road scenario prior to the RTA and the interpretation the drivers made of these scenarios. In addition, the data collection was geared towards factors that may have influenced information processing.

The data collection was geared towards reconstructing the scenario that resulted in an RTA, and identifying mechanisms and interactions that made up the scenario. Since much of this information is temporal in nature, the investigators were required to examine the RTA scene as soon as possible after the incident. In practice, the INRETS team were alerted to an RTA at the same time as the emergency services and collected as much information as was possible at the scene of the accident. This on the scene data collection focused on vanishing data, (Girard 1993), such as skid marks, final locations of the vehicles involved, weather and roadway conditions. These data, together with preliminary assessments of the vehicles were collected by a trained technician. A psychologist assisted with this data collection and interviewed the driver on the scene if possible, or as soon as was possible afterwards. The driver was asked to describe firstly what happened, then was interviewed in detail concerning their intentions at the time of the RTA, what they had seen and were aware of and the nature of the actions they had taken.

Subsequently, a second phase of data collection was undertaken which concentrated on demographics of the driver, details of the journey being undertaken and a
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technical vehicle inspection. An initial reconstruction was then undertaken which was the basis for a full kinematic reconstruction of the scene.

The analysis proceeded in two phases. Firstly, the sequence of events leading to the RTA was explicitly described with special reference to the triggering event and any emergency manoeuvres undertaken. Secondly, the mechanisms contributing to the sequence of events were identified having divided the RTA scenario as a whole into four phases. These phases were the driving phase, (the normal driving situation); the discontinuity phase, (the unexpected event interrupting the normal driving); the emergency phase, (the time between the discontinuity and accident in which the drivers may attempt any avoiding actions); and the crash phase, (in which the crash and its consequences occur). It can be seen that a number of parallels between these phases and the accident sequence model presented in Figure 2.1 therefore exist.

One of the most important results of this study was the description of what was described as 'prototypical accident scenarios', (Fleury, Fline and Peytavin 1988, Fleury and Brenac 1997, Lechner and Ferrandez 1990, Malaterre, Fontain and van Elslande 1992). The prototypical accident scenarios were described as a series of processes 'corresponding to a series of accidents which are similar in terms of the chains of facts and causal relationships found throughout the various accident stages', (Fleury and Brenac 1997, pp. 1). The concept of prototypical scenarios allows data from a number of RTAs to be combined to allow knowledge to be generalised across a number of studies. In practice, cases with overall similarities were grouped into categories before the sequential analysis was undertaken, thus this process was essentially qualitative in nature. Since the focus of this work was to provide a basis to design countermeasures, the RTAs in the database were split at a very gross level into global RTA types, (for example RTAs involving HGVs, Fleury and Brenac 1997, or RTAs involving elderly pedestrians in urban areas, Yerpez 1996, Yerpez and Girard 1996). Each of these global types lead to a different number of prototypical scenarios, HGV RTAs for example resulting in 5, (Fleury and Brenac 1997), RTAs at roadworks resulting in 6, (Mercier 1993). Due to the variety of possible factors influencing RTA causation across different global RTA
types, it should not be expected that different global accident scenarios would produce the same number and structure of prototypical accident scenarios. A similar position has already been stated with respect to the failure to produce a single universally acceptable theory of human error.

2.7.4.2 Transport Research Laboratories, United Kingdom.

Three case study based RTA investigations have been carried out and published by Transport Research Laboratories, (TRL, formerly TRRL), since 1995, Clarke, Forsyth and Wright (1995), Broughton and Markey (1996) and West (1997).

Clarke et al (1995) studied 200 police reports of right turn accidents provided by Nottinghamshire constabulary in the UK. The main purpose of this study was to attempt an in-depth study that clustered accidents in a systematic manner using a computer based sequential analysis of the accident reports, (utilising a specially devised Transport Related Accident Analysis Language). Clarke et al (1995), had argued that many of the previous RTA studies had suffered from the problem of subjectivity in coding RTA types and causal factors. It was demonstrated that using the algorithms devised RTAs could be categorised meaningfully into a natural taxonomy of scenarios which could then be used as the basis for future interventions. For example, the severity of an incident could be determined with 77% accuracy from consideration of the nature of the other vehicle involved, the season and junction type and from whether the driver noticed another road user or not, (Clarke et al 1998). Some problems existed however with the algorithms which resulted in specific failures. For example, no distinction could be made between RTAs involving young or old drivers, nor could a distinction be drawn between male and female drivers. Given the number of other studies making these distinctions, both of these can be viewed as serious methodological failures.

Broughton and Markey (1996) specifically aimed to provide guidance to motor manufacturers about the nature of equipment they could provide to drivers to reduce the number of RTAs. To achieve this, they studied two samples of 1000 RTAs, one sample of fatal accidents reported to the police and accessed through their records,
and one of non fatal accidents reported to the drivers’ insurance company. This latter sample was accessed directly through the insurance company involved. Thus the final sample comprised approximately one fifth of all fatal RTAs in the UK in 1994 as well as a range of severities from the insurance company. The majority of the RTAs accessed from the insurance group, (88%) involved damage, but no personal injury.

A single causation factor list was drawn up from a review of previous studies and similarly to the Leeds study a hierarchy of factors was produced. This hierarchy was simpler than that of the Leeds study as this was felt to be unnecessarily complex. Broughton and Markey (1996) distinguished between precipitating and causation factors, the former being the failures and manoeuvres that immediately lead to the RTA and the latter being the causes of these failures.

Broughton and Markey (1996) identified 7 accident clusters by cross tabulating the most common precipitating and causation factors. These clusters were as follows;

- Fatal RTA: Driver looses control due to driving too fast, (224 cases).
- Fatal RTA: Driver looses control because of a lack of judgement about their own path, (77 cases).
- Fatal RTA: Pedestrian fails to give way to driver, (262 cases).
- Non-fatal RTA: Driver hits object in carriageway due to distraction, (61 cases).
- Non-fatal RTA: Driver hits object in carriageway due to failure to judge another vehicle’s speed, (60 cases).
- Non-fatal RTA: Driver looses control on slippery surface due to ice or snow.
- Non-fatal RTA: Other driver hits an object in the carriageway due to excessive speed, (112 cases).
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Additionally, each RTA cluster was associated with specific situational and demographic factors, for example cluster 1 was more likely than the average to involve a single vehicle, driven by a young male driver on a wet road and at night with no street lights.

Whilst demonstrating the efficacy of their procedure in clustering accidents, some methodological problems existed. Firstly, as the insurance company data were collected over winter months, Broughton and Markey (1996) acknowledged that the role of poor weather appears to be more prevalent in their data than would be expected. Secondly, the samples in the police and insurance company datasets were not equivalent. The fatal RTAs were sampled exclusively from vehicles with a registration prefix of G or later whereas the insurance company dataset had no such restriction. Demographic differences between the two datasets and temporal differences between the occurrence of the two sets of RTAs may have influenced the distribution of the final clusters.

Finally, analyses of data collected initially for other purposes are problematic as Frampton (1997) described. In the current case, it was not possible to obtain more detailed information regarding specific accidents in the data sets. By necessity therefore, some accidents were excluded from the analyses. It is likely therefore that less severe RTAs would have differentially been excluded from the results as these are in general not recorded as completely as more severe accidents. Although no differences in causation have been found in fatal compared to non fatal RTAs, (Sabey and Staughton 1975, Sabey and Taylor 1980), significant advances in methodology since these findings may call this conclusion into question.

West (1997) described the results of two studies started in 1987 and 1990 in which drivers were asked to describe RTAs that they had recently been involved in. Drivers were asked to provide brief written statements concerning RTAs as part of a national driver survey. These descriptions were then rated into 'scripts' by trained judges who were in general in agreement concerning the nature of the script assigned for each RTA, (80% of the cases being rated similarly). Additionally, the drivers were
rated as being active or passive in the RTA depending on the role they played in its causation, (passive drivers being those hit by another who was regarded as causing the RTA whilst active drivers were those responsible for the cause of the RTA). The resultant scripts were;

- Shunts.

- Right of way violations.

- Accidents involving loss of control of the vehicle.

- Accidents while reversing.

- Accidents caused by lane changing.

- Hitting pedestrians on the roadways.

- Hitting animals on the roadways.

- Hitting objects on the roadways.

- Hitting open car doors.

A comparison of 8900 drivers replying in 1987 and 1990 revealed that involvement in certain types of RTAs in the years preceding 1987 differentially increased the risk of being involved in the same RTA types between 1987 and 1990. Active and passive shunts, active right of way violations and active loss of control RTAs all showed this pattern. In addition, examination of demographic characteristics across these scripts showed that different types of drivers are more likely to be involved in different RTA scripts, young male drivers for example being at more risk of active shunts and active loss of control violations. Overall drivers were concluded to be reliable both in their reporting of the RTAs in which they were involved and in the consistency of the type of these RTAs over time.
2.7.5 Data collected in in-depth investigations.

2.7.5.1 Reliability and validity of data.

The reliability of the data obtained in any investigation is of paramount importance. The data themselves can be split into three categories; factual evidence from observation, evidence based on interviews or questionnaires administered to either those involved or witnesses, and the evidence based on the assessment of errors made by the road users, (most commonly performed by the investigation team, for example see Sabey and Staughton 1975). Whilst considerable efforts are made to ensure that all of these data are accurate and reliable, errors can and do occur within the data. Factual evidence such as the age or gender of the individuals involved in an incident are usually subject to little error. However errors of this type have been demonstrated to occur in the STATS19 database, (Southwell et al 1990).

The quality of the evidence obtained from interviews or questionnaires will vary greatly, much of the reliability depends on the honesty and reliability of the interviewee, (Sabey and Staughton 1975, Clarke et al 1995), but additionally the skill of the interviewer in administration if applicable. A common technique to ensure inter-rater reliability is to record a number of the interviews and have another member of the RTA investigation team score an interview independently. Any serious differences between the two assessments are resolved by the two interviewers concerned and where necessary some retraining has been done. This technique has been used by most in-depth studies with good effect, (Sabey and Staughton 1975, Southwell et al 1990, Treat 1980, West 1997). However, it has been argued that over learned behaviour such as driving may be inaccessible to verbal reports by drivers and that therefore such approaches are inherently flawed, (Clarke et al 1995).

A notable feature of all large scale, in-depth studies is that they involve a team of researchers, usually with varied backgrounds. Such studies are usually referred to as Multidisciplinary Accident Investigations, (MDAI), the members of the teams
involved typically varying widely, and have included; trained accident investigators, mechanical engineers, automotive engineers, interviewers, doctors, sociologists, accident reconstruction specialists, police and psychologists, (Grime 1987, Evans 1991, Southwell et al 1990).

An important feature of such teams is that by increasing the variety of different team members, potential biases within the team due to a narrow range of experience within a group of given profession are lessened (Southwell et al 1990), i.e. the ‘stop rules’ applied in any given accident investigation are less likely to be biased towards a particular domain. However, in large scale studies, strenuous efforts must be made to ensure that the team members are consistent with their data collection, (Southwell et al 1990). As has been noted, there exists a potential bias wherein inexperienced interviewers may in inadvertently lead a person being interviewed, (Carsten et al 1989, Evans 1991, Grime 1987, Southwell et al 1990). Similarly inexperienced RTA investigators may well miss some aspect of the vehicles condition that would have contributed to the RTA's causation. When the required efforts to ensure reliability and consistency have been made, it is generally assumed however, that with in-depth investigations involving some aspect of reconstruction, such large multidisciplinary teams are worthwhile, though expensive undertakings. Clarke et al (1995) however note the possibility of heterogeneous teams resulting in differing interpretations of the events surrounding an RTA which may lead to an obscuration of the actual events.

In-depth studies may be categorised according to the length of time between the RTA's occurrence and the time of the investigation. The majority of studies are performed 'on the spot', i.e. at the site of the RTA and at the time, or as near as possible after the time of the RTA's occurrence, (for example Fleury et al 1988, Fleury and Brenac 1997, Lechner and Ferrandez 1990, Malaterre, et al 1992, Sabey and Staughton 1975, Sabey and Taylor 1980, Treat 1980). These studies are thus arranged such that the researchers attend the scenes of the RTAs as soon as possible after the RTA has occurred.
The reason for on-the-spot investigations is that the quality and accuracy of the data obtained is potentially enhanced over studies in which data are obtained in a different manner. Thus accurate measurements of the positions of debris and of the vehicles themselves after the crash can be obtained rather than for example relying on sketches from drivers. Finally, interviews may be attempted at the scene with those that have been directly or indirectly involved in the RTA, (either RTA participants or witnesses). This has the advantage that those interviewed will have a recent memory of the events and will not have had the time to modify their version of the events in an effort to shift the blame to another person involved in the RTA. This can be demonstrated by the fact that a majority of drivers report that they viewed the RTA was the other driver’s fault, and that consequently the other driver could have prevented the RTA by some action that was not performed, or by performing some aspect of the driving task differently, (Southwell et al 1990).

The major disadvantages to on-the-spot investigations are the costs involved in having a team on standby for 24 hours a day and the logistics of obtaining notification of the RTAs sufficiently quickly for the research team to be able to arrive on scene. Studies have addressed the second issue by using a variety of methods of obtaining RTA notifications, for example direct phone links with the police or ambulance services or by monitoring the emergency service radio frequencies, (Southwell et al 1990). Due to the requirement of large scale studies to be statistically representative of the whole population of RTAs, no large scale studies have addressed the first issue by specifically comparing in depth the factors impinging on RTA causation throughout different times of the day. Grayson and Hakkert (1987) suggested that on-the-spot investigations are inherently biased towards RTAs involving injury and those occurring during office hours as few efforts are made to perform these studies in any other manner.

An alternative methodology to obtaining the information from the scene, is to interview those involved at some time after the RTA. In practice, this means that the vehicle would be looked at within one week of the RTA, the interviews or questionnaire distribution is then carried out at some time, (usually within three
months) of the RTAs occurrence, (Carsten et al 1989, Southwell et al 1990). The RTA scenes may be viewed at any time afterwards. The obvious advantage of such a method is that the team members do not have to be on call 24 hours a day in order to arrive at the scene in sufficient time to record the necessary information.

However, as the scene is not investigated with the vehicle in situ, no non-permanent information regarding the RTA are preserved, (for example the final position of the vehicles, the position of any debris and the environmental and road traffic conditions at that time). Such data may however be obtained from the police report forms, (RT7s), but it should be borne in mind that this form of data collection cannot be viewed as one hundred percent reliable. The degree of completion of such forms will vary depending on several factors such as the individual officer filling the form out, the severity of the RTA and the time constraints under which the officer is acting. Additionally, examination of several weeks worth of RT7s, (by the current author), has demonstrated that there is a tendency for the more severe RTAs and those in which fault can easily be attributed to one participant or another to be accompanied by more detailed RT7s.

Importantly, when those involved are not interviewed at the time of the RTA there is the potential of biases being introduced into the data obtained from the RTA participants or witnesses.

These biases may be of several forms, and may be consciously or unconsciously generated. Examples of deliberate biases are those resulting when one of the participants intentionally misleads the investigation team as to the sequence of events leading to the RTA. This is most commonly seen where drivers each blame the other for an RTAs occurrence. Whilst in some cases the attribution of fault may be either unclear or shared amongst the RTA participants, undoubtedly in some cases, one or more involved in an RTA will deliberately lie in order to shift blame from themselves to another party and thereby attempt to reduce or remove possible effects of punitive measures from the police or insurance companies.
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Additionally, unconscious biases may exist within the data. These result largely from those involved not knowing exactly what happened and attempting to form a plausible explanation for their actions and those of others. Whilst these rationalisations may be a correct representation of the sequence of events, they may potentially introduce large, and potentially difficult to detect biases in the data.

In terms of the size and type of RTAs investigated, in-depth studies have varied widely. Due to the complexity of RTA scenarios and the number of factors involved, (a total of 5793 factors amongst 1254 RTAs were identified in the Leeds study, Southwell et al 1990), very large sample sizes are generally required for such studies to be statistically representative. Most RTA investigation studies have aimed to have a sample size of at least 1000 cases. In practice, these studies are often larger, with the sample sizes for the TRRL study and the Leeds study being respectively 2130 and 1254 RTAs, (Carsten et al 1989, Southwell et al 1990, Sabey 1975, Sabey and Taylor 1980).

The Indiana study was unusual in that it dealt with the RTAs at three interrelating levels, a baseline study involving police records, on-site investigation by RTA investigators, and an in-depth investigation by a multi-disciplinary RTA investigation, (MDAI) team, Treat (1980). Each of these data collection programmes was investigated by a separate team and due to the differing types of data collected and the consequential different data collection procedures different numbers of cases were investigated in each phase of the study, the baseline, on-site and MDAI phases each accounting for 13,568, 2258 and 420 cases respectively. Whilst RTA causation studies have generally attempted to study in excess of 1000 cases, others have concentrated on in-depth analyses of much fewer cases. Van Elslande and Faucher-Alberton (1996) for example studied 177 RTAs drawn from the INRETS database in an analysis of errors related to rigid expectations on behalf of the drivers involved.
2.7.5.2 Summation of data: The case conference.

A feature of all RTA investigations is a case conference concerning each particular RTA under investigation. Typically a team of between two and five members of the RTA investigation team will gather all of the information on a specific case and review it. This has two purposes, the first of which is to check the accuracy of the data between sources as errors have been demonstrated in a variety of official data sources for example within the STATS19 dataset, (Southwell et al 1990).

A second important aspect of the case conference is that it is at this stage that the contributing factors for any given RTA are decided upon and assigned by the RTA investigation team. Whilst most RTA investigation studies have asked the RTA participants questions pertaining to their perceptions of the cause of the RTA, (for example had they been drinking and did they feel this was a factor that may have lead to the RTA?), in all cases to date, the contributory factors have been assigned by the RTA investigation team. As such there is potential for biases and subjective error, amongst those not witnessing the RTA assigning the cause, (Sabey and Staughton 1975, Sabey and Taylor 1980, Southwell et al 1990). However, using a multidisciplinary team in a case conference should alleviate this to some extent.

2.8 Potential accident countermeasures.

2.8.1 How is technology entering the car market?

Recent advances in sensor, communications and computing technology have led motor manufacturers and their suppliers to consider introducing high technology driving aids into vehicles. This has led to a vast increase in the potential information available to drivers, as well as to the facilities and functions that their vehicles may perform for them. In order to achieve this, two research programmes have been conducted in Europe, PROMETHEUS and DRIVE.
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Both of these research programmes focused on the issues underlying the implementation of advanced technology into vehicles and were undertaken to perfect these technologies. Nevertheless, in practice, these research programmes were technology led, focusing on the design and eventual implementation of what was technologically feasible, (Broughton and Markey 1996, Galer Flyte 1995). These technologies have largely been transferred from other domains, principally aerospace. As a consequence, issues of safety, in particular primary safety have not been addressed specifically. In effect, any positive safety benefits may be regarded as a by product of the desire to implement such technologies into vehicles.

A vast body of research literature concerning these technologies has been published. This literature may be divided roughly into two parts, that concerned with the basic human factors issues of interface design, (and to a lesser extent the desired functionality of the technology), and that concerned with the behavioural effects of such technologies when implemented into vehicles. It is beyond the scope of the current review to describe these technologies in detail, however they have been categorised as follows, (Table 2.9, from Galer Flyte 1995):

**Table 2.9 Taxonomy of high technology in vehicles, (from Galer Flyte 1995).**

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples of systems</th>
</tr>
</thead>
</table>
| Systems that directly impinge on the driving task | Collision avoidance  
|          | Lane keeping  
|          | Intelligent cruise control  
|          | Vision enhancement               |
| Systems that provide information relevant to components of the driving environment, vehicle or driver | Dynamic route guidance  
|          | Vehicle condition monitoring      
|          | Driver condition monitoring       |
| Systems that are unrelated to driving | Mobile data terminals  
|          | In-car telephones                 |

When considering potential accident countermeasures, Sabey and Staughton (1975) noted that the most effective remedy is not necessarily related directly to the main cause and may even lie in a different domain, particularly in the case of RTAs in which the road user fails to cope with the road environment. Additionally, even in
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circumstances in which human error or impairment has been judged to be the sole contributor, it may be possible to influence human behaviour more readily by engineering means than by education or enforcement of legislation. However, it can be readily seen that the technologies above have been designed without reference to the needs of the drivers with respect to preventing RTAs, the results of the RTA investigation studies described above have largely been overlooked when considering these technologies, (Broughton and Markey 1996).

As a consequence, motor manufacturers are faced with a plethora of technologies at various stages of development but they have no means to determine which of these, if any, will have significant effect in reducing the toll of RTAs, (Broughton and Markey 1996). The situation is even worse with respect to long term strategic decision making concerning which of these technologies should be further researched with a view to implementation in the next generation of vehicles. No method to achieve this has been published as yet. However, two in-depth RTA studies have specifically addressed the issue of RTA prevention by considering the requirements of drivers and the implications of these requirements on technology development and implementation, (Malaterre et al 1992, Broughton and Markey 1996).

Malaterre et al (1992) performed an analysis of driver needs on the basis of RTA data derived from the INRETS database with a view to determining how effective the PROMETHEUS technologies would be. The research proceeded in four phases, definitions of driver needs, definition of potential system functionalities, correlation of needs with functionalities and evaluation of the effectiveness of systems using real life RTA data.

Initially, 3200 RTAs were reviewed on a case by case basis to identify the driver’s errors immediately prior to the RTA. From a description of these errors, a list of needs was deduced. Needs were defined as the critical information or function that was required, that had it been satisfied ‘the error and therefore the accident, could have been avoided’, (Malaterre et al 1992, pp. 6). 17 needs were identified across the
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RTAs studied, each backed up by a description of a case requiring this need. The needs were as follows:

- Normal level of driver alertness.
- Normal level of mechanical functions of vehicle.
- Detection of road related difficulty ahead, (for example dangerous bend).
- Fixed or mobile obstacle detection.
- Detection of an oncoming road user, (when vision obscured by environmental factors).
- Detection of road user on intersecting path, (side or rear impact when other user seen too late to take avoiding action).
- Detection of a road user outside of the normal frontal field of view.
- Detection of unseen pedestrian, (either because of obscuration of vision or due to driver’s poor attention).
- Appropriate speed adaptation to roadway conditions.
- Maintaining appropriate headway to vehicle in front.
- Estimation of collision at intersection with another road user, (when neither road users had halted).
- Gap assessment when overtaking or changing lanes.
- Gap assessment when joining traffic flow or cutting across a traffic flow.
- Predicting that other road user will allow self to move at intersection.
- Predicting manoeuvres of another road user.
- Predicting pedestrian behaviour.
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- Maintaining control of vehicle.

As part of the PROMETHEUS programme, a series of demonstrator vehicles were developed by the motor manufacturers heading the projects each of which served as a platform to illustrate and research a specific system. From a review of the literature pertaining to PROMETHEUS and an analysis of these vehicles, a list was produced of the functions that the systems would perform if introduced into the vehicle fleet as they were. In total, 23 functions were identified, 14 of which Malaterre et al (1992) deduced were related to primary safety. These were as follows:

- Obstacle detection.
- Monitoring of environment and road.
- Monitoring the driver.
- Monitoring of the vehicle.
- Vision enhancement.
- Safety margin determination.
- Critical course determination.
- Dynamic vehicle control.
- Supportive driver information.
- Intelligent manoeuvres.
- Intelligent cruise control.
- Intelligent intersection control.
- Medium range pre-information.
- Emergency warning.
Driver needs were then cross referenced with PROMETHEUS functionalities to produce a matrix illustrating which needs would be served by which functions. Two raters then coded 3179 RTA case studies from the INRETS database for 1989 to determine the relative numbers of the different needs previously identified.

Two main results were evident. Firstly, a comparatively large percentage of the RTAs could not be coded sufficiently well given the information available, 12.5% were coded as indeterminate, (a specific need could not be identified) and 17.2% were coded as no need, (no need required). These were coded thus because the nature of the data presented to the raters did not always allow a specific need to be identified, the raters being presented with case study summaries of the RTAs. Secondly, it was noted that comparatively few of the needs would be addressed by the functions identified from the PROMETHEUS demonstrators. It would seem that this was largely due to issues relating to the implementation of the technologies; whilst in theory many of the needs would have been satisfied by the functions outlined, in practice the technical specification of the systems precluded their use in a large number of cases. Malaterre et al (1992) did note the difficulties in foreseeing the effectiveness of driving aids which had not yet been developed and were consequently not yet in the vehicle fleet. However, Malaterre et al (1992) concluded, (pp. 53);

'It would seem a pity, however, the choice of demonstrators appears to have been motivated more by technological considerations than by taking actual needs, supported by accident analysis or on-the-spot studies, into account'.

This is not to say that the PROMETHEUS work would be potentially ineffective in reducing the number of RTAs experienced on the roads, merely that the functions performed by the demonstrator vehicles would have limited effect. Broughton and Markey (1996) however were more critical of the previous work on advanced technologies being introduced into the vehicle fleet, stating that, (pp. 1);

'much of the earlier research had failed to pay sufficient attention to the actual requirements of the car driver in respect of safety. Many research projects have
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developed new technology, and only then considered the potential safety implications".

Broughton and Markey (1996) therefore adopted the reverse and they argued the more natural approach of identifying real needs from an analysis of RTA data, then specifying functions, (described as Logical Solutions), that a driver would need to avoid the RTA in which they were involved. Table 2.10, represents a summary of the Logical Solutions identified.

Table 2.10. Summary of RTA clusters and associated Logical Solutions, (from Broughton and Markey 1996).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fatal RTA: Driver loses control due to driving too fast.</td>
<td>Monitors friction, predicts imminent friction requirement and assesses maximum safe speed.</td>
<td>Speed advice, speed warning, automatic intervention.</td>
</tr>
<tr>
<td>2. Fatal RTA: Driver loses control because of a lack of judgement about their own path.</td>
<td>Predicts trajectory and checks for potential conflicts with vehicles, infrastructure etc.</td>
<td>Warning of collision, automatic intervention.</td>
</tr>
<tr>
<td>3. Fatal RTA: Pedestrian fails to give way to driver.</td>
<td>Detects pedestrians and checks for potential conflicts.</td>
<td>Automatic intervention.</td>
</tr>
</tbody>
</table>

It is apparent from the above table that to have an effect on the 7 RTA clusters identified, only 5 Logical Solutions would be required. Broughton and Markey
Literature reviews.

(1996) additionally considered the level of intervention that any systems should perform, some of the Logical Solutions by necessity automatically intervening by for example automatically braking when a requirement is detected whilst others merely warn the driver of an impending hazard. In addition, assessments were made of the likely uptake of these systems into the vehicle fleet and the expected costs and benefits of such systems. Based on an economic model of the costs of various clusters of accidents, it was concluded that only those systems that would reduce RTAs in clusters 1, 4, 5 and 7 would be commercially viable and therefore likely to be introduced in cars. However, suggestions for effective accident countermeasures effecting the other RTA clusters were made.

2.8.2 Implications of case study based RTA countermeasure assessments.

Malaterre et al (1992) demonstrated that the PROMETHEUS demonstrators as they function at the time of writing, would have comparatively few benefits with respect to reducing the number of RTAs experienced on the roads. Broughton and Markey (1996) suggested that when systems are devised based upon the functional requirements of drivers in a specific RTA scenario, the systems when implemented appropriately could reduce the likelihood of the RTA occurring. Additionally, they demonstrated that such systems could be economically viable and that thus they may enter the vehicle market and effect a real reduction in the toll of RTAs.

However, there are three considerations from these studies. Firstly, the effectiveness of any system based upon a clustering of RTA scenarios is subject to the potential bias inherent in clustering. In effect, statistical procedures may force the data into clusters spuriously and therefore the resultant systems would not be generalisable to the RTA population as a whole. It is for this reason that statistical approaches to this technique should only be performed on appropriately large sample sizes.

Secondly, even if all new vehicles are equipped with such devices, it will take many years for such systems to reach full saturation within the vehicle fleet. The potential
benefits of systems requiring interaction between similarly equipped vehicles will thus be sub-optimal during this period.

Thirdly, whilst any warning or intervention based system may reduce the likelihood of an RTA occurring, (or even prevent it completely), unless these systems are fully automated, to some extent the probability of an RTA being prevented will depend upon the driver behaving in a reasonable manner, (see Treat 1980). Certain classes of drivers may for example choose to ignore warnings. There is the suggestion in addition, that drivers will actively drive in a more dangerous manner so as to maintain their subjective level of risk, (Adams 1985, Deering and Viano 1994, Wilde 1991, 1994). The implication is, that as well as being educated in the use of such systems, drivers should in addition be motivated to drive in a socially more responsible manner, (Wilde 1994).

In conclusions, new technologies, when implemented appropriately show great potential for reducing the number of accidents through provision of advisory information or interventions. Currently however, advanced technologies may prove ineffective due to a failure to account for the actual needs of the drivers.

2.9 Chapter conclusions and summary.

The conclusions from this chapter are as follows.

- It is clear that human factors and specifically errors play a major role in RTA genesis. However, no single model of human error is appropriate for all domains and within a given domain more than 1 model may be applicable. Ramsey (1985) and Rasmussen (1987) both provide workable frameworks for current study that may be applied to RTAs. However, Ramsey's (1985) model describes the sequence of events in a generic accident, whilst Rasmussen's (1987) model describes the errors made. Neither model is therefore complete and each therefore requires elements of the other before a full picture of any given accident may be derived.
Literature reviews.

- Demographic studies of those involved in RTAs and where these RTAs occur are useful only as descriptions of these factors. Largely due to the methods that are employed in collecting these data, few conclusions with respect to appropriate accident prevention technologies are possible. Additionally, the issue of the nature of the statistics quoted complicates the situation with respect to the size of the RTA problem, and hence of any possible effects of the implementation of accident countermeasures. Due to the inaccuracies in data recording it would seem sensible to limit consideration to absolute numbers of accidents, and in specific to fatalities.

- Early in-depth studies of RTAs are similarly of limited use. Whilst it is clear that human error plays a significant role in RTA causation, for the most part the factors were described vaguely which in itself leads to imprecise conclusions. Few suggestions for accident prevention measures were offered as a result of these studies.

- The study undertaken at the Institute of Transport Studies, Leeds was a significant breakthrough in terms of understanding the factors impinging on RTAs. In contrast to earlier studies, the factors were explicitly defined and placed in a hierarchy that allowed causal chains to be inferred. This study therefore most closely matches a composite of the models of Ramsey (1985) and Rasmussen (1987). The study was of limited use otherwise, concentrating as it did purely on urban accidents resulting in non injurious outcomes. In addition, no accident countermeasures were suggested.

- The INRETS and TRL case studies both suggested appropriate accident prevention measures. INRETS demonstrated the use of clustering of accident types and illustrated concept of needs with respect to the drivers. This was advanced further by the TRL work. To some extent, both studies suffer from the problem of how appropriate the categories used were, and little consensus was achieved between these studies in terms of suggested technologies. Use of more reliable data from a wider database, (for example fatalities from STATS19)
should allow a single strategic approach to accident reduction to be achieved. Additionally, concentration on RTAs resulting in fatalities for the purposes of accident prevention measure deduction will result in the most costly and serious RTAs being addressed by the limited resources available.

- Using a functional definition of the needs of the drivers and hence of the performance of the accident prevention measures will allow these technologies to be developed in a more driver centred manner. This has been demonstrated by Malaterre et al (1992) and Broughton and Markey (1996).

The aim of this project is to develop a methodology for assisting primary safety decision support. Ultimately this will assist designers or engineers to design and build usable accident prevention technologies based on the functional requirements of the drivers. A first stage in the design of such technologies is to gain an understanding of what's going wrong in critical situations leading to RTAs. Data must therefore be collected on a sample of RTAs in order to the critical failures leading to the RTA. Once these failures have been deduced, appropriate accident prevention measures may be designed.
3.0 Study 1: RTA data collection.

3.1 Chapter summary.

The overall aim of this thesis is the development of a methodology to determine primary safety strategy with respect to the choice of appropriate RTA prevention measures that a motor manufacturer may develop and implement to effect a reduction in the number of RTAs. This chapter addresses the second objective outlined in Chapter 1, namely to collect information pertaining to the causes of RTAs. To achieve this, a method to collect information on the causes of RTAs was devised and a study was conducted to collect this information.

This chapter firstly reviews the aims and objectives of this phase of the work and describes the RTA data collection study conducted. The pilot work and main data collection are outlined and this chapter then describes the contribution of the studies detailed herein to the thesis as a whole.

3.2 Introduction to the RTA data collection.

The aim of this thesis is methodological; to develop and operationalise within a motor manufacturer a procedure, the application of which will aid that motor manufacturer when making strategic decisions in respect of the development of appropriate primary safety technologies. This was needed as although there is a considerable body of research literature relating to the potential effects of high technology in vehicles and on driver behaviour in general, currently no methodology to aid such decision making exists.

As such, this research was conceived to develop and operationalise this methodology so that it could subsequently be used by the motor manufacturer, rather than
Study 1: RTA data collection.

specifically to collect data to determine the causes of a sample of RTAs. The methods and procedures outlined in this thesis are therefore a description of the whole methodology that was developed during this research.

In order to develop this methodology, two forms of data were required. Firstly, data on the causes of RTAs was needed, as a more complete understanding of the factors impinging on RTA causation was required before the reasons for the RTAs occurrences could be addressed by technological interventions. Secondly, with the addition of data relating to the nature of technologies that may be introduced in vehicles, these RTA causation data could be subsequently used in a decision support system to enable decisions to be made concerning the appropriateness of any given technology.

However, as has been described, currently published data on the causes of RTAs are insufficient for determining the efficacy of potential RTA countermeasures. In addition, a motor manufacturer would not have ready and on going access to data concerning the causes of RTAs unless they were to collect these data themselves.

A new data collection procedure was therefore developed that not only facilitated a better understanding of the antecedent events relating to RTAs than was previously available, but could be conducted within the normal business of a motor manufacturer. Following this, two suitable populations of drivers were identified and a study was undertaken using the RTA data collection procedure to determine the causes of a sample of RTAs. The data collected in this study was then used to develop and operationalise the decision support procedure within the motor manufacturer.

This chapter specifically addresses the development of the RTA data collection procedure. It firstly reiterates the need for a novel data collection procedure, before describing the development, piloting and testing of this procedure. As an illustration of the use of this procedure, the data collected from a study conducted within the motor manufacturer is then described.
3.3 Aims and objectives.

The aim of the RTA data collection study was to collect in-depth RTA data to inform a motor manufacturer of the causes of RTAs. This information was required to enable a methodology to be developed to devise a primary safety strategy for this motor manufacturer. The objectives of this study were therefore:

- To devise a data collection tool to obtain information on the causes of RTAs;
- To find suitable populations of drivers from whom to obtain data;
- To collect data on RTA causation;
- To provide information to enable a methodology to devise primary safety strategy to be developed.

The first two objectives were addressed by the pilot work in which a questionnaire was devised and two populations of recently RTA involved drivers were identified. The subsequent work was concerned with the collection and analysis of data.

3.4 RTA data collection: Pilot study.

3.4.1 Aims of the pilot study.

The aims of the pilot work for study 1 were to determine a methodology for collecting information on the causes of RTAs and to identify a population from which these data could be collected.
3.4.2 Pilot study method.

3.4.2.1 Data collection method.

The factors identified in the Leeds study were employed in the current project as a basis from which to develop a data collection tool. The Leeds study provided a significant advance in the technology of determining the factors impinging on RTA causation. This was due both to the hierarchical nature of the factors, (enabling the resultant data to be similarly ordered) and to the number of factors identified. Potentially, the top level failures may be each caused by many of the lower level errors, either singly or in combination. A hierarchy of factors as described allowed such interactions to be described whereas previously identified factors were listed with no systematic links. The factors identified were used to produce a data collection method in which a structured approach to determining factors impinging on RTA causation was used.

There were several possibilities for the data collection method that could have been employed in the first phase of the study. These include observational methods, interview techniques and questionnaires.

Observational methods can be argued to have the strongest ecological validity of any of the techniques potentially available. Using observational techniques it would therefore be possible to study a great number of variables and their interaction with dependant variables simultaneously, as well as these techniques having the advantage of not being as open to abuse as interview studies potentially may be, (for example due to deliberate biasing by the respondents). There are however, four major problems associated with the use of observational techniques in the current study.

Firstly, the problem of the inferences that an observer can draw from simply observing behaviour needs to be addressed, (Poulton 1975). Whilst the observer may draw conclusions about behaviours on the basis of observation rather than simply observing and recording the behaviours, these techniques suffer from the weakness
Study 1: RTA data collection.

of subjectivity on the part of the observer. As has been noted, the majority of the in-depth studies to date have the potential weakness in the subjectivity on behalf of an albeit experienced RTA investigator or team of investigators. There is some question as to whether someone not at the scene of the RTA would be in a position to accurately assess the factors leading to an RTA.

This itself is linked to the second and third issues, those of validity and reliability. A given behaviour may be coded by two different researchers in two different ways, for example by including an underlying cause of behaviour or not. There is a question in any case involving an assumption of an underlying behaviour as to the validity of the assumption of the behaviour. Similarly, it is essential if such assumptions are to be made by the team that two or more observers agree on the behaviours observed if the results are to have any reliability. For some types of data, statistical procedures exist to assess the reliability of the data obtained, for example by using such tests as Cronbeck's Alpha, or Cohen's Kappa, (Hays 1994, Tabachnick and Fidel 1989).

The final issue associated with the use of observational techniques in the current study is related to the frequency of the events to be studied. In a study of drivers' risk perceptions, it was noted that even the worst RTA blackspot studied had only 8 RTAs in a period of four years, (Watts and Quimby 1980). Additionally, given that the average driver will have an RTA rate of one every ten years, (Evans 1991), it is simply not practical to use a direct observational technique, as the period of the current project is insufficiently long to guarantee sufficient data would be collected by the use of observational methods.

Indirect observational techniques, such as using police or traffic authority videos of RTAs, (which may then be presented to drivers to describe), present three problems. Firstly, due to the nature of the recordings, i.e. having been made and stored by police authorities, these RTAs may be of the sort that the police would want to proceed with prosecutions for. Thus for legal reasons, it may not be possible to obtain additional data pertaining to the cause of the crash from those involved within
Study 1: RTA data collection.

a sufficiently short time period from the RTA. Additionally, it is very doubtful that those involved would be willing to help by giving an unbiased assessment of the events leading to an RTA if they were to have been approached through this manner. Finally, the sample that could be obtained through this process would be fairly small, spread potentially nationally, and would be highly biased towards RTAs occurring on major roads such as motor ways and urban dual carriageways.

A second method of obtaining data from those involved in RTAs is to utilise interview techniques. Essentially there are four types of interview, unstructured qualitative interviews, semi-structured qualitative interviews, standardised open interviews and interviewer administered open questionnaires or check lists. Each of these will now be briefly discussed in turn.

Unstructured qualitative interviews are the method of choice when developing hypotheses and may be performed either as individual in-depth interviews or as group interviews/group discussions. The advantages of unstructured interviews are that they may be used in a very flexible manner to obtain data that are rich in detail and reflect the respondent's individual perspectives and perceptions. Unstructured group interviews may help decrease the power relationship that may occur between an interviewer and interviewee, and may facilitate full expression of true opinions due to group support. Additionally, group interviews of this sort are cheaper and quicker to obtain large sample size than individual interviews. However, both individual and group unstructured interviews require data to be collected in an unstructured manner and as such the data may reflect very diverse aspects of the topic in question. As such, the collation and analysis of the data can be extremely difficult and time consuming which would thus put heavy time constraints on data collection and hence necessitate a reduction in sample size obtained.

Semi-structured qualitative interviews are similar in essence to unstructured interviews but they are expanded to ensure particular topics are addressed by all respondents. Additionally, the benefits of informal, individual orientations being deduced are retained, whilst ensuring more consistent data sets are obtained.
Study 1: RTA data collection.

However, imposition of a researcher's conceptual framework may distort a respondent's perspective and miss aspects of importance to the target population. Sequencing and flexibility of wording questions may effectively result in different questions being asked of different respondents with adverse implications for response comparability. Additionally, although by comparison with unstructured interviews semi-structured interviews are quicker to administer and analyse they are still time consuming compared to alternative methodologies.

Standardised open interviews involve the use of a formal interview schedule in which all required topics are introduced to each respondent in a structured form and sequence, thus facilitating data organisation, comparability and analysis and reducing interviewer effects. However, imposition of such a rigid format may omit areas of importance to the target population. Additionally, a lack of flexibility in wording and sequencing reduces the ability to adapt an interview to particular individuals and circumstances. Nevertheless an open interview of this type does allow the respondents to reply in an open ended manner, the respondents are thus able to determine the length and orientation of their replies. This suffers the disadvantage however that analysis of open answers is time consuming, and may still be open to interviewer effects.

The final interview technique that may be applicable in the current project is an interviewer administered open questionnaire or check list. This technique allows collection of standardised quantitative data in response to standardised, pre-determined questions. All questions are therefore accompanied by pre-determined answer sets, and interviewers ask the questions as it appears on the interview schedule. This is thus less time consuming than other techniques and thus is most commonly employed where large sample sizes are required and a probability sampling technique is used. This technique allows responses to be aggregated and directly compared and greatly reduces interviewer effects and recording biases. There is the potential danger with this technique that as the respondents must adapt their perspectives and perceptions to fit into those of the response categories which although will have been tested and piloted, may seem irrelevant to an individual
Study 1: RTA data collection.

respondent. Restriction of responses may thus mean that the data obtained may not reflect the respondent's true feelings and intentions, and the technique may seem impersonal and mechanistic which may limit response willingness.

An alternative method of obtaining the required data for the first phase of the project is to utilise a self completion questionnaire design. Self completion questionnaires in general require a tight definition of the research problem and are thus designed to address a specific research problem. The information required from a questionnaire is normally of a known form beforehand in that the questionnaire will have been designed, usually from a set of pilot studies in which the participants from the prospective sample will have been interviewed as an aid to design the questionnaire. Thus before the questionnaire is administered, it will be possible to design the analysis from a set of tables detailing the nature of the expected information.

Several considerations must be born in mind when designing a questionnaire, (as outlined by Sinclair 1975, Brigham 1975, Wright and Barnard 1975). The overall plan of the questionnaire should be logical and flow from one section to the next, and the items within each section must be similarly ordered. It is necessary to avoid an overly complex questionnaire design, such as those in which questions are so ordered that necessitates referral from one question to previous questions or conditioning of later responses by earlier ones. The phrasing of questions is also a crucial concern, the questions must be appropriate to the target population and unambiguous. There are certain types of questionnaire phrasing which should be avoided, namely ones that are vague, negative questions, (especially double negatives), in addition to leading questions and those that are loaded. Consideration must be given to the nature of the answers that the respondents are to give, either open or pre-coded. Additionally, instructions to the respondents must be clear, for example filter techniques are generally preferable to wordy instructions on each question. The questionnaire should additionally be kept as short as is practicable to attempt to maintain response rates as high as possible, thus for example, the 'for interest' type questions should be avoided. In terms of the nature of the data to be collected, in general, it is better to collect the highest form of data, (i.e. continuous)
Study 1: RTA data collection.

as these data may subsequently be collapsed into categories, but not vice versa. Finally, there must be a differentiation between the different types of missing data, i.e. true missing data and data that are missing due to the inappropriateness of a question. This will facilitate coding of the data onto the pre designed coding sheets and will therefore allow the analysis to be more readily performed.

The methodology chosen for the RTAs data collection was a self completion postal questionnaire, distributed to a sample of drivers drawn from a population who had recently been involved in an RTA whilst driving. Rather than a single mailshot of drivers, an ongoing process to collect data over an extended time period was used. Data collection throughout an extended period thus enabled a wider range of RTA causation mechanisms, to be collected, (for example weather conditions prevailing at the time of the RTA). This method ensured that the questionnaire would be as effective as possible with respect to determining the underlying reasons for car RTAs. A large sample of drivers who had recently been involved in an RTA was required to ensure the data gathered was representative, but was in addition on going in nature. In effect, a notification system was required that facilitated identification of recently occurring RTAs.

3.4.2.2 Questionnaire development.

To develop the questionnaire, a literature review of previous studies concerned with RTA data collection and RTA causation was performed. From this, a number of factors of importance in RTA causation were listed and structured using the hierarchy devised by Carsten et al (1989). An iterative development process was then undertaken to produce and refine a postal questionnaire. This entailed progressing from unstructured interviews, to semi-structured interviews, to a questionnaire being administered to a sample of recently RTA involved drivers. Whilst questionnaires are normally developed in this manner, (e.g. Sinclair 1975), a somewhat more lengthy procedure than is usual was required necessitating a gradual move from an interview format to a questionnaire completed by the driver in the presence of the experimenter. There were three reasons for this. Firstly, the number of antecedent factors are such that the situations prior to RTAs are both complex and
Study 1: RTA data collection.

varied. A significant amount of questionnaire development work was therefore required at the piloting phase to ensure that the questionnaire could be easily completed by drivers involved in a very wide variety of RTAs with a wide variety of causative factors.

Secondly, the sensitivity of the topic required that the questionnaire underwent extensive work prior to distribution. All drivers were required to describe not only the situation immediately prior to the RTA but in addition any mistakes they themselves made as well as anything they may have been able to do to try to avoid the RTA.

Thirdly, whilst apportioning blame to the drivers was not an issue, pains were taken both in the questionnaire and the covering letters to ensure that the drivers did not feel that the data they provided was going to be categorised in this manner. However, in order for the results to be representative, data were required from both drivers who were in actuality at fault for the RTA, (by for example failing to give way at an intersection), as well as those who were not at fault, (for example a driver whose car was hit by another failing to give way). This was necessitated by the nature of the required results in terms of strategic decision making with regards to potential RTA countermeasures. Traditional approaches to investigating the potential of accident prevention measures to reduce the number of RTAs have concentrated on providing information or assistance to the driver that may be considered to be at fault in the RTA. In the above example, the driver failing to give way at an intersection may be assisted by having warning of the intersection presented in the vehicle, or the automatic application of brakes may prevent the driver from proceeding. In either case however, those travelling on the road with right of way would not be provided for by current technology. If the vehicle approaching the intersection from a minor road was not equipped with any accident prevention technologies, an RTA may still occur. If those on the main road however are provided for appropriately, it may be possible for an RTA to be prevented. In order to provide appropriate accident prevention technologies to these drivers, the reasons for the RTA from their perspective must be deduced.
Study 1: RTA data collection.

Thus, those drivers that were at fault had to be encouraged to describe the RTA in which they were involved in a non threatening manner. Additionally, those drivers that were not at fault were required to describe the RTA in as best a manner as they could.

Throughout the course of this initial work, the participants completed the questionnaire and gave feedback including wording and the order of questions.

3.4.2.3 Participants.

Participants were obtained from three different populations during questionnaire development and the postal pilot.

The participants in the pilot were all aged 17 or over, who had been involved in RTAs as drivers whilst they had a full driving licence.

Loughborough Campus Pilot: The population from which drivers were obtained for the original questionnaire development pilot work comprised staff and students from Loughborough University. Initially, a sample of 12 drivers were interviewed to refine the list of factors impinging on the causation of RTAs. The questionnaire was then drawn up and an additional 12 drivers from this population were subsequently contacted to refine the questionnaire. Finally, this population was extended to include an additional 24 undergraduate students for the final campus based piloting once the questionnaire was complete.

Since the questionnaire was aimed to be distributed to recently RTA involved drivers, initially only those who had an RTA in the previous 3 months were contacted. However, it soon became obvious that a sufficiently large sample to adequately pilot the questionnaire could not be obtained by using such a population. The population was therefore extended to include those drivers who had been involved in an RTA more than 3 months ago. Ultimately, the population from which the drivers were taken for this phase of the pilot was extended to include those that had an RTA as a driver within the previous 18 months.
Postal Pilot: The participants for the postal pilot study were drawn from two different populations; notification of recent RTA involved drivers was an on going process for each of these. One of these populations was of drivers drawn from the insurance group of a major motor manufacturer. The insurance group handles the motor insurance for all vehicles owned by the company and leased to company employees. In practice, the majority of these employees are managers at the company, though it is not infrequent that two or more cars will be leased from the company for use by other members of the employee’s family. 300 drivers were selected for questionnaire distribution from this population.

The population drawn from police records was identified through the Co-operative Crash Injury Study, (CCIS), undertaken by ICE ergonomics Ltd., in Loughborough. CCIS was set up in 1983 as an on going, in-depth study to investigate vehicle crash performance and the resulting occupant injuries in the UK. As such, CCIS requires up to date notifications of the occurrence of car RTAs, and accordingly, ICE receive notifications from Leicestershire, Nottinghamshire and Derbyshire constabularies of all police reported RTAs in their jurisdictions. (The data collection protocols are more fully described by Mackay, Ashton, Galer and Thomas 1985). Over a period of three weeks, each of these was obtained and reviewed for possible inclusion in the current study. Names and addresses of 300 drivers were selected for questionnaire distribution.

3.4.2.4 Sampling frame.

The basis for sampling was:

- Only the drivers involved in an RTA were included, (passengers and witnesses were excluded).

- RTAs resulting in a fatality, serious head injury, or serious injury to either the elderly or young were not included due to the sensitive nature of the RTA.

- RTAs with pending prosecutions were not included.
Several additional factors required consideration when drawing the samples.

Insurance Group RTAs: Accessing data through the insurance group offered several advantages. Firstly, due to the requirements of the insurance group themselves, the RTA claim forms that were received by the insurance group from the drivers were readily classified into a number of categories dependent upon the nature of the RTA. Thus, distinctions such as the nature of the objects that the driver was in collision with, (if any), could be determined. Within the insurance group, each of the possible RTA configurations is allocated a unique number. All RTAs conforming to the three caveats above and within the specified RTA categories of interest were selected for inclusion in the study.

CCIS RTAs: Names and addresses from the CCIS notification scheme could only be obtained retrospectively. All drivers contacted for this study were therefore required to have previously agreed to take part in the study by returning an initial contact letter signed to indicate their willingness to take part in the study. This procedure ensured that the Data Protection Act (1984) was not contravened.

However, only RTAs that were not required for CCIS itself could be included. This was to protect CCIS from any potentially adverse effects of the RTA causation study. For example, drivers may have been reluctant to complete a questionnaire concerned with the nature and extent of their injuries if they had previously been asked to fill out a questionnaire detailing the causes of the RTA.

3.4.2.5 Equipment.

RTA causation questionnaire: The questionnaire used in the postal pilot comprised 7 sections covering 342 variables over 20 pages. Initially, the drivers were asked to draw a diagram of the RTA scene and describe the RTA in their own words, this section being designed to ease the drivers into describing the RTA in as non-threatening a manner as possible. Following this, questions were asked about the situation in which the RTA took place, including the nature of the road layout and the weather conditions at the time of the RTA. It was then explained that RTAs in cars are often caused by errors or misjudgements on the part of any or all of those
Study 1: RTA data collection.

concerned and the drivers were asked specifically about which of those errors
described may have had an influence on the causation of the crash. Additionally, any
vehicle failures that may have led to the crash were asked about. Finally,
demographic information was requested.

The questionnaire by necessity was long and complex, but simple to complete as the
majority of the questions were of a check box type, (see Figure 3.1). (The final
questionnaire is presented in Appendix 2).

2.1. What Sort Of Area You Were In?

☐ City Centre Shopping  ☐ Suburban Industrial/Business Park
☐ City Centre Residential  ☐ Village/Town Shopping
☐ City Centre Industrial/Business Park  ☐ Village/Town Residential
☐ Suburban Shopping  ☐ Village/Town Industrial/Business Park
☐ Suburban Residential  ☐ Open Countryside
☐ Other (Please Describe) ...........................................
...........................................................................
...........................................................................

Figure 3.1 Extract from the RTA causation questionnaire.

Covering Letters: In addition to the questionnaires, the purpose and scope of the
study was described to each driver in a covering letter. This letter also assured the
respondents of the confidentiality of the data they provided. The covering letters
were personally addressed in the case of the sample chosen from the CCIS
population, whereas in the case of the questionnaires distributed to the sample from
the motor company's insurance group, the covering letters were addressed 'Dear
Driver'. (The covering letters are presented in Appendix 3).

Insurance Group Population: Since the insurance group themselves distributed the
questionnaires, the distribution procedure for this population was comparatively
simple. Once the desired sample within the population had been identified, a list of
RTA categories of interest was drawn up. The insurance group themselves
Study 1: RTA data collection.

RTA categories of interest was drawn up. The insurance group themselves distributed the questionnaires with their own acknowledgement slip notifying the driver that their claim was being processed. The questionnaires were returned to Loughborough via pre-paid envelopes and collated for analysis.

As no records of to whom the questionnaires were sent were made at the time of questionnaire distribution, it was not possible to distribute follow up questionnaires to the sample drawn from this population.

CCIS Population: The CCIS population was sampled over a three week period commencing June 1996. The procedure for sampling the CCIS population was as follows:

- Notifications were received by ICE and reviewed for inclusion in CCIS.
- Notifications not required by CCIS were reviewed for inclusion in the current study. Those notifications pertaining to RTAs that were to be specifically excluded from the RTA causation study were removed.
- Initial contact letters were sent to those from the cut down sample requesting the drivers assistance in the RTA causation study. 300 contact letters were distributed.
- Questionnaires were posted, together with covering letters to those responding positively to the initial contact letter. The returned questionnaires were collated for analysis.

To attempt to increase the overall response rates, follow-up letters were written. These were to be sent to the whole CCIS sample two weeks after the initial questionnaire was distributed. Since the questionnaire was distributed anonymously it was impossible to determine if any given person in the sample had previously returned the questionnaire and thus the follow-ups were planned to be sent to the entire sample. Instructions to ignore the second mailing were included however, and some checks within the dataset to ensure that multiple responses were not received.
were designed. Following this, the names and addresses of those that were contacted were deleted from computer files and all paper records destroyed.

3.4.2.6 Data management and analysis.

Due to the size of the questionnaire and the number of variables within it, 6 Excel spreadsheets were required to enter the data for analysis. A macro was written to combine these spreadsheets into a single text file which was then exported to SPSS running under UNIX on a Hewlett Packard 9000/827 mainframe. Inevitably, given the size of the database, missing values were encountered, techniques to rectify some of which were applied accordingly to the data, (Frampton 1997, SPSS 1990). The data were thus checked for missing values and error trapped for data punching errors using SPSS.

3.4.3 Results of the pilot study.

3.4.3.1 Data sources.

Insurance Group RTAs: Problems existed in the distribution procedures that the insurance group used. This was readily evidenced by the number of questionnaires returned by drivers that were not specified in the required sample. Specifically, almost 20% of the returns received from the insurance group sample were from drivers that were not personally involved in an incident in which damage occurred to their vehicle. Principally, these were drivers who were making insurance claims due to either vandalism of their vehicle, or due to damage sustained in a car park when the vehicle was unattended. (These returns were not counted in the return rates presented).

The population as a whole, did result in a 25% response rate, 75 out of 300 questionnaires were returned completed sufficiently well for analysis. It was apparent that several modifications were required to the sampling frame and the manner in which the questionnaires were distributed, but it was decided at this stage that this population could be used with a modified questionnaire and distribution procedures for the main survey.
Study 1: RTA data collection.

CCIS RTAs: The response rate for the CCIS sample was poor. Of the 300 initial contact letters distributed, only 42 were returned to Loughborough indicating willingness to take part in the study. Of these, only 11 returned questionnaires were received. It was decided that this population would no longer be used in the remainder of the study. Additionally, since the response was so poor, follow up letters and questionnaires were not distributed to those that had returned the initial letter.

3.4.3.2 Data collection tool.

The major finding of the postal pilot work was that the postal pilot method and the questionnaire devised were acceptable as a method to collect data regarding the causes of RTAs. Overall, of the 342 questionnaires distributed, 86 were returned in a sufficiently complete form to be analysed, representing an overall response rate between the populations sampled of 25.1%. From an assessment of the quality of the questionnaires returned, it was apparent that the majority were completed correctly, few for example contained missed pages or inappropriately missed questions. Additionally, it was apparent that the majority of the questionnaires were completed in a meaningful manner, that is that the data provided were sufficient to gain a reasonable understanding of the RTAs in question.

3.4.3.3 Findings from the postal pilot survey.

Due to the relative numbers of questionnaires returned compared to the number of variables contained within the questionnaire, a full analysis of the results could not be meaningfully performed at this time. However, an outline of the preliminary findings is presented below.

3.4.3.4 Demographics of the sample.

- The returned sample did not have an even demographic split 70.9% being male with an average age of 41, (SD = 11.75, ranges from 17 to 63). Whilst the majority of the sample were married, (71.8%), slightly more than half, (52.3%) had no children under 18.
Study 1: RTA data collection.

- The largest represented group were those with a degree or higher degree, (23.3%), the most common job being engineering or management, (accounting for 28% of the returned sample).

- 22.1% of the sample held a motorcycle licence in addition to a licence for driving a car, this car licence being held for an average of 19 years, (SD=10.5 years). There was a large range of time since passing the driving test from only just passing the test, (1 month), to having passed the test up to 40 years ago, (as would be expected most drivers passing their test around the age of 17 or 18).

- Nearly 40% of the sample drove over 15,000 miles per year, this figure rising to 63% when including those drivers that drive between 10,000 and 15,000 miles per year.

- The majority of the sample, (60.7%), reported they have been involved in no major RTAs before as a driver, (a major RTA being one in which the costs were in excess of £500). This figure dropped for minor RTAs to 34.1%. The range of time from the previous RTA was between 1 month and 30 years, the average length of time being 7 years (SD=6.3).

- The overwhelming majority of the drivers who had previously been involved in an RTA had been involved in only one or two previous RTAs indicating that although the drivers have crashed more frequently than may be expected, they were not in general frequently involved in crashes. However, of those contacted in the pilot work, one driver stated involvement in 7 major RTAs as a driver.

- The biased nature of company car drivers sample was also reflected in the range of values obtained for the distance driven by the driver in the particular car involved in the crash. These values ranged from 120 miles to over 95000 miles, (this latter figure representing a privately owned vehicle), with a mean value of 9600 miles, (SD = 13100).
**3.4.3.5 RTA scenarios.**

- The largest group of RTAs occurred in suburban residential areas, (30.2%) and accordingly the average speed limit of the crash scenarios were between 30 and 40 mph (61% of the sample of RTAs occurred in either 30 or 40 mph zones).

- In total 61.2% of the sample were involved in an incident at or within 20 m of a junction, (the values for each of these being 30.6%), the majority of which were uncontrolled junctions, (i.e., one at which no traffic controls were present).

- Of these junction related crashes, the majority were at T junctions, (40.7%), the next most represented junction scenarios being Y junctions, (slip roads), and roundabouts, (both occurring 16.7% of the time). The majority of drivers, (59.2%), were on the main road at the junction and were therefore not instructed to stop.

- Most of the RTAs occurred on straight, flat roads and accordingly, the majority of the sample (69%) stated that the visibility along the road prior to the RTA scenario was not restricted. However, 26.7% suggested that a partial restriction in visibility may have contributed to the RTA and 3.6% stated that a severe restriction in visibility contributed to the cause of the RTA. These restrictions were most commonly due to environmental factors, (such as the weather or vegetation at the side of the road), but other vehicles were also frequently cited as a cause of restricted visibility.

- 77.9% of the RTAs sampled involved only another car, of these the largest group were those that were involved in a front/rear collision, (35.7%).

- The majority of the sample saw what they were in collision with before the impact, (56.1%). However, 53.4% of these drivers did not expect the impact to occur, these being equally split between those that thought they would be able to avoid the impact and those that thought the other driver would be able to avoid the impact.
Study 1: RTA data collection.

- 84.9% of the vehicles involved were manufactured by the company whose insurance group assisted in the questionnaire distribution. Overall, 56.0% were company cars, (leased through the motor manufacturer), whereas 20% were the driver's own vehicle. Some confusion may have existed however as to whether the drivers viewed company cars as their own or the companies. Irrespective of this, 81.2% drove the vehicle in which they had the RTA every day.

- Nearly 85% of the vehicles involved in the RTAs were less than 2 years old, 61.6% being between one and two years, and 23.3% up to a year since first registered. As may be expected from a sample of comparatively new vehicles, 20% had anti-lock braking systems (ABS), fitted.

- Most of the RTAs occurred within 4 miles of the expected destination, although the journeys to that point took on average less than half the time the driver expected them to take. The standard deviations of both the expected and actual estimates of time and distance were large, (respectively 110 minutes and 50 minutes for time and 80 miles and 110 miles for distance). This is unsurprising when considering that the actual lengths of journey planned ranged from 1 mile to over 700 miles.

3.4.3.6 Causative factors.

With respect to the causes of the RTAs, the drivers were asked to make an assessment of any mistakes they themselves made and of their impressions of any mistakes that the other road user involved in the RTA may have made, (if applicable). For simplicity, in the following discussion, 'our driver' will refer to the driver that received and completed the questionnaire and 'other driver' will refer to the most directly involved other road user, (if any).

- 26.0% of the RTAs were single vehicle RTAs in which our driver was the lone RTA participant. It was immediately apparent from an inspection of the returned questionnaires that the overwhelming majority of these RTAs involved parking manoeuvres, principally in car parks. (Whilst the SPSS analysis at this stage was not designed to analyse these RTAs, it was subsequently modified accordingly.)
Study 1: RTA data collection.

However, parking area RTAs per se were beyond the scope of the RTA causation project, and accordingly are not discussed further in specific).

- On average, when considering multi-vehicle RTAs, for any specific error type more of the other drivers involved than our drivers were attributed to have made the error. Whilst our drivers were not specifically asked who was to blame for the RTA, few volunteered that the other driver was solely responsible. Of note however, is that the errors attributed to be causal with respect to the RTA involved were not solely attributed to the other drivers. In effect, approximately 25% of our drivers admitted that there was something they themselves may have been able to do to prevent the RTA from occurring.

- 61.6% of the RTAs occurred in daylight and 76.5% occurred when there was no precipitation that may have affected the cause.

- In 25.4% of the RTAs the road surface had an effect on the cause of the crash. This is a higher figure than may be expected from inspection of the STATS 19 database and reflects that the data collection was mostly carried out over the winter months.

- The most common error made prior to the RTA was a failure to judge the speed of the other vehicles when present. 24.4% of RTAs had some failure of our driver to judge the other vehicle speed and 18.3% of RTAs were caused in part by failing to judge another vehicle’s distance.

In summary, the most common RTA scenario in the pilot sample were middle aged males, driving in daylight in good conditions. Whilst a larger proportion of drivers attributed the RTA to the other road users involved, than to themselves, significant numbers admitted at least partial culpability on their part.
3.4.4 Discussion of the pilot study.

The pilot work had two objectives;

- To devise a data collection tool to obtain information on the causes of RTAs,
- To find suitable populations of drivers from whom to obtain data.

Each of these will be addressed in turn.

3.4.4.1 Data collection tool.

There were only two viable options for the data collection tool to be employed, face to face contact with the drivers involved, (either through interviews or interviewer administered questionnaires), or postal questionnaires. Face to face interviews had the advantage of being able to probe in considerable detail the exact circumstances surrounding an RTA in a manner difficult to achieve in a questionnaire. However, interviews are costly in terms of time to administer and analyse. Additionally, interviews are not anonymous, and given the sensitivity of the subject under investigation, this was a significant drawback.

A postal questionnaire can be assured to be anonymous once distributed and thus does not suffer from the disadvantages of the interviewee feeling social pressure to answer in a socially desirable manner due to the presence of the interviewer. Whilst the need to respond in a socially acceptable manner will not be completely eliminated by using a postal questionnaire, it was hoped that this effect would be very much reduced.

Additionally, postal questionnaires may be sent to a specified sample and confidentiality maybe ensured as a given respondent will not be identifiable from the data recorded if sufficient precautions are taken. Whilst assurances of anonymity and confidentiality could equally be given for interviews, the necessity for face to face contact may have made some potential interviewees uncomfortable and thus the sample may be compromised further.
For these reasons, a questionnaire format was decided upon for the RTA data collection tool.

The questionnaire developed was demonstrated to be effective in eliciting information pertaining to the causes of RTAs. In addition to describing the physical and roadway environment surrounding the vehicle at the time of the RTA, the drivers were able to describe some of the errors made, and the reasons for those errors which contributed to the cause of the RTA. In the case of an RTA where our drivers admitted for example that they had difficulty in controlling their vehicle and skidded, countermeasures such as enhanced road holding may be deduced.

When our driver states no possible error on their part, (most typically blaming the other drivers involved totally), at first thought, it may seem that comparatively few countermeasures may be deduced. For example, in the case of our driver colliding with another failing to stop at a junction, it may seem that no countermeasures may be deduced and accordingly that these drivers should not be contacted. However, by the provision of appropriate information or assistance to our driver, irrespective of the actions of the other driver, it may be possible to either prevent the RTA from occurring, or reduce its severity such that injuries are limited. This may occur through a warning being presented to our driver, or an automatic manoeuvre by our vehicle to avoid the other vehicle. Thus, the reasons underlying RTAs of this nature are as valid for the purposes of determining appropriate countermeasures as for RTAs in which our driver played a more active part, and accordingly our drivers were contacted for the purposes of this study.

3.4.4.2 Sampling.

The samples although initially obtained with the assistance of external agencies were approached in a manner that demonstrated the study was independent of these agencies. It was anticipated that this would enhance response rates over alternative samples obtained directly through the police or an insurance agency wherein respondents may perceive that fault or blame may be attributed to them as a result of their responses and subsequently reported back to an external agency. Whilst
alternative populations were considered, they were not considered to be appropriate for the current study and the postal pilot work was conducted with populations drawn from CCIS and the insurance group of a motor manufacturer. The sample returned from CCIS proved to be insufficient in size to be viable for the main study, and was discontinued with. The poor response rate relative to the alternative population employed may reflect that members of this population were generally unwilling to discuss the nature of the causes of the RTAs they were recently involved in. Additionally, the procedures of having to indicate their willingness to participate before being sent the questionnaire may have put some drivers off.

There were several reasons for using the populations described. Most importantly, the populations allowed contact with those who have recently been involved in an RTA. Alternative samples were considered, for example databases of drivers, such as the ones maintained by the AA or by the Transport Research Laboratory. However, whilst these databases are large, (the TRL one containing 18000 individuals), it was likely that an insufficiently large number of drivers who had recently been involved in an RTA as a driver would be accessible through these populations. In addition, the alternative databases were not specifically designed for an RTA investigation study and accordingly were not sufficiently up to date with respect to the RTA history of the drivers within the population. Whilst the majority of the drivers within these databases could be expected to have been involved in an RTA in the course of their driving careers, it was not possible to selectively sample these drivers from these databases.

That the insurance group sample provided a relatively good response rate, (given the nature of the study and the size of the questionnaire), may be indicative of the nature of the population itself. Being largely drawn from the employees of a motor manufacturer, these drivers may by their nature have more interest in motoring issues and thus in the study at hand and therefore be more willing to participate. Alternatively, as the sample was devised from the insurance group’s procedures, these drivers may have felt more compelled to complete the questionnaire than they would have done had they been contacted in another manner. If this were to be the
Study 1: RTA data collection.

case, it may seem surprising that up to 25% admitted some culpability for the RTAs in question.

It was felt therefore that the main phase of the RTA data collection could be conducted using the notification scheme devised from the insurance group. Whilst a biased sample resulted from this population, (in terms of demographic split of the respondents and therefore to some extent of RTA causation mechanisms), this population was felt to be acceptable for the main phase of RTA data collection.

3.4.5 Conclusions of the pilot study.

• Despite extensive piloting, some problems still existed with the questionnaire itself, and with the populations employed in the pilot work.

• Sufficient knowledge was gained throughout the course of the piloting to enable a larger scale study to be conducted to elicit more data.

• Modifications were made to both the questionnaire and the procedures in which the insurance group population was sampled to enable the main study to be conducted.

3.5 RTA data collection: Main study.

Following on from the pilot work, in the main phase of the data collection a study was conducted utilising the data collection method and population piloted. The aim of this study was to collect in depth data on the causes of RTAs which would then be built upon when devising the primary safety strategy. Sufficient data were therefore required to develop and test the decision support tool devised, (described in Chapter 4), in order to draw preliminary conclusions pertaining to the most effective technical solutions to RTAs.


**3.5.1 Aim.**

The aim of the main data collection phase was to obtain sufficient data about RTAs to develop a decision support system to help a motor manufacturer make strategic decisions with respect to technological solutions.

**3.5.2 Method.**

3.5.2.1 Experimental design.

The methodology chosen was a self completion postal questionnaire distributed to a sample of recently RTA involved drivers. The returned questionnaires were anonymous once completed and data were entered into a series of spreadsheets before being combined into a single SPSS data file for analysis.

3.5.2.2 Participants.

The participants were drawn from the insurance group of the motor manufacturer as before.

3.5.2.3 Sampling.

The sampling frame remained the same as for the pilot study, however larger numbers than was achieved in the piloting were required. 3000 questionnaires were therefore printed and delivered to the premises of the Insurance Group for distribution over a period of approximately one year. Given the return rate estimated from the pilot study, it was anticipated that approximately 1000 completed questionnaires would be returned. Problems with the distribution became evident during the course of the analysis of the pilot sample which resulted in only 1000 questionnaires being distributed.

3.5.2.4 Equipment.

The questionnaire contained 124 questions covering a total of 342 variables, (many of the questions covering several variables simultaneously), divided into 6 sections.
Study 1: RTA data collection.

(In the light of experienced gained in piloting, two sections were combined from the pilot questionnaire thus reducing the size of the questionnaire at this stage). The questionnaire was a self completion format, the majority of the questions being simple check boxes with some space for additional comments if required.

3.5.2.5 Procedure.

Questionnaires were delivered to the offices of the insurance group packed into their distribution envelopes with the return envelopes and covering letters.

The same sampling frame was employed in the main data collection phase as was used in the piloting work. It was emphasised that care was to be taken to ensure that the questionnaire was only distributed to those drivers of interest to the RTA causation project. The distribution procedure was the same as for the pilot study.

3.5.2.6 Data management and analysis.

5 Excel spreadsheets were used to enter the data for analysis and the data exported to SPSS running under Windows 95 on a Pentium PC rather than the previous mainframe. The data were error trapped and analysed using SPSS in this manner. In practice, data were entered in batches of 20 questionnaires at a time and each group error trapped individually.

The data files and analysis programs written to analyse the pilot data were preserved for future use. However, a copy of the data file produced in the piloting was modified to match the new format required by the final questionnaire. The data from the main phase of the questionnaire distribution was therefore appended to this modified data file and all analyses carried out on the full data set.

The data contained a mixture of categorical and interval variables, the analysis methodologies for both being well documented, (Hays 1988, Tabachnick and Fidel 1989, SPSS 1993). The analysis employed predominantly descriptive statistics to classify the data according to the frequency of occurrence of certain events in the data set. In addition, some inferential statistics, (correlations and cross tabulations) were performed as necessary.
Study 1: RTA data collection.

3.5.3 Results.

3.5.3.1 Method.

Overall, the main questionnaire distribution resulted in 241 returns out of the 1000 distributed, representing a return rate of 24.1%. Of these however, 30 were excluded from the analysis due to inappropriate sampling, (the vehicles in question most commonly having been hit whilst unattended), resulting in a valid return rate of 21.1%. When appended to the pilot study data, the final database contained data on 297 cases. As can be seen from Figure 3.2, overall, the main phase of the questionnaire distribution, (IG Main) accounted for 71% of the returns.

![Figure 3.2 Returned questionnaires by sample percentage.](image)

The results of the main questionnaire distribution work were appended to the pilot data for analysis and accordingly the following represent a composite of both samples.
3.5.3.2 Demographics of the total sample.

Nature of the drivers involved: The majority of the returned questionnaires were from males, (73.6%) with an average age of 41.6 years, (range 17 to 82 years, SD=12.3 years). The majority of the sample were British born, (96.7%), and married, (70.0%), though the largest group had no children under 18, (58.6%). As would be expected of a sample drawn through the insurance group of a motor manufacturer, the majority of the sample were in full-time employment, (81.4%), the largest group being employed as engineers or managers, (30.3%). The two largest groups of respondents who were not in engineering or management, were car assembly workers, (6.5%), or nurses (3.4%). In general, the education levels of those responding were high, 30.1% having a degree or higher.

4.8% of the sample (14 drivers) regarded themselves as professional drivers, (driving more than 4 hours a day as part of their job), these drivers mostly being employed by the motor manufacturer as test drivers. 5 drivers, (1.7%) had not passed their driving test at the time of the RTA, the remainder having held a driving license for an average of 20.3 years, (SD = 11.6 years). Of those with licenses, these had been held for between 1 month and 65 years at the time of the RTA, and most drivers therefore passed their test at the age of 17 or 18 although as some drivers passed their driving tests considerably later, the average age of getting a full license was 21.3 years. A little over three quarters of the drivers held only 1 license, (that being for motor cars), although an additional 20% held a motorcycle license in addition. 13.1% of the sample had some form of additional driver training, this mostly being vehicle handling courses organised by their employer.

The drivers were asked about their driving habits, specifically how far they typically drove in a year and how frequently they drove on specific road types. 32% of the sample drove over 15,000 miles per year and an additional 30% drove over 10,000 miles per year, (Figure 3.3). The sample obtained thus comprised a high percentage of drivers with a high annual mileage as may be expected by the nature of the drivers contacted.
Study 1: RTA data collection.

Figure 3.3 Average miles driven per year by percentage of the respondents.

Figure 3.4 describes the percentages of the respondents stating that they drove frequently for each of several classes of road. From this, it can be seen that the most frequently driven on road class was rural roads, 32% of drivers reporting they frequently drove on them. Additionally, 25% of the drivers frequently drove on motorways and 19.4% frequently drove on urban roads. Single carriageway main roads were least frequently driven on, 13.3% reporting their frequent use.
Study 1: RTA data collection.

Drivers were also asked about their RTA records prior to the RTA in question. These RTAs were described either as minor RTAs, (in which the costs were less than £500), or major RTAs, (resulting in costs of over £500). These are presented respectively in Tables 3.1 and 3.2.

Table 3.1 Number of prior minor RTAs driver had been involved in.

<table>
<thead>
<tr>
<th>Number of RTAs</th>
<th>Frequency</th>
<th>Percentage of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>88</td>
<td>30.5</td>
</tr>
<tr>
<td>1</td>
<td>54</td>
<td>18.7</td>
</tr>
<tr>
<td>2</td>
<td>68</td>
<td>23.6</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>15.9</td>
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<td>4</td>
<td>14</td>
<td>4.8</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>3.1</td>
</tr>
<tr>
<td>More than 5</td>
<td>10</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Table 3.2 Number of prior major RTAs driver had been involved in.

<table>
<thead>
<tr>
<th>Number of RTAs</th>
<th>Frequency</th>
<th>Percentage of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>154</td>
<td>52.6</td>
</tr>
<tr>
<td>1</td>
<td>78</td>
<td>26.6</td>
</tr>
<tr>
<td>2</td>
<td>41</td>
<td>14.0</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>3.1</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>1.4</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>More than 5</td>
<td>4</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Two drivers reported having been involved in 10 minor RTAs over the course of their driving career, additionally, one driver reported being involved in 14 major RTAs.

In terms of how long ago these RTAs occurred, just over 20% had an RTA in the previous year, whereas slightly less than half, (49.3%) had an RTA more than 10 years ago. The range of time since the last RTA varied hugely, from 1 month to 65 years, the average being 8.5 years, (SD=11.3 years).

The majority of those replying, (83%), had no penalty points on their driving license, of those with points, most commonly, (12%) they had three points for speeding.

Only 3 of the drivers, (1.01%), stated that they had some disability that may have affected the cause of the RTA, two of these drivers stating a visual disability and one stating a physical disability. Of the 126 drivers who normally wore spectacles when driving only one stated that this was a factor in the RTA.

The distribution was initiated in October, and continued with for 9 months. Accordingly, a significant number of the questionnaires returned related to RTAs occurring in autumn and winter months and a higher than expected proportion of RTAs therefore involved poor weather conditions. Thus, data relating to the
Study 1: RTA data collection.

environmental conditions at the time of the RTA are known to be biased and are not discussed further.

Nature of the vehicles involved: As expected, the majority of the sample drove company cars, (67.7%), these vehicles having been driven for an average of 7500 miles, (SD=12,350 miles). Some confusion may have existed however between those drivers that viewed a company leased vehicle as their own as compared to those who regarded it as a company vehicle however. Irrespective of this, nearly 80%, (79.3%) drove the vehicle which they were involved in an RTA in everyday, although 4.8%, (14 individuals) were driving a new vehicle that they had not previously driven before.

All but 4% of the drivers who responded to this survey were contacted through the insurance group of a motor manufacturer and accordingly 94.2% of the sample drove vehicles manufactured by them. To simplify the analysis, vehicles not manufactured by this company were excluded from the analysis of vehicles and their features. This was justified by the high percentage of vehicles manufactured by this company in the dataset which ensured little data were lost by excluding other vehicles. Inclusion of vehicles from other manufacturers would have complicated the analysis as vehicles from several manufacturers were present in the dataset.

Figure 3.5 is a breakdown of the nature of the vehicles included in the sample.
As can be seen from Figure 3.5, 43% of the vehicles involved were lower medium sized vehicles, (equivalent in size to a Ford Escort or Vauxhall Cavalier). Only 16% of the vehicles involved could be classed as large vehicles, (i.e. ones that could seat 5 adults or more comfortably), whereas 41% were classed as small cars. Additionally, 59% of the vehicles were described by their drivers as being hatchbacks and 35% as saloons. (Although for reasons of commercial confidentiality, data relating to the proportions of these classes of cars in the vehicle fleet as a whole cannot be presented, these are in agreement with the figures presented above in Figure 3.5)

With respect to the registration year of the vehicles involved, 12.5% were less than a year old at the time of the RTA, 49.5% were between a year and two years old and 36.5% were up to three years old. Only 1.5% (4 vehicles) were older than three years at the time of the RTA.
Study 1: RTA data collection.

There was not an even split in terms of the colours of the vehicles involved in the RTAs as Figure 3.6 shows. 20% of the sample had RTAs in red cars, the next largest proportions being those involved in RTAs in dark blue cars, or light blue cars, (13.0% and 10.9% respectively).

![Figure 3.6 Analysis of the colours of the RTA involved vehicles by percentage of returned sample.](image)

As could be expected from a sample of predominantly new vehicles, features such as power steering and Anti-lock braking systems were not uncommon, (respectively being present in 72.7% and 32.8% of the vehicles in the returned sample). However, these figures too must be treated with caution given the problems identified above.

7 drivers reported vehicle failures led directly to the RTA occurring, 2 of which stated that blown tyres and 1 stating total light failure was solely responsible for the RTA. The remaining four drivers reported multiple failures including delayed braking, (1), pull to one side when applying the brakes, (2); loss of effectiveness of the brakes, (3); and play in the steering column, (1).
2 drivers stated that a load in their vehicle affected their ability to drive the vehicle or altered the vehicle’s performance and thereby affected the cause of the RTA.

3.5.3.3 RTA Scenarios.

From Figure 3.7 it can be seen that the largest group of RTAs occurred in residential areas, with the next largest proportion occurring in open countryside. Accordingly, from Figure 3.8 a large proportion of the RTAs occurred on single carriageway A roads and B roads as would be expected of largely residential areas. The majority of the roads classified as other in Figure 3.8 were parking areas.

![Figure 3.7 Situations in which the RTAs occurred by percentage of the respondents.]

Figure 3.7 Situations in which the RTAs occurred by percentage of the respondents.
In terms of the proximity to junctions two thirds of the RTAs occurred either at, or within 100m of a junction, (respectively 40% of the sample and 27% of the sample), the most represented junctions being T junctions, (35.18% of junction related RTAs). The next largest group were roundabouts, (21.11% of junction related RTAs), (Figure 3.9).
Figure 3.13 shows the directions that the drivers were heading at junctions when the RTA occurred. Interestingly, 52% of the drivers were heading straight on the road they were currently on rather than turning. Of those that were turning, fewer were crossing a line of traffic than those that were merging with a line of traffic, (i.e. 19% were turning right compared to 22% turning left).

A similar pattern was seen when considering the priority of the roadway on which the drivers were travelling at the time of the RTA, half of the drivers were heading straight on at this junction. Of the remaining drivers, 43% were either expected to stop or specifically instructed to stop at this junction, (Figure 3.11).
Figure 3.11 Roadway priority at junction by percentage of junction RTAs.

Figure 3.12 shows the nature of the traffic controls if any, present at each junction. Of the 194 junction involved RTAs, 124 junction controls were mentioned. Of these, only 14 had two or more controls mentioned, the majority, (109) had only one mentioned.
Study 1: RTA data collection.

Figure 3.12 Frequency of occurrence of traffic controls at junction RTAs.

Of those drivers involved in RTAs at junctions, whilst 53.3% stated they stopped at the junction, only 37.9% stated that they didn’t stop. The distinction between those that didn’t stop and were not expected to, and those that simply didn’t stop was made in the questionnaire, but was not sufficiently reliably reported.

Table 3.3 below describes the speed limits of the areas in which the RTAs occurred. The 30 mph or less category includes parking RTAs, (from Figure 3.7, approximately 14% of all RTAs), typically occurring in areas with speed limits regulated to be less than 30 mph. Irrespective of these parking RTAs therefore, approximately 50% of the RTAs in the returned sample occurred in a 30mph zone.

Table 3.3 Percentage of the sample in each speed limit category.

<table>
<thead>
<tr>
<th>Speed limit</th>
<th>Percentage of the sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>30mph or less</td>
<td>63.4</td>
</tr>
<tr>
<td>40</td>
<td>11.9</td>
</tr>
<tr>
<td>50</td>
<td>5.4</td>
</tr>
<tr>
<td>60</td>
<td>10.3</td>
</tr>
<tr>
<td>70</td>
<td>9.1</td>
</tr>
</tbody>
</table>
Study 1: RTA data collection.

In terms of the configuration of the roadways around the RTA scene, Tables 3.4 and 3.5 respectively describe the frequency of occurrence of each of the roadway types. More data were missing for areas after the RTA scene than for areas before and at the RTA scene and thus percentages of the responses would have distorted the true nature of the data. The data presented are therefore frequencies of respondents answering for each question rather than percentages of those answering the question positively. However, as is clear from both tables, the majority of the RTAs occurred on straight, flat roads. Additionally, 86.46% of the drivers reported that there were no road signs to indicate the presence of a difficult or dangerous section of the roadway ahead of the RTA scene.

In only 21 cases were any significant roadway changes in the areas before the RTA and the area of the RTA noted, (12 being road width decreases and the remaining 9 road width increases). In terms of the area of the RTA and areas after the RTA, 29 cases noted any significant change, (these being 14 width increases and 15 decreases).

Table 3.4 Horizontal bends in roadway around RTA scene.

<table>
<thead>
<tr>
<th></th>
<th>Before RTA scene (frequency)</th>
<th>At RTA scene (frequency)</th>
<th>After RTA scene (frequency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight</td>
<td>177</td>
<td>172</td>
<td>171</td>
</tr>
<tr>
<td>Single Wide Curve</td>
<td>42</td>
<td>37</td>
<td>34</td>
</tr>
<tr>
<td>Multiple Wide Curves</td>
<td>14</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Single Narrow Curve</td>
<td>17</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td>Multiple Narrow Curves</td>
<td>9</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>259</td>
<td>256</td>
<td>239</td>
</tr>
</tbody>
</table>
Study 1: RTA data collection.

Table 3.5 Vertical bends in roadway around RTA scene.

<table>
<thead>
<tr>
<th></th>
<th>Before RTA scene (frequency)</th>
<th>At RTA scene (frequency)</th>
<th>After RTA scene (frequency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>164</td>
<td>182</td>
<td>176</td>
</tr>
<tr>
<td>Uphill Slope</td>
<td>35</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Downhill Slope</td>
<td>51</td>
<td>41</td>
<td>39</td>
</tr>
<tr>
<td>Top of Hill</td>
<td>3</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Bottom of Hill</td>
<td>3</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Hump</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>257</td>
<td>259</td>
<td>245</td>
</tr>
</tbody>
</table>

3.5.3.4 Factors leading to the RTAs.

The specific details of the RTAs in the database will now be discussed. These will be split into several sections for clarity.

Situational factors affecting the drivers ability to control the vehicle: Only 23 cases described any significant visibility restrictions that affected their driving and may have helped to cause the RTA in question. In 8 of these cases, multiple restrictions were noted, the remaining 15 cases noting only one cause of lack of visibility, (Figure 3.13).
Study 1: RTA data collection.

Figure 3.13 Summary of the frequency of visibility restrictions along roadway at RTA scene.

In general, glare from external sources was not reported as a problem, 93.1% of those returning the questionnaire stating that glare was not a factor leading to the RTA. Of those for whom glare was a problem, glare from the sun, (most typically when low in the winter months) was a problem in 9 cases, and glare from other vehicle’s headlights at night a problem in 8 cases. Of the 33 drivers reporting that some vehicle related restriction to visibility out of the vehicle contributed to the RTA, the largest group of these, (10 cases, 33%), reported that the restriction was due to misting on the windows of the vehicle they were driving. 54.4% of the drivers when asked about vehicle related restrictions to visibility however stated that restrictions were caused by factors outside of the vehicle, these mostly being restatements of the factors described previously.

When asked if the driver saw the object they were in collision with, 55% reported that they had seen the object and 41% that they had not. 171 drivers therefore saw what they were in collision with prior to the RTA. These drivers were asked, what, if
any actions they undertook to try and avoid the RTA, and were asked about any other drivers involved as to whether they tried to avoid the RTA as well. In total, 80 of these drivers, (46.78%) stated that they could not avoid being in the RTA irrespective of their actions.

Of those that did not view the collision to be inevitable, more drivers thought that they themselves could slow down sufficiently or would avoid the RTA than thought that the other driver would do this. Those whose responses were categorised as ‘Other’ most frequently stated that they saw the other vehicle, but just assumed that the driver of the other vehicle saw themselves and would have avoided the RTA. Most commonly comments such as ‘I did not expect the other driver to hit me’ were made by these drivers. These are shown in Figure 3.14.

![Figure 3.14 Driver’s perceptions of actions that would have avoided the RTA, (by frequency of occurrence).](image)

The majority of the RTAs involved collisions between cars, (Table 3.6). Similarly, the vast majority of the RTAs involving other vehicles had only one other vehicle
involved, (95.43%), the remainder having 2, (11 cases), or 3 vehicles involved, (1 case).

Table 3.6 Summary frequencies of objects hit in RTAs.

<table>
<thead>
<tr>
<th>Object hit</th>
<th>Frequency of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>217</td>
</tr>
<tr>
<td>Van</td>
<td>16</td>
</tr>
<tr>
<td>Truck</td>
<td>13</td>
</tr>
<tr>
<td>Bus or coach</td>
<td>4</td>
</tr>
<tr>
<td>Construction vehicle</td>
<td>1</td>
</tr>
<tr>
<td>Bicycle</td>
<td>4</td>
</tr>
<tr>
<td>Moped or motorbike</td>
<td>0</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>1</td>
</tr>
<tr>
<td>Object on roadway</td>
<td>4</td>
</tr>
<tr>
<td>Animal on roadway</td>
<td>4</td>
</tr>
<tr>
<td>Object at side of roadway</td>
<td>21</td>
</tr>
<tr>
<td>Other in roadway</td>
<td>12</td>
</tr>
</tbody>
</table>

Figure 3.15 describes the nature of the impacts experienced by the vehicles. As can be seen, 42% of the impacts were front to rear collisions wherein one of the vehicles ran directly into the back of the other vehicle concerned. The next largest group of collisions, front to side collisions accounted for half of the number of collisions that the front/rear collisions did, (21%). The majority of the collisions in the ‘other’ category were parking area RTAs.
Study 1: RTA data collection.

Figure 3.15 Nature of the impacts of the vehicles in the returned sample.

In only 18 cases, (6.11%) did our driver admit to having driven too close to a vehicle in front prior to the RTA, the majority of the respondents (159 cases, 53.9%) stating that they were not following a vehicle in front too closely.

Figure 3.16 describes the volume of traffic at the time of the RTA. As can be seen, the majority of the sample, (52%) were involved in RTAs with a low traffic volume, (this includes a high proportion of the parking area RTAs).
Study 1: RTA data collection.

![Pie chart showing traffic volume by percentage](image)

**Figure 3.16 Volume of traffic at the time of the RTA, (by percentage).**

The drivers were asked if there were any hindrances to the usual flow of traffic at the time of the RTA and 44 of them, (15 %) replied that this was the case. Figure 3.17 describes the causes of these hold-ups where known. Most of the drivers stated only one cause of traffic hold-ups, and the largest group of them, (23 drivers, 52.27%) stated that the hold-ups were due to factors other than those mentioned in the questionnaire. Most commonly, these were related to either just the volume of traffic at the time of the RTA, or the weather conditions.
In 9 cases, (3.06%), the RTA in question followed closely from a previous RTA.

Psychological factors leading to the RTA: At several stages throughout the questionnaire, drivers were asked about any errors they themselves may have made in addition to those of others prior to the RTA. Additionally, psychological factors, (such as fatigue and distraction), were asked about. The following section is concerned with these factors.

25 drivers, (8.4%) stated that they felt that more experience of their own vehicle would have helped them to avoid the RTA.
Study 1: RTA data collection.

Table 3.7 Our driver’s perceptions of the other drivers intentions prior to the RTA.

<table>
<thead>
<tr>
<th></th>
<th>Other Driver Careless</th>
<th>Other Driver Confusing Or Ambiguous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage</td>
<td>Frequency</td>
</tr>
<tr>
<td>No</td>
<td>28.7</td>
<td>85</td>
</tr>
<tr>
<td>Yes</td>
<td>57.4</td>
<td>170</td>
</tr>
<tr>
<td>Not Sure</td>
<td>7.8</td>
<td>23</td>
</tr>
</tbody>
</table>

From Table 3.7 it can be seen that the majority of our drivers felt the other driver to be careless, (57.43%), however only 19.45% of our drivers felt the other driver to be confusing or ambiguous.

Our drivers were asked to assess any actions that they performed immediately prior to the RTA that may have contributed towards it. These actions were presented as being actions that they felt were reasonable to perform at the time, but that other road users may have felt to be unexpected, thus emphasising both that the actions were not blameworthy errors, but simply may have been misunderstood by other drivers. Additionally, they were asked to describe the reasons for these actions and were asked to make an assessment of whether these actions were also performed by the other road user in the RTA, (if there was one). The results are summarised in rank order of the frequency of occurrence, in Tables 3.8 to 3.10. These results are simplified by including in the action performed category, those actions that our driver felt maybe were performed in addition to those that were definitely performed. Thus these results are overly inclusive and deliberately cautious.
Study 1: RTA data collection.

Table 3.8 Reasonable but potentially misleading actions by our driver, (in rank order by percentage for those answering the question).

<table>
<thead>
<tr>
<th>Action.</th>
<th>Action performed or maybe performed</th>
<th>Action not performed.</th>
<th>Don’t know if action performed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Braked really hard</td>
<td>13.3</td>
<td>86.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Had difficulty braking effectively</td>
<td>8.5</td>
<td>91.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Vehicle was either stationary or barely moving and in a position that would have endangered itself or other road users, e.g. waiting to turn at a busy junction</td>
<td>7.4</td>
<td>92.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Lost control of the vehicle e.g. by skidding on ice</td>
<td>5.5</td>
<td>94.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Had difficulty steering effectively</td>
<td>4.0</td>
<td>95.8</td>
<td></td>
</tr>
<tr>
<td>Deliberately drove in an erratic course, e.g. swerving to avoid something</td>
<td>3.3</td>
<td>96.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Reversing in an inappropriate place, e.g. onto a main road</td>
<td>1.7</td>
<td>98.3</td>
<td></td>
</tr>
<tr>
<td>Made some manoeuvre that you normally would not have done, e.g. you overtook in a more risky situation than you would normally have done</td>
<td>1.7</td>
<td>96.6</td>
<td></td>
</tr>
<tr>
<td>Made a turn or other manoeuvre from the wrong lane, e.g. turning left from the outside lane of a roundabout</td>
<td>1.3</td>
<td>98.6</td>
<td></td>
</tr>
<tr>
<td>Gave a misleading signal e.g. signalled and failed to turn or turned without signalling</td>
<td>0.3</td>
<td>99.7</td>
<td></td>
</tr>
<tr>
<td>Made a U turn or 3 point turn in an inappropriate place</td>
<td>0.3</td>
<td>99.7</td>
<td></td>
</tr>
<tr>
<td>Overtook another vehicle where you would not normally do</td>
<td>0.3</td>
<td>99.7</td>
<td></td>
</tr>
<tr>
<td>Drove the wrong way up a one way street or other restricted road</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From Table 3.8, it can be seen that the most frequent actions performed involved braking, 38 drivers stating they had to brake really hard which may have helped to cause the RTA and 25 drivers stating they had difficulty in braking effectively.
Study 1: RTA data collection.

(respectively 13.3% and 8.5% of the sample). 22 of our drivers stated that their vehicle was stationary or slow moving and in a position in which it was endangered, (8.5% of the sample). These vehicles were typically attempting to turn or were in slow moving traffic and were hit by other vehicles as they waited. 12 of our drivers, (4.0%), experienced difficulty in steering effectively and 10 drivers stated they deliberately drove in an erratic manner by for example swerving.

Table 3.9 shows the responses given by our driver when they were asked to assess the frequency of the same actions being performed by the other driver involved. The 53 RTAs that were single vehicle RTAs are excluded from the table and thus the percentages given are based on the number of multi-vehicle RTAs not the whole sample.
**Study 1: RTA data collection.**

Table 3.9 Unexpected actions by other driver, (in rank order by percentae for those actions performed).

<table>
<thead>
<tr>
<th>Action.</th>
<th>Performed or maybe performed</th>
<th>Not performed</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>They did not brake effectively</td>
<td>22.1</td>
<td>75.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Braked really hard</td>
<td>17.5</td>
<td>80.6</td>
<td>1.8</td>
</tr>
<tr>
<td>They did not steer effectively</td>
<td>16.1</td>
<td>81.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Their vehicle stationary or barely moving in a position that would have endangered itself or other road users e.g. waiting at a junction</td>
<td>13.4</td>
<td>86.2</td>
<td>0.5</td>
</tr>
<tr>
<td>They made a manoeuvre that you would not have done, e.g. risky overtake</td>
<td>13.4</td>
<td>85.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Lost control of the vehicle</td>
<td>9.0</td>
<td>88.7</td>
<td>2.2</td>
</tr>
<tr>
<td>They made a manoeuvre from the wrong lane, e.g. turned left from the outside lane of a roundabout</td>
<td>6.3</td>
<td>92.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Signalled in a misleading manner, e.g. signalled and failed to turn, turned without signalling</td>
<td>5.8</td>
<td>91.4</td>
<td>2.7</td>
</tr>
<tr>
<td>Deliberately drove in an erratic course, e.g. swerving to avoid something</td>
<td>5.4</td>
<td>92.8</td>
<td>1.8</td>
</tr>
<tr>
<td>They were reversing in an inappropriate place, e.g. onto a main road</td>
<td>3.7</td>
<td>95.4</td>
<td>0.9</td>
</tr>
<tr>
<td>They overtook another vehicle in a place that you would not normally do</td>
<td>3.2</td>
<td>95.9</td>
<td>0.9</td>
</tr>
<tr>
<td>They ran off the road</td>
<td>1.9</td>
<td>97.7</td>
<td>0.5</td>
</tr>
<tr>
<td>They made a U turn or 3 point turn in an inappropriate place</td>
<td>1.4</td>
<td>98.2</td>
<td>0.5</td>
</tr>
<tr>
<td>They were driving the wrong way up a one way street or other restricted road</td>
<td>1.4</td>
<td>98.2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

As with manoeuvres performed by our driver, the most frequent manoeuvres performed by the drivers that may have contributed to the RTA occurring were those
associated with braking, 49 stating that the other driver did not brake effectively and 39 stating that the other driver braked really hard prior to the RTA, (respectively 22.1% and 17.5% of the sample). Steering ineffectively by the other driver was stated to be an issue by 36 (16.1%), of our drivers and 29, (13.4%), stated that the other vehicle was either stationary or slow moving and this may have contributed to the RTA. In addition, 29 of our drivers, (13.4%), stated that the other driver made a manoeuvre that they themselves would not have done.

Two trends can be seen from these two tables. Firstly, in all but one of the manoeuvre types, at least one of our drivers admitted performing some action that may have been misinterpreted by any other road users and thus this may have helped to cause the RTA. Secondly, for all manoeuvres, more of the other drivers than of our drivers were attributed to have made the manoeuvre. In the case of multi-vehicle accidents, up to 22% of RTAs therefore have some contributory factors associated with a road user making a manoeuvre that was unexpected.

The drivers were asked for the reasons for these errors being made. The results are presented in Table 3.10.
Study 1: RTA data collection.

Table 3.10 Driver based reasons for our driver’s errors, (in rank order by percentage of RTAs).

<table>
<thead>
<tr>
<th>Did any of the following affect the cause of the RTA?</th>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overconfident in your driving abilities</td>
<td>11.4</td>
<td>87.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Felt tired or fatigued</td>
<td>8.9</td>
<td>90.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Were late and in a rush</td>
<td>8.2</td>
<td>90.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Distracted by problems on your mind at the time</td>
<td>7.2</td>
<td>91.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Difficulty in concentrating on driving</td>
<td>5.5</td>
<td>94.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Felt angry or annoyed</td>
<td>4.5</td>
<td>94.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Frustration</td>
<td>3.4</td>
<td>82.8</td>
<td>7.4</td>
</tr>
<tr>
<td>Distracted by looking for something in the vehicle</td>
<td>3.5</td>
<td>96.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Distracted by disturbances in your vehicle, e.g. children</td>
<td>1.3</td>
<td>98.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Felt depressed</td>
<td>1.3</td>
<td>97.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Felt panicked</td>
<td>1.3</td>
<td>97.2</td>
<td>1.4</td>
</tr>
<tr>
<td>You were nervous when driving</td>
<td>1.0</td>
<td>98.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Felt unwell</td>
<td>0.7</td>
<td>98.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Receiving encouragement</td>
<td>0.7</td>
<td>91.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Driving to impress other</td>
<td></td>
<td>91.9</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table 3.10 illustrates some of the reasons for the errors being made by our drivers. Of note, is that 11.4% of our drivers stated that overconfidence in their own driving abilities contributed to the cause of the RTA. Additionally, fatigue and being in a rush accounted partially for up to 8.9% and 8.2% of the RTAs.
Table 3.11 Environment based reasons for our driver's errors, (in rank order by percentage of RTAs).

<table>
<thead>
<tr>
<th>Did any of the following affect the cause of the RTA?</th>
<th>Yes</th>
<th>No</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>You could not avoid being in an RTA</td>
<td>49.9</td>
<td>48.1</td>
<td>2.0</td>
</tr>
<tr>
<td>There was another road user present who caused the RTA</td>
<td>10.2</td>
<td>89.1</td>
<td>0.7</td>
</tr>
<tr>
<td>The road surface made the car difficult to control</td>
<td>7.9</td>
<td>91.7</td>
<td>0.3</td>
</tr>
<tr>
<td>The road layout was misleading</td>
<td>5.1</td>
<td>94.8</td>
<td></td>
</tr>
<tr>
<td>Street lighting</td>
<td>4.3</td>
<td>92.1</td>
<td>3.6</td>
</tr>
<tr>
<td>Unfamiliar with road layout</td>
<td>3.7</td>
<td>3.7</td>
<td>4.3</td>
</tr>
<tr>
<td>Distracted by looking for street names or route directions</td>
<td>3.1</td>
<td>96.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Road signs were missing</td>
<td>2.8</td>
<td>96.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Poorly placed road signs</td>
<td>2.8</td>
<td>96.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Traffic lights were not working or were misleading</td>
<td>2.0</td>
<td>97.9</td>
<td></td>
</tr>
<tr>
<td>Being chased</td>
<td>1.4</td>
<td>90.9</td>
<td></td>
</tr>
<tr>
<td>The road signs were misleading</td>
<td>1.0</td>
<td>98.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Pedestrians were crossing in an inappropriate place</td>
<td>0.7</td>
<td>99.3</td>
<td></td>
</tr>
</tbody>
</table>

With respect to environmental reasons for the RTA, when asked, approximately half of our drivers, (49.9%), stated that they could not avoid being in the accident. Additionally, 10.2% of the drivers, (30 drivers) stated that there was another road user present who caused the RTA without themselves crashing. Problems with the road were associated with a number of RTAs, poor road surface accounting for up to 7.9% of the RTAs and misleading road layout accounting for up to 5.1% of the RTAs. Other road factors such as being distracted by looking for route directions accounted for RTAs associated with drivers who were in general unfamiliar with the road they were driving along at the time.

3.5.4 The use of collected data to infer a primary safety strategy.

The data above illustrate the nature of the scenarios in which the RTAs studied occurred, the nature of the involved drivers and some issues relating to the errors
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made by these drivers and the reasons for these errors being made. In terms of the approach described by Malaterre et al (1992), the needs have thus been described. In order to deduce a strategy for primary safety system development these needs must now be cross tabulated with potential accident countermeasures, (this work will be described further in Chapter 4). However, in order to achieve this, the RTAs were grouped into similar categories. Correlating needs with potential accident countermeasures for individual RTAs would have served only to illustrate the countermeasures for these RTAs. Additionally, in order to produce a strategic approach to system development, it was necessary to deduce how frequently each of the implied systems would be required. Weightings were therefore required to illustrate which systems would be more beneficial to the driver population as whole.

Two RTA taxonomies were possible given the data presented above, based either on the nature of the errors and reasons for these errors, or based upon the scenario in which these errors occurred.

The latter categorisation was chosen as the quantity of data collected precluded an error based approach to categorisation that would be generalisable to the driver population as a whole. Given the number of questionnaires returned, (approximately 300), they cannot be generalisable to the estimated 500,000 RTAs occurring annually.

Secondly, the data relating to the scenarios in which the RTAs occurred is more reliable and more easily verifiable. The frequency of RTAs in different scenarios, (for example motorways or T junctions), are known and obtainable from large national and international databases. Additionally, data relating to fatalities that occur at each of these scenarios are obtainable, and as has been noted, in general likely to be more accurate than other available data.

It is for this reason, that the categorisation system used to deduce strategy was based upon the scenario in which the accident occurred and the weightings used to determine the relative efficacy based upon fatality data.
Table 2.4 illustrates the relative numbers of RTAs of varying severity at different accident scenarios. These data are summarised below for fatalities with the addition of the currently collected sample, (Table 3.12. This table excludes parking area incidents, thus the total sample size on which the percentages are based is 279).

Table 3.12 Fatal RTA frequency and percentage of total RTAs from STATS19 compared to the current sample (by rank ordering of RTA scenario for 1996).

<table>
<thead>
<tr>
<th>RTA Scenario</th>
<th>Frequency of RTAs, (from STATS19)</th>
<th>Frequency of returned data</th>
<th>Percentage of total, (from STATS19, N=3274)</th>
<th>Percentage of returned data, (N=279)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at junction</td>
<td>2012</td>
<td>64</td>
<td>61.4</td>
<td>22.9</td>
</tr>
<tr>
<td>T Junction and Crossroads</td>
<td>940</td>
<td>95</td>
<td>28.7</td>
<td>34.1</td>
</tr>
<tr>
<td>Private drive or entrance</td>
<td>94</td>
<td>39</td>
<td>2.8</td>
<td>13.9</td>
</tr>
<tr>
<td>Y Junction or slip roads</td>
<td>84</td>
<td>24</td>
<td>2.6</td>
<td>8.6</td>
</tr>
<tr>
<td>Other</td>
<td>56</td>
<td>15</td>
<td>1.7</td>
<td>5.4</td>
</tr>
<tr>
<td>Roundabout</td>
<td>52</td>
<td>42</td>
<td>1.6</td>
<td>15.1</td>
</tr>
<tr>
<td>Multiple Junction</td>
<td>34</td>
<td>N/A</td>
<td>1.0</td>
<td>N/A</td>
</tr>
<tr>
<td>All junctions</td>
<td>1262</td>
<td>215</td>
<td>38.5</td>
<td>77.1</td>
</tr>
<tr>
<td>Totals</td>
<td>3274</td>
<td>279</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

From this and analysis of the returned questionnaires, the scenarios considered for the strategy derivation were as follows:

- Non junction
- T junction and Crossroads (combined)
- Y junctions or slip roads
- Roundabouts.

Significant differences can be seen between the two samples as would be expected from the differing nature of the populations sampled. For example, the current study firstly excluded contact with any drivers involved in an RTA resulting in a fatality.
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and included a large number of low speed damage only RTAs. However, given the relatively small sample of the current study, a comparison with a larger data set is required to illustrate the distribution of the two samples across RTA scenarios. A statistical comparison however, is not appropriate due to the differences in the population sizes.

T junctions and Crossroads were combined due to the similar nature of the tasks that drivers must perform at both; they must either assess the state of traffic in one direction before either crossing it or merging with it, or assess the state of traffic in two directions before crossing either one or both traffic flows. Similar reasoning may be applied to roundabouts and slip roads in that drivers must merge with a line of traffic moving in the same direction that the merging traffic wishes to take. However, in the case of slip roads, both major and minor roads will be moving and the minor road is not expected to stop. As slip roads are a characteristic mainly of high volume roads, (usually dual carriageways or motorways), the traffic on the major road may attempt to allow other traffic to merge by moving into adjacent lanes. On roundabouts however, no such manoeuvres are possible on the roundabout itself and merging drivers are instructed in the highway code to stop unless it is safe to proceed, (Department of Transport 1996). Roundabouts and slip roads therefore differ and were grouped in separate categories accordingly.

Private driveways and entrances were excluded from this analysis because the nature of these within the data collected was atypical of those within STATS19. Inspection of the returned questionnaires showed that a large number of these RTAs in the database were low speed impacts, largely related to commuting traffic around the sites of the company sponsoring this research. In addition, a number of low speed parking related incidents were noted which could not sufficiently reliably be distinguished from parking area incidents which were specifically excluded from the analysis. This is unsurprising given that the single largest group of RTAs found in the current study, (37.6%) were in suburban areas and the data themselves were derived from an insurance group.
Each of these scenarios were analysed separately from the main dataset to determine if any differences between the scenarios or between the scenarios and the dataset as a whole existed. First order cross tabulations of the RTA scenario and other variables are presented below. These allow a comparison of the percentage of occurrence of the various factors across the scenarios used. It will be readily apparent that the numbers of cases for the same scenario in different tables are not constant due to the varying numbers of missing responses across the questionnaire. A comparison based on the percentage of valid responses for each scenario will allow these missing values to have a minimal effect on the trends demonstrated. For each of the following tables, the numbers presented in parentheses are the frequencies of the cell counts. The other numbers presented in each cell are the percentage occurrence of the frequencies when compared to the scenario in the column heading. Thus the factors in the rows may be assessed across scenarios with different absolute frequencies in the returned sample to determine if any of these factors are differentially associated with different scenarios. The variables chosen for this analysis were those that may have some relevance to the production of accident countermeasures when considering the differing scenarios. Additionally, only those variables with sufficiently large frequency counts when considering the whole sample were employed. Other variables were not entered into this analysis. Due to the low sample size and corresponding cell counts, much of the data in the following tables could not be analysed statistically. Therefore, the following tables are presented to illustrate the trends found within the data.

3.5.4.1 Demographics of the sample by scenario.

A Chi square analysis of the numbers of cases within each scenario indicated significant differences, (Chi-Square = 48.9, D.F=3, p=0.00). Although some differences did exist in the demographic breakdown of drivers across RTA scenarios, no significant effects were found. This is unsurprising given the relatively homogeneous nature of the sampling frame employed.
Table 3.13 Scenarios by age of driver.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 20 years</td>
<td>3.1 (2)</td>
<td>8.5 (8)</td>
<td>4.2 (1)</td>
<td>2.3 (1)</td>
</tr>
<tr>
<td>21 to 25 years</td>
<td>9.2 (6)</td>
<td>6.4 (6)</td>
<td>4.2 (1)</td>
<td>9.3 (4)</td>
</tr>
<tr>
<td>26 to 30 years</td>
<td>6.1 (4)</td>
<td>5.3 (5)</td>
<td>12.5 (3)</td>
<td>16.3 (7)</td>
</tr>
<tr>
<td>31 to 40 years</td>
<td>27.7 (18)</td>
<td>23.4 (22)</td>
<td>16.7 (4)</td>
<td>27.9 (12)</td>
</tr>
<tr>
<td>41 to 50 years</td>
<td>35.4 (23)</td>
<td>25.5 (24)</td>
<td>25.0 (6)</td>
<td>27.9 (12)</td>
</tr>
<tr>
<td>51 to 60 years</td>
<td>15.4 (10)</td>
<td>28.7 (27)</td>
<td>33.3 (8)</td>
<td>9.3 (4)</td>
</tr>
<tr>
<td>61 years and above</td>
<td>3.1 (2)</td>
<td>2.1 (2)</td>
<td>4.2 (1)</td>
<td>6.9 (3)</td>
</tr>
</tbody>
</table>

Conclusions from this table are difficult to draw due to the variance in ages throughout the sample obtained; the majority of drivers being company car drivers and being aged on average 41.6 years. It would appear that drivers aged 50 and above are involved in proportionally more RTAs at T junctions and slip roads than open roadways and roundabouts. A similar pattern exists for drivers aged under 25 years. Both of these may be expected from inspection of STATS 19.

Table 3.14 Scenarios by gender of driver.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>83.1 (54)</td>
<td>70.2 (66)</td>
<td>66.7 (16)</td>
<td>73.8 (31)</td>
</tr>
<tr>
<td>Female</td>
<td>16.9 (11)</td>
<td>29.8 (28)</td>
<td>33.3 (8)</td>
<td>26.2 (11)</td>
</tr>
</tbody>
</table>

Proportionally fewer females were involved in RTAs on open roadways than at junction related scenarios. Overall, males represented between 66% and 83% of all RTAs.

Table 3.15 Scenario by was our driver impaired before the RTA?

<table>
<thead>
<tr>
<th>Impairment</th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>6.1 (4)</td>
<td>3.2 (3)</td>
<td>4.2 (1)</td>
<td>4.6 (2)</td>
</tr>
<tr>
<td>No</td>
<td>93.9 (61)</td>
<td>96.8 (91)</td>
<td>95.8 (23)</td>
<td>95.4 (41)</td>
</tr>
</tbody>
</table>
Study 1: RTA data collection.

Across the 4 scenarios chosen, in over 90% of the RTAs driver impairment was not felt to be a factor in the causation of the RTA. Whilst the absolute numbers of drivers that felt impairment was an issue was small and it is therefore difficult to generalise, it is curious that the highest proportion of drivers that were influenced by impairment of some kind were on open roadways. It might be expected that the tasks involved in negotiating junctions being more complex would lead to higher proportion of impaired drivers being involved in RTAs at these scenarios.

Table 3.16 Scenarios by did our driver have any additional driver training?

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=92)</th>
<th>Y Junction or Slip road (N=23)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>12.3 (8)</td>
<td>7.6 (7)</td>
<td>8.7 (2)</td>
<td>13.9 (6)</td>
</tr>
<tr>
<td>No</td>
<td>87.7 (57)</td>
<td>92.4 (85)</td>
<td>91.3 (21)</td>
<td>86.1 (37)</td>
</tr>
</tbody>
</table>

Overall, few drivers had any additional driver training; on a scenario by scenario basis slightly more drivers that were involved in RTAs at roundabouts or on open roadways had additional driver training as compared to T junctions or slip roads.

Table 3.17 Scenario by would more experience of driving in general would have helped?

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=93)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1.5 (1)</td>
<td>2.2 (2)</td>
<td>4.2 (1)</td>
<td>4.7 (2)</td>
</tr>
<tr>
<td>No</td>
<td>90.8 (59)</td>
<td>92.5 (86)</td>
<td>91.7 (22)</td>
<td>90.7 (39)</td>
</tr>
<tr>
<td>Not applicable</td>
<td>7.7 (5)</td>
<td>5.4 (5)</td>
<td>4.2 (1)</td>
<td>4.7 (2)</td>
</tr>
</tbody>
</table>

Unsurprisingly, most of the drivers stated that they felt they would not have benefited from more experience of driving in general. However, of those feeling that more experience may have helped, a higher percentage of the sample were present in the junction RTA scenarios than the open roadway.
Table 3.18 Scenario by how often our driver had driven the particular vehicle prior to the RTA.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=92)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>81.3 (52)</td>
<td>85.9 (79)</td>
<td>87.5 (21)</td>
<td>74.4 (32)</td>
</tr>
<tr>
<td>Several times a week</td>
<td>10.9 (7)</td>
<td>7.6 (7)</td>
<td>4.2 (1)</td>
<td>20.9 (9)</td>
</tr>
<tr>
<td>Several times a month</td>
<td>4.7 (3)</td>
<td>4.4 (4)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Less than once a month</td>
<td>1.6 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>First time</td>
<td>3.1 (2)</td>
<td>2.2 (2)</td>
<td>8.3 (2)</td>
<td>4.7 (2)</td>
</tr>
</tbody>
</table>

Across all scenarios, approximately 75% or more of the drivers had driven the vehicle in which they were involved in the RTA in daily. With the exception of slip road RTAs, the majority of the remainder drove the vehicle several times a week, whereas 8.3% of those involved in RTAs on slip roads were driving the vehicle for the first time.

Table 3.19 Scenario by would more experience of vehicle have helped?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1.5 (1)</td>
<td>3.2 (3)</td>
<td>4.2 (1)</td>
<td>2.3 (1)</td>
</tr>
<tr>
<td>No</td>
<td>87.7 (57)</td>
<td>96.8 (91)</td>
<td>91.7 (22)</td>
<td>95.4 (41)</td>
</tr>
<tr>
<td>Not sure</td>
<td>10.7 (7)</td>
<td>0.0 (0)</td>
<td>4.2 (1)</td>
<td>2.3 (1)</td>
</tr>
</tbody>
</table>

In all scenarios, the majority of drivers felt that they would not have been helped to avoid the RTA if they had more experience of the vehicle in which they were at the time.
Table 3.20 Scenarios by number of miles typically driven per year.

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=92)</th>
<th>Y Junction or Slip road (N=23)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5,000</td>
<td>9.2 (6)</td>
<td>20.6 (19)</td>
<td>13.0 (3)</td>
<td>6.9 (3)</td>
</tr>
<tr>
<td>5,000 to 10,000</td>
<td>18.5 (12)</td>
<td>29.4 (27)</td>
<td>17.4 (4)</td>
<td>23.3 (10)</td>
</tr>
<tr>
<td>10,000 to 15,000</td>
<td>32.3 (21)</td>
<td>30.4 (28)</td>
<td>30.4 (7)</td>
<td>37.2 (16)</td>
</tr>
<tr>
<td>15,000 to 20,000</td>
<td>7.7 (5)</td>
<td>8.7 (8)</td>
<td>8.7 (2)</td>
<td>13.9 (6)</td>
</tr>
<tr>
<td>Over 20,000 miles</td>
<td>32.3 (21)</td>
<td>10.8 (10)</td>
<td>30.4 (7)</td>
<td>18.6 (8)</td>
</tr>
</tbody>
</table>

For all road scenarios, the percentages involved in RTAs increase as distances driven per year increase to 15,000 miles per year. With the exception of roundabout RTAs, the percentage of those involved in RTAs at specific scenarios is least for those who typically drive between 15,000 and 20,000 per year. The percentage involved by scenario then increases again for those that typically drive over 20,000 miles per year.

Table 3.21 Scenario by years since last RTA.

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 1 year</td>
<td>13.9 (9)</td>
<td>17.0 (16)</td>
<td>20.8 (5)</td>
<td>18.6 (8)</td>
</tr>
<tr>
<td>2 years</td>
<td>4.6 (3)</td>
<td>8.5 (8)</td>
<td>4.2 (1)</td>
<td>2.3 (1)</td>
</tr>
<tr>
<td>3 years</td>
<td>4.6 (3)</td>
<td>8.5 (8)</td>
<td>4.2 (1)</td>
<td>9.3 (4)</td>
</tr>
<tr>
<td>4 years</td>
<td>7.7 (5)</td>
<td>4.3 (4)</td>
<td>0.0 (0)</td>
<td>4.7 (2)</td>
</tr>
<tr>
<td>5 years</td>
<td>12.3 (8)</td>
<td>3.2 (3)</td>
<td>0.0 (0)</td>
<td>2.3 (1)</td>
</tr>
<tr>
<td>6 years</td>
<td>6.2 (4)</td>
<td>1.1 (1)</td>
<td>4.2 (1)</td>
<td>4.7 (2)</td>
</tr>
<tr>
<td>7 years</td>
<td>0.0 (0)</td>
<td>6.4 (6)</td>
<td>0.0 (0)</td>
<td>6.9 (3)</td>
</tr>
<tr>
<td>8 years</td>
<td>4.6 (3)</td>
<td>2.1 (2)</td>
<td>8.3 (2)</td>
<td>2.3 (1)</td>
</tr>
<tr>
<td>9 years</td>
<td>1.5 (1)</td>
<td>4.3 (4)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>10 years or more</td>
<td>44.6 (29)</td>
<td>44.7 (42)</td>
<td>58.3 (14)</td>
<td>48.8 (21)</td>
</tr>
</tbody>
</table>

In the case of open roadway and T junction RTAs, approximately 45% of those involved were involved in an RTA 10 or more years previously. For these scenarios,
Study 1: RTA data collection.

approximately 14% and 17% of the drivers were involved in an RTA within the previous year. These figures are slightly higher for roundabout RTAs, 49% being involved in an RTA10 or more years ago and 19% being involved in an RTA within the previous year. These figures are higher still for slip road RTAs, (respectively 58.33% and 20.83%) although the relatively small sample must be considered.

Table 3.22 Scenarios by previous number of minor RTAs.

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=55)</th>
<th>T junction or Crossroads (N=88)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 3 previous minor RTAs</td>
<td>60.0 (33)</td>
<td>75.0 (66)</td>
<td>70.8 (17)</td>
<td>78.5 (33)</td>
</tr>
<tr>
<td>3 to 5 previous minor RTAs</td>
<td>34.5 (19)</td>
<td>21.6 (19)</td>
<td>29.2 (7)</td>
<td>19.1 (8)</td>
</tr>
<tr>
<td>Over 5 previous minor RTAs</td>
<td>5.5 (3)</td>
<td>3.4 (3)</td>
<td>0.0 (0)</td>
<td>2.4 (1)</td>
</tr>
</tbody>
</table>

In terms of junction RTAs, no significant differences existed between the scenarios when comparing the number of previous minor RTAs a driver had been involved in. For open roadways, more drivers had been involved in 1 to 3 minor RTAs whereas comparatively fewer had been involved in 3 to 5 minor RTAs.

Table 3.23 Scenario by previous number of major RTAs.

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=91)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 3 previous major RTAs</td>
<td>90.8 (59)</td>
<td>94.5 (86)</td>
<td>95.8 (23)</td>
<td>95.4 (41)</td>
</tr>
<tr>
<td>3 to 5 previous major RTAs</td>
<td>9.2 (6)</td>
<td>4.4 (4)</td>
<td>0.0 (0)</td>
<td>2.3 (1)</td>
</tr>
<tr>
<td>Over 5 previous major RTAs</td>
<td>0.0 (0)</td>
<td>1.1 (1)</td>
<td>4.2 (1)</td>
<td>2.3 (1)</td>
</tr>
</tbody>
</table>

Of those involved in junction related RTAs, approximately 95% had been involved in up to 3 previous major RTAs, whereas 90% of those involved in open roadway RTAs had been similarly involved.
Table 3.24 Scenario by roadway on at time of the RTA.

<table>
<thead>
<tr>
<th>Roadway Type</th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=93)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorway</td>
<td>12.5 (8)</td>
<td>0.0 (0)</td>
<td>29.2 (7)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>A road dual carriageway</td>
<td>10.9 (7)</td>
<td>7.5 (7)</td>
<td>29.2 (7)</td>
<td>52.4 (22)</td>
</tr>
<tr>
<td>A road single carriageway</td>
<td>17.2 (11)</td>
<td>30.1 (28)</td>
<td>16.7 (4)</td>
<td>21.4 (9)</td>
</tr>
<tr>
<td>A road signed overtaking lane</td>
<td>1.6 (1)</td>
<td>5.4 (5)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>B road</td>
<td>28.1 (18)</td>
<td>34.4 (32)</td>
<td>4.2 (1)</td>
<td>9.5 (4)</td>
</tr>
<tr>
<td>C or unclassified</td>
<td>20.3 (13)</td>
<td>12.9 (12)</td>
<td>8.3 (2)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>One way street</td>
<td>3.1 (2)</td>
<td>2.2 (2)</td>
<td>4.2 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Other</td>
<td>6.3 (4)</td>
<td>7.5 (7)</td>
<td>8.3 (2)</td>
<td>14.3 (6)</td>
</tr>
</tbody>
</table>

Table 3.24 shows the nature of the roadways our drivers were on at the time of the RTA. B roads are the most common road types for open roadway scenarios and T junctions, whereas A road dual carriageways are mostly associated with roundabout RTAs. Motorways and A road dual carriageways are equally associated with slip roads. It can be seen that half of the motorway RTAs occur on the motorway itself with the remainder either on slip roads or on roundabouts next to the motorway.
Study 1: RTA data collection.

Table 3.25 Scenario by road class approaching.

<table>
<thead>
<tr>
<th></th>
<th>T junction or Crossroads (N=92)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorway</td>
<td>0.0 (0)</td>
<td>33.3 (8)</td>
<td>3.2 (1)</td>
</tr>
<tr>
<td>A road dual</td>
<td>8.7 (8)</td>
<td>29.2 (7)</td>
<td>64.5 (20)</td>
</tr>
<tr>
<td>A road single</td>
<td>34.8 (32)</td>
<td>4.2 (1)</td>
<td>32.3 (10)</td>
</tr>
<tr>
<td>A road signed lane</td>
<td>2.3 (2)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>B road</td>
<td>32.6 (30)</td>
<td>16.7 (4)</td>
<td>12.9 (4)</td>
</tr>
<tr>
<td>C or unclassified</td>
<td>10.9 (10)</td>
<td>4.2 (1)</td>
<td>3.3 (1)</td>
</tr>
<tr>
<td>One way street</td>
<td>2.2 (2)</td>
<td>4.1 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Other</td>
<td>8.7 (8)</td>
<td>8.3 (2)</td>
<td>16.1 (5)</td>
</tr>
</tbody>
</table>

Unsurprisingly, with respect to the nature of the roadway the driver was approaching at the time of the RTA, motorway RTAs are most commonly associated with slip roads and dual carriageway RTAs with roundabouts. T junctions RTAs are most commonly associated with single carriageway A roads.

Table 3.26 Scenario by direction heading at junction.

<table>
<thead>
<tr>
<th></th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight on</td>
<td>53.2 (50)</td>
<td>66.7 (16)</td>
<td>54.7 (23)</td>
</tr>
<tr>
<td>Turning right</td>
<td>23.4 (22)</td>
<td>12.5 (3)</td>
<td>7.1 (3)</td>
</tr>
<tr>
<td>Turning left</td>
<td>20.2 (19)</td>
<td>16.7 (4)</td>
<td>30.9 (13)</td>
</tr>
<tr>
<td>Other</td>
<td>3.2 (3)</td>
<td>4.2 (1)</td>
<td>7.1 (3)</td>
</tr>
</tbody>
</table>

In all junction manoeuvres, Table 3.26 shows that T junctions are the most represented scenarios, the majority of drivers proceeding straight on at these junctions. Overall, the largest group of drivers at each scenario were driving straight on at these junctions. Table 3.27 shows that for each scenario, more drivers did not stop than stopped, this being especially evident in the case of roundabout RTAs. This concurs with the results presented in figures 3.10 and 3.11.
Study 1: RTA data collection.

Table 3.27 Scenario by did driver stop?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>T junction or Crossroads (N=87)</th>
<th>Y Junction or Slip road (N=22)</th>
<th>Roundabout (N=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>16.1 (14)</td>
<td>27.3 (6)</td>
<td>10.0 (4)</td>
</tr>
<tr>
<td>No</td>
<td>47.1 (41)</td>
<td>40.9 (9)</td>
<td>77.5 (31)</td>
</tr>
<tr>
<td>Not sure</td>
<td>3.5 (3)</td>
<td>4.6 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Not applicable</td>
<td>33.3 (29)</td>
<td>27.3 (6)</td>
<td>12.5 (5)</td>
</tr>
</tbody>
</table>

Table 3.28 Scenario by did vehicle run off road?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=93)</th>
<th>Y Junction or Slip road (N=23)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle ran off road</td>
<td>17.2 (11)</td>
<td>4.3 (4)</td>
<td>13.1 (3)</td>
<td>7.1 (3)</td>
</tr>
<tr>
<td>Vehicle did not run off road</td>
<td>82.8 (53)</td>
<td>95.7 (89)</td>
<td>86.9 (20)</td>
<td>92.9 (39)</td>
</tr>
</tbody>
</table>

Across the differing scenarios, Table 3.28 shows that more vehicles ran off the roadway when on open roads than on the other scenarios. The majority of vehicles across all scenarios did not however run off the roadway.

Table 3.29 Scenario by was the driver changing lanes?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=92)</th>
<th>Y Junction or Slip road (N=23)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was changing lanes</td>
<td>6.2 (4)</td>
<td>5.4 (5)</td>
<td>13.0 (3)</td>
<td>7.1 (3)</td>
</tr>
<tr>
<td>Not changing lanes</td>
<td>93.8 (61)</td>
<td>94.6 (87)</td>
<td>87.0 (20)</td>
<td>92.9 (39)</td>
</tr>
</tbody>
</table>

As a percentage of the RTAs at a given scenario, slightly more were changing lanes on slip roads than at other scenarios.
Study 1: RTA data collection.

Table 3.30 Scenario by speed limit at RTA scene.

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Open Roadway (N=59)</th>
<th>T junction or Crossroads (N=84)</th>
<th>Y Junction or Slip road (N=20)</th>
<th>Roundabout (N=33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 30 mph</td>
<td>52.2 (31)</td>
<td>78.6 (66)</td>
<td>25.0 (5)</td>
<td>39.4 (13)</td>
</tr>
<tr>
<td>40</td>
<td>10.2 (6)</td>
<td>9.5 (8)</td>
<td>15.0 (3)</td>
<td>18.2 (6)</td>
</tr>
<tr>
<td>50</td>
<td>1.7 (1)</td>
<td>3.6 (3)</td>
<td>15.0 (3)</td>
<td>16.2 (5)</td>
</tr>
<tr>
<td>60</td>
<td>16.9 (10)</td>
<td>5.9 (5)</td>
<td>20.0 (4)</td>
<td>15.2 (5)</td>
</tr>
<tr>
<td>70</td>
<td>16.6 (11)</td>
<td>2.4 (2)</td>
<td>25.0 (5)</td>
<td>12.1 (4)</td>
</tr>
</tbody>
</table>

Table 3.30 shows that all of the roadway scenarios are associated more with speed limits of up to 30 mph. In terms of absolute numbers, the largest groups of RTAs on 60 and 70 mph roads were associated with open roadways whereas 30 and 40 mph zones were more commonly associated with T junctions. 50 mph zones however, were more frequently associated with roundabouts.

Table 3.31 Scenario by speed of driver.

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=23)</th>
<th>Roundabout (N=39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15 mph</td>
<td>41.5 (27)</td>
<td>60.6 (57)</td>
<td>56.5 (13)</td>
<td>74.4 (29)</td>
</tr>
<tr>
<td>16-20 mph</td>
<td>12.3 (8)</td>
<td>6.6 (9)</td>
<td>4.4 (1)</td>
<td>10.3 (4)</td>
</tr>
<tr>
<td>21-30 mph</td>
<td>24.6 (16)</td>
<td>18.1 (17)</td>
<td>13.1 (3)</td>
<td>10.3 (4)</td>
</tr>
<tr>
<td>31-40 mph</td>
<td>1.5 (1)</td>
<td>8.5 (8)</td>
<td>17.4 (4)</td>
<td>5.1 (2)</td>
</tr>
<tr>
<td>41-50 mph</td>
<td>3.1 (2)</td>
<td>0.0 (0)</td>
<td>4.4 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>51-60 mph</td>
<td>4.6 (3)</td>
<td>1.1 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>61-70 mph</td>
<td>1.5 (1)</td>
<td>0.0 (0)</td>
<td>4.4 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>71 or more mph</td>
<td>10.8 (7)</td>
<td>2.1 (2)</td>
<td>4.4 (1)</td>
<td>10.3 (4)</td>
</tr>
</tbody>
</table>

For each scenario, the majority of drivers estimated they were travelling at less than 15 mph prior to the RTA, the next largest proportion estimating their speed to be between 20 and 30 mph. The absolute numbers of drivers travelling at higher speeds are insufficient to make reliable comparisons across scenarios. However, of note is that in total 14 drivers, (6.33% of the drivers within these scenarios) admitted to driving in excess of the speed limit at the time of the RTA.
Overall, the most frequent impact configuration across the scenarios was front to rear collisions accounting for between 35% and 68% of all impacts. These front to rear collisions are more common in slip road and roundabout scenarios, the next most common scenarios being side swipes and front to side collisions for these two scenarios. For T junctions, nearly as many RTAs occur in front to side configurations as front to rear with the next most common being side swipes. On open roadways, front to rear impacts account for 35.2% of all collisions whereas side swipes, (the next most common impact configuration), account for less than half of this number, (16.7%).

Table 3.33 Scenario by time of the day.

For open roadways, T junctions and slip roads, between 54% and 68% of the RTAs occurred during the day, with between 19% and 25% occurring at night; only 10% of the RTAs occurred during dusk or dawn hours. A lower percentage of RTAs
Study 1: RTA data collection.

occurred during the night for roundabout RTAs and a higher percentage during the day, (respectively 14.6% and 70.7%).

Table 3.34 Scenario by time of RTA.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Open Roadway (N=61)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=30)</th>
<th>Roundabout (N=39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00.00-03.59</td>
<td>1.6 (1)</td>
<td>1.1 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>04.00-07.59</td>
<td>16.4 (10)</td>
<td>9.6 (9)</td>
<td>10.0 (3)</td>
<td>15.4 (6)</td>
</tr>
<tr>
<td>08.00-11.59</td>
<td>19.7 (12)</td>
<td>28.7 (27)</td>
<td>26.7 (8)</td>
<td>18.0 (7)</td>
</tr>
<tr>
<td>12.00-15.59</td>
<td>34.4 (21)</td>
<td>28.7 (27)</td>
<td>26.7 (8)</td>
<td>18.0 (7)</td>
</tr>
<tr>
<td>16.00-19.59</td>
<td>23.0 (14)</td>
<td>29.8 (28)</td>
<td>33.3 (10)</td>
<td>41.0 (16)</td>
</tr>
<tr>
<td>20.00-23.59</td>
<td>4.9 (3)</td>
<td>2.1 (2)</td>
<td>3.3 (1)</td>
<td>7.7 (3)</td>
</tr>
</tbody>
</table>

Across all scenarios, the majority of RTAs occur between 08.00 and 19.59. No particular trend can be seen from these data although it would appear that more RTAs occur on open roadways between the hours of 20.00 and 03.59 than on junctions.

Table 3.35 Scenario by temperature.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=93)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot</td>
<td>1.6 (1)</td>
<td>0.0 (0)</td>
<td>4.2 (1)</td>
<td>2.3 (1)</td>
</tr>
<tr>
<td>Warm</td>
<td>11.0 (7)</td>
<td>14.0 (13)</td>
<td>4.2 (1)</td>
<td>18.6 (8)</td>
</tr>
<tr>
<td>Neutral</td>
<td>21.9 (14)</td>
<td>26.9 (25)</td>
<td>33.3 (8)</td>
<td>32.6 (14)</td>
</tr>
<tr>
<td>Cool</td>
<td>43.8 (28)</td>
<td>32.3 (30)</td>
<td>37.5 (9)</td>
<td>34.9 (15)</td>
</tr>
<tr>
<td>Cold</td>
<td>18.8 (12)</td>
<td>22.6 (21)</td>
<td>16.7 (4)</td>
<td>9.3 (4)</td>
</tr>
<tr>
<td>Not sure</td>
<td>3.1 (2)</td>
<td>4.3 (4)</td>
<td>4.2 (1)</td>
<td>2.3 (1)</td>
</tr>
</tbody>
</table>

In all scenarios, the largest group of RTAs occurred when the temperature was described as cool; the vast majority of all RTAs occurring when the temperature was described as neutral, cool or cold. As with the pilot work, the majority of the questionnaires were distributed over the winter months and so a higher than may be expected proportion of RTAs were associated with poor environmental conditions.
Study 1: RTA data collection.

Table 3.36 Scenario by road surface.

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=23)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes it influenced RTA</td>
<td>29.2 (19)</td>
<td>14.9 (14)</td>
<td>17.4 (4)</td>
<td>19.1 (8)</td>
</tr>
<tr>
<td>No it did not influence RTA</td>
<td>60.0 (39)</td>
<td>83.0 (78)</td>
<td>60.9 (14)</td>
<td>71.4 (30)</td>
</tr>
<tr>
<td>Not sure</td>
<td>10.8 (7)</td>
<td>2.1 (2)</td>
<td>21.7 (5)</td>
<td>9.5 (4)</td>
</tr>
</tbody>
</table>

Across all scenarios, the majority of RTAs occurred on roadways that did not influence the causation of the RTA. However, nearly a third of open roadway accidents were influenced by the condition of the roadway, whereas less than 20% of the RTAs occurring in the other scenarios were influenced by the condition of the roadway.

Table 3.37 Scenario by visibility restriction along the road.

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=93)</th>
<th>Y Junction or Slip road (N=22)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not restricted</td>
<td>56.9 (37)</td>
<td>63.4 (59)</td>
<td>81.8 (18)</td>
<td>83.3 (35)</td>
</tr>
<tr>
<td>Partially restricted</td>
<td>30.8 (20)</td>
<td>26.9 (25)</td>
<td>9.1 (2)</td>
<td>16.7 (7)</td>
</tr>
<tr>
<td>Severely restricted</td>
<td>12.3 (8)</td>
<td>9.7 (9)</td>
<td>9.1 (2)</td>
<td>0.0 (0)</td>
</tr>
</tbody>
</table>

As may be expected from Figure 3.11, the majority of the RTAs occurred in situations in which no visibility restrictions were present. In terms of visibility restrictions that were in evidence, open roadways exhibited a higher percentage of both partial and severe restrictions as compared to the other scenarios. These visibility restrictions were most commonly due to other vehicles on the roadway.
Study 1: RTA data collection.

Table 3.38 Scenario by did driver see other road user?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=92)</th>
<th>Y Junction or Slip road (N=22)</th>
<th>Roundabout (N=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>64.6 (42)</td>
<td>50.0 (46)</td>
<td>68.2 (15)</td>
<td>68.3 (28)</td>
</tr>
<tr>
<td>No</td>
<td>30.8 (20)</td>
<td>42.4 (39)</td>
<td>27.3 (6)</td>
<td>31.7 (13)</td>
</tr>
<tr>
<td>Not Sure</td>
<td>4.6 (3)</td>
<td>7.6 (7)</td>
<td>4.6 (1)</td>
<td>0.0 (0)</td>
</tr>
</tbody>
</table>

The majority of drivers across all scenarios stated they could see the other road user involved in the RTA. Of those that did not see another road user in the RTA, 50% were at T junctions and approximately a quarter were on open roadways.

Table 3.39 Scenario by was our driver unable to see other until too late?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=91)</th>
<th>Y Junction or Slip road (N=23)</th>
<th>Roundabout (N=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, unable to see until too late</td>
<td>48.4 (31)</td>
<td>42.9 (39)</td>
<td>30.4 (7)</td>
<td>29.3 (12)</td>
</tr>
<tr>
<td>No, could see</td>
<td>37.4 (22)</td>
<td>53.9 (49)</td>
<td>52.2 (12)</td>
<td>65.9 (27)</td>
</tr>
<tr>
<td>Not sure</td>
<td>7.8 (5)</td>
<td>2.2 (2)</td>
<td>4.4 (1)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>Not applicable, (single vehicle RTA)</td>
<td>9.4 (6)</td>
<td>1.1 (1)</td>
<td>13.0 (3)</td>
<td>2.4 (1)</td>
</tr>
</tbody>
</table>

For T junctions, slip roads and roundabouts the majority of our drivers could see the other driver involved. However, the largest group of drivers involved in RTAs on open roadways could not see the other driver in sufficient time, (31 drivers, 48.44%).

Table 3.40 Scenario by did driver see it too late to avoid collision?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=16)</th>
<th>T junction or Crossroads (N=33)</th>
<th>Y Junction or Slip road (N=9)</th>
<th>Roundabout (N=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>100.0 (16)</td>
<td>87.88 (29)</td>
<td>100.0 (9)</td>
<td>94.44 (17)</td>
</tr>
<tr>
<td>No</td>
<td>0.0 (0)</td>
<td>12.12 (4)</td>
<td>0.0 (0)</td>
<td>5.56 (1)</td>
</tr>
</tbody>
</table>

When subsequently asked, the majority of drivers in all scenarios stated that they saw the vehicle they were in collision with too late to avoid an RTA.
Study 1: RTA data collection.

Table 3.41 Scenario by did driver expect collision?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=19)</th>
<th>T junction or Crossroads (N=31)</th>
<th>Y Junction or Slip road (N=11)</th>
<th>Roundabout (N=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>68.4 (13)</td>
<td>71.0 (22)</td>
<td>72.7 (8)</td>
<td>81.3 (13)</td>
</tr>
<tr>
<td>No</td>
<td>0.0 (0)</td>
<td>19.4 (6)</td>
<td>9.1 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Not Sure</td>
<td>31.6 (6)</td>
<td>9.7 (3)</td>
<td>18.2 (2)</td>
<td>18.7 (3)</td>
</tr>
</tbody>
</table>

Of those that did see the other road user prior to the RTA they were asked if they expected the collision prior to its occurrence. For each scenario, the majority of our drivers expected the collision once the other vehicle was seen.

Table 3.42 Scenario by was driver driving too close to vehicle in front?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>6.2 (4)</td>
<td>5.3 (5)</td>
<td>12.5 (3)</td>
<td>12.2 (5)</td>
</tr>
<tr>
<td>No</td>
<td>55.4 (36)</td>
<td>56.4 (53)</td>
<td>54.2 (13)</td>
<td>58.5 (24)</td>
</tr>
<tr>
<td>Not sure</td>
<td>3.1 (2)</td>
<td>1.1 (1)</td>
<td>4.2 (1)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>Not applicable</td>
<td>35.4 (23)</td>
<td>37.2 (35)</td>
<td>29.2 (7)</td>
<td>26.8 (11)</td>
</tr>
</tbody>
</table>

The majority of drivers across all scenarios were not driving too close to a vehicle in front prior to the RTA. The next largest group across all scenarios were those that stated this question was not applicable as they were not following a lead vehicle. Of those junction related RTAs in which the drivers stated they were following a lead vehicle and were too close, twice as many, (by percentage across the scenarios) were at roundabouts or slip roads as compared to T junctions.

Table 3.43 Scenario by traffic volume.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=93)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>60.9 (39)</td>
<td>51.6 (48)</td>
<td>37.5 (9)</td>
<td>20.0 (8)</td>
</tr>
<tr>
<td>Medium</td>
<td>15.6 (10)</td>
<td>24.7 (23)</td>
<td>25.0 (6)</td>
<td>40.0 (16)</td>
</tr>
<tr>
<td>High</td>
<td>14.1 (9)</td>
<td>17.2 (16)</td>
<td>33.3 (8)</td>
<td>35.0 (14)</td>
</tr>
<tr>
<td>Traffic jam</td>
<td>9.4 (6)</td>
<td>6.4 (6)</td>
<td>4.2 (1)</td>
<td>5.0 (2)</td>
</tr>
</tbody>
</table>

In general, most of the RTAs on open roadways, at T junctions and on slip roads occurred when the traffic volume was low.
Table 3.44 Scenario by hindrance to traffic flow.

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=23)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No unusual hindrance</td>
<td>87.5 (56)</td>
<td>83.0 (78)</td>
<td>87.0 (20)</td>
<td>88.1 (37)</td>
</tr>
<tr>
<td>Some hindrance to traffic flow</td>
<td>12.5 (8)</td>
<td>17.0 (16)</td>
<td>13.0 (3)</td>
<td>11.9 (5)</td>
</tr>
</tbody>
</table>

Table 3.44 shows that between 12% and 17% of the RTAs occurred when there was some unusual hindrance to the traffic flow.

Table 3.45 Scenario by frequency of drivers passage along the route in question.

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=92)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>31.2 (20)</td>
<td>48.9 (45)</td>
<td>33.3 (8)</td>
<td>32.6 (14)</td>
</tr>
<tr>
<td>At least once a week</td>
<td>23.4 (15)</td>
<td>26.1 (24)</td>
<td>33.3 (8)</td>
<td>27.9 (12)</td>
</tr>
<tr>
<td>At least once a month</td>
<td>3.1 (2)</td>
<td>7.6 (7)</td>
<td>0.0 (0)</td>
<td>9.3 (4)</td>
</tr>
<tr>
<td>Several times a year</td>
<td>21.9 (14)</td>
<td>12.0 (11)</td>
<td>29.2 (7)</td>
<td>23.3 (10)</td>
</tr>
<tr>
<td>Extremely rarely</td>
<td>9.4 (6)</td>
<td>4.4 (4)</td>
<td>4.2 (1)</td>
<td>2.3 (1)</td>
</tr>
<tr>
<td>First time</td>
<td>10.9 (7)</td>
<td>1.1 (1)</td>
<td>0.0 (0)</td>
<td>4.7 (2)</td>
</tr>
</tbody>
</table>

In terms of the frequency of drivers passage along the route they were on at the time of the RTA, the largest faction for each scenario had driven along that route daily or at least once a week. When these two frequencies are combined, they account for between 55% and 75% of the RTAs. In general, across the scenarios, comparatively few drivers were involved in RTAs on roads they had driven along at least once a month or less frequently than that. However, for all scenarios, RTAs were more common on roadways that the drivers have used several times a year than at least once a month or extremely rarely. Of note is that of those driving along the route in question for the first time, the largest group were on open roadways; 10% of all open roadway accidents were on roads that the driver had never driven along before.
Study 1: RTA data collection.

Table 3.46 Scenario by how well driver knew road at time of RTA.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=65)</th>
<th>T junction or Crossroads (N=93)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very well</td>
<td>58.5 (38)</td>
<td>77.4 (72)</td>
<td>66.7 (16)</td>
<td>67.4 (29)</td>
</tr>
<tr>
<td>Quite well</td>
<td>16.9 (11)</td>
<td>16.1 (15)</td>
<td>29.2 (7)</td>
<td>23.3 (10)</td>
</tr>
<tr>
<td>Not very well</td>
<td>12.3 (8)</td>
<td>4.3 (4)</td>
<td>0.0 (0)</td>
<td>7.0 (3)</td>
</tr>
<tr>
<td>Not at all</td>
<td>12.3 (8)</td>
<td>2.2 (2)</td>
<td>4.2 (1)</td>
<td>2.3 (1)</td>
</tr>
</tbody>
</table>

As may be expected from Table 3.46 a similar pattern exists when considering how well the driver knew the road at the time of the RTA.

Table 3.47 Scenarios by model of vehicle involved.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=52)</th>
<th>T junction or Crossroads (N=83)</th>
<th>Y Junction or Slip road (N=16)</th>
<th>Roundabout (N=37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini/supermini</td>
<td>11.5 (6)</td>
<td>30.1 (25)</td>
<td>25.0 (4)</td>
<td>16.2 (6)</td>
</tr>
<tr>
<td>Small</td>
<td>21.2 (11)</td>
<td>21.7 (18)</td>
<td>6.3 (1)</td>
<td>27.0 (10)</td>
</tr>
<tr>
<td>Lower Medium</td>
<td>40.4 (21)</td>
<td>43.4 (36)</td>
<td>43.8 (7)</td>
<td>43.2 (16)</td>
</tr>
<tr>
<td>Upper Medium</td>
<td>25.0 (13)</td>
<td>4.8 (4)</td>
<td>12.5 (2)</td>
<td>25.0 (4)</td>
</tr>
<tr>
<td>Luxury Executive</td>
<td>1.9 (1)</td>
<td>0.0 (0)</td>
<td>12.5 (2)</td>
<td>2.7 (1)</td>
</tr>
</tbody>
</table>

For any given scenario, the most frequently represented vehicles were medium family sized cars. Small cars were proportionally more likely to be involved in RTAs at T junctions, whereas luxury or large family sized vehicles were more likely to be involved in RTAs on open roadways.

3.5.4.3 Contributory factors analysis by scenarios.

The following section describes the contributory factors in the RTAs in question categorised by scenario of the RTA. These include the behaviours of our driver and the other driver, (if applicable), that contributed to the RTAs occurrence.
Study 1: RTA data collection.

Table 3.48 Scenario by did another person behave in a careless manner?

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=66)</th>
<th>T junction or Crossroads (N=94)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>45.5 (30)</td>
<td>70.2 (66)</td>
<td>54.2 (13)</td>
<td>65.1 (28)</td>
</tr>
<tr>
<td>No</td>
<td>36.4 (24)</td>
<td>20.2 (19)</td>
<td>20.8 (5)</td>
<td>30.2 (13)</td>
</tr>
<tr>
<td>Not applicable</td>
<td>13.6 (9)</td>
<td>7.5 (7)</td>
<td>12.5 (3)</td>
<td>2.3 (1)</td>
</tr>
<tr>
<td>Not sure</td>
<td>4.6 (3)</td>
<td>2.1 (2)</td>
<td>12.5 (3)</td>
<td>2.3 (1)</td>
</tr>
</tbody>
</table>

For junction related incidents, the majority of our drivers stated that the other driver involved drove in a careless manner. Whilst this was also the case for open roadway incidents in a much higher proportion of these drivers stated that another driver was not driving in a careless manner.

Table 3.49 Scenario by did another behave in a confusing manner?

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=66)</th>
<th>T junction or Crossroads (N=92)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>13.6 (9)</td>
<td>20.7 (19)</td>
<td>20.8 (5)</td>
<td>33.3 (14)</td>
</tr>
<tr>
<td>No</td>
<td>71.2 (47)</td>
<td>65.2 (60)</td>
<td>62.5 (15)</td>
<td>61.9 (26)</td>
</tr>
<tr>
<td>Not applicable</td>
<td>13.6 (9)</td>
<td>3.3 (3)</td>
<td>12.5 (3)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>Not sure</td>
<td>1.5 (1)</td>
<td>10.9 (10)</td>
<td>4.2 (1)</td>
<td>2.4 (1)</td>
</tr>
</tbody>
</table>

In contrast however, the majority of drivers in all scenarios felt that the other drivers involved did not behave in a confusing manner. Up to one third of our drivers however did state that the driver was behaving in a confusing manner which may have helped to cause the RTA.

Table 3.50 Scenario by did our driver misjudge speed of other?

<table>
<thead>
<tr>
<th></th>
<th>Open Roadway (N=56)</th>
<th>T junction or Crossroads (N=88)</th>
<th>Y Junction or Slip road (N=19)</th>
<th>Roundabout (N=38)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>10.71 (6)</td>
<td>5.68 (5)</td>
<td>21.05 (4)</td>
<td>21.05 (8)</td>
</tr>
<tr>
<td>No</td>
<td>85.71 (48)</td>
<td>90.91 (80)</td>
<td>73.68 (14)</td>
<td>78.95 (30)</td>
</tr>
<tr>
<td>Not applicable</td>
<td>3.57 (2)</td>
<td>3.41 (3)</td>
<td>5.26 (1)</td>
<td>0.0 (0)</td>
</tr>
</tbody>
</table>

The majority of those drivers answering this question felt that they did not misjudge the speed of the other driver involved in the RTA. However, over 20% of the slip
Study 1: RTA data collection.

road and roundabout RTAs and 10% of open roadway RTAs were associated with our driver stating that they misjudged the speed of another road user.

Table 3.51 Scenario by did our driver misjudge distance to another.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway (N=26)</th>
<th>T junction or Crossroads (N=39)</th>
<th>Y Junction or Slip road (N=12)</th>
<th>Roundabout (N=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>19.2 (5)</td>
<td>7.7 (3)</td>
<td>25.0 (3)</td>
<td>40.0 (6)</td>
</tr>
<tr>
<td>No</td>
<td>76.9 (20)</td>
<td>92.3 (36)</td>
<td>75.0 (9)</td>
<td>60.0 (9)</td>
</tr>
<tr>
<td>Not applicable</td>
<td>3.9 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
</tbody>
</table>

Similarly, the majority of our drivers felt that they did not misjudge the distance to the other road user involved. The absolute numbers of responses for this question are lower than for the comparable questions and therefore conclusions from these data are tentative. However, it would seem that up to 40% of our drivers felt that they misjudged the distance to another road user and that this may have helped to cause the RTA. The rank ordering of scenarios between Tables 3.50 and 3.51 in terms of the percentage within each that felt speed or distance misjudgements were an issue is the same. This may indicate that there are specific, consistent problems across the scenarios.

The following tables represent summary tables for the errors made by both our driver and the other driver and reasons for our driver making these errors. Multiple errors may of course be made in any RTA and consequently may occur in combinations when considering scenarios. The percentage values given therefore represent the proportion of RTAs in each scenario in which the individual errors occurred. For each scenario, N represents the number of occasions in which this particular scenario occurred in the dataset as a whole.

Table 3.52 describes the nature of the errors made by our driver that may have led to the RTA. By far the most common behaviours noted are those associated with vehicle control. On open roadways, approximately 16% of RTAs were associated with our driver braking hard, and approximately 9% felt that they were unable to brake effectively prior to the RTA. A similar situation existed for T junction RTAs with approximately 14% stating problems associated with braking hard and 7% not
being able to brake effectively. Roundabout RTAs were also associated with failures in braking, but in contrast to the other scenarios, the proportion stating they could not brake effectively exceeded that of those who felt they braked excessively hard. Of all the scenarios, slip road RTAs are most associated with braking problems, 29% stating that braking hard was an issue and 12.5% stating that they were unable to brake effectively.

The proportions stating a failure to be able to steer effectively were more similar across scenarios, with between 7% and 12.5% stating this was an issue in the RTA in which they were involved.

Overall, relatively few drivers stated they made a manoeuvre from the wrong lane, however, 8.3% of those on slip roads did, equating to 50% of those who made this manoeuvre. In terms of those that were stationary or barely moving, the highest proportion by scenario were on roundabouts, (6 drivers, 14.3%), equating to 43% of those that were in this situation. An additional 7 drivers involved in RTAs at T junctions stated this factor was an issue in the RTA in which they were involved. Due to the relatively low numbers of drivers in the sample as a whole, definitive conclusions are difficult to draw, but it would seem that being stationary in a position in which the vehicle is endangered by others is not an infrequent problem in RTAs amongst the population sampled.
Table 3.52 Scenario by our drivers own errors.

<table>
<thead>
<tr>
<th>Error</th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=95)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Braked really hard</td>
<td>15.6 (10)</td>
<td>13.7 (13)</td>
<td>29.2 (7)</td>
<td>9.5 (4)</td>
</tr>
<tr>
<td>Deliberately drove in an erratic course, e.g. swerving to avoid something</td>
<td>4.7 (3)</td>
<td>3.2 (3)</td>
<td>4.2 (1)</td>
<td>4.8 (2)</td>
</tr>
<tr>
<td>Lost control of the vehicle e.g. by skidding on ice</td>
<td>10.9 (7)</td>
<td>4.2 (4)</td>
<td>12.5 (3)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Had difficulty steering effectively</td>
<td>9.4 (6)</td>
<td>1.1 (1)</td>
<td>12.5 (3)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Had difficulty braking effectively</td>
<td>9.4 (6)</td>
<td>7.4 (7)</td>
<td>12.5 (3)</td>
<td>11.9 (5)</td>
</tr>
<tr>
<td>Made a turn or other manoeuvre from the wrong lane, e.g. turning left from the outside lane of a roundabout</td>
<td>1.6 (1)</td>
<td>0.0 (0)</td>
<td>8.3 (2)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>Made a U turn or 3 point turn in an inappropriate place</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
<td>4.2 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Reversing in an inappropriate place, e.g. onto a main road</td>
<td>1.6 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Vehicle was either stationary or barely moving and in a position that would have endangered itself or other road users, e.g. waiting to turn at a busy junction</td>
<td>4.7 (3)</td>
<td>7.4 (7)</td>
<td>4.2 (1)</td>
<td>14.3 (6)</td>
</tr>
<tr>
<td>Drove the wrong way up a one way street or other restricted road</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Made some manoeuvre that you normally would not have done, e.g. you overtook in a more risky situation than you would normally have done</td>
<td>1.6 (1)</td>
<td>2.1 (2)</td>
<td>4.2 (1)</td>
<td>0.0 (0)</td>
</tr>
</tbody>
</table>
Study 1: RTA data collection.

Across all the scenarios, Tables 3.52 and 3.53 show that in general, the errors attributed by our drivers to other drivers involved were more frequent than those our drivers attributed to themselves. Of note especially are that 23.8% of drivers involved in RTAs at roundabouts and 25.0% of those involved at skip roads stated that the other driver involved braked really hard and this may have contributed to the RTA.
### Study 1: RTA data collection.

#### Table 3.53 Scenario by others actions.

<table>
<thead>
<tr>
<th>Action</th>
<th>Open Roadway (N=64)</th>
<th>T junction or Crossroads (N=95)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Braked really hard</td>
<td>12.5 (8)</td>
<td>10.5 (10)</td>
<td>25.0 (6)</td>
<td>23.8 (10)</td>
</tr>
<tr>
<td>Deliberately drove in an erratic course, e.g. swerving to avoid something</td>
<td>7.8 (5)</td>
<td>3.2 (3)</td>
<td>8.3 (2)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Lost control of the vehicle</td>
<td>6.3 (4)</td>
<td>10.5 (10)</td>
<td>0.0 (0)</td>
<td>7.1 (3)</td>
</tr>
<tr>
<td>Signalled in a misleading manner, e.g. turned without signalling</td>
<td>3.1 (2)</td>
<td>5.3 (5)</td>
<td>4.2 (1)</td>
<td>11.9 (5)</td>
</tr>
<tr>
<td>They did not brake effectively</td>
<td>7.8 (5)</td>
<td>22.1 (21)</td>
<td>8.3 (2)</td>
<td>26.2 (11)</td>
</tr>
<tr>
<td>They did not steer effectively</td>
<td>12.5 (8)</td>
<td>11.6 (11)</td>
<td>4.2 (1)</td>
<td>16.7 (7)</td>
</tr>
<tr>
<td>Made a turn or other manoeuvre from the wrong lane, e.g. turned left from the outside lane of a roundabout</td>
<td>4.7 (3)</td>
<td>5.3 (5)</td>
<td>0.0 (0)</td>
<td>14.3 (6)</td>
</tr>
<tr>
<td>They made a U turn or 3 point turn in an inappropriate place</td>
<td>1.6 (1)</td>
<td>2.1 (2)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>They overtook another vehicle in a place that you would not normally do</td>
<td>3.1 (2)</td>
<td>4.2 (4)</td>
<td>8.3 (2)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>They were reversing in an inappropriate place</td>
<td>3.13 (2)</td>
<td>1.05 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Their vehicle was in a position the would have endangered itself or other road users</td>
<td>6.3 (4)</td>
<td>9.5 (9)</td>
<td>4.2 (1)</td>
<td>19.1 (8)</td>
</tr>
<tr>
<td>They were driving the wrong way up a one way street</td>
<td>1.6 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>They ran off the road</td>
<td>1.6 (1)</td>
<td>2.1 (2)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>They made a manoeuvre that you would not have done, e.g. they overtook in a risky situation</td>
<td>10.9 (7)</td>
<td>12.6 (12)</td>
<td>8.3 (2)</td>
<td>9.5 (4)</td>
</tr>
</tbody>
</table>
Study 1: RTA data collection.

Problems associated with the other driver not braking effectively were associated with 22.1% of T junction RTAs and 26.2% of roundabout RTAs. However only 8.3% of slip road RTAs were associated with this factor.
**Study 1: RTA data collection.**

Table 3.54 Scenarios by reasons for the error.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Open Roadway (N=64)</th>
<th>T junction / Crossroads (N=95)</th>
<th>Y Junction or Slip road (N=24)</th>
<th>Roundabout (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distracted by looking for something in the vehicle</td>
<td>4.7 (3)</td>
<td>6.3 (6)</td>
<td>0.0 (0)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>Distracted by looking for street names or directions</td>
<td>1.6 (1)</td>
<td>2.1 (2)</td>
<td>0.0 (0)</td>
<td>7.1 (3)</td>
</tr>
<tr>
<td>Distracted by disturbances in your vehicle, e.g. children</td>
<td>1.6 (1)</td>
<td>2.1 (2)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Distracted by problems on your mind at the time</td>
<td>7.8 (5)</td>
<td>6.3 (6)</td>
<td>8.3 (2)</td>
<td>7.1 (3)</td>
</tr>
<tr>
<td>Felt tired or fatigued</td>
<td>12.5 (8)</td>
<td>5.3 (5)</td>
<td>12.5 (3)</td>
<td>7.1 (3)</td>
</tr>
<tr>
<td>Felt angry or annoyed</td>
<td>6.3 (4)</td>
<td>2.1 (2)</td>
<td>4.2 (1)</td>
<td>7.1 (3)</td>
</tr>
<tr>
<td>Felt unwell</td>
<td>1.6 (1)</td>
<td>0.0 (0)</td>
<td>4.2 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Felt depressed</td>
<td>3.1 (2)</td>
<td>1.6 (1)</td>
<td>4.2 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Difficulty in concentrating on driving</td>
<td>0.0 (0)</td>
<td>2.6 (2)</td>
<td>8.3 (2)</td>
<td>2.38 (1)</td>
</tr>
<tr>
<td>Were late and in a rush</td>
<td>6.3 (4)</td>
<td>6.3 (6)</td>
<td>4.2 (1)</td>
<td>7.14 (3)</td>
</tr>
<tr>
<td>Felt panicked</td>
<td>1.6 (1)</td>
<td>1.1 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Overconfident in your driving abilities</td>
<td>10.9 (7)</td>
<td>10.5 (10)</td>
<td>12.5 (3)</td>
<td>9.5 (4)</td>
</tr>
<tr>
<td>The road surface made the vehicle difficult to control</td>
<td>15.6 (10)</td>
<td>6.3 (6)</td>
<td>8.3 (2)</td>
<td>4.8 (2)</td>
</tr>
<tr>
<td>The road layout was misleading</td>
<td>3.1 (2)</td>
<td>4.2 (4)</td>
<td>4.2 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>The road signs were misleading</td>
<td>1.6 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
<td>4.8 (2)</td>
</tr>
<tr>
<td>Road signs were missing</td>
<td>3.1 (2)</td>
<td>0.0 (0)</td>
<td>4.2 (1)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>Poorly placed road signs</td>
<td>6.3 (4)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>Traffic lights were not working or were misleading</td>
<td>1.6 (1)</td>
<td>2.1 (2)</td>
<td>0.0 (0)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>There was another road user who caused the accident without themselves crashing</td>
<td>17.2 (11)</td>
<td>12.6 (12)</td>
<td>12.5 (3)</td>
<td>2.4 (1)</td>
</tr>
<tr>
<td>You were nervous when driving</td>
<td>1.6 (1)</td>
<td>0.0 (0)</td>
<td>4.2 (1)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>You could not avoid being in an accident</td>
<td>60.9 (36)</td>
<td>53.7 (51)</td>
<td>41.7 (10)</td>
<td>54.8 (23)</td>
</tr>
<tr>
<td>Pedestrians were crossing in an inappropriate place</td>
<td>1.6 (1)</td>
<td>1.1 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
</tbody>
</table>
In terms of those viewed to have made a manoeuvre from the wrong lane, 14.3% of the roundabout RTAs were associated with this factor, accounting for the single largest proportion of RTAs across the scenarios.

Errors associated with improper driving practices, such as overtaking in dangerous places or making manoeuvres that our driver would not normally do were more frequent than those same behaviours exhibited by our driver. However, in general given the sample size and the relatively low numbers assessed to make such errors firm conclusions across scenarios may not be made from these data. Whilst this contrasts with the work of Parker et al (1995) who associated RTAs with non malevolent violations of the highway code, it can be expected both that drivers may be unwilling to report all of these errors in a questionnaire of this nature, and, when given the option to report these behaviours in other drivers would do so.

Table 3.54 shows the reasons attributed by our drivers for the RTAs occurrence. Of note, is that between 41.7% and 60.9% of the drivers stated they were in a situation in which they could not avoid being involved in an RTA, and between 2.4% and 17.2% stated there was another road user present who effectively caused the RTA without themselves being involved. Additionally, between 9.5% and 12.5% of the drivers stated they were overconfident in their driving abilities and that this overconfidence may have contributed to the RTA. Thus although on face value these data suggest the major reasons for the RTAs relate to the driving of other drivers, a proportion of our drivers were prepared to admit that they were partially culpable by attempting manoeuvres that in retrospect they were not capable of. Finally, some of our drivers also admitted some degree of temporary impairment such as distraction or fatigue that affected their ability to drive the vehicle they were in.

3.5.5 Discussion of the main RTA causation study.

The aim of the main phase of the RTA data collection was to collect sufficient data to develop a decision support system to help a motor manufacturer make strategic decisions with respect to the development and implementation of primary safety technologies. In order to achieve this, sufficient data that would allow deduction of
Study 1: RTA data collection.

the factors underlying a range of RTAs were required. In addition, to facilitate a strategic approach to the development of primary safety technologies, sufficient data were required to determine the incidence of these factors in the causation of RTAs in the general driver population. The data collection tool employed was a self completion postal questionnaire and it was decided that in line with previous in-depth RTA studies, a minimum return sample of 1000 cases was planned for.

3.5.5.1 Method.

The pilot study demonstrated that the self completion questionnaire itself was effective in eliciting factors underlying the causation of a sample of RTAs. Our drivers were able to describe the RTAs in which they were involved, and could complete the questionnaire in a meaningful manner. Some problems existed with the structure of the questionnaire and the wording of some of the questions. The questionnaire was modified in the light of this work and distributed to a sample of drivers drawn from the one of the same populations as in the pilot work.

Although these changes were for the most part beneficial, it became apparent when coding the questionnaires for the main phase of the data collection, that additional modifications to the questionnaire may have been useful. In general, the questionnaires were completed fully by our drivers, however some questions still proved problematic and were answered incorrectly, (for example in the case of drivers describing visibility restrictions external to the vehicle when asked about those internal to the vehicle such as misting on the windscreen). Additionally some questions were inappropriately missed. The missing data was not consistent across all questions. For example in section 4 some of the respondents only ticked the check boxes to indicate that a factor was either definitely or maybe present, or that they did not know. The factors that were presumably not present were not always indicated to be not present. Percentage values of the factors present are therefore given according to the number of valid responses which varied from question to question.
Study 1: RTA data collection.

Some of the precoded responses were misunderstood by our drivers when they completed the questionnaire. Any problems with interpretation of these responses were thought to have been overcome throughout the piloting phase of the questionnaire development. It is likely that misinterpretation of these questions was due more to our drivers on occasion not taking sufficient care when completing the questionnaire rather than misunderstanding the question or responses. This is backed up by a number of discrepancies between the free recall section and section 2 of the questionnaire. In a small number of cases, obvious discrepancies occurred, for example a diagram of an accident scene at a roundabout may have not been subsequently accompanied by the driver ticking the questions relating to junction related RTAs appropriately. Additionally, in a number of cases the drivers would refer backwards to previous questions when asked about factors they felt that had previously answered when in fact a different factor was being questioned. This may have been due to the subtle nature of some of the distinctions between the factors being misunderstood by our drivers. For example, in the questionnaire, visibility restrictions were presented as being either external or internal to the vehicle. This distinction may not have been made by those completing the questionnaire and therefore each restriction was repeated for each question.

The respondents may therefore have felt the questionnaire to be too long and repetitious due to their misunderstanding of the nature of the factors. However, a number of factors were asked about twice since no objective data was present in the data set and an indication was required of the honesty of the responses. These included questions relating to whether our driver saw the vehicle in which they were in collision with and whether they felt tired or impaired before the RTA. Although insufficient data were collected to perform a statistical analysis of these responses, it would appear from an inspection of the data that these questions were answered consistently by the majority of respondents.

Other problems may have existed with the questionnaire. Our drivers were specifically asked to complete the questionnaire as fully as they could and were instructed to answer every question they were able to. For the majority of questions
in which ambiguities may have arisen, the drivers were given the option of answering 'Maybe' or 'Not Sure'. Some respondents may have inclined to answer in a more cautious manner, responding that factors may have been present when in actuality the likelihood of this was small. Alternatively, some may have been inclined to indicate that these factors were not present, (either by indicating so or not answering the question) when in actuality they were present but felt to be unimportant.

Many of these effects above would be minimised obtaining a larger sample of returned questionnaires. The effects of different biases amongst different respondents would thereby be minimised.

However, two sources of bias may exist that are potentially more problematic for the study. Firstly, the respondents may know the reasons for the RTAs but be unwilling to state these in a questionnaire. Secondly, the drivers may simply not know about the causation of the RTAs in which they were involved and may post hoc make attributions of the behaviours of themselves and others prior to the RTA.

With respect to the first bias, it would seem likely that a proportion of respondents acted in this manner. Were those responding to the questionnaire equally likely to be the active as passive participants in the genesis of the RTA, equal numbers of returned questionnaires would reflect this. However, inspection of the returned questionnaires indicates that a higher proportion of these are ones in which our driver was passive in the genesis of the RTA and were hit by another road user that may be regarded to be at fault in legal sense. This to some extent is inevitable as it is expected that our drivers would perceive themselves to be above average in driving ability, (see for example Svenson 1981) and therefore not liable for the RTA. Additionally, it is reasonable to expect that those that may be regarded to be at fault would not be as willing to respond to a questionnaire as those that were not at fault.

However, it can be seen that a proportion of those answering the questionnaire were being honest in their responses to the best of their ability. Some of our drivers were demonstrated to have behaved in a manner that would have been unexpected by
Study 1: RTA data collection.

other road users and may have contributed to the RTA. Additionally, it was demonstrated that some were driving whilst impaired in some manner, (for example by distraction or fatigue), and that they may have driven in contravention of the highway code, (by for example speeding). Collection of more data in this manner would allow a direct statistical comparison with the data collected by the Institute of Transports Studies in Leeds, (Carsten et al 1989, Southwell et al 1990). As the Leeds study concentrated specifically on urban RTAs, (and the factors were assessed by a team), an estimation of the relative numbers of the factors present in the two data sets for urban RTAs may be arrived at and thus the effects of conscious biases deduced. This estimation may then be applied to the data collected in the current study for those factors repeated.

This approach may also be used to deduce the effects of unconscious biases within the current sample. Since no objective data was accessible in the current study, a comparison with a known data set is the only manner in which the these data may be validated. Insufficient data were collected in the current study to justify a meaningful statistical analysis of the current data set with regard to previously collected data and therefore the effects of unconscious biases remain unquantified.

Finally, there is an enormous loss of data when coding RTA case files into a numerical database, (Clarke 1992, Clarke, Forsyth and Wright 1993). Such data include the wealth of qualitative data that cannot be entered into the data files, including in this case exact descriptions of the RTA, diagrams of the RTA scene and driver's spontaneous comments. The analyses above all rely on a statistical approach to determining the relative incidence of the factors and thus the qualitative data are not employed other than to check the coding when entering the data.

3.5.5.2 Sampling.

The population of drivers involved in RTAs accessible through the insurance department of a motor manufacturer was the only population accessible to the current study. As was demonstrated, the sample obtained was atypical of the general driving population, comprising as it did of a high percentage of middle aged, male,
company car drivers. In addition many of these drivers drive over the average distance that an average driver may be expected to drive in a year and are consequently exposed to more risk and an increased objective chance of being involved in an RTA. As was seen, they are typically involved in more RTAs than would be expected, and these RTAs occurred more frequently than would be expected in a population drawn from average drivers. At least in some part, the increased RTA involvement may be explained by these factors, but in addition, the nature of the relationship the driver has with the vehicle and the costs that the driver incurs may result in some drivers behaving in a more risky manner than the average driver. This study cannot therefore be viewed to be generalisable to the driving population as a whole, but may potentially be regarded as being representative of this population of drivers.

There are three issues relating to the sampling of the current study. Firstly, whilst the return rate was 21.1% and therefore slightly higher than comparable studies, (for example 19.7% by Southwell et al 1990) the absolute numbers of returned questionnaires was relatively low and was considerably less than was originally intended. Generalisations from the current sample to the population of drivers as a whole may not be achieved simply because of the sample size resulting. It is questionable given the resulting sample size if this study may be generalisable to the population from which this sample was drawn.

Additionally, a significant proportion of the questionnaires were returned by those involved in incidents that were not required in the current study, (for example their vehicle having been hit whilst unattended in a car park). Some of these inappropriate returns were not immediately obvious when reviewing the questionnaire and these caused considerable difficulties when coding the data for analysis. Finally, preliminary analysis of the insurance groups own data indicated that the required sample size was obtainable given the time scale of the current study. In actuality, the insurance group distributed one third of the required questionnaires in this time and thus a significant proportion of the desired population were not sampled. No
Study 1: RTA data collection.

information could be gained regarding the nature of the desired population as a whole, nor of which of these drivers were actually contacted.

In order to proceed with this methodology of questionnaire distribution and of data collection, the distribution procedures required tightening up, in terms of who the questionnaires are distributed to by including within the distribution all that are required and excluding those that are not required. As insufficient data were collected to determine with any degree of accuracy the relative incidence of human factors in the causation of RTAs only preliminary conclusions may be drawn from this work.

3.5.3.3 Results.

Trends in the pattern of RTAs were drawn from an analysis of the data rather than performing full statistical analyses of the RTAs. Descriptive analyses of the data showed that the respondents in general performed in a manner that they would have been expected to have done. In general for example, they felt that the other drivers were more culpable than themselves and felt that they would not have benefited from more experience of driving or of the vehicle in which they were travelling.

The RTAs studied were distributed between urban and rural areas and between roads characterised by low mean traffic speeds and higher traffic speeds. The single largest proportion of the drivers were involved in RTAs in urban residential areas, but open roadways were also highly represented. Approximately a quarter of the returned questionnaires related to RTAs not occurring in the vicinity of junctions whereas overall 35% were associated with T junctions. The majority of the sample involved at junctions were on the main road and not expected to stop at this junction. Overall, the RTAs were most commonly on straight, flat roads in the daylight, with good visibility and good weather conditions. In common with previous in-depth RTA studies, the situations in which our drivers were involved in an RTA could be described as those commonly found during normal driving.

The human factors associated with the genesis of these RTAs were deduced in more detail than has previously been published, and from the point of view of those
involved rather than an independent investigation team. Other drivers were perceived to be careless, although for the most part not confusing in their actions. A proportion of our drivers admitted to misperceptions of the others speed and admitted to speeding. Although not common, failures such as having difficulty in braking or steering effectively were admitted by our drivers. These same failures however were more frequently attributed to have been made by other drivers across all scenarios. Errors were attributed to have been caused in some part by a number of failings on the part of our drivers, for example distraction by problems on their mind at the time or feeling fatigued. Finally, although our drivers were involved in RTAs in situations which may be described as normal and everyday the majority of our drivers stated that the situations they were in were ones in which they could not avoid being in an RTA.

The RTAs did however, occur in a variety of different roadway scenarios. When analysed across the scenarios, patterns in the data emerged that may have been expected, for example front to rear impacts were more commonly associated with slip road and roundabout scenarios and front to side impacts with T junctions. In common with previous studies, the RTAs were distributed unevenly throughout the day and throughout the week, although the majority of the RTAs occurred when the traffic volume was assessed to be low.

Given that these situations were predominantly straight, flat roads, in good weather, and with no visibility restrictions, it would seem likely that either our drivers were simply not aware of the hazards sufficiently quickly, or either themselves or another driver made either dangerous manoeuvres or ones that brought about a conflict. In either case, our driver was not able to perform corrective actions sufficiently quickly. Given that it has been demonstrated that a better understanding of the antecedent events may be arrived at, and thus an understanding of these factors may be achieved, it is argued that appropriate RTA countermeasures may be designed.
3.6 Chapter conclusions and summary.

- A data gathering procedure was developed that allowed deduction of the factors underlying the causation of RTAs from the point of view of the driver concerned and in greater detail than has previously been possible.

- This self completion postal questionnaire was piloted successfully and modified accordingly.

- In parallel, a population of recently RTA involved drivers was identified and procedures established to allow this questionnaire to be distributed to these drivers shortly after they had been involved in an RTA.

- The questionnaire was then distributed to a sample of drivers and data was drawn to illustrate the nature of the human factors underlying RTA causation.

- The returned questionnaires were entered into a database for analysis and preliminary conclusions drawn pertaining to the nature of the factors relating to RTA causation for a sample drawn from the specified population.

The nature of RTA causation has been described for a sample of drivers drawn from a population of recently RTA involved drivers. Preliminary conclusions relating to these RTAs have been drawn and 4 specific scenarios investigated in more detail. Firm conclusions cannot be drawn from a sample of this size, however sufficient data were gathered to allow further work towards developing a methodology to determine primary safety strategy.
4.0 Study 2: Developing A Decision Support Tool.

4.1 Chapter summary.

This chapter is concerned with the third and fourth objectives of the thesis as a whole, namely to define a procedure for correlating RTA causation mechanisms and potential RTA countermeasures, and to develop this procedure so a motor manufacturer may utilise the methodology to determine their primary safety strategy. To this end, a series of Solutions Matrices were developed and subsequently used by employees of a motor manufacturer to build a strategy for primary safety system development. This chapter reviews the aims and objectives of this work before describing the studies undertaken and the contribution of this work to the thesis as a whole.

4.2 Introduction.

The overall aim of this thesis was to develop a methodology to enable a motor manufacturer to make strategic decisions in respect of the development of appropriate primary safety technologies. Specifically, motor manufacturers need to know which primary safety technologies would be potentially most effective in reducing the number of crashes on the roads. At present however, no method to assist in this decision making exists. As a consequence of this, and the development process of high technology being introduced into vehicles, much of the technology introduced into vehicles is decided upon in a non systematic manner. A tool to enable strategic decisions regarding appropriate primary safety technologies was therefore required.

In order to develop this tool, a novel RTA data collection procedure was developed and is described in Chapter 3. This data collection procedure enabled a greater
understanding of the causes of the RTAs and thus the actual needs of the drivers could be deduced.

Having determined the needs of the drivers, a decision support methodology detailing potential primary safety technologies was required in order to deduce which of these technologies would potentially be most effective.

This chapter addresses the development of this decision support tool. The methodology employed was developed from the HUFIT toolset, (Galer et al 1992), in which scenarios of use of systems are correlated against potential system functions in a functionality matrix. In the current context, potential RTA countermeasures were correlated against RTA scenarios as described by the results of the RTA data collection. When employing functionality matrices, one of the key aspects to their success is the quality of the descriptions of the information presented within them. In the current context, this represents the RTA scenarios and potential primary safety technologies. This chapter describes the development of these information sources and of the coding scheme employed in the completion of the matrices, through a pilot study and main study conducted with the assistance of the motor manufacturer. Following this, this chapter demonstrates how the data gathered in the RTA data collection study may be used to enhance the matrices in order to derive a strategy for primary safety system development.

4.3 Aims and objectives.

The aim of this phase of the work was to employ the real RTA data collected in the questionnaire survey to aid a motor manufacturer to make strategic decisions concerning primary safety system development.

The objectives of this study were:

• To develop a methodology to determine appropriate RTA countermeasures;
• To operationalise this methodology within a motor manufacturer;

• To deduce a preliminary outline for primary safety strategy within a motor manufacturer.

This chapter describes the pilot work and main work undertaken to develop the methodology to determine safety strategy, before describing the implications for strategy from the data collected.

4.4 Pilot study: Development of the Solutions Matrices.

4.4.1 Aim of the pilot study.

The pilot work for this study was concerned with the first two objectives above. Specifically, the pilot work developed the methodology to determine appropriate RTA countermeasures and made initial efforts towards operationalising this methodology within a motor manufacturer.

4.4.2 Pilot study method.

4.4.2.1 Experimental design.

To develop a safety strategy, a series of RTA scenarios needed to be cross referenced with a number of potential RTA countermeasures to determine which technologies were likely to be the most effective overall at reducing the number of RTAs. Only one decision making methodology specifically addresses system functionality in addition to user and task requirements, that being functionality matrices, (Galer, Harker and Ziegler 1992). The methodology chosen was modified slightly from the functionality matrices originally developed in the HUFIT Toolset, but retained essentially the same format. A brief description of the matrices outlining some example RTA countermeasures and scenarios is given below in Table 4.1. In
the current context, a series of functionality matrices were developed that detailed a number of RTA scenarios and RTA countermeasures. These were known as Solutions Matrices. A coding system was required that indicated the strength of the likely association between these two information types and thereby rated the effectiveness of the countermeasures in each RTA scenario.

To complete the matrices, groups of up to 6 people considered each RTA countermeasure in turn for a given RTA scenario. Assessments were made of the effectiveness of that RTA countermeasure with respect to its likelihood of preventing the RTA in question from occurring and the appropriate code marked in the sheet. This process was then repeated for a number of additional RTA scenarios. The overall effectiveness of any given RTA countermeasure was determined, when sufficient, appropriate RTA scenarios have been investigated and weightings relating to the frequency of occurrence of the individual factors applied.

Table 4.1 Schematic outline of the Solutions Matrices with example technologies and RTA scenarios.

<table>
<thead>
<tr>
<th>Accident Scenarios</th>
<th>Potential Accident Countermeasures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Level Stop Lights</td>
</tr>
<tr>
<td>T Junction at Night</td>
<td></td>
</tr>
<tr>
<td>Pedestrian in Roadway</td>
<td></td>
</tr>
</tbody>
</table>

4.4.2.2 Iterative development of the pilot study Solutions Matrices.

In addition to determining which RTA scenarios and countermeasures were to be presented in the Solutions Matrices, the nature of their descriptions required considerable development in order that the matrices accurately reflected these. An iterative development process was therefore undertaken in which the potential RTA countermeasures, the RTA scenarios and the coding system were continuously modified. This was performed simultaneously for the two information types in the
Study 2: Developing A Decision Support Tool.

Solutions Matrices, (RTA scenarios and RTA countermeasures), and for the coding system. For clarity, the development is presented here separately.

4.4.2.3 Development of the RTA countermeasures in the Solutions Matrices.

To derive a list of potential RTA countermeasures, a review of academic and trade literature was first performed. This included any countermeasures not based solely on the long term aspects of the drivers' behaviour, (and thus did not include such aspects as improved driver training), but did include transient aspects such as fatigue. Additionally, environmental changes such as roadway straightening were included. The methodology was devised for a motor manufacturer and thus of primary interest were those systems that a motor manufacturer may develop and implement themselves. When developing the method however, countermeasures relating to environmental modifications were initially included at the request of the motor manufacturer sponsoring this work.

This review produced a list of 53 potential countermeasures. These countermeasures, (when system based), were ones that motor manufacturers or suppliers were currently either implementing or researching the potential effects of, with the view of introducing them into vehicles in the near future. In essence, these were systems that a motor manufacturer may bolt onto the existing vehicles that would provide some form of driver assistance or driver support. Additional to these, were some non system based countermeasures. Typically these were environmental changes, (such as roadway design).

Due to the number of countermeasures identified, a categorisation system was required to structure the matrices and to facilitate completion and use of them. Several approaches were considered, for example categorising the countermeasures on the nature of the interaction with the driver, (e.g. Galer Flyte 1995, see Table 2.8), or by the nature of driver support the system provides, (Michon 1993).

Since the focus of the thesis as a whole was directed from a systems approach to driving, and most specifically within the driver vehicle interactions, a framework
that is consistent with this approach was employed to categorise the RTA countermeasures. Thus the systems were split into categories that could be described as either driver based, vehicle based, or environment based, or the interactions of each of these, (see Figure 4.1, based on Figure 1.1).

![Figure 4.1 Schematic outline of the Solutions Matrices domains including some example technologies.](image)

This allowed amendments to be made in the future in such a manner that would be of most use to a motor manufacturer. Most frequently, future amendments would be made by a motor manufacturer requiring information concerning a particular countermeasure either developed themselves, or by one of their suppliers. Whilst the
Study 2: Developing A Decision Support Tool.

The approach taken by the project is to design RTA countermeasures as indicated by the nature of the RTAs studied in the real world sample, the alternative approach of determining the efficacy of a novel system is equally likely to be employed by a motor manufacturer. Designing the matrix in the manner described below facilitated both approaches.

The domains in which the RTA countermeasures were described are represented in Figure 4.1, and briefly described below, (a full matrix is presented in Appendix 4);

Driver: These systems are directly concerned with the driver. Primarily, they assess the state or performance level of the driver at any time to determine the fitness of the driver to continue with the driving task. The purpose of the systems is to detect when the driver is either no longer safe to continue driving, or is becoming unsafe to drive, (for example the onset of fatigue or high levels of workload), so that appropriate remedial actions may be initiated. Additionally, countermeasures designed to reduce the effects of fatigue or excessive workload, or reduce fatigue from building up in the driver were included here.

Vehicle: These RTA countermeasures are those that are primarily improvements to the design of the vehicle itself over and above its current design or systems that monitor the functions of the vehicle. Thus, any improvements such as enhanced lights of a driver's vehicle or removing blind spots on the vehicle were included here. Although infrequent occurrences, systems that monitor the vehicle for failures were included within this category.

Environment: Countermeasures described under this heading were such as improved road surface quality or layout and were primarily out of the direct control of a motor manufacturer. For the pilot work however, they were included to attempt to determine their efficacy so that a motor manufacturer may have the data resulting for their consideration. These data would only be of indirect use to the manufacturer themselves, but were of relevance to producing a complete safety strategy.
Environment-vehicle interactions: These systems are mainly concerned with physical aspects of the driving task such as the alignment of the vehicle on the road and lane choice. Whilst some of these systems present information to the driver, (for example a parking aid system), the majority of these were concerned directly with modifications to the environment or the vehicles themselves. Examples of these are road surfaces or tyres with higher coefficients of friction which allow for better grip on the road for traction, steering and braking. As with RTA countermeasures in the environment domain, many of these are not within the control of a motor manufacturer but were included initially for completion.

Driver-vehicle interactions: These systems are mostly information input and output devices and are most typically what could be thought of as high technology in-vehicle systems. They may facilitate safety in vehicles by allowing a driver to input information to the vehicle in a less distracting way, (e.g. by using stalk input devices for controlling a car stereo), or by controlling the output of information to the driver in a manner which is less likely to cause distraction to the driver. Examples of these may be systems that are not yet implemented, such as Intelligent Cruise Control or systems that are currently in production vehicles such as automatic transmission. Additionally, novel interfaces designed specifically for drivers with special needs were included as they may facilitate the driving task for all drivers and thus improve road safety.

Environment-driver interactions: These systems are primarily designed to enhance the drivers ability to perceive the environment outside of their vehicle by either enhancing the view ahead directly or providing medium or long range pre-information not normally accessible to the driver. Included within this domain are such systems as route navigation systems as well as road side beacons or variable message signs, (VMS), providing information to the driver concerning the roadway ahead.

Driver-vehicle-environment interactions: For the most part, RTA countermeasures in this domain were already described in the other domains. However, some specific
systems were more appropriately described here due to the extensive nature of the interactions between the driver, vehicle and environment.

Additionally, space was left at the end of the matrices in this section for bespoke systems to be detailed by the participants. Most frequently, these were combinations of several systems previously described in the matrices.

This hierarchy was devised for the purposes of describing the countermeasures in a usable framework and was not intended to be indisputable for the purposes of assigning a given countermeasure to a specific domain. It is arguable in the case of many of the countermeasures whether a given system should be placed, for example within the vehicle or the driver-vehicle interaction domain. It was impossible to completely define many systems as belonging within any specific domain due to the nature of the interactions within the whole driver, vehicle and environment system. This was therefore a description of the RTA countermeasures from the point of view of producing a usable framework for the matrices development, rather than a description of the systems and their place within the driver, vehicle or environment domains as a whole.

4.4.2.4 Development of RTA information in the Solutions Matrices.

A list of driving scenarios was drawn up from a review of the literature, with special regard to situations in which RTAs were known to occur. Initially a series of three matrices were devised. These separately concerned the psychological, traffic and environmental scenarios that were determined to be linked to RTAs and defined these scenarios in a very specific manner. For example, fatigue or driving under the influence of alcohol were mentioned as specific psychological factors, T junctions were described as environmental scenarios and overtaking with an oncoming vehicle was described as a traffic scenario.

A matrix completion session was performed by the author. This refined the list by removing duplicates and modifying the definitions of some of the scenarios. This refined list was then used in a matrices completion session held at Loughborough
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University and subsequently the first matrices completion session held with the motor manufacturer employees at their premises.

Although the matrices had been developed and piloted before being presented to a population of employees of a motor manufacturer, the first session in which motor manufacturer's employees were participants was viewed to be a test for the remainder of the piloting sessions to determine if the underlying process was acceptable to a motor manufacturer and the process would be acceptable to their organisation.

The participants felt that the scenarios when described at the level of individual factors were too abstract to be of use to them in the completion of a matrix. Essentially, too many unknown variables had to be assessed simultaneously and the resulting assessments in the matrices were as a result too general to be of use. As a result of this, the descriptions of the scenarios were changed significantly. Real data from the questionnaire survey were then employed in subsequent sessions, the participants being given access to individual questionnaires from that survey for this purpose. RTAs were divided into 3 categories, (according to the most frequent RTA scenarios described in STATS19); T junctions, Roundabouts and non junction RTAs. Each matrices completion group received RTAs from only one of these groups to ease completion, these being presented as photocopies of the first two pages of each questionnaire. Six RTAs were chosen randomly for each session, the choice of the individual RTAs from within these six being determined by the participants themselves.

4.4.2.5 Development of the coding scheme.

Rather than simply stating that a given system would be effective or not, in order to produce a strategy for primary safety system development it was necessary to distinguish between potential effectiveness of systems at a number of levels. A coding scheme was required to identify the level of effectiveness of each of the RTA countermeasures. Functionality matrices typically employ a non numerical coding
scheme which avoids the preconceptions that numerical codes have regarding the strength of the associations within the matrices.

The coding scheme employed for this task was however a numerical one, as in this case the strength of association between the potential countermeasures and the RTAs was required. A strategic approach needed to reflect these associations so that overall an assessment of which countermeasures would be most beneficial. The participants were asked to rate the size of the likely effect with respect to preventing such an RTA in the future as being either small, medium or large, (1, 2 and 3 respectively). The coding scheme was presented as follows;

- Small effect. The system may not have prevented the RTA, but would have made the RTA less severe, for example by warning the driver earlier such that they could initiate braking more rapidly.

- Medium effect. The system would have had a strong likelihood of preventing the RTA.

- Strong effect. The system would almost certainly have prevented the RTA from occurring.

The ratings were intended to be ordinal in value, (i.e. 3 is a bigger effect than 1 but not necessarily 3 times the effect). This scheme was employed rather than a more abstract scheme because the ordinal nature of the ratings were of importance. A more abstract scheme as is usually employed in functionality matrices would not have been as appropriate as the strength of the effects could not easily be quantified. Additionally, a more abstract scheme would have complicated the process of strategy building from the completed matrices as weightings according to frequency of occurrence would be more difficult to apply to non numerical ratings.

The results were collated by totalling the number of times each number is present in the matrices columns rather than summing or averaging the columns. Thus the
Solutions with the largest number of 3 ratings are those that are most likely to be effective across the RTA scenarios listed.

4.4.2.6 Solutions Matrices completion procedure.

Participants were introduced to the study as a whole and the tasks to be undertaken by a 15 minute presentation prior to the completion of the matrices. This included details of the countermeasures and coding scheme and the purpose of the whole procedure.

Participants were each given a photocopy of the first two pages of six of the questionnaires for a given scenario to review before one of these was chosen by consensus of the participants for detailed consideration. (These 6 had previously been randomly selected from the returned questionnaires). A question and answer session was next undertaken in which the participants asked the experimenter for details about the RTA from the original questionnaire sufficient for them to gain what they felt was an accurate appreciation of the nature of the RTA. Following this, the matrix was completed for the first RTA, the participants being encouraged to refer back to the RTA questionnaire itself at any stage for clarification. When the group had completed the ratings, a further RTA was chosen. Each group completed two RTAs from those chosen per session.

4.4.3 Participants.

The initial matrices development work was conducted at Loughborough University. Three postgraduate Ergonomics students familiar with the functionality matrix technique refined the list of scenarios, and countermeasures and developed the coding technique.

For the main piloting work, the matrices were completed by groups of up to 6 employees of a motor manufacturer. The participants were drawn from a cross section of a motor manufacturer employees from such departments as Safety Strategy, Accident Research, Lighting and Concept Engineering. Where possible, it
was arranged so that each group had members from several disciplines and from a varying level of responsibility within the company. It was thus ensured that a range of responsibilities and experiences were present to be drawn upon. For the pilot work, 4 groups were convened at the motor manufacturer’s premises, each group lasting 2 hours.

4.4.4 Results: Iterative development of the Solutions Matrices.

The main objective of the pilot work was to develop the Solutions Matrices methodology with special regard to the nature of the descriptions of the RTA scenarios, the countermeasures and the coding scheme. Each of these were developed concurrently in an iterative process. The results of the pilot work are concerned with the modifications to that methodology and the iterative development of the information contained within the matrix. Typically, several modifications were made concurrently before the matrices were presented to the subsequent groups. The main modifications will now be described separately.

4.4.4.1 RTA scenarios.

In the first pilot session using motor manufacturer employees, the RTA scenarios employed were described in the simplest terms possible. The scenarios themselves were grouped into three categories, road traffic scenarios, environmental scenarios and psychological scenarios. Use of RTA scenarios described at this level of detail was in general too difficult to be undertaken meaningfully. Although the RTA scenarios were described very specifically, use of these scenarios in isolation was too vague to be useful in respect of determining the effects of possible countermeasures as too many other factors were unknown. Additionally, when considering upwards of 50 factors and 50 countermeasures, this process would have been too time consuming to proceed with to the point of gaining enough data to build a strategy.
Subsequently, real RTA scenarios from a random sample of the questionnaires were employed. The participants were able to extract information relating to the causes of the RTAs in question from the questionnaires and were able to use this information to complete the matrices. However, at this point, the participants were not asked to explicitly list the factors leading to each RTA. Weightings could not be applied to the codings for each countermeasure and thus a strategy could not be deduced from the data collected in this manner. For this reason, the analysis of the pilot data was not completed with respect to the determination of strategy.

The methodology to determine the factors relating to each RTA was however developed and utilised in the main Solutions Matrices completion sessions. 

4.4.4.2 RTA countermeasures.

Whilst the countermeasures information when described as systems was useful in the context of describing systems, to achieve the aims of the study a significant limitation was identified during piloting. Specifically, although this approach focused on the requirements of drivers to avoid RTAs, it focused primarily on what motor manufacturers were currently thinking of in terms of countermeasures or potential countermeasures. It was therefore not possible using this approach to design novel systems, but at best only existing systems could be accepted or rejected. Additionally, the design of these countermeasures as noted before did not focus on the causes of crashes as they occur now. Essentially, the manufacturers of these systems were proposing to add technology to a vehicle in an attempt to perform several functions to increase the marketability of these vehicles. Thus these systems were designed to perform several functions, only one of which was to attempt to reduce the number of crashes. However, as has been argued, these systems were developed from a technological perspective and thus they essentially attempt to prevent crashes without knowing why the crashes occur in the first instance.

The effect of describing the countermeasures in this manner was that the matrices completion groups were viewed by the participants as a means to reaffirm their own
decisions regarding a strategy for appropriate technology development rather than a means to decide on what appropriate strategy for technology development would be.

Additionally, it was clear that some of these potential solutions would have to be present on other vehicles in order to prevent an RTA. Thus, the matrix was effectively doubled in size by the addition of an extra column for each countermeasure for other vehicles involved in the RTA. In practice, as some of the RTAs involved more than 2 vehicles, only the vehicle nearest to 'our vehicle', (that belonging to the driver completing the questionnaire), was considered when completing the matrices. This was known as 'other vehicle' for the purposes of completing the matrices. Assessments of the efficacy of countermeasures for vehicles other than 'our vehicle' and 'other vehicle' were not made.

Finally, to distinguish between existing RTA countermeasures and the functional descriptions of those countermeasures, the term technological solutions was adopted to apply to the functional descriptions and the systems resulting from completion of the matrices.

4.4.4.3 Method of completion of the Solutions Matrices.

Overall, the first objective of the piloting sessions was achieved, in that it was determined that a motor manufacturer was able to complete the matrices in a meaningful manner and that the information resulting was potentially of use in building a strategy for primary safety system development. Additionally a number of modifications to the matrices and the processes involved in matrices completion were suggested which were incorporated in the main matrices completion sessions. Specifically, modifications to the coding scheme, the descriptions of the scenarios and the descriptions of the RTA countermeasures were made before the main matrices completion sessions.

Due to the nature and extent of the modifications required after the pilot, it was not possible to determine with any certainty the likely efficacy of any specific system or series of systems and thus a strategy was not developed. However, the procedures
and matrices themselves were modified to such an extent that future work, (that did provide useful data and enabled a strategy to be designed), was more easily performed.

4.4.5 Conclusions of the pilot study.

The objectives of this phase of the research were to develop a methodology whereby a motor manufacturer could decide upon primary safety system development strategy and to operationalise this methodology within a motor manufacturer.

Overall, it was concluded that the first objective was successfully achieved, in that a methodology was produced that was both acceptable, (to motor manufacturer employees), and usable, (by a motor manufacturer), that would enable a motor manufacturer at a future stage to determine which RTA countermeasures would be of most efficacy in preventing RTAs in the future. The second objective, to operationalise this methodology was partially achieved. A number of important modifications to the methodology and processes were implied as a result of the piloting which were incorporated in the main Solutions Matrices work.

4.4.5.1 Coding system.

The coding system employed in the pilot work required considerable modification prior to use in the main phase of the work. Firstly, the system needed to be modified to account for any negative effects that the presence of any of the countermeasures may have had. Secondly, in some cases, it was not possible to make an assessment of the efficacy of any given countermeasure, and the coding system needed to acknowledge this. Thirdly, some of the countermeasures would have had no effect on the RTA in question and a distinction was required between these countermeasures and those that could not be assessed for the RTA in question, (for example due to insufficient information). Finally, it was necessary to tie the questionnaire data and the Solutions Matrices more closely together. This was achieved by limiting the use of coding 3 to those situations in which the
questionnaire specifically mentioned that a factor was of importance in the aetiology of the RTA. Thus in the future, 3 was only coded when it was definitely known that this factor was of relevance to the RTA in question.

Overall, the time taken to complete the matrices was too long. Whilst some of the groups of participants were able to complete two matrices well within the time allowed, most groups struggled to achieve this. To alleviate this, participants were subsequently asked to complete the matrices as quickly as possible. This also reflected the fact that the data the participants were using was potentially biased, especially when concerned with other drivers actions. Making a quick judgement of the efficacy of a system precluded extensive debate about the factors underlying each RTA and allowed a more global, strategic approach to be taken.

4.4.5.2 Accident scenarios.

From the piloting, it was immediately apparent that the participants had considerable difficulty in utilising scenarios at the level of individual factors. However, using complete questionnaires was also problematic as it was not immediately apparent how to utilise individual questionnaire data to produce a methodology to determine overall safety strategy. In order to produce a strategy, it was necessary to not only know which RTA countermeasures were most useful, but how frequently each of these RTA countermeasures would be required in order to prevent RTAs. Thus, a mechanism was required to explicitly elicit these factors from the questionnaires that would allow subsequent determination of the frequency of these factors in the whole database.

This was achieved by defining the factors that lead to the RTA from the perspective of our driver. Thus for example, our driver may have been unable to anticipate the actions of another road user, or may have failed to anticipate their actions accurately. It was important to note that although it was possible to assign culpability in many cases no blame was implied at any stage to any of the drivers involved in the RTA. Errors and failures were defined as being actions that lead to an RTA occurring, that once described could be countered, but were not assigned as human failings per se. It
should be noted that RTAs in which our driver was the innocent party, (for example one on which our vehicle was hit by a car crossing its path inappropriately), were included. Although it would seem that there was little that our driver may have been able to do to avoid such RTAs, provision of appropriate information or interventions, may have been able to either avoid the RTA, or reduce the consequences of these RTAs.

4.4.5.3 Technological Solutions.

The main issue identified with respect to the RTA countermeasures was that of the nature of the descriptions of these in the matrices. In the piloting, the RTA countermeasures were described as technological systems currently in existence, or as potential systems being prototyped or simulated. Thus systems such as Autonomous Intelligent Cruise Control, (AICC), or forward mounted collision avoidance sensors were described as in the literature from which they were derived.

Whilst for the most part these systems were familiar to the participants, this approach has an important disadvantage in that it focuses on existing technology, which as has already been discussed has been developed from a technological rather than human perspective. Whilst the matrices techniques may be employed to determine the efficacy of such systems, (and indeed is likely to be used in this manner in the future by motor manufacturers), for the purposes of determining primary safety strategy and especially for producing novel systems this approach, focusing as it does purely within the framework of existing thought will not produce novel systems. In essence, this approach will only at best serve to confirm or dispute the efficacy of currently conceived systems.

To alleviate this, a functional analysis of the potential countermeasures was performed. These functions were described as being part of a hypothetical system that would allow the driver to perform certain actions when the systems were in operation. Thus the functions that a driver would need the vehicle to perform to prevent an RTA could be rated in the Solutions Matrices. It was necessary to
research these systems in some detail however to ensure that the functions that each system would perform were appropriately represented in the matrix.

As an example of this, when braking, ABS, (Anti-lock Braking System), constantly monitors the wheels and detects when they are skidding on the roadway. When skidding is detected, the brakes are automatically released for a fraction of a second before being reapplied in a manner very similar to but considerably faster than when a driver 'pumps the brakes' (i.e. the driver rapidly depresses then releases the brake pedal in an attempt to slow the vehicle without skidding). ABS effectively allows the drivers to steer the car when otherwise the car would skid and thus allows the vehicle to be manoeuvred around objects in the roadway. ABS would therefore be presented in the matrix as a system that 'prevents skidding under braking' and as a system that 'allows steering to be maintained under braking'.

The functional descriptions were then separated before being categorised as before into driver, vehicle or environment domains and the various interactions thereof as before. Since many of the existing systems could be split into more than one function, the size of the matrices was therefore considerably increased over those used than in the piloting. However, many of the new functions were repeated being performed by several systems in a slightly different manner. For this reason, the functions were redefined where possible and duplicates removed. The matrices were then reduced in size by removing several domains, notably the environment, (since the functions performed by RTA countermeasures described in this domain were out of the direct control of a motor manufacturer), and the driver-vehicle-environment interactions, (the systems previously described herein being broken into functions that more appropriately where described in other domains). Additionally, those functions within the vehicle that were directly concerned with monitoring the vehicle for failures were removed since vehicle failures are an extremely rare occurrence and did not warrant inclusion. In effect, these modifications resulted in a matrix only slightly larger than the initial matrices used in piloting which was felt to be manageable for the main study.
The change in emphasis from technology systems to functions of technology resulted in the matrices being more effectively utilised for the purposes of determining strategy. Rather than attempting to determine the efficacy of a given system or series of systems, or attempting to determine which would be most effective, combinations of functions could be more readily described. Thus, for any given RTA, a bespoke system could be developed from a combination of potential countermeasure functions. Throughout the course of the main solutions matrices sessions, the participants were therefore encouraged to make as many comments about individual functions as they felt to be appropriate and to make links between functions in order to build up novel systems from a series of linked functional requirements.

4.4.5.4 Procedure.

For the purposes of determining countermeasure efficacy, a distinction between the different drivers of the vehicles involved in the RTAs was required. The driver that completed the questionnaire under discussion was defined as 'our driver' and their vehicle 'our vehicle'. Other vehicles involved in the RTA and their drivers were therefore defined accordingly as 'other vehicle' and 'other driver' respectively. In the case of there being more than one other driver, only the driver of the vehicle in closest proximity to our vehicle was considered when assigning factors.

Since many of the functions relied on vehicles other than the one defined as being driven by the driver who completed the questionnaire having the systems, an additional column in the matrix was added for other vehicles for each individual function described. This thus acknowledged the possible effects of our vehicle on one other vehicle and one other vehicle on our vehicle when considering the effects of the RTA countermeasures.

An illustrative example of these effects is that of the differences in braking performance between disk and drum brakes. Most modern cars are now equipped with much more efficient disk brakes which were more widely introduced into production cars in the 1970s. Disk brakes are generally much more efficient at
stopping vehicles as compared to drum brakes, the effect of this being that stopping
distances are greatly reduced. In a line of traffic, if one vehicle is equipped with disk
brakes whereas the others are all equipped with drum brakes, it is likely, (given that
other factors are held constant), that the disk brake equipped car will be able to stop
more quickly than the drum brake equipped cars. Thus while the disk brake
equipped car will be potentially more able to avoid a hazard on the roadway ahead,
vehicles following it may not be able to avoid it, and thus the disk brake equipped
vehicle will be exposed to a change in risk as compared to the road traffic situation
prior to the introduction of such brakes. In the current context, our vehicle may be
behind or in front of the disk brake equipped vehicle in question which will have
implications for the nature and efficacy of RTA countermeasures when presented in
the matrix.

4.4.5.5 The use of groups to complete the Solutions Matrices.

The main advantage of completing the matrices in groups was that it allowed
discussion amongst a number of experts before conclusions regarding the system
efficacy were drawn. A group whose members were drawn from differing
backgrounds ensured a diversity of opinions and facilitated a more extensive range
of opinions than would have been possible with a more homogeneous group. A
group approach did have disadvantages however, in that considerable time was
required, (in terms of total man hours), and the resultant costs were correspondingly
high. However, the functionality matrices from the HUFT toolset on which these
matrices were based, were designed themselves to be completed by groups and it
was felt that the advantages of utilising groups in terms of the diversity of
information gathered far outweighed the disadvantages.

The procedure and materials for the second series of matrices completion groups
were altered in the light of the experience gained, and results from, the piloting
matrices. In addition to determining the efficacy of the method, changes in the
descriptions of the RTA countermeasures, the scenarios and the procedures were
also altered in the light of the piloting.
4.4.6 Discussion of the pilot study.

The first objective of the pilot work was successfully achieved; a methodology to determine appropriate countermeasures was produced and primary safety strategy derivation made possible by application of this methodology. The second objective was partially achieved in that considerable progress towards operationalising this methodology within a motor manufacturer was made. Significant modifications to the process of completing the matrices were made that enabled the main phase of the work to be undertaken. Although the matrices and the method of completion thereof were modified sufficiently to be utilised further, insufficient data were gathered to allow a strategy to be meaningfully developed at this stage. The data were not therefore weighted for this purpose at this stage.

4.5 Main Solutions Matrices study.

4.5.1 Introduction.

Having demonstrated the matrices methodology to be both effective in determining potential Technological Solutions and usable by a motor manufacturer for this purpose, the main phase of the Solutions Matrix sessions was aimed to produce preliminary requirements for Technological Solutions with a view to determining how effective this methodology would be for determining safety strategy. Thus the information gained in the main phase of the Solutions Matrices work was added to that gathered in the questionnaire survey, and preliminary conclusions concerning the safety strategy were drawn.
4.5.2 Aims and objectives.

The aim of the main phase of the Solutions Matrices work was to develop preliminary conclusions pertaining to primary safety strategy. To this end, two objectives were to be achieved:

- The Solutions Matrices completion methodology was to be operationalised within a motor manufacturer.

- A series of Solutions Matrices groups were to be completed such that sufficient data were gathered to draw preliminary conclusions pertaining to primary safety strategy.

4.5.3 Method.

4.5.3.1 Experimental design.

Having demonstrated that the Solutions Matrices were effective and could be used by motor manufacturer employees, the main phase of this work built upon the pilot work.

A series of nine Solutions Matrices completion groups were held over a week at the premises of a motor manufacturer. Each session lasted 3 hours and up to 6 employees participated.

4.5.3.2 Participants.

The participants were all employees of a motor manufacturer. Each individual group was arranged so a broad range of disciplines and responsibilities were present and in addition, each group contained at least one individual that had previously been involved in the pilot work.
4.5.3.3 Procedure.

Four categories of RTAs were chosen for the main matrices work; namely open roadways, T junctions and crossroads, Y junctions and slip roads and roundabouts. Together, these categories accounted for the 83.6% of RTAs within the RTA database, (see Table 3.14). Each group considered only one category of RTA and each participant chose one questionnaire at random from the category under investigation from the whole population of drivers within that category.

The Solutions Matrices completion sessions were started with a fifteen minute presentation concerning the nature of the project, the aims and expected outcomes of the session. Since this work was designed as a follow on exercise from the questionnaire survey, a detailed description of the questionnaire itself was next given together with some definitions of the factors that may underlie an RTA.

Following this, for the category of RTA scenario under investigation at the time, six questionnaires were randomly selected from the RTA database and distributed one to each of the participants of the matrices session.

The participants were then allowed 10 minutes each to review the questionnaire and make some notes on important contributory factors. The nature of the factors and the manner in which they were to be described were each again emphasised at this stage.

Each participant then briefly presented the RTA to the other participants and listed the most salient factors contributing to it. Some of the participants being more familiar with the processes of RTA investigation or with this project itself, produced considerably more detail than others and frequently questioned other participants concerning the RTAs they had reviewed. This was proceeded with only to the point of ensuring that all present had a good understanding of both the questionnaire and the nature of the descriptions of factors impinging on the RTAs. Detailed examination of the RTAs was reserved for later in the sessions.
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At this stage another fifteen minute presentation was given which principally focused on the matrices and the nature of the actions required by those participating in the sessions. Thus, having described and discussed the RTA scenarios, the functional nature of the Technological Solutions and the coding scheme to be employed were described more fully. The participants were then asked if their understanding of the matrices and the required tasks was sufficiently complete and they were given the opportunity to ask such questions as they felt necessary to supplement their understanding of the task in hand.

One of the questionnaires was then selected for detailed discussion. In practice, since each of the groups contained at least one participant who had previously been involved in the piloting, the selection of the RTA to discuss at this stage was not random within the 6 possible RTAs. Most frequently, the RTA chosen was that described by the participant that had previously been involved in piloting. This participant was then designated to be the leader for this particular RTA and was given the task of coding the matrices for this RTA. With the assistance of the other participants, the leader was then asked to list the contributory factors that were implicated in the causation of the particular RTA under consideration. The participants were required to describe these factors at the level of the errors or behaviours made by our driver rather than those of any others involved. Thus for example, in the case of another driver hesitating at a junction and our driver colliding into the rear of this vehicle, the factor would be listed as our driver failing to observe the other, or misinterpreting their actions, rather than the other driver hesitating.

Ideally, the participants of the matrices completion groups should have been familiar with the factors as outlined by Carsten et al (1989). However, pragmatically this was not possible due to time constraints; prodigious additional efforts would have been required to familiarise the participants with the definitions of the factors as intended. However, defining the factors at the level of our driver's failures most closely matched the definitions of the contributory factors as defined by Carsten et al.
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(1989). In addition, defining the contributory factors at the level of the errors and behaviours of our driver allowed a focus on our driver from the point of view of defining appropriate functional technological solutions. Thus in the example above, our driver may be warned that the other driver had not proceeded at the junction, or our vehicle may have prevented our driver from attempting to pull away when there was a vehicle stationary ahead. There is therefore no reliance upon the other vehicles involved being equipped with any additional primary safety technologies and our vehicle and driver may therefore avoid an RTA irrespective of the nature of the lead vehicle.

At any stage all the participants were encouraged to ask questions both of the experimenter and leader and were asked to refer back to the original questionnaire if required. The coding scheme for the matrices was as follows:

- X Function not applicable. The participants were encouraged to strike through any functions that were deemed to be inapplicable for the current RTA in question. This was largely to save time, since quite frequently the participants worked through the matrices in a non linear manner, i.e. rather than starting at one end and working through it solution by solution, the participants frequently would move to specific areas of the matrices first. This was especially evident after each group had completed the first RTA for each session. The participants being more familiar with the matrix as a whole and especially the functions contained within it would frequently either remove functions they felt were ineffective then concentrate on efficacious ones, or vice versa.

- ? Not known, (the participants were not able to make an assessment of the function given present knowledge).

- + Positive effects, (the functions would have contributed towards preventing the RTA).
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- Negative effects, (the functions would have contributed towards making the RTA worse).

Rate either as 1,2, or 3 depending on the size of the effect, (i.e. small, medium or large effect).

The participants were instructed that they were only to code 3 for a given technological solution if it was known from the questionnaire that the factor they were considering was definitely associated with the underlying causes of the RTA. For example in the case of our driver affirming that they were fatigued prior to the RTA, technological solutions relating to fatigue could be coded 3. If fatigue was not stated to be a factor in the RTA, the participants were instructed that they could only code 1 or 2 even if they were highly suspicious of the effect of fatigue. Additionally, when considering the efficacy of any specific function, the participants were instructed to be overly cautious when any disputes arose concerning the codings thereby ensuring functions that may have a positive effect are included rather than excluded at this stage. With reference to the aims of the project, it was felt more important that potentially useful systems were included at this stage, (then possibly removed at a later stage), than being removed now and thus being discarded. To this end, the participants were encouraged to make any amendments to the Technological Solutions as they felt were required. Thus for example, they were encouraged to specify the functions in more detail, and to link the functions together wherever was deemed necessary. In addition, the participants were asked to define new functions where they felt these to be necessary.

Additionally, the participants were instructed to code each functional technological solution quickly where possible rather than debating specific issues at depth. By proceeding in this manner, it was acknowledged that the data from which factors were elicited, (i.e. the questionnaires) were both subjective in nature and potentially biased. This was especially important when considering the actions of any other drivers involved in the RTA. Whereas the participants had some data concerning the
actions and motivations of our driver in the time period immediately before the RTA. Any such data regarding other drivers had to be treated with more caution.

Once the Solutions Matrix had been completed for the first RTA scenario chosen, it was reviewed briefly to ensure that all relevant comments had been elicited before a brief review of the resultant functionality produced. Additional RTAs were then chosen from the original questionnaires reviewed and the process repeated. The groups normally completed two RTAs per session, although in some cases a third RTA was attempted.

4.5.3.4 Data analysis.

The data analysis proceeded in three phases. Firstly, the ratings for each individual RTA were combined to produce a series of functionally defined Technological Solutions for that RTA. Secondly, an estimate of the likely efficacy of each functionally described technological solution was derived by determining the relative frequency of occurrence of each RTA in terms of its scenario, (as defined in Table 3.12) and the contributory factors leading to each individual RTA, (as in Tables 3.13 to 3.54). Finally, the ratings for each scenario were combined with the frequency data to produce a preliminary outline for a strategic approach to primary safety system development.

4.5.4 Results.

4.5.4.1 Nature of the functionally defined Technological Solutions.

This section will deal with the nature of the RTAs under investigation and the resultant Technological Solutions. An example of one specific RTA will be used from each scenario presented to the participants of the Solutions Matrices completion sessions. In each case, the RTA is first described, followed by the contributory factors as assessed by the participants of the Solutions Matrices completion groups. Finally, the functions that a Technological Solution would require are described.
4.5.4.2 Open Roadway: Case number 131.

This RTA occurred on the nearside lane of the M74 heading north at approximately 11.30 PM on a Friday evening. Our driver had worked a full day before embarking on a trip that he expected to take approximately 4 1/2 hours but due to heavy congestion on the M6 heading northbound had taken 7 hours to that point. He stated that he was fatigued, was distracted from driving by problems on his mind at the time, had difficulty in concentrating on driving and was overconfident in his abilities. There was very little traffic on the motorway at the time of the RTA, our driver stated that he saw a vehicle approximately 2-300 yards ahead which he felt was travelling too slowly on a motorway, (50 mph or less). Our driver nevertheless believes he “momentarily fell asleep whilst driving” and consequently although he braked, he saw the vehicle in front too late to avoid it. Furthermore, our driver states that he “cannot pass on much of the blame for this accident”.

The participants felt that these were the main factors impinging on this RTA;

- Fatigue.
- Failure of our driver to control his vehicle.
- Lack of judgement of the speed of and distance to the other vehicle.
- Failure to observe the other vehicle properly.
- Lack of concentration of our driver.

In terms of technological solutions, two main approaches were identified. Firstly, systems to reduce our driver’s fatigue could be implemented such as a route guidance system that would have re-routed the driver so that the extra delay did not occur, (rated as +3). Additionally, appropriate warning of the onset of fatigue may allow our driver to take corrective action, (+3).
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Alternatively, given that our driver was fatigued and may not have been able to determine the speed of and distance to the vehicle ahead, some driver assistance may have aided our driver avoiding the crash. Increasing braking efficiency (+2) or detection of the need for and automatic application of braking (+3) both were deemed to be potentially effective. Warning the driver of the need for braking was viewed to be potentially effective either by an object detection system, (+3), or via a novel system that warns the driver of a dangerously high closing speed, (such as by flashing the speedometer of our vehicle, +3). Given that our driver was fatigued, it is questionable as to the efficacy of such warnings however. Finally, given that the motorway was clear apart from the two vehicles in collision, a system that communicates between the vehicles to allow each to inform the other of their speed and path may allow the vehicles themselves to take corrective action, (+3). An ‘automatic swerving’ system was suggested to be of some use, (+2), though conventions would need to be established as to which vehicle swerved and the direction of this manoeuvre.

4.5.4.3 T junctions: Case number 188.

In this RTA, in heavy rain, our driver had followed the other vehicle for approximately half a mile through a small village that he knew reasonably well, when the other driver slowed as if to turn right off the main road into a side road. Our driver was unsure if the other driver was indicating right or not, and when the other driver stopped to allow a third vehicle past in the opposite direction, our driver applied the brakes heavily on his car, “I braked heavily and skidded on leaves”. Our driver admitted that the other driver did not do as he expected, “Beware other drivers do not do as you expect”, but believed he was driving correctly and “did not appreciate how many leaves were on the road surface”.

The participants viewed the following factors to be of relevance:

- Our driver misjudged the road surface, due to both heavy rain and the presence of leaves on the road.
Study 2: Developing A Decision Support Tool.

- Our driver misjudged the speed and path of the other driver, (had not appreciated the rate of deceleration of this vehicle).

Two major contributory factors were noted in this RTA, that our driver did not appreciate the rate of deceleration of the other vehicle until too late and once our driver had become aware of the need to slow, our driver was unable to slow sufficiently due to the road surface. A system that would allow our vehicle to brake more rapidly than is currently possible, especially under poor road conditions, (both rated +3) was noted to be effective. A system to detect the road surface friction was also identified as being useful, (+3), as were systems that communicate this between vehicles and the roadway, (+2) and between the roadway and approaching vehicles, (+2). A system that maintains a safe stopping distance between vehicles was noted to be useful, (+3), as was automatic indication of direction change for the other vehicle, (+2), perhaps combined with more visible brake and indicator lights on this other vehicle, (+2 for each respectively).

4.5.4.4 Slip roads: Case number 130.

This RTA occurred 3 miles into a 95 mile journey at approximately 6 pm in October. Our driver had left a 30 mph residential area and was on the outside lane of a slip road about to join a 60 mph dual carriageway. Our driver saw a vehicle ahead that was accelerating to join the carriageway in the near side lane, glanced towards his off side mirror to check that the dual carriageway was clear to join and on looking forward again, saw that the other vehicle had swerved across his path and slowed considerably. Our driver braked hard, but could not swerve into the carriageway to avoid the vehicle as the dual carriageway was busy and could not avoid an impact with the front of his car hitting the rear offside of the other car.

The factors impinging on this RTA were assessed to be;

- Our driver failed to adequately observe the other driver.

- Our driver failed to adequately anticipate the speed and path of the other driver.
Study 2: Developing A Decision Support Tool.

- The road layout at that junction is misleading; a motor dealer’s exit is on the edge of the slip road. Traffic attempting to merge with the dual carriageway must observe traffic moving at a very much slower pace leaving the motor dealer’s premises.

- Significant visibility restrictions exist along the slip road due to the gradient of the road and a sharp corner on it.

The main technological solutions identified as being potentially of benefit concerned the braking performance of our vehicle, overall, shorter stopping distances were rated at +3. Detection of and enhancement of emergency braking were both rated at +3 for our driver, (although one group rated this function as -2 for the other vehicle unless our vehicle additionally had the system). Systems that would detect an object to the front of our vehicle were rated +3, as were automatic braking systems that would have detected the vehicle and applied our vehicle’s brakes. Finally, vehicle to vehicle communications, thus enabling faster reaction by either our driver or our vehicle were rated +3.

4.5.4.5 Roundabouts: Case number 186.

This RTA occurred when our vehicle ran into the rear of the other vehicle as the other vehicle was attempting to join a busy roundabout in Monday morning rush hour traffic. Our driver, (a 35 year old automotive engineer), stated that he knew the roadway well, (he was driving to his normal place of work) and he felt the cause of the RTA to be the other driver being indecisive. Having just left a busy dual carriageway, our driver stated that the “driver in front hesitated when attempting to join the roundabout traffic, missed his opportunity and stopped suddenly... I attempted to brake very quickly as the other driver in front had started to move then stopped suddenly”. Our driver did feel some liability for the RTA, he felt that he should have maintained a larger distance to the vehicle in front and he should not have attempted to read the traffic for him. Additionally, whilst our driver felt that the situation was one in which he could not have avoided being in an RTA, he admitted
that immediately prior to the RTA, he was attending to the roadway to the right on
the roundabout rather than the roadway and vehicles ahead of him and, that he was
frustrated by the traffic situation and that he was maybe overconfident in his driving
abilities.

The factors that the participants felt were pertinent to the current crash were as
follows;

- Our driver was frustrated.
- Our driver failed to observe the roadway appropriately.
- Our driver was overconfident.
- Our driver failed to correctly anticipate the other vehicle, (speed and distance).

Countermeasures deduced for this RTA would have one of several functions. Firstly,
from the perspective of the other driver, either a decision support system of some
form would enable the other driver to make a more timely, (and potentially accurate)
assessment of the traffic flow at the roundabout, or an intervention system would
prevent this driver from starting and stopping a manoeuvre. Both of these were rated
as highly beneficial, (+3).

From the perspectives of our driver, his attention could be brought to the stationary
vehicle ahead in a sufficiently timely manner to enable him to avoid the stationary
vehicle, for example with a forward mounted object detection system, (+3) or via
vehicle to vehicle communications, (rated as +3 for our vehicle and +2 for the other
vehicle). Alternatively, an intervention may be designed that would enable our
vehicle to avoid the collision, for example a system that maintains appropriate safe
headway, (+3), or one that prevents our vehicle from starting a manoeuvre, when a
vehicle ahead is not travelling sufficiently quickly to clear the junction, (it was not
clear whether our driver was moving at all times prior to the RTA or started to
move when the other driver started to pull away). Both systems were rated +3.
4.5.5 Towards a strategy for primary safety system development.

4.5.5.1 Summary ratings for ‘our driver’ for required Technological Solutions.

Tables 4.2 to 4.7 present a summary of the ratings for the technological solutions considered in the matrices completion sessions across all scenarios. In order to present sufficient data to allow meaningful discussion, these include ratings for all the RTAs in the matrices, rather than being restricted to those described in sections 4.5.4.2 to 4.5.4.5. For simplicity, only those technological solutions that were deemed to be effective are presented here and the ratings shown are only for our vehicle. The values presented are the frequency of occurrence of the ratings, i.e. the number of occasions in which +3 for example was rated for each technological solution. In total, 10 individual RTAs were assessed, the maximum score for any individual rating being 10 ratings of +3. The tables present these technological solutions as entire systems, these systems at their heart being based around the functional descriptions in the matrices. The systems are grouped into the tables according to the similarity of their operation and additionally, where possible the systems are presented in the tables in order of increasing intervention, the systems at the top of the tables being warning based whereas the systems presented lower down being those that would automatically intervene.

Table 4.2 Technological Solutions concerning driver performance.

<table>
<thead>
<tr>
<th>Technological solution</th>
<th>+1</th>
<th>+2</th>
<th>+3</th>
<th>-1</th>
<th>-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection of mental and physical fatigue, (both induced by driving and prior to driving)</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System to reduce fatigue build-up, (automatic gearbox, automatic climate control)</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>System that warns driver of their violation of the highway code, (violation has occurred or will occur unless the driver acts appropriately)</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention to prevent violation of highway code, (e.g. red light running, speeding)</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As table 3.12 shows, 8.9% of the RTAs in the database were related to fatigue, yet 9 of the 10 RTAs considered in the Solutions Matrices work would have been positively influenced by a system that reduced the build-up of fatigue in our driver. Of note, is that in one case, potentially negative effects were noted. This was described as the possible effect of reduced arousal leading to drowsiness and an increased chance of an RTA. Detection of a currently fatigued state was noted to be effective in 3 out of the 10 cases, but this is still approximately three times what would have been expected from table 3.12. Violations of the highway code were noted to be infrequently effective, only one RTA scoring +3 for this function.

Table 4.3 Technological Solutions concerning visibility of the vehicle and visibility from the vehicle.

<table>
<thead>
<tr>
<th>Technological solution</th>
<th>+1</th>
<th>+2</th>
<th>+3</th>
<th>-1</th>
<th>-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>More visible brake lights, (flash rate indicating braking intensity, variable intensity lights, ‘fill bar’ type lights)</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased power of forward lights</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vision enhancement of roadway, (enhanced visual overlay of roadway information, or night vision enhancement)</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass that reduces rainwater and snow from adhering to it</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass that reduces glare from external sources</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System automatically optimising lighting of vehicle</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System that detects rain and automatically adjusts wiper speed appropriately</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although more visible brake lights may serve to warn a following driver that a vehicle ahead is braking more effectively, in the RTAs studied our drivers did not notice that a lead vehicle was slowing as the drivers were not attending to it, prior to the RTA, (for example case number 186). As the majority of the RTAs studied
occurred during the daylight, increased power of the forward lights was not viewed
to be very effective, although vision enhancement was regarded to be more effective.
This vision enhancement was suggested to be a head up display which not only
presented a visual overlay of the roadway ahead, but presented the driver with
additional information such as may be presented by a route navigation system that
would warn the driver of an impending hazard. The effects of glare and poor lighting
were in general not felt to contribute to the causes of the RTAs studied and were in
consequence not noted to be effective in preventing them.

Table 4.4 Technological Solutions based on enhanced vehicle performance and
handling.

<table>
<thead>
<tr>
<th>Technological solution</th>
<th>+1</th>
<th>+2</th>
<th>+3</th>
<th>-1</th>
<th>-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>System that prevents skidding when braking</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System that allows shorter stopping distances</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System that allows steering to be maintained under braking</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System helping to maintain optimum roadway position with respect to centre of lane and other vehicles, (laterally)</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>System helping to maintain optimum roadway position with respect to choice of lane and other vehicles, (laterally)</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System maintaining traction under varying/poor conditions</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>System automatically optimising braking under varying/poor roadway conditions, (detection of low friction co-efficient on roadway)</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>System that automatically enhances braking efficiency, (detection and enhancement of panic braking)</td>
<td></td>
<td></td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Tables 3.8 and 3.52 show that overall, braking failures were the most common errors
across all scenarios although our drivers in general did not skid whilst braking. The
majority of the RTAs occurred on roadways with a good surface level of friction and therefore systems that would prevent skidding while braking were not frequently rated to be effective. Systems that allow shorter stopping distances were rated to be very effective, (+3), in 6 cases but were noted in one case to be potentially disadvantageous, (in the case of close following vehicles). Systems that automatically optimise braking efficiency by for example detecting the state of the roadway and automatically applying the brakes appropriately were noted to be very effective in 4 cases. This system when combined with a system that allows steering to be maintained under braking would be most similar to the operation of Anti lock Braking Systems, (ABS), currently available, although the steering functions of ABS were not noted to be frequently effective.

A system that detected panic braking by our driver and automatically enhanced braking efficiency in this situation was noted to be very effective, (+3) in 4 cases, and moderately effective, (+2) in 3 cases. Such systems have however been introduced recently in some vehicle and have proved ineffective due to the high rate of inappropriate system operation. Several caveats to the introduction of such systems were required, most notably that the systems only operate when required and that the rate of false system activation’s should be as low as possible.

Analyses of the 10 RTAs studied show that in the majority of cases, our driver was not able to brake as efficiently as they would have liked to do once they became aware of the need to initiate braking. This would suggest that either the efficiency of brakes should be increased in order to allow our drivers to brake sufficiently well or that our driver’s attention should be brought to the need to brake more rapidly. The work of McKenna suggests that the critical failures involved in RTAs are related to failures in hazard perception which would indicate that provision of driver support in hazard perception would be beneficial. Table 4.5 illustrates some of the potential technological solutions targeted specifically at providing driver assistance in hazard perception.
Table 4.5 Technological Solutions based on providing enhanced environmental information to the driver.

<table>
<thead>
<tr>
<th>Technological solution</th>
<th>+1</th>
<th>+2</th>
<th>+3</th>
<th>-1</th>
<th>-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>System providing information concerning the nature of the roadway ahead of vehicle,</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(normally out of sight)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System that detects objects to the side of the vehicle</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System that detects objects to the rear of the vehicle, (including C pillar blind spot)</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>System that detects objects to the front of the vehicle, (speed dependent with visual</td>
<td>1</td>
<td></td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and audible warning)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System that helps to maintain optimum stopping distance from the vehicle ahead.</td>
<td>1</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed dependant radar that allows warning, (for example flashing speedometer indicator),</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>or actively controls the distance to lead vehicle, (intelligent cruise control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System that detects the need for braking and applies the brakes more rapidly than the</td>
<td>2</td>
<td></td>
<td>1</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>driver would have been able to, (prevention of false starts at junctions, object detection and avoidance)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Systems that inform the driver of the state of the roadway ahead of their vehicle were not viewed to be particularly effective in respect of preventing the RTAs studied. Systems that detect objects to the side of the vehicle were noted to be very effective in 3 of the 10 cases, whereas object detection to the rear of the vehicles were not rated to be particularly effective. These may have been more frequently noted to be effective had parking area incidents been included in the Solutions Matrices work.
Study 2: Developing A Decision Support Tool.

Systems that detect objects to the front of the vehicle and warns the driver appropriately were viewed to be very effective, (+3), in 9 of the 10 RTAs studied. A system that utilises this detection function to help the driver to maintain the optimum stopping distance from this vehicle ahead was viewed to be very effective in 8 cases whereas one that detects the need to braking and applies the brakes appropriately was viewed to be very effective in 7 cases.

Table 4.6 Technological Solutions based on vehicle and environment communication.

<table>
<thead>
<tr>
<th>Technological solution</th>
<th>Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle to vehicle communication, (direct broadcast of intention to change speed or direction of travel, or of coefficient of friction of roadway)</td>
<td>+1 1 8</td>
</tr>
<tr>
<td>Vehicle to environment communication, (intention to turn off carriageway, current coefficient of friction of roadway)</td>
<td>+2 1</td>
</tr>
<tr>
<td>Environment to vehicle communication, for example advisory speed based on hazard ahead, (dangerous bend, low coefficient of friction of roadway or presence of vehicle turning off or onto carriageway)</td>
<td>+2 2 2</td>
</tr>
</tbody>
</table>

Two types of information were stated to be of use with respect to the communication between vehicles, and between vehicles and the environment. Firstly, the vehicles may broadcast and receive information relating to the state of the roadway in terms of the coefficient of friction to allow appropriate performance modifications to be made. Thus for example, the vehicles may receive information relating to the state of the roadway from a roadside beacon that may allow traction control or four wheel drive to be automatically enabled. Upon passage through this section of the roadway, this information may be updated if required. Alternatively, the vehicles may inform each other of their intention to change lanes, speed up or slow down or
pull out of or into a side road. It is most likely that due to the nature of this information the systems would be intervention based in nature. In the case for example of the slip road RTA discussed, (case number 130), the slow moving vehicle joining the slip road may broadcast its intention to so do and the two vehicles on the slip road that were involved in the RTA, (our vehicle and other vehicle) could automatically slow to allow sufficient space to allow passage.

**4.5.5.2 Summary of Technological Solutions.**

Overall, three main functions were required of the Technological Solutions. These were enhanced braking capabilities, object detection systems, (primarily directed towards the front of the vehicle), and vehicle to vehicle communications concerned with the relative speeds and paths of each vehicle. To some extent, although providing for different needs, they are all concerned with control aspects of vehicle performance and are specifically related to avoiding other road users on the roadway. The most common failures in the RTA database were ones in which our drivers stated they were unable to brake sufficiently to avoid an impact. Some of these were related to a vehicle performing a manoeuvre which was unpredictable from the perspectives of our driver, (for example the slip road case discussed, number 130). Others, (for example the open roadway case, number 131) could be more associated with a failure on the part of our driver to maintain appropriate attention to the roadway ahead.

**4.5.5.3 The efficacy of the Technological Solutions.**

The ratings in sections 4.5.4.2 to 4.5.4.5 briefly illustrate some of the functions that the drivers in the RTAs described would have required in order to prevent those particular RTAs from occurring. A number of individual technological solutions may be devised and implemented from consideration of these functional requirements. However, in order to produce a strategy for primary safety system development, it was necessary to consider the frequency of occurrence of these and other RTA types and of the factors impinging on these RTAs both in the current population of drivers and in the general driving population.
In Chapter 3, Tables 3.12 to 3.54 show the frequencies and percentage of occurrence, (by scenario) of the situational variables and contributory factors impinging on the RTAs collected. The questionnaire in the current work was based on the factors outlined in the Leeds study, (Carsten et al 1989, Southwell et al 1990), however the results from the Leeds study may not be used to weight the current data directly. Although the Leeds study collected information on approximately three times as many RTAs as the current study, (and therefore would have provided a data set to cross validate the current data), in the current work additional factors were included from previous studies and literature and some of the factors used in the Leeds study were not included. Exclusions of certain factors occurred either due to their infrequent occurrence in the data gathered by Carsten et al (1989) or due to the sensitivity of the particular factor. For example, Carsten et al (1989) included such factors as bloodymindedness or thoughtlessness on the part of the drivers concerned in RTAs. These factors were too emotive to ask of our drivers and likely to produce biased results when asked of any others involved in the RTAs in question. Additionally, the definitions of some of the factors were such that they could not be sensibly worded in a manner that would produce meaningful results. For example, in the pilot interviews, many drivers stated that they were involved in an RTA largely because they were in a position in which an RTA could not be avoided. Once the critical situation had been recognised a large proportion of the drivers believed their actions to be reasonable and that therefore they could not avoid the RTA, (see for example Tables 3.12 and 3.54). Thus, an attempt to make a distinction between their being in a situation in which a reasonable road user could have avoided the RTA and one in which the RTA would not be avoided by such a driver could not be drawn. Additionally, the distinction between for example those unable and those failing to perceive a hazard could not be drawn. Thus, the factors described in Tables 3.12 to 3.54 do not correspond directly to the results of Carsten et al (1989) and Southwell et al (1990). Additionally, these factors were described by the participants of the matrices completion groups in their own words rather than with reference to the factors described by Carsten et al (1989). Thus the factors described in Chapter 3 do
not correspond directly to those of previous studies and therefore could not be used
directly to weight the current data.

However, sufficient data were gathered to allow a methodology to be devised for
deciding upon primary safety strategy. Broughton and Markey (1996) showed how
data relating to the causes of RTAs may be interpreted to produce an estimate of the
percentage of RTAs that may be avoided by appropriate implementation of their
logical Solutions. Broughton and Markey (1996) used a two level hierarchy of
factors as they argued that the 4 levels used by Carsten et al (1989) was too complex
to be used. Thus Broughton and Markey (1996) distinguished between Precipitating
Factors, (the manoeuvres and failures immediately leading to the RTA), and
Causation Factors, (the causes for these failures which relate to a specific failure).
Additionally, Broughton and Markey (1996) distinguished between primary and
secondary factors, the primary factors being ‘very probably’ linked to either the
accident, (in the case of precipitating factors) or to the precipitating factors, (in the
case of causation factors), (Broughton and Markey 1996, pp 6). Broughton and
Markey (1996) gave an example of RTAs involving loss of control and driving too
fast. In their example, loss of control was the precipitating factor and driving too fast
was either the sole, the primary or a secondary causation factor.

The formula presented below, (modified from that of Broughton and Markey 1996),
allows calculation of the expected percentage of RTAs avoided, (%avoid), when
Technological Solutions address specific factors in RTA causation.

\[
\%\text{avoid} = \text{Npf} \left( \frac{N_x + N_y + N_z}{100} \right)
\]

\(Npf\) is the percentage of total RTAs associated with a particular precipitating factor,
\(N_x\) to \(N_z\) are the percentage occurrence of each contributory factor for the given
precipitating factor, and \(\%\text{avoid}\) is the expected overall percentage reduction in RTA
numbers given implementation of an appropriate technological solution addressing
factors \(Npf\) and \(N_x\) to \(N_z\). Thus, an estimate of the number of RTAs that may be
avoided by appropriate implementation of a technological solution in a given
scenario may be achieved when estimates of the occurrence of the factors $Npf$ and $Nx$ to $Nz$ are obtained.

Although complex, given sufficient data this reasoning may be applied to the hierarchy of factors devised by Carsten et al (1989) and also those in the current study. Thus, by progressing through Carsten’s hierarchy assessing the relationship between factors, individual and very specific RTAs may be addressed and the relative merits of Technological Solutions based upon these factors determined. The effectiveness of Technological Solutions addressing a particular error caused by a specific skills lapse and a particular reason associated with this skills lapse may be represented as follows;

\[
\%\text{avoid} = N\text{error} \left( \frac{N\text{skill} + N\text{reason}}{100} \right)
\]

It is immediately obvious that a very large sample of RTAs would be required to perform the multivariate analyses necessary to partial out the exact relationship between the factors at different levels.

In the current context, the factors impinging on the RTAs in question were determined by the participants of the matrices completion sessions. The following are worked examples for each scenario discussed based upon the questionnaire data presented in Chapter 3 and the analysis of the RTAs by the matrices completion groups presented above. As sections 4.5.4.2 to 4.5.4.5 show, a number of skills lapses and reasons for these lapses, (as defined by Carsten et al 1989), occurred for each RTA. However, in the following worked examples, only one skill lapse and one reason for this skill lapse were utilised. Thus the formula used was;

\[
\%\text{avoid} = N\text{scenario} \left( \frac{N\text{skill} + N\text{reason}}{100} \right)
\]

Thus to estimate the expected reduction in RTA numbers overall, ($\%\text{avoid}$), the percentage of overall RTAs corresponding to a particular scenario, ($N\text{scenario}$) is multiplied by the sum of the proportion of those RTAs in the given scenario in
which a particular skill lapse and a particular reason for that skill lapse occurs, \((N_{\text{skill}}+N_{\text{reason}}/100)\). Ideally, \(N_{\text{reason}}\) should be the proportion of those RTAs in the particular scenario, that make the specific skill lapse due to the reason under consideration. Thus for example, it should include those drivers that failed to brake properly due to fatigue, rather than those that failed to brake properly due to other reasons such as not being aware of the need to brake. It was not possible however to perform the analyses in this manner due to the volume of data gathered in the current study. Table 4.7 represents estimates of the values of \(\%\text{avoid}\) for the RTAs used in the matrices. Insufficient questionnaire data were collected therefore no attempt was made to determine the causal relationship between the factors outlined on the questionnaires. Similarly, none was made to distinguish between precipitating and causal factors. However, the data were categorised by the scenario of the RTAs, and sufficient data were collected to allow the formula above to be applied to specific scenarios and the skills lapses commonly found in each scenario.

Table 4.7 Percentage of RTAs avoided, \((\%\text{avoid})\), by implementation of appropriate Technological Solutions implied in the current study.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Open Roadway</th>
<th>T junction</th>
<th>Slip road</th>
<th>Roundabout</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N_{\text{scenario}})</td>
<td>22.9</td>
<td>34.1</td>
<td>8.6</td>
<td>15.1</td>
</tr>
<tr>
<td>Skill lapse</td>
<td>Difficulty in braking</td>
<td>Misjudged braking distance</td>
<td>Misjudged speed of other</td>
<td>Failed to observe roadway appropriately</td>
</tr>
<tr>
<td>(N_{\text{skill}})</td>
<td>9.4</td>
<td>7.7</td>
<td>21.1</td>
<td>94.4</td>
</tr>
<tr>
<td>Reason for skill lapse</td>
<td>Fatigue</td>
<td>Poor road surface</td>
<td>Visibility restriction</td>
<td>Overconfidence</td>
</tr>
<tr>
<td>(N_{\text{reason}})</td>
<td>12.5</td>
<td>14.9</td>
<td>9.1</td>
<td>9.5</td>
</tr>
<tr>
<td>(%\text{avoid})</td>
<td>5.0</td>
<td>7.7</td>
<td>2.6</td>
<td>15.7</td>
</tr>
<tr>
<td>Number of avoided RTAs (current study)</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>
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Table 4.7 illustrates the values of $\%_{avoid}$ implied for the specific RTAs studied in the matrices completion sessions were the Technological Solutions implied to be implemented. In practice, these figures are likely to be an overestimate as the figures for $N_{reason}$ are approximations as stated above. Additionally, inspection of the data relating to the estimates of $N_{skill}$ and $N_{reason}$ shows that the number of cases on which these proportions are estimated maybe too small to be generalisable. This is especially evident for the estimates relating to the roundabout RTA. Table 3.43 shows that of the 18 drivers answering the question relating to their seeing the vehicle in which they were in collision with too late to avoid the collision, 17 stated this was the case. The value of $N_{skill}$ for this scenario is therefore based on less than half of the roundabout RTAs for which there are data in the current study and cannot be viewed to be generalisable.

Table 4.8 A schematic outline of summed data to derive primary safety strategy for T junction and Roundabout RTAs.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>T junction, (case 188)</th>
<th>Open Roadway, (case 131)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skills lapse</td>
<td>Difficulty in braking</td>
<td>Misjudged braking distance</td>
</tr>
<tr>
<td>Reason</td>
<td>Poor road surface</td>
<td>Fatigue</td>
</tr>
<tr>
<td>Rating from Solutions Matrices for implied Technological Solutions</td>
<td>+3 (braking under poor road surface)</td>
<td>+3 (Automatic application of brakes)</td>
</tr>
<tr>
<td>$%_{avoid}$</td>
<td>7.7</td>
<td>5.0</td>
</tr>
<tr>
<td>Loading factors, (e.g. cost per RTA, number of RTAs of this type)</td>
<td>To be estimated by the Motor Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Expected gains from technology ($%_{avoid} \times$ loading factor)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.8 illustrates how the data collected in the two studies may be integrated into a single table to define a strategy for primary safety system development. As has been stated, more data is required before definitive conclusions may be drawn,
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however the methodology employed may be summarised thus. Specific RTA scenarios can be chosen from the RTA database devised either as a result of a requirement to consider specific RTA types, or as a result of a particular scenario being overly represented in the population of RTAs as a whole, (as illustrated by the Solutions Matrices work described herein). The skills lapses and reasons for these may be deduced from a statistical analysis of the RTA database and appropriate Technological Solutions devised. By consideration of the proportion of RTAs in this scenario that are related to the specific skills lapses and reasons noted, an approximation of the proportion of RTAs at these scenarios that may be avoided may be deduced, (%avoid). Thus, the absolute number of RTAs that may be addressed by a technological solution of estimated efficacy may be deduced.

Additionally, loading factors may be applied to the data in table 4.8. Pragmatically, these loading factors may be related to the costs involved in the RTAs in question, both in respect of the costs involved in the likely outcome of the RTAs in question were they to occur unchecked, and those involved in the development and implementation of appropriate Technological Solutions. The exact nature of these loading factors are beyond the scope of this project, but in addition, they are likely to involve consideration of the marketability of the Technological Solutions under consideration. These loading factors are to be deduced by the Motor Manufacturer undertaking this work at a later date.

4.5.6 Conclusions.

Overall, whilst sufficient data were gathered during the questionnaire distribution phase of this project to develop and implement the Solutions Matrices methodology, firm conclusions pertaining to a suggested primary safety strategy cannot be drawn from these data. The causal chain of events relating to the various factors could not be deduced, and therefore the Technological Solutions devised were only suggestions based on an inadequate sample size. This however is not a significant failing of the project as the project was aimed at a strategic level, and as such was
not expected to yield precisely quantifiable results at this stage. As a strategic study, it is a means to an end, (IPD 1996).

The methodology chosen for the deduction of Technological Solutions relied upon the functionality matrices approach devised by the HUFIT project, (Galer et al 1992). The method itself has been used extensively elsewhere, and as such has been demonstrated to be valid. The main advantage of this approach and therefore the reason for its use is that it readily allows large amounts of complex data to be summarised in a single easily usable format.

In the current case, the Technological Solutions outlined were viewed positively by the participants of the matrices completion groups who felt that these were appropriate for the RTAs under consideration. In order to produce a definitive strategy for primary safety system development, additional questionnaire data are required to finalise the scenarios chosen for the Solutions Matrices work. In addition, more Solutions Matrices completion sessions may be required as indicated by the analysis of the additional questionnaire data.

The use of multi-disciplinary groups to complete the Solutions Matrices may potentially have complicated the processes of completion due to those with differing specialisations suggesting different approaches to a given RTA. However, the instruction to code the specific Technological Solutions quickly rather than to debate issues at length not only prevented excessive debate, but effectively encouraged a rapid consensus concerning the functions that a given driver would require. Although most of the RTAs studied did produce a number of Technological Solutions, they were in general in agreement concerning the functions that the systems should perform, but may have differed slightly in the manner in which these functions were to be implemented. A functional description of the required Technological Solutions was produced but a technological specification (i.e. a description of how the technologies should produce the functions), was not produced. The same matrices approach may be subsequently employed to define the
technological specification of any systems suggested once a more complete functional specification has been deduced.

The disadvantage of utilising groups to complete the matrices, is the costs inherent in requiring 6 engineers to allocate half a day for each matrices completion session. However, approximately 50 such engineers have now participated in at least one matrices completion session and the experience of the pilot work demonstrates that once familiar with the technique subsequent sessions are completed very much more rapidly. As approximately half of the time period in which the participants were in attendance was used in familiarising the participants with the technique it is envisaged that approximately twice the number of RTAs will be considered during each completion session.

The ratings employed in the final completion sessions reflected that negative as well as positive effects may be resulting from the implementation of the Technological Solutions. However, negative ratings were infrequently associated with the systems, and when present were in general not attributed to be serious. Restricting the use of the code 3 for those RTAs in which a failure on the part of our driver could be directly addressed by a specific technological solution focused the participants attention on factors that were known to have influenced the occurrence of the RTAs in question. However, being cautious in rating, (i.e. applying a higher rating when consensus could not be achieved), ensured that functions would be included rather than rejected at this early stage.

Describing the Technological Solutions in terms of functions that they may perform avoided focusing on existing systems that a motor manufacturer may already be considering. As has been noted, these systems are frequently designed from a technological perspective and as such are not directed primarily at increasing the safety of those driving. Additionally, a functional approach allows the needs of the drivers in the RTAs considered to be addressed directly, ensuring that these needs are fundamental in the process of the design of the systems.
With respect to the RTA scenarios considered, the individual RTAs were chosen at random from 84% of the RTAs in the database of returned questionnaires. As such, the 10 RTAs that were considered account for approximately 4% of this sample. Additionally, the sample returned cannot be regarded to be completely generalisable to the population of drivers from which it was drawn, and this population as has been described is not typical of the general driving population. Table 3.12 shows that the distribution of RTAs in the current sample differs from those in the STATS19 database. However, a larger sample size will allow a statistical comparison to be performed and ultimately the loading factors described in Table 4.8 may be adjusted accordingly. A larger sample size will in addition allow the factors outlined in the questionnaires to be analysed in a hierarchical manner as originally intended and thus the summary data presented in Table 4.7 may be deduced with more accuracy.

Only preliminary conclusions could be drawn at this stage, however, sufficient data were gathered to develop a methodology to produce a primary safety strategy. Additionally, this methodology has been modified to enable it to be performed by a motor manufacturer to facilitate their independent development of a strategy for primary safety system development.

**4.6 Chapter conclusions and summary.**

- A methodology to determine appropriate Technological Solutions to RTAs was developed and tested. This methodology employed a series of matrices that allowed the errors and failures of the drivers in the RTAs to be explicitly listed and cross tabulated with potential Technological Solutions defined in a functional manner. An approach of this nature encouraged the participants of the matrices completion sessions to develop novel technologies rather than focusing on existing technologies.
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- This methodology was operationalised within a motor manufacturer such that the company was able to utilise it without external assistance. The motor manufacturer may now obtain data from returned questionnaires and transfer the needs outlined in these questionnaires into the Solutions Matrices in a meaningful manner. The Solutions Matrices can be completed by the participants to produce a list of functionally defined Technological Solutions for the RTAs considered. By considering the frequency of occurrence of the factors impinging on the RTAs considered in the population as a whole, these Technological Solutions may be evaluated for their potential impact with respect of reducing the toll of real world RTAs. When additional data pertaining to the costs of the individual RTAs and the development costs and efforts required are tabulated with these efficiency estimates, a strategy for primary safety system development may be drawn up.

- Given that the current Solutions Matrices work was based upon an insufficiently large sample of returned questionnaires, only preliminary requirements could be drawn concerning the strategy for system development. However it was clear from the data gathered that three issues were in particular need of addressing with respect to system development. The braking performance of the vehicles involved in the collisions was in general felt to be inadequate. A forward mounted object detection system was felt to be beneficial in many of the RTAs studied, as was a system that allowed direct communication between the vehicles involved with respect of their relative velocities.

A methodology to determine a strategy for primary safety system development has been developed and described. The procedure involved cross-tabulating functionally defined potential Technological Solutions with details of specific RTAs derived from a database of questionnaires completed by recently RTA involved drivers. Following this, the implied Technological Solutions are weighted according to the frequency of occurrence of the factors to which they are addressing. A summation of the factors will allow a strategy to be developed. This methodology has been applied
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within the business processes of a motor manufacturer and found to be both practicable and to produce meaningful results.
5.0 Discussion of the project.

5.1 Chapter summary.

This chapter addresses the project as a whole, and specifically discusses the project with respect to the stated aims and objectives of the research. This chapter firstly discusses the project in general, before addressing the methodologies developed and their limitations. The application of the methodologies employed within the framework of the business processes of a motor manufacturer is outlined, and this chapter concludes by briefly discussing the implications of the study with respect to the application of the strategic decision making framework described.

5.2 General discussion.

The underlying hypothesis of this thesis is that in order to develop appropriate primary safety technologies, one needs to collect data on the causes of RTAs and have a means to decide upon which technologies would be of most benefit in reducing the number of RTAs experienced. The goal of this thesis is to produce a methodology the application of which would allow a motor manufacturer to make such decisions and thus develop their primary safety strategy. This methodology comprised of two parts, an RTA data collection tool to determine in detail the causes of a sample of RTAs, (described in Chapter 3), and a decision support tool to enable decisions to be made concerning which technologies would be most appropriate to prevent the RTAs from occurring, (described in Chapter 4). This thesis was necessitated by the lack of such methodologies and the consequential poor decision making in respect of appropriate primary safety technologies by motor manufacturers.

It can be readily seen from chapter 2 that no overall model exists to adequately account for both the nature of human error and the sequence of events leading to an
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accident. Ramsey (1985) described a model of the sequence of events leading to an accident, but without specific reference to the individual errors made. Rasmussen (1987), described the nature of these errors and placed them in a hierarchical taxonomy, but did not address the sequence of multiple errors that may occur in an accident’s genesis.

With reference to RTAs in particular, although a number of large and small scale studies have been conducted both of individual factors and of general RTA causation, few models exist to adequately explain the causation of RTAs. There is a tendency to focus either on the sequence of events exclusive of the errors in depth, or on the errors exclusive of the sequence. The hierarchy of factors described by Carsten et al (1989), is the most complete RTA error taxonomy to date and was specifically designed to allow the sequence of errors leading to an RTA to be investigated. Accordingly, this thesis used these factors as a basis for the development of a bespoke data collection tool from which to collect information pertaining to the causes of RTAs.

A bespoke data collection tool was required for two reasons. Firstly, the existing data is insufficient to derive a safety strategy. STATS 19 for example contains very little data relating to the causes of the RTAs. Data such as the environmental conditions and the nature of the driver at the time of the RTA are described, but are not readily correlated within STATS 19. Additionally, these data are of limited use as they were not collected for the purposes of deducing in depth the reasons for the RTAs and consequently do not go into sufficient detail. Secondly, of the traditional in-depth studies conducted, the majority were not aimed at deducing primary safety technologies and therefore their use for this purpose is extremely limited. In common with this, for example the Leeds study did not suggest appropriate primary safety technologies. Nevertheless, it was an important advance in that it not only described explicitly the factors underlying RTA causation, but provided a hierarchy through which their sequence could be analysed. The study was deliberately limited by considering only urban RTAs that occurred on roadways below the speed of 30
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mph. Consequently, these data would have been insufficient to build a strategy for primary safety system development; the data from this study would be contained within this population of RTAs to the exclusion of all other RTA types.

From the perspectives of a motor manufacturer wishing to reduce the number of RTAs in their own vehicles, the Leeds study population would have proved to be inadequate as it would be expected to contain comparatively few of these vehicles. Similarly, the case study based approaches, although geared towards suggesting primary safety technologies, would have provided little evidence for the motor manufacturer in question in respect of the nature of RTAs involving their cars. These case studies did however demonstrate how appropriate primary safety technologies may be devised from consideration of the causes of RTAs.

The underlying hypothesis to this thesis is that in order to effect a genuine reduction in the number of RTAs experienced on the roads, by way of the implementation of appropriate technologies in vehicles, it was necessary to gain an understanding of the causes of these RTAs, in order to build appropriate countermeasures. An Ergonomics approach to the problem has therefore been followed; to effect a desired system change, one must first understand the nature of the system. This however presupposes that the problem and the methods employed to address this problem do not pass one another by, (Wittgenstein 1953). It has been argued that the development of high technologies in vehicles as evidenced by the DRIVE and PROMETHEUS programmes has fallen into this trap. These technologies have been developed on the basis of what is technologically feasible at the expense of the actual requirements of the drivers; the problem of the causes of RTAs has therefore been overlooked when designing the 'solution'.

That the errors associated in RTA causation, and the manner in which these errors may be addressed, do not necessarily lie in the same domain was first suggested some 20 years ago, (Sabey and Staughton 1975). However, much of the research into the causes of RTAs, (including that of Sabey and Staughton 1975) was not
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specifically aimed at deducing primary safety systems. Of those primary safety systems that have been considered, their implementation has largely been technology, rather than driver centred in approach. The RTA causation studies that did focus on primary safety, almost exclusively focused on these technologies. Due largely to the technological lead in the development of such systems, there exists the considerable danger that not only do such systems not address the needs of the driver, but they may actively hinder the driver’s use of the vehicle. In order to have any benefits, not only must these systems avoid adding unnecessary technical complexity, (Oliver and Hall 1997), but they must actively address the needs of the drivers. This was explicitly stated by Broughton and Markey (1996), who accordingly defined the technologies implied by their work as Logical Solutions.

To address the first point, considerable efforts have been directed at ensuring that any such systems are ergonomically appropriate and thereby do not place unnecessary burdens on the drivers. To this end ergonomic standards now exist, for example Galer and Simmonds (1984), Robertson and Southall (1992). With respect to the needs of the drivers, designing systems from a functional perspective, based on the requirements of the drivers themselves will alleviate the danger of overlooking the needs of the drivers in respect of their avoiding RTAs. The current study differed from that of the Leeds study, (Carsten et al 1989, Southwell et al 1990) in that the drivers themselves were asked in more detail concerning the factors leading to the RTA in which they were involved. It has been argued that this may be inappropriate, because as driving is largely automatic, the processes involved in driving are not directly accessible to conscious thought, (Clarke et al 1995). Consideration of Rasmussen’s (1987) model of behaviour appears to verify the theory that the largely automatic, knowledge based errors may not be accessible to drivers.

However, this overlooks that fact that irrespective of the everyday nature of the scenarios in which drivers are involved in RTAs, the act of being involved in an RTA itself is not an everyday one. Thus the reasoning that drivers cannot describe
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the occurrence of an RTA due to the everyday nature of driving is inherently flawed. In addition, West (1997) demonstrated that not only are drivers able to provide some explanation of the occurrence of RTAs in which they were involved, (sufficient to be reliably coded into scripts), but these scripts are reliably reported over the period of several years. The current study in comparison involved drivers who had comparatively recently been involved in RTAs. They were however asked in considerable detail as to the reasons for these RTAs. That the drivers were not always able to ascribe the reasons in detail in the current study, (as reflected by the number of occasions 'Don't Know' was indicated), mirrors the results of Carsten et al (1989) who determined that approximately one third of the 4th level failures were coded by a multi-disciplinary team as unknown. In the current study, our drivers were given the opportunity to answer 'Don't Know' for many of the questions, but few chose to do so. Approximately 25% of our drivers nevertheless admitted some behaviour on their part may have contributed to the causation of the RTA. However, this does not mean that the remaining 75% were merely innocent victims of a third party's actions. The absence of evidence with respect to errors does not equate to the evidence of absence of these errors. In this respect however, no conclusions may be drawn; insufficient data were gathered to statistically cross validate the current data against a larger population. However, at a strategic level, sufficient data were gathered to enable a methodology to be devised. The data gathered in this project were of use in both designing the format of and weighting the results of the Solutions Matrices. As has been argued, existing data would not have been sufficient to serve this purpose.
5.3 Discussion of the methodologies employed.

To reiterate, the goal of this thesis was the development of a tool through which a motor manufacturer could decide upon their primary safety strategy. To achieve this, two main methods were developed and employed in this study; a questionnaire administered to a population of recently RTA involved drivers and a series of Solutions Matrices completed by domain experts drawn from the employees of a motor manufacturer. In practice, the development of the methodologies occurred in parallel. The initial developmental work was carried out at Loughborough University with some assistance from the sponsoring motor manufacturer, whilst the main data collection phase of each was performed with the direct support of the manufacturer. Each of the methodologies employed is discussed in turn.

5.3.1 Questionnaire study.

Section 2.7.2 describes the nature of data usually collected in in-depth studies. In the current study, it was not possible to obtain data in addition to that collectable via the questionnaire; no on the scene investigations, vehicle examinations or interviews with witnesses were possible. This was due to the manner in which the populations studied were approached, itself constrained by the business processes of the sponsoring motor manufacturer. Unlike Broughton and Markey (1996) who were restricted to the use of data collected by an insurance company for their own purposes, the current study was able to approach the drivers involved with a view to their completing an extensive RTA causation questionnaire. Due to the manner in which the population was obtained together with issues of personal and commercial confidentiality however, cross validating data was not obtainable through the motor manufacturer.

The aim of the questionnaire study was to collect in-depth RTA data to inform a motor manufacturer of the causes of RTAs. This information was required to enable
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a methodology to be devised to develop a primary safety strategy for a motor manufacturer. With respect to this, the objectives were therefore;

1. To devise a suitable data collection tool to obtain information on the causes of RTAs,

2. To provide information to enable a methodology to devise primary safety strategy to be developed.

The methodology chosen for the collection of the RTA data was a self completion postal questionnaire, the reasoning for the choice of which is outlined in section 3.4.2.1. In retrospect, the reasoning underlying the choice of this methodology was verified by the information and experience gained throughout the course of this study. Observational methods for example, would have required a prohibitively long time period to collect the data given the extensive efforts required to collect these data, (as noted by others, for example Mukherjee 1997).

Interview techniques were employed in the initial piloting work but were rejected as the methodology of choice from the main data collection phase of the study. In common with observational techniques, interviews take a considerable time to both collect and to analyse the resultant data. In addition, considerable social pressures exist for interviewees to bias their responses in a socially desirable manner when face to face with an interviewer. Whilst time consuming to design, the distribution, collection and collation of questionnaire data is very much more straightforward than conducting interviews or obtaining observational data.

A comparison with the Loughborough Campus based piloting indicates that as a percentage of overall returns, the main sample contained more incomplete questionnaires. This may be due to the differences in educational levels amongst the two populations although this is not verifiable due to the small numbers of returned questionnaires in the main phase of the questionnaire distribution.

A number of biases may exist in respect of the completion of the questionnaire. Both
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conscious and unconscious biases are expected to exist. Those likely to make conscious biases, (deliberate falsifications), are equally likely to not return the questionnaire, unless they felt compelled to do so by the manner of distribution. Unconscious biases are more difficult to quantify and essentially relate to our drivers not knowing why the RTA occurred and attributing actions, and underlying factors to themselves and to others. If additional data were available, these biases may be estimated. For example, physical evidence may be collected from the scene, though it is unlikely that many aspects of physical data such as these were exposed to biases of this nature. Unlike the physical evidence, which by its nature is mostly verifiable, unconscious biases are not quantifiable for the most part given their psychological nature. Nevertheless, given sufficient data, the random effects of these biases will be reduced. Systematic biases in these data will not however be affected with the addition of more data but will remain as at a constant level. Given the present sample and methodology employed, the effects of these biases remain unquantified.

This raises the issue of the quality of the data collected. Obviously, since cross validation was not possible, it is impossible to draw definitive conclusions. However, it would appear that the data returned in the main questionnaire distribution period are of a lower quality than that obtained during piloting. As discussed, this is likely to be due to educational differences in the two populations. In addition to this there was no motivation to complete the questionnaire over and above the request in the covering letter. Whilst some respondents may have felt compelled to complete the questionnaire as it was distributed through their insurance company, (and thus the response rate resulting may be enhanced), none stated this to be the case. It is obvious that for some of the respondents however, care was not taken to complete the questionnaire. Overall, the questionnaires were completed to such a degree that the data were usable in the Solutions Matrices work. Given that the expected use of the data is at a strategic level, the data collected are concluded to be of a sufficient quality. Cross validation of the questionnaire data should of course be conducted if possible.
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Although the questionnaire was devised using the factor structure developed in the Leeds study, (Carsten et al 1989, Southwell et al 1990), the ordering of the questions did not exactly match the ordering of the factor structure. The questionnaire was organised in such a manner so that the hierarchy of factors leading to the RTAs in question could be pursued however. To some extent this was achieved, however insufficient data were collected to allow a full analysis of this. Given that for the most part the questionnaire was completed correctly, with sufficient data the relationship between the factors at various levels in the hierarchy may be deduced statistically. For example, RTAs resulting from a driver's failure to stop at a T junction due to their failure to see another vehicle, (and thereby recognise the need to stop), may be distinguished from those that were unable to stop due to a poor road surface. Applying the principle of Occam's Razor to this, it may be considered unnecessary to reduce the descriptions of the RTAs to this level for the purposes of defining appropriate countermeasures. However, in the absence of sufficient data to perform such analyses, this is a moot point.

Clustering of RTAs of similar types has been frequently performed in previous in-depth studies, (notably the case study based studies described in section 2.7.4). This serves to simplify the data and allows large quantities of similar data to be combined. However, these clustering techniques are only valid with respect of their matching the general population, when based on sufficiently large samples. In the current study, due to the small sample size resulting, the clustering was based upon the very much larger STATS 19 database. Since fatality data is generally considered to be more reliable, the clustering was based upon the size of the clusters of RTAs resulting in fatalities from STATS 19. Sabey and Staughton (1975) concluded that there were no differences in the genesis of RTAs resulting in fatalities as compared to non injurious outcomes. However, advances in RTA investigation techniques to date have not been applied to this problem, and consequently this may be viewed with some caution. Irrespective of the validity of the clusters employed, the methodology created is argued to be valid for the purposes of developing a strategy for primary safety system development.
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5.3.2 Solutions matrices.

The Solutions Matrices were based on functionality matrices developed by the HUFIT project. (Galer et al 1992). Functionality matrices were the only technique available for correlating a system's functionality and users requirements that could be applied to the current study. The aim of the Solutions Matrices work was to develop a procedure for correlating information relating to the causes of RTAs and possible technologies which may be employed to reduce the number of these RTAs. When reviewing the literature concerning these technologies, it became apparent that these technologies themselves were flawed with respect to their primary safety application as primary safety was a largely peripheral concern in their developmental process.

A Solutions Matrices methodology was therefore devised that facilitated both the specification of the functions actually required of these technologies, (thereby ensuring that the solution did indeed address the problem), and enabled strategic decisions to be made regarding their relative efficacy. The development of these Solutions Matrices was an iterative process. Both the nature of the descriptions of the RTA scenarios and the potential technological solutions, as well as the rating scheme itself were modified considerably over the course of a number of matrices completion sessions. The result was a series of matrices, in which the participants were able to deduce from the questionnaires the factors underlying the RTAs in question and were able to employ these data to determine appropriate technological solutions.

The major question concerning the use of the Solutions Matrices relates to the validity of the findings. It is firstly acknowledged that the sample of RTAs on which the matrices work was based may inherently be biased. In respect of the high level scenarios, table 3.14 shows that the proportions in each of the high level scenarios for the current study and for STATS 19 for 1996 were essentially similar. A statistical validation was not performed however for the reasons outlined above.
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Secondly, as this study was conducted at the level of deducing primary safety strategy, no information pertaining to the actual efficacy of the resultant systems may be deduced. This is in part due to the fact that many of the resultant systems are not in production and hence their effect on real world RTAs cannot be quantified as these systems do not exist other than on paper. It was implicit in this work that engineers from a motor manufacturer would be an appropriate population from which the technological solutions could be derived. The procedure of completing the Solutions Matrices was not performed in its final form using participants drawn from any other sample, largely because one of the purposes of this study was to devise a methodology that could be employed by this motor manufacturer.

Finally, it was assumed that the technological solutions derived, having been produced by specific consideration of the factors underlying the RTAs in question would in actuality effect a reduction in the number of RTAs experienced on the roads. A number of researchers have suggested that any purely technological interventions will not serve to lower the number of injuries experienced on the roads due to the effects of behavioural compensation, (see for example Adams 1985, Evans 1991 and Wilde 1981, 1994). It should be noted that the functionally described technological solutions outputted from the Solutions Matrices work are not defined in terms of anything other than their desired functionality. Technical specifications were not deduced, (though may be using the Solutions Matrices technique), and these systems exist only on paper. Prior to implementation, additional work, such as simulation and analyses of the behavioural effects on drivers of these systems should be undertaken.

5.4 Application in a motor manufacturer.

5.4.1 Questionnaire distribution, collection and analysis.

Overall, the data collected in the questionnaire distribution were collected in a
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manner which was consistent with the business processes of the sponsoring motor manufacturer. The major difficulty with respect to the questionnaire data collection related to the process through which the sample was identified and the questionnaires distributed. As this study was carried out with the assistance of a motor manufacturer, and the population of recently RTA involved drivers identified exclusively through this motor manufacturer, (with the exception of the piloting work), several constraints were placed upon the questionnaire distribution procedures. For example, due to the sensitivity of the data, names and addresses of those involved in the RTAs could not be directly released by the insurance group for questionnaire distribution purposes. Additionally, since the names and addresses to whom the questionnaires were distributed were not recorded, follow-up questionnaires or letters could not be distributed. This was largely because the insurance group's records were not computerised. However, had they been computerised, the implications of the Data Protection Act would have directly precluded the insurance group from divulging personal data.

The questionnaires were thus delivered to the premises of the insurance group and distributed solely by them. Accordingly, the distribution procedures had to be designed so as to fit in with the business processes of the insurance group. A driver involved in an RTA would therefore be sent the questionnaire and covering letter once they had returned the initial claim form to the insurance department. This distribution procedure offered two potential advantages over other potential procedures.

- Firstly, the ongoing nature of the procedure allowed distribution to be continued throughout the year and thus the complete range of environmental conditions could be sampled. In actuality, resource limitations within the motor manufacturer precluded this.

- Secondly, and importantly, the insurance group had already initiated their processing procedures at the stage that the questionnaires were to be distributed.
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Whilst the exact sample required was specified, it was not possible, (again due to resource limitations), to ensure that only these drivers were selected for the study. It was stressed in the covering letter that the questionnaire was anonymous and would in no way be attributable to themselves at a later date. Additionally, it was stated that the study was being conducted with the assistance of the insurance department, but independently of them and that individual questionnaires would not be identifiable. However, given the return rate in the current study, it can be concluded therefore that the questionnaire was an acceptable data collection methodology for the purposes of the study in question.

The major limitation of this study relates to the distribution procedure and the resultant sample size. The distribution of the questionnaires was inadequate; responses were obtained from those to whom a questionnaire should not have been sent and a significant number of those to whom the questionnaire should have been distributed were not included. In total, 3000 questionnaires were prepared for distribution, yet over the time period outlined for distribution of this number, only 1000 were distributed. Largely, this was due to the resources available to the insurance group for the current study. Both financial and time resource limitations prevented the insurance department from distributing the questionnaires to the entire sample selected within the population of RTA involved drivers. The resultant sample cannot be regarded as generalisable to this population as a whole, and clearly given the biased nature of this population nor to the general driving population as a whole. The results of the questionnaire analysis in terms of the scenarios of, and factors underlying RTAs cannot be regarded as generalisable to the general population of RTA involved drivers.

Additionally, non returned questionnaires remain a significant problem for the current study for three reasons. Firstly, due to the distribution methodology, no data are available concerning those to whom the questionnaire was distributed and that did not return it. Secondly, no data exist pertaining to those that should have
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received a questionnaire but didn’t and thus the true size of the non returned sample remains unquantified. Finally, it has to be acknowledged that those returning the questionnaire may differ significantly from those not returning the questionnaire. This may be a demographic difference, (such as younger male drivers being differentially overly represented in the non-returnees), or a difference in the nature of the RTAs in which the drivers were involved.

However, it can be concluded that with respect to the stated aims and objectives of the questionnaire study, this methodology was successful; although the distribution process was clearly inadequate for the purposes of determining the causes of RTAs in general, it enabled the Solutions Matrices and the method of weighting the resulting data to be developed.

In order for the questionnaire distribution to be continued with in house, resources will be required to enable the insurance group to target only those to whom a questionnaire should be distributed. It is anticipated that when the distribution is undertaken by the motor manufacturer, these resources may be made available and hence the number of inappropriate distributions minimised. The resulting return rate should therefore be enhanced accordingly.

In respect of the distribution, collection and analysis of the questionnaires, the following are required:

- The population identified through the insurance group of the motor manufacturer should be sampled as described above, but in a systematic manner and specifically data relating to the nature of those that were included and excluded should be obtained. From this, an analysis of the non returns would enable an estimation of the effectiveness of the sampling strategy can be obtained.

- The questionnaires should be distributed using the procedures outlined above in a timely manner, (as soon as is practically possible after the RTA).

- The questionnaires should be collated and entered into SPSS for analysis as
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described. It is particularly important that the resultant data are error trapped prior to analysis.

The expected output of this will be a database of RTAs from the population identified, which may be compared against existing databases, (notably STATS 19) in order to determine the generalisability of the collected data compared to national norms. In addition to determining with more accuracy the underlying reasons for RTAs occurrence, the database of collected RTA data will outline the frequency of occurrence of these factors. This may then be used to determine the number of RTAs technologies addressing these factors and hence estimates of overall effectiveness of specific technologies may be arrived at.

5.4.2 Completion of the Solutions Matrices.

In the final form, the Solutions Matrices were completed by the employees of the motor manufacturer in a relatively straightforward manner. It was possible for these employees to make judgements regarding the potential efficacy of the technological solutions when phrased in terms of the functions that these systems may provide. In addition, the participants were able to make links between the individual functions and were able to specify in some detail the nature of the required systems.

With respect to operationalising the completion of the Solutions Matrices within the motor manufacturer’s business, as with the questionnaire data, the major issue pertains to the resources required. These resource limitations effectively reduced the number of individual RTAs that were considered in the matrices completion sessions. The Solutions Matrices were always completed by groups, these completion sessions typically running for between 3 and 4 hours. Thus, the time resources required simply to complete the matrices were considerable. Considerable time was also required to train the participants in the methodology. As approximately 50 staff have now been trained, the motor manufacturer may now complete the matrices themselves with little additional training required. By
be made in respect of the motor manufacturer's primary safety strategy.

5.4.3 Integration of the Questionnaire and Solutions Matrices.

In addition to developing and operationalising the questionnaire and Solutions Matrices methodologies, it was necessary to map out the processes through which the motor manufacturer would integrate these into their core business. An important aspect of this is the need for continual updates of the situation pertaining to the causes of RTAs and of the resultant injuries. As has been described, driving may be viewed from a systems perspective, altering any one of the components of these systems will cause an effect throughout the entire system. For example Wilde (1994) describes how changes in the economic prosperity of a country causes an effect on the absolute number of RTAs experienced on the roads of that country; during periods of recession, less money is available for transportation, fewer miles are driven overall and the RTA rates consequently fall in line with the lower levels of exposure. It is important that once a strategy is devised, it is continuously updated to reflect changes in the driver - vehicle - environment system, (see Figure 1.1).
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Figure 5.1 A schematic business process map to illustrate the development of safety strategy within a motor manufacturer.

In effect, a business process map was required and is presented in Figure 5.1. There are two major sources of information presented; that pertaining to RTAs and that related to potential technological solutions and RTA countermeasures. The model below does not specify in detail any of these information sources, but outlines at a
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high level the nature of the information to be considered at each stage. Prior to the initiation of the current project, no methodology existed to integrate these two information sources, and accordingly the development of many RTA countermeasures was largely undertaken with no attention being paid in a systematic manner to the nature of RTAs. Figure 5.1 illustrates at high level the process through which a motor manufacturer may optimise their decision making with respect to a strategy for primary safety system development.

5.4.3.1 RTA information sources and priority checklists.

Two types of RTA information are presented within the model; relating specifically to primary or secondary safety. The information sources detail the main research in primary and secondary safety and include studies such as the current study and the literature published concerning the causes of both RTAs and the injuries resulting from these. An overall set of priorities will need to be devised by consideration of the strategic, organisational aims and objectives of the motor manufacturer with respect to their safety policy. From consideration of the relative frequencies, severities and costs of the RTAs and resultant injuries, priorities for primary and secondary safety may be deduced. These priorities are best represented as checklists; when new information relating to either primary or secondary safety becomes available, it must be compared to the checklists referring to the safety policy. Overall, a data monitor will monitor changes in RTA and injury patterns and will compare the effects of these changes to the priority checklists. In addition, the checklists themselves will need to be continuously updated, by considering the wider social context in which the motor manufacturer operates.

Motor manufacturers are to a large extent driven by legislation, and for example new legislation may necessitate that specific injury types are addressed by a motor manufacturer’s products. Alternatively, in order to maintain competitive advantage, a motor manufacturer may require that specific efforts are directed at aspects of occupant protection. Given that recently attention has been directed more towards primary safety, and that arguably a plateau is rapidly being approached in secondary
safety, (Deering and Viano 1994), it is expected that in the near future legislation will be directed towards the prevention of RTAs.

Due to changes in the patterns of RTA or injury causation over time, conflicts will arise with respect to the checklists. It can be seen that most of the conflicts that will arise in the short term are associated with secondary safety, largely because legislation currently focuses almost exclusively on injury rather than RTA prevention. When these conflicts are noted by the Data Monitor, these must be reflected in the Solutions Matrices, and a new series of Solutions Matrices completed to specifically address these changes.

From the perspectives of the current thesis, two sources of information are of particular interest in regards to primary safety strategy; that published in STATS 19, and that collected from recent RTAs in the manner described in Chapter 3. Priority checklists will be required for each of these to monitor for example any changes in the patterns of RTAs over time. Such changes will have implications for the nature of the primary safety technologies that should be deployed and hence the changes must be reflected in any long term primary safety strategy.

5.4.3.2 Countermeasures and Technological Solutions.

A similar procedure will be needed to account for changes in RTA countermeasures. The primary inputs for this work are derived from motor manufacturers awareness of the nature of primary safety technologies that may be deployed. It is particularly important that these are described in functional terms, and that a constant review of technologies is undertaken by the motor manufacturer. Two main sources of information should be reviewed, market requirements and countermeasure information sources. Market requirement information will be needed, largely to account for any safety measures that a motor manufacturers competitors may introduce. There is a need for such technologies to be analysed and catalogued. In addition to this, legislation may necessitate specific products are introduced into the vehicle fleet, (such as occurs now with the requirement for rear seat belts to be
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fitted). Additionally, customer requirements will need to be considered and reflected. For the most part, these requirements will at present be related to secondary safety measures, as technologies as air bags are now a sought after feature of a new vehicle. If a culture change occurs in respect of the desirable qualities of vehicles, primary safety features may become more desirable.

Countermeasures information sources relate specifically to the technologies that may be introduced into vehicles to either prevent RTAs or the injuries that result. In addition to technical and functional specifications, this information must contain data related to the costs, availability and implementation efforts that are required for each system.

In contrast to the RTA information sources, priorities for the initial choice of technologies should not be raised at this stage, (all possible technologies should be included due to the strategic nature of the work), but a solutions monitor is required to assimilate the market requirement and countermeasure information sources. When significant changes have been noted, these should be carried forward to the Solutions Matrices for consideration.

5.4.3.3 Solutions Matrices.

Initially, more data should be obtained from the questionnaire study to enable the Solutions Matrices to be completed with a statistically valid sample of RTAs. This will produce a series of matrices to illustrate the causes of RTAs as they occur now, and will illustrate the functions required to overcome these RTAs. A strategy for primary safety system development may then be deduced as illustrated in section 4.5.5.

The Solutions Matrices should be updated periodically to account for changes in the driver - vehicle - environment system. These changes will be noted by the Data and Solutions Monitors within the motor manufacturer and amendments made to the
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Solutions Matrices accordingly. These changes will be of two main types. Firstly, the nature of RTAs, injuries or countermeasures will change over time\(^1\). These changes will need to be reflected in the Solutions Matrices by updating the descriptions of the potential countermeasures and the RTA scenarios. Secondly, quantitative changes in the priorities will need to be added to the Solutions Matrices. These are most likely to be added after the main Solutions Matrices completion sessions have been completed to illustrate the resources required to develop the technologies. These resources will include the development time, the costs and the actions and efforts required.

In summary, by use of the methods described in this thesis, a better understanding of the causes of RTAs and how to decide between alternative primary safety technologies may be arrived at.

5.4 Chapter Conclusions and Summary.

This chapter has briefly discussed the project as a whole and has discussed the methodologies with respect to the stated aims and objectives of the research. The limitations of the studies have been outlined and the implications for applying this research within the business processes of a motor manufacturer have been outlined. The specific conclusions are as follows:

- Additional data, (in the form of that collected in the RTA causation questionnaire), was required due to the inability to effectively use existing data for the purposes of defining primary safety strategy.

\(^1\) The nature of injuries and injury producing RTAs was not specifically addressed within the current study. However, different RTA scenarios will result in different injury patterns and therefore priorities for reducing these injury types will naturally require some consideration of the scenarios in which the RTAs occurred.
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- Although the quality of these data was not as good as may have been if enhanced by additional data sources, it was of sufficient quality to be used in the subsequent work.

- The resource limitations of operating this study within the confines of the core business of a motor manufacturer precluded extensive data collection for both the questionnaire and the Solutions Matrices work. Sufficient data were collected however to allow these methodologies to be developed and implemented within the motor manufacturer concerned.

- Additional financial and personnel resources are required however if the motor manufacturer is to continue with this work in such a manner so the results of the Solutions Matrices work will be of optimum benefit with respect to defining a strategy for primary safety system development.

Although limitations to this study exist, the goal to develop a tool for a motor manufacturer has been achieved. By application of the RTA data collection methodology, a motor manufacturer can deduce with more certainly the reasons for a sample of RTAs occurring and can use these data to inform a decision support tool of the causes of these RTAs. When combined with functionally defined potential primary safety technologies, the output of the decision support system will indicate which of the technologies would be more effective at reducing the likelihood of the RTAs in question occurring. By applying weighting data based on the frequency of the RTA scenarios, (as defined in STATS 19), and the frequency of the factors in each scenario, (informed by the results of the RTA data collection), a strategic plan of the development of appropriate primary safety technologies may be produced.
Conclusions and further research.

6.0 Conclusions and further research.

6.1 Chapter Summary.

This chapter presents a summary of the conclusions of this research and suggests some areas for further research in similar areas. It firstly reiterates the aims and objectives of the study, before outlining these conclusions. Finally, suggestions for further research are made.

6.2 Aims and Objectives.

The underlying hypothesis of this thesis is that in order to understand priorities for primary safety system development, one needs to understand in more detail the reasons for RTAs occurring. Accordingly, one needs to collect data on real life RTAs and have a means of evaluating the value of potential technological solutions in respect of their ability to help a driver avoid RTAs. The aim of this work was therefore to develop a methodology which could be employed by a motor manufacturer to assist their decision making in respect of their primary safety strategy. It was implicit that any methodology developed would be consistent with the core business processes of a motor manufacturer, so that they could effectively utilise the methodology independently. There were 4 objectives to this research;

- To perform state of the art literature reviews of the current situation with respect to accident causation, RTAs in specific, and available and prototype technologies that may address primary safety in vehicles.

- To collect information on RTAs to determine the nature of the causative factors in more detail.
Conclusions and further research.

- To define a procedure for correlating information on RTA causation and potential RTA countermeasures.

- To develop processes within a motor manufacturer whereby they can utilise such a methodology to determine their primary safety strategy.

6.3 Conclusions.

The conclusions of the study are briefly outlined below.

- With recent advances in computing technology, it has been possible to place high technology in vehicles to aid the driver in their task. However, it is obvious that these technologies, developed as they were largely from other domains and applied to vehicles, are not focused at the causes of RTAs. In order to design appropriate RTA countermeasures, an understanding of the reasons for RTA's occurrence is needed.

- Demographic studies of those involved in RTAs and where these RTAs occur are useful only as descriptions of these factors. Largely due to the methods that have been employed in collecting these data, few conclusions with respect to appropriate accident prevention technologies are possible. Additionally, the issue of the nature of the statistics quoted complicates the situation with respect to the size of the RTA problem, and hence of any possible effects of the implementation of accident countermeasures. Due to the inaccuracies in data recording it would seem sensible to limit consideration to absolute numbers of accidents, and in specific to fatalities.

- It is clear that human factors and specifically errors play a major role in RTA genesis although no single model of human error in isolation is appropriate to describe RTAs. Ramsey’s (1985) model describes the sequence of events in a generic accident, whilst Rasmussen’s (1987) model describes the nature of the errors made. Neither model is therefore complete and each therefore requires
Conclusions and further research.

elements of the other before a full picture of any given accident may be derived. Whilst not outlining potential countermeasures, the study undertaken at the Institute of Transport Studies, Leeds was a significant breakthrough in terms of understanding the factors impinging on RTAs. In contrast to earlier studies, the factors were explicitly defined and placed in a hierarchy that allowed causal chains to be inferred. This study therefore most closely matches a composite of the models of Ramsey, (1985) and Rasmussen, (1987).

- A data collection method was devised that allowed collection and analysis of the factors impinging on RTA causation and enabled a motor manufacturer to gain an appreciation of these factors in individual RTAs. The data from the Leeds study was insufficient for the current work because it was restricted to urban RTAs involving low speed collisions. In addition, since the current work was conducted on behalf of a motor manufacturer, their primary interest was RTAs involving their production vehicles. The Leeds data would therefore have provided comparatively few of these on which to base a strategy for this manufacturer.

- In common with previous studies, the RTA data collected found that the majority of RTAs occurred on straight, flat roads in good visibility and in good weather conditions. The drivers completing the questionnaire were able to describe in some detail the factors impinging on the RTAs in which they were involved and approximately 25% of them admitted some liability on their part contributed to the cause of the RTA. As was expected of a sample of predominantly middle aged, male company car drivers, they drove a higher than average number of miles per year and consequently their increased exposure may be related to a higher than average RTA rate.

- The INRETS and TRL case studies both suggested appropriate accident prevention measures. INRETS demonstrated the use of clustering of accident types and illustrated concept of needs with respect to the drivers. This was advanced further by the TRL work.
Conclusions and further research.

- Using a functional definition of the needs of the drivers and hence of the performance of the accident prevention measures allowed these technologies to be developed in a more driver centred manner. This has been demonstrated by Malaterre et al (1992) and Broughton and Markey (1996).

- No methodology existed prior to this study to systematically enable a motor manufacturer to make decisions regarding the appropriateness of individual Technological Solutions. Furthermore, no strategic decision making framework existed. Applying a functional definition of potential technologies and utilising a modified functionality matrix, the efficacy of a large number of technologies was estimated with reference to the needs of the drivers as expressed in terms of the errors made in the sequence of events leading to an RTA.

- From an analysis of the functions required by the drivers completing the questionnaires, it was apparent that three functions were commonly required by the drivers: enhanced braking capability, object detection systems, (sufficient to warn of impending collisions) and vehicle to vehicle communications, (to warn of intended velocity change).

- When combining data from the questionnaire study and the Solutions Matrices work, a strategic approach to primary safety system development was developed. This enables a motor manufacturer to obtain data pertaining to the factors underlying individual RTAs and correlate them with potential technological solutions. A strategy for primary safety system development can then be deduced from these data.

6.4 Further research.

There are two main areas in which further research may be undertaken following this project:
Conclusions and further research.

- In respect of the current work, cross validating data may be obtained from additional sources and thus the validity of the findings may be deduced. This should be performed to determine the validity of the responses given by for example conducting on the scene investigations of the RTAs. In addition, the nature of the population employed in the questionnaire study may have affected the resulting conclusions pertaining to the causes of RTAs. This could be addressed in a wider scale survey.

- Secondly, more questionnaire data is required for the motor manufacturer to determine with accuracy the direction of their primary safety strategy.

With respect to other similar areas of research three areas of research are possible.

- The Solutions Matrices methodology may be employed in other areas of a motor manufacturer's operations, for example to determine market requirements. Additionally, motor manufacturer's suppliers may be approached and the methodology applied to determine the technological specification of systems. Applying a user centred design philosophy, were the suppliers to consider the factors underlying RTAs earlier in the design of technologies, it would enable them to produce systems tailored to the requirements of the drivers. The current work has focused specifically on the causes of RTAs, but this reasoning could equally be applied to any technology placed into vehicles, or the design of the vehicles themselves.

- Given that it has been shown that it may be possible to build safer cars, the motivational aspects of drivers behaviour in respect of their current behaviour and attitudes to road safety require consideration. It has been suggested that drivers will drive so as to maintain their target level of risk and consequently would drive in an objectively more dangerous manner in an objectively safer vehicle. Advances in primary safety technologies may therefore have no net effect if drivers compensate by behaving in a more dangerous manner. This must be objectively quantified, and were it to be the case, addressed via training or
education. In many respects the pervasive culture surrounding the use of the motor car in motorised societies still glamorises speed. Only recently has safety become a selling point in vehicles, and this is the case for comparatively few vehicles. Research must therefore be directed towards understanding the culture surrounding the usage of vehicles such that an understanding of drivers motivations may be gained.

- Currently, drivers may purchase any vehicle within their means once they have the required license. No specific driver training is mandatory over and above that required by the government and there is the danger that even if a vehicle is objectively safer due to the presence of primary safety technologies the driver may be unable to use these effectively. Whilst it is hoped that these technologies would make driving safer for a driver in a vehicle so equipped, the issue of the training of the driver requires investigation. In addition, it must be ensured that the risks faced on the roads are not loaded towards other more vulnerable road users due to the presence of high technology in vehicles.

6.5 Chapter Conclusions and Summary.

The aims and objectives of this research have been described and the conclusions from this research briefly outlined. Suggestions for further research have been made.
References.


Appendices.

Appendix 1 Scheme of Contributory factors, (from Carsten et al 1989).

Appendix 2 RTA Causation questionnaire.

Appendix 3 Covering Letters.

Appendix 4 Solutions Matrices.
101 Braking suddenly reasonably
102 Braking suddenly unreasonably and sharpenly
103 Erratic course
104 Loss of control/falling over
105 Failure to avoid
106 Failure to stop, stop signline
107 Failure to stop, zebra crossing
108 Failure to stop, red light
109 Failure to stop, pelican flashing orange
110 Failure to stop, other control
111 Turn/maneuver from wrong lane
112 U-Turn
113 Inappropriate overtaking
114 Poorly carried out maneuver, turning
115 Poorly carried out maneuver, overtaking
116 Reversing
117 Opening door
118 Failure to anticipate
119 Unable to anticipate
120 Dangerous position
121 Driving wrong way
122 Failure to signal
123 Failure to put on lights
124 Turning right
125 Turning left
126 Failure to yield, changing lane
127 Pulling in
128 Pulling out
129 Pedestrian crossing site
130 Misleading signaling

Where the reasonable road user would.
Where the reasonable road user would not.
Any road user following an unpredictable course not resulting from loss of control. Does not include driving wrong way.
Sudden loss of adhesion, steering or stability.
Insufficient or absent evading action once the likelihood of an accident occurring has been perceived (the reasonable driver should have been able to avoid).
Not stopping for a pedestrian who has right of way on a zebra crossing. A pedestrian only has right of way when a reasonable driver could have stopped.
(e.g., school crossing patrol or police person)
Turning off a road from the wrong lane.
Turning in an inappropriate place or an appropriate place, but failing to carry it out properly (does not include failure to yield).
Turning in an appropriate place, but failing to carry it out properly. Does not include failure to yield, changing lane.
Opening a door where or when a reasonable person would not have.
Driver/rider or pedestrian who perceives a vehicle, person or object in their own carriageway or on the footpath too late to permit avoidance, and where the road user would normally have had right of way. The reasonable road user should have perceived it earlier (note this includes the situation where another vehicle turns into a major road in front of the vehicle concerned).
Driver/rider or pedestrian who perceives a vehicle, person or object in their own carriageway or on the footpath too late to permit avoidance, and where the driver/rider would normally have had right of way. The reasonable road user would also have been unable to anticipate, note this includes the situation where another vehicle turns into a major road in front of the vehicle concerned.
Pedestrian or stationary or barely moving vehicle at a location that endangers itself and/or other road users (does not apply to vehicles crossing a road by a reasonably direct route). This category excludes maneuvers defined elsewhere.
Driving/riding on the wrong side of the road, or up a one-way carriageway the wrong way.
Before undertaking any maneuver.
At a junction where there are no marks or signs and there is no obvious priority.
Whether marked, signed or not.
Includes failing to yield to pedestrians crossing the road into which the vehicle is turning.
Includes failing to yield to pedestrians crossing the road into which the vehicle is turning.
Includes failure to yield to pedestrians on the footpath.
Crossing at a place in the road where a reasonable pedestrian would be aware that it was dangerous. The reasonable pedestrian would choose to cross elsewhere.
Pedestrian stepping into path of vehicle and unreasonably obstructing it.
Doing something which the other road user would not expect you to do in the light of your signal (includes gestures, signs, signals, lights flashing, etc.).
134 Vehicle failure

Non-collision event, in which a vehicle failure such as a tire causes injury to an occupant or rider.

135 Other

Top-level failure not otherwise specified.

198 No failure

A road user, for whom no factors are applicable - whether human, site or vehicle.

199 Unknown (top level)

Road user for whom we do not have enough information to code failures or no failure.

201 Situational problem

Site or environmental factor from which the reasonable road user would have difficulty.

202 Following too close

Road user following a vehicle with insufficient time to stop.

203 Driving too fast for the situation

Exceeding the speed at which a reasonable driver/rider would have travelled given the circumstances.

200 Did not see, type unknown

One of the following factors applied:
- Failed to look, at all
- Failed to look, partial
- Looked but failed to see
- Unable to see

301 Failed to look, at all

Road user who fails to look in any directions in which the reasonable road user would have looked.

302 Failed to look, partial

Road user who fails to look in all directions in which the reasonable road user would have looked.

303 Looked but failed to see

Looked in one or more directions in which the reasonable road user would have looked, but having looked failed to see what the reasonable road user should have seen.

304 Misinterpretation, other road users

Misunderstood the true intentions of other road users where the reasonable road user might be misled.

305 Misinterpretation, layout

Misunderstood the true nature of the layout where the reasonable road user might be misled.

306 Lack of judgement - path

Road user who shows errors in judgement with regard to the path of other road users where the reasonable road user would not have done, and therefore fails to correctly assess the risks in the situation.

307 Lack of judgement - speed/distance

Road user who shows errors in judgement with regard to the speed or distance of other road users where the reasonable road user would not have done, and therefore fails to correctly assess the risks in the situation.

308 Lack of judgement - other

Road user who shows errors in judgement with regard to other aspects of the situation where the reasonable road user would not have done, and therefore fails to correctly assess the risks in the situation.

309 Lack of motor skills - braking

Road user who shows lack of braking skills, where a reasonable road user would not.

310 Lack of motor skills - steering

Road user who shows lack of steering skills, where a reasonable road user would not.

311 Lack of motor skills - general

Road user who shows lack of general driving skills, where a reasonable road user would not.

312 Unable to see

The reasonable road user would not have seen.

313 Foolhardy

Road user who, judging the situation correctly, attempts a risky action not believing an accident will occur.

314 Deliberate

Road user who attempts to precipitate an accident.

315 Aggressive behaviour

Road user who maliciously attempts to impose his/her will on other road users, intending to force the other road users to reduce the risks in the situation.

316 Unable to drive

Road user whose actions we are unable to explain.

399 Unknown (3rd level)

Road user who is unable to drive/ride reasonably due to lack of experience of driving/riding:

Inexperience with the particular accident vehicle.

401 Inexperience - driving

Inexperience with the particular accident vehicle.

402 Inexperience - of vehicle

Inexperience with the particular accident vehicle.

403 Panic

Over- or under-reaction due to the fear of an apparently impending accident.

(Whether or not OPJ)

404 Impairment - alcohol

Road user whose mental and/or motor abilities are adversely affected due to consumption of drugs (whether prescribed, illegal or other), or non-consumption of necessary drugs.

405 Impairment - drugs

(excludes mental illness)

406 Impairment - fatigue

(excludes mental illness)

407 Impairment - illness

(excludes mental illness)
408 Impairment - emotional state of mind (Includes mental illness)
409 Disability - sight
410 Disability - hearing
411 Disability - other
412 Thoughtlessness
413 Bloodymindedness
414 Distraction - physical, external
415 Distraction - physical, internal
416 Distraction - physical, pedestrian
417 Distraction - mental
418 Overconfidence
419 Tyre deflation before impact
420 Tyre - lack of tread
421 Tyre - wrong pressures
422 Brake defect
423 Steering defect
424 Lights defect
425 Lights inadequate
426 Lights, signal defect
427 Mech defects, motive power/drive train
428 Total electrical failure
429 Load defective
430 Windscreen defective
431 Wiper not working
432 Fire
433 Overall poor condition
434 *, snow/ice on window
435 Obstruction/obscuration, lead
436 Obstruction/obscuration, missed up
437 *, other interior
438 *, pedestrian clothing/equipment
439 *, site, vertical/horizontal curvature
440 *, site, street furniture
441 *, site, weather condi, snow/sleet/cha
442 *, site, weather condition, rain
443 *, site, weather condition, fog/mist
444 *, site, object in road
408 Impairment - emotional state of mind (Includes mental illness)
409 Disability - sight
410 Disability - hearing
411 Disability - other
412 Thoughtlessness
413 Bloodymindedness
414 Distraction - physical, external
415 Distraction - physical, internal
416 Distraction - physical, pedestrian
417 Distraction - mental
418 Overconfidence
419 Tyre deflation before impact
420 Tyre - lack of tread
421 Tyre - wrong pressures
422 Brake defect
423 Steering defect
424 Lights defect
425 Lights inadequate
426 Lights, signal defect
427 Mech defects, motive power/drive train
428 Total electrical failure
429 Load defective
430 Windscreen defective
431 Wiper not working
432 Fire
433 Overall poor condition
434 *, snow/ice on window
435 Obstruction/obscuration, lead
436 Obstruction/obscuration, missed up
437 *, other interior
438 *, pedestrian clothing/equipment
439 *, site, vertical/horizontal curvature
440 *, site, street furniture
441 *, site, weather condi, snow/sleet/cha
442 *, site, weather condition, rain
443 *, site, weather condition, fog/mist
444 *, site, object in road

Road user with partial or total, temporary or permanent, endogenous sight problem.
Road user with partial or total, temporary or permanent, endogenous hearing problem.
Road user with partial or total, temporary or permanent, endogenous problem, other than of sight or of hearing. (This would include a sudden cramp, for example).

Driver/ rider who is distracted from pertinent aspects of his/her situation or vehicle, due to attention unduly focussed on an aspect external to the vehicle.
Driver/ rider who is distracted from pertinent aspects of his/her situation or vehicle, due to attention unduly focussed on an aspect internal to, or of, the vehicle. (This includes distraction due to passengers in/on vehicles).
Pedestrian who is distracted from pertinent aspects of his/her situation, due to attention unduly focussed on any external cause.
Road user who is distracted from pertinent aspects of his/her situation, due to attention unduly focussed on other thoughts.
Road user who assesses the risk as lower than it really is.
Sudden loss of air pressure that occurred prior to accident.
Fault or degradation in the braking system.
One or more lights not in working order other than lights too dim.
One or more lights too dim to be seen or too dim to light up the road (headlights).
One or more signals not in working order other than signals too dim.
Car does not respond properly to accelerator, clutch or gearbox.
If this results in a lighting, signal, braking, or motive power failure this also should be noted if relevant.
Improperly secured or inappropriate load.
Break or permanent mark on windscreen such that vision is obscured, or complete absence of windscreen.
Numerous faults such that vehicle required total overhaul to be put in safe condition or such that vehicle should have been scrapped.
Sufficient snow or ice on a window such that normal vision is obscured and which the reasonable driver would have cleared.
Load such as to block vision of driver/rider.
Interior of a window steamed up such that normal vision is obscured and which the reasonable driver would have cleared.
Obstruction from some other person, object or animal in the interior such that normal vision is obscured and which the reasonable driver would have moved.
Vision of pedestrian obscured by a piece of their own clothing or equipment.
Geometry of road surface such as to block vision of road user.
Position of street furniture such as to block vision of road user.
Road user vision hindered by severe snow or sleet or hail.
Road user vision hindered by severe rain.
Road user vision hindered by fog or mist.
Object in road such as to block vision of road user.
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Parked vehicles such as to block vision or path of road user.
Stationary vehicles such as to block vision of road user.
Moving vehicles such as to block vision of road user.
Vegetation such as to block vision of road user.
Pedestrian such as to block vision of road user.
One or more building/fences/walls such as to block vision of road user.
Road user vision hindered by spray.
Read user who fails to adjust or clean their vehicle properly prior to or during driving/riding, or fails to ensure that their clothing is suitable for driving/riding.
Wrongly or dangerously positioned street furniture (excludes obscuration factors).
CROSSING FACILITIES FOR PEDESTRIANS WHICH ARE ABSENT, OR, IF PRESENT, ARE NOT WORKING CORRECTLY OR NEED TO BE UPGRADED. CROSSING FACILITIES INCLUDE PEDESTRIAN REFUGES, ZEBRA CROSSINGS, PEDELCROSSINGS, PEDESTRIAN PHASE OF TRAFFIC LIGHTS, POLICE OR SCHOOL CROSSINGS, AND SUBWAYS OR BRIDGES OVER ROADS.
Traffic lights which are not working in part, or at all, or wrongly programmed signal settings (excluding pedestrian crossing facilities).
A road layout with visual clues from the physical environment, excluding inadequate signs or markings, which might mislead the reasonable road user. This could include a deceptively sharp bend.
A faulty guard rail is either one that is damaged or one whose design makes it unstable.
A road/pavement surface which is likely to deflect the paths of a driver/ rider, or cause a pedestrian to stumble or fall.
Applies to road, pavement or verge.
Applies to road, pavement or verge.
Applies to road, pavement or verge.
Applies to road, pavement or verge.
Appplies to road, pavement or verge.
Appplies to road, pavement or verge.
Appplies to road, pavement or verge.
A road user or object which, as a result of its presence or action, influences other road users to take an action which results in an accident. The "phantom" is not directly involved in the accident. Not applicable when being chased/scared is a factor.
Sufficient to temporarily blind a road user.
Sufficient to temporarily blind a road user.
A road user whose ability to use the road or pavement has been reduced by their motivation to get somewhere quickly (other than panic). Includes chasing.
A road user who encountered a road environment of which they have little or no experience and which prevents them from acting safely.
A road user who challenges another road user to alter their path or speed by placing himself/herself directly in their path, for reasons of gaming or amusement.
Only as a result of impatience with the traffic situation.
As a result of doing something meant to impress (excluding playing 'chicken').
Receiving advice, support, or courage from another person (excluding playing 'chicken').
A young road user whose guardian doesn't attempt to control the young road user to the degree expected of a reasonable guardian.
Excessive camber or improper or inadequate banking.
481. Inadequate road signs/markings

A site where the signs and/or markings are faulty, non-existent, improper or wrongly placed.

482. Weather condition (general)

(factors other than obscuration or road surface factors).

499. Unknown (4th level)

Road user whose actions we are unable to explain.
Accident Questionnaire

This questionnaire is divided into sections dealing with different aspects of the accident you were involved in. You may find that it will help you to answer the questionnaire if you read through it once to familiarise yourself with it before you complete it. Some questions provide a line for you to print your answer... answer... or ask you to tick a box. Tick as many boxes as are relevant. If you want to change your response, put a cross through it and tick your new response. Even if you are not sure about the answer, do not leave the item blank, pick the answer that is closest to what you think. Please tick the ‘No’ box where applicable rather than leaving the item blank. It is important that you complete all the sections and answer every relevant question.

Section 1: The Accident Situation

This section is about what you can recall of the accident, how the accident may have been caused and how others may be able to avoid a similar accident in the future.

To start with, please draw a diagram of the accident and its location as best you can. Include as much detail as you can recall e.g. roads, road markings or crossings, vehicles involved in the incident, the paths that they were travelling, the directions of impacts and the final resting place of each vehicle involved, if you know.

Diagram of accident location.
1.1. Please describe the circumstances that led up to the accident, i.e. where you were going to and from, and where the accident occurred.

Driving from: .................................................................................................................................................................

Driving to: ...........................................................................................................................................................................

The accident occurred at: ....................................................................................................................................................

1.2. What happened immediately before the accident, e.g. did you have time to swerve or brake and did the other driver, if there was one, appear to do so? ............................................................................................................................................................................

1.3. What do you think were the main reasons for the accident? ............................................................................................................................................................................................................................................................................................................

1.4. Was there anything you could have done to reduce the risk of an accident such as this? ............................................................................................................................................................................................................................................................................................................

1.5. If there was another person involved in the accident, could they have done anything to avoid or reduce the risk of an accident such as this? ............................................................................................................................................................................................................................................................................................................

1.6. If you had to make a list of Do’s and Don’ts to give to other road users to avoid an accident such as this, what would they be?

Do’s .......................................................................................................................................................................................

Don’ts .................................................................................................................................................................................
Section 2: Accident Situation

This section is about the area immediately around the accident scene, e.g. the layout of the road and the problems you may have experienced as a result of this.

### 2.1. What sort of area you were in?
- City centre shopping
- City centre residential
- City centre industrial/business park
- Suburban shopping
- Suburban residential
- Suburban industrial/business park
- Village/town shopping
- Village/town residential
- Village/town industrial/business park
- Open countryside
- Other (please describe)

### 2.2. What type of road you were on?
- Motorway
- 'A' road dual carriageway
- 'A' road single carriageway
- 'A' road with signed overtaking lane
- 'B' road
- 'C' road or unclassified
- One way street
- Other (please describe)

### 2.3. Did the accident occur?
- At a junction
- Close to but not at a junction, (within 100 metres)
- Not at/close to a junction (Please go to question 2.10)

### 2.4. What type of junction?
- Cross road
- T junction
- Y junction or slip road e.g. Motorway junction
- More than 4 turnings
- Mini roundabout
- Roundabout
- Pulling into or out of a driveway or entrance
- Other (please describe)

### 2.5. Which direction were you heading at this junction?
- Straight on
- Turning right
- Turning left
- Other (please describe)

### 2.6. When the accident occurred, which road were you on?
- Main road, you were not expected to give way
- Main road, you were instructed to stop e.g. by traffic lights
- Secondary road, you were expected to give way
- Priority not explicit, unclear whether you were to give way or whether other road users were to give way
- 'C' road or unclassified
- One-way street
- Pulling into or out of a driveway or entrance
- Other (please describe)
2.8. What type of traffic controls were there at this junction?
- Stop or give-way sign
- Traffic lights
- Roundabout
- Painted lines or chevrons
- Traffic island

2.9. Did you stop at this junction?
- Yes
- Not sure
- No
- Not applicable, not expected to stop

2.10. What was the speed limit on the road on which the accident occurred? ........................................ mph  ❑ Don't Know

2.11. Did your vehicle run off the road?
- Yes
- No
- Not sure

2.12. What was the road layout like close to the accident scene? Please tick all that apply.

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<thead>
<tr>
<th>Types of bends</th>
<th>Approaching accident scene</th>
<th>At accident scene</th>
<th>After accident scene</th>
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<td>Multiple wide curves</td>
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<td>Multiple narrow curves</td>
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<th>Types of slopes</th>
<th>Approaching accident scene</th>
<th>At accident scene</th>
<th>After accident scene</th>
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<tr>
<td>Uphill slope</td>
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<td>Downhill slope</td>
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2.13. Were there any other changes in the road layout between the area immediately before the accident and the area of the accident?
- No changes
- Speed limit change, new limit........ mph ❑ Don’t know
- Road width increase
- Road width decrease
- Leaving a zone with road lighting
- Entering a zone with road lighting

2.14. Were there any other changes in the road layout between the area of the accident and the area immediately after it?
- No changes
- Speed limit change, new limit........ mph ❑ Don’t know
- Road width increase
- Road width decrease
- Leaving a zone with road lighting
- Entering a zone with road lighting

<table>
<thead>
<tr>
<th>Other (please describe)</th>
<th>road width increase</th>
<th>road width decrease</th>
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2.15. Did the accident occur close to any of the following?
- Access/slip road
- Parking area
- Bridge
- Underpass/overpass
- Pedestrian crossing
- Bicycle path/lane
- Chicane
- Speed retarders e.g. road humps
- None of these
- Other (please describe)

2.16. Immediately before the accident occurred, were you changing lanes e.g. preparing to overtake?
- Yes
- No
- Not sure

2.17. How was the visibility along the road?
- Partially restricted
- Severely restricted
- Not restricted (please go to question 2.19)

2.18. What was restricting the visibility along the road?
- Hill or slope in the road
- Bend in the road
- Trees, bushes, hedges etc.
- Roadworks
- Street signs
- Wall or houses
- Snow, sleet, rain or hail
- Fog or mist
- Spray from another vehicle
- Parked vehicle
- Stationary but not parked vehicle, i.e. one in stationary or slow moving traffic
- Other (please describe)

2.19. Do you think being dazzled by glare may have helped to cause the accident?
- Yes
- No (please go to question 2.21)

2.20. What was this glare from?
- An oncoming car's headlights
- The sun
- Other (please describe)

2.21. Please describe where you were looking immediately before the accident.

2.22. Was the view out of the vehicle obscured by?
- A break or mark on the windscreen
- Snow or ice on the vehicle's windows
- Mist on the windows
- Another person or animal inside your vehicle
- Other (please describe)
- Vision not obscured

2.23. Were you unable to see until too late an object or vehicle that caused you to have the accident?
- Yes
- No
- Not sure
- Not applicable no other vehicles involved (please go to 2.27)
2.24. What vehicles or objects were in the accident?
- Another car
- Van
- Truck
- Bus or coach
- Construction vehicle, e.g. JCB
- Bicycle
- Moped or Motorbike
- Pedestrian
- An object on the road
- An animal on the road
- An object at the side of the road, e.g. a lamp post
- Other (please describe)
- No other road users or objects involved please go to question 2.27

2.25. What was the nature of the impact with the other objects?
- Front to front, head-on
- Front to side
- Side swipe
- Front to rear
- Multiple impacts
- Roll over
- Other (please describe)
- Not sure

2.26. In total, including your own, how many vehicles were involved in the accident?

2.27. Did you see what you were in collision with before the accident happened?
- Yes
- No (please go to question 2.30)
- Not sure

2.28. Did you expect a collision?
- Yes
- No
- Not sure

2.29. Did you think you could have avoided the collision by any of the following?
- I thought it would slow down enough
- No, I saw it too late to avoid it
- Other (please describe)
- I thought I could slow down enough
- I thought it would avoid me
- I thought I could avoid it

2.30. Do you now think that you were driving too close to a vehicle in front prior to the accident?
- Yes
- Not sure
- No
- Not driving behind another vehicle

2.31. Did the road surface influence the vehicle’s handling?
- No (please go to question 2.33)
- Yes, it influenced handling
- Not sure

2.32. What was the condition of the road?
- Wet, after long dry period
- Wet
- Snow
- Ice
- Loose gravel
- Mud
- Oil
- Other (please describe)
2.33. Approaching the accident scene, were there any road signs to indicate a difficult section of road ahead, e.g. chevrons on a bend, a warning of the road narrowing?
- Yes
- No (please go to question 2.34)
- Not sure (please go to question 2.34)

Please describe..........................................................................................................................................................................

2.34. What marked the centre of the road?
- No centre markings
- Barrier
- Grass verge
- Double white lines
- Broken line and single white line, your side
- Broken line and single white line, other side
- Broken line
- Other (please describe).................................................................
- Not sure

2.35. What was the volume of traffic at the time of the accident?
- Low
- Medium
- High
- Traffic jam

2.36. Was there any unusual hindrance to the flow of traffic?
- Yes
- No (please go to question 2.38)

2.37. What was this due to?
- Not sure
- Road works
- Commuting traffic
- School
- Factory
- Enforced detour, due to an accident
- Other (please describe).................................................................

2.38. Did the accident follow another accident?
- Yes
- No
- Not sure

2.39. Is there anything else about the accident situation that you would like to mention?................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................
Section 3: Journey Details

This section is about the journey such as the weather at the time, how long you had been driving and other things that may have affected the way you drove. Tick as many boxes as you feel are appropriate.

3.1. When did the accident happen?
Month ........................................ Day of the week ...................... Approximate time of the accident .................... AM/PM

3.2. How light was it at the time of the accident?
☐ Dawn  ☐ Dusk  ☐ Day  ☐ Night

3.3. Was there anything special about the day of the accident?
☐ Day before a public holiday  ☐ Nothing special
☐ Day of public holiday  ☐ Other (please describe) .........................
☐ Day after a public holiday  ☐ Heavy vacation traffic

3.4. What did you do the day before the accident?
☐ Driving less than 4 hours  ☐ Driving more than 4 hours
☐ Normal working day

3.5. What was the temperature at the time of the accident?
☐ Hot  ☐ Cool
☐ Warm  ☐ Cold
☐ Neutral  ☐ Not sure

3.6. Was there any rain, snow or hail at the time of the accident?
☐ None (please go to question 3.8)  ☐ Sleet or snow
☐ Rain or hail  ☐ Not sure

3.7. What was the rate?
☐ Light  ☐ Strong
☐ Medium  ☐ Not sure
☐ Heavy

3.8. Was there any wind at the time of the accident?
☐ None  ☐ Strong
☐ Slight  ☐ Not sure
☐ Medium

3.9. What sort of vehicle were you driving at the time of the accident?
Manufacturer ........................................ Model ........................................

3.10. Year of manufacture or registration year, e.g. P ........................................

3.11. What colour is the car?
☐ White  ☐ Yellow
☐ Black  ☐ Bright red
☐ Light grey  ☐ Burgundy
☐ Dark grey  ☐ Light brown
☐ Light blue  ☐ Dark brown
☐ Dark blue  ☐ Silver
☐ Light green  ☐ Other (please describe) ...........................................
☐ Dark green
☐ Orange
3.12. What sort of body does the vehicle have?
- Saloon
- Hatchback
- Estate
- Pickup
- Small van

3.13. What features does the vehicle have?
- Front wheel drive
- Rear wheel drive
- 4 Wheel drive
- Manual gearbox
- Automatic gearbox
- Continuously variable transmission
- Servo assisted braking system
- Anti-lock braking system
- Power steering
- Automatic traction control
- Cruise control
- Other (please describe)

3.14. Including yourself, how many occupants did your vehicle have at the time of the accident?
- Other (please describe)

3.15. What was the purpose of your journey?
- To or from your place of work or study
- As part of your job
- Social, domestic, pleasure
- Other (please describe)

3.16. What was the direction of the trip in which the accident happened?
- Going
- Returning
- Round trip

3.17. How often have you driven along that route?
- Daily
- At least once a week
- At least once a month
- Several times a year
- Extremely rarely
- First time
- Other (please describe)

3.18. What was the total trip distance you planned?

3.19. What was the distance you actually drove?

3.20. How long had you thought the journey would take?

3.21. How long did the journey take up to the accident?

3.22. How would you describe the atmosphere in passenger compartment immediately before the accident?
- Neutral, alone or no interaction with passengers
- Conflict/argument
- Calm conversation
- Playful
- Other (please describe)
3.23. How well do you know the road on which the accident occurred?
- ☐ Very well
- ☐ Quite well
- ☐ Not very well
- ☐ Not at all

3.24. Did any of the following factors affect the cause of the accident?
- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ Don't Know

- [ ] Street lighting
- [ ] Being in a hurry
- [ ] Being chased or scared by another road user
- [ ] Being in an unfamiliar road layout
- [ ] Being frustrated by the traffic situation
- [ ] Driving so as to impress a passenger or other road user
- [ ] Receiving encouragement to do something you ordinarily would not have done

3.25. Did you drink any alcoholic drinks in the 24 hours prior to the accident?
- ☐ No (please go to the next section)
- ☐ Yes, what type of drink? When?

3.36. Do you think this may have been a factor in the accident?
- ☐ No
- ☐ Yes, (please describe)
It is not uncommon for drivers to make minor errors or misjudgements in their driving during the development of an accident. This section is about the actions of those involved and any errors or misjudgements that may have been made.

For each of the following, please indicate if you feel it affected the cause of the accident by ticking the appropriate box.

### Section 4: Causes of the Accident

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<th>YES</th>
<th>NO</th>
<th>MAYBE</th>
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<td>4.1. Immediately before the accident, did you do anything that you felt to be reasonable at the time but that other road users may have considered to be unexpected?</td>
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<tr>
<td>Braked really hard</td>
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<td>Deliberately drove in an erratic course, e.g. swerving to avoid something</td>
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<td>Lost control of the vehicle e.g. by skidding on ice</td>
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<td>Gave a misleading signal e.g. signalled and failed to turn or turned without signalling</td>
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<td>Had difficulty steering effectively</td>
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<tr>
<td>Had difficulty braking effectively</td>
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<td>Made a turn or other manoeuvre from the wrong lane, e.g. turning left from the outside lane of a roundabout</td>
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<td>Made a U turn or 3 point turn in an inappropriate place</td>
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<td>Overtook another vehicle where you would not normally do</td>
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<td>Reversing in an inappropriate place, e.g. onto a main road</td>
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<td>Vehicle was either stationary or barely moving and in a position that would have endangered itself or other road users, e.g. waiting to turn at a busy junction</td>
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<td>Drove the wrong way up a one way street or other restricted road</td>
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<td>Made some manoeuvre that you normally would not have done, e.g. you overtook in a more risky situation than you would normally have done</td>
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<tr>
<td>Other, (please describe)</td>
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### 4.2. If you had more experience of the particular vehicle you were driving, do you think you could have avoided the accident?

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<th>YES</th>
<th>NO</th>
<th>MAYBE</th>
<th>DON'T KNOW</th>
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<td></td>
<td>Yes</td>
<td>No</td>
<td>Not sure</td>
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### 4.3. In your opinion, did another person behave in such a way that you consider to be careless?

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<td></td>
<td>Yes</td>
<td>No</td>
<td>Not applicable (single vehicle accident)</td>
<td>Not sure</td>
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### 4.4. Did another road user behave in a way that was confusing or ambiguous?

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<th>MAYBE</th>
<th>DON'T KNOW</th>
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<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Not applicable (single vehicle accident)</td>
<td>Not sure</td>
</tr>
</tbody>
</table>

Please describe........................................................................................................................................................................................................................................
4.5. Immediately before the accident, did another road user do anything that you consider to be unexpected? Please tick as many boxes as you feel are important.

- Single vehicle accident (please go to question 4.6)
- Braked really hard
- Deliberately drove in an erratic course, e.g. swerving to avoid something
- Lost control of the vehicle
- Signalled in a misleading manner, e.g. signalled and failed to turn, turned without signalling
- They did not brake effectively
- They did not steer effectively
- They made a turn or other manoeuvre from the wrong lane, e.g. turned left from the outside lane of a roundabout
- They made a U turn or 3 point turn in an inappropriate place
- They overtook another vehicle in a place that you would not normally do
- They were reversing in an inappropriate place, e.g. onto a main road
- Their vehicle was either stationary or barely moving and in a position that would have endangered itself or other road users e.g. waiting to turn at a busy junction
- They were driving the wrong way up a one way street or other restricted road
- They ran off the road
- They made a manoeuvre that you would not have done, e.g. they overtook in a risky situation
- Other, (please describe).

4.6. What was your approximate speed immediately before the accident? ......mph

4.7. Before the accident, did you misjudge the speed of another road user, e.g. by thinking the other road user was moving more slowly than they turned out to be?

- Yes
- No (please go to question 4.9)

4.8. Before the accident, did you misjudge the distance to another road user, e.g. by thinking the other road user was further away than they turned out to be?

- Yes
- No (please go to question 4.9)

4.9. If you had more experience of driving do you think you could have avoided the accident?

- Yes
- No
- Not sure
This section addresses in more detail things that you feel may have contributed to the accident.

5.1. Did any of the following affect the cause of the accident?

- Distracted by looking for something in the vehicle
- Distracted by looking for street names or route directions
- Distracted by disturbances in your vehicle, e.g., children
- Distracted by problems on your mind at the time
- Felt tired or fatigued
- Felt angry or annoyed
- Felt unwell
- Felt depressed
- Difficulty in concentrating on driving
- Were late and in a rush
- Felt panicked
- Overconfident in your driving abilities
- The road surface made the car difficult to control
- The road layout was misleading
- The road signs were misleading
- Road signs were missing
- Poorly placed road signs
- Traffic lights were not working or were misleading
- There was another road user who caused the accident without themselves crashing
- You were nervous when driving
- You could not avoid being involved in an accident
- Pedestrians were crossing in an inappropriate place

Other, (please describe)...........................................................................................................

5.2. Do you feel your mental and/or physical abilities were impaired before the accident?

- Yes
- No (please go to question 5.4)
- Not sure (please go to question 5.4)

5.3. What was this due to?

- Consumption of alcohol
- Non-consumption of necessary prescribed drugs
- Consumption of necessary prescribed drugs
- Fatigue
- Illness

Other (please describe).................................................................

5.4. Do you suffer from any disabilities that may have helped to influence the cause of the accident?

- No disabilities
- Physical disability
- Visual
- Hearing

Other (please describe).................................................................

---

Section 5: Causes of misjudgements
5.5. Do you normally wear spectacles or contact lenses for driving?
- No (please go to question 5.7)
- Yes, worn at the time of the accident
- Yes, not worn at the time of the accident

5.6. Do you feel vision was a factor in the accident?
- Yes
- No
- Not sure

5.7. Before the accident, was there a problem or a mechanical failure with the vehicle, such as a blown tyre that may have contributed to or caused the accident?
- No (please go to question 5.9)
- Brake defect
- Sudden tyre deflation
- Steering defect
- Other tyre fault, e.g. lack of tread, or tyres being at the wrong pressure
- Light defect
- Other (please describe) .............................................

5.8. What was the effect of this?
- Delay in braking
- Loss of effectiveness of brakes
- Pull to one side
- Lack of precision or play in steering system
- Lights didn’t work at all
- Reduced visibility
- Intermittent light failure
- Other (please describe) .............................................

5.9. Were you carrying a load in your vehicle that may have affected either your driving or the performance of the vehicle and affected the cause the accident?
- Yes
- No
- Not sure

5.10. Were there any other factors that may have caused the accident? (Please describe) .............................................

..............................................................................................................................................................................................
Please tell us a bit about yourself.

6.1. What was your age last birthday .................. years?

6.2. Sex
- Male
- Female

6.3. Nationality ....................................

6.4. Length of residency in UK?
- From birth
- Resident for less than one year
- Resident for more than one year
- In transit/temporary stay

6.5. What is your present marital status?
- Single
- Co-habiting
- Married
- Separated or divorced
- Widowed

6.6. How many children under 18 do you have?...............

6.7. What is your highest educational qualification?
- Secondary school, (O levels)
- Secondary school, (A levels)
- BTech
- City and Guilds
- HND/HNC
- Degree
- Higher degree
- Other, (please describe)..........................

6.8. What is your present employment status?
- Employed full time
- Employed part time
- Unemployed
- Retired
- Housewife/husband
- Student

6.9. What kind of work have you done most of your adult life? e.g. accountant, bus driver, housewife ..........................................................

6.10. Are you a professional driver? e.g. a taxi driver or other profession in which you drive for a large proportion of your time, (more than 4 hours a day)
- No
- Yes, (please describe)..........................................................

6.11. What type of driver's licence do you have?
- Provisional
- Full

6.12. For which type of vehicles is this licence valid?
- Motorcycle
- Car, automatic only
- Car, manual and automatic
- PSV
- HGV
- Other (please describe)..........................................

6.13. Approximately how long have you held this licence? ............... years
6.14. Have you had any professional or advanced drivers training?
- No
- Yes, (Please describe).................................................................

6.15. Approximately how many miles have you driven in the last year
- Less than 5,000 miles
- 5,000-10,000 miles
- 10,000-15,000 miles
- 15,000-20,000 miles
- Over 20,000 miles

6.16. Please tick if you drive frequently on:
- Motorways
- Dual carriageways
- Other main roads
- Urban roads
- Rural roads

6.17. How many minor accidents have you been involved in all together as a driver? A minor accident is one in which no-one required medical treatment and the costs of damage to vehicles and property were less than £500. Number of minor accidents..................

6.18. How many major accidents have you been involved in all together as a driver? A major accident is one in which either someone required medical treatment or the costs of damage to vehicles and property were more than £500 or both. Number of major accidents.............

6.19. Approximately how long has it been since your last accident ...................... years? ❑ Not applicable

6.20. Before the accident, how many penalty points did you have on your licence?.................................

6.21. What is your connection to the vehicle you were driving at the time of the accident?
- Own vehicle
- Rental
- Spouse's vehicle
- Other (please describe)..................................................
- Borrowed from other family member
- Borrowed
- Company car / car pool

6.22. Approximately how far have you driven in this vehicle since you acquired it? ...................... miles

6.23. How often have you used this vehicle before?
- Daily
- Several times a week
- Several times a month
- Less than once a month
- First time

6.24. Finally, do you have any other comments you would like to make? .................................................................

Thank you very much for completing this questionnaire and for assisting us with our research. Please return the completed questionnaire to Loughborough University in the FREEPOST reply envelope provided. NO STAMP IS REQUIRED.
Dear

The Vehicle Safety Research Centre, which is part of Loughborough University, has for the last 13 years been researching into the cause of injuries that are sustained in a sample of car accidents. The anonymous results from the data collected provide the government and motor manufacturers with valuable information to develop safety policy and safer cars. The Centre has worked with the full co-operation of the police forces in the East Midlands who provide summary information about who was involved in the accident, the type of car, date and time of the accident. The Centre then contacts those people involved.

For the purposes of this research your accident was not sampled, however I have been seconded to the Centre to help with my own project on accident causation the aim of which is to provide motor manufacturers with a better understanding of some of the reasons why motor vehicle accidents are caused so that these manufacturers can find ways to reduce the number of accidents in the future by producing improvements in car design and implementing new technologies into cars.

I must emphasise that your returned questionnaire will be completely anonymous, I do not require personal details such as your name or vehicle registration number to be recorded on them and any comments you make on the questionnaire will in no way be attributable to you in the future. Additionally, the individual questionnaires themselves and the prepaid return envelopes are not numbered or marked and cannot be traced to a given accident.
Additionally, no information from individual questionnaires will be passed onto anyone else under any circumstances. Although this project is being carried out by Loughborough University with the assistance of external agencies, this research is being carried out independently of these and as such no individual data will be passed to them for any reason.

Finally, the names and addresses of drivers to whom this letter has been sent have not been recorded. I would like you to indicate your willingness to participate in this study by returning this letter to Loughborough University in the FREEPOST reply envelope provided, having ticked the box below. You will then be sent a questionnaire to complete and return in another FREEPOST reply envelope. If you do not wish to be contacted for this study, please ignore this letter and you will not be contacted again by the University for this project.

Yours sincerely

Simon Fletcher, (Research Student)

☐ I am prepared to assist by completing a questionnaire about the causes of motor vehicle accidents.
Dear

Thank you for returning my letter indicating your willingness to take part in the current study concerned with the causes of motor vehicle accidents. I have enclosed with this letter the questionnaire for you to complete and a FREEPOST reply envelope for you to return the questionnaire to us at Loughborough University.

As I outlined in our previous letter, this research is being independently conducted by Loughborough University, the aim being to provide motor manufacturers with a better understanding of some of the reasons why motor vehicle accidents are caused so that these manufacturers may then develop technical solutions to reduce the number of accidents in the future.

As I stated before, the questionnaires we have distributed are completely anonymous and confidential. I do not require any personal details such as the registration number of your vehicle or your address so any comments you may make can in no way be attributed to you in the future. In addition, neither the questionnaires themselves, or the return envelopes are numbered so cannot be traced to any given person or accident. Under no circumstances will any individual questionnaires be passed to anyone else, including the external agencies that are assisting this project.

The questionnaire itself is relatively long and detailed, however, the majority of the questions require you to tick a number of appropriate responses so the questionnaire should not take you long to complete. Even if you are not sure about an answer, please do not leave the item blank but pick an answer that is closest to what you think. It is important that you complete all the sections and answer every relevant question.

I will be sending out a follow-up questionnaire as a reminder in approximately two weeks from now. As I will have no way of identifying whether you have previously completed this questionnaire, you will receive this follow-up whether you have completed the first questionnaire or not. Please ignore the follow-up questionnaire if you have previously completed this questionnaire. Following this, you will not be contacted by me for this study again.

I would like to thank you for completing this questionnaire and for helping us in our research. Please return the questionnaire to Loughborough University in the FREEPOST reply envelope provided.

Yours Sincerely,

Simon Fletcher. (Research Student)
Dear Driver,

Loughborough University request your assistance in a research project designed to provide motor manufacturers with a better understanding of some of the reasons why motor accidents happen. The intention is to provide information to aid the development of car design improvements and technologies with a view to reducing accident frequency.

Attached is a questionnaire which is very detailed, along with a FREEPOST envelope for its return. The majority of questions require a tick response and should not take long to complete. If you are unsure about an answer please do not leave a blank section, but choose an answer closest to what you think.

This project is being independently conducted by Loughborough University and no information from individual questionnaires will be passed onto any other parties.

The names and addresses of drivers to whom this questionnaire has been sent have not been recorded and all returned questionnaires will be completely anonymous. Personal details are not sought, any comments made will not be attributable to you in the future.

Success of the project is dependant on your goodwill, thank you for taking the time to help.

Yours sincerely,

Simon Fletcher (Research Student)
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- Speed appropriately and automatically adjust the wiper and windshield wiper to maintain optimal visibility.
- Monitor the speed of the vehicle and adjust the wipers accordingly.
- Ensure that the wipers are always clean and functioning properly.
- Keep the windows clean and clear to maintain optimal visibility.
- Monitor the speed of the vehicle and adjust the wipers accordingly.
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