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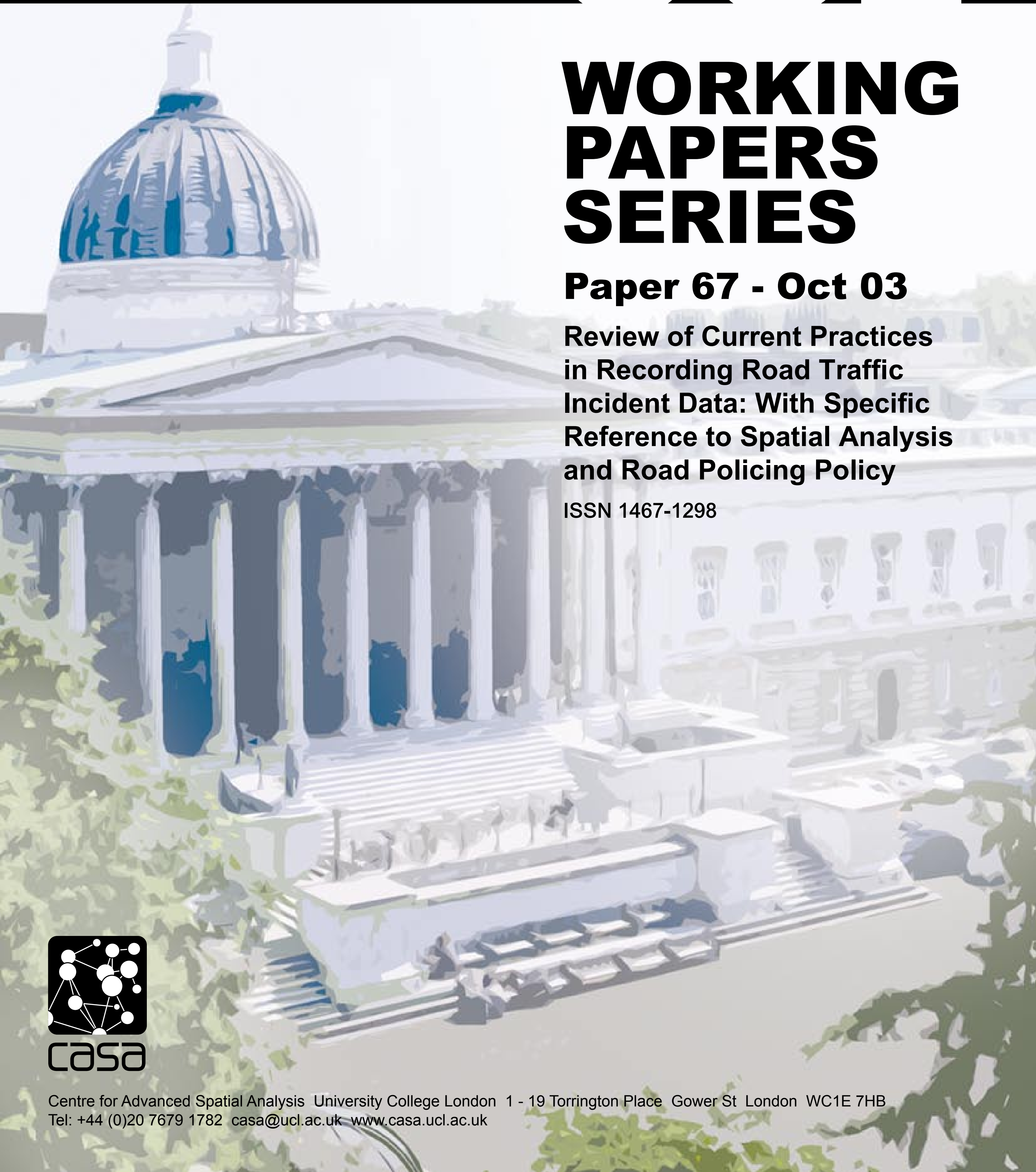

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Review of Current Practices in Recording Road Traffic Incident Data: With Specific Reference to Spatial Analysis and Road Policing Policy

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REVIEW OF CURRENT PRACTICES IN RECORDING ROAD TRAFFIC INCIDENT DATA: With Specific Reference to Spatial Analysis and Road Policing Policy

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INTRODUCTION

Road safety involves three major components: the road system, the human factor and the vehicle element. These three elements are inter-linked through geo-referenced traffic events and provide the basis for road safety analyses and attempts to reduce the number of road traffic incidents and improve road safety. Although numbers of deaths and serious injuries are back to approximately the 1950s levels when there were many fewer vehicles on the road, there are still over 100 fatalities or serious injuries every day, and this is a considerable waste of human capital. It is widely acknowledged that the location perspective is the most suitable methodology by which to analyse different traffic events, where by in this paper, I will concentrating on the relationship between road traffic incidents and traffic policing. Other methods include studying road and vehicle engineering and these will be discussed later. It is worth noting here that there is some division within the literature concerning the definitions of 'accident' and 'incident'. In this paper I will use 'incident' because it is important to acknowledge a vast majority of 'road accidents' are in fact crimes. However I will use the term 'accident' where it is referred to in the literature or relevant reports. It is important to mention here that a road traffic accident can be defined as 'the product of an unwelcome interaction between two or more moving objects, or a fixed and moving object' (Whitelegg 1986). Road safety and road incident reduction relates to many other fields of activity including education, driver training, publicity campaigns, police enforcement, road traffic policing, the court system, the National Health Service and Vehicle engineering.

Although the subject of using GIS to analyse road traffic incidents has not received much academic attention, it lies in the field of crime mapping which is becoming increasingly important. It is clear that studies have been attempted to analyse road traffic incidents using GIS are increasingly sophisticated in terms of hypotheses and statistical technique (for example see Austin, Tight and Kirby 1997). However it is also clear that there is considerable blurring of boundaries and the analysis of road accidents sits uncomfortably in crime mapping. This is due to four main reasons:

- Road traffic incidents are associated with road engineering, which is concerned with generic solutions while road traffic analysis is about sensitivity to particular contexts.
- Not all road traffic incidents are crimes
- It is not just the police who have an interest in reducing road traffic incidents, other partners include local authorities, hospitals and vehicle manufacturers
- The management of road traffic incidents is not just confined to the police

GIS has been used for over thirty years however it has only been recently been used in the field of transportation. The field of transportation has come to embrace Geographical Information Systems as a key technology to support its research and operational need. The acronym GIS-T is often employed to refer to the application and adaptation of GIS to research, planning and management in transportation. GIS-T covers a broad arena of disciplines of which road traffic incident detection is just one theme. Others include in vehicle navigation systems.

Initially it was only used to ask simple accident enquiries such as depicting the relative incidence of accidents in wet weather or when there is no street lighting, or to flag high absolute or relative incidences of accidents (see Anderson 2002). Recently however there has been increased acknowledgement that there is a requirement to go beyond these simple questions and to extend the analyses. It has been widely claimed by academics and the police alike that knowing where road accidents occur must lead to better road policing, in order to ensure that road policing becomes better integrated with other policing activities. This paper will be used to explore issues surrounding the analysis of road traffic accidents and how GIS analysts, police and policy makers can achieve a better understanding of road traffic incidents and how to reduce them.

For the purpose of this study I will be trying to achieve a broader overview of the aspects concerning road accident analysis with a strong emphasis on data quality and accuracy with concern to GIS analysis. Data quality and accuracy are seen as playing a pivotal role in the road traffic management agenda because they assist the police and Local Authorities as to the specific location whereby management can be undertaken. Part one will consider the introduction to road incidents and their relationship with geography and spatial analysis and how this were initially applied to locating 'hotspots' and the more recent theory of 'accident migration'. Part two will address current data issues of the UK collection procedure. This section will pay particular reference to geo-referencing and the implication of data quality on the procedure of analysing road incidents using GIS. Part three addresses issues surrounding the spatial analysis of road traffic incidents, including some techniques such as spatial autocorrelation, time-space geography and the modifiable area unit problem. Finally part four looks at the role of effective road traffic policing and how this can be achieved due to better understanding of the theory and issues arising from analysing road traffic incidents. It will also look at the diffusion and use of GIS within the police and local authorities.

1. ROAD TRAFFIC INCIDENTS: A SPATIAL PHENONMENON

All road traffic incidents occur somewhere. Every accident has the potential of having a grid reference. The analysis of the patterns of incidents in relation to variables such as road geometry or speed limits may give insights into cause, and hence amelioration. A GIS is principally concerned with analysing point, line and area objects. In the case of incident analysis, a GIS can locate an incident as an object (the vehicles location), as well as a line (road 'hotspot' – all accidents on a map occur on a line). It is important to acknowledge here that much geographic analysis is devoid of natural units therefore there are no 'natural' units to measure road traffic incidents. As mentioned its use in road safety has been confined to answering simple queries, however a more detailed review of road traffic incidents and spatial analysis will be discussed later. In this section, focus will be on the initial attempts at road accident analysis with little regard for GIS but an understanding of the spatial setting of road traffic incidents.

1.1 The geography of road traffic incidents

It has been argued by Whitelegg (1987) that geographers have not paid enough attention to the geography of road traffic incidents. For many years it was considered by police and local authority road engineers alike that road engineering, road layout and vehicle manufacturing faults that were the main causes for road incidents. However it has become evident through increasing police awareness and that road incidents need to be dealt with in a geographical capacity (both spatial and temporal). In March 2000 the UK Government recorded that every year 3, 500 people are killed on Britain's roads and 40, 000 are seriously injured. In total it was recorded an average of 300, 000 road casualties every year. The report also acknowledges that since the number of vehicles on the road has increased since 1930, the number of accidents has not increased in as rapidly (however this is largely to do with vehicle safety technology). Although the number of accidents has not increased in proportion to the number of vehicles it is accepted that a large number of road traffic incidents go unreported due mainly to them not resulting in any injury but still however costing considerable amounts of money and time to put right.

Whitelegg, in his paper 'The Geography of road accidents' seeks to understand road traffic incidents with reference to scale of analysis and the importance of focusing on neighbourhood and community scale for an answer to the reduction of incidents (see below). Whitelegg outlines the strong links of road traffic incident analysis and other geographical fields, which include population density, and distribution movement and spatial designs of neighbourhoods:

The movement whether it is pedestrians or motorists will be a function of the land use system, residential patterns, population densities, street geometry, location of workplace, shopping precinct or health centre etc. Therefore with this knowledge geographers can specify circumstances in which road incidents are more likely to occur due to the pre-occupation geographers have had in recent years with patterns of movement and patterns of location. The themes that come across in this paper is the beginnings of a spatial understanding of road traffic incidents and the understanding of the statistical importance of accurate data. For the purpose of this review this research paper can be acknowledged to be the beginnings of understanding road traffic incidents from a spatial perspective in a academic environment (as opposed to government or private consultancy firms).

	Scale	Policy Response
	Local/particular	**Blackspot eradication/road hump/small scale engineering**
Increasing	**Neighbourhood**	**Alternating residential design**
Spatial scale	**Sector of City**	**Traffic management and routeing**
	City Wide	**Public transport system/land use planning**

Diagram 1: Road traffic accident: relationship between spatial scale and policy response (Whitelegg 1986)

Whitelegg's article is associated with outlining the importance of a scale based approach when trying to reduce road traffic incidents, who argues at the same time that human error alone is not responsible for road traffic accidents and the importance of spatial factors has been 'grossly underestimated' (1987). Road accidents can be associated with three main areas of causation categories:

1. Human error
2. Vehicle error
3. Environment (i.e. road layout)

It is important to consider the inter-relationships between these three factors and the part they play in the wider spatial system.

There are a range of scales at which road traffic incidents can be analysed. For example, local authorities may record incident rates along a specific segment of road to understand the cause in terms of road engineering. The police collect accident data for their authority which can cover many counties. This data is then broken down into subsequent areas and so the cycle continues. It is an important point that due to the variability of scales, it makes the data incompatible and therefore worthless for and valid comparison.

1.2 <u>Accident hotspots</u>

There is very little information in the literature as to what is an accident 'hotspot' and how it is defined spatially and numerically eg the absolute and relative incidence of events. This lack of a readily available definition highlights the high margin for error when analysing road traffic 'hotspots'. For example a study by Gregory and Jarrett into the long term analysis of accident remedial measures at high risk sites in Essex classes a hotspot or in their words a 'high risk site' by the number of personal injury accidents occurring in a 100m grid square or 100m length in a three year, one year or six month period on a particular class of road (1987). Therefore if 12 accidents are recorded over a period of three years on a 100m length of road, then the area is deemed a high-risk site. However this is only one interpretation of the size and frequency of accident an 'hotspot'. Thomas highlights the importance of clustering accidents, and how the size and shape of the spatial units bias the statistical results and therefore influence modelling choices and results. The issue of scale and aggregation, which can be applied to incident 'hotspots' is known as the Modifiable Areal Unit Problem, and it was Openshaw and Taylor in 1979 that first coined the phrase and distinguished the scale problem from the shape problem.

At a practical level because there is no standardisation of what constitutes as a hotspot it is very challenging to undertake any sort comparative analysis all the results would be open to interpretation. It is the police forces and local authorities, which are deeply affected by this lack of guidelines and standardisation. The data and information sharing between these two institutions at a local level is very important and frequent. Although data sharing will be mentioned later in the paper, both these institutions rely on the identification of a hotspot in order for the police to deploy traffic police and for the local authority to plan for road engineering remedial treatment. This leads on to the other issue surrounding the scale of hotspot. In order to reduce the hotspot and 'high-levels' of accidents in one specific area the exact cause of the hotspot must be established. In other words the hotspot is there because of a high number of accidents but the cause of the accidents may differ. For example some incidents could be caused by weather conditions, others by a blind bend and others because it is near a public house, and all of these factors put together cause a 'hotspot', but take the accident rate on their own (i.e. the independent causation factor) and the area may not be a hotspot (ie the problem of equifinality of outcome). This is just one issue of 'incident blackspots'; another problem that has been widely researched is the theory of 'incident migration'.

1.3 Accident migration

Many studies have been conducted in this area especially in the late 1980s and early 1990s. These include work by Gregory and Jarrett 1994, Boyle and Wright 1984, McGuigan 1985, Persaud 1987. Most studies follow a similar format of analysis, which consists of collecting incident rate data pertaining to an 'incident hotspot' and then accident data for after the remedial intervention has been administered. This flurry of papers has resulted in a stagnant period since the early nineties in this area. All the studies are based on a pioneering study in the United States by Ebbecke (1976) who studied 222 one-street stopped intersections in Philadelphia to multi way stop control during a four year period from 1968 –1972. The importance of studying the theory of accident migration lies in the theory of regression –to-mean, i.e. whether the accidents are just randomly fluctuating around a medium rate of accidents of whether the accident blackspot has migrated or not. It all four studies, they found this difficult to prove.

It is worth noting that these studies have only dealt with engineering remedial treatment (although none of the studies specifically outline what exactly has been done to try and reduce the number of accidents). There are no studies on the effects of policing on incident hotspots and whether a different method of policing means high risk accident locations migrate. All the studies follow a common research theme which consisted of identifying a number of incident hotspots and then obtaining data for before the remedial treatment was administered and then obtaining data for after the treatment was installed. Although all the studies acknowledge there is a large margin for error and lack of control procedures. Boyle and Wright argue that the ideal procedure for establishing a control would be to select a number of hotspots, treat half of them and then compare the changes in accident numbers at the hotspots and the surrounding areas after a sufficient period of time. This leads to the next problem with these various studies, that what constitutes the correct amount of time after the remedial treatment has been installed to analyse the accident rates? In Boyle and Wright's study of the incident migration of the Greater London area, they outline a number of limitations to the study, which the other studies also acknowledge. These include:

- The extent to which the parts of the surrounding areas of blackspots had to be excluded because of their overlap with other blackspots.
- A lack of precise and adequate data to demonstrate the relative effects of accident migration arising from different forms of remedial treatment.

These four limitations were found in all the other studies and highlight maybe why this theory has not been at the forefront of accident analysis since due to the high variables in the studies which make accident migration difficult to prove.

2. CURRENT DATA COLLECTION PROCEDURE

This section will discuss in detail the importance of good data for successful accident reduction and police deployment. It is important here to make clear exactly what we mean by 'accuracy' and 'precision' in terms of datum:

Accuracy – Is the degree to which information on a map or digital database matches true or accepted values. Accuracy is an issue pertaining to the quality of data and the number of errors contained in a dataset or map. With regard to a GIS database it is possible to consider horizontal and vertical accuracy with respect to geographic position. It must be remembered that firstly the level of accuracy required for particular applications varies greatly. Secondly, highly accurate data can be very difficult and costly to produce and compile.

Precision – Refers to the level of measurement and exactness of description in a GIS database. Precise locational data may measure position to a fraction of a unit. Precise attribute information may specify the characteristics of features in great detail. It is important to note that precise data no matter how carefully measured maybe inaccurate. As with accuracy there are certain points which should be remembered. Firstly the level of precision required for particular applications will vary greatly. Secondly as mentioned before highly precise data can be difficult and costly to collect.

Data issues have been at the centre of GIS analysis due to if being the driving force for any application. If the datum isn't accurate then the GIS application results cannot be seen to be accurate. Important decisions are made on the outcome of GIS application and therefore they cannot be predicted upon inaccurate data. The importance of this theme cannot be stressed enough. Although it has been several years since the advent of digital maps, global positioning systems (GPS) technology and machine searchable street names and co-ordinates, it can be surprisingly difficult for the average person to describe a location, and this problem is faced daily by people (namely the police) reporting accidents. Problems with location reporting have been observed anecdotally for a number of years, but there has been relatively little scientific documentation on the scale of the problem and its solution.

At this point it is important to stress that individual police authorities have autonomy in deciding what if any data they collect beyond the Home Office Requirements. The police forces have plenty of opportunity to collect data within their own forces however the data gathered is not systemised within police authorities and therefore not geographically comparable between authorities. The important point to make here is that the causes and consequences of road traffic incidents do not respect the artificial boundaries of police jurisdictions.

2.1 The need for 'good' data

GIS in a policing and engineering environment is used as a decision making tool (Veregin 1989). The role of GIS as a spatial decision support tool has been widely acknowledged but its potential in the role of accident reduction and traffic policing has yet to be integrated into the road policing environment. In any data collection process there is a large margin for error and it is the way that this error is reduced through various filters and checks is what is important. Michael Goodchild has been quoted in saying[4]:

- all spatial data are limited in accuracy
- available precision in GIS software systems exceeds the accuracy of data
- the means to characterise the accuracy of spatial data, track uncertainty through GIS processes and compute and report uncertainty are inadequate.

2.1.1 Sources of uncertainty in measuring and analysing road traffic incidents

In order to achieve better data and more reliable decisions the following points should be remembered when discussing the importance of data accuracy and quality within the police (these points are based on Guptill 1989)

- improvement of models of uncertainty
- methods of encoding uncertainty in databases
- methods of tracking uncertainty
- methods of computing and communicating error in products and policies

Recently the term 'data quality' as been replaced by uncertainty (this does not mean we should discontinue using the term 'data quality') (Buttenfield and Weibel 2001). Uncertainty does not mean unreliable, changeable or erratic (Oxford 1996 cited in Buttonfield and Weibel 2001). Uncertainty can be defined in terms of either an affirmative or negative character. Uncertain data possess attributes of either accuracy (an affirmative attribute, measured in terms of similarity) or error (a negative attribute, measured in terms of discrepancy).

Recording road traffic incidents is a process which is highly vulnerable to uncertainty and is important because the objective would be to minimise the time and cost spend on policies which derive from inaccurate and uncertain data. Listed below are some of the various types of uncertainty which may occur within road traffic incident data collection and analysis:

- Measurement error; whereby the location of the incident (an eight figure grid reference) is recording either as textual information and later encoded into a grid reference or either recording the grid reference at the scene of the incident incorrectly. Most police officers attending an incident do not have sophisticated GPS equipment to make accurate recordings of location.

- Due to the fact there are no 'natural' units of road traffic incident measurement this provides uncertainty in terms of boundaries. The boundaries are created on a individual force basis (there are no universal guidelines but are usually based on policing units. However this proves inaccurate due to the incidents often not conforming to the boundaries because their causes and consequences have a much wider scope.

- From the example of the Metropolitan Police collection process, it is apparent that there is uncertainty at the stage where the textual data is transformed into a grid reference and relies on a number of factors in order to be precise. These include the accuracy of the textual information and how well the encoder can interpret it to a grid referenced map.

It is possible to create dazzling and impressive map using wholly inaccurate information. Why? This is mainly due to inherent data quality issues within an organisation can mean the difference between meaningful maps and a simple graphic or poster. One must be aware of the fact that high data quality is not necessarily data that is devoid of errors. Incorrect data is only part of the data quality equation and even incorrect data can be consistent and go undetected in data quality filters. In the realm of road traffic accidents the organisation that is collecting the data is the Police, and they are not necessarily the only other organisation to be using the finished data set so data quality is even more important due to the number of partners involved in reducing accidents.

2.2 Stats19 collection system

Personal injury road accidents were first collected in 1909. The modern 'Stats19' collection system was established in 1949 and the current collection system was implemented in 1979 after a wider ranging review. Road accident statistics are essential for informing and monitoring road safety policy at local, regional and national levels. Locally they are used to support remedial engineering work on public roads. At a local and national level they are used to underpin road safety strategy and targeting casualty reduction. Individual police forces and local authorities require road accident statistics to support their own road safety policy programmes, which vary in focus (from child pedestrian safety to tackling drink drivers). The collection process and data collected vary in local authority and police force areas, reflecting the different road safety requirements and initiatives. However each local area is required to report the same set of accident records for national purposes and to transmit them to central government. These are what are known as Stats19 records.

The accuracy and credibility of the Stats19 collection process depends upon the close co-operation between central government, local government and police forces. It is a voluntary process. There is no statutory duty upon the police or local authorities to report the Stats19 data to central government. The Stats19 system is jointly owned and managed by the Standing Committee on Road Accident Statistics (SCRAS).

In England, within each local area, Stats19 data are collected by a central unit referred to as the Local Processing Authority which can be managed directly either by the police or local authority, or be sub-contracted to a private consultancy. There are 58 Local Processing Authorities in Great Britain of which just under half are managed by local police authorities and the rest by local authorities. The Stats19 report form consists of an accident record, a vehicle record to be completed for each involved vehicle and a casualty record for each casualty arising from the injury accident. In 2000, local authorities and police forces collected, coded and validated and reported 234, 000 accident records, 430, 000 vehicle records and 320, 000 casualty records for central government (see appendix for a copy of the STATS19 record sheet).

Example of road accident data collection: The Metropolitan Police

The map below shows the different boroughs that combined together form the Metropolitan Police

Source: **http://www.met.police.uk/about/boromap.htm** (20.05.03)

All police forces (there are 43 in England and Wales) have a different verification procedure of the accident data. Within the London Metropolitan Police as with all other forces, they only record accident locations to which they are called. This means many accidents go unrecorded but this will be discussed in the next section. The following steps are taken to record an accident and its location and is an example of one police force.

- A police officer will attend an accident and in a small black logbook with the questions from the Stats19 completion form. There are eight boxes for an eight-figure grid reference however it would be naïve to assume that police officers would know the exact location of an accident so the attending gives an interpretation of the location (usually in the form of landmarks and road markings).

- The paperwork is then photocopied three times and two copies are filed within in each police borough and the other is sent to the London Processing Unit so it can be entered on a database and a grid reference can be determined from the notes. This has a clear high margin for error and mistakes could occur. It will rely on interpretation from transcript to relate it to a ordnance survey map.

- The database is then sent to the London Accident Analysis Unit for analysis at a basic level and a breakdown at a borough by borough level.

This is one example of a police force and is unique because it is London's accident reporting system and is responsible for a high population density and a large number of accidents. Other forces have different agendas and reporting units.

2.3 **Under-reporting and accuracy of accident data**

This theme mirrors that of the 'accident migration' theories of the late 1980s:

> *"When a black spot is treated, the reduction in accident numbers at the accident blackspot is often accompanied by a increase in accident numbers elsewhere. This phenomenon has been labelled accident 'migration'"*
>
> Boyle and Wright 1984 (Traffic Engineering and Control)

In the same way, a cluster of articles were written in the early 1990s however little has been attempted recently apart from the quality review of the Stats19 (see later). Before I explore the nature of under-reporting and accuracy it is important to differentiate between the two terms as there is a certain amount of blurring in recent years between the two. The under-reporting of accidents concerns the notion that legally only accidents in which a motor vehicle is involved causing injury to person other than the driver must be reported to the police (James 1991). Therefore there is an increased number of accidents that go unreported for the many reasons which will be discussed later on in the section. Secondly accuracy concerns how correct the information is regarding the road traffic incident.

James (1991) presents an argument for the under-reporting of road traffic incidents especially that of incidents involving children. Ibrahim and Silcock (1992) focus on the notion that accuracy of road traffic incident data is reduced because of the increased under-reporting that occur, therefore the incident data is misleading because it doesn't portray all the incidents (this is especially true because police only collect data on road traffic accidents that are reported to them. It doesn't include minor accidents that may only result with an insurance claim). There has little or no attempt to estimate the number of un-reported accidents that occur, and the only way would be to investigate insurance companies and hospital in-patient records. Both studies portray a common theme of concern for under-reporting and outlining that the responsibility lies with the police at the scene of the initial incident to final comprehensive databases. Ibrahim and Silcock (1992) devote more time discussing how much time is spent checking the accident data (although primarily this is in the hands of the individual police forces). There seemed to be no specific agenda for who responsibility it was, it seemed to be done on an ad hoc basis depending on the area. The article clearly states that:

> *'The inaccuracy of accident location by the grid reference and the plain language description are the two most frequent problems'* (Ibrahim and Silcock 1992, Traffic Engineering and Control)

It seems clear that even ten years ago, the accuracy of road incident data was an issue, however the lack of follow up has been dismal. Although James (1991) tackles a broader study of data which consisted of comparing hospital statistics and reported road traffic incident statistics to see the comparison. It is also possible to outline possible uncertainties which surround this area of research being that road traffic incidents have no 'natural' unit of analysis and any studies have varied areas of study making it difficult if not impossible to compare and establish any relationships between areas. Even James (1991) remarks:

> *'In addition to under-reporting, the problem of misclassification of information by the police was also apparent. Assessment of injury severity was often inaccurate…..'* (James 1991, Traffic Engineering and Control)

From these articles we can clearly see that the theme of accuracy and under-reporting has been acknowledged for a number of years, however there has been little work which has built on these foundations.

2.4 <u>Quality review 2003</u>

The 2002 quality review of the national statistics on road accidents (a governmental review team set up to acknowledge the Stats19 collection process and the information collected) involving personal injury is still in progress. The review team consists of representatives for the interests of central and local government, as well as local police forces. The review team was fundamentally set up to evaluate the consultation papers from 2001, which are concerned with the data collection process and the coverage of the data to be collected. It was drawn up to assist both suppliers and users of road traffic incident data to formulate their ideas for change. At the heart of this initiative is the need to improve public confidence in National Statistics and is part of the five yearly review of road traffic incident data.

In earlier years the STATS19 collection system was subjected to a quinquennial review to check that it continued to provide essential information for government but at the same time minimised the burden of form filling and data provision upon local police forces and local authorities. Each review has identified minor problems and has modified them as seen fit mainly in response to the changing road safety agenda over time. For example the increased importance of mobile phones in increasing road traffic incident rates.

Among the members of the review panel, it consisted of representatives from the Association of Chief Police Officers (both England, Wales and Scotland), Local Authorities, Welsh and Scottish National Assemblies and the Department for Environment, Transport, and the Regions.

The review has covered the following issues:

- Evaluation of the 1997 changes – were they successful?
- Concerns about current reporting and coding practises
- Casualty reduction targets and changes in severity definition
- Proposals for the addition of new variables
- Proposals for the deletion of variables
- Proposal to formally adopt the collection of contributory factors
- Data linkage with health institutions and socio-economic statistics
- International perspective and commitments
- Availability of statistics
- Ownership, supply and charging arrangements for local and national road accident statistics.

Due to the fact that the final review has not been published the points raised here are questions only and have to left open-ended but give some idea as to the scope of the review and changes that may be implemented as a result. Below is a list of detailed issues raised:

- Are the new variables producing useful and reliable information
- Accuracy of ‘place accident reported (there is currently confusion over interpretation)
- Is the driver and casualty post-code data providing data linkage potential and is the post code data complete?.
- Some police forces are considering reducing the Stats19 reporting requirement for ‘over the counter’ reported accidents.
- The potential for using global positioning systems to improve grid reference information
- The 1997 review accepted the need for driver and casualty post-code information to enhance the potential for linking road accident data with health, crime and population statistics. The post-code information could distinguish between locals and non-locals.
- The 2002 review will ascertain whether or not any data linkage has been achieved

These are just a few main points that the review will address, however at this stage because the report has yet to be published any interpretation would be premature.

2.5 Contributory factors and new added variables

At present there are no current guidelines for the collection of contributory road traffic incident data information. Police forces are at liberty to collect any other data regarding the road incident, usually with regard to a road safety initiative being implemented. The contributory data collected between forces may vary due to the differences in rurality, road networks and road density. Firstly I am going to address the issues about the proposals for new variables for the Stats19 recording form, and secondly I am going to look at the role of contributory factors.

There have nine proposals for new variables outlined by the Standing Committee on Road Accident Statistics which include:

- Work related accidents – this has the problem of definition of company car use for 'company' business.
- Damage accidents only - Although this would mean an increased amount of under-reporting of accidents because the police do not record all damage only accidents. This information is more likely to obtained from insurance companies.
- School child injury after having alighted from a school bus - there is the problem in defining 'after having alighted', and children are more likely now to be driven to school.
- Mobile phones - This is a contentious issue that has been strongly supported by Ministers in the 1997 review. However it was rejected by ACPO as being too difficult to collect. At present no police force collects data concerning the use of mobile phones in relation to accident causation.
- Driver experience from Driving Licence number – Again deemed to difficult to collect, because drivers do not always carry a driving licence. This also leads to the question about identity cards, and then is age a better indicator of experience? There are many issues surrounding this variable
- Text description to identify trunk road accidents. This relies on the potential of GPS in the next few years.
- Foreign vehicles – The use of a specific code for foreign vehicles to differentiate between locals and non-locals.

As well as these variables which may or may not be added to the Stats19 accident completion form, police forces are at liberty to collect any other type of data concerning the road traffic incident. As of yet there has been no comprehensive study of the scope and usage of this supplementary data. In a forthcoming paper by Anderson (2003) there will be a police authority wide based User Requirements Audit of the type of extra data collected if any and what relation this bears to road incident and policing policy and at a 'ground level' policing base. The Audit will also look at the extent to which the data is shared amongst other users such as local authorities, the hospitals and other private road user organisations.

2.6 The police and geo-referencing

The main aspect of this paper is explore and review road traffic incidents and their analysis with specific emphasis on the role of police and their part in the process. It is challenging to portray how every different police force goes about collecting and analysing road accident data as that would take a whole book but we can outline a brief explanation of collection procedure.

Due to the restricted nature of police budgets and government goals, the collection procedure of road accident data is still quite archaic. As mentioned in the example of the metropolitan police the reporting system has very serious implications for error margins. All accidents have the potential to have a 10 figure grid reference, and all the data processed does possess a grid reference but relying on the attending police officer to ascertain an accurate location using descriptive text is highly inaccurate and could lead to potential disastrous policy implications.

The problem has been acknowledged within The Association of Chief Police Officers (ACPO) and other policing organisations; however it would be inaccurate to assume police officers could work out an accurate grid reference for each accident they attend without having the use of a ordnance survey map or Global Positioning System (GPS). The only possible way this problem could be solved would be with the use of Global Positioning Systems (GPS).

2.7 The potential of GPS

The use of GPS within GIS is a very powerful tool as it enables users to gain spatial information about most parts of the world, at almost any level of detail (Kennedy 2002). If a differential GPS is used (where two receivers are used) the accuracy can be up to 10cm, however a stand alone GPS will have accuracy of approximately 1m. GPS can serve as a means of data input for GIS. GPS provides users with a convenient method for assigning and using absolute co-ordinates. Therefore humans can now know their positions and combined with a map they can then know their location (i.e., where they are in relation to other objects around them).

Only a few police cars are equipped with GPS receivers. The accuracy of GPS is extremely sophisticated and you would be able to measure the location of an accident within 5-10 metres of where it occurred. There are a few locations that GPS cannot be used, however the only one that would be applicable to road accident data would be that of underground (so accidents in tunnels would be restricted to police officer recording), and in ‘urban canopies’ amongst tall buildings. In practise this would probably account for large swathes of urban areas where incidents are disproportionately concentrated. Without going into too much technological detail regarding the GPS, it is more important to understand the potential for GPS within the realm of road traffic incident data and how accuracy could be increased and error decreased by implementing such a tool.

3. SPATIAL ANALYSIS

Over the years, road traffic incidents and policing have been analysed in a non-spatial environment, increasingly concerned with reducing numbers of accidents and improving driver behaviour. In other words focus has been on stretches of track which exist in space but are not geographical in that specificity of occurrences at unique points on the Earth's surface is not a focus of attention. However in the past twenty years there has been a dramatic shift mainly associated with the advances within GIS and its scope of applications. Within the realm of road safety and road incident reduction it is clear that GIS plays a particular role for each road end user. For example:

- **Road engineers –** Use GIS to identify blackspot locations and then applying remedial measure such as traffic lights of traffic sign.
- **Police –** The Police are concerned with government reduction goals. The goals vary according the different authority but they play a multi dimensional task, in so far as they are responsible for the safety on the roads, keeping them clear tackling the road incidents that are considered crimes for example, speeding and drink driving. The police use GIS to identify the locations of blackspots and then act on the information, the level of spatial analysis varies immensely from force to force.
- **Emergency services –** Rely on GIS for optimal routing for the ambulances, fire engines and police vehicles to the site of an emergency to avoid traffic congestion, road works and road closures etc.
- **Private road and safety organisations (i.e. Automobile Association) –** These provide the mass of road users with comprehensive and up-to –the minute information regarding congestion, accidents, road closures and potential hazards. It relies on GIS immensely for a practical application of location-based information and optimal routing options. The private sector is clearly interested in the provision if operational GIS services to customers that demand them, but there is rather less interest in the strategic management by police of disruptions that leads to disruptions in the first place.
- **Local Authorities –** Work closely with the road engineers and GIS to identify hotspots in their area or borough. Analysts use an accident database (for example the London boroughs obtain the data from the London Accident Analysis Unit) and they use a standard GIS software package such as MapInfo or ArcView to identify hotspots and then they consult the engineers as to best practise concerning the specific area.

This by no means an exhaustive list and there are other users of GIS in this field however this is not the topic of the paper. The following section will look at the various spatial approaches concerning road traffic incidents and an overview of the spatial and analytical themes associated with this theme. The focus will be mainly on road traffic incidents, as the next section will focus more on road traffic policing in a spatial and technological setting.

3.1 The use of GIS

Moellering (in this study entitled 'Road accidents: A Spatial Study' published in 1969) achieved one of the very first spatial analyses of road traffic incidents in 1969[5]. Based in America the study used the 'link and node' system, where nodes are defined as a specific highway intersection and where the links are the linear highways stretches in between. The accidents are located within the linked sections as either a distance from a node, subsection increment or some similar measure. The study, pioneering at the time of publication deals with scale problems and acknowledges the idea which we know today as the 'Modifiable Areal Unit Problem'. However as far as accurate geo-referencing is concerned Moellering only collects data for 'Police district' and 'highway class'. This is by no means an accurate analysis of location based incidents but he also goes on to investigate how long the driver travelled before being involved in a traffic incident, a subject which has been much neglected in recent years and could provide vital information regarding fatigue policy formation.

It would be easy to talk about GIS in a practical sense and how the analysis of accidents is achieved, however this would be ineffectual because every police authority and local authority approaches this in different ways. In a broad sense one can differentiate between the police and local authorities methods (bearing in mind this is not uniform across all authorities and police forces, it will vary)

Police forces – Police forces collect the data on every road accident and are fundamentally using the data through a networked GIS in order to identify the hotspots and use that knowledge to make the road policing more efficient and to pin point areas suitable for speed cameras implementation and other proactive policing issues (such as drink driving campaigns)

Local authorities – Local authorities use the same data as the police (obtained through a Local Processing Unit). However the emphasis for local authorities is improving the physical aspects of the road which are causing road traffic incidents. Therefore a basic GIS is used (such as MapInfo) to identify areas of over average numbers of incidents and then road layout is analysed in accordance with the noted causation of the incident to try and ascertain whether a physical alteration to the area/road needs to be made.

It is important to acknowledge GIS as a tool to enable the effective management of information aiding decision making. An important issue the police authorities face (I am going to concentrate on policing rather than the other organisations mentioned earlier) is which GIS software package to choose. This relies on the types of questions and information they want to yield from the data. As Bernhardsen commented that the scope of a GIS implementation project is proportional to the final impact of the GIS on the organisation and vice versa (1999).

The police have a budget which is more focused on strategic policing rather than operational policing. Therefore the notion of cost benefit analysis is very important to the overall application outline. Obermeyer outlines the notion of cost-benefit analysis which will be briefly explained here:

Cost – benefit analysis – Cost benefit analysis begins with the determination of GIS implementation costs which could be software, hardware, data and people and predicted benefits (in this case the reduction of accident and more efficient deployment of resources). A value is assigned to the benefits and costs and when added up the benefits should exceed the costs (Obermeyer 1999)

Whether the reduction in road traffic incidents can warrant the cost of implementation of a GIS, with the added costs of obtaining the hardware, software and training people to use the equipment and keep the analysis consistent depends on the number of accidents in the given area used. The information regarding the type of GIS the different police forces use, to what extent and purpose and to what challenges they face has received little attention. The User Requirements Audit will be able to tell us more about the GIS environment within the police to aid road traffic incident reduction.

3.2 The importance of spatial analysis

Spatial data analysis is involved when data are spatially located (Bailey and Gatrell 1995). Road traffic incidents occur in time and space and therefore all incidents have an exact geographical location which is identified as a point on a map therefore the analysis used could be point pattern analysis, looking at the locations of particular events and seeing of if there is any pattern. The points of the incidents all lie on or near a road network so therefore the lines are the elemental units of analysis. The spatial analysis regarding road traffic incidents is usually area analysis because the data is broken down into police authority areas (e.g. Thames Valley, Kent, West Midlands) then the data will get broken down further into force areas such as the centre of Birmingham, or Oxford city centre. This will depend on the organisation of the particular authority, whereby some have centralised traffic units and others have devolved traffic units. Spatial analysis is especially important to the analysis of road accidents because unlike crime mapping, road traffic incidents will only occur on roads and therefore the patterns will always have the same shape, of being along a road, however the road needs to be broken down into segments of analysis. This is dealt with in a paper by Thomas (1996) in which she focuses on spatial data aggregation, and the scale at which the incidents should be analysed prior to identifying road incident hotspots (1996). Bailey and Gatrell outline three different methods concerned with the spatial data analysis, all of which can be applied to the analysis of road traffic incidents

1. Visualising – this is the practical mapping and cartography. Linking the dataset to a GIS and plotting the accidents on a map, where clusters can be seen and filtering can enable to identify for example clusters of accidents that were fatal and occurred on B roads.

2. Exploratory – There is a significant blurring between this and visualising but implies descriptions of the patterns identified.
3. Modelling – In terms of statistical models concerned with the fact that road accidents and their data are subject to uncertainty.

In the road traffic incident and road policing environment spatial analysis has three main aims based on those identified by Haining (1994):

- A careful and accurate descriptions of road accidents in geographic space
- Systematic exploration of patterns of accidents and association between the accidents in space and time
- Improving the ability to predict and control accidents occurring in geographical space

Geographers have been slow to integrate both a spatial and temporal dimension with regard to road traffic incidents which has meant that the understanding of the location of road traffic incidents has barely gone past a purely locational and statistical evaluation of patterns. However little attention has been paid to systematically understanding the patterns of causes of accidents and identifying how to tackle the locational causes through engineering, policing and improving driver behaviour.

3.3 The importance of spatial autocorrelation

Spatial autocorrelation is a theme that lies as far as road accidents are concerned alongside time geography, the modifiable areal unit problem and the location-allocation technique. It is of fundamental importance for road traffic analysis. Goodchild defines spatial auto-correlation as:

> *'the degree to which objects or activities at some place on the earth's surface are similar to other objects or activities located nearby'*
> (Goodchild 1986)

It relies on Tobler's (1970) first law of geography which says 'everything is related to everything else but near things are related more than distant things'. Spatial analysis in this sense deals with two types of information, firstly, attributes as spatial feature and secondly spatial feature as location. As with most geographic themes, the degree of spatial autocorrelation present in a pattern depends on scale.

To relate this to the road traffic incident analysis one can interpret it as the extent to which road accidents can be related to other geographical attributes such as the distance between the accident and a public house or a another fatal accident. The accident would be defined as a 'spatial object' with the information regarding the accident such as the number of passengers, or severity would be the attributes of the data.

This is one type of technique to acknowledge when analysing road traffic incidents and other should be acknowledged but the length of paper does not permit a more detailed explanation and analysis of the other techniques.

4. ROAD TRAFFIC POLICING

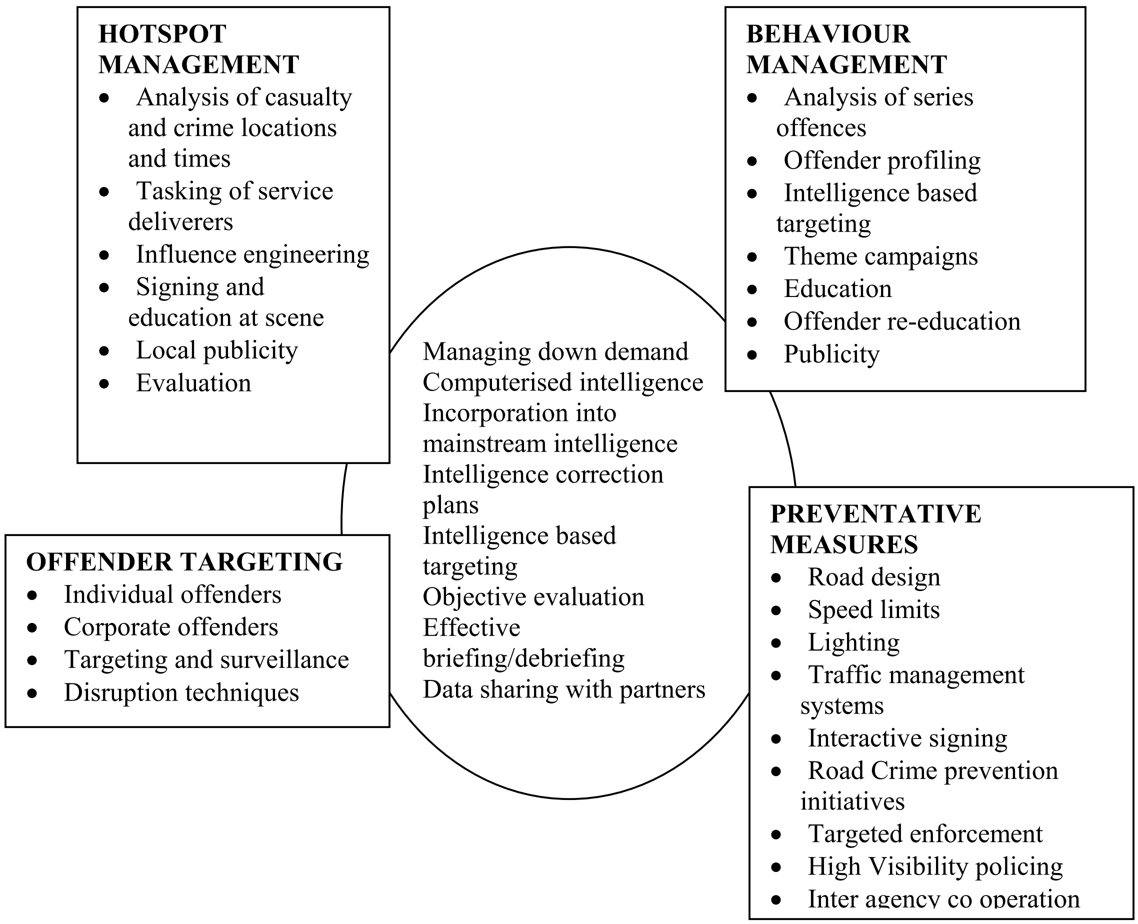
This section deals with the current policing practices and the extent to which they embrace the issues of spatial analysis, GIS and data accuracy. It will focus on how the policies surrounding today's traffic policing need to be enhanced to embrace a more spatial and locational based focus. The section will be based on findings and policies outlined in the two reports:

- Road policing and traffic – HMIC Thematic Inspection Report 1998
- Tomorrow's roads: safer for everyone – Department for Environment, Transport and the Regions 2000

There has been little attempt to merge road traffic incident reduction and road traffic policing within a spatial context. Both themes have received separate attention in the past. This has partly been because of the different organisational structure of the police authorities and because some authorities do not even employ analysts for the data because the emphasis of the force and its goals do not concern road traffic policing. The next section broadly outlines the main policy initiatives of the government concerning road accidents and road policing.

4.1 Current government policy

There is a significant diversity in road policing structures, some centralised, some devolved and no structure was found better or worse (Home Office Research Study 124 1991). One of the major concerns that has come across not only in the government publications but also 'ground policing' level are the cost-benefits of training police officers to manipulate and understand the data to be able to relate it to every day policing. If the skills are not used on a regular basis then the cost-benefit ratio is greatly reduced. It has proven difficult to persuade and show the policemen and women on the street the importance of data collection and to show what analysis of data can do to enable them to improve policing. Another issue that comes out of the HMIC road policing report is that of how to measure police performance as far as road policing is concerned. There is required a benchmark standard or measurement with which to outline a level of performance which can be used across the police forces. The diagram below does not mention this aspect but it is important to remember when analysing road accident data and road policing. With respect to this is has been important in recent years to see road policing as an important aspect of policing as a whole and to integrate it into the mainstream policies and objectives, instead of keeping it separate (see diagram below).



Source: Road Policing and Traffic HMIC Thematic Inspection Report 1998

This intelligence model shows the needs of road policing, and identifies the need for intelligence led policing and to some extent multi-tasking. Police officers see them themselves as police officers first and traffic police second and if the two skills can be overlapped then the efficiency of the police will increase considerably. The government report concerning road policing identifies the need for the police to re-address the existing balance of resources, which is a point supported by the analysts and academics who believe that there is an increased need for pro-active and problem orientated policing (Goldstein 1991). This needs to be done in order to increase the police returns and also increase public faith in the police force in reducing crime and road accidents. Road policing is increasingly seen as the ‘shop window’ for the police and it is important they are to be seen pro-active policing and multi-tasking.

The main flaw in the two government reports however is the lack of reference to effective spatial referencing. Road policing in inherently a spatial role within the police and needs to be treated with reference to some theory and effective resource management. It has been clear that the success of speed cameras has incurred a specific spatial element, however this needs to be more widely applied to the nature of road policing as a whole.

It is easy to outline the flaws within the road policing divisions but in order to establish some guidelines and proposals the problem needs to be tackled from the bottom and this starts with better data collection techniques and more emphasis in police forces on road policing. It should not been seen as a task that encompasses only catching speeding drivers and attending the odd severe accident. There are four key activities identified by the intelligence model mentioned earlier and these include:

1. Hot spot management (proactive policing)
2. Targeting identified offenders (e.g. disqualified offenders)
3. Behaviour management
4. Preventative measures (e.g. speed cameras and traffic management systems)

The significance between all these four points is that intelligence is needed in order to succeed in all four aspects therefore putting more pressure on the police to collect better data and for it to analysed more efficiently. The HMIC report identifies many police forces managing road-policing intelligence on a 'piecemeal, ad hoc basis which is often personality driven' (HMIC report on road policing 1998). The idea of partnerships also features heavily in the report and states it is important to distinguish between a partnership and a liaison with other agencies. Partnerships involve two or more agencies jointly designing a common strategy, monitored by or on behalf of all parties and often involving the pooling of resources. On the other hand, multi agency liaison involves several bodies, each with its own aims and strategies co-operating with each other because it is beneficial to work together.

As far as targeting certain 'under-achieving' police forces within the road policing sphere it proves difficult because where one force succeeds on reducing the number of fatal accidents another force maybe successful in reducing the number of accidents relating to speeding. The report acknowledged many recommendations however the success depends on the implementation at a local force wide level and how each individual force tackles their issues which are specific to their own area.

A study concerning 'Traffic Policing in changing times'[6] was conducted over 10 years ago and there have been little or no further studies since which seems to suggest that the role of policing and specifically the spatial aspect as received very little attention. The main point that has to be acknowledged with regard to road policing is that the police cannot control or reduce every single accident because the cause of the most accidents will be beyond their control. This is with reference to accidents which occur due to road layout, weather or traffic density such as in urban centres. Although it may present itself as a blackspot but there is nothing police would be able to do, apart from work in successful partnership with the local authorities and/or road engineers in order to rectify the problem.

In response the research which outlined that policing needed to be either 'policing by objectives' or using 'traffic policing priorities' has seemed to be applied in many of the police forces in England and Wales over the last ten years. Policing by objectives can be defined as 'setting goals and objectives, developing action plans which provide guidelines for control and corrective action' (Lubans and Edgar 1979). As mentioned earlier police force goals vary from force to force but there should be some universal guidelines for education, training, supervision and communication. The research outlined the amount of time spent on different traffic policing activities. This only supported what academics and police officers already knew, which was that the majority of their time was spent completing paperwork. There are so many contentious issues surrounding these activities such as whether the police are stopping the right people, and whether that police action has any significance impact upon drivers subsequent driving behaviour.

As mentioned before many of the solutions to traffic safety lie in things such as road engineering which is out of their immediate control. The impact of this kind of police activity on road accident figures is extremely difficult to measure. In the concluding remarks of the study it outlines the options for traffic policing problems, which consist of:

- Police officers needing to be more aware of the wider economic, social, political and environmental issues concerning management
- Physical preventative measure, i.e. that the roads need to be physically safe
- Technology
- Extra police man power

This only one interpretation to a very complex problem encompasses many issues.

5. THE FUTURE OF DATA QUALITY AND GIS IN THE ROAD POLICING ENVIRONMENT

This paper has attempted to bring together the ideas and themes surrounding road traffic incidents and policing in a spatial and GIS – enabled spatial context. It has tried to explore the problems facing road accident data and its knock-on effect for ultimately decision making and deployment of resources and effective use of time and manpower. In recent years road policing and its data has received little attention however with the advances in crime mapping and GPS this field of research no doubt become subject to more research and funding. Already road policing units have seen an increase in funding because the government has recognised a potential role for traffic policing and other policing activities, since most criminal activities entail the use of a vehicle or some other mode of transport.

Finally in terms of data, it is important to acknowledge that it is unlikely that there will ever be a standardised collection procedure for contributory variables and there will always be some data error and inaccuracy. However with time a systematic approach to road traffic incident data collection would be very valuable and advances in technological innovations would lead to better measurement and monitoring of what is going on. One can never eliminate all the inaccuracies you can only manage them, which is something that the police need to seriously concentrate on. Road accident reduction as become more than just using a GIS to map hotspots, and send police officers out to the location to try and reduce the number of speeding drivers.

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