An exploratory study and analysis of secondary data of road traffic collisions in the United Kingdom resulting in human injury with the aim of influencing the design of products

by

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Concurrent registration for two or more academic awards: N/A

I declare that while registered as a candidate for the research degree, I have not been a registered candidate or enrolled student for another award of the University or other academic or professional institution.

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ABSRACT

The purpose of this study is to analyse secondary data, which originates from an evidence base opposed to a perceived need that the industry often relies on. The industry in question is road transport infrastructure. The industry is made up of numerous Government and private sectors all collectively responsible for providing a variety of products that makes the road network a safe place to drive for the public.

Although the United Kingdom has one of the safest road casualty records in the world it still sees over two thousand deaths a year and thousands more seriously injured. It is the Government's goal to improve road safety to eliminate fatalities. There are many avenues for improvement currently being made such as driver education and vehicle safety. However, to date there has been limited research into road infrastructure, especially research that considers an evidence base.

This study uses data from historic road traffic collisions as its evidence base. The data is collected at every road traffic collision where an injury has occurred by trained Police Officers and held by the Government's Department for Transport. This study uses statistical analysis along with visual cues to determine locations with multiple collisions that could benefit from improved product design.

Due to the complexity and political issues within the industry, plus time constraints, it is known that the results of this study will not be implemented into government departments and product designers until after this study is complete. With this in mind the study highlighted four typical types of location that are deemed dangerous. They can be described easily as; high speed rural road, high-speed junctions, pedestrian crossing not within a junction and collisions with permanent objects off the road. These were determined using years of historic data and should therefore be reviewed for their safety. There are multiple locations with these characteristics. It is intended for these results to be shared with industry to seek new ways in which product design can improve the safety of these types of location.

Finally, this study created an additional benefit alongside the analysis of the data that in the long-term road safety can be improved. This benefit is the creation of a road traffic collision database. The database includes all road traffic collision data and allows the user to compute various factors that will ultimately provide areas, including local Authorities, with road safety difficulties.

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ABBREVIATIONS

DfT – Department for Transport

NHS – National Health Service

KT – Knowledge Transfer

KTP – Knowledge Transfer Partnership

LCC – Lancashire County Council

TRL – Transport Research Laboratory

UK – United Kingdom

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I'd like to dedicate this study to the thousands of people directly affected by road traffic collisions each year. I hope this study is another step in the right direction to the ultimate goal of having no persons killed or serious injured in road collisions.

I would like to appreciate the hard work and dedication to the cause of this study by the Knowledge Transfer Partnership, the University of Central Lancashire and Simmonsigns Limited.

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1. INTRODUCTION

The United Kingdom has one of the safest road networks in the world. However, nearly two thousand people are killed on the roads each year, seven every day. There are many organizations attempting to reduce this. The World Bank and United Nations are running a campaign called the ‘Decade of Action’ (2011). Accidents on the road network are the second biggest killer of younger adults and this costs the government billions of pounds every year, for instance: in emergency services and health services, as well as repair of damaged roads. We should note that over seventy five percent of the United Kingdom’s population drives a vehicle. Driving is considered the most dangerous daily activity we do every day, which reflects the thousands of studies, campaigns, and programmes developed to make the road network safer. For these reasons it is essential that every step be taken to reduce the number of people killed or injured on the United Kingdom’s road network.

The aim of this study is to indentify common areas in the United Kingdom that have had a large amount of road traffic accidents and resulting human injury. To deliver this aim several research objectives have been indentified:

- Source and statistically analyse historic road traffic collisions
- Examine historic road traffic collisions to identify common accident types
- Geographically study the longitude and latitude co-ordinates of each road traffic accident to identify areas with multiple accidents
- Investigate the cost of road traffic accidents in relation to accident type and location
- Visually analyse accident locations to determine common physical features
- Identify common road traffic furniture at locations with multiple road traffic accidents
- Conduct focus groups to analyse road traffic accident locations to determine what makes them dangerous
- Use the statistical, geographic and visual analysis to build a picture of the most dangerous locations for road traffic accidents

The United Kingdom’s road network is managed by a government agency: the Department for Transport (DfT). The DfT employs Local Authorities to manage their regions and the Highways Agency manage all Motorways and major A-Roads. The Department of Transport enforces standards and legislation set by the European Union. There are many private companies that support the DfT in maintaining the roads, these include, contractors, engineers and designers. Each company, along with the Local Authorities, are responsible for meeting the standards set by the European Union and DfT.

The United Kingdom has a well-established road use education programme, with many children taught cycling proficiency at school from a young age. Many Local Authorities give free road safety classes to vulnerable road users such as the elderly. In comparison to educating road use the knowledge of road infrastructure is minimal. There are many sectors working in the background including street lighting, road furniture, communication systems, and traffic management. All sectors require a level of product design and consideration of road safety. But they also require the road user to have an understanding of their purpose and use which can be lacking in comparison to road use knowledge.

All sectors aim to provide a variety of products, such as street lighting, to make the roads safer and more accessible, These products broadly have to meet minimum national standards, which are those meeting a European Standard and specified in detail. The buyer who is often the Local Authority usually sets product specifications. Because of pressure on local authority budgets, factors such as cost may be a priority. The Department for Transport has standardised all road signs to keep signs legible and easily recognisable. However, it is the supporting structures such as steel posts or aluminium lighting columns and installation that vary. These variations could reduce effectiveness and safety. This was a key reason many road infrastructure companies grouped together to form the Passive Revolution (2009). The Passive Revolution is a group of companies that formed a committee to advise the government regarding implementation of products and campaign for new laws to ensure that signs are mounted on passively safe posts. When a passively safe post is truck by a vehicle it will break off on impact and not stop the vehicle in its track, resulting in no serious damage to the occupants.

There is an understanding of dangerous roads in the United Kingdom. However, there is little knowledge of historical collision research. Although there has been a lot of activity on improving products, educating drivers and safety policy, currently, there are no advisory groups that focus on the historical analysis and interpretation of road structure at a regional level and there is no information sharing of policies or protocols between road traffic engineering companies and public services with the cause to improve public safety. This study aimed to change that culture.

The current study focuses on the location and type of historical road traffic collisions. It is hoped that future work will use this study to inform the development of new products with functions that are relevant and specific to the location but also have the potential to reduce the number of people killed or seriously injured. This study used secondary historic collision data to understand road areas that are most dangerous and under what conditions collisions often occur. This included consideration of the vehicle type, daylight conditions and if a vehicle impacted any road furniture.

This study was born from the transfer of new, evidence based, knowledge into industry from education to aid development of new products where the primary function is road safety and where their placement within the road network will have the greatest effect. The recommendations of this study are intended to inform an industry that often works on a perceived need rather than an evidence based requirement. It is essential to understand the relationship between evidence and product design so that proposed interventions and improvements can be implemented effectively.

The research focused purely on the road network and its surroundings. It was not within the scope of this study to consider road users behaviour in a psychological sense, although factors that relate to road users behaviour that are recorded on the available database, as detailed in the methodologies, can be analysed statistically and therefore some discussion of these elements, supported by appropriate literature was considered.

During this study, it was important to explore cultural barriers to sharing information, trade secrecy and responsibility in researching and releasing new products onto the market. The road industry is over one hundred years old and with it new recommendations or changes to existing products must conform to the European Union and Department for Transport legislation. With this in mind, appropriate routes to entry of new products onto the market should be recognised. This study found that the introduction of holistic teams could be considered as a way of implementing new knowledge and products across the many sectors within the industry.

Although this study focuses on an evidence base approach, expert opinion is used where there is only a limited amount of evidence base available. Expert opinion is acquired from credible industry experts and where possible has been compared against the available data to clarify its accuracy.

2. REVIEW OF LITERATURE

Since 1926 each road traffic accident, where a casualty has occurred, a Police Officer will attend and complete a four-page document (the STATS19 form). The DfT combine these data onto a national database but there are limitations and criticisms (Labatt, Langham 2005) because the exact cause of accidents is not documented. Furthermore, Labatt and Langham (2005) have pointed out that the data could be better used to generate ideas in evidence-based approaches whereas researchers currently develop an idea and only afterwards refer to STATS19 to support it.

2.1 Procedures for Searching, Retrieving and Reviewing Existing Literature

The procedure for searching existing literature took three distinguished methods. These were online literature database searches, existing industry advisory documents and the World Wide Web. There was also the addition of expert analysis that is detailed in the methodology.

The process of searching literature databases was primarily online as it gave the ability to search for key words and eliminate were possible. This increased the speed in which to search multiple documents compared to manually searching a library database. Using access to Athens online the search mostly used three different literature-searching portals. These were Web of Knowledge, Science Direct and although this was directly through the web, Google Scholar. Each term in the search was applied in all databases.

Existing industry documents originates from sources such as the Department for Transport and Transport Research Laboratory. These published documents are specific to the industry and rarely focus on the locations of road traffic accidents, although the detail is vital in understanding the industry. To ensure as much of the industry knowledge was search industry knowledge was taken on board and the industry trade for Traffex 2011 was attended.

Finally the World Wide Web was searched using Google to find websites with specific information relating to road traffic accident information. This included the Department for Transport website. Although these were the main searching methods other techniques were used such as the University Library, industry seminars such as ROPSA 2012 and advice from industry experts.

As discussed later in the literature review there was a distinctive lack of previous literature on the specific topic of this study – accident location using secondary data. Admittedly there is a very large pool of information regarding road traffic collisions but not specific to the aim of this study. As an example below are five different search terms used in the database of Google Scholar. Each shows the key term searched and the filters applied with the number of publications received.

Search Term	Filters	Number of Publications
Road Traffic Collision Locations	None	48,900
Road Traffic Collisions Secondary Data	Animal	26,000
Road Traffic Collision Vehicles and Pedestrians	Driver, Error	17,600
Road Accidents Location Infrastructure Engineering Product	Car, Vehicle, Motor, Pedestrian	13,700
Road Traffic Accident Collision Impact Cause Location	Manual, Human, Injury	5,650

Although each of the above search term provided results in the thousands they were not directly related to the aim of this study. For example the third search term above provided results relating to the design of vehicles and type of injuries occurring from accidents. There is a vast pool of information but only a few studies have directly taken secondary data to locate areas of danger with the purpose of influencing road traffic product design. Those studies are detailed in this literature review.

2.2 Locating Accidents

An Irish study report in 2010 used data collected at accidents over an eight-year period to highlight fundamental problems (Road Safety Authority 2010). The report attempted to identify who caused road traffic collisions, which drivers are most vulnerable and drivers' behaviours that contributed to accidents causing serious injury and fatalities. The report provided information that could potentially support the development of new road safety products. However, the report did not detail on two specific areas linking collision factors together and how the most dangerous locations could benefit from new design of road furniture.

A study by Candappa (2007), found that over two thirds of fatalities occur when a vehicle leaves the road in a collision. Candappa was successful in identifying the specific types of locations with high levels of fatality that could benefit from new techniques in road and product design. Candappa went on to develop 'clear zones' that proved effective in reducing the severity of human injury in road traffic collisions. A clear zone is additional space on the side of the road with no obstacles, enabling a vehicle to slow down or avoid an accident. However, Candappa's study was undertaken in Australia where the landscape allows for a clear zone on the side of many roads, whereas many of Britain's roads are located in smaller, built-up areas. It is important to recognize this study for its use of secondary data as the basis for the design of new products. The quality and method of Candappa's study is commended for using historic data that improves the quality of the study. Due to the high quality and positive outcomes of this study it is aimed that this study will use the same method of using secondary data and statistically analysing it.

A DfT Consultation report, with the support of MP Jim Fitzpatrick in 2009, attempted to describe the Government's main challenges and aims for road safety from 2010 and beyond (DfT 2009). The research used secondary data to highlight areas with high collision rates, such as rural roads. These areas accounted for sixty two per cent of all fatalities. Although the DfT pointed towards areas in most need of improved road safety products, they did not link varying factors such as weather and type of road together. For new product design to be effective the designer must know all the requirements, such as function and cost. This is often known as a design specification. The DfT did not state the speed limit, type of vehicle being used or the type of road, which makes it difficult for a designer to develop a new product.

A research tool called MAST is being used by a number of local authorities to ascertain how safe or unsafe their roads are. The same STATS19 data is used but it is transformed into data cubes. Data cubing is a technique of presenting data in a visual simplistic manner using rows and columns and does not require an in-depth understanding of statistics. The limitation in using this method is that the creator can bias the data accidently, as they may not have the necessary statistical knowledge. Also, as they are not using appropriate statistical tests they cannot perform comparisons. Often, the designers of the road furniture themselves do not see the output information and consequently, not all the relevant individuals that could improve road furniture have access to the information.

2.3 Type of Collision

There are a number of detailed investigations into single collisions seeking the cause of fatalities involved. However, specific collisions are not within the scope of this study. A type of road traffic collision can be described in various ways, but every collision begins with the driver's response. It is important to recognize how driver's respond as this information is useful in supporting new designs. Olson (2002) used secondary data to determine driver's response time and concluded that a driver goes through four distinct stages when making a decision in the run up to a collision: detection, identification, decision and response. This study applied historic knowledge to increase our understanding of road collisions. Another study went on to state that the time it takes to complete the four stages are lengthened if the driver was focused on a different primary task, such as using a mobile phone (Hole & Langham 2003). It is important to note that driver's reaction times decreases if they are not focused on the correct primary task. The quality of Olson's study could be criticised, as the source of his secondary data was not defined from a reliable source. This has informed this study to only use secondary data from reliable sources.

Henderson (2009), the Managing Director of GBB Limited, investigated how the design of a vehicle impacts whiplash. He used his expertise in accident investigation and secondary data to conclude how and why whiplash was severe in certain collisions. Henderson's findings concluded with how vehicle design should be revised to reduce the severity of whiplash.

Secondary historic data along with expert industry knowledge have been used in this study to suggest improvements for new and improved product design in road traffic furniture.

Kineer (2009) studied the behaviour of novice drivers. He concluded that drivers ‘drive as they feel’, seeing the road in front of them and taking it as it comes whilst using signs as secondary information. Chen (2008) found that a greater numbers of passengers carried by younger drivers incur more risk of fatalities in a collision, but he did not find specific reasons for this. Kineer attempted to change legislation by presenting these trends to the House of Commons with the intention of changing how drivers obtain their licence, but was unsuccessful. For Kineer’s study and other potential considerations from this study, a lengthy consultation process with testing and validation is required before the DfT will consider any implementation of new ideas or products. This is an issue for designers bringing in new technology. Technology improves at a considerable pace and as new products must meet the current legislation by the DfT and the Conformité Européenne (CE) directives (NANDO 2013) new technology is not included making it extremely difficult and timely to implement.

2.4 Road Furniture Design

In relation to Kineer’s study, Edquist (2009) found that not only did drivers ‘drive as they feel’ but also road furniture play a significant role in how fast they travelled. Surprisingly it was not the information conveyed by the road furniture but their placement on the road. Edquist concluded that the closer the vehicle was to the perceived edge of the road the slower the driver would drive. However, the further away from the edge of the road, the safer the driver would feel and therefore was more likely to drive faster. In areas with building infrastructure, drivers would slow down, as they believed additional obstacles such as pedestrians could be present. Edquist’s study focused on qualitative data alone. Studies such as Edquist’s have supported designers and Local Authorities in deciding where to place new road furniture.

Continuing with ‘driving as you feel’, the Transport Research Laboratory (TfL 2002) conducted a study to move more notable furniture that is on the edge of the road on to the road surface, such as painting speed limits on the road. This brought the driver’s focus from a secondary task of seeing the off road object to integrating the information into the driver’s primary task of reading the road. This study showed some improvements in the driving ability of drivers although Chapman (2005) concluded that there was little scientific evidence to support this. Road treatment signage still relies heavily on expert opinion. It is vital to recognize how vast the road industry is and although it is over a century old it is still developing rapidly. There is not always scientific evidence available to inform development, thus expert opinion is sort to inform product development. Any sectors lacking in historical data or readily available scientific knowledge will rely on independent industry expert opinion.

Cooper (2009) conducted a study of street lighting and bollards. His findings concluded various suggestions on what levels of lighting were and were not required. It was found that the United Kingdom spent over one billion pounds on maintaining road lighting each year although with new Microprismatic material this cost can be decreased. However, Microprismatic material should only be used in specific locations and therefore inappropriate use can have a reverse effect on road safety, making the roads and important signage illegible. Cooper found that certain areas and road signs must be illuminated whilst some savings can be made to others. Cooper’s independent study not only attempted to identify potential savings but considered road safety as vital.

Leeming’s (1969) study of the United Kingdom’s road network is still considered one of the most influential and important studies to date. He recognized that road furniture should be strategically placed, not over used or under used. Whilst in his role working for a Local Authority he had a request from a worried parent asking for a warning sign outside the school. He asked the parent to look out of her window, as there had been a sign there for over fifteen years. With appropriate measures Leeming found that signs had their benefit but they had to be strategically placed if they were to be effective. Leeming’s findings suggest products should be location focused and the primary function clearly defined. The learning’s of this are considered in the research of this study within the focus groups, as it is sometimes objects that we do not see that can be the problem.

2.5 Driver Behaviour

A study by Kumar in 1985 used historic data on collisions to create a Venn diagram that detailed three main reasons for a collision. Kumar found that fifty seven per cent of accidents were the driver’s fault. However, a further twenty seven per cent was a combination of both driver and the road in which they were on. This twenty seven per cent could account for over five hundred fatalities a year in the United Kingdom. Kumar found that only two per cent of collisions were due to failures of the vehicle. The findings suggest that the most effective way to reduce collisions would be to influencing the driver’s behaviour through well-designed road furniture.

Mitchell (2006) concluded that although road signs are important it is actually the road that is important. The marked bitumen and the landscape help us guide our way whilst using our periphery vision to see other objects for references. Mitchell suggests it is important to place new products where a driver will see and use it. Drivers do not attend to every road sign but use the road itself to guide them; therefore new designs should focus on a product that goes directly on the road surface. However, Mitchell recognized that in some areas altering the road design may be unsafe and thus road furniture plays a vital role.

It has become evident that the road industry is multi-facetted and a single solution to stop road collisions will not emerge. However, if multiple new designs work together they can collectively bring an improved opportunity of improving road safety.

2.6 Holistic Approach to Road Safety

This study aimed to improve product design in traffic engineering through introducing new knowledge gained through research techniques and finding pathways this information could be used to influence product design. In order to eventually impact on road safety and policy, the project has wider applications. A number of people and organisations would also be required to take on, absorb and implement this new knowledge for it to be successful. Ideally, learning institutions, industry partners, local authorities and services, engineers, the public and the Department for Transport would communicate and work together.

The Highways Agency is responsible for the management and upkeep of all Motorways and major A-Roads in the United Kingdom. Goulding (2009) on behalf of the Highways Agency stated that for the road network to be improved there are five areas that need to work together, known as the ‘5 E’s’. These were; engineering, enforcement, education, evaluation and encouragement. The most important one to note is engineering. Goulding recognised that not only engineers were required to improve the road network but also a number of other supporting teams.

Working together has been identified as one of the most difficult practices to implement in industry. Welch (2007) in a study of the relationship between occupational health and industry, recognized a gap in collaborative work. The study highlighted a lack of evidence-based practitioners such as design researchers and their inability to work collaboratively. We should recognize that the communication or partnership gap between each sector in the industry should be closed to allow for a more collaborative working industry. Welch suggested a model combining research with collaborative learning in other professions. This model called for evidence based practitioners to not only collaborate but also be a pivotal stage in the development of any project within a company.

Therefore part of the wider implementation of this project means a change in culture in the traffic engineering industry and the DfT. The industry must understand how it can successfully co-operate more like the practice of service industries and learning institutions with their respective policy makers. Although, the co-operation would occur after this study it is important to understand how the new knowledge should be implemented for it to work.

3. APPROACH TO RESEARCH

The approach and strategy of this study is so the aims set out in the introduction can be achieved. The approach is to select historic secondary data of road traffic collisions and the strategy is to carry out varying types of analysis on the data that includes statistical and visual analysis.

3.1 Secondary Data

Historic secondary data is the primary source of data for this study. There are a number of reasons for using this approach as it reflects the positives of other studies within the transportation industry stated in the literature review. There are three key reasons:

- Accuracy
- Use of real life data
- A large pool of data

Historic recorded data from road traffic collisions is deemed accurate as it is recorded by highly trained Police Officers at every road traffic collision. This data was used by Chief Superintendent Lumley's (2010) study along with his knowledge as a road traffic investigation officer. He found, by studying historical data, convicted criminals were twice as likely to be involved in fatal road traffic accidents. This went on to influence the Police and Governments decisions on the lengths of motoring bans. However, the key part of this research was the consideration to use historical data to develop results, which in turn would help reduce the risk of fatal road traffic collisions. The benefit of using historical data in this study was the accuracy that came with it and the confidence levels the Government had in it. It is also important to note that within the time of this study it is not feasible to predict all future road traffic accidents as there are over one hundred thousand collisions a year with large variations in driver behaviour or vehicle type and therefore would not be as accurate as historical data. It would be very difficult to compile and account for double counting and other problems in another data set

By using real historical data the information can be analysed with more confidence and can be related to real life situations. This reflects Kineers (2007) methods; he looked at collisions involving young adults over a period of time and used historical real-life data to draw his conclusions. Using real data will provide the ability to draw conclusions that are relevant to a real world scenario compared with predicting data that may not relate.

Using a large pool of information should enhance the credibility of the results thus minimising any unusual or untypical situations that might confuse the interpretation of the results. The industry standards and Transport Research Laboratory (TRL) take a set number of samples for all testing purposes. This is due to potential anomalies in results. For example, within TRL's research into bicycle accidents, data was taken across the whole of London knowing some anomalies will be present. This also reflects the information known regarding STATS19 and anomalies. A prime example of an anomaly is a driver in a stolen vehicle in a

Police pursuit. This is something that is a rarity and in the context of this study would be deemed an anomaly. The ability to have a large pool of historical data will allow me to remove or reduce the potential number of anomalies within the data which in turn will provide more accurate and relevant conclusions.

The reason for not using primary data in the collection of historical data was feasibility due to time constraints and resources as mentioned by Cooper (2005), plus the historical data has already been collected by trained Police Officers. It would be impossible to collect current data of road traffic collisions during my study. However, secondary data from a six-year period is available. This is often used across many industries where time and cost are limitations. It is possible to compare results between different years to check findings are consistent.

3.2 Use of the STATS19 database (DfT)

All the data for this study were sourced in a raw numerical format from the DfT's publicly available database. Access to the database is acquired through a password issued to the researcher from DfT.

The source of the historical data will be from the Department for Transport (DfT) who manages the National vehicle collision data. After consultation and research it was understood that Police Forces across the United Kingdom record information at all collisions and submit them to DfT for storage. At every road traffic collision, a trained road accident investigation Police officer, records all details on a 'tick-box' document called STATS19. The STATS19 form consists of four pages, each with a different purpose.

1. Accident: Details such as date, type of road, weather conditions.
2. Vehicle: Details include vehicle type, manoeuvre and first point of impact.
3. Casualty: Information such as age, sex and injury severity.
4. Contributing Factors: The final page is used for the Police officer to highlight up to six factors that contributed to the accident in his/her expert opinion. This information includes, excessive speed, impaired by alcohol and aggressive driving.

Road collisions have been recorded in the United Kingdom since 1926. STATS19 has been heavily used in research studies, including the Road Accidents for Great Britain publication by the DfT in 1951. Every four years a panel of industry experts reviews the STATS19 document. Here they vote on the inclusion or exclusion of material. For example in 1994 the use of seatbelts was added to the STATS19 form. This is to keep the document as accurate and up-to-date as possible in a rapidly changing industry. Although these changes are made to keep STATS19 accurate, there are widely recognised inaccuracies.

There are three fundamental reasons for inaccuracies:

1. Not all collisions are reported to the police. Therefore the form is not filled out.

2. It is a ‘Tick-Box’ document. STATS19 gives only tick-box options. Although this keeps consistency it does not allow the Police officer to record other factors that are not specified on the form.
3. Human Error – The document is recorded by a Police Officer who can tick a box inaccurately but also the DfT can input the tick box incorrectly into the database.

Although these inaccuracies are recognised it is believed they do not have an effect on the final outcome, as the amount of data is vast compared to the amount of potential errors. In 2008 the DfT announced that all fatal collisions were to be recorded although many collisions with slight injuries are not. The total number of collisions was believed to be approximately 800,000 opposed to 240,000. An analysis in 2007 showed the total number of hospital admissions from road collisions and total number of serious injuries record in STATS19 were under reported by nearly forty percent, although this is not directly comparable because certain scenarios are not reported in STATS19; such as vehicle collisions on an airport field or with a train. Due to the large potential of missing data relating to slight accidents there are potential errors in results for studies (such as Kineer’s 2009). With this in mind and the minimal impact of slight injuries to individuals and the economy, it was logical for this study to focus on fatal and serious road traffic collisions only. This removed the potential error of missing over 600,000 accidents that go unreported to DfT.

3.3 Expert Analysis

Experts who contributed and gave permission to use their views to this study were:

- *Superintendant Keith Lumley*
- *Poppy Holland – Devon County Council*
- *Simmonsigns Limited*

The importance of expert knowledge is fundamental to this study. In some topics there is a right and a wrong, although the road industry has so many layers and variations statistics alone cannot have all the answers. This can be seen from Kineer’s (2009) study into driver behaviour. There are so many variations in driving behaviour and emotive experiences when driving; a balanced and experienced opinion is required to confirm the findings. This is also seen in the Department for Transport research where not only statistics but also the experiences of its employees in delivering practical solutions are used.

Australian University MONASH studied road traffic collisions using expert opinion to support conclusions. MONASH recognised the need for products that reduce the speed of vehicles at junctions in rural locations, but lacked enough evidence to support any theories. Therefore they collaborated with industry experts to use their expert knowledge and judgement. The experts explained limitations in resource such as power and maintenance along with issues in the design of the location. Researchers used this new knowledge along with the available evidence to develop new products. This highlights the need to use expert knowledge where an evidence base is limited, although it is important to validate suggestions from industry experts to ensure they are accurate and relevant to the aim of the study. It is also vital that any expert knowledge is looked at from both directions as opinion can become clouded over a long period of time. For example some limitations existing decades ago no longer exist such as variable message signs. The technology was not originally available and would not have been taken seriously by researchers if they had not gone against the norm in the industry. To summarise expert opinion will be used when evidence base is limited but it will be reviewed for its accuracy and relevance.

3.4 Geographical Analysis

The visual data in this study was accessed from Google Street View, a publicly available resource through the Internet. The images are taken predominately from 2009. This means there is a possibility that road furniture shown in the picture, may have changed since the accidents in 2007. However, a view is taken that with such a large amount of data and the frequency in which Local Authorities can change road furniture (most products are warranted for over ten years) the number of errors will be minimal. It should be noted that this method is by its nature a faster method of reviewing locations than visiting every locations and therefore this novel method of research should be noted as a quicker method of reviewing road traffic locations.

Data analysis is an effective method of presenting results and discussions. One method of evolving this data beyond data analysis was to analyse geographic and visual locations. The data shows both longitude and latitude co-ordinates of collisions plus the Local Authority it occurred in. This allowed me to visually analyse a location to see what road furniture was, or was not there, plus the road layout and condition. This allowed analysis beyond the numerical data, something that other studies have previously been restricted to (for instance Transport Research Laboratory studies into bicycle accidents). The study of bicycle accidents analysed data alone and therefore did not visually identify specific locations. This can mean vital information such as a change in width of bike lane or appropriately marked lanes can be missed. The data provided from the STATS19 datasets can never cover each individual piece of detail at a collision such as number of trees or damaged road markings. A road traffic collision can involve a number of elements outside the STATS19 form such as glare from the sun or as simple as a broken sign. The use of visual analysis helped support conclusions that may not be readily available within the STATS19 data.

3.5 Descriptive Analysis

Primarily all statistical analysis in this study focuses on descriptive statistics. The data is descriptive as it describes a set of real results, in this case historical road collisions. The benefit of using descriptive data is principally because it will allow the study to use varying methods of statistical analysis yet keep it relevant and as close to the real life collisions that took place. It is important to note that although the data is factual it will not show the underlying key reason that caused the collision. Most of the STATS19 data is a quantitative series of numerical data, but it is important to note that some aspects come from a qualitative aspect such as the weather. For example the recording officer must decide if the weather is light rain or heavy rain. Therefore we should note that some of the data will have a qualitative origin and will consequently vary from one person to another, whereas the quantitative results lend best to the descriptive approach of this study.

3.6 Ethical Approach

It is important to consider ethics before entering into the analysis of this data. The Department for Transport does not provide data that can link a collision back to the people or vehicle involved in a collision. This is positive in terms of ethics for this study, but on the other hand we should note that we are dealing with real-life collisions where persons have been killed. So a cautious approach should be considered when analysing results so not to offend persons affected or sensationalise results. There is no formal ethics approval to sign with the Department for Transport for using the STATS19 dataset, although care should be taken when working with others as a large number of people have been affected by loved ones killed or injured in road traffic collisions.

4. METHODS OF RESEARCH

Taking into considering the Literature and Methodologies, the next section details precisely how the research took place. The Methods section is split into four distinct parts; pilot study, statistical analysis, visual analysis and focus groups. The purpose of the analysis was to locate scenarios of importance regarding human injury in road traffic collisions with special attention to road traffic furniture.

4.1 Pilot Study

At the beginning the full set of STATS19 data was not available although a sub set from a specific council was readily available. With this in mind the purpose of the pilot study was to learn and understanding the STATS19 data whilst I obtained the full set of STATS19 data. The pilot study is directly related to the aims of this study as it is intended to highlight the most dangerous locations on the road network.

The Lancashire County Council (LCC) maintains an interactive map called MARIO (Maps and Related Information Online). MARIO is an online programmable mapping tool that locates data from Police into a visual map. The tools include location of a variety of council owned works such as Primary Schools, traffic lights and road works.

Illustration 1: ***Screenshot of MARIO***

The interactive map is maintained by LCC and includes traffic data taken from the police records in Lancashire County; this includes Preston, Burnley and Chorley. Roads owned by both LCC and the Highways Agency, such as the M6 going through Lancashire are included. However, it does not contain any data outside this area. The tool allows you to view all road traffic collisions between 2007 and 2011. Collisions are classified in four ways:

1. Up to two vehicles
2. Up to two vehicles involving child, cyclists or pedestrian
3. More than two vehicles
4. More than two vehicles involving child, cyclists or pedestrian

Selection of individual collisions provides further details such as, date, time, type of vehicle and weather. After a scoping exercise it was possible to examine high volumes of collisions in small areas. However, the data from MARIO cannot be exported, so the data could only be assessed visually. The number of collisions was manually counted within a one hundred metre-squared area. After exploring the information for its credibility this data set was found to be limited and potentially time consuming therefore questions could be asked about its quality and usefulness. Taking the results and learning from this, the pilot study fed into the next stage, with a large National Data set.

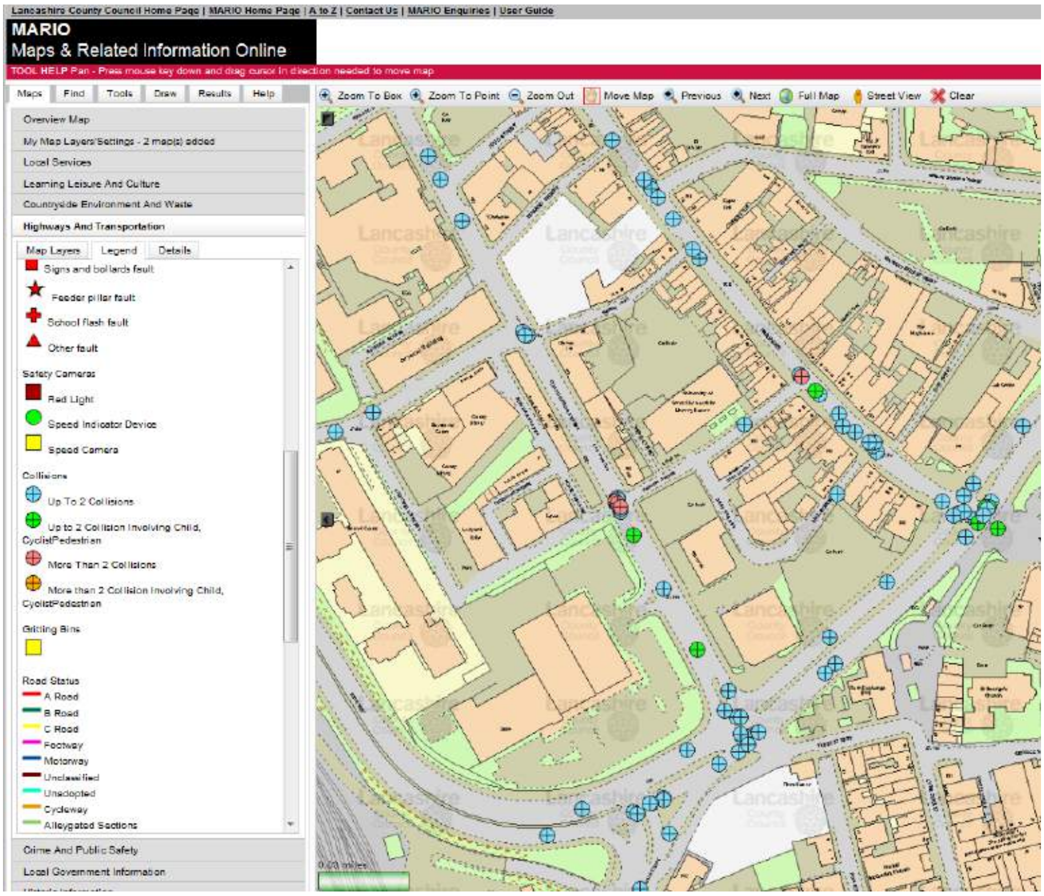
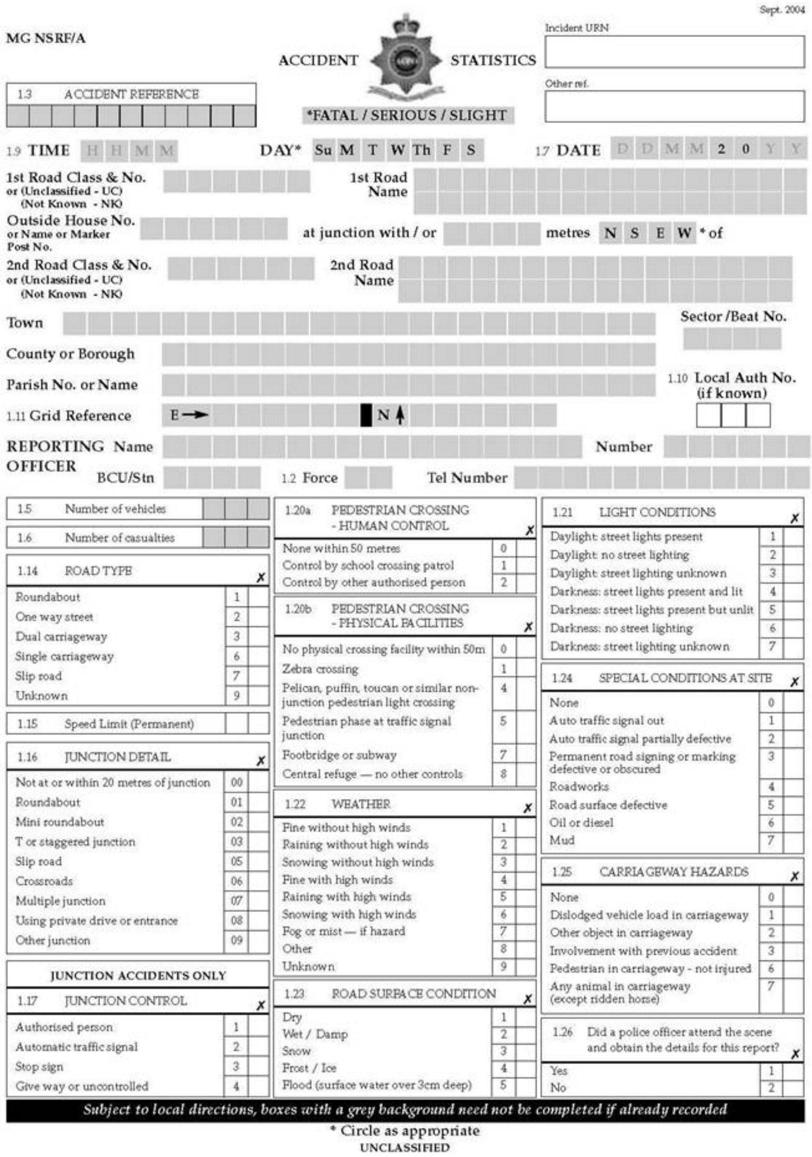


Illustration 2: ***Screenshot of Traffic Collisions on MARIO***

4.2 STATS19 Access and Organisation

The DfT maintains the STATS19 database. As discussed in the methodology, the STATS19 database has numerous tick-box options with fields such as speed, weather and vehicle type. Under each field are a number of ‘factors’. The factors represent independent and dependent conditions, for example, speed would be the field and 30mph would be the factor.


Sept. 2004
MG NSRF/A
ACCIDENT STATISTICS
Incident URN
Other ref.
1.3 ACCIDENT REFERENCE
*FATAL / SERIOUS / SLIGHT
1.9 TIME H H M M
DAY* Su M T W Th F S
1.7 DATE D D M M 2 0 Y Y
1st Road Class & No. or (Unclassified - UC) (Not Known - NK)
1st Road Name
Outside House No. or Name or Marker Post No.
at junction with / or
metres N S E W * of
2nd Road Class & No. or (Unclassified - UC) (Not Known - NK)
2nd Road Name
Town
Sector /Beat No.
County or Borough
Parish No. or Name
1.10 Local Auth No. (if known)
1.11 Grid Reference E→ N↑
REPORTING OFFICER Name
Number
BCU/Stn
1.2 Force
Tel Number

1.5 Number of vehicles	
1.6 Number of casualties	

1.14 ROAD TYPE	✗
Roundabout	1
One way street	2
Dual carriageway	3
Single carriageway	6
Slip road	7
Unknown	9

1.15 Speed Limit (Permanent)	

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

JUNCTION ACCIDENTS ONLY

1.17 JUNCTION CONTROL	✗
Authorised person	1
Automatic traffic signal	2
Stop sign	3
Give way or uncontrolled	4

1.20a PEDESTRIAN CROSSING - HUMAN CONTROL	✗
None within 50 metres	0
Control by school crossing patrol	1
Control by other authorised person	2

1.20b PEDESTRIAN CROSSING - PHYSICAL FACILITIES	✗
No physical crossing facility within 50m	0
Zebra crossing	1
Pelican, puffin, toucan or similar non-junction pedestrian light crossing	4
Pedestrian phase at traffic signal junction	5
Footbridge or subway	7
Central refuge — no other controls	8

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

1.23 ROAD SURFACE CONDITION	✗
Dry	1
Wet / Damp	2
Snow	3
Frost / Ice	4
Flood (surface water over 3cm deep)	5

1.21 LIGHT CONDITIONS	✗
Daylight: street lights present	1
Daylight: no street lighting	2
Daylight: street lighting unknown	3
Darkness: street lights present and lit	4
Darkness: street lights present but unlit	5
Darkness: no street lighting	6
Darkness: street lighting unknown	7

1.24 SPECIAL CONDITIONS AT SITE	✗
None	0
Auto traffic signal out	1
Auto traffic signal partially defective	2
Permanent road signing or marking defective or obscured	3
Roadworks	4
Road surface defective	5
Oil or diesel	6
Mud	7

1.25 CARRIAGEWAY HAZARDS	✗
None	0
Dislodged vehicle load in carriageway	1
Other object in carriageway	2
Involvement with previous accident	3
Pedestrian in carriageway - not injured	6
Any animal in carriageway (except ridden horse)	7

1.26 Did a police officer attend the scene and obtain the details for this report?	✗
Yes	1
No	2

Subject to local directions, boxes with a grey background need not be completed if already recorded
* Circle as appropriate
UNCLASSIFIED

Illustration 3: ***A STATS 19 form***

Access was provided to a database maintained by DfT, containing the STATS19 data set for a six-year period. To keep the analysis within the scope of the thesis, certain information was removed. This data included gender, age of driver and if a Police Officer attended the scene. The raw data are presented as numerical text files. This was organised for analysis. The raw data were obtained in three files; accident, vehicle and casualty, linked by an index number (Acc_Index). This allows any accident to be linked with the relevant casualty or vehicle.

There can be only one set of ‘Accident’ data per collision. However; there can be multiple rows for ‘Vehicle’ and ‘Casualty’ as there may be more than one vehicle and one casualty. The diagram below explains the relationships.

<table>
<tr><td rowspan="2">Acc 1</td><td rowspan="2">Veh 1</td><td>Cas 1</td></tr>
<tr><td>Cas 2</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="3">Acc 2</td><td>Veh 1</td><td>Cas 1</td></tr>
<tr><td rowspan="2">Veh 2</td><td>Cas 1</td></tr>
<tr><td>Cas 2</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="6">Acc 3</td><td rowspan="3">Veh 1</td><td>Cas 1</td></tr>
<tr><td>Cas 2</td></tr>
<tr><td>Cas 3</td></tr>
<tr><td rowspan="2">Veh 2</td><td>Cas 1</td></tr>
<tr><td>Cas 2</td></tr>
<tr><td>Veh 3</td><td>-</td></tr>
</table>

Illustration 4: ***Example of STATS19 forms Relationships***

The above table shows that;

- Acc 1: there is only one vehicle with two casualties.
- Acc 2: there are two vehicles, the first with one casualty the second with two.
- Acc 3: there were three vehicles. The first with three casualties, the second with two but, the third vehicle has no casualties.

The data had to be organised so no duplication was made, yet each casualty had to be related to the appropriate vehicle and accident. To do this I used QlikView x64 Personal Edition Version 10.00.8935.7. QlikView is a relational database and allows the use of Syntax Coding in conjunction with raw data. (See Appendix A for sample coding). The data were first transferred from comma-limited text into Microsoft Excel; the Syntax Coding reads the Excel files and manipulates it into manageable information on the QlikView database. The version of Excel used was Microsoft Excel 2010 Professional Edition.

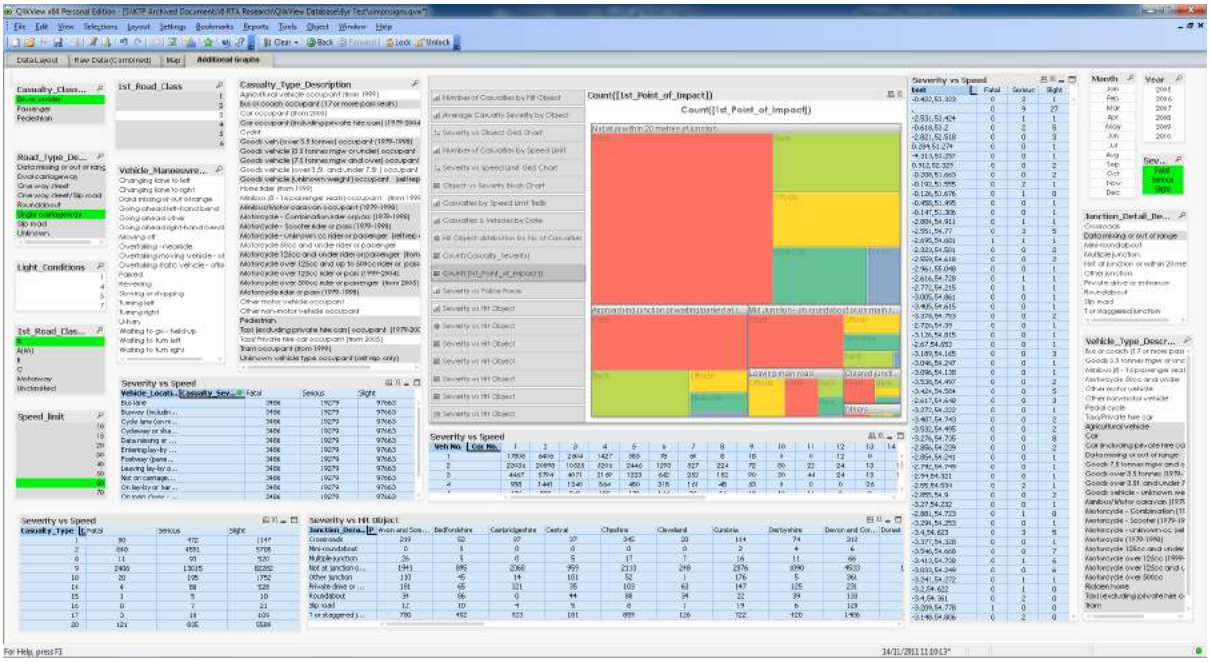


Illustration 5: ***Screenshot of the QlikView Database***

4.3 Selection of Information to Analyse

To keep the research within the scope of the project and to time, key decisions were made in the selection of information to analyse. For the selection to be unbiased and credible, both industry experts and literature influenced any decisions. A key decision was to focus the analysis on collisions that contained either fatalities or serious injuries. As discussed in the methodology, fatalities are classified as a death within thirty days of the collision, whereas casualties emitted to hospital are classed as serious. Serious injuries can range from sprained ankles to long-term brain damage. Below is a summary of types of injuries and costs to the economy in 2009. It is important to note the cost of fatalities as over one and a half million pounds. DfT developed these figures by calculating the average cost to all persons affected by an accident, such as the emergency services, loss of work and compensation.

2009				**£ June 2009**
Injury severity	**Lost output**	**Human costs**	**Medical & ambulance**	**Totakl**
Fatal	545,040	1,039,530	940	1,585,510
Serious	21,000	144,450	12,720	178,160
Slight	2,220	10,570	940	13,740
Average, all casualties	9,740	35,740	2,250	47,470

Table 1: ***Cost of Injuries from the DfT in 2009 (Taken from DfT Report 2009)***

The total number of casualties to analyse was 15,929 fatalities and 158,785 seriously injured, over a six year period. (A list of key data fields and factors from the STATS19 used in testing can be found in Appendix B.)

4.4 Statistical Analysis

4.4.1 Initially Numerical Testing

Each field was tested individually to gather top-level information using QlikView. To keep within the scope of the thesis and influencing product specifications, some data were omitted. An example of this was carriageway hazards; 97% of all collisions had no carriageway hazards.

Carriageway Hazards	Total	
None	116823	97%
Vehicle on Road	1815	2%
Animal on Road	88	0%
Pedestrian on Road	1702	1%

Table 2: ***Example of extremely low number of accidents for a particular factor***

The initial numerical testing was converted to percentages to show visually the impact of each factor. The first stage results showed clear areas within the United Kingdom road network that would be deemed more likely to include more accidents than other areas. Like carriageway hazards, above, fields were removed if categories combined to three per cent or less of accidents because statistically, including these categories would overemphasise risk proportionately for the majority. Three per cent was taken based on the differences in the initial percentages and on the advice of a statistician. By selecting less than three percent any recommendations would not support the majority of road traffic accidents.

4.4.2 Export of Data to SPSS (Statistical Package for the Social Sciences)

Further statistical tests required a comparison between fields to look for common factors within collisions. SPSS was used for all further statistical analysis. All statistical tests were completed on SPSS Version 17 for Windows.

The data were exported into SPSS from Excel. In order to minimise double counting, all the data was combined to one database in SPSS and the unit of analysis was the Accident Index field (i.e. there could only be one accident but variable numbers of people, vehicles and conditions involved).

4.5 Descriptive Statistics – Crosstabs & Further Organisation

The Pearson Chi-Square test was used for testing hypotheses especially in descriptive statistics. It allowed the study to compare different categories from the STATS19 data set to find out if results are statistically meaningful, this is found using the method 'goodness of fit', i.e. whether the result is likely to have occurred in that portion of a curve plotted on a normal set of responses that is probable by chance alone. In this study the goodness of fit was set at under p=0.01 (only 1% chance that the result is significant by chance alone) due to the vast amount of data. The study has a lot of power. The usual level is p=0.05, but this would invite a type 1 error because small differences would be over emphasised. The benefit of a vast amount of data will also allow the study to avoid a Type II error (a false positive), which occurs when too small a data set, is used. Chi-square test is the most appropriate statistical method for analysing descriptive results because it allows comparisons between proportions.

Once the data were organised in SPSS, data were compared using used cross-tabulations with two fields. The use of percentages gave an immediate visual representation and level of importance of each field.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2717.217[a]	16	.000
Likelihood Ratio	2243.488	16	.000
Linear-by-Linear Association	1370.133	1	.000
N of Valid Cases	208648		

Illustration 6: ***Example of Pearson Chi-Square result***

The results were split into road collisions with pedestrians only and road collisions with no pedestrians as road collisions with pedestrians produce a different set of fields and factors. Both sets of cross tabulations were discussed with two-industry experts for practical relevance.

This was to ensure not only were the results theoretically correct but also realistically reliable. The results gave an overview of the issues, but also a foundation for further testing.

4.5.1 Regression Analysis

A regression analysis was used, more specifically a multiple linear regression. This allowed the data to be manipulated into a scalar format to show statistically and visually which categories was more or less an influence on a vehicle collision than others. This is vital for this study, as it allows us to find out which categories of the secondary data are likely to cause a collision and result in fatalities. This method also allowed us to be specific in results stating what categories need to be reviewed by a designer. It is important to note that one category had to be used as the constant (the comparison variable) upon which the other results will fit before or after it. All constants will have a set figure of one. A significance level was set at p=0.01 for all regression analysis results. If the result is above this then it will be deemed unreliable.

Using the cross-tabulations I ran a regression analysis to show which factors might contribute to severe human injury. To do this I re-introduced the data for less serious injuries to one category ‘slight’. The purpose of this was to build a picture of the most dangerous scenarios (more accidents) in the United Kingdom road network. A regression analysis was used as it makes a quantitative prediction of one variable against another.

A linear regression analysis was calculated using one factor as the dependant, with the value of zero. The other factors were measured against this to see if they were less or more likely to result in a serious injury. The example below (Table 3) works like an odds ratio; against the unclassified road (constant at 1.00) you would be equally as likely to die in a collision on an A-Road at 1.043 but 25% less likely on a Motorway at 0.753.

Table 1	Frequency	B	S.E.	Wald	df	Sig.	Exp(B)
Road class				111.148	5	.000	
Motorway	9697	-.283	.038	55.396	1	.000	.753
A(M)	672	-.437	.145	9.082	1	.003	.646
A	97482	.041	.017	6.148	1	.013	1.042
B	26721	.104	.023	21.138	1	.000	1.110
C	18336	.053	.026	4.076	1	.043	1.055
Unclassified	55740						
Constant		-2.042	.013	23628.133	1	.000	.130

Table 3: ***Regression analysis sample using road type***

It is possible to include more than two fields in a regression analysis. When fields were directly related to one another, I included them for analysis. One example of this is both road type and speed to determine the possible level of human injury. As with the cross-tabulations, I used two expert opinions to validate if the theoretical results made practical sense.

4.5.2 Selection of Results

After theoretical testing was complete I had varying critical factors that determined the level of human injury and the number of collisions. This was split into four groups, each with a varying number of fields that covered the largest proportion of all fatal and serious road traffic collisions. These groups were:

- Road collisions on high speed single carriageways
- High speed T-junctions
- Pedestrian crossings not within a vehicle junction
- Impacts with permanent objects off the road.

The QlikView database was used to filter all accidents by the critical factors. This provided four separate lists of historical collisions with supporting field information.

4.6 Geographical Analysis

Using the four groups I calculated the best and worst locations in the United Kingdom to travel, based on the number of accidents occurred. As road safety funding is filtered to Council level for spending this part of the research was essential. Proper use of this data would focus spending in the appropriate places based on evidence and not a perceived need.

Each collision contains the field Local Authority, this references where the collision took place. Using this I organised the data to show the total number of human injuries in each area and using a costing model (which includes hours lost, NHS attendance and cost of operations) derived from DfT (DfT 2009) I was able to calculate an area based comparison example of the total cost for each levels of human injury: slight, severe and fatal.

Local Authority	**Fatal**	***£ 1,585,510***	**Serious**	***£ 178,160***	**Total**
Bath & N-E Somerset	7	£ 11,098,570	2	£ 356,320	£ 11,454,890
Bedford	7	£ 11,098,570	0	£ -	£ 11,098,570
Buckinghamshire	6	£ 9,513,060	1	£ 178,160	£ 9,691,220
Cambridgeshire	6	£ 9,513,060	0	£ -	£ 9,513,060
Cheshire East	5	£ 7,927,550	3	£ 534,480	£ 8,462,030
Cheshire West and Chester	5	£ 7,927,550	2	£ 356,320	£ 8,283,870
City of Bristol	4	£ 6,342,040	10	£ 1,781,600	£ 8,123,640
Halton	5	£ 7,927,550	1	£ 178,160	£ 8,105,710
Middlesbrough	5	£ 7,927,550	1	£ 178,160	£ 8,105,710
Milton Keynes	3	£ 4,756,530	17	£ 3,028,720	£ 7,785,250
North Somerset	4	£ 6,342,040	3	£ 534,480	£ 6,876,520
Peterborough	4	£ 6,342,040	2	£ 356,320	£ 6,698,360
Redcar & Cleveland	3	£ 4,756,530	10	£ 1,781,600	£ 6,538,130
Slough	4	£ 6,342,040	1	£ 178,160	£ 6,520,200
South Gloucestershire	4	£ 6,342,040	1	£ 178,160	£ 6,520,200
Stockton-on-Tees	4	£ 6,342,040	1	£ 178,160	£ 6,520,200
Warrington	4	£ 6,342,040	1	£ 178,160	£ 6,520,200
Windsor and Maidenhead	4	£ 6,342,040	1	£ 178,160	£ 6,520,200

Table 4: ***Example Cost of Fatal and Serious Accidents in Local Authority***

GeoCommons is an online mapping tool that uses longitude and latitude co-ordinates to plot locations on a map. Using GeoCommons I constructed a map of the United Kingdom, with the boundaries of each Local Authority. This gave a visual representation of the Local Authority in most need of additional road safety funding. The version of the mapping tool was GeoCommons by GeoIQ Release 4.1.

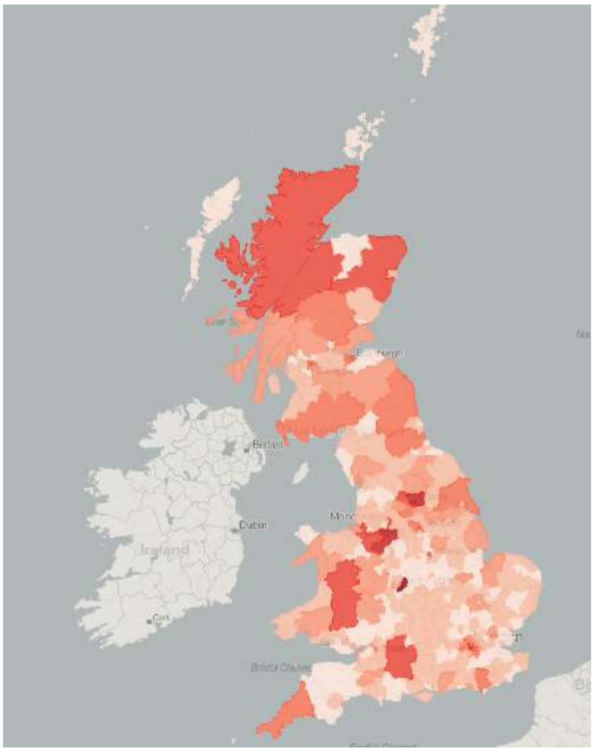


Illustration 7: ***Example of Local Authority Scalar Map***

I then populated these boundaries using data from the Department of National Statistics and DfT. Each area was compared visually using a combination of factors such as population and calculated by combining the cost of human injury with an additional factor. Additional tests were carried out replacing population; they were traffic counts and size of Local Authority.

The purpose of using this data was to compare STATS19 data with a different source, but also to look for different relationships, such as: high volumes of traffic in areas with high volumes of fatalities. It was sensible to split the cost relationship into 5 groups based on the standard deviation of the cost between authorities. There are over one hundred local authorities so I created five levels of standard deviation based on cost. DfT costs were calculated against each new factor and were classified as:

1. High cost: Two levels above the standard deviation.
2. Above average: One level above the standard deviation.
3. Average cost: The standard deviation.
4. Below average: One level below standard deviation.
5. Low cost: Two levels below standard deviation.

Level one can be described as the Local Authority in most need of additional funding as they have the most human injury cost. The standard deviation levels were also mapped to give a visual representation.

4.7 Visual Analysis

This exercise took visual locations and manual scanned pictures of each location to identify anything dangerous, obvious and visible that could be discern.

4.7.1 Data and Site Selection

Using the four sets of data as specified previously in the statistical analysis, I exported the longitude and latitude co-ordinates with the various human injury levels to Excel. Here, I reduced the longitude and latitude co-ordinates to three decimal places from five which meant each co-ordinate would cover a one hundred metre squared area. Based on the total number of collisions and statistician advice, one hundred-metre area were deemed an appropriate size that would allow the detailed comparison of factors that, in a larger area, could be misinterpreted or missed because of variation of environment.

Following the organisation of data in Excel, the number of human injuries for each area was multiplied by DfT (2009) cost per casualty. This was to keep the analysis consistent and relevant to existing literature, minimalizing any potential risk of bias or inaccuracy. The results created a list of co-ordinates in order of the highest human injury cost. This occurred four times, one for each type of collision as specified earlier.

4.7.2 Mapping

Using the results of the above analysis, I took the top one hundred co-ordinates (the most dangerous accident areas) and used Extensible Markup Language (XML coding) to import the locations into Google Maps. The purpose of using XML coding was its functionality and reliability. (Example of the coding can be seen in Appendix C) For each of the locations I captured four images. One aerial and three street view. This visually captured the area where collisions occur and its surrounding features. This novel approach was used as the quickest yet reliable method of visually seeing each site without going to them. It was impractically visiting each site within the time period of this study.

The first task, with the images collected, was to count the number and types of products that were currently there such as bollards and signs. Google Inc. took the images in 2009. There were three products counted:

1. Total number and type of road infrastructure
2. Total number of reflective or illuminated bollards
3. Total number of reflective or illuminated sign-lights

Manually, I went through each of the one hundred sites counting the number of each product, giving a total within the one hundred metre squared area. This needed a comparison so I selected the least dangerous accident locations from the co-ordinates list. To select the best locations I had to select areas with no or minimal amount of collision. Locations where no collision had taken place are not recorded in the STATS19 data and would have been impractical to physically search the United Kingdom for hundreds of locations where no single collision had occurred within the timescales of this study. Therefore, I took one hundred locations where only one accident with one slight injury occurred in a six year period; known as the least dangerous accident locations.

I processed these into Google maps resulting in four sets of one hundred images, one for each of the four dangerous location type. They were also counted for the number of products under the three headings.

The results showed a total number of products in the most dangerous locations versus the total number of the same product in the least dangerous locations.

4.8 Focus Group

As I had a large number of locations, with background information of each collision and visual images, I took the step of discussing the sites with a focus group. The focus group was selected using a variety of industry professionals and general members of the public. This was to avoid using only my own observations but to gather views from a range of people and take into account the literature and methodologies in this study. The group consisted of four men and two women, varying in age, experience and life-style. Two were industry infrastructure experts, two were unknown to the industry but were regular drivers, a fifth was a non-driving pedestrian, whilst the sixth was a road safety police officer.

The purpose of the focus group was to find out information that is not currently available in literature. This was the selection of common physical factors at each site. For example, high number of trees, no road markings or narrowed road width. I personally could have calculated the information, but I could have a biased opinion to what might be classified as ‘high’ or ‘low’. This is where the focus group gave a consensus opinion based on the majority. It is important to note that individuals within the focus group could also have non-standard opinions and that is why a majority representative opinion is sought. There is currently no National database of physical features on the road, such as traffic bollards, vegetation or permanent objects.

The focus group was essential as the analysis had to influence future design of new products and therefore it had to be commercially viable. To be commercially viable future products should be transferable across varying locations and not designed for one specific location alone.

The first task was to select one hundred of the most dangerous locations and show an image of each of the sites to the focus group. The novel concept of this was that each image was shown for only a few seconds one after another. Whilst the group saw the images they were to shout allowed the dangers they saw. This novel approach was taken, as it was the closest method that could be taken to simulate the group driving past each site other than taking them to the location.

To capture the group’s thoughts I used a mind-mapping tool. A mind-map effectively captures all thoughts in a short space of time but also shows links between different items. For example, one member stated trees whilst another stated vegetation. They both can be directly linked and influence the decision of the product specification.

Following the mind mapping exercise the group were asked to use their own thoughts and knowledge from the mind map, to think of potential solutions. This part of the research, although empirical, was to see if new viable products could be suggested by both industry experts and persons with no direct links to the industry. All product ideas were captured and entered into an innovation hopper. The hopper was presented to a leading organisation that had the opportunity to develop one or many products, with the purpose of improving road safety.

4.9 Additional Research from Industry Experts

Although numerous theoretical tests were carried out it was important to gather industry experts' advice to keep the project practical. For example, initial statistical testing showed that 95 per cent of all collisions occur in dry weather with no rain. Therefore, the new product specification would not have information on the IP rating (IP rating is the level of water ingress). This would mean new products could malfunction in the rain and subsequently cause more accidents. Industry experts included industry leaders, Road Safety Police Officers and Local Authorities. A number of dialogues occurred throughout the research in the form of interviews, e-mails and phone calls. The findings in this thesis are clearly referenced to either theoretical or expert opinion.

5. RESULTS

The next section displays the results of this study following on from the methods detailed in the literature and methodology. The results are split into four key sections; pilot study, statistical analysis, visual analysis and focus groups.

5.1 Pilot Study

The purpose of the pilot study was to learn and examine a smaller sub set of accidents in a small geographic area. The pilot study was beneficial in understanding STATS19 data and reporting system and helped shape the process of statistically analysing the whole set of STATS19 data. The pilot study initially showed a large buildup of collisions within town and city centres (Example shown in Appendix J). As stated in the methodology there is no facility to highlight hotspots on MARIO, only by manually selecting areas.

5.1.1 Manual Selection

Five hotspot locations were selected within Lancashire. These were selected for their high number of collisions. Of the five locations, one was a controlled (i.e. By traffic lights or a person) T-Junction whilst the other were large uncontrolled roundabouts; illustration 8 shows an example. Only the total number of collisions between 2005-2010 in Lancashire County was available. Each area is a 100m^2 location.

Illustration 8: MARIO close up of a controlled T-Junction with accidents highlights and close up of uncontrolled roundabouts with accidents highlighted

5.1.2 Manual Counting Results

Table 5 below shows the number of collisions there were within the one hundred squared metre area areas selected. It is clear to see that roundabouts have more accidents. Although the data was manually counted and therefore probably fairly accurate, it was not discriminatory enough. It is not clear if these accidents include slight injuries or fatalities and what types of vehicles are involved and furthermore it was difficult to collate for more detailed investigation.

Site	Two Collisions	Two collisions with child/cyclist/pedestrian	Total within 100m area
T-Junction	11	4	15
Roundabout 1	21	1	22
Roundabout 2	24	1	25

Table 5: Number of collisions reported on MARIO over three locations

5.1.3 Conclusion

Although MARIO was useful in understanding collisions and types of junctions and allowed exploration of different methods of detailed investigation, it is too difficult to statistically analyse due to the structure of its data. For the next phase I have used this learning in comparing details on a larger scale, from national STATS19 data.

5.2 Results of the Analysis of STATS19 data

5.2.1 Introduction

The information in the results section here contains relevant figures relating to key findings of significance and therefore not all the tests are covered. Some variables are not tested as explained in the methods section, most of the accidents fell into the main category and very few were distributed into the variables making up the rest of the field. A summarised list of combined variables and tests are included in Appendix D of this thesis.

The information form STATS19 contains over 400 different factors with thousands of accidents and thousands of different combinations. Three sets of STATS19 data were combined into one manageable set. Incorporating casualties' vehicles and accidents for this analysis. Cross tabulations helped prepare the data for analysis by exploring combinations of categories, that were unnecessarily detailed and isolated out small numbers of accidents, for example: weather was combined to fine or not fine due to the number of accidents in the 'fine' category rather than separated by a number of categories isolating wind factors. Vehicle types particularly included very uncommon vehicles and in some analysis these were excluded because not enough data fell into these categories. I have not detailed every combination, but most of the analysis was performed on combined variables rather than those in the original data set. This was to simplify the analysis and provide a more even distribution of accidents among categories.

Most analysis was completed against 2010 data. Where there is a combination of data across the 5 years, 2005-2011 it has been specified. 'KSI' relates to the combination of fatalities and serious injuries (Killed or Seriously Injured) against slight injury

5.2.2 Descriptive analysis

Table 6 below shows the number of casualties reported in 2010 for all fatal, serious and slight injuries combined on a road type. The first table clearly shows few accidents (0.3%) happen on A (M) roads, whilst nearly fifty per cent (50%) of all accidents occur on A-roads.

Classification of Road	Number of Casualties	Per cent (%)
Motorway	9697	4.6
A (M)	672	.3
A	97482	46.7
B	26721	12.8
C	18336	8.8
Unclassified	55740	26.7
Total	208648	100.0

Table 6: Number of Casualties Reported on Different Road Classifications 2010

Table 7 below shows that single carriageways have the most accidents. Seventy four per cent (74%) of all accidents occur on single carriageways.

Road Type	Number of Casualties	Per cent (%)
Roundabout	13317	6.4
One Way	3758	1.8
Dual Carriageway	33969	16.3
Single Carriageway	154330	74.0
Slip Road	2399	1.1
Unknown	875	.4
Total	208648	100.0

Table 7: Number of Casualties Reported on Different Road Types

Table 8 below shows casualties by type of road junction. Thirty per cent (30%) of casualties occur at T or Staggered-T junctions, ten per cent (10%) at crossroads. Forty per cent (40.7%) of all accidents do not occur within twenty metres of a junction; therefore the other sixty per cent (60%) occur within twenty metres of a junction

Junction Detail	Number of Casualties	Per cent (%)
Not within 20 metres	84975	40.7
Roundabout	17369	8.3
Mini-Roundabout	2277	1.1
T or Staggered-T Junction	63574	30.5
Slip Road	3268	1.6
Crossroads	21462	10.3
Multiple Junctions	2919	1.4
Private Drive	7422	3.6
Other	5382	2.6
Total	208648	100.0

Table 8: Number of Casualties Reported on Different Junction Details

Table 9 shows where a vehicle first impacted with another object or vehicle. Nearly fifty per cent (50%) of casualties result from a frontal impact and this is supported by the literature.

First Point of Impact	Number of Casualties	Per cent (%)
No Impact	9862	4.7
Front Impact	101216	48.5
Back Impact	42673	20.5
Offside Impact	27679	13.3
Nearside Impact	27218	13.0
Total	208648	100.0

Table 9: Number of Casualties Reported detailing the First Point of Impact

Table 10 below shows number of casualties between 2005 and 2011, from the result of collisions involving different types of vehicle. The casualties are categorized into fatal, serious and slight. Nearly fifty per cent (50%) of all fatalities were car occupants whilst twenty two per cent (22%) were pedestrians. Looking at slight accidents, sixty per cent (66%) of casualties were car occupants whilst only eleven per cent (11%) was pedestrians.

Casualty Type Description	**Fatal**		**Serious**		**Slight**	
Agricultural Vehicle Occupant	15	0.09%	113	0.07%	599	0.05%
Car Occupant	7763	48.74%	65398	41.19%	839297	66.39%
Cyclist	760	4.77%	14652	9.23%	84086	6.65%
Goods Vehicle ^3.5t & under 7t	488	3.06%	4160	2.62%	39680	3.14%
Horse Rider	10	0.06%	138	0.09%	562	0.04%
Minibus	105	0.66%	2749	1.73%	44089	3.49%
Motorcycle below 50cc	3124	19.61%	33659	21.20%	95765	7.58%
Other vehicle	98	0.62%	800	0.50%	5423	0.43%
Non-motor vehicle	26	0.16%	150	0.09%	559	0.04%
Pedestrian	3469	21.78%	35927	22.63%	136272	10.78%
Taxi	71	0.45%	1039	0.65%	17854	1.41%
Total	15929	100%	158785	100%	1264186	100%

Table 10: Number of Casualties by Casualty Type and Level of Human Injury 2005-2011

Casualty Type	Fatal	Serious	Slight	Total
All Pedestrians	2%	20%	80%	175668
All Car Types	0.80%	7%	91%	9162459

Table 11: Shows a breakdown of Table 10 for pedestrians and cars

This suggests that in numbers for every five deaths as a car occupant, two deaths occur as a pedestrian. However, there are more car injuries than pedestrians. Table 12 shows ninety one per cent (91%) of car drivers who are injured are only slightly injured whilst less than one per cent (0.8%) was fatal. Although, if injured as a pedestrian eighty per cent (80%) were only slight injured and two per cent (2%) were fatal. This is a massive difference on the scale of numbers involved. This shows how dangerous it can be to be a pedestrian on the road network in the United Kingdom.

5.2.3 Considerations of Factors with minimal Impact

As it can be seen below most accidents occur in fine weather (79.6%) and a further eleven per cent (11%) in rain. All other factors were present in less than three per cent of all road traffic collisions. Due to the small percentages compared to accidents in fine, normal conditions, it can be suggested that weather does not play a key factor in the majority of road traffic collisions.

Weather Conditions	Frequency	Per cent
Fine	166097	79.6
Rain	23069	11.1
Snow	4379	2.1
Fine with High wind	1662	.8
Rain with High Wind	1812	.9
Snow with High wind	523	.3
Fog/Mist	1354	.6
Other	6241	3.0
Unknown	3511	1.7
Total	208648	100.0

Table 12: Frequency of weather conditions

Table 13 below shows an analysis of the ratio of vehicles to pedestrians over the years 2005-2011. Vehicle and pedestrians were separated because pedestrian accidents cannot be analysed efficiently if using all data. For every seven injuries in road accidents, one is a pedestrian. The number of vehicles overwhelms the number of pedestrians. Therefore, from this point forward, all statistical analysis is shown either vehicle or pedestrian related. Pedestrians only use a small proportion of the road network yet; they contribute a large percent to road accidents.

All Casualty Levels	Vehicle Occupant	Pedestrians	Ratio (Veh : Ped)	Total
2010	182,803	25,845	7.1 : 1	208,648
2009	195,259	26,887	7.3 : 1	222,146
2008	202,423	28,482	7.1 : 1	230,905
2007	217,589	30,191	7.2 : 1	247,780
2006	227,422	30,982	7.3 : 1	258,404
2005	237,736	33,281	7.1 : 1	271,017
Total	1,263,232	175,668	7.2 : 1	1,438,900
Average (per yr)	210,539	29,278	7.2 : 1	239,817

Table 13: Casualties in vehicles and as pedestrian

5.2.4 Vehicle Casualties Only

Table 14 describes the severity of casualties by class of road. On an A-road the proportion of casualties' increases as the level of injury becomes more severe. Throughout the cross-tabulations I used the chi-square test to see if an analysis was significant. Due to the high volume of information tested I looked for a P-Value of less than 0.01. This can be seen at the bottom of each test and for each of the cross-tabulations below, all were deemed significant. The Chi Square gave a result of $x^2 = 214.7$, DF = 10, P<0.01. Forty eight per cent (48%) of all slight casualties were on A-Roads whilst forty nine per cent (49%) of all serious and fifty seven per cent (57%) of all fatal.

Casualty Severity		1st Road Class						
		Motorway	A (M)	A	B	C	Unclassified	Total
Fatal	Count	87	7	830	217	119	185	1445
	% within Casualty Severity	6.00%	0.50%	57.40%	15.00%	8.20%	12.80%	100%
Serious	Count	737	42	8578	2496	1626	3981	17460
	% within Casualty Severity	4.20%	0.20%	49.10%	14.30%	9.30%	22.80%	100%
Slight	Count	8802	620	79189	20979	14143	40165	163898
	% within Casualty Severity	5.40%	0.40%	48.30%	12.80%	8.60%	24.50%	100%
Total	Count	9626	669	88597	23692	15888	44331	182803
	% within Casualty Severity	5.30%	0.40%	48.50%	13%	8.70%	24.30%	100%

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	214.704	10	0
Likelihood Ratio	232.422	10	0
Linear-by-Linear Association	20.338	1	0
N of Valid Cases	182803		

Table 14: Cross tabulation of severity of casualty by road class.

Table 15 below shows more accidents occur on single carriageways than any other road type, with very little variation between fatal, serious and slight human injury severity levels.

Casualty Severity		Road Type						
		Roundabout	One Way	Dual Carriageway	Single Carriageway	Slip Road	Unknown	Total
Fatal	Count	22	4	307	1107	5	0	1445
	% within Casualty Severity	1.50%	0.30%	21.20%	76.60%	0.30%	0.00%	100%
Serious	Count	852	166	2633	13578	177	54	17460
	% within Casualty Severity	4.90%	1.00%	15.10%	77.80%	1.00%	0.30%	100%
Slight	Count	12065	2259	29103	117778	2113	580	163898
	% within Casualty Severity	7.40%	1.40%	17.80%	71.90%	1.30%	0.40%	100%
Total	Count	12939	2429	32043	132463	2295	634	182803
	% within Casualty Severity	7.10%	1.30%	17.50%	73%	1.30%	0.30%	100%

Table 15: Cross tabulation of severity of casualty by road type

Speed limit showed the most significant change when broken down into each human injury level. Whilst examining full frequencies it was believed the majority of injuries occur when the speed limit is 30mph so full attention should be given to these roads. Although cars could have been speeding this is not within the scope of this study to discuss or consider. However, from the table below you can see that as injury levels increase the percentage of accidents at 30mph decrease whilst at 60mph they increase. Therefore, over 47% of accidents with fatalities occur in a 60mph limit whilst at 30mph only 21%. This changes the findings from the earlier frequencies (table 16).

Casualty Severity		Road Type								
		10	15	20	30	40	50	60	70	Total
Fatal	Count	0	0	3	308	127	101	679	227	1445
	% within Casualty Severity	0%	0%	0.2%	21.30%	8.80%	7.00%	47%	16%	100%
Serious	Count	0	0	98	8160	1530	822	5234	1616	17460
	% within Casualty Severity	0%	0%	0.6%	46.70%	8.80%	4.70%	30%	9%	100%
Slight	Count	2	1	1116	95596	15691	6747	29156	15589	163898
	% within Casualty Severity	0%	0%	0.7%	58.30%	9.60%	4.10%	18%	10%	100%
Total	Count	2	1	1217	104064	17348	7670	35069	17432	182803
	% within Casualty Severity	0%	0%	0.7%	57%	9.50%	4.20%	19%	10%	100%

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2625.251	14	0
Likelihood Ratio	2413.931	14	0
Linear-by-Linear Association	1645.81	1	0
N of Valid Cases	182803		

Table 16: Cross tabulation of severity of casualty by speed limit

Table 17 below shows that the percentage of accidents not within 20 metres of a junction increases as the level of human injury severity increases, whilst all other accidents in and around junctions decrease. The increase is dramatic from forty per cent (40%) of slight accidents up to sixty eight per cent (68%) of all fatalities not within 20 metres of a junction.

Casualty Severity		Road Type									
		Not within 20m	Round -about	Mini-Round -about	T / Stagge-red T	Slip Road	Cross-roads	Multiple Jnct	Private Drive	Un-known	Total
Fatal	Count	963	24	6	262	25	78	3	41	23	1445
	% within Casualty Severity	68%	1.70%	0.40%	18.10%	1.70%	5.40%	0%	3%	2%	100%
Serious	Count	8604	1028	125	4754	279	1437	144	697	392	17460
	% within Casualty Severity	49.3%	5.90%	0.70%	27.20%	1.60%	8.20%	1%	4%	2%	100%
Slight	Count	63922	15608	1954	49464	2865	17500	2385	6002	4198	163898
	% within Casualty Severity	39%	9.50%	1.20%	30.20%	1.70%	10.7%	2%	4%	3%	100%
Total	Count	73509	16660	2085	54480	3169	19015	2532	6740	4613	182803
	% within Casualty Severity	40.2%	9.10%	1.10%	30%	1.70%	10.4%	1%	4%	3%	100%

Table 17: Cross tabulation of severity of casualty by junction detail

These results start to build a picture of the landscape in the most dangerous locations; A-roads, single carriageways not within 20 metres of a junction. All possible variations were compared using cross tabulations, examples of these results can be found in appendix E.

Table 18 is a cross-tabulation used to define the most dangerous objects a vehicle can impact; defined as ‘off the road’. In sixty per cent (60%) of accidents a vehicle does not hit an object. Therefore to show more detail, Table 18 below shows the number of objects struck ‘off the road’ only, between 2005 and 2010. It is clear to see that the single most dangerous objects to hit is a tree suggesting infrastructure around trees need to be improved. STATS19 does not contain detail about other objects unless they are fixed permanent object such as buildings, signs and walls.

Total (n)		Road Sign	Lamp Post	Telegraph Pole	Tree	Bus Shelter	Central Barrier	Near/ Offside Barrier	In Water	Entered Ditch	Other	Total
1850	Fatal	8%	6%	3%	32%	0%	7%	5%	2%	6%	32%	100%
22660	Serious	7%	8%	3%	24%	0%	6%	6%	0%	10%	34%	100%
184138	Slight	9%	9%	3%	15%	1%	9%	9%	0%	11%	35%	100%
208648	Total	8%	9%	3%	17%	1%	8%	8%	0%	11%	35%	100%

Table 18: Cross tabulation of severity of casualty by road infrastructure

A detailed analysis was conducted for vehicles leaving the road and striking a permanent object. There are a large number of very low percentages, with many common features. For example a similar number of accidents were classified as ‘leaving the road nearside' to 'leaving the road nearside and rebounding'. This information was grouped to see if there were any trends or patterns more clearly.

Vehicle Leaving Carriageway		Road Type											
		None	Sign Post	Lamp Post	Telegraph Pole	Tree	Bus Stop	Central Barrier	Nearside/ Off side	Submerged in Water	Entered Ditch	Other	Total
Did Not	Count	144306	273	182	49	120	14	265	303	0	56	688	146256
	% within Casualty Severity	98.7%	0.2%	0.1%	0%	0.1%	0%	0%	0%	0%	0%	1%	100%
Nearside	Count	5662	1141	1360	483	2666	103	114	992	23	1850	4448	18842
	% within Casualty Severity	30%	6.1%	7.2%	2.6%	14.1%	0.5%	1%	5%	0%	10%	24%	100%
Nearside & Rebounded	Count	346	102	204	75	411	7	49	582	1	33	977	2787
	% within Casualty Severity	12.4%	3.7%	7.3%	2.7%	14.7%	0.3%	2%	21%	0%	1%	35%	100%
Straight Ahead	Count	261	182	77	15	77	0	4	26	0	62	353	1057
	% within Casualty Severity	24.7%	17.2%	7.3%	1%	7.3%	0%	0%	3%	0%	6%	33%	100%
Offside on to Central Reservation	Count	308	73	39	1	58	0	787	46	0	13	50	1375
	% within Casualty Severity	22.4%	5.3%	2.8%	0%	4.2%	0%	57%	3%	0%	1%	4%	100%
Offside & rebounded on central reservation	Count	46	24	11	0	18	1	963	91	0	8	33	1195
	% within Casualty Severity	3.8%	2%	0.9%	0%	1.5%	0.1%	81%	8%	0%	1%	3%	100%
Offside & crossed central reservation	Count	123	25	20	1	18	0	84	12	0	5	31	319
	% within Casualty Severity	38.6%	7.8%	6.3%	0%	5.6%	0%	26%	4%	0%	2%	10%	100%
Offside	Count	2716	531	513	286	1318	27	81	210	54	1096	2732	9564
	% within Casualty Severity	28.4%	5.6%	5.4%	3%	13.8%	0.3%	1%	2%	1%	12%	27%	100%
Offside & Rebounded	Count	142	65	63	54	217	4	64	82	0	37	680	1406
	% within Casualty Severity	10.1%	4.6%	4.5%	4%	15.4%	0.3%	5%	6%	0%	3%	48%	100%

Table 19: Cross tabulation of vehicle leaving the road and road infrastructure

Table 20 shows when leaving the road nearside or offside casualties are more likely to be serious, especially on an impact with a tree or other permanent object. Leaving the road nearside is slightly more frequent than leaving the road offside. It could be suggested, that where budget is minimal, more money should be spent on crash barriers on the nearside rather than the offside.

Total (n)		Road Sign	Lamp Post	Telegraph Pole	Tree	Bus Shelter	Central Barrier	Near/ Offside Barrier	In Water	Entered Ditch	Other	Total (%)
2612	Nearside All	4%	5%	2%	16%	0%	0%	4%	0%	6%	19%	57%
126	Straight ahead at junction	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%
1866	Offside All	3%	2%	1%	10%	0%	5%	2%	0%	4%	14%	41%
4605	Total	7%	7%	3%	26%	0%	6%	6%	0%	10%	34%	100%

Table 20: Detailed Cross tabulation of vehicle leaving the road and road infrastructure

Below (Illustration 9) is a histogram showing impact with an object and three levels of injury. Fatalities (being in blue and the larger the box the more percentage of fatalities shows that they) are more likely to occur if the vehicle has struck a tree. Bus shelters and vehicles submerged in water (e.g. entered a river and sunk) can be discredited due to such a low number of accidents at these locations.

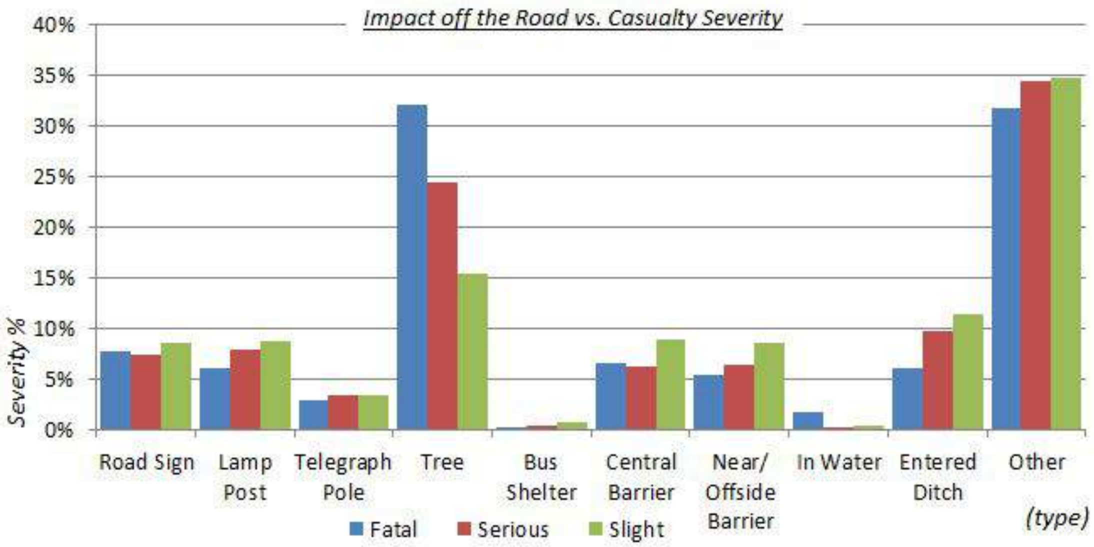


Illustration 9: Histogram of casualty severity and road infrastructure

Light conditions vary from no lighting to high and low street lighting. There are varying levels of street lighting a designer must consider. Table 21 shows a cross tabulation between speed limit and lighting conditions. Similar to the previous cross tabulation there are many small percentages that make it difficult to find trends and the common issues. Therefore common features were grouped or removed from the selection.

Vehicle Leaving Carriageway		Light Conditions				
		Light	Darkness with Lights	Darkness with no Lights	Unknown	Total
10	Count	0	2	0	0	2
	% within Casualty Severity	0.00%	100.00%	0.00%	0.00%	100%
15	Count	1	0	0	0	1
	% within Casualty Severity	100.00%	0.00%	0.00%	0.00%	100%
20	Count	915	259	26	17	1217
	% within Casualty Severity	75.20%	21.30%	2.10%	1.40%	100%
30	Count	77335	24503	1357	869	104064
	% within Casualty Severity	74.10%	20.80%	4.30%	1%	100%
40	Count	12858	3606	743	141	17348
	% within Casualty Severity	74.10%	20.80%	4.30%	1%	100%
50	Count	5671	1250	682	67	7670
	% within Casualty Severity	73.00%	16.30%	8.90%	1%	100%
60	Count	26117	1483	7240	229	35069
	% within Casualty Severity	74.50%	4.20%	20.60%	1%	100%
70	Count	12265	2478	2498	191	17432
	% within Casualty Severity	70.40%	14.20%	14.30%	1%	100%

Table 21: Cross tabulation of speed limit and lighting conditions

The data below (table 22) details killed or seriously injured persons. Considering only accidents that happen at night (with or without street lights) the graph figure 22 shows which speed limits most frequently occur when there are higher numbers of injuries. Most noted is the number of injuries in the dark with streetlights on at 30mph. But what is also worth noting is how at higher speeds (60mph) and with no street lighting you are more likely to obtain a serious injury or be killed in an accident compared to when there is street lighting. The graph (illustration 10) shows the varying total percentages of accidents, with the blue line showing accidents with street lights on and a peak at 30mph whilst the red line is with street lights are off and a peak at 60mph.

KSI Only	Speed limit					Total
	30	40	50	60	70	
Darkness- with lights	42%	7%	2%	4%	5%	60%
Darkness- no lights	3%	2%	2%	27%	6%	40%
Total	19752	4147	1833	13824	4834	44390

Table 22: Cross tabulation of speed limit and lighting conditions in the dark

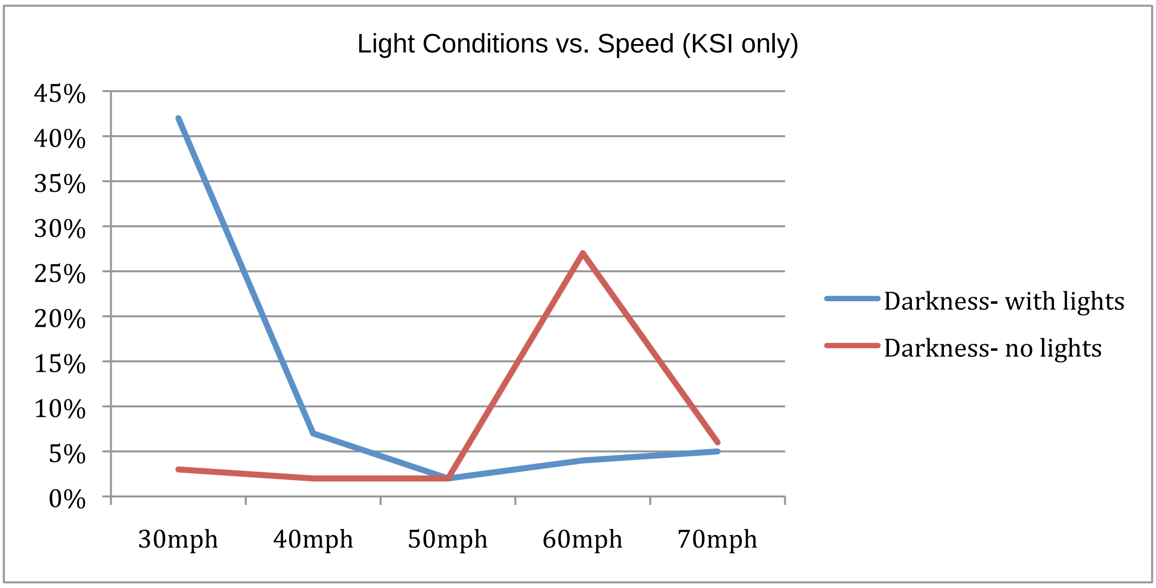


Illustration 10: Diagram of lighting conditions in the dark and percentage of road accidents

5.2.5 Pedestrian Casualties Only

Table 23 below shows on what types of roads the majority of human injuries occur. It is clear to see that the majority of accidents occur on single carriageways. However, the percentage of accidents decreases as the level of human injury increases. In contrast percentages of accidents increase as human injury increases on dual carriageways. This shows that when on a dual carriageway you are more likely to obtain a serious injury.

Vehicle Leaving Carriageway		Road Type						
		Round-about	One-way	Dual Carriageway	Single Carriageway	Slip Road	Unknown	Total
Fatal	Count	7	9	103	280	5	1	405
	% within Casualty Severity	1.70%	2.20%	25.40%	69.10%	1%	0.20%	100%
Serious	Count	60	238	485	4370	12	35	5200
	% within Casualty Severity	1.20%	4.60%	9.30%	84.00%	0%	0.70%	100%
Slight	Count	311	1082	1338	17217	87	205	20240
	% within Casualty Severity	1.50%	5.30%	6.60%	85.10%	0%	0.90%	100%

Table 23: Cross tabulation of Pedestrian human injury and road type

When comparing road classes the most notable location is on an A road shown on table 24. This is most evident as the level of human injury increase. Only one third of slight accidents occur on an A road with pedestrians, whilst over half of all pedestrian fatalities occur on A-roads.

Casualty Severity		1st Road Class						
		Motorway	A (M)	A	B	C	U	Total
Fatal	Count	21	3	220	48	27	86	405
	% within Casualty Severity	5.20%	0.70%	54.30%	11.90%	7%	21.20%	100%
Serious	Count	19	0	1987	605	436	2153	5200
	% within Casualty Severity	0.40%	0.00%	38.20%	11.60%	8%	41.40%	100%
Slight	Count	31	0	6678	2376	1985	9170	20240
	% within Casualty Severity	0.20%	0.00%	33.00%	11.70%	10%	45.30%	100%

Table 24: Cross tabulation of Pedestrian human injury and road class

In vehicle injuries you are more likely to be killed as speed increases to 60mph (table 25). This is similar for pedestrians but with much smaller numbers; at 30mph sixty three per cent (63%) of all fatalities occur whilst only eleven per cent (11%) occur at 60mph. However, we must note that this chi-square test is not entirely reliable as some cells have less than five and therefore should be deemed invalid.

Casualty Severity		Speed Limit							
		10	20	30	40	50	60	70	Total
Fatal	Count	1	2	255	44	11	45	47	405
	% within Casualty Severity	0.20%	0.50%	63.00%	10.90%	3%	11.10%	12%	100%
Serious	Count	0	110	4558	273	47	157	55	5200
	% within Casualty Severity	0.00%	2.10%	87.70%	5.30%	1%	3.00%	1%	100%
Slight	Count	0	494	18625	590	99	356	76	20240
	% within Casualty Severity	0.00%	2.40%	92.00%	2.90%	1%	1.80%	0%	100%

Table 25: Cross tabulation of Pedestrian human injury and speed limit

Using the histogram below in illustration 11 there are multiple features with very low values that in the context of this thesis are not important (See Appendix K for figures). However, the histogram does show human injury increases as the percent of accidents decreases when crossing ‘elsewhere’.

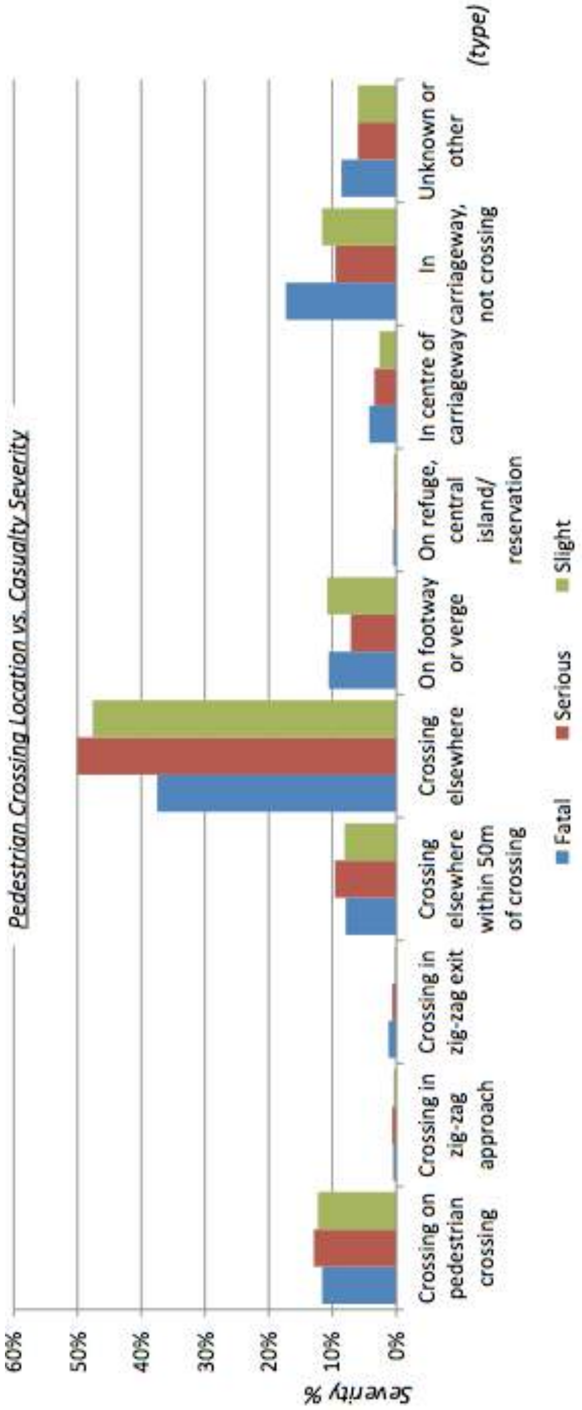


Illustration 11: Histogram of pedestrian crossing locations and casualty severity

5.2.6 Results of the Regression Analysis

Regression analysis was used to see what features are most likely to contribute to high levels of human injury. Table 26 below shows how likely someone is to have a serious injury or be killed on various road classes. Unclassified roads are taken as the standard (1), which means all other factors are compared with it. Most noted from the table below is how Motorways are deemed to be the safest places to drive (0.753) compared to the constant.

	Frequency	B	S.E.	Wald	Df	Sig.	Exp(B)
Road class				111.148	5	.000	
Motorway	9697	-.283	.038	55.396	1	.000	.753
A(M)	672	-.437	.145	9.082	1	.003	.646
A	97482	.041	.017	6.148	1	.013	1.042
B	26721	.104	.023	21.138	1	.000	1.110
C	18336	.053	.026	4.076	1	.043	1.055
Unclassified	55740						
Constant		-2.042	.013	23628.133	1	.000	.130

Table 26: Regression analysis of road class

The analysis below also contains a graphic. The graphic shows visually the results from the regression analysis shown in table 27 and illustration 12. Exp (B) shows odds compared to the constant. The further to the right the feature the more likely you are to be involved in a serious accident. With car/taxi as the standard, you are nearly five times more likely to be involved in a serious accident on a motorbike (4.857).

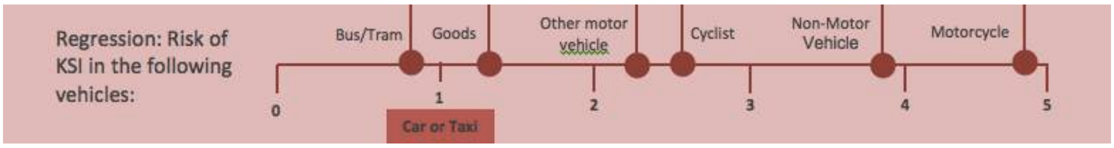


Illustration 12: Regression analysis visual scale of vehicle type

Table 9	Frequency	B	S.E.	Wald	df	Sig.	Exp(B)
Vehicle type				7218.759	7	.000	
Cycle	17185	.889	.023	1459.561	1	.000	2.432
Motorcycle	18686	1.580	.019	6605.810	1	.000	4.857
Minibus	582	-.211	.175	1.462	1	.227	.810
Bus or tram	6277	-.144	.053	7.503	1	.006	.866
Other motor	1153	.817	.083	97.510	1	.000	2.264
non motor	225	1.385	.156	78.389	1	.000	3.996
Goods	6072	.273	.045	36.347	1	.000	1.313
car or taxi	132623						
Constant		-2.538	.011	57983.412	1	.000	.079

Table 27: Regression analysis of vehicle type

The last regression example (table 28, illustration 13) below looks at the first point of impact of a vehicle. Using 'nearside' as the standard a person is slightly more likely to be severely hurt when the vehicles are hit from the front. It should be noted that when looking to improve road infrastructure the vehicle is struck from the back a person is very unlikely to be severely hurt. This suggests accidents involving impacts from the back should have less consideration given.

	Frequency	B	S.E.	Wald	df	Sig.	Exp(B)
1st point impact				2901.321	3	.000	
Front	101216	.091	.020	20.629	1	.000	1.095
Back	42673	-1.341	.031	1895.561	1	.000	.262
Offside	27679	-.099	.026	15.094	1	.000	.905
Nearside	27218						
Constant		-1.872	.018	11022.054	1	.000	.154

Table 28: Regression analysis of the first point of vehicle impact in a collision

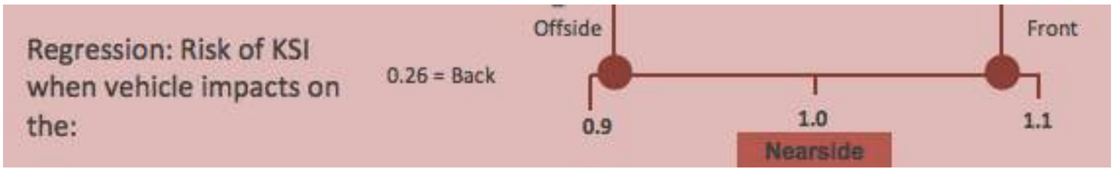


Illustration 13: Visual regression analysis of the first point of vehicle impact in a collision

5.3 Common Factors

Using the statistical analysis a number of flow or path diagrams were created to show the flow of accidents, the total percent of accidents and the riskiest paths that it was possible to take through the pathway. The example below (illustration 14) shows the total flow of common factors, with one hundred percent of accidents at the beginning, then a further thirty four per cent (34%) at 60mph. This is then grouped with accidents not within 20 metres of a junction. This results in a list of features that are all common in the total percentage of collisions. This was used to help base a decision on the most dangerous locations. To summarise this diagram shows visually the common factors resulting in a high number of accidents.

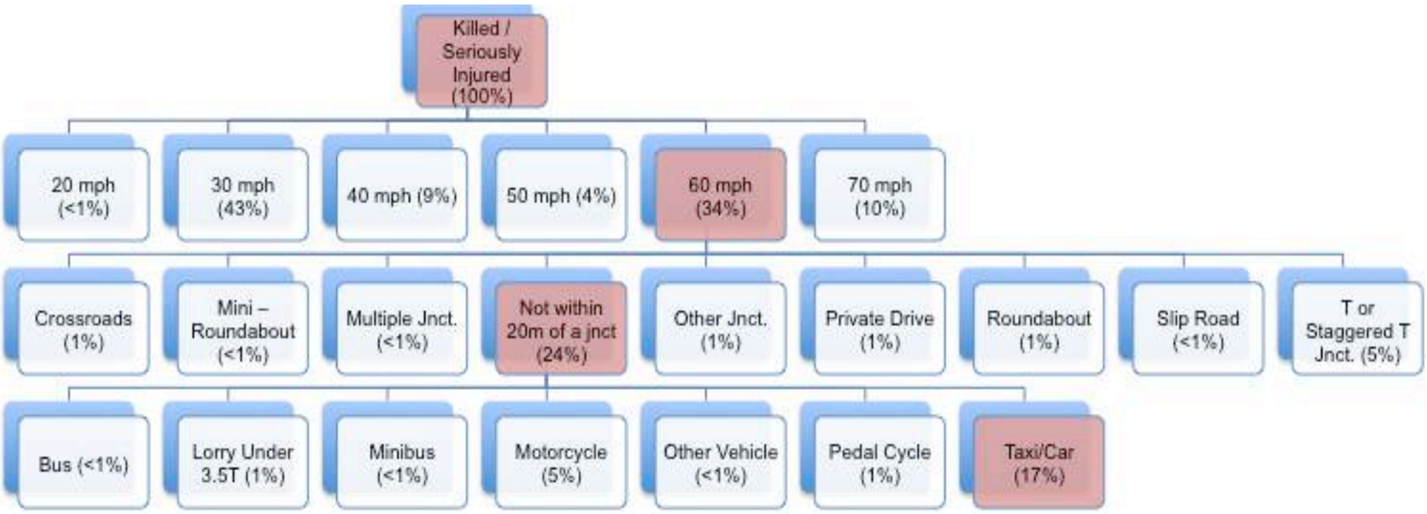


Illustration 14: Typology of the Locations with the most accidents

Illustration 15 below shows four locations chosen from interpretation of the proceeding analysis. Each of these locations was deemed an area requiring most attention to improve the safety of infrastructure in the United Kingdom. They all have common features relating to the results. Location 1 looks at high-speed roads for vehicle accidents. The second is near to crossroads or T-junctions. The third area is the most dangerous location for pedestrians with signaled crossings not near a vehicle junction is the most dangerous. The fourth location has a low number of collisions but a high majority of fatalities. This location is most common with vehicles coming off the road and striking a permanent object such as a tree.

Rural Road Location 1	Rural Junction Location 2	Pedestrian Crossing Location 3	Object off Road Location 4
Fatal	Fatal	Fatal	Fatal
Serious	Serious	Serious	Serious
NO Pedestrians	NO Pedestrians	ONLY Pedestrians	NO Pedestrians
60 mph	60 & 50mph	30 & 40 mph	60mph
A-Road	A & C Road	A Road	A & C Road
Straight Road	Crossroads	Moving near to crossing	Hit object off road
Sharp Bend	T or Staggered T Junction	Multiple vehicle lanes	Trees
No Junction	Give-way System	Signalled crossing	Lamp post
Single Carriageway	Single Carriageway	No vehicle junction	Other permanent object
Cars	Cars	Cars	Cars
Motorcyclists	Motorcyclists	Cyclists	Motorcyclists
Fine Weather	Fine Weather	Fine Weather	Fine Weather
Daylight	Daylight	Crossing drivers side	Sharp bend
Darkness NO streetlights	Darkness NO streetlights		No streetlights

Illustration 15: Typology of the Locations with the most accidents

5.4 Cost to the Economy

The overall goal of the project was to provide information and investigate the potential information could contribute to product design infrastructure in the transport industry. An initially analysis using the Department for Transport costs shows that the total cost loss to the United Kingdom economy is over £70 billion over a six year period. The table below shows this information more clearly. The costs of both fatalities and serious injuries are so high improvements will benefit the United Kingdom both financially and socially.

Casualty Type	Total (2005-2010)	Cost (£) [From DfT]	Total Cost of Casualties
Fatal	15929	£ 1,585,510	£ 25,255,588,790
Serious	158785	£ 178,160	£ 28,289,135,600
Slight	1264186	£ 13,740	£ 17,369,915,640
		Six year Total	£ 70,914,640,030
		Average Yearly	£ 11,819,106,672

Table 29: Casualty severity and cost to the economy

5.5 Geographical Analysis

5.5.1 Local Authority Analysis

Using the four different locations detailed above and derived from the analysis, the data were filtered to show only each of the accident types. Then the accidents were related to the relevant local authority and plotted onto a map. Below are the results for each of the four locations.

The table (and map in Appendix L) below shows results from location type one, rural high-speed roads. Each location has had the number of accidents multiplied by the DfT figure for the level of human injury. It is important to note that the Local Authorities with the most accidents and most cost are open rural locations such as Scotland and Wales.

Local Authority	Fatal	£1,585,510	Seriou	£178,160	Total 1	
Highland	126	£199,774,260	484	£86,229,440	£	286,003,700
Aberdeenshire	111	£175,991,610	533	£94,959,280	£	270,950,890
Powys - Powys	83	£131,597,330	433	£77,143,280	£	208,740,610
East Riding of Yorkshire	76	£120,498,760	459	£81,775,440	£	202,274,200
Scottish Borders	61	£96,716,110	344	£61,287,040	£	158,003,150
Dumfries and Galloway	53	£84,032,030	350	£62,356,000	£	146,388,030
County of Herefordshire	56	£88,788,560	272	£48,459,520	£	137,248,080
South Cambridgeshire District	60	£95,130,600	215	£38,304,400	£	133,435,000
Argyll and Bute	47	£74,518,970	305	£54,338,800	£	128,857,770
Perth and Kinross	45	£71,347,950	274	£48,815,840	£	120,163,790
Fife	42	£66,591,420	298	£53,091,680	£	119,683,100
Wealden District	42	£66,591,420	269	£47,925,040	£	114,516,460
Harrogate District (B)	40	£63,420,400	273	£48,637,680	£	112,058,080
North Kesteven District	49	£77,689,990	169	£30,109,040	£	107,799,030
Stratford-on-Avon District	42	£66,591,420	225	£40,086,000	£	106,677,420

Table 30: Casualty severity and cost to Local Authority for Location Type 1

The table (and map in Appendix M) below shows results from location type two, rural high-speed junctions. Each location has had the number of accidents multiplied by the DfT figure for the level of human injury. It is evident that both Aberdeenshire and East Riding of Yorkshire have serious issues with injuries in these locations, with an estimate here of nearly forty and twenty million pounds lost in accidents compared to all other Local Authorities.

Local Authority	Fatal	£1,585,510	Seriou	£178,160	Total 2	
Aberdeenshire	33	£52,321,830	163	£29,040,080	£	81,361,910
East Riding of Yorkshire	20	£31,710,200	162	£28,861,920	£	60,572,120
Harrogate District (B)	14	£22,197,140	122	£21,735,520	£	43,932,660
East Lindsey District	18	£28,539,180	85	£15,143,600	£	43,682,780
Milton Keynes (B)	14	£22,197,140	98	£17,459,680	£	39,656,820
Powys - Powys	16	£25,368,160	65	£11,580,400	£	36,948,560
West Lindsey District	15	£23,782,650	73	£13,005,680	£	36,788,330
King's Lynn and West Norfolk District (B)	12	£19,026,120	83	£14,787,280	£	33,813,400
Craven District	15	£23,782,650	46	£8,195,360	£	31,978,010
Cotswold District	15	£23,782,650	46	£8,195,360	£	31,978,010
Wealden District	11	£17,440,610	74	£13,183,840	£	30,624,450
Breckland District	11	£17,440,610	74	£13,183,840	£	30,624,450
South Oxfordshire District	14	£22,197,140	44	£7,839,040	£	30,036,180
Dumfries and Galloway	8	£12,684,080	96	£17,103,360	£	29,787,440
Highland	12	£19,026,120	60	£10,689,600	£	29,715,720

Table 31: Casualty severity and cost to Local Authority for Location Type 2

The table (and map in Appendix N) below shows results from location type two, pedestrian crossings. Each location has had the number of accidents multiplied by the DfT figure for the level of human injury. It is important to note that the Local Authorities with the most accidents are major cities such as Birmingham, Glasgow and Leeds.

Local Authority	Fatal	£1,585,510	Seriou	£178,160	Total 3
Birmingham District (B)	40	£63,420,400	686	£122,217,760	£ 185,638,160
Glasgow City	38	£60,249,380	442	£78,746,720	£ 138,996,100
Leeds District (B)	33	£52,321,830	341	£60,752,560	£ 113,074,390
Bradford District (B)	23	£36,466,730	306	£54,516,960	£ 90,983,690
Liverpool District (B)	21	£33,295,710	322	£57,367,520	£ 90,663,230
Manchester District (B)	21	£33,295,710	276	£49,172,160	£ 82,467,870
Sheffield District (B)	21	£33,295,710	271	£48,281,360	£ 81,577,070
City of Westminster London Boro	14	£22,197,140	239	£42,580,240	£ 64,777,380
Barnet London Boro	23	£36,466,730	139	£24,764,240	£ 61,230,970
Kirklees District (B)	12	£19,026,120	201	£35,810,160	£ 54,836,280
City of Edinburgh	13	£20,611,630	175	£31,178,000	£ 51,789,630
Lambeth London Boro	11	£17,440,610	175	£31,178,000	£ 48,618,610
Wirral District (B)	12	£19,026,120	155	£27,614,800	£ 46,640,920
Brent London Boro	17	£26,953,670	108	£19,241,280	£ 46,194,950
South Lanarkshire	17	£26,953,670	105	£18,706,800	£ 45,660,470

Table 32: Casualty severity and cost to Local Authority for Location Type 3

The table (and map in Appendix O) below shows results from location type two, striking objects off the road. Each location has had the number of accidents multiplied by the DfT figure for the level of human injury. It is important to note that the Local Authorities with most accidents are open rural locations with potential for unprotected trees on the roadside.

Local Authority	Fatal	£1,585,510	Seriou	£178,160	Total 4
Highland	73	£115,742,230	238	£42,402,080	£ 158,144,310
East Riding of Yorkshire	57	£90,374,070	340	£60,574,400	£ 150,948,470
Aberdeenshire	58	£91,959,580	320	£57,011,200	£ 148,970,780
Powys - Powys	36	£57,078,360	187	£33,315,920	£ 90,394,280
Dumfries and Galloway	24	£38,052,240	186	£33,137,760	£ 71,190,000
Argyll and Bute	26	£41,223,260	158	£28,149,280	£ 69,372,540
Stratford-on-Avon District	29	£45,979,790	125	£22,270,000	£ 68,249,790
Harrogate District (B)	24	£38,052,240	163	£29,040,080	£ 67,092,320
West Lindsey District	29	£45,979,790	97	£17,281,520	£ 63,261,310
Scottish Borders	26	£41,223,260	115	£20,488,400	£ 61,711,660
Fife	24	£38,052,240	126	£22,448,160	£ 60,500,400
South Cambridgeshire District	26	£41,223,260	93	£16,568,880	£ 57,792,140
North Kesteven District	28	£44,394,280	69	£12,293,040	£ 56,687,320
East Lindsey District	21	£33,295,710	131	£23,338,960	£ 56,634,670
Newark and Sherwood District	24	£38,052,240	96	£17,103,360	£ 55,155,600

Table 33: Casualty severity and cost to Local Authority for Location Type 4

The mapping of local authorities was expanded to account for the total population within an area. For example one local authority may contain an average amount of accidents. However, they have a very small population and therefore the number of accidents should be low. Locations like Birmingham that have a high number of accidents have a very high population and are therefore not as extremely dangerous.

A number of tests were run including traffic counts and lengths of road. Table 35 (and the map in Appendix P) below is a comparison of KSI against the population of an area. It is clear to see that many Welsh authorities have a high number of accidents yet low populations.

Local Authority	ksi - vehicle	population	rate ksi/residents (x1000)
Ryedale District	463	53600	8.64
Richmondshire District	374	53000	7.06
Eden District	364	51800	7.03
Hambleton District	571	87600	6.52
Craven District	352	55400	6.35
Derbyshire Dales District	443	70400	6.29
North Warwickshire District (B)	369	61900	5.96
Powys - Powys	764	131300	5.82
South Bucks District	388	67500	5.75
Argyll and Bute	498	89200	5.58
Daventry District	439	79000	5.56
Chichester District	583	113500	5.14
Selby District	423	82900	5.10
Newark and Sherwood District	569	113600	5.01
Epping Forest District	621	124700	4.98

Table 34: Casualty severity and cost to Local Authority per Population

5.5.2 Results for categories of safety

Standard deviations were used to create categories for figures derived from the above analysis, population against the extent of human injury. This was split into five levels with the middle group being the standard (one standard deviation either side of the mean). Table 35 below shows the results.

TOTALS FOR 5 CATEGORIES OF SAFETY		
Average above and SD applies same		
Also super unsafe from 3 x SD		Total
1 SD (1)	safe	38
within normal (2)	below average	190
within normal (3)	above average	97
1 SD (4)	well above average	47
3 SDs (5)	Extremely unsafe	6
		378

Table 35: Standard Deviation – Road Location Safety

Using this method the results below in table 36 show that many Welsh and Scottish authorities can be deemed unsafe whilst rural English authorities are very safe.

Local Authority	ksi - vehicle	population	rate ksi/residents (x1000)	5 categories of safety
Ryedale District	463	53600	8.64	5
Richmondshire District	374	53000	7.06	5
Eden District	364	51800	7.03	5
Hambleton District	571	87600	6.52	5
Scottish Borders	549	112900	4.86	4
Stratford-on-Avon District	571	119000	4.80	4
Aberdeenshire	1149	243510	4.72	4
Dumfries and Galloway	698	148200	4.71	4
Wealden District	677	144100	4.70	4
Wellingborough District	245	75700	3.24	3
Sedgemoor District	365	112800	3.24	3
Wychavon District	378	117000	3.23	3
North East Derbyshire District	314	98300	3.19	3
North Norfolk District	323	101700	3.18	3
Taunton Deane District	263	109400	2.40	2
Wakefield District	780	325600	2.40	2
Dover District	256	106900	2.39	2
Basingstoke and Deane District	395	165100	2.39	2
Stockport District	264	284600	0.93	1
Central Bedfordshire	211	255200	0.83	1
Tamworth District	59	76000	0.78	1
Worcester District	71	94800	0.75	1

Table 36: Numbers of Killed and Seriously Injured in each local authority per 10,000 residents, 2010.

Following the standard deviation approach and considering the cost to the economy, below is a table showing the most unsafe and safest location in the United Kingdom by accident and cost. Authorities falling into the average range (within one SD of the mean) are classified as 3, those with 2 SDs above the mean, are classified as 1, and those 2SDs below the mean are classified as 5.

Local Authority – Casualty Money Lost – Average per year –

"Standard Deviation Number Classification"

Below are eleven L/As classified 2 degrees above the national average for money lost in casualty injuries and the ten safest locations.

The standard Deviation is classified as 3. With 1 being two degrees below and 5 being two degrees above.

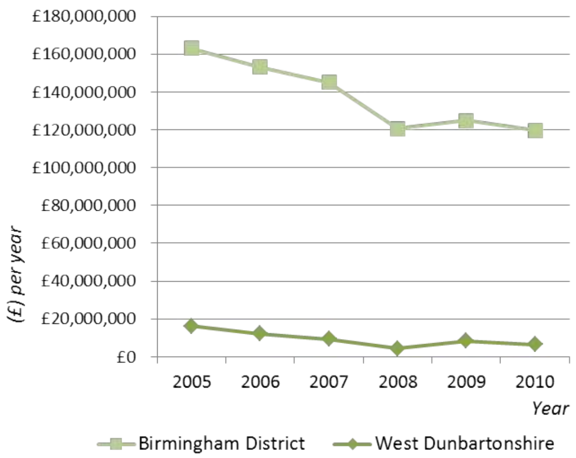
No.	SD	Classification
5	2 degree above	Very Unsafe
4	1 degree above	Unsafe
3	Average	Average
2	1 degree below	Safe
1	2 degree below	Very Safe

Local Authority	Total 6 Years	Average per year	Extremely Unsafe
Birmingham District	£770,130,020	£128,355,003	5
Leeds District	£641,906,310	£106,984,385	5
Cheshire East	£550,179,680	£91,696,613	5
Cornwall	£484,082,250	£80,680,375	5
Aberdeenshire	£481,561,850	£80,260,308	5
East Riding of Yorkshire	£479,102,190	£79,850,365	5
Wiltshire	£471,501,940	£78,583,656	5
Cheshire West and Chester	£461,153,220	£76,858,870	5
County Durham	£446,893,730	£74,482,288	5
Highland	£435,262,800	£72,543,800	5
Bradford District	£432,345,620	£72,057,603	5

Local Authority	Total 6 Years	Average per year	Lowest Casualty Costs
West Dunbartonshire	£56,261,580	£9,376,930	1
Castle Point District	£55,822,430	£9,303,738	1
Watford District	£54,895,420	£9,149,236	1
Epsom and Ewell District	£52,588,160	£8,764,693	1
Stevenage District	£52,315,270	£8,719,211	1
Rushmoor District	£51,073,150	£8,512,191	1
Broxbourne District	£50,013,850	£8,335,641	1
Adur District	£48,689,430	£8,114,905	1
Inverclyde	£45,563,360	£7,593,893	1
Redditch District	£45,214,490	£7,535,748	1

Table 37: Estimated cost for numbers of casualties killed or seriously injured on the roads

A comparison was created between the best and worst authorities. The results below, illustration 16, show that authorities with the most accidents are losing over £100 million in injuries every year whilst those with the least accidents locations are losing less than £10 million. From these estimates the government could review the locations and apply additional safety funding to the locations were large amount of money is lost. This would not only have an economic benefit but a social improvement as less people are injured.



Year	Local Authority	Fatal	Serious	Slight	Total
2005	West Dunbartonshire	6	21	209	£16,126,080
	Birmingham District	20	291	4192	£141,152,840
2006	West Dunbartonshire	3	25	204	£12,013,490
	Birmingham District	29	256	4031	£146,974,690
2007	West Dunbartonshire	2	20	178	£9,179,940
	Birmingham District	19	282	4035	£135,806,710
2008	West Dunbartonshire	0	15	120	£4,321,200
	Birmingham District	16	218	3790	£116,281,640
2009	West Dunbartonshire	2	16	159	£8,206,240
	Birmingham District	19	218	3474	£116,696,330
2010	West Dunbartonshire	1	16	144	£6,414,630
	Birmingham District	19	223	3156	£113,217,810

	2005	2006	2007	2008	2009	2010
West Dunbartonshire	£16,126,080	£12,013,490	£9,179,940	£4,321,200	£8,206,240	£6,414,630
Birmingham District	£146,974,690	£141,152,840	£135,806,710	£116,281,640	£116,696,330	£113,217,810

Illustration 16: Cost comparison between West Dunbartonshire and Birmingham District

5.6 Longitude & Latitude Analysis of Locations with Most Frequent Accidents

Using the longitude and latitude co-ordinates and the DfT cost figures table 39 below, we can see the locations in the United Kingdom with more accidents for each of the four types of locations. The example below is for location three (pedestrian crossings) and shows that the location with the most accidents has generated a loss of over six million pounds in five years from human injury. This information is helpful to a purchaser of road infrastructure as they can compare the cost of a product against the potential cost of human injury. (Appendix Q shows the four maps for each of the locations).

Location 3	Longitude & Latitude		Fatal	£1,585,510	Serious	£178,160	Slight	£13,740	Total Casualty Cost per $100m_2$ Location
1	-0.147	51.515	3	£4,756,530	6	£1,068,960	15	£206,100	£6,031,590
2	-0.07	51.589	3	£4,756,530	1	£178,160	2	£27,480	£4,962,170
3	-2.561	51.474	3	£4,756,530	1	£178,160	0	£0	£4,934,690
4	-0.127	51.508	2	£3,171,020	8	£1,425,280	18	£247,320	£4,843,620
5	-2.126	53.429	3	£4,756,530	0	£0	0	£0	£4,756,530
6	0.865	51.136	2	£3,171,020	3	£534,480	0	£0	£3,705,500
7	0.757	51.533	1	£1,585,510	11	£1,959,760	8	£109,920	£3,655,190
8	-0.251	251.59	2	£3,171,020	2	£356,320	4	£54,960	£3,582,300
9	-0.124	51.483	2	£3,171,020	2	£356,320	2	£27,480	£3,554,820
10	-0.235	51.514	2	£3,171,020	2	£356,320	1	£13,740	£3,541,080
11	-3.336	51.604	2	£3,171,020	2	£356,320	1	£13,740	£3,541,080
12	-1.615	54.971	1	£1,585,510	9	£1,603,440	25	£343,500	£3,532,450
13	-0.162	51.514	2	£3,171,020	1	£178,160	6	£82,440	£3,431,620
14	-0.165	51.554	2	£3,171,020	1	£178,160	5	£68,700	£3,417,880
15	-1.177	52.964	2	£3,171,020	1	£178,160	4	£54,960	£3,404,140
16	-1.846	52.466	2	£3,171,020	1	£178,160	3	£41,220	£3,390,400
17	-2.927	54.889	2	£3,171,020	1	£178,160	2	£27,480	£3,376,660
18	-0.145	51.515	1	£1,585,510	8	£1,425,280	26	£357,240	£3,368,030
19	1.191	52.052	2	£3,171,020	1	£178,160	1	£13,740	£3,362,920
20	-2.126	52.589	2	£3,171,020	1	£178,160	1	£13,740	£3,362,920
21	0.107	52.669	2	£3,171,020	1	£178,160	1	£13,740	£3,362,920
22	-1.829	52.463	2	£3,171,020	1	£178,160	0	£0	£3,349,180
23	-2.732	52.718	2	£3,171,020	1	£178,160	0	£0	£3,349,180
24	-1.064	52.225	2	£3,171,020	1	£178,160	0	£0	£3,349,180
25	-1.676	54.645	2	£3,171,020	1	£178,160	0	£0	£3,349,180

Table 38: Estimated cost for casualties killed or seriously and slightly injured on longitude and latitude co-ordinates

5.7 Results from Street View

Once all the maps were plotted each location had four images attached. (Example can be seen in Appendix R). Individually each site was looked at for different features. A sample list of locations and lists of details can be seen in appendix F.

5.7.1 Results of the Infrastructure Counting

5.7.1.1Chevrons

It was found that on rural roads there were more chevrons present than at rural roads with minimal accidents. The comparison showed seventy-two chevrons at fifty bad locations and fifty-six on fifty good locations. However, there are many types of chevrons and a variety of positions they could be placed in.

5.7.1.2 Sign Lights

Counting the total number of sign lights gave very interesting results. As seen in table 39 below the total number of reflective signs in dangerous locations was over three hundred whilst at good sites there were only one hundred and eleven.

Using a chi-square test, a result of p< 0.01 was achieved which can be deemed a significant result.

Signs at 100 Sites	Reflective	Illuminated	Row Total
Bad	306	120	426
Good	83	111	194
Column Total	389	231	620

Chi-Square Test Result	Significance (p)	DF	Chi-Square
	0.012	1.01	57.11
Description	Significant at or below the 5% level		

Table 39: Sample street view location and counts of road infrastructure

5.8 Focus Group

5.8.1 Quick Fire Round

Using location two as the example the focus group were presented with one hundred locations. Each location had the four images from Street View. Each site was shown to them for five seconds in which they were asked to shout out what they saw as potential issues within the area. Examples of the results are shown below. Issues at site one included bollards, lack of signage and guard railing.

The list of all issues covered is shown in Appendix G. There were many issues gathered but the majority of these were repeats. The list was minimized to show only a raw list of potential issues to the group.

5.8.2 Grouping

Continuing the example of using location two, the focus group was asked to select each of the factors and group the items together. This group system was put into a mind map, which can be seen below. The benefit of this is the ability to see how items interact with one another. For example overall vegetation is an issue but in detail the issues are algae on signage or overgrown bushes obstructing views at junctions.

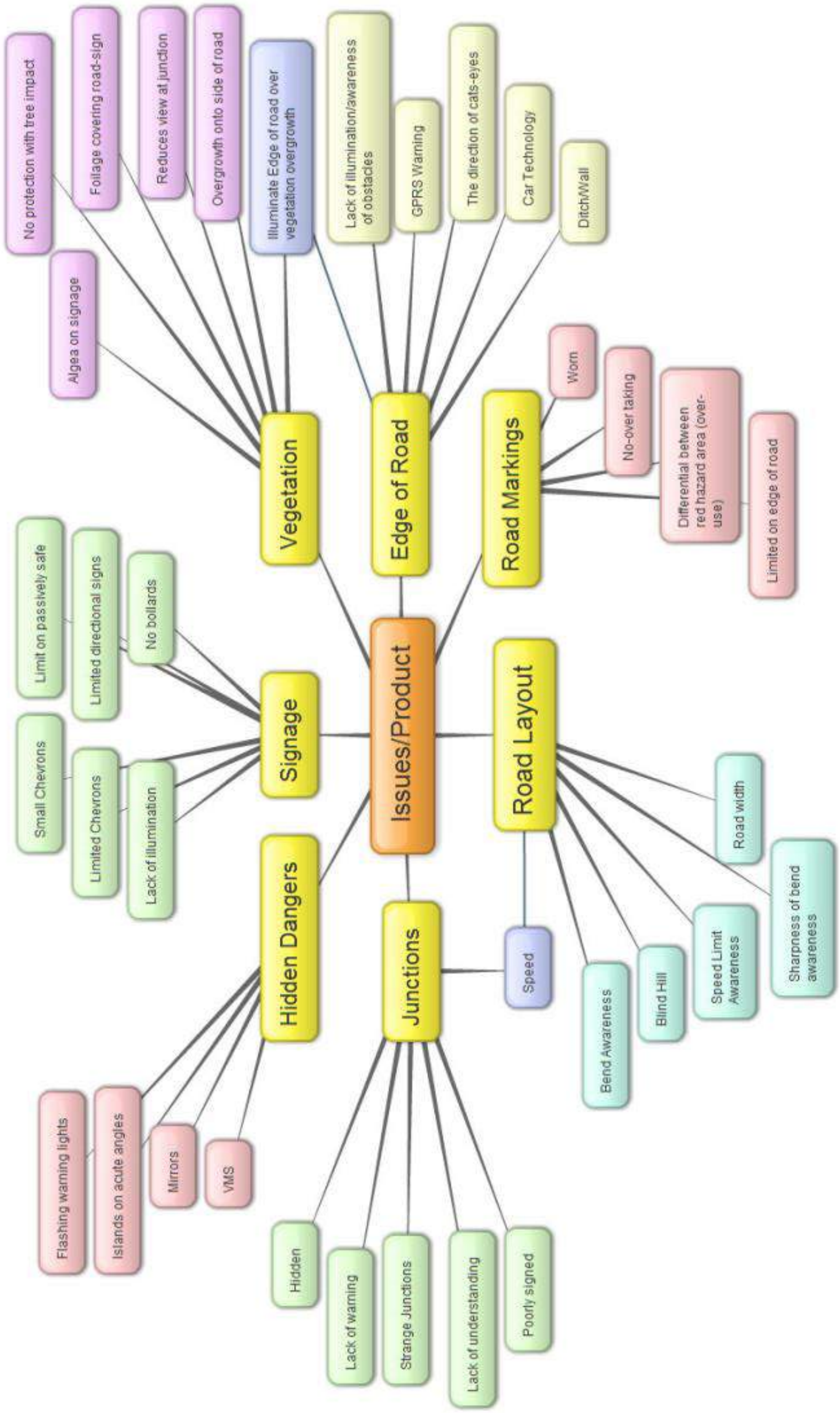


Illustration 17: Mind map of the items that stood out to focus groups as likely to cause accidents

5.8.3 Ranking

With the issues of each location grouped it was important to see which issues concerned the focus group most. After being presented with the results from the statistical analysis they were asked to rank each item. At the top of this list were limited views at junctions. Every member of the focus group saw this as a major issue. Secondly both concealed junctions and confusing junctions were found to be most difficult for the users. It could be suggested that these areas required either better clarity in signing or the road layout changing to make it easier to navigate for the road user.

5.8.4 Suggestions

Following the ranking of the key issues to the focus group they were presented with a variety of dangerous locations. With the information they have gained they were asked to suggest solutions to improve the safety of the area. Many suggestions were not practical or not part of the designer's responsibility. An example of this was the focus group suggesting the road to be wider; this is the responsibility of the council and not the product designer. The finalized information was condensed by the team to result in practical product solutions that an infrastructure designer could create within their role. This included directional cats-eyes, on-coming traffic warning light and interactive speed bumps.

The team drew on the images, which allowed them to be more creative and engage with the site. An example of this is below. It was clear from this task that there were many improvements that could be made to the locations. However, the majority of these improvements were not with the remit of a product designer, but spread across many persons including; local authorities, Department for Transport, British Standards and contractors. It would require a holistic approach and team effort for many of the improvements to be made.

5.9 Overall Location Selection – Summary of Selection

Using the information from the statistical and visual analysis the four locations were detailed further considering all possible scenarios that contain high number of serious road traffic accidents. Each location details the road layout around collisions plus any additional attributing factors such as speed. It is the intention that these four locations will help inform the designer and others within the industry with new information that previously would have not been known. Each location is detailed below describing the features of each type of location and one accompanying picture that is one example of this type of location.

Location 1 has a high fatality rate with the following characteristics –

- Of all fatalities 57% occur on A-Roads
- Of all fatalities 47% occur at 60mph
- Together 60mph A-Roads contain over 25% of all fatalities
- Of all fatalities 75% occur on single carriageways
- 66% do not occur within twenty metres of a junction
- Risk of KSI nearly doubles when in a collision with no street lights present compared to when there is
- 60% of all fatalities are in cars and 22% on motorcycles

- You are five more times likely to die when in a collision on a motorcycle than when in a car
- Weather downs not play a significant role
- 23% of drivers fail to look properly
- 58% of fatalities the vehicle was proceeding straight ahead & 23% ahead on a left or right bend
- 67% of fatalities are head on impacts

The focus group have also stated that:

- Vegetation overgrowth and algae on signs
- Unable to identify edge of road
- Lack of speed calming and awareness
- Lack of illumination

Below is a visual example of this type of road:

Illustration 18: Location 1 – High Speed Rural Road

Location 2 has a high fatality rate with the following characteristics –

- 57% of accidents occur on A-Roads
- 54% occur at 50 & 60 mph
- 20% occur at T or Staggered T Junctions
- When at a junction 86% of fatalities occur at uncontrolled or give-ways
- 37% of fatalities occur when the vehicle is approaching a junction whilst 35% are situated mid-junction
- The risk of KSI nearly doubles when in a collision at a T-Junction than at a roundabout

- Weather does not play a significant role
- 12% of drivers failed to judge other vehicles speed whilst 23% failed to look properly
- 21% of vehicles skid in a collision
- 67% of fatalities are head on impacts

The focus group have also stated:

- Lack of warning before a junction
- Unable to judge oncoming vehicle speed
- Poorly signed and unorthodox junction layout
- Lack of illumination
- Acute angle at junction exit and unable to see approaching vehicle
- Narrow road width

Below is a visual example

Illustration 19: Location 2 – High Speed T-Junction/Staggered T-Junctionof this type of road:

Location 3 has a high pedestrian fatality rate with the following characteristics –

- 69% fatalities are struck by a car/taxi
- 50% of fatalities are during daylight hours and 33% are in the dark with lights present, whilst 16% are in the dark with no lights
- 54% of fatalities occur on A-Roads
- 63% occur at 30mph
- 69% are not using a pedestrian crossing
- 34% were crossing from the drivers side and 18% from the offside
- For every four vehicle occupant deaths there is one pedestrian
- 11% of fatalities the pedestrian was on the footpath
- It is safer to walk towards traffic than with it
- Aged 8 – 24 year olds make up 40% of all pedestrian casualties
- 60% of all fatalities the pedestrian has failed to look properly and 25% where reckless or in a hurry
- Less than 2% of fatalities were on the zig-zag approach lines but 10% were on the actual crossing

Below is a visual example of this type of road:

Illustration 20: Location 3 – Pedestrian Cross not within a Vehicle Junction

Location 4 has multiple accidents with vehicles impacting permanent objects. Below are characteristics of these locations:

- 60% of vehicles do not hit an object off the road
- 48% of vehicles do not leave the carriageway
- 89% of vehicles do not hit an object on the road

  However –

  - 13% of all fatalities a vehicle has struck a tree
  - 13% of all fatalities a vehicle has hit a permanent object such as a brick wall
  - 7% have struck lamp posts, road signs or telegraph poles
  - Less than 10% of vehicles would have left the road but were projected back onto the road due to crash barrier or equivalent
  - Total of 17 deaths in 2010 from a collision with a bollard or refuge
  - You are twice as likely to die in a collision with a tree than any other object

The focus group noted:

- Low number of passively safe products
- Limited protection from permanent objects
- No protection from soft verges or ditches

Illustration 21: Location 4 – Impact with Permanent Objects

6. DISCUSSION

The results illustrate two findings. The first were the four dangerous locations. The four locations highlighted scenarios where there is potential for high levels of road traffic accidents and human injury. Each location can be described as rural roads, rural junctions, pedestrian crossings and impacts with permanent objects off the road.

The second finding was the benefit of the research process. The process was able to use historical collision data to determine a real need based actual evidence. Whereas the knowledge gained from the research process is useful, it was difficult to feed this knowledge into the business process in its raw form. It was only in feeding this information in a practical form to the focus group to help relate it to products and issues in the real world that a way through the complexity of the information was found. It was possible to use complementary processes of research and development to track through a real world scenario and enlist the expert skills of the group to help relate the understanding to practice.

Although both findings have potential to improve road safety and dramatically improve the industry there are issues implementing them due to the complexity of today's industry politics and structure. The discussion below details not only the four locations and the research process but also suggests ways in which they should be implemented.

6.1 Pilot Study

The results of the pilot study showed the need for a multifaceted exploratory approach. Conclusions could not be made, as the data was not detailed and only sourced from a small area within Lancashire but it was helpful to the development process. More diverse data from a larger area was required to determine how roads could be improved for the whole of the United Kingdom. It can be noted that other studies use a variety of data sources such as Kineers study of young drivers (2009). The United Kingdom road network is also a large multi-faceted public use product and therefore needs a variety of approaches from an assortment of sectors to fulfill all the requirements to ultimately improve road safety.

6.2 Discussion of Key Results

6.2.1 STATS19

Initial examination of vehicle casualties showed inclinations of areas for concern. For example, the initial frequencies showed that only a small percentage of casualties (4.3%) were injured on a Motorway. This observation suggests the need to focus road safety products in other locations in more need.

Furthermore, over seventy percent (70%) of all types of injuries occur on single carriageways. But if we focus on the serious and fatal accidents only, seventy seven percent (77%) occur in these locations. Considering an altruistic approach and the aim of this study, it can be suggested that due to the high percentage of accidents on single carriageways, especially those involving serious injuries, new products should be focused on single carriageways rather than motorways.

As discussed in the literature review, some studies focused on road surface treatments at or within a junction (Chapman 2005). However, this study shows that sixty eight percent (68%) of all fatalities do not occur within twenty metres of a junction. The literature review revealed that there is minimal research into road safety for single carriageways not within a junction (Cooper 2007). It is suggested that these studies did not look at the higher percentage of accidents when making decisions to develop new products. News studies can follow the new process this study has created to develop new products or in this case, road surface treatments, for areas with the most need.

6.2.2 Geographical Analysis

The terrain of councils varies dramatically from urban London to rural Hertfordshire. The road and type of accident varies as seen in the findings, with London having a high pedestrian casualty rate and Hertfordshire having a high vehicle casualty rate on high speed roads. This calls for a variety of product design, which could be informed by the research process developed within this study. Although, locations with a high number of road traffic accidents and human injury cannot only be identified but the road type defined.

6.2.3 Site Specific Product Design

Black Spot is the name given to locations known for a high number of road traffic accidents and human injury. There have been a number of studies into these locations (DfT 2009), which have demonstrated that displaying black spots to motorists reduces their speed, thus reducing the risk of accidents. The findings of this study can be used to identify black spots for both national and regional locations. They can also identify black spots for specific types of roads such as the four locations detailed in the results section.

This information can allow Local Authorities to identify these locations to the public with appropriately designed products. The main issue with identifying black spots is once the location has been improved the ‘black spot’ no longer exists. Taking the title of this study into consideration, new products should be adaptable and portable. This will allow black spots to not only be identified but also be relocated in a new location. This not only allows it to improve the safety of multiple roads but also be reusable which will have a positive effect on budgets.

As detailed in the literature review, a MONASH (2007) study found that road side signs with variable safety messages can improve the safety of the road. The ability to provide information on the side of the road can be made easier with technology such as Variable Message Signs (VMS).

Illustration 22: Example of a Variable Message Sign

Designers can now develop VMS for areas with high numbers of accidents. However it is suggested they collaborate with researchers to display specific messages to suit the location dangers. Researchers can use the research process of this study to identify specific reasons for road traffic accidents compared to a perceived reason. This begins to identify the need for a holistic and collaborative approach, using the transfer of knowledge between researchers and designers.

6.3 Infrastructure

The findings showed that there is scope for further research into areas with high accident rates and its surrounding road infrastructure. It is outside the scope of this study but initial findings showed a difference in both the number of illuminated and reflective traffic signs and bollards. The Department for Transport has carried out numerous research projects in laboratories regarding lit products with varying results. (TRL 2007) However, there has been no research into lit products in a real environment. As the results show there are varying types of accidents in varying locations. Therefore it is suggested further investigation is required that takes into consideration the surroundings to determine what product designers should develop further. Currently, the majority of industry sellers provide both illuminated and reflective products, to suit varying needs. This takes time and resource. However, if researchers found definitive results for the type of lit product in varying areas, designers can be more focused and create products to suit the specific needs of a location. Again this reflects the need for knowledge transfer and collaborative teams.

Considering road infrastructure and safety, the findings show issues with permanent objects, particularly trees. The obvious solution is to removal the dangerous tree. However, in areas of natural beauty it is deemed inappropriate to remove trees. The next solution would be to create a protective barrier around the tree although this proves very expensive which many local authority budgets could not afford and not feasible due to terrain and space. The dilemma is to create an effective solution to reduce the severity of road casualties but meet the requirements of all the other parties involved. Only a collaborative and holistic team approach could solve this issue. Taking a team of people from varying sectors, including members from the National Trust can share ideas to identify a solution whilst keeping their own primary objective intact.

6.4 Focus Group

The secondary data creates a picture of the most dangerous locations in the United Kingdoms road network. To help reduce the number of fatalities and seriously injured persons from road accidents, new products should be focused in the four areas highlighted in the findings.

1. High speed rural road with no junction
2. High speed rural road at T-Junction or crossroads
3. Pedestrian crossings not within the vicinity of a vehicle junction
4. Impacts with permanent objects off the side of the road on high speed roads

Using these locations product designers should collaborate with different sectors to focus their attention on making these locations safe. Products alone cannot stop accidents because driver behaviour will override (Kineer 2007). But the literature (Kumar 1985) also shows they will go a long way to reducing the overall number of accidents. If collaborative teams were used it would improve the possibility of reducing more accidents as each team member would approach the task from their own angle based on their experience and background.

6.5 Four Key Locations

As stated previously there are four key locations that should be reviewed for the safety. The locations have originated from a mixed of statistical analysis along with visual and geographic with input from focus groups and experts. It can be said that the mixture of research techniques to define and locate these types of locations makes the results much more credible as if it were to come from just one research technique. Each type of locations is very distinguished in its features and have relevance in places to previous literature. These are detailed in the next four sections.

6.5.1 High Speed Rural Road with no Junction

High-speed rural roads do in their nature carry less traffic than a motorway. However, the data clearly shows they are the most dangerous with fifty seven percent of all fatalities on them and furthermore seventy five percent on single carriageways. These roads need additional attention not just because they have had a large number of fatalities but also because they are also dangerous in their design for today’s traffic. The focus group noted lack of illumination and overgrowth, which indicates these roads are poorly maintained. In comparison the literature review showed the DfT (2009) highlighted rural roads as an area for improvement, but as shown they failed to detail the specific types of roads these accidents occur in, whereas this study does. This more specific description of rural dangers should enable the Government to focus their improvements and ultimately improve this dangerous location easier.

The study by Kineer (2009) showed that drivers drive as they feel. This is typical of accidents in these locations. As found in the results the lack of information such as chevrons and illumination or the narrow roads with oncoming vehicles can all occur from the driver having a lack of information. The driver is not made aware of impeding obstacles and when those obstacles do arrive such as a narrowing of road they are already travelling at a high speed on a narrow road and therefore have no time to react. On the other hand Mitchell (2006) found that it was not the signs on the side of the road but there marked bitumen on the road that guided drivers. Considering this any improvements should be to either remove an obstacle or place warning devices directly on to the road in line with the driver’s vision.

The risk of being killed or seriously injured nearly doubles when travelling at a high speed with no lights present was one of the key findings in this location. It can be said that to reduce road traffic accidents streetlights should be placed at all high-speed rural locations. However, the practicality of this implication is vital to consider. The cost of implementing street lights in the whole of high speed rural locations in essentially impossible and the idea of placing street lights in locations where accidents have already occurred is returning back to the current reactive response rather than forward thinking. Therefore further studies should take place to identify each road and label it by a specific type and therefore placing street lights or improvements on roads that are highly likely to have an accident in the future rather than on ones where they have already occurred. In reflection this varies from Cooper’s (2009) study where he suggested lights and bollards should be placed in specific locations and that microprismatic material could be used where there are no other external lights. This means that in rural high-speed locations many signs have used microprismatic material. However, this material does not give as much prior warning than any other light source as the material only works once the vehicles headlights are facing towards it. With this in mind and the lack of maintenance to rural roads there is a distinct lack of prior warning of dangers and thus drivers have minimal time to react to any danger.

Upon reflection recommendations for this location would be to remove all overgrowth and improve the maintenance of high-speed rural roads. Locate roads that have similar traits to the features identified in the results and in turn place warnings directly on to the road or in line with driver's visions to highlight any dangers. Finally place lighting where accidents can possibly occur.

6.5.2 High Speed Rural Road at T-Junction or Crossroads

The difference between this type of dangerous location and the previous is the addition of slow moving vehicles at a junction moving on to a high-speed road. As stated in the results eighty six percent of accidents occur at uncontrolled or give way junctions. Considering this and the focus groups acknowledgment of lack of warning rural junctions are not designed or maintained to suit today's traffic. Fatal road accidents are occurring in these locations and the evidence points towards lack of understanding. Considering Olson's (2002) study, at a high speed the driver has less time to react and therefore the risk of collision increases. What makes T-Junctions and crossroads more dangerous is the structure and layout of them, as vehicles approaching at high speed in both directions, one must come to a stop, recognising where the junction is and the other vehicle know if they are going to pull out or not and therefore slow down. The focus group highlighted the dangers of acute angles and lack of visibility at these junctions and so further work should be done to improve visibility at these sights.

It can also be said that drivers are left feeling unsafe in these locations and as Kineer (2009) and Chen (2008) both found young drivers make more mistakes when not knowing what they are doing as they lack experience but also the fact that drivers have multiple distractions such as radios or passengers so mistakes are made. T-Junctions and crossroads do have prior warning signs but with these 'in car distractions' they can be missed. It could be suggested to follow Mitchell (2006) recommendations and move warning signs of approaching junctions on to the road itself.

What is evident is that the results of identifying the most dangerous locations by rural high-speed junctions alone will not improve road safety. Using this information it is suggested that further studies are undertaken to ensure vehicles approaching the junction are aware of the junction and oncoming vehicles whilst the vehicle at high speed is aware of potential vehicles joining the road and therefore have enough time to react.

Recommendations for high speed rural junctions is for the junctions to increase in size giving the joining vehicles more time to judge oncoming vehicles speed and also allow oncoming vehicles to react to any vehicle joining them. It is important to not react to junctions just because they have had a previous accident but to react to ones with multiple accidents or ones that have the same design and layout and can therefore be judge as a potential danger for the future. Fundamentally T-Junctions and crossroads require more research to understand the interaction between the vehicle and road.

6.5.3 Pedestrian Crossings not within the Vicinity of a Vehicle Junction

This study shows that the majority (69%) of pedestrians have not been using a prescribed pedestrian crossing when a vehicle, most often a car, has hit them. Edquist (009) found that in built up areas drivers proceed with caution as the idea of more obstacles made the driver feel they had to proceed slowly to manage potential pedestrians. However, with this type of location the areas are not built up and the driver has no additional obstacles such as a junction. This means that a driver can miss the addition of a single pedestrian crossing. It can be suggested that these pedestrian crossing are built up such as narrowing the on-coming road or placing bollards to make the driver feel unsafe and therefore proceed at a slower pace subsequently stopping for pedestrians.

It is noted that sixty nine percent of pedestrians where not actually using the designated crossing. The reason for this is ever ending due to peoples varying needs although sixty percent of pedestrians failed to look properly and twenty five percent were reckless or in a hurry. This suggests pedestrians are not using the crossing out of carelessness. It can be suggested that future design of crossing should be so pedestrians are forced to cross at the crossing and can physically not cross elsewhere. However, future research is required to see if this works and if any more relevant studies reflect this.

Recommendations for this type of location are minimal due to the current lack of literature support pedestrian safety at this type of location. With this in mind it is suggested future studies focus on pedestrians crossing safely and vehicle awareness, at pedestrian crossings with no junction. Along with further studies it is suggested real life trials are carried out to determine what specific reasons cause accidents at these locations.

6.5.4 Impacts with Permanent Objects off the Side of the Road on High Speed Roads

This location saw that few cars left the carriageway in an accident although thirteen percent of all accidents involved a collision with a tree and a further thirteen percent with a permanent object such a s a brick wall. With this in mind Candappa (2007) study is relevant as he found that when a driver left the road they were highly likely to be killed or seriously injured and therefore developed ‘clear zones’. These clear zones would allow a vehicle to come to a gradual stop without striking a tree or other object subsequently dramatically improving the safety of an accident. The issue with this is clear zones were developed for Australia where additional road space is of abundances whereas in the United Kingdom it is not.

Henderson’s (2009) study is important as he highlighted the issue with whiplash and the affect on internal organs when coming to a sudden stop. As the force of a vehicle hitting a solid object is so high it is suggested that if the vehicle is going to leave the road with no barriers measure should be put in place to slow the vehicle gradually.

Considering this it is recommended that areas that have similar features to that of area four have permanent obstacles removed and where this is not possible Government should adopt designers and engineers to create an alternative that allows the vehicle to come to a stop without striking a solid object.

6.6 The Use of the Findings

The secondary data and the resulting four locations can be used by a host of people in the industry such as;

- The buyer – often the council, are responsible for the upkeep and purchasing of new products but are also responsible for maintaining and improving the roads within their area. The council's budget is funded by the government and is dependent on many factors including size of territory and population. However, the new approach to looking at secondary data, league tables, as shown in the results can highlight areas where additional funding should be sought based on evidence of need to improve road safety.

- The designer – Designers are driven by the buyer's needs, which can be a perceived need opposed to an evidence based one. These can vary from ease of installation and vandal resistance. But the underlying factor should always be safety. The use of the findings by designers can help them develop new products that can then influence buyers purchasing beliefs. Following this study, designers within the industry are already considering this approach. An industry leader used the evidence base to develop a low bridge detection system that was pitched and then implemented at the entrance to the Blackwell Tunnel in London. Many products are designed for a buyer's perceived need, but designers should take a more active role in specifying what the requirements are. Good design is often one, which meets the customer's needs. However, products that excel are ones that customers did not know they required until they had it. An example of this is Apple's iPhone, a product many consumers did not know they needed, but when they had, it changed their lives and ways in which they worked. (De Leo 2008)

- The Government – Governments allocate funding to local authorities, which is not always determined by how much work is required to make roads safe, but often by size of populations and perceived needs. The findings from this study show a real need for councils such as the Highlands and Aberdeen to improve the safety of their roads, but their budget is dramatically less than that of a London Borough. The findings from this study can be used to help local authorities petition Governments for funding based on evidence of actual rather than perceived need.

6.7 Cost to the Economy

The cost of road traffic accidents to the economy is undisputable excessive. For example the findings show that over a six-year period the Highlands Local Authority has accumulated a loss of over a quarter of a billion pounds in loss of human life and injury. The cost of loss of life and human injury heavily outweighs the expenditure on maintaining and improving the road network. Below is an image of one site that in six years has had a total of four fatalities costing nearly ten million pounds. The images do not justify an expenditure of ten million pounds in products and there maintenance. It can be suggested that if this amount was spent on products first it could have stopped these accidents. If this theory was adopted throughout the United Kingdom a saving to the public purse could be seen along with an improved altruistic view.

Illustration 23: Street view of road in the Highlands

The loss of resources affects both Government and taxpayer and their ability to use funds for improvements. The government departments effected includes the emergency services, National Health Service (NHS), road traffic maintenance and civil servants. Considering the variety of sectors affected by road traffic accidents, it can be suggested that designers should not only consider permanent products for the roadside, but also design products that can assist persons in and around accidents. An example of this is the need for the Police Force to make a location safe for other road users when an accident has occurred or the Local Authority who have to repair products damaged following an accident. It would be a breakthrough if temporary products could be put in place of damaged products until they are fixed or replaced permanently.

Although Motorways have one of the lowest casualty rates they have a well-coordinated cohesive team at every accident. With the emergency services carrying out their normal roles the Highways Agency will make any repairs to the damaged carriageway immediately after an accident to return it to normal. Therefore, the quality and safety of the road is maintained. It is suggested that high accident-prone roads within the United Kingdom could adopt this approach. Currently, after a fatality a Local Authority representative will compile a collision report within seven days of the accident and the police will remove any dangerous objects from the side of the road. However, it often takes a long time after the accident for the road to be repaired and improvements are not necessarily made. If councils had a rapid response team, locations can be made safe to reduce the possibility of other collisions occurring whilst the road is damaged and unsafe.

6.8 Theory vs. Practicality

New products could be developed for the four key locations and government funding focused on the Local Authority areas in most need. However, there are many practical issues stopping this happening from this one study. There are often barriers created by existing business practices. For example, an established business will have its own product development process. This can result in employees being resistant to change making it difficult for designers to work with researchers or people outside the industry. This can be a barrier for the company not only to implement a new process but also to protect new intellectual property and covering extra expense.

Products can be developed from information in this study alone, but further testing and development is required to confirm the new design is capable of meeting any set specification. As seen in the study of road treatment in the literature review (Chapman 2005), products need to be tested in a real environment to demonstrate any improvements in road safety. It is beyond the scope of this study to both develop and test products based on the findings. However, it is advised that the results of this study are used to develop future studies specific to the product and its location. It is also important to note that further studies bridge the gap between theory and reality allowing the evidence-based findings become a product that improves road safety.

There are other practical issues that products need to consider, such as cost. Designers face the ever-increasing pressures to design inexpensive solutions. As the majority of products are bought with government funding by Local Authorities, products that suit only one location will not be bought for a considerable cost because the industry is so vast it works on mass production. Therefore products developed for one specific location take a considerable time and resource, which is often not available. With this in mind new products need to be practical and consider additional factors determined outside of this study such as economical, material conformances and environmental considerations.

Another challenge in developing new products is the need to comply with legislation and standards. Designers are restricted by European standards and cannot release new products’ onto the market without the approval of the Department for Transport plus approval from a Notified Body providing certification to the Conformité Européenne (CE). Without these the product cannot be sold. This proves very difficult in the development of new products. The current findings show a need for products in specific locations such as pedestrian crossings. Considering this design not only need to improve road safety in these locations but meet all the applicable standards for any council to legally place a product on the road. Difficulties can occur when a new product defers from the current standards, this can result in a number of years of consultation with industry bodies to gain approval of a new product.

6.9 New Research Approach

It should be noted for two novel approaches to the research of historic road traffic collisions. The first was the visual analysis using Google Street View and the second was the focus group review of dangerous locations using quick fire images of each site.

The use of Google Street allowed each dangerous location to be studied for objects that are not collected by STATS19 data. This method of collecting data does have its downfalls as Google only had images from 2009 and therefore could be deemed inaccurate. However, as products have on average over a five-year guarantee the images are highly likely to be accurate. The benefits of collecting the data in this way allowed the research to include a visual analysis that the STATS19 data does not include. It would have been impractical to manual collect the data in any other way. This approach should be considered for future work as an exploratory method of analysing locations where time constraints are an issue.

It was important that the focus group had as close of an experience reviewing each location as they would if they were driving at it. If the group had more time they would not be experiencing the locations and have more time to think of dangers, the purpose of seeing each site as they would is to make them think quick and see those hidden dangers. The method proved fruitful with the group giving many varying answers and engaging. Due to financial and time constraints the group could not of driven at each site. The method of research can be used for other studies with focus groups, as it is an inexpensive time saving method of exploring data in a realistic method to achieve new information to study.

6.10 Recommendations

In summary the four types of location have highlighted areas that need attention to improve their safety. However, certain approaches and requirements should be considered:

- High speed rural roads require more maintenance to remove overgrowth and advanced warnings placed in the drivers view
- High speed T-Junctions and crossroads need decluttering to improve driver visibility and awareness
- Pedestrians crossing need improving to force pedestrians to the crossing and not cross before whilst vehicle need to be made more aware of the crossing
- Obstacles at the side of the road should be removed where vehicles are likely to come off the road and where they cannot be moved new products are required to make vehicles come to a natural stop without impacting a solid object
- More studies are required to determined specific reasons accidents are occurring in these locations
- The information from this study should be disseminated to all sectors in the industry

- The cost to the economy is great and therefore the cost of a product may be expensive but it may be directly proportional to the cost of a fatality at the location. So Councils should consider spending more money upfront and save money and lives in the future
- The use of focus groups and new novel approaches to research has provided many answers that have been very useful. It is noted that they can be deemed inaccurate in places but due to cost and time constraints this information would have otherwise not been available.

7. CONCLUSION

To conclude we must review the original aim of this study – "to indentify common areas in the United Kingdom that have had a large amount of road traffic accidents and resulting human injury."

This study has successfully done this by stating the four most dangerous types of locations in the United Kingdom them being:

1. High speed rural road with no junction
2. High speed rural road at T-Junction or crossroads
3. Pedestrian crossings not within the vicinity of a vehicle junction
4. Impacts with permanent objects off the side of the road on high speed roads

To complete the aim of the study several objectives were set and each have been met. They are as follows -

- Source and statistically analyse historic road traffic collisions – Obtained six years of historic STATS19 data from the Department of Transport and carried out a number of statistical analysis methods
- Examine historic road traffic collisions to identify common accident types – Examined STATS19 data to identify types of road traffic accidents such as high speed rural roads
- Geographically study the longitude and latitude co-ordinates of each road traffic accident to identify areas with multiple accidents – Used geographic analysis to identify both dangerous locations but also Local Authorities with trouble
- Investigate the cost of road traffic accidents in relation to accident type and location – Located a typical cost of human injury and converted it to show the cost of accident locations and the effect on the public purse
- Visually analyse accident locations to determine common physical features – Used Google Maps and Street View to examine locations and analysed each location for potential dangers
- Identify common road traffic furniture at locations with multiple road traffic accidents – Counted and analysed then umber of bollards, signs and chevrons at dangerous and safer locations to see if the products affect the level of safety on the road
- Conduct focus groups to analyse road traffic accident locations to determine what makes them dangerous – Carried out a number of focus groups using new novel techniques to identify dangers not listed by STATS19
- Use the statistical, geographic and visual analysis to build a picture of the most dangerous locations for road traffic accidents – Used all results from the research to create four distinctive types of road location that have the most types of road collisions

It is intended for these results to be transferred into the varying sectors of the industry and used to develop new road side products that will ultimate reduce and eliminate the number of people killed on the road network.

The results of the statistical study alongside the visual analysis and focus groups successfully allowed the study to progress to the development of four sample areas with specific factors that resulted in large numbers of fatalities and serious injuries.

The statistical analysis was evident in showing areas on the United Kingdom road network that require immediate attention. The four locations stated where the most common accidents were with common features across each collision type. These features included speed, road type and vehicle type. The four locations began with high-speed single carriageway roads in rural locations. On reflection it was evident that only a small proportion of road furniture is present at these locations compared to urban locations. It can be suggested that these locations require inexpensive, self-powered products to make it feasible to purchase and install.

Location two illustrated high-speed rural junctions, such as T-Junctions and crossroads. High-speed junctions require safety features that make the driver more aware of their surroundings rather than just the road ahead. With eighty per cent (86%) of all fatalities at a junction being ‘give-ways’ it can be said that drivers are not aware of these locations and how dangerous they can be. It is recommend road engineers review the layout of the road but it is also evident from industry experts that this is a high cost and time consuming solution, therefore it should be recommended that product designers and further studies investigate the possibility off developing inexpensive products to improve the awareness of junctions at high-speed rural locations.

Location three consisted of accidents at pedestrian crossings with no vehicle junction present. It can be said that as the driver has no immediate driving obstacle they are unaware of pedestrians. It is not within the scope of this study but it should be recommended that before any new product is developed for these high-risk location further studies are required to determine why drivers do not recognise pedestrians at crossings or why pedestrians put themselves in danger of on-coming vehicles.

The fourth location found that when vehicles are involved in road traffic collisions and leave the road it is highly likely are seriously injured or are killed. Following the further research into visual analysis and the discussions with the focus group, it was found that treatment to the side of roads should be strategic to ensure any dangerous object are removed or measures are taken to avoid a vehicle striking permanent objects. As discussed in the literature review, no product can stop someone driving dangerously if they want to, therefore obstacles off the road should be passively safe to help minimalise potential injuries. New products that protect vehicles leaving the road should be extended from the current barriers we see on Motorways to site-specific locations in rural locations such as tree or building protection. Considerations Local

Authorities give to spending and feasibility are important but so are the socio-economic aspects such as not disrupting an area of natural beauty. A more altruistic approach should be given to road safety with cost not being an issue as we are considering someone's safety.

We should note limitations and issues in the analysis. Limitations in the statistical analysis begun with secondary data used. As stated in the methodology the STATS19 data is collected by the Police Force and is input manually into a database by Civil Servants. Therefore human error can occur plus some fields within STATS19 are qualitative and therefore could be deemed bias. However, each Police Officer is a trained expert in recording collisions and STATS19 is recognised as the most accurate public available recording of collisions within the United Kingdom. The second limitation is the visual analysis, which used Google Maps and Google Street View. The majority of images were taken from 2009. However, the accident data ranged from 2005 to 2010. This meant some images may have shown road furniture that was not there or in a different condition when an accident occurred. We must recognize these potential inaccuracies, although it is believed the potential errors are minimal due to the large number of areas examined and the frequency in which road furniture is replaced.

The Local Authority review was beneficial as locations were identified that were dangerous and require the development of innovative road safety products. Another success that wasn't originally intended was the ranking of Local Authorities and the ability to use an evidence base to apply for further funding. The secondary data showed Local Authorities with a high number of fatalities and serious injuries. With this in mind it can be suggested that the league tables developed could be used by the Government to filter high value grants to Authorities in most need of improving the safety of their roads.

It was vital to investigate how an industry leader could develop new products adopting the recommendations from the four locations. It is important to note that the industry leader has developed road furniture for over twenty-five years and are highly respected within the industry. Therefore, it could be said they are well suited to developing new products. However, this study was not to create a new product but actually locate the requirement for one. As the buyer, often the Local Authority, determines what is required, the industry partner had to find a market for a new product that potentially does not exist if the Local Authority has not suggested it. In a market that relies heavily on budget this is a fundamental issue. This finding supports the need for a holistic and collaborative team across the industry that has the ability to use this evidence base to determine what is required rather than develop from a 'perceived' need.

The discussion showed that clear differences between various sectors in the transportation industry. The issue surrounds each sector having different goals and requirements. It was most evident when a member of the public was unaware of the difference between an illuminated and reflective bollard, a topic much argued in the industry. If new products are to be effective in reducing the number of collisions they must overcome many barriers to entry. It is recommended that holistic teams be created to collaborate on projects.

This will include buyers and designers so barriers are broken and effective products designed. It will also allow collaborative work and ensure each party achieves its primary and improve road safety goal in the project. However, we should note potential issues with this method of work. The major issue with collaborative work in industry is timing. Business practices can mean that collaborative work can be time consuming, such as ensuring necessary meetings are made to suit each partner. With this in mind the Government's recent attempt to make a Transportation Catapult can be seen as a positive bringing businesses together to work on projects collaboratively. The catapult will have a central location where businesses can communicate more effectively. It is a recommended that results from this study should be implemented as a trial Catapult project to investigate the possibility of Transportation Catapult businesses working collaboratively on a road safety product.

Following the results and discussion this research has the opportunity to provide benefits in improving both road safety and products beyond the four recommendations and focus group results. The database created can be easily maintained and has the ability to extract specific data by Local Authorities, designers and researchers when required. This will allow persons to locate new information, support theories. For instance, in the pilot study it was found that a high percentage of slightly injured people were at roundabouts. Although these accidents were mostly low speed 'bumps' there is an opportunity to support the public purse by reducing the amount of claims made with insurance companies for damage to vehicles, properties and potential whiplash. This study has already provided improvements to road safety in partnership with the industry partner. The industry leader, with the support of the evidence base from this study detected locations for low bridge accidents and developed a new solution to reduce road traffic collisions, which again would reduce injuries and support the public purse.

Taking the results of this study the four most dangerous locations require immediate attention and new products to reduce the number of accidents and level of human injury. However, each location requires further research to determine how and why accidents occur at these locations. The visual study showed that each location is different with varying features outside the STATS19 form such as trees or width of road. Without further studies, we cannot specifically define products for these locations. We should also note the need to test products at varying locations to take into consideration the varying surroundings features that can have an impact.

Following the results of the study it is vital we continue the study more specifically and to develop holistic teams to collaborate on new product development. New products should focus on the primary goal of reducing the number of collisions and injuries at the four most dangerous locations. With collaborative work stakeholders can hold their primary working goal whilst working together to develop the most effective product to improve the safety of the location. We must recognize though that no product will completely stop road collisions as human misjudgment, such as drink driving, can occur.

To conclude appropriately we must consider the purpose of the study; ‘An exploratory study of how an analysis of secondary data can be used to inform design of products used to reduce road traffic collisions resulting in human injury’. The question here is, did the analysis of secondary data inform design of products and reduce collisions? The answer to this is no. However, as specified in the discussion, it is more a timing and political issue rather the study not being adequate. The secondary data has the potential to inform product design and reduce road collisions but it needs sufficient time and support from the industry to implement .Not until then can we completely justify if this study has been successful or not.

Overall the study has successfully located areas that have the most collisions and high level of human injury. They have also taken into account visual information and expert’s opinions in the focus groups to support any findings. The study highlights the requirement for future detailed scientific studies and the ability to develop holistic and collaborative teams within the industry to work towards one goal of improved, specific and relevant road safety products.

I leave you with this parting image that highlights the importance of road traffic furniture by Phil Simmons, the Managing Director of Simmonsigns Limited.

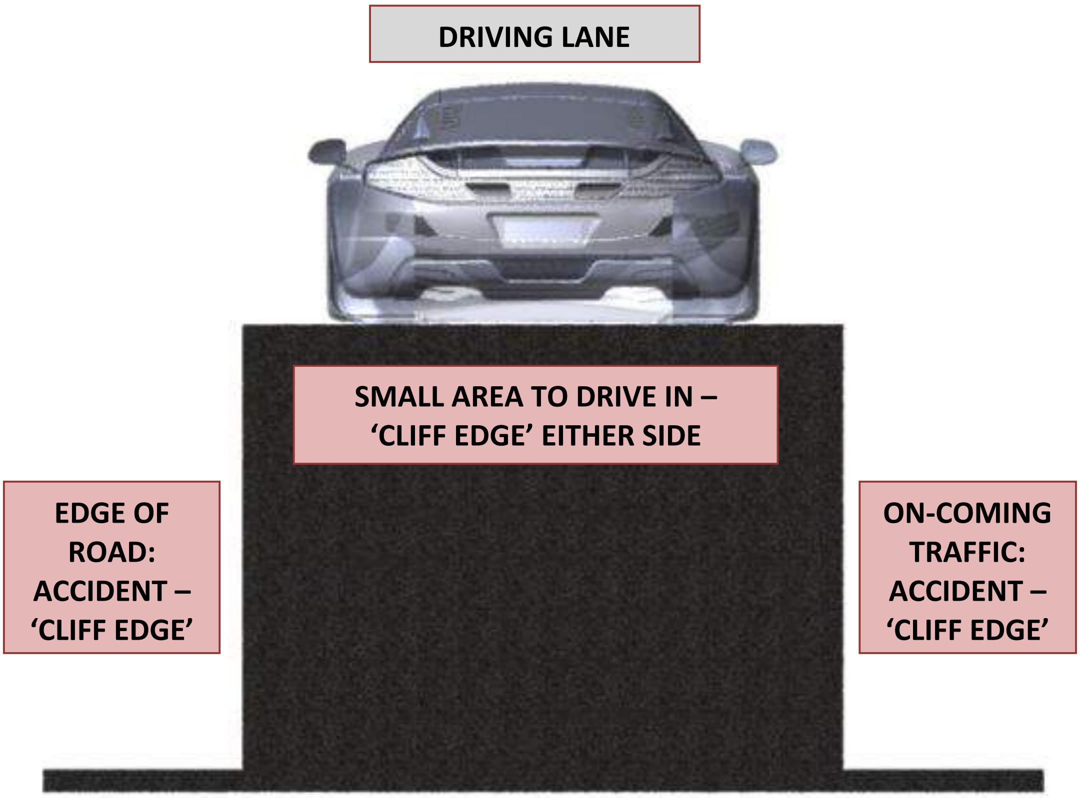


Illustration 24: The narrow road and the ‘cliff edge’

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APPENDICES

Appendix A - Syntax Coding from QlikView

```
SET ThousandSep=',';
SET DecimalSep='.';
SET MoneyThousandSep=',';
SET MoneyDecimalSep='.';
SET MoneyFormat='£#,##0.00;-£#,##0.00';
SET TimeFormat='hh:mm:ss';
SET DateFormat='DD/MM/YYYY';
SET TimestampFormat='DD/MM/YYYY hh:mm:ss[.fff]';
SET MonthNames='Jan;Feb;Mar;Apr;May;Jun;Jul;Aug;Sep;Oct;Nov;Dec';
SET DayNames='Mon;Tue;Wed;Thu;Fri;Sat;Sun';

Directory;

Accident:
LOAD Accident_Index as Acc_Index,        // comment: I renamed Accident_Index
to Acc_Index to match the field name in the other two tables
     Longitude as longitude,
     Latitude as latitude,
     Police_Force,
     Number_of_Vehicles,
     Number_of_Casualties,
     Date,
     Year(Date) as Year,
     Month(Date) as Month,
     Day(Date) as Day,
     Time,
     [Local_Authority_(District)],
     [1st_Road_Class],
     Road_Type,
     Speed_limit,
     Junction_Detail,
     Junction_Control,
     [Pedestrian_Crossing-Human_Control],
     [Pedestrian_Crossing-Physical_Facilities],
     Light_Conditions,
     Weather_Conditions,
     Road_Surface_Conditions,
     Carriageway_Hazards,
     test
FROM
[Test Sheet (simmonsigns).xlsx]
(ooxml, embedded labels, table is Accident);

Casualty:
LOAD AutoNumber(Acc_Index & Casualty_Reference) as Unique_Casualty_Id,
           Acc_Index,
     Casualty_Reference,
     //Vehicle_Reference,  // comment: I have commented this field out so that
it is not loaded. We will use Vehicle_Reference in the Accident table only
     Acc_Index & '_' & Vehicle_Reference as AccVehId,
     Casualty_Class,
     Casualty_Severity,
     Pedestrian_Location,
     Pedestrian_Movement,
     Casualty_Type
FROM
[Test Sheet (simmonsigns).xlsx]
(ooxml, embedded labels, table is Casualty);

Vehicle:
LOAD AutoNumber(Acc_Index & Vehicle_Reference) as Unique_Vehicle_Id,
           //Acc_Index,
           Acc_Index & '_' & Vehicle_Reference as AccVehId,
     Vehicle_Reference, //
     Vehicle_Type,
     Vehicle_Manoeuvre,
```

```
      Junction_Location,
      Skidding_and_Overturning,
      Hit_Object_in_Carriageway,
      Vehicle_Leaving_Carriageway,
      Hit_Object_off_Carriageway,
      [1st_Point_of_Impact]
FROM
[Test Sheet (simmonsigns).xlsx]
(ooxml, embedded labels, table is Vehicle);

Accident:
LOAD Accident_Index as Acc_Index,       // comment: I renamed Accident_Index
to Acc_Index to match the field name in the other two tables
      Longitude as longitude,
      Latitude as latitude,
      Police_Force,
      Number_of_Vehicles,
      Number_of_Casualties,
      Date,
      Year(Date) as Year,
      Month(Date) as Month,
      Day(Date) as Day,
      Time,
      [Local_Authority_(District)],
      [1st_Road_Class],
      Road_Type,
      Speed_limit,
      Junction_Detail,
      Junction_Control,
      [Pedestrian_Crossing-Human_Control],
      [Pedestrian_Crossing-Physical_Facilities],
      Light_Conditions,
      Weather_Conditions,
      Road_Surface_Conditions,
      Carriageway_Hazards,
      test
FROM
[Test Sheet (simmonsigns)2.xlsx]
(ooxml, embedded labels, table is Accident);

Casualty:
LOAD AutoNumber(Acc_Index & Casualty_Reference) as Unique_Casualty_Id,
            Acc_Index,
      Casualty_Reference,
      //Vehicle_Reference,  // comment: I have commented this field out so that
it is not loaded. We will use Vehicle_Reference in the Accident table only
      Acc_Index & '_' & Vehicle_Reference as AccVehId,
      Casualty_Class,
      Casualty_Severity,
      Pedestrian_Location,
      Pedestrian_Movement,
      Casualty_Type
FROM
[Test Sheet (simmonsigns)2.xlsx]
(ooxml, embedded labels, table is Casualty);

Vehicle:
LOAD AutoNumber(Acc_Index & Vehicle_Reference) as Unique_Vehicle_Id,
            //Acc_Index,
            Acc_Index & '_' & Vehicle_Reference as AccVehId,
      Vehicle_Reference, //
      Vehicle_Type,
      Vehicle_Manoeuvre,
      Junction_Location,
      Skidding_and_Overturning,
      Hit_Object_in_Carriageway,
      Vehicle_Leaving_Carriageway,
      Hit_Object_off_Carriageway,
      [1st_Point_of_Impact]
FROM
[Test Sheet (simmonsigns)2.xlsx]
```

```
(ooxml, embedded labels, table is Vehicle);

Accident:
LOAD Accident_Index as Acc_Index,       // comment: I renamed Accident_Index
to Acc_Index to match the field name in the other two tables
     Longitude as longitude,
     Latitude as latitude,
     Police_Force,
     Number_of_Vehicles,
     Number_of_Casualties,
     Date,
     Year(Date) as Year,
     Month(Date) as Month,
     Day(Date) as Day,
     Time,
     [Local_Authority_(District)],
     [1st_Road_Class],
     Road_Type,
     Speed_limit,
     Junction_Detail,
     Junction_Control,
     [Pedestrian_Crossing-Human_Control],
     [Pedestrian_Crossing-Physical_Facilities],
     Light_Conditions,
     Weather_Conditions,
     Road_Surface_Conditions,
     Carriageway_Hazards,
     test
FROM
[Test Sheet (simmonsigns)3.xlsx]
(ooxml, embedded labels, table is Accident);

Casualty:
LOAD AutoNumber(Acc_Index & Casualty_Reference) as Unique_Casualty_Id,
           Acc_Index,
     Casualty_Reference,
     //Vehicle_Reference,  // comment: I have commented this field out so that
it is not loaded. We will use Vehicle_Reference in the Accident table only
     Acc_Index & '_' & Vehicle_Reference as AccVehId,
     Casualty_Class,
     Casualty_Severity,
     Pedestrian_Location,
     Pedestrian_Movement,
     Casualty_Type
FROM
[Test Sheet (simmonsigns)3.xlsx]
(ooxml, embedded labels, table is Casualty);

Vehicle:
LOAD AutoNumber(Acc_Index & Vehicle_Reference) as Unique_Vehicle_Id,
           //Acc_Index,
           Acc_Index & '_' & Vehicle_Reference as AccVehId,
     Vehicle_Reference, //
     Vehicle_Type,
     Vehicle_Manoeuvre,
     Junction_Location,
     Skidding_and_Overturning,
     Hit_Object_in_Carriageway,
     Vehicle_Leaving_Carriageway,
     Hit_Object_off_Carriageway,
     [1st_Point_of_Impact]
FROM
[Test Sheet (simmonsigns)3.xlsx]
(ooxml, embedded labels, table is Vehicle);

Accident:
LOAD Accident_Index as Acc_Index,       // comment: I renamed Accident_Index
to Acc_Index to match the field name in the other two tables
     Longitude as longitude,
     Latitude as latitude,
     Police_Force,
```

```
      Number_of_Vehicles,
      Number_of_Casualties,
      Date,
      Year(Date) as Year,
      Month(Date) as Month,
      Day(Date) as Day,
      Time,
      [Local_Authority_(District)],
      [1st_Road_Class],
      Road_Type,
      Speed_limit,
      Junction_Detail,
      Junction_Control,
      [Pedestrian_Crossing-Human_Control],
      [Pedestrian_Crossing-Physical_Facilities],
      Light_Conditions,
      Weather_Conditions,
      Road_Surface_Conditions,
      Carriageway_Hazards,
      test
FROM
[Test Sheet (simmonsigns)4.xlsx]
(ooxml, embedded labels, table is Accident);

Casualty:
LOAD AutoNumber(Acc_Index & Casualty_Reference) as Unique_Casualty_Id,
            Acc_Index,
      Casualty_Reference,
      //Vehicle_Reference,  // comment: I have commented this field out so that
it is not loaded. We will use Vehicle_Reference in the Accident table only
      Acc_Index & '_' & Vehicle_Reference as AccVehId,
      Casualty_Class,
      Casualty_Severity,
      Pedestrian_Location,
      Pedestrian_Movement,
      Casualty_Type
FROM
[Test Sheet (simmonsigns)4.xlsx]
(ooxml, embedded labels, table is Casualty);

Vehicle:
LOAD AutoNumber(Acc_Index & Vehicle_Reference) as Unique_Vehicle_Id,
            //Acc_Index,
            Acc_Index & '_' & Vehicle_Reference as AccVehId,
      Vehicle_Reference, //
      Vehicle_Type,
      Vehicle_Manoeuvre,
      Junction_Location,
      Skidding_and_Overturning,
      Hit_Object_in_Carriageway,
      Vehicle_Leaving_Carriageway,
      Hit_Object_off_Carriageway,
      [1st_Point_of_Impact]
FROM
[Test Sheet (simmonsigns)4.xlsx]
(ooxml, embedded labels, table is Vehicle);
```

Appendix B - Data fields and factors from the STATS19

- Accident Index:
    - Longitude
    - Latitude
    - Police Force
    - Number of Vehicles
    - Number of Casualties
    - Date
    - Time
    - Local Authority District

  - 1st_Road_Class
  - Road Type
  - Speed limit
  - Junction Detail
  - Junction Control
  - Pedestrian Crossing-Human Control
  - Pedestrian Crossing-Physical Facilities
  - Light Conditions
  - Weather Conditions
  - Road Surface Conditions
  - Carriageway Hazards

- Casualty Reference
  - Casualty Class
  - Casualty Severity
  - Pedestrian Location
  - Pedestrian Movement
  - Casualty Type

- Vehicle Reference
  - Vehicle Type
  - Vehicle Manoeuvre
  - Junction Location
  - Skidding and Overturning
  - Hit Object in Carriageway
  - Vehicle Leaving Carriageway
  - Hit Object off Carriageway
  - 1st Point of Impact

Appendix C - Google Street View example coding

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.google.com/earth/kml/2">
<Document>
<name>kml_sample1.kml</name>
<Placemark><name>1</name><description>Attached to the ground. Intelligently places itself at the height of the underlying terrain.</description><Point><coordinates>-1.714,51.951,0</coordinates></Point></Placemark>
<Placemark><name>2</name><description>Attached to the ground. Intelligently places itself at the height of the underlying terrain.</description><Point><coordinates>-0.497,51.498,0</coordinates></Point></Placemark>
<Placemark><name>3</name><description>Attached to the ground. Intelligently places itself at the height of the underlying terrain.</description><Point><coordinates>-0.758,52.935,0</coordinates></Point></Placemark>
<Placemark><name>4</name><description>Attached to the ground. Intelligently places itself at the height of the underlying terrain.</description><Point><coordinates>-0.242,51.265,0</coordinates></Point></Placemark>

</Document>
</kml>
```

Appendix D - STATS19 summarised list of combined variables for human injury

Casualty_Severity * Pedestrian_Location

Crosstab

	Pedestrian_Location											Total
	Not a Pedestrian	On designated crossing	ZigZag Approach Lines	ZigZag Exit	Within 50m	Crossing Elsewhere	Footway/ Verge	Refuge/ Island	In centre of carriageway	In carriageway not crossing	Unknown	
Fatal	1445	47	2	5	32	152	43	2	17	70	35	1850
	78.1%	2.5%	.1%	.3%	1.7%	8.2%	2.3%	.1%	.9%	3.8%	1.9%	
Serious	17460	672	29	29	499	2602	367	17	177	495	313	22660
	77.1%	3.0%	.1%	.1%	2.2%	11.5%	1.6%	.1%	.8%	2.2%	1.4%	
Slight	163898	2495	71	48	1645	9629	2180	73	523	2357	1219	184138
	89.0%	1.4%	.0%	.0%	.9%	5.2%	1.2%	.0%	.3%	1.3%	.7%	
Total	182803	3214	102	82	2176	12383	2590	92	717	2922	1567	208648
	87.6%	1.5%	.0%	.0%	1.0%	5.9%	1.2%	.0%	.3%	1.4%	.8%	

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3083.026[a]	20	.000

Crosstab

	Casualty_Class: Vehicle Occupant	Casualty_Class: Pedestrian	Total
Fatal	1445	405	1850
	78.1%	21.9%	
Serious	17460	5200	22660
	77.1%	22.9%	
Slight	163898	20240	184138
	89.0%	11.0%	
Total	182803	25845	208648

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2813.109[a]	2	.000

Crosstab

	Carriageway_Hazards: None	Carriageway_Hazards: Previous Accident/Vehicle Load	Carriageway_Hazards: Animal in Road	Carriageway_Hazards: Pedestrian in Road (Not hurt)	Total
Fatal	1810	35	4	1	1850
	97.8%	1.9%	.2%	.1%	
Serious	22210	256	47	147	22660
	98.0%	1.1%	.2%	.6%	
Slight	180828	1868	416	1026	184138
	98.2%	1.0%	.2%	.6%	
Total	204848	2159	467	1174	208648
	98.2%	1.0%	.2%	.6%	

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	27.838[a]	6	.000

Casualty_Severity * Junction_Control

Crosstab

	Junction_Control: Not within 20m	Junction_Control: Authorised Person	Junction_Control: Auto Traffic Signal	Junction_Control: Stop Sign	Junction_Control: Give way/uncontrolled	Total
Fatal	1221	3	77	7	542	1850
	66.0%	.2%	4.2%	.4%	29.3%	
Serious	11026	24	1784	109	9717	22660
	48.7%	.1%	7.9%	.5%	42.9%	
Slight	72955	290	20554	1117	89222	184138
	39.6%	.2%	11.2%	.6%	48.5%	
Total	85202	317	22415	1233	99481	208648
	40.8%	.2%	10.7%	.6%	47.7%	

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1245.624[a]	8	.000

Crosstab

	Speed_limit								Total
	10	15	20	30	40	50	60	70	
Fatal	1	0	5	563	171	112	724	274	1850
	.1%	.0%	.3%	30.4%	9.2%	6.1%	39.1%	14.8%	
Serious	0	0	208	12718	1803	869	5391	1671	22660
	.0%	.0%	.9%	56.1%	8.0%	3.8%	23.8%	7.4%	
Slight	2	1	1610	114221	16281	6846	29512	15665	184138
	.0%	.0%	.9%	62.0%	8.8%	3.7%	16.0%	8.5%	
Total	3	1	1823	127502	18255	7827	35627	17610	208648
	.0%	.0%	.9%	61.1%	8.7%	3.8%	17.1%	8.4%	

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1857.379[a]	14	.000

Crosstab

	1st_Road_Class						Total
	Motorway	A (M)	A	B	C	Unclassified	
Fatal	108	10	1050	265	146	271	1850
	5.8%	.5%	56.8%	14.3%	7.9%	14.6%	
Serious	756	42	10565	3101	2062	6134	22660
	3.3%	.2%	46.6%	13.7%	9.1%	27.1%	
Slight	8833	620	85867	23355	16128	49335	184138
	4.8%	.3%	46.6%	12.7%	8.8%	26.8%	
Total	9697	672	97482	26721	18336	55740	208648
	4.6%	.3%	46.7%	12.8%	8.8%	26.7%	

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	281.515[a]	10	.000

Appendix E - Example cross tabulation using STATS19 variables

Light_Conditions * Pedestrian_Location

Crosstab

			Pedestrian_Location											Total
			0	1	2	3	4	5	6	7	8	9	10	
Light_Conditions	4	Count	33581	837	36	34	637	2732	487	14	184	701	365	39608
		% within Pedestrian_Location	72.8%	98.5%	100.0%	100.0%	98.6%	94.5%	89.0%	100.0%	83.6%	76.9%	88.2%	75.2%
	5	Count	12546	13	0	0	9	160	60	0	36	210	49	13083
		% within Pedestrian_Location	27.2%	1.5%	.0%	.0%	1.4%	5.5%	11.0%	.0%	16.4%	23.1%	11.8%	24.8%
Total		Count	46127	850	36	34	646	2892	547	14	220	911	414	52691
		% within Pedestrian_Location	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1284.548[a]	10	.000
Likelihood Ratio	1746.746	10	.000
Linear-by-Linear Association	626.102	1	.000
N of Valid Cases	52691		

a. 1 cells (4.5%) have expected count less than 5. The minimum expected count is 3.48.

Light_Conditions * Junction_Location

Crosstab

			Junction_Location							
			0	1	2	3	5	7	8	Total
Light_Conditions	4	Count	13185	9091	2808	1756	2094	131	10543	39608
		% within Junction_Location	57.1%	86.7%	89.5%	96.0%	83.5%	66.2%	92.2%	75.2%
	5	Count	9908	1398	328	74	415	67	893	13083
		% within Junction_Location	42.9%	13.3%	10.5%	4.0%	16.5%	33.8%	7.8%	24.8%
Total		Count	23093	10489	3136	1830	2509	198	11436	52691
		% within Junction_Location	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Casualty_Class * Casualty_Severity * Pedestrian_Crossing-Physical_Facilities Crosstabulation

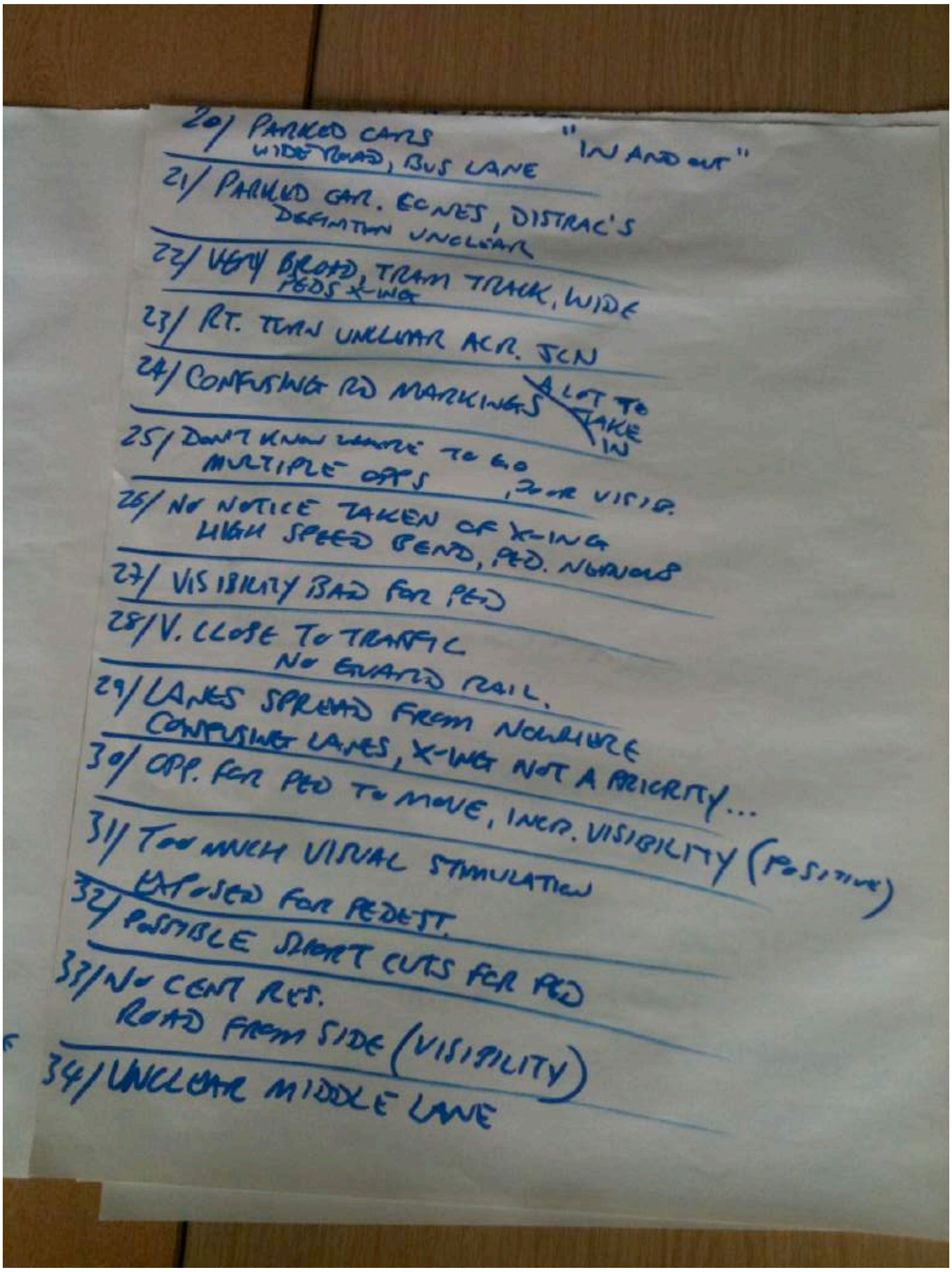
Pedestrian_Crossing-Physical_Facilities				Casualty_Severity fatal	serious	slight	Total
0	Casualty_Class	driver or passenger	Count	1367	15545	139026	155938
			% within Casualty_	83.1%	81.5%	90.7%	89.6%
		Pedestrian	Count	278	3536	14328	18142
			% within Casualty_	16.9%	18.5%	9.3%	10.4%
	Total		Count	1645	19081	153354	174080
			% within Casualty_	100.0%	100.0%	100.0%	100.0%
1	Casualty_Class	driver or passenger	Count	8	290	3514	3812
			% within Casualty_	34.8%	50.1%	74.7%	71.8%
		Pedestrian	Count	15	289	1191	1495
			% within Casualty_	65.2%	49.9%	25.3%	28.2%
	Total		Count	23	579	4705	5307
			% within Casualty_	100.0%	100.0%	100.0%	100.0%
4	Casualty_Class	driver or passenger	Count	28	535	7163	7726
			% within Casualty_	33.7%	46.1%	76.9%	73.2%
		Pedestrian	Count	55	625	2153	2833
			% within Casualty_	66.3%	53.9%	23.1%	26.8%
	Total		Count	83	1160	9316	10559
			% within Casualty_	100.0%	100.0%	100.0%	100.0%
5	Casualty_Class	driver or passenger	Count	21	767	10948	11736
			% within Casualty_	39.6%	58.7%	84.9%	82.4%
		Pedestrian	Count	32	539	1943	2514
			% within Casualty_	60.4%	41.3%	15.1%	17.6%
	Total		Count	53	1306	12891	14250
			% within Casualty_	100.0%	100.0%	100.0%	100.0%
7	Casualty_Class	driver or passenger	Count	3	47	549	599
			% within Casualty_	50.0%	71.2%	91.8%	89.4%
		Pedestrian	Count	3	19	49	71
			% within Casualty_	50.0%	28.8%	8.2%	10.6%
	Total		Count	6	66	598	670
			% within Casualty_	100.0%	100.0%	100.0%	100.0%
8	Casualty_Class	driver or passenger	Count	18	276	2698	2992
			% within Casualty_	45.0%	59.0%	82.4%	79.1%
		Pedestrian	Count	22	192	576	790
			% within Casualty_	55.0%	41.0%	17.6%	20.9%
	Total		Count	40	468	3274	3782
			% within Casualty_	100.0%	100.0%	100.0%	100.0%
Total	Casualty_Class	driver or passenger	Count	1445	17460	163898	182803
			% within Casualty_	78.1%	77.1%	89.0%	87.6%
		Pedestrian	Count	405	5200	20240	25845
			% within Casualty_	21.9%	22.9%	11.0%	12.4%
	Total		Count	1850	22660	184138	208648
			% within Casualty_	100.0%	100.0%	100.0%	100.0%

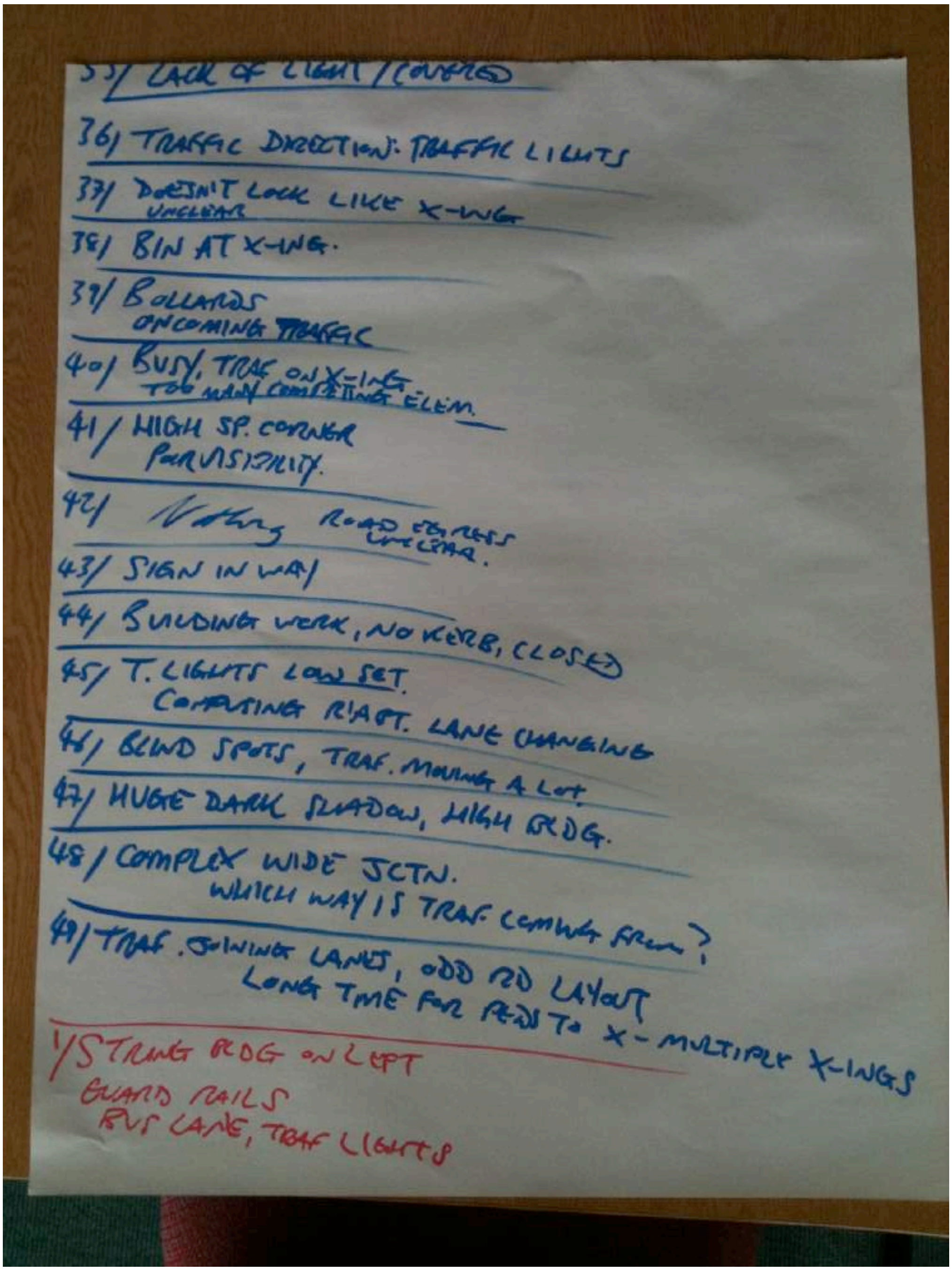
Chi-Square Tests

Pedestrian_Crossing-Physical_Facilities		Value	df	Asymp. Sig. (2-sided)
0	Pearson Chi-Square	1609.320[a]	2	.000
	Likelihood Ratio	1380.987	2	.000
	Linear-by-Linear Association	1457.124	1	.000
	N of Valid Cases	174080		
1	Pearson Chi-Square	169.858[b]	2	.000
	Likelihood Ratio	154.486	2	.000
	Linear-by-Linear Association	168.982	1	.000
	N of Valid Cases	5307		
4	Pearson Chi-Square	563.720[c]	2	.000
	Likelihood Ratio	501.537	2	.000
	Linear-by-Linear Association	552.636	1	.000
	N of Valid Cases	10559		
5	Pearson Chi-Square	627.052[d]	2	.000
	Likelihood Ratio	506.469	2	.000
	Linear-by-Linear Association	625.435	1	.000
	N of Valid Cases	14250		
7	Pearson Chi-Square	36.530[e]	2	.000
	Likelihood Ratio	26.334	2	.000
	Linear-by-Linear Association	36.474	1	.000
	N of Valid Cases	670		
8	Pearson Chi-Square	164.521[f]	2	.000
	Likelihood Ratio	141.760	2	.000
	Linear-by-Linear Association	162.879	1	.000
	N of Valid Cases	3782		
Total	Pearson Chi-Square	2813.109[g]	2	.000
	Likelihood Ratio	2398.033	2	.000
	Linear-by-Linear Association	2597.155	1	.000
	N of Valid Cases	208648		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 171.44.
b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.48.
c. 0 cells (.0%) have expected count less than 5. The minimum expected count is 22.27.
d. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.35.
e. 1 cells (16.7%) have expected count less than 5. The minimum expected count is .64.
f. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.36.
g. 0 cells (.0%) have expected count less than 5. The minimum expected count is 229.16.

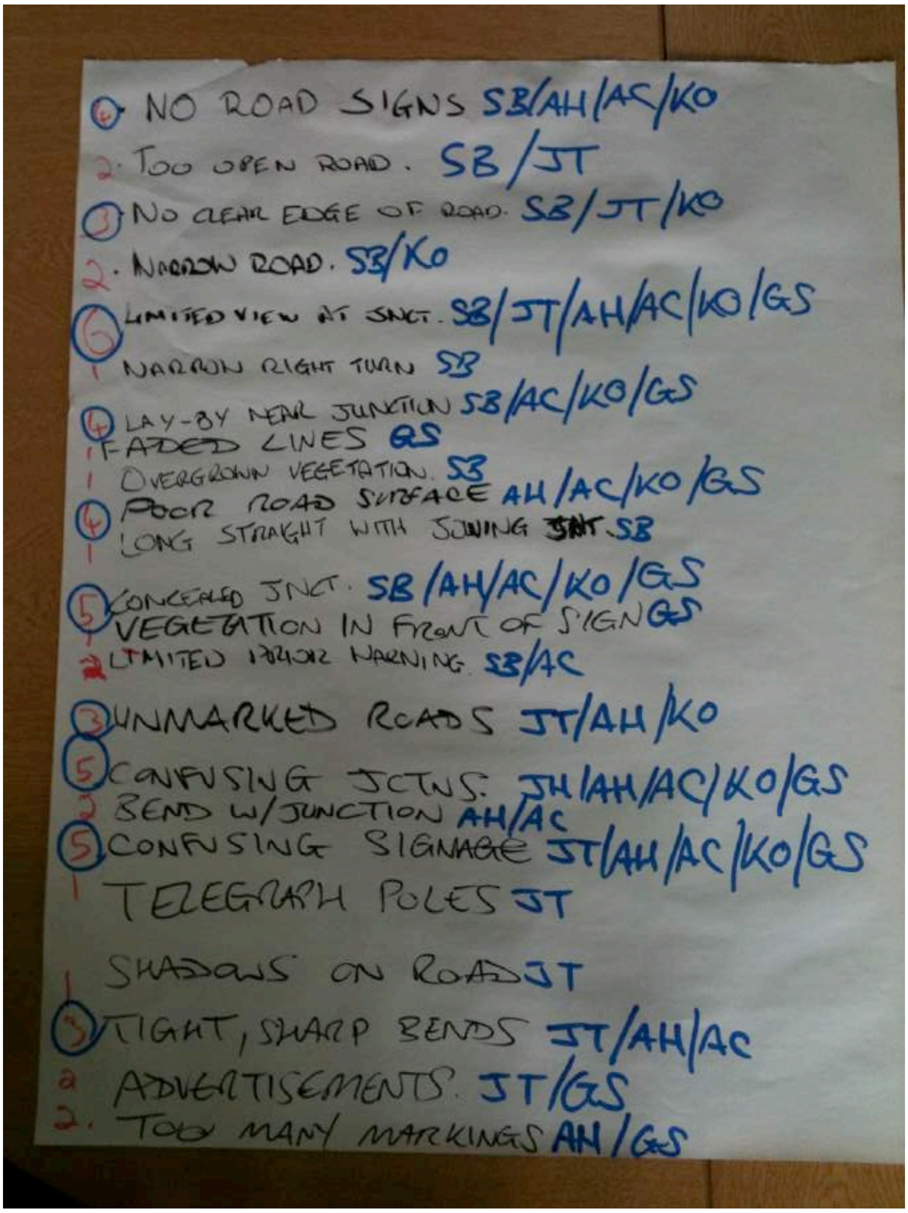
Appendix F - Sample list of dangers from Focus Group



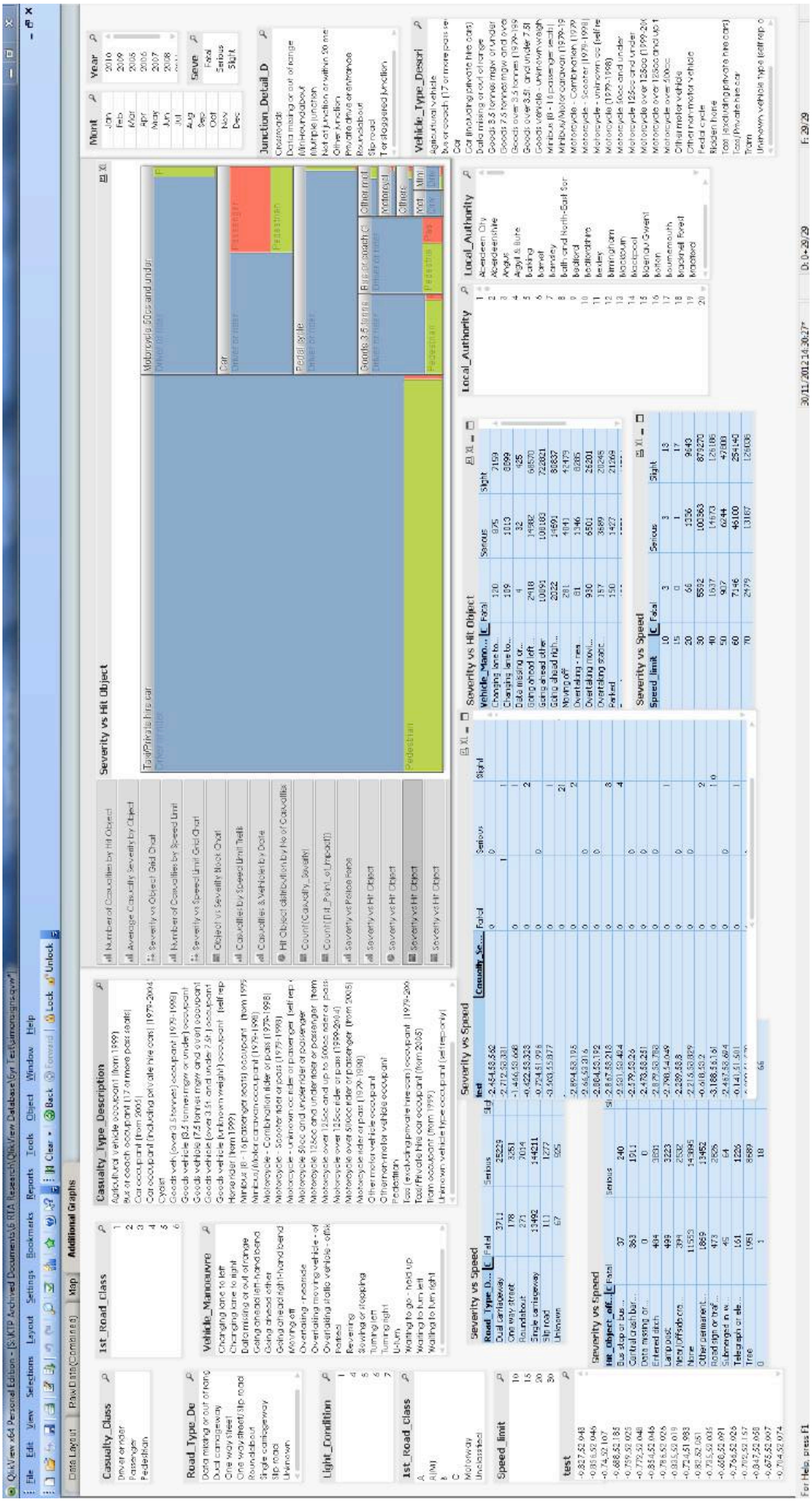


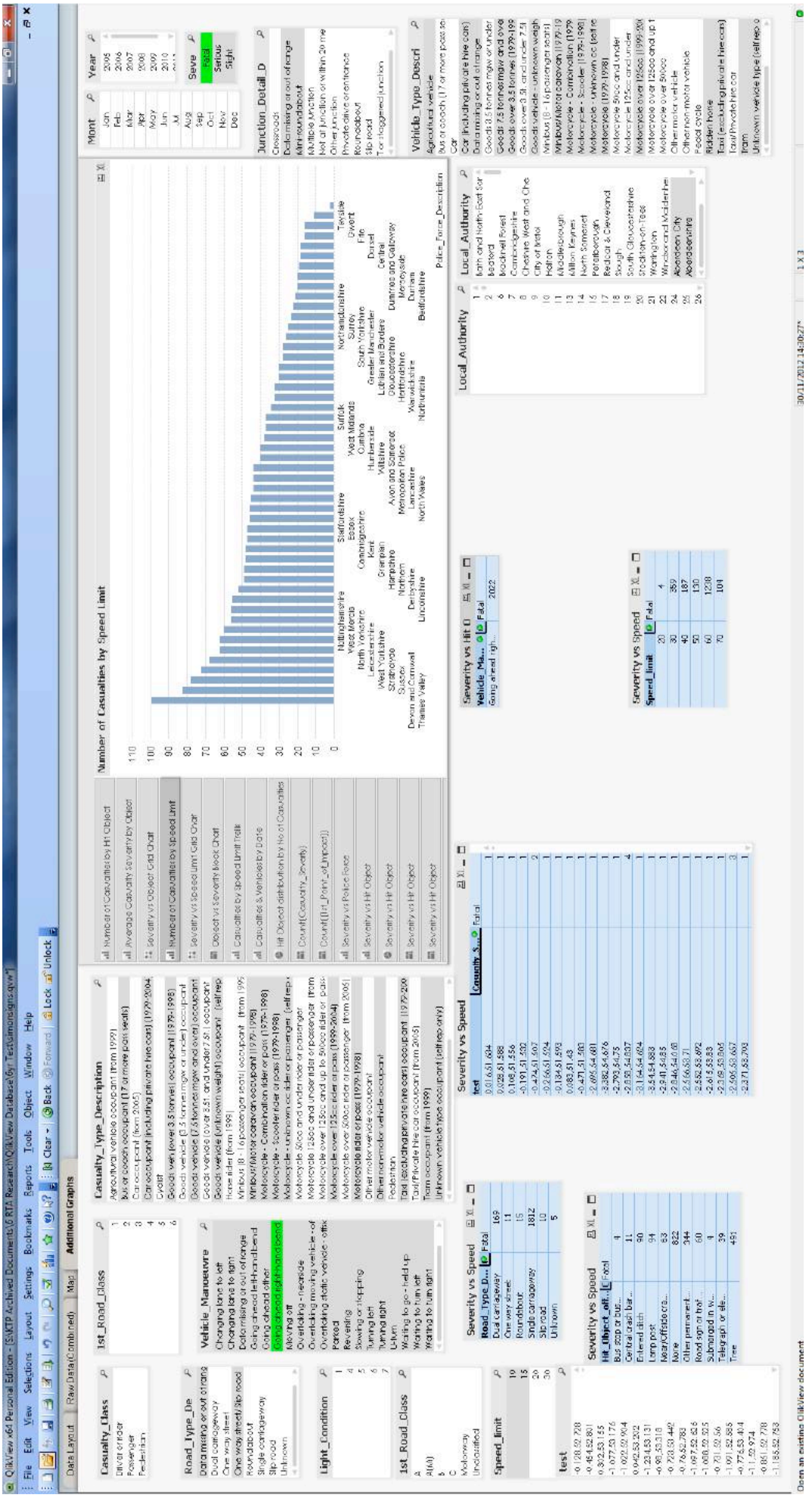
35/ LACK OF LIGHT / COVERED
36/ TRAFFIC DIRECTION: TRAFFIC LIGHTS
37/ DOESN'T LOOK LIKE X-ING
UNCLEAR
38/ BIN AT X-ING.
39/ BOLLARDS
ONCOMING TRAFFIC
40/ BUSY, TRAF ON X-ING
TOO MANY COMPETING ELEM.
41/ HIGH SP. CORNER
POOR VISIBILITY.
42/ Nothing ROAD EGRESS UNCLEAR.
43/ SIGN IN WAY
44/ BUILDING WORK, NO KERB, CLOSED
45/ T. LIGHTS LOW SET.
COMPETING R'ABT. LANE CHANGING
46/ BLIND SPOTS, TRAF. MOVING A LOT.
47/ HUGE DARK SHADOW, HIGH BLDG.
48/ COMPLEX WIDE JCTN.
WHICH WAY IS TRAF. COMING FROM?
49/ TRAF. JOINING LANES, ODD RD LAYOUT
LONG TIME FOR PEDS TO X - MULTIPLE X-INGS
1/ STRONG BLDG ON LEFT
GUARD RAILS
BUS LANE, TRAF LIGHTS

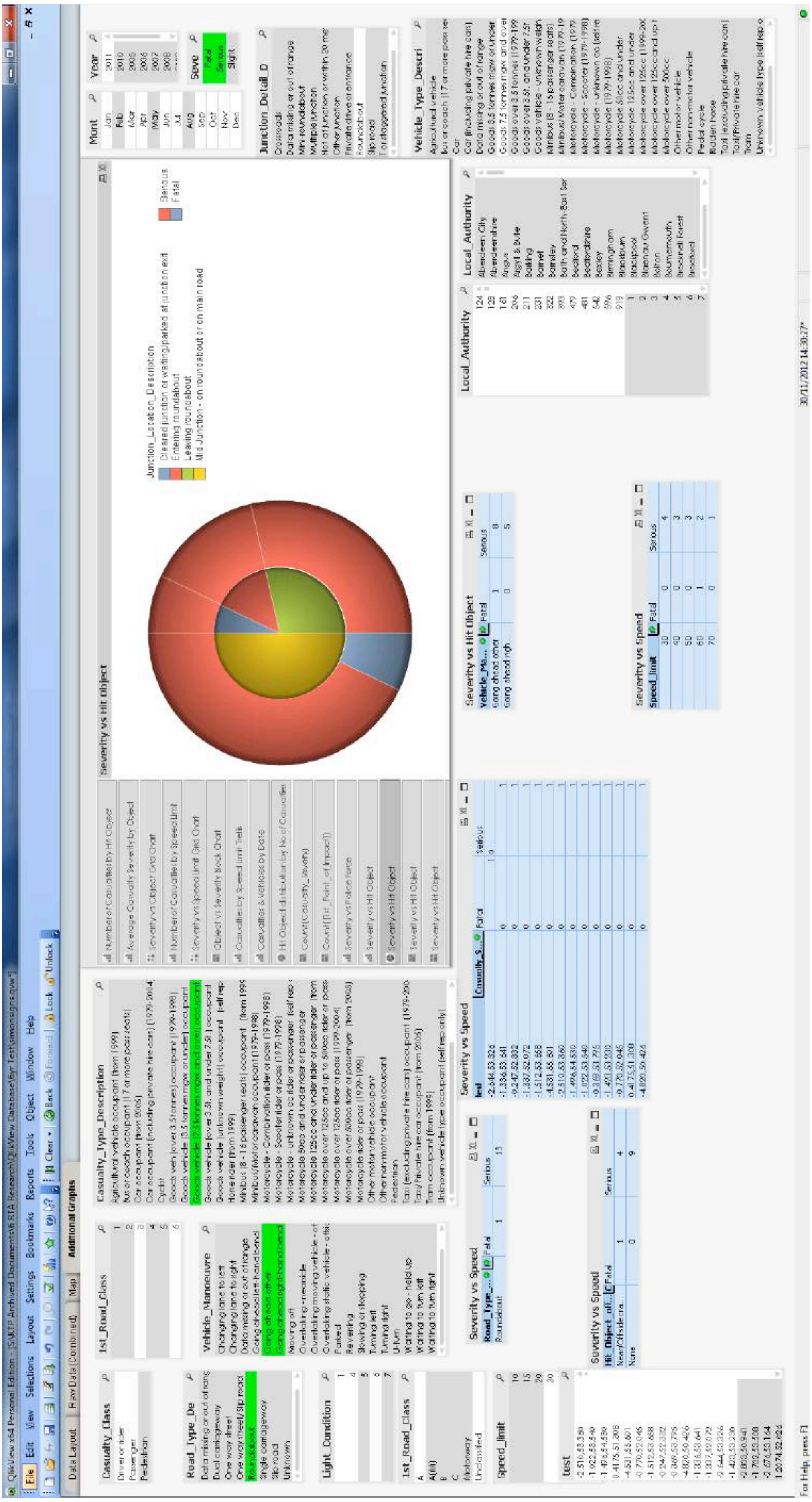
Appendix G – Google Street View list of road infrastructure dangers

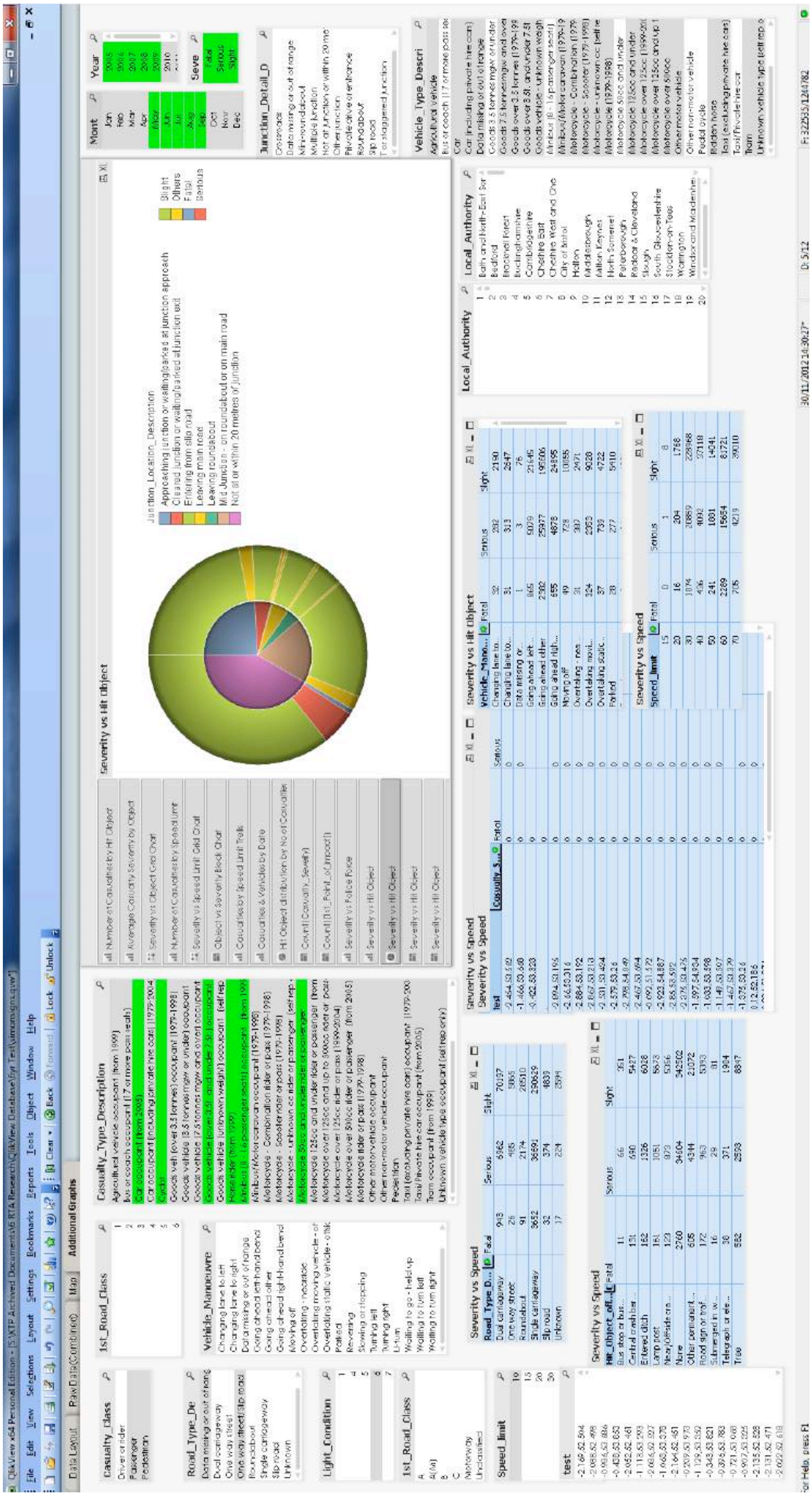


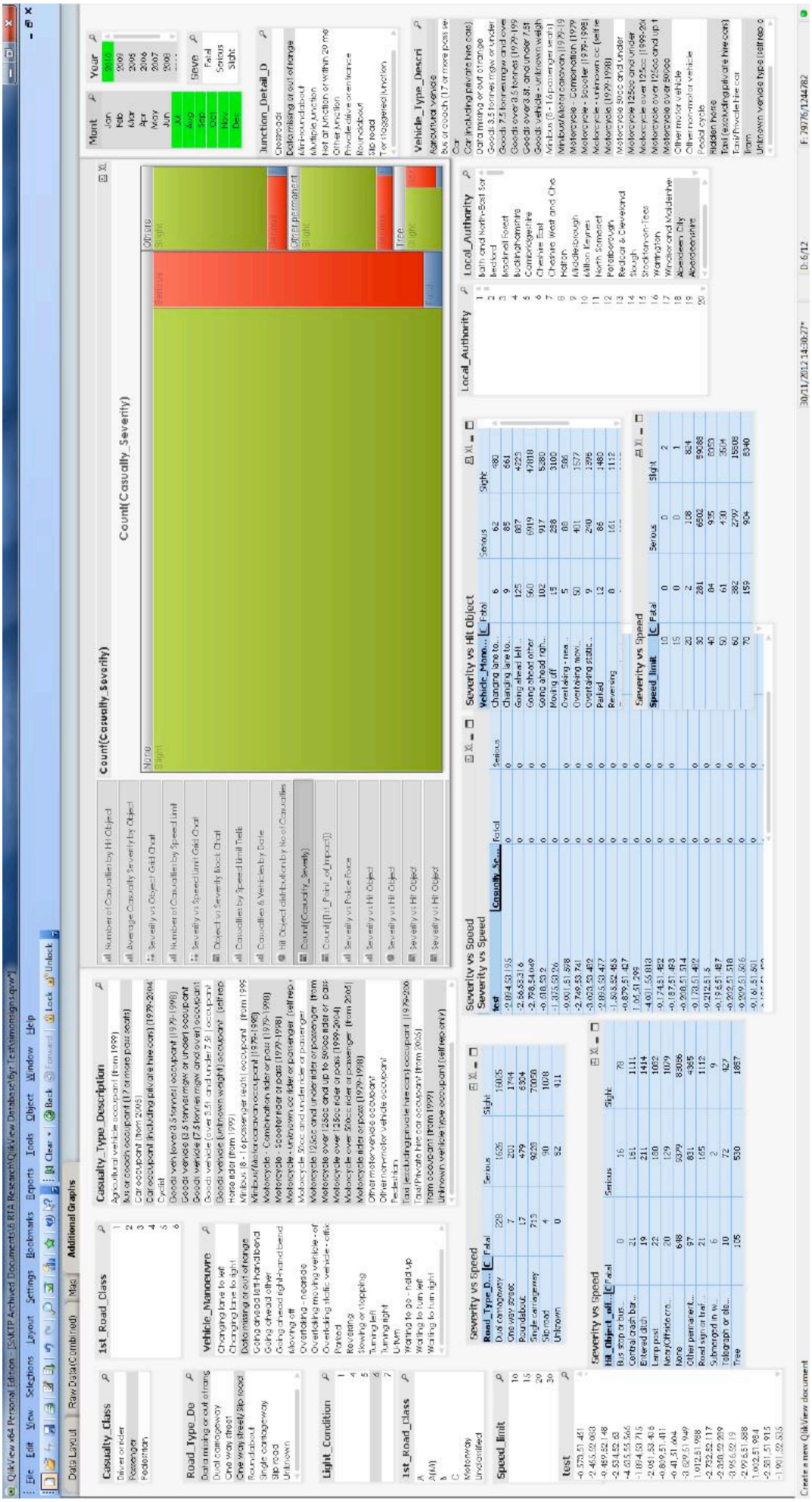
Appendix H - Screenshots of the QlikView STATS19 Database






Severity vs Hit Object
Severity vs Speed
Junction_Location_Description
Local_Authority
Vehicle_Manoeuvre
Casualty_Type_Description





Appendix I - STATS19 Form

Sept. 2004

MG NSRF/A

ACCIDENT STATISTICS

Incident URN

Other ref.

1.3 ACCIDENT REFERENCE

*FATAL / SERIOUS / SLIGHT

1.9 TIME H H M M

DAY* Su M T W Th F S

1.7 DATE D D M M 2 0 Y Y

1st Road Class & No. or (Unclassified - UC) (Not Known - NK)

1st Road Name

Outside House No. or Name or Marker Post No.

at junction with / or

metres N S E W * of

2nd Road Class & No. or (Unclassified - UC) (Not Known - NK)

2nd Road Name

Town

Sector /Beat No.

County or Borough

Parish No. or Name

1.10 Local Auth No. (if known)

1.11 Grid Reference E→ N↑

REPORTING OFFICER Name

Number

BCU/Stn

1.2 Force

Tel Number

1.5	Number of vehicles
1.6	Number of casualties

1.14 ROAD TYPE	✗
Roundabout	1
One way street	2
Dual carriageway	3
Single carriageway	6
Slip road	7
Unknown	9

1.15 Speed Limit (Permanent)

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

JUNCTION ACCIDENTS ONLY

1.17 JUNCTION CONTROL	✗
Authorised person	1
Automatic traffic signal	2
Stop sign	3
Give way or uncontrolled	4

1.20a PEDESTRIAN CROSSING - HUMAN CONTROL	✗
None within 50 metres	0
Control by school crossing patrol	1
Control by other authorised person	2

1.20b PEDESTRIAN CROSSING - PHYSICAL FACILITIES	✗
No physical crossing facility within 50m	0
Zebra crossing	1
Pelican, puffin, toucan or similar non-junction pedestrian light crossing	4
Pedestrian phase at traffic signal junction	5
Footbridge or subway	7
Central refuge — no other controls	8

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

1.23 ROAD SURFACE CONDITION	✗
Dry	1
Wet / Damp	2
Snow	3
Frost / Ice	4
Flood (surface water over 3cm deep)	5

1.21 LIGHT CONDITIONS	✗
Daylight: street lights present	1
Daylight: no street lighting	2
Daylight: street lighting unknown	3
Darkness: street lights present and lit	4
Darkness: street lights present but unlit	5
Darkness: no street lighting	6
Darkness: street lighting unknown	7

1.24 SPECIAL CONDITIONS AT SITE	✗
None	0
Auto traffic signal out	1
Auto traffic signal partially defective	2
Permanent road signing or marking defective or obscured	3
Roadworks	4
Road surface defective	5
Oil or diesel	6
Mud	7

1.25 CARRIAGEWAY HAZARDS	✗
None	0
Dislodged vehicle load in carriageway	1
Other object in carriageway	2
Involvement with previous accident	3
Pedestrian in carriageway - not injured	6
Any animal in carriageway (except ridden horse)	7

1.26 Did a police officer attend the scene and obtain the details for this report?	✗
Yes	1
No	2

Subject to local directions, boxes with a grey background need not be completed if already recorded

* Circle as appropriate

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VEHICLE RECORD

Sept. 2004

2.26 VEHICLE REGISTRATION MARK

Vehicle 001

Vehicle 002

Vehicle 003

Vehicle 004

2.28 FOREIGN REGISTERED VEHICLE ✗

		VEHICLE 1	2	3	4
Not foreign registered vehicle	0				
Foreign registered vehicle LHD	1				
Foreign registered vehicle RHD	2				
Foreign reg' vehicle-two wheeler	3				

2.5 TYPE OF VEHICLE ✗

Pedal cycle	01
M/cycle 50cc and under	02
M/cycle over 50cc and up to 125cc	03
M/cycle over 125cc and up to 500cc	04
Motorcycle over 500cc	05
Taxi / Private hire car	08
Car	09
Minibus (8-16 passenger seats)	10
Bus or coach (17 or more passenger seats)	11
Other motor vehicle	14
Other non-motor vehicle	15
Ridden horse	16
Agricultural vehicle (include diggers etc)	17
Tram / Light rail	18
Goods vehicle 3.5 tonnes mgw and under	19
Goods vehicle over 3.5 tonnes mgw and under 7.5 tonnes mgw	20
Goods vehicle 7.5 tonnes mgw and over	21

2.6 TOWING AND ARTICULATION ✗

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

2.21 SEX OF DRIVER ✗

Male	1
Female	2
Driver not traced	3

2.22 AGE OF DRIVER (Estimate if necessary)

Vehicle 001 Vehicle 002

Vehicle 003 Vehicle 004

2.27 DRIVER HOME POSTCODE

or Code: 1- Unknown 2- Non UK Resident 3 - Parked & unattended

Vehicle 001

Vehicle 002

Vehicle 003

Vehicle 004

2.23 BREATH TEST ✗

		VEHICLE 1	2	3	4
Not applicable	0				
Positive	1				
Negative	2				
Not requested	3				
Refused to provide	4				
Driver not contacted at time of acc'	5				
Not provided (medical reasons)	6				

2.24 HIT AND RUN ✗

Not hit and run	0
Hit and run	1
Non-stop vehicle, not hit	2

2.29 JOURNEY PURPOSE OF DRIVER/RIDER ✗

Journey as part of work	1
Commuting to / from work	2
Taking school pupil to/from school	3
Pupil riding to / from school	4
Other/Not known	5

2.9 VEHICLE LOCATION AT TIME OF ACCIDENT RESTRICTED LANE/AWAY FROM MAIN C'WAY ✗

On main carriageway not in restricted lane	00
Tram / Light rail track	01
Bus lane	02
Busway (inc. guided busway)	03
Cycle lane (on main carriageway)	04
Cycleway or shared use footway (not part of main carriageway)	05
On lay-by / hard shoulder	06
Entering lay-by / hard shoulder	07
Leaving lay-by / hard shoulder	08
Footway (pavement)	09

2.10 JUNCTION LOCATION OF VEHICLE ✗

Not at or within 20m of junction	0
Approaching junction or waiting /parked at junction approach	1
Cleared junction or waiting/ parked at junction exit	2
Leaving roundabout	3
Entering roundabout	4
Leaving main road	5
Entering main road	6
Entering from slip road	7
Mid junction– on roundabout or on main road	8

2.7 MANOEUVRES ✗

Reversing	01
Parked	02
Waiting to go ahead but held up	03
Slowing or stopping	04
Moving off	05
U turn	06
Turning left	07
Waiting to turn left	08
Turning right	09
Waiting to turn right	10
Changing lane to left	11
Changing lane to right	12
O'taking moving veh on its offside	13
O'taking stationary veh on its offside	14
Overtaking on nearside	15
Going ahead left hand bend	16
Going ahead right hand bend	17
Going ahead other	18

2.11 SKIDDING AND OVERTURNING ✗

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

2.12 HIT OBJECT IN CARRIAGEWAY ✗

None	00
Previous accident	01
Roadworks	02
Parked vehicle	04
Bridge-roof	05
Bridge-side	06
Bollard / Refuge	07
Open door of vehicle	08
Central island of roundabout	09
Kerb	10
Other object	11
Any animal (except ridden horse)	12

2.13 VEHICLE LEAVING CARRIAGEWAY ✗

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

2.14 FIRST OBJECT HIT OFF CARRIAGEWAY ✗

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

2.16 FIRST POINT OF IMPACT ✗

Did not impact	0
Front	1
Back	2
Offside	3
Nearside	4

2.17 FIRST CONTACT BETWEEN EACH VEHICLE

Example: In a 3 car collision vehicle 1 collides with the rear of vehicle 2 pushing it into vehicle 3.

Example Code:			
Vehicle 001 first collides with vehicle 002	0	0	2
Vehicle 002 first collides with vehicle 001	0	0	1
Vehicle 003 first collides with vehicle 002	0	0	2

Vehicle 001 0 Vehicle 002 0

Vehicle 003 0 Vehicle 004 0

Subject to local directions, boxes with a grey background need not be completed if already recorded

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Sept. 2004

2.8 DIRECTION OF VEHICLE TRAVEL

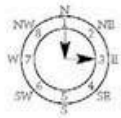
1. Using the Example shown complete the FROM and TO boxes for the vehicles concerned, indicating direction of travel FROM and TO
2. If PARKED enter '00'

Vehicle 001		Vehicle 002	
FROM	TO	FROM	TO

Vehicle 003		Vehicle 004	
FROM	TO	FROM	TO

EXAMPLE

FROM	TO
1	3



CASUALTY RECORD

3.4 VEHICLE REFERENCE NUMBER
Enter VEH No. which CASUALTY occupied (for pedestrians, code vehicle that struck them) e.g. 001,002 etc.

Casualty 001	0			Casualty 002	0		
Casualty 003	0			Casualty 004	0		
Casualty 005	0			Casualty 006	0		

3.18 CASUALTY HOME POSTCODE
or Code: 1- Unknown
2- Non UK Resident

Casualty 001								
Casualty 002								
Casualty 003								
Casualty 004								
Casualty 005								
Casualty 006								

3.7 SEX OF CASUALTY ✗		CASUALTY					
		1	2	3	4	5	6
Male	1						
Female	2						

3.8 AGE OF CASUALTY (Estimate if necessary)
For children less than a year enter 00

Casualty 001			Casualty 002		
Casualty 003			Casualty 004		
Casualty 005			Casualty 006		

3.6 CASUALTY CLASS ✗		1	2	3	4	5	6
Driver/Rider	1						
Veh./pillion Passenger	2						
Pedestrian	3						

3.9 SEVERITY OF CASUALTY ✗		1	2	3	4	5	6
Fatal	1						
Serious	2						
Slight	3						

3.13 SCHOOL PUPIL CASUALTY ✗		CASUALTY					
		1	2	3	4	5	6
School pupil on journey to or from school	1						
Other	0						

3.15 CAR PASSENGER (not driver) ✗		1	2	3	4	5	6
Not a car passenger	0						
Front seat passenger	1						
Rear seat passenger	2						

3.16 BUS OR COACH PASSENGER ✗
(17 passenger seats or more)

		1	2	3	4	5	6
Not a bus or coach passenger	0						
Boarding	1						
Alighting	2						
Standing passenger	3						
Seated passenger	4						

PEDESTRIAN CASUALTIES ONLY

3.10 PEDESTRIAN LOCATION ✗		CASUALTY					
		1	2	3	4	5	6
In carriageway, crossing on pedestrian crossing facility	01						
In carriageway, crossing within zig-zag lines at crossing approach	02						
In carriageway, crossing within zig-zag lines at crossing exit	03						
In carriageway, crossing elsewhere within 50m of pedestrian crossing	04						
In carriageway, crossing elsewhere	05						
On footway or verge	06						
On refuge, central island or central reservation	07						
In centre of carriageway, not on refuge, island or central reservation	08						
In carriageway, not crossing	09						
Unknown or other	10						

3.11 PEDESTRIAN MOVEMENT ✗		CASUALTY					
		1	2	3	4	5	6
Crossing from driver's nearside	1						
Crossing from driver's nearside-masked by parked or stationary veh'	2						
Crossing from driver's offside	3						
Crossing from driver's offside-masked by parked or stationary veh'	4						
In carriageway, stationary - not crossing (standing or playing)	5						
In carriageway, stationary -not crossing (standing or playing), masked by parked or stationary veh'	6						
Walking along in carriageway-facing traffic	7						
Walking along in carriageway-back to traffic	8						
Unknown or other	9						

3.12 PEDESTRIAN DIRECTION ✗		CASUALTY					
		1	2	3	4	5	6
Standing still	0						
Northbound	1						
Northeast bound	2						
Eastbound	3						
Southeast bound	4						
Southbound	5						
Southwest bound	6						
Westbound	7						
Northwest bound	8						
Unknown	9						

3.19 PEDESTRIAN INJURED IN THE COURSE OF 'On The Road' WORK
Work actively carried out on public road (e.g. delivery services, road maintenance, postal delivery, traffic control etc.) ✗

		1	2	3	4	5	6
No	0						
Yes	1						
Not known	2						

LOCAL STATISTICS

Subject to local directions, boxes with a grey background need not be completed if already recorded

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CONTRIBUTORY FACTORS

Sept. 2004

1. Select up to six factors from the grid, relevant to the accident.
2. Factors may be shown in any order, but an indication must be given of whether each factor is **very likely (A)** or **possible (B)**.
3. Only include factors that you consider contributed to the accident. (i.e. do NOT include "Poor road surface" unless relevant).
4. More than one factor may, if appropriate, be related to the same road user.
5. The same factor may be related to more than one road user.
6. The participant should be identified by the relevant vehicle or casualty ref no. (e.g. 001, 002 etc.), preceded by "V" if the factor applies to a vehicle, driver/rider or the road environment (e.g. V002), or "C" if the factor relates to a pedestrian or passenger casualty (e.g. C001).
7. Enter U000 if the factor relates to an uninjured pedestrian.

	Road Environment Contributed	101	102	103	104	105	106	107	108	109	
		Poor or defective road surface	Deposit on road (e.g. oil, mud, chippings)	Slippery road (due to weather)	Inadequate or masked signs or road markings	Defective traffic signals	Traffic calming (e.g. speed cushions, road humps, chicanes)	Temporary road layout (e.g. contraflow)	Road layout (e.g. bend, hill, narrow carriageway)	Animal or object in carriageway	
	Vehicle Defects	201	202	203	204	205	206				
		Tyres illegal, defective or under-inflated	Defective lights or indicators	Defective brakes	Defective steering or suspension	Defective or missing mirrors	Overloaded or poorly loaded vehicle or trailer				
Driver/Rider Only (Includes Pedal Cycles and Horse Riders)	Injudicious Action	301	302	303	304	305	306	307	308	309	310
		Disobeyed automatic traffic signal	Disobeyed 'Give Way' or 'Stop' sign or markings	Disobeyed double white lines	Disobeyed pedestrian crossing facility	Illegal turn or direction of travel	Exceeding speed limit	Travelling too fast for conditions	Following too close	Vehicle travelling along pavement	Cyclist entering road from pavement
	Driver/ Rider Error or Reaction	401	402	403	404	405	406	407	408	409	410
		Junction overshoot	Junction restart (moving off at junction)	Poor turn or manoeuvre	Failed to signal or misleading signal	Failed to look properly	Failed to judge other person's path or speed	Passing too close to cyclist, horse rider or pedestrian	Sudden braking	Swerved	Loss of control
	Impairment or Distraction	501	502	503	504	505	506	507	508	509	510
		Impaired by alcohol	Impaired by drugs (illicit or medicinal)	Fatigue	Uncorrected, defective eyesight	Illness or disability, mental or physical	Not displaying lights at night or in poor visibility	Cyclist wearing dark clothing at night	Driver using mobile phone	Distraction in vehicle	Distraction outside vehicle
	Behaviour or Inexperience	601	602	603	604	605	606	607			
		Aggressive driving	Careless, reckless or in a hurry	Nervous, uncertain or panic	Driving too slow for conditions or slow vehicle (e.g. tractor)	Learner or inexperienced driver/rider	Inexperience of driving on the left	Unfamiliar with model of vehicle			
	Vision Affected by	701	702	703	704	705	706	707	708	709	710
		Stationary or parked vehicle(s)	Vegetation	Road layout (e.g. bend, winding road, hill crest)	Buildings, road signs, street furniture	Dazzling headlights	Dazzling sun	Rain, sleet, snow or fog	Spray from other vehicles	Visor or windscreen dirty or scratched	Vehicle blind spot
	Pedestrian Only (Casualty or Uninjured)	801	802	803	804	805	806	807	808	809	810
		Crossing road masked by stationary or parked vehicle	Failed to look properly	Failed to judge vehicle's path or speed	Wrong use of pedestrian crossing facility	Dangerous action in carriageway (e.g. playing)	Impaired by alcohol	Impaired by drugs (illicit or medicinal)	Careless, reckless or in a hurry	Pedestrian wearing dark clothing at night	Disability or illness, mental or physical
	Special Codes	901	902	903	904						*999
		Stolen vehicle	Vehicle in course of crime	Emergency vehicle on a call	Vehicle door opened or closed negligently						Other – Please specify below

	1st	2nd	3rd	4th	5th	6th
Factor in the accident						
Which participant? (e.g. V001, C001, U000)						
Very likely (A) or Possible (B)						

* If 999 Other, give brief details ....

(Note: Only use if another factor contributed to the accident **and include it in the text description of how the accident occurred**)

These factors reflect the reporting officer's opinion at the time of reporting and may not be the result of extensive investigation

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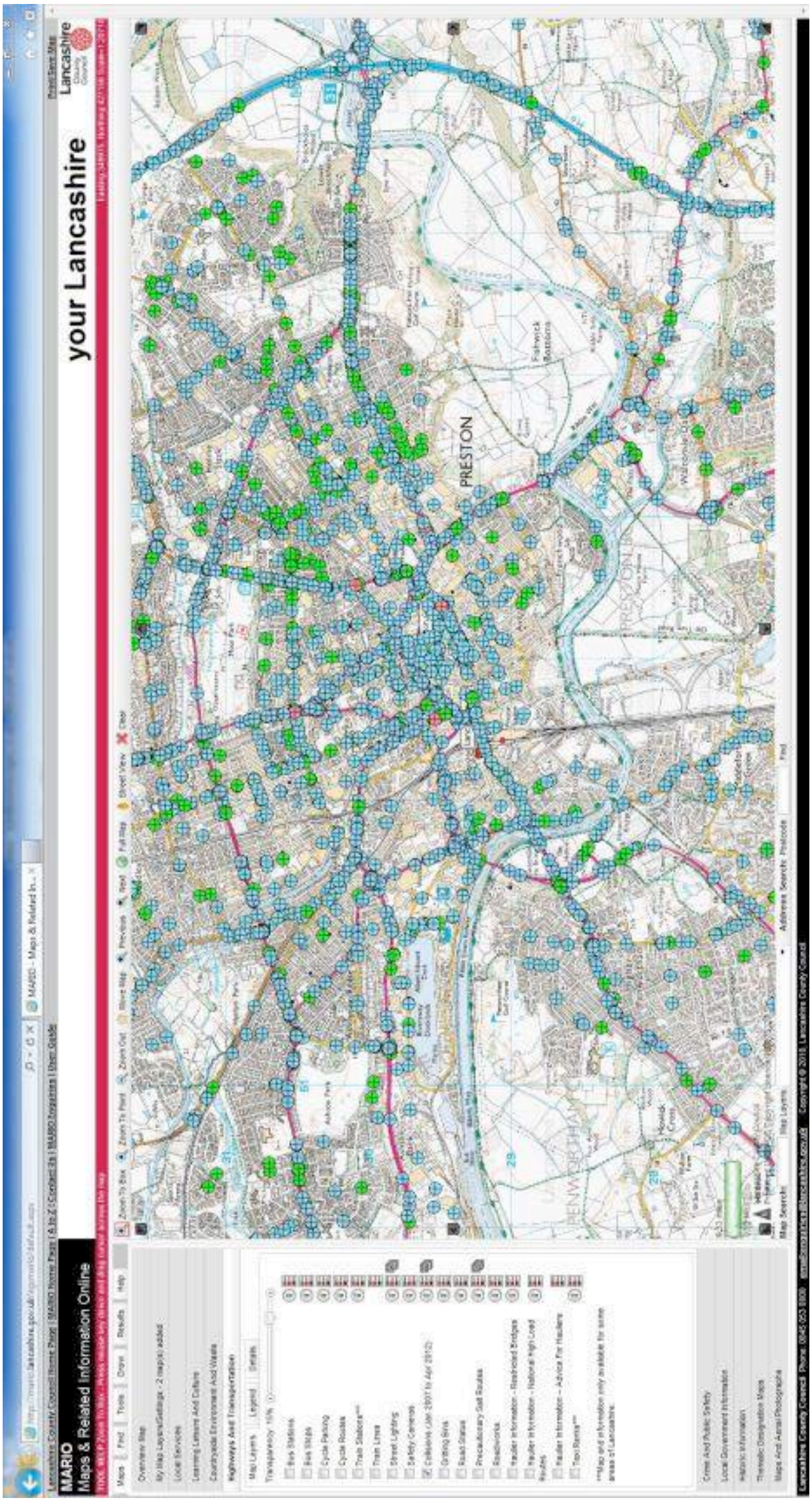
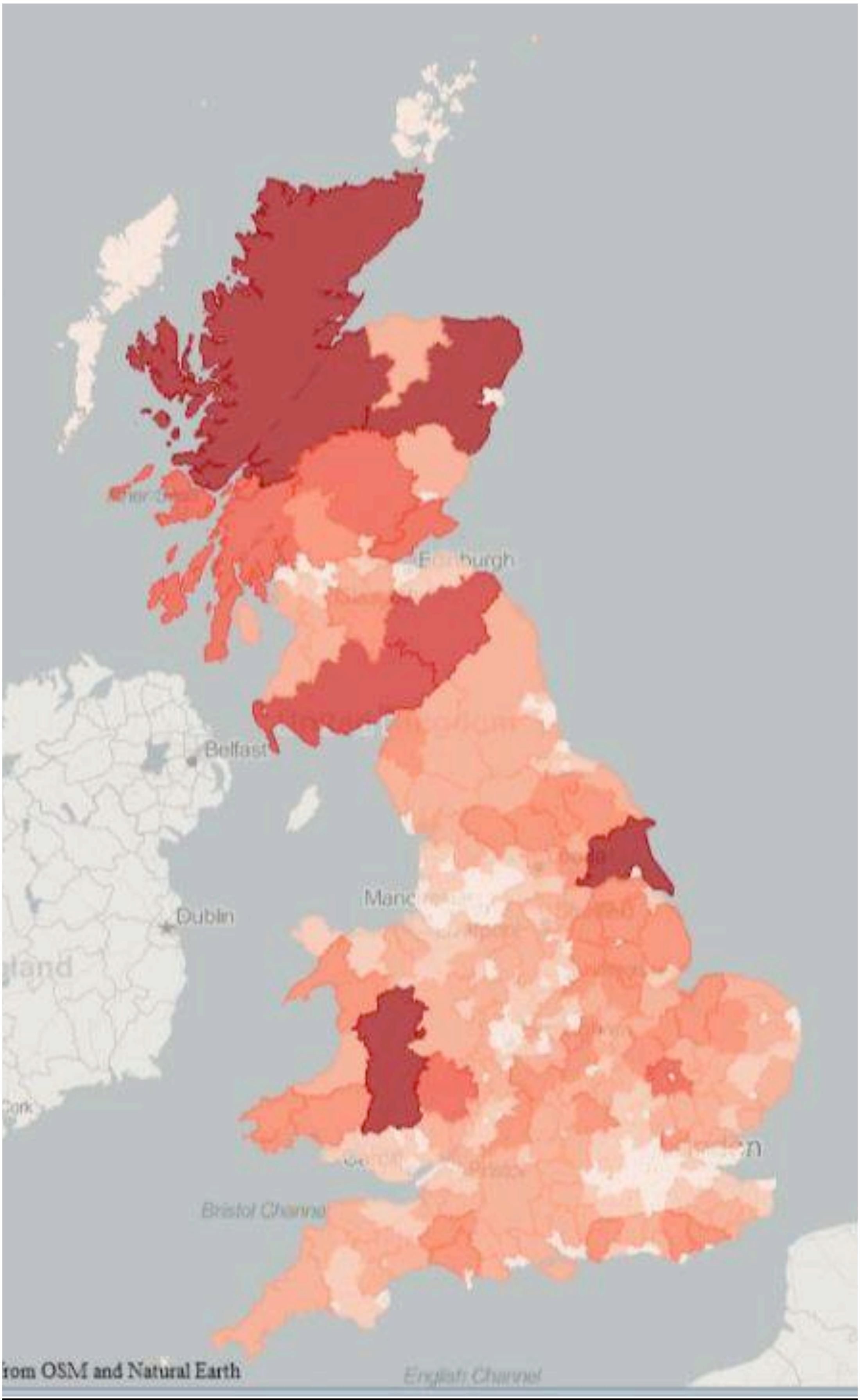
Appendix J – MARIO Accident Map



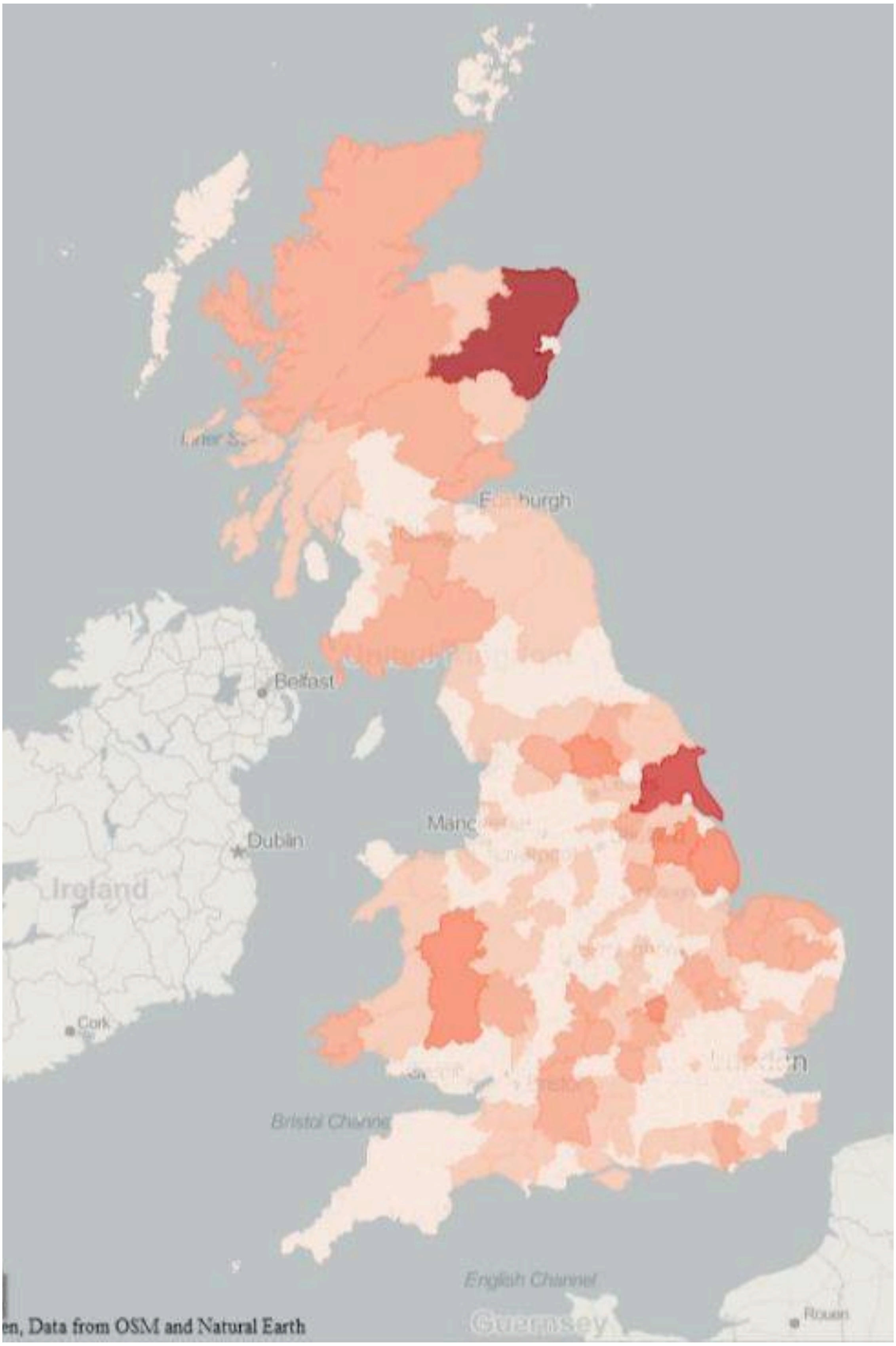
Appendix K – Pedestrian Movement and Injury Severity

		Pedestrian_Movement: Crossing from driver's nearside	Crossing from nearside - masked by parked or stationary vehicle	Crossing from driver's offside	Crossing from offside - masked by parked or stationary vehicle	In carriageway, stationary - not crossing (standing or playing)	In carriageway, stationary - not crossing (standing or playing) - masked by parked or stationary vehicle	Walking along in carriageway, facing traffic	Walking along in carriageway, back to traffic	Unknown	Total
Casualty_Severity	Fatal	115	137	15	72	14	26	0	9	17	405
		28.4%	33.8%	3.7%	17.8%	3.5%	6.4%	.0%	2.2%	4.2%	100.0%
	Serious	883	1958	537	1047	329	229	34	66	117	5200
		17.0%	37.7%	10.3%	20.1%	6.3%	4.4%	.7%	1.3%	2.3%	100.0%
	Slight	4490	7026	1796	3717	1107	1201	198	272	433	20240
		22.2%	34.7%	8.9%	18.4%	5.5%	5.9%	1.0%	1.3%	2.1%	100.0%
Total		5488	9121	2348	4836	1450	1456	232	347	567	25845
		21.2%	35.3%	9.1%	18.7%	5.6%	5.6%	.9%	1.3%	2.2%	100.0%

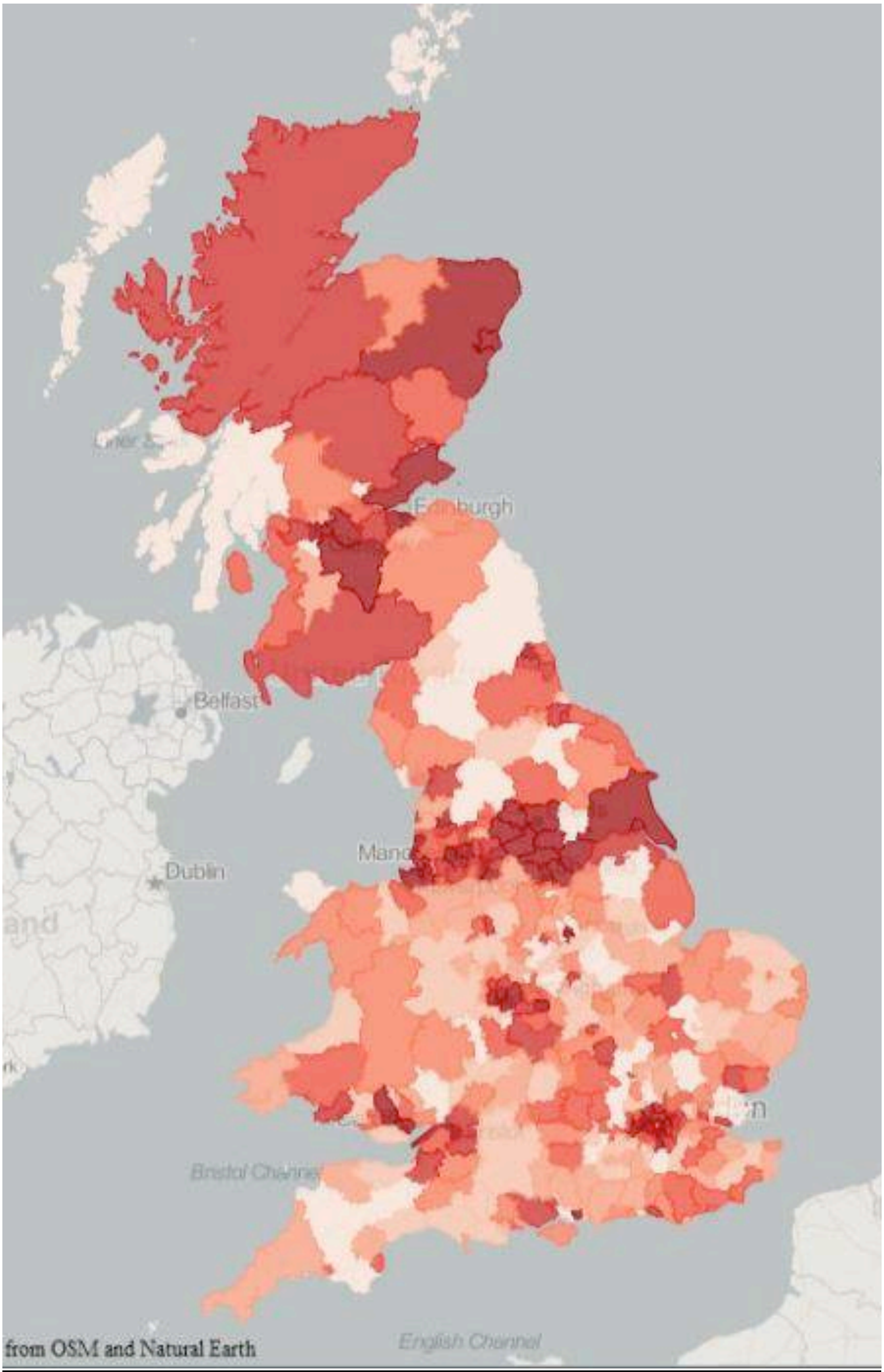
Appendix L – Location 1 Heat Map



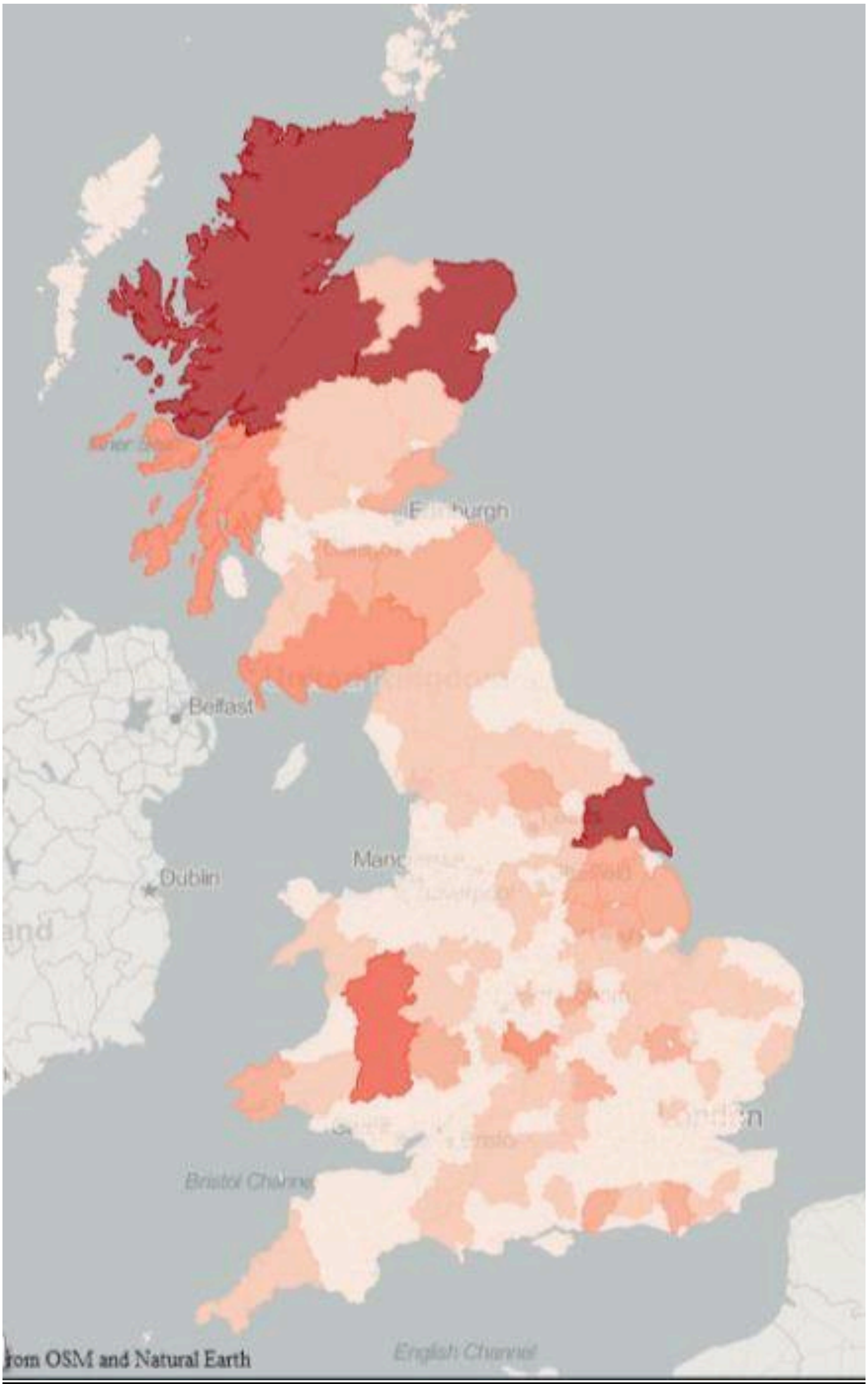
Appendix M - Location 2 Heat Map



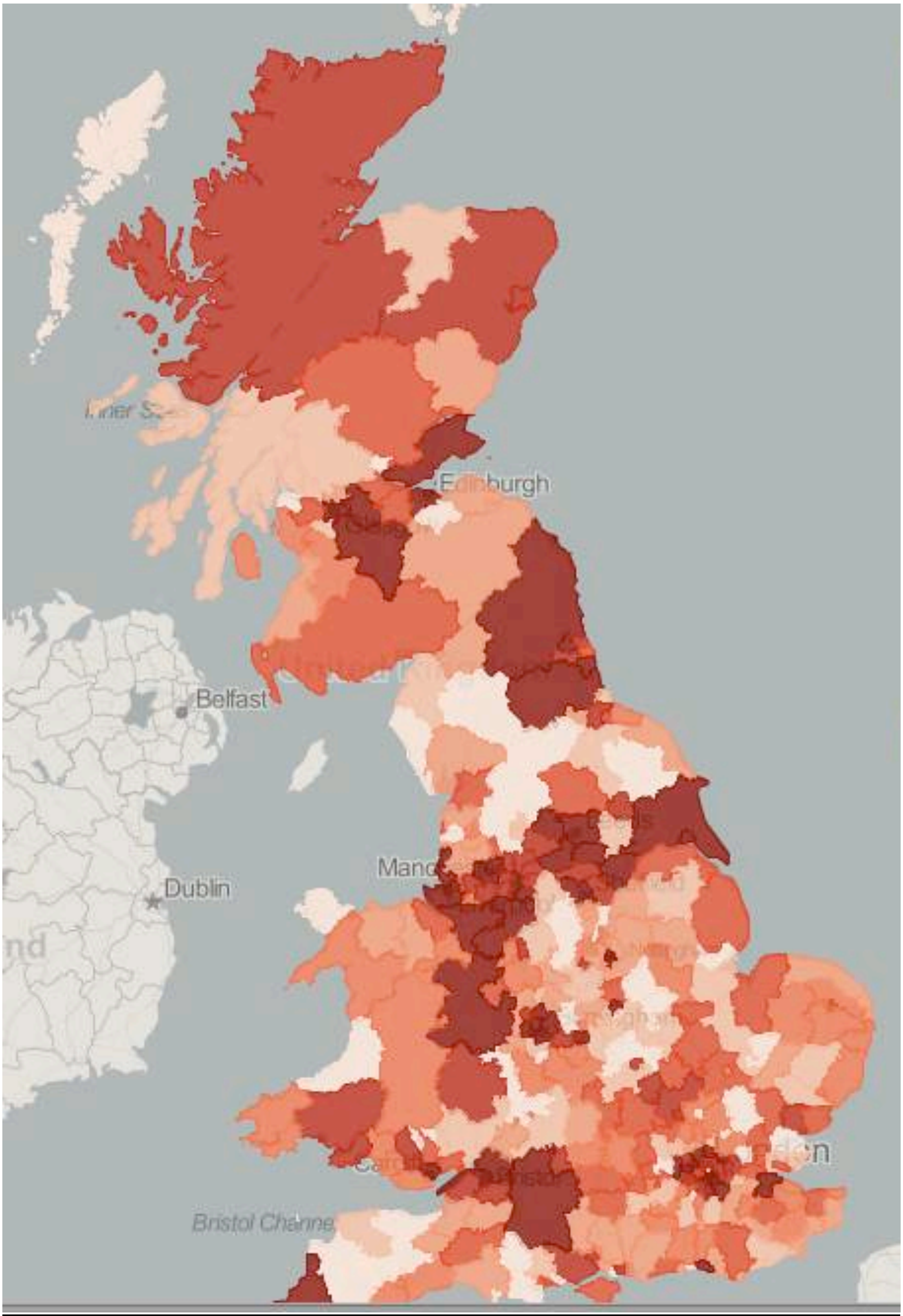
Appendix N - Location 3 Heat Map



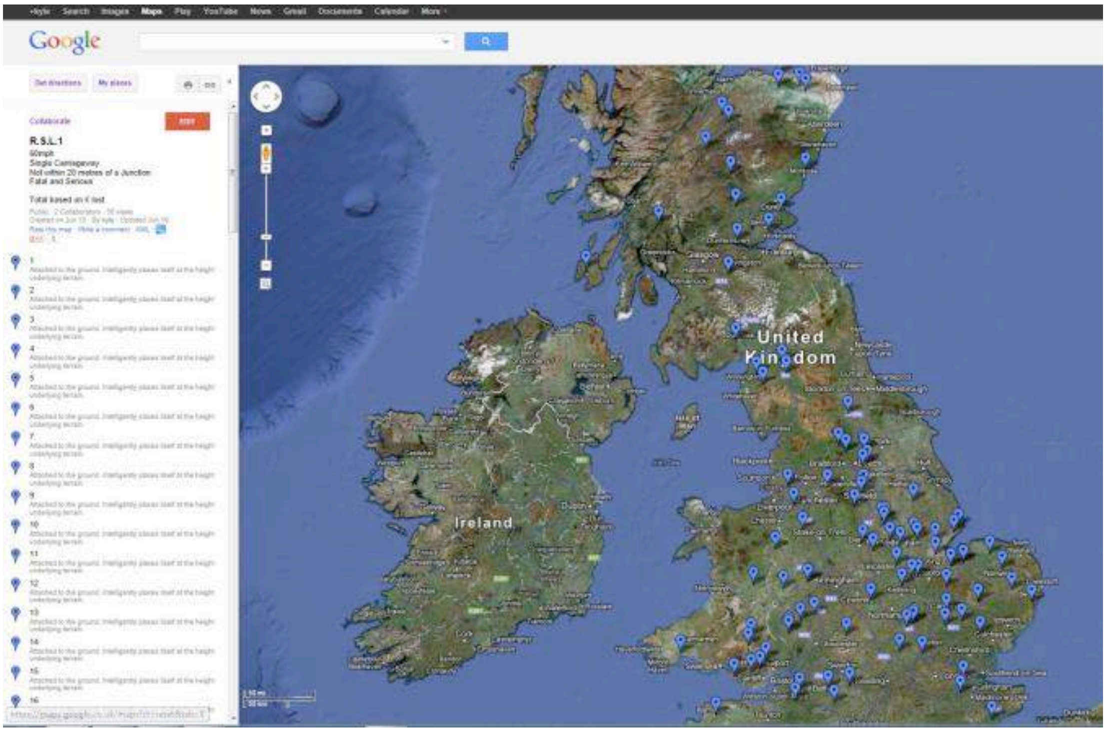
Appendix O - Location 4 Heat Map



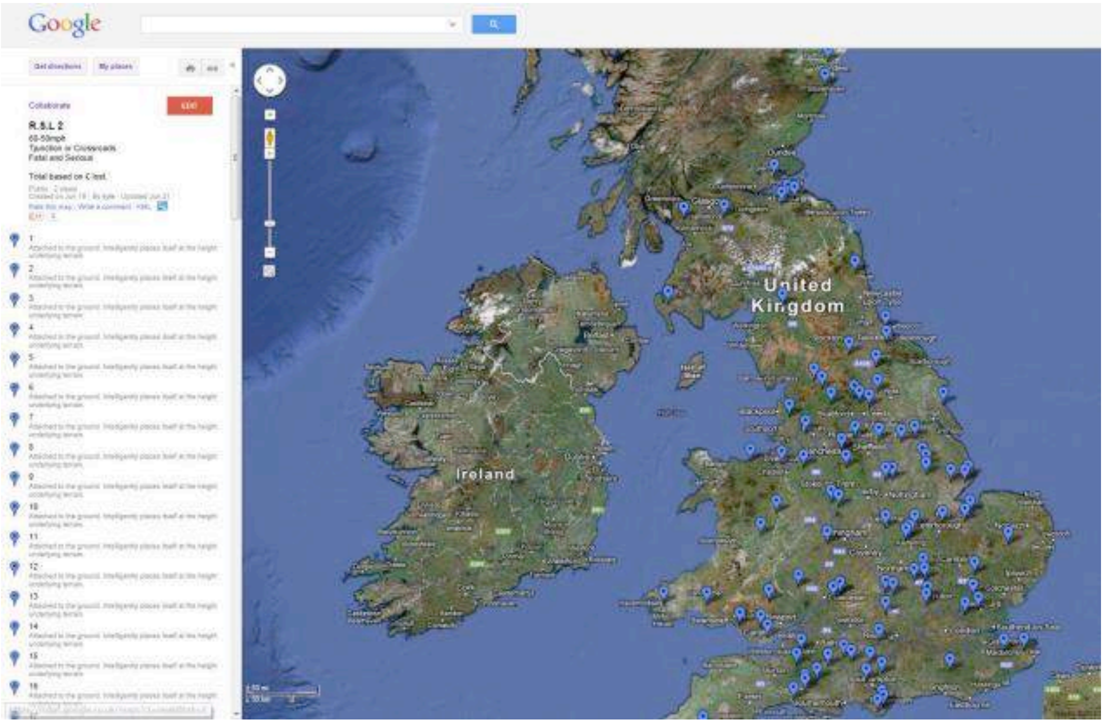
Appendix P – Local Authority Heat Map



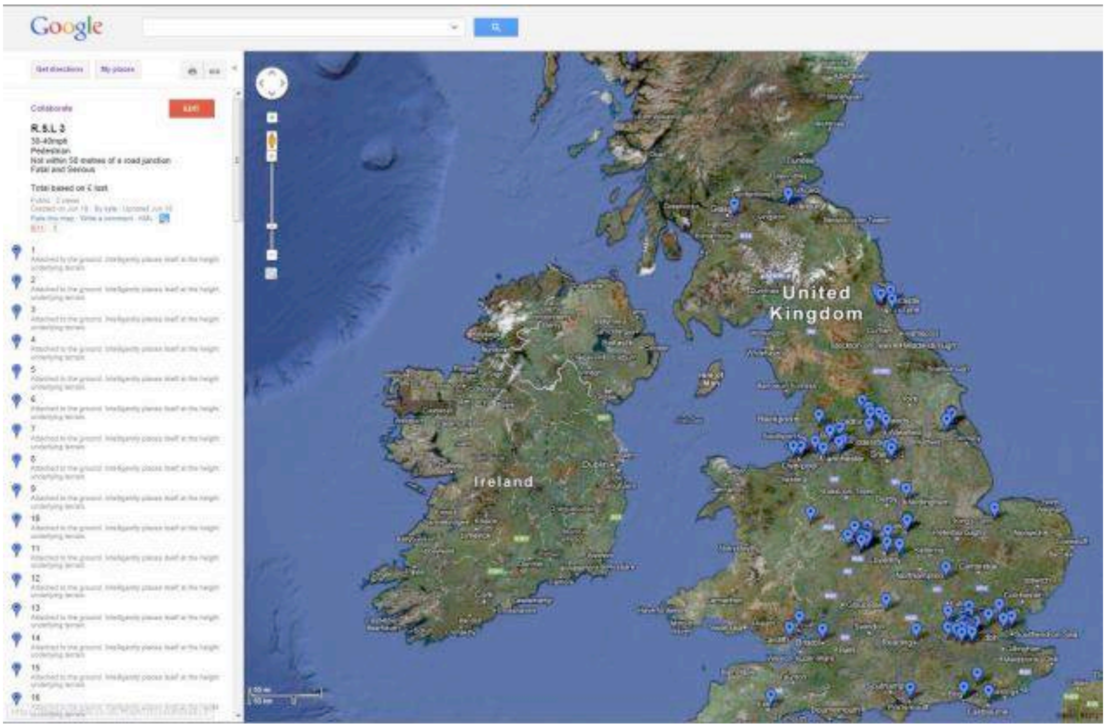
Appendix Q – 100 Worst Locations



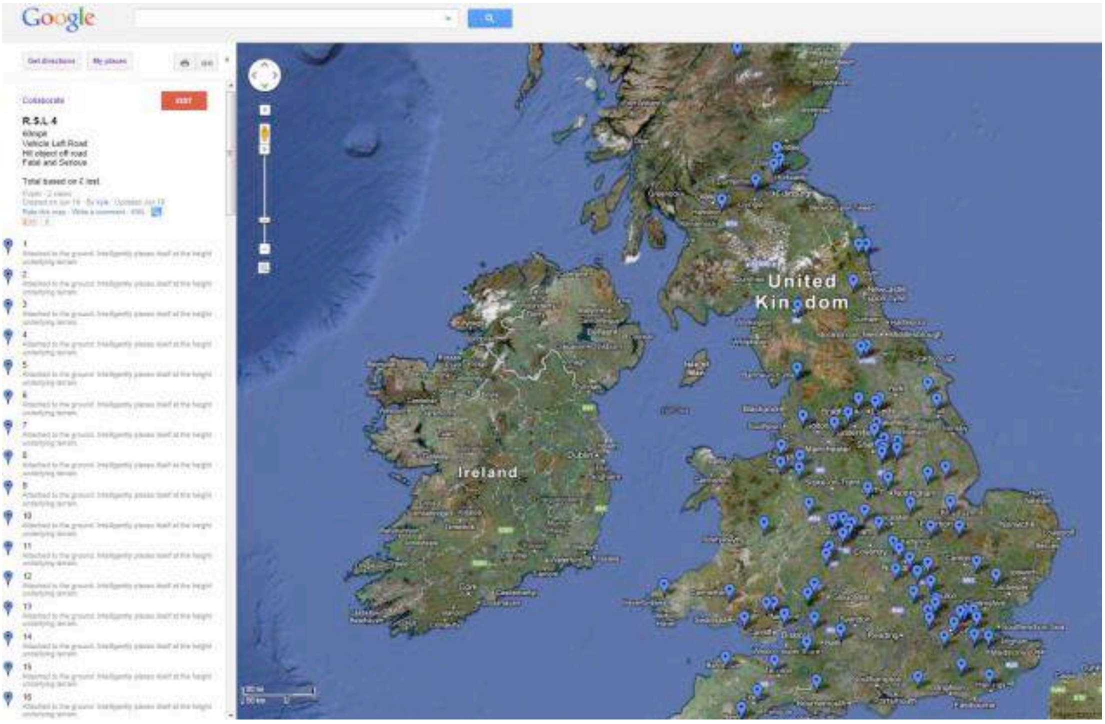
Location 1: Accidents spread across the United Kingdom but all in rural unpopulated locations.



Location 2: Accidents are similar to Location 1 and are spread across the United Kingdom in rural locations.



Location 3: Accidents are seen around areas of high population and cities.



Location 4: Initially there is no pattern to this result.

<u>Appendix R – Example visual analysis</u>

Appendix S – Focus group example