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USE OF CCTV TO DETERMINE ROAD ACCIDENT FACTORS IN URBAN AREAS

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ABSTRACT

This paper sets out to assess whether there is a potential use for images collected through the increasingly ubiquitous use of CCTV cameras in urban areas as a means of increasing understanding of the causes of road traffic accidents. Information on causation and contributory factors is essential as a means of understanding why accidents occurred and how the occurrence of similar events may be prevented in the future. CCTV records of accidents could provide an independent perspective on an accident and have the potential to increase both the quality and quantity of information available to the safety researcher.

This study focuses on an area of central Leeds in the UK and shows that an existing CCTV camera system used for urban traffic management reasons has the potential to record around a quarter of the accidents which occur in the area, based on patterns of past occurrence. Most city centres in the UK will have similar camera systems set up. By the introduction of additional strategically placed cameras and replacement of existing cameras with ones dedicated to accident recording, this figure could be increased substantially.

The paper also considers how effective cameras and video records will be as a means of identifying contributory factor information once an accident is recorded. The contributory factor classification used by a recently introduced system in Britain is assessed in terms of how visible each of the factors is likely to be on video and their relative frequency of occurrence. It is concluded that CCTV has a high potential to provide corroborative evidence about many of the most commonly occurring factors, and to throw further light on accident causation.

Keywords: Road accidents, Contributory factors, CCTV, safety, video records.

1. INTRODUCTION

This paper sets out to assess whether there is a potential use for images collected through the increasingly ubiquitous use of CCTV cameras in urban areas as a means of increasing understanding of the causes of road traffic accidents. Information on causation and contributory factors is essential as a means of understanding why accidents occurred and how the occurrence of similar events may be prevented in the future. A key problem with accident data is that it is mostly collected after the event has occurred through a mix of testimonies from those involved, site and environmental information and in some cases vehicle checks. Sometimes the information is collected by professionals with considerable experience of accidents and accident causation, at other times by those without such experience. Those who are present at the time of the accident may have reasons not to recount the complete story of the accident, rather a biased view, or they may simply be unable to do so due to memory lapse, injury or just that they do not know or understand what happened. For the accident investigator the process of reconstructing a reasonable picture of the events that led up to and during an accident is a difficult process and fraught with opportunities for misinterpretation.

An obvious approach to overcome some of these problems is to access independent records of such events and use those to improve understanding of what actually happened. It is unlikely that it will ever be possible to accurately record all such events through specialized systems set up all along the road network given, among other things, the expense, however, with the increasing use of CCTV to record all sorts of things (traffic problems, crime etc), particularly in urban areas, there is a possible source of independent records for some road traffic accidents. This paper seeks to assess how useful that source might be.

A contributory factor has been defined as “a road user or traffic system failure without which the accident would not have happened” (Carsten et al, 1989). They are of particular use at a local level for accident remedial work and to design and target educational and training programmes, but also at a more strategic level to Highway Authorities and Government to develop their road safety policy. In Britain, from

January 2005, information on contributory factors is routinely collected as part of the national accident data collection system known as STATS 19 (DfT, 2004).

Accident data suffer from two main problems: under-reporting (James, 1991; Hopkin, 1993; Austin, 1995a; Simpson, 1996; Dhillon et al, 2001; Alsop and Langley, 2001; Amoros et al, 2006) and inaccuracy. This paper focuses more on the use of video records to enhance the accuracy of our understanding of known accidents, however, it is acknowledged an additional benefit could be that the techniques described will pick up accidents which had not previously been reported to the authorities, though it is unclear how frequently such events may be identifiable.

Inaccuracy has been studied in terms of location (Ibrahim and Silcock, 1992; Austin, 1995b) and in terms of casualty data (Bull and Roberts, 1973; Hopkin, 1993; Austin, 1995a; Simpson, 1996), but it should also certainly be an important consideration when using contributory factors data. Indeed, whereas the majority of variables typically collected in accident reports (whether they relate to vehicles, casualties or the accident itself) are objective and based on observations or measured values, this is not the case for contributory factors which retain a high degree of subjectivity and imply that a judgement has been made. That judgement is normally made by the police officers who attend the accident scene, though it is worth noting that this is inevitably some time after the accident occurred and in many cases an accident may be reported directly at a police station by a participant some considerable time later. This subjectivity can also lead to inconsistency in the way that factors are coded (Broughton et al, 1998).

Police accident data are not the only source of information on road accidents and safety. Other methods of collection of information about accidents are available, for example multidisciplinary in-depth studies (OECD, 1988; Staughton and Storie, 1977; Carsten et al, 1989; Larsen, 2004) or traffic conflicts techniques (Perkins and Harris, 1967; Amundsen and Hyden, 1977; Grayson and Hakkert, 1987). The former of these are usually done on a one-off basis and are often limited by cost, whilst for the latter there still remains a degree of uncertainty about the true nature of the relationship between accidents and conflicts.

Section 2 looks at some of the literature which has reported on the use of cameras in safety studies. Section 3 examines the technical feasibility for using existing camera systems in a case study area, section 4 considers the potentially observable accidents in the case study area, Section 5 looks at the potential for cameras to capture useful information on contributory factors. A discussion of the cost effectiveness of such systems is provided in section 6, with overall conclusions in section 7.

2. USE OF VIDEO RECORDS FOR SAFETY STUDIES

2.1 Non-automated recording

Video recordings have been used over a long period of time to capture data on things such as traffic flow, road user behaviour and also for conflict studies. Spicer (1972; 1973) used video along with trained observers to record traffic conflicts and showed that in the majority of conflicts a vehicle other than those central to the conflict was involved. More recently, videos have been used to undertake detailed studies of road user behaviour in relation to safety, for example Lawton et al (2003) used video to examine the effect of roundabout geometry on cyclist behaviour, while Gray et al (2004) examined the use of a cycle track in London to more fully understand aspects of driver/cyclist interaction at certain points along the route, and Hamed and Jaber (1997) used video to collect data on vehicle-time headways..

On rare occasions a video will, by chance, capture an accident, but such events are so infrequent that it is hard to generalize from the data gained. Relatively few studies have sought to directly use video records of accidents. Pasanen and Salmivaara (1993) equipped two junctions in Helsinki with video cameras to record actual traffic accidents as part of a project on pedestrian safety. Cameras were connected to a video recorder which was continuously running and which automatically rewound to record on top of the previous recording. Therefore the last 3 hours of events were always available on tape. When an accident occurred at one of the locations a fresh tape was loaded in the recorder and the existing one stored for analysis by the researchers. Information on 11 pedestrian accidents over a period of almost 2 years was obtained and analysed. The video records confirmed what was already known, that most of the pedestrians were at fault crossing against a red light, but also that they had been hit by free moving vehicles, with a time gap from the previous car of at least 3 seconds.

2.2 Automated monitoring of safety

Malkhamah et al (2005), on the basis of measurement of vehicle decelerations and video records of driver and pedestrian behaviour at a signalized pedestrian crossing, developed a model to predict safety at such locations. This showed a good relationship between decelerations and safety and provided a means by which the safety performance of such crossings could rapidly be monitored.

The Centre d'Etudes Techniques de l'Equipement (CETE) Normandie Centre in 1985 developed a system called EURECA (Evènement Unique ou Rare Enregistré par Caméscope Automatisé) which enables the automatic video recording of abnormal and unusual road user behaviour (SETRA - CSTR, 1998). The system is composed of a video camera and a recorder controlled by a laptop which continuously records a road scene. It has various detectors, chosen as a function of the type of events to be recorded, which determine if an image should be kept: if an interesting event has been detected during the time period the sequence is validated and memorised on the cassette, otherwise the cassette is rewound to the end of the last validated sequence. Therefore only desired events are recorded on the cassette and it is possible to see what happened before and after an event. EURECA has been used in several studies related to safety, including studies of a problem location on a curve (CETE NC, 1995), evaluation of the safety of hard shoulders (CETE NC, 1989), an evaluation of lateral rumble strips on motorways (CETE NC, 1991), and analysis of road users' behaviour at railway crossings (CETE NC, 2001).

The Mitsubishi Electric Company has since 1995 been involved in the development of an automated system variously called the Traffic Accident Auto Memory System (TAAMS) or the Auto Incident Recording System (AIRS). This was first implemented in Japan at high-incident intersections before being used in particular in the USA (Rich, 2004 and Ueyama, 1996). The system uses sound-activated video recording and consists of one or two cameras with directional microphones, a video cassette recorder and a central controller. Video and sound are continuously recorded on a memory unit. When a “crash-like” sound is detected pre- and post-accident scenes are sent from the memory unit to the video cassette recorder. Then the system returns to recording on the memory unit until another incident is detected. It can also monitor and record traffic signal phases.

A study with TAAMS was conducted at six intersections in Japan to observe driver behaviour (Ueyama, 1996). Four cases (2 accidents and 2 conflicts) were selected from among accidents and conflicts recorded at a non signalised junction and studied in detail. In these 4 cases, a car on the minor road crosses the junction and a car on the major road is forced to stop. For each case speed of vehicles is calculated on each frame, that enables the identification of when drivers decide to cross the intersection (acceleration) or when they recognise a dangerous situation (about 1 second before braking). Results show that drivers usually misjudge gap distance or speed of the other vehicle.

AIRS was used in Louisville (Kentucky, USA) by the Kentucky Transportation Cabinet from 2001 to study a high-crash intersection (Rich, 2004). The memory unit was an 8 second digital memory loop which meant that for each accident only 8 seconds of information were recorded, 4 seconds before the accident and 4 seconds after. Data were collected over a 5 month period, following which several modifications were made to the intersection. Subsequent results were monitored over 6 months, showing that the accident rate dropped from 5 to 0.7 accidents per million vehicles. Valicenti (2002) identified the following benefits:

- the system does not require an expensive use of manpower,
- it provides information on near-incidents,
- it is portable and easy to install,
- it permits calculation of vehicle speeds, angles of impact and gives information on driver behaviour.

According to Valicenti, the system cost around $58,000, though these costs are expected to be recovered within 4 studies equivalent to the one described above.

A common feature of a number of specialized automated systems is that they have a high initial cost. They are thus more useful to locate in areas known to have high accident frequencies where it is likely that there will be a high rate of return from the initial investment. It is unlikely that such systems will be used to provide blanket coverage of accidents occurring across the road network, though at some locations they may provide information on accidents not reported to the authorities and hence an indication of reporting rates.

One possible way to generate wide coverage of potential accidents, which is explored in this paper, is to use existing camera systems which are spread more widely around the road network, in particular in urban areas. Although this wouldn’t give total coverage it could significantly increase the coverage available compared to other sources.

3. FEASIBILITY OF USING CAMERA SYSTEMS TO MONITOR SAFETY

This study uses information collected in part of the City of Leeds in the United Kingdom. This is a city with a population in excess of 700,000 inhabitants in which 2778 injury accidents occurred in 2004, involving 4126 casualties, of whom 45 were killed and 390 seriously injured. The total financial cost of these accidents is just over £164 million. The focus of the work reported here is a study area within the city centre which was chosen for two reasons: firstly a high volume of traffic and pedestrians result in a complicated network with relatively high accident totals over a reasonably small and manageable area; and secondly, and perhaps more importantly, there is already a high density of CCTV cameras in the area as a result of urban traffic control, police and security needs.

The first step was to estimate the proportion of accidents that could potentially be recorded with existing camera systems. This meant collecting information on the CCTV network coverage and its capability and on accidents in the study area. Principally two types of usable camera systems exist in the study area – those run by the City Council through their Urban Traffic Management and Control (UTMC) group and those run through the Leeds Community Safety *LeedsWatch* scheme. The UTMC system has been set up with the intention of monitoring traffic and traffic behaviour – hence the cameras have good coverage of the road network, particularly the main road network. The *LeedsWatch* cameras have mainly been installed from a crime prevention perspective, hence the cameras are less likely to naturally observe the road network and are biased to a degree to the more minor road network and pedestrianised areas. Other privately run cameras also exist and may have some coverage of the road network, but are more likely to be focused on buildings or locations where unruly behaviour may occur, whilst access to the images is unlikely to be forthcoming. Because of these reasons and difficulties of obtaining dedicated access from the *LeedsWatch* cameras it was decided to focus on the UTMC camera network alone to assess the potential to observe and provide useful additional information on accidents.

Within or close to the study area there are 22 UTMC cameras to monitor and manage traffic. They are controlled remotely from a central control room and all have rotate and zoom capabilities, which enable the operators to look in different directions and over some considerable distance. The usable field of view of all these cameras has been identified. Of the 22, 4 cameras were found not to be useful to monitor the study area - 3 are in a tunnel on the Ring Road (not included in the study area) and the other is designed to monitor the entrance and exit to an underground car park. Each of the 18 remaining cameras were handled in all directions in order to assess their coverage of the road network which is shown in Figure 1**.** Overall, the proportion of the total area which could be used in an accident study (the usable coverage) is about 60%.

Figure 1 about here.

In reality further examination of the camera capabilities showed that the actual practical coverage of the camera system was, for a number of reasons, somewhat less than the theoretical usable coverage. Figure 2 provides a visual example of some of the more practical problems which were encountered. These included:

- The physical impediment of buildings (Figure 2a) are a particular issue where streets are not straight since in such cases they obstruct the view after the curve.
- Problems of vegetation (Figure 2b/2c) blocking the view arise especially in spring and summer. The map of usable coverage drawn is thus representative of summer coverage.
- Street furniture (Figures 2d, e and f), such as street lamps, traffic lights and signs are common on urban streets. They may cause difficulties where a zoom is necessary if they are located between the camera and the scene to be observed.
- Road alignment (Figure 2g), in particular steep gradients, may prevent observation of the street after a crest point if the camera is not high enough.
- Large vehicles (Figure 2h) such as double-decker buses can obstruct the view, especially in more distant views.
- Temporary works (Figure 2i) carried out on streets or buildings may obstruct the view.

Figure 2 about here.

Moreover, it is also useful when studying a junction to see the whole junction. Although it may seem obvious it is in fact a major problem as most of the cameras are located at junctions in order to monitor as many roads as possible with as few cameras as possible, and because of the angle of view of the cameras, usually not high enough to observe the whole junction.

Time of day may also affect the visibility: even if cameras can “see” at night it might be difficult to observe some details. This problem is less important in urban areas since most streets are lit, but some points may still be dark. Visibility may also be affected by adverse weather conditions, though during this study the only adverse weather experienced was rain which was not felt to be a major problem, especially as some cameras are equipped with a screen-wiper which can be activated remotely from the control room. Other conditions such as snow or fog may cause more difficulties but this has not been tested as part of this study. A less obvious impact is the high contrast between shadow and bright sunshine, which the cameras have difficulty managing. Whilst these latter factors have not been taken into account to construct the usable coverage area, they will most likely result in a small reduction to the number of accidents that could be successfully recorded.

It should be noted that the primary function of the UTMC cameras used in this study is not to record accidents. For the purposes of this study, the researchers were permitted to position the cameras where required, but on the understanding that if required for UTMC business they would be reallocated. In practice this was not a problem and no coverage was lost.

The final key issue relates to the direction in which the cameras are pointed. Each camera can look in several directions and an accident may occur in the coverage area of one camera while it is pointed in the opposite direction or in the same direction but with the wrong tilt or zoom. This problem can be illustrated by the example of camera L108. Figure 3 shows the coverage area of that camera and the accidents that occurred during 2002-2004 in the vicinity.

Figure 3 about here.

A total of 35 accidents occurred in the coverage area of camera L108, 7 in the northern part, 13 in the eastern part, 13 in the southern part and 2 in the western part. Not all accident locations in the southern part can be observed at the same time, that part can be divided into 2 zones (zones 1 and 2): it is necessary to zoom to observe zone 2 at which point zone 1 moves out of view (though it may be technically possible to overcome such problems with the use of appropriate lenses). The same problem arises in the eastern and northern parts but it is more difficult to group the accidents as they are more scattered than in the southern part.

For camera L108, to maximise the chance of recording an accident it may be preferable to record only in the eastern and southern directions where most accidents occur, pointing the camera towards one of the 4 zones shown in figure 3. Each zone contains between 5 and 8 accidents, thus by recording randomly these zones an average of 6.5 accidents per period of 3 years could be expected to be recorded, just under 20% of the accidents in the coverage area of the camera.

4. POTENTIALLY OBSERVABLE ACCIDENTS

Accident data were available for the 3 year period January 2002 to December 2004, during which 534 accidents were reported in the study area resulting in 704 casualties. 459 out of the 534 accidents (86%) occurred within the camera coverage area, of which 320 (60%) occurred within the usable coverage area (see Figure 4). During this study no accidents occurred in poor visibility conditions. However, with the actual camera network as it currently exists and the fact that the cameras can rotate, zoom and tilt it is not possible to observe the whole coverage area at any one time. Given known patterns of past accident occurrence an assessment was undertaken of the likely numbers of accidents to be observable with different combinations of camera configuration. This showed that the configuration with the maximum coverage would have been capable of recording 143 (27%) accidents.

Figure 4 about here.

Cost effective solutions potentially exist to increase that proportion. The number of cameras is the principle limiting factor to the number of accidents that can be recorded and thus, adding cameras to the current network would allow the number of recordable accidents to be increased, though inevitably there would come a point where there were diminishing returns in terms of the information gained for each additional camera. It is also likely that some key accident locations would change over time, though it was concluded that the use of a recent 3 years of accident data gives a reasonable indication of future problems. The installation of additional cameras may have two distinct objectives: increasing the coverage area (and the usable coverage area if the cameras are well situated) or increasing the number of accidents that could be recorded at the same time within the existing coverage area. In Leeds City centre, given the distribution of accidents, the latter approach would probably give better results. Indeed there are few locations with high accident frequency outside the current usable coverage area, whereas the coverage area of some cameras contains several places where a number of accidents occur which currently cannot be observed simultaneously.

New cameras could also be useful to study some junctions that are actually only partly covered. Indeed junctions between a main road and a minor road are only observable from a camera located on the main road, which does not always permit observation of the approaches from the minor roads. So if such a junction is of particular interest an additional camera on the minor road located far enough from the junction or high enough over the junction would overcome that problem. Increasing the usable coverage area could also be done by locating the cameras with a view to minimizing obstacles encountered, or in some cases, such as for vegetation, removal of the obstacles.

Clearly the observable accidents are likely to show a degree of bias given the camera locations so that the recorded accidents are most likely to occur on main roads or at major junctions. However, as the aim of the approach described here is to increase researcher knowledge about the causation of as many accidents as possible occurring in the study area, it is argued that the bias issue is of minimal importance in this context.

There are various ways in which a system to video record accidents could be developed. The approach used here examines the effectiveness of using a pre-existing camera system and how it could be put to best use to record information on accidents in the study area. An alternative approach would be to focus resources on a relatively few locations, but to try to provide complete 360 degree coverage. The advantage of the former relates partly to cost (the system is essentially already in place) and the coverage of a wider range of different types of locations. The latter would enable more complete knowledge of accident occurrence to be obtained, though for fewer locations, and perhaps a more useful perspective on underreporting.

5. IDENTIFICATION OF CONTRIBUTORY FACTORS

Video recording of accidents provides the capability to ascertain and check a number of facts about an accident which may or may not be clear from the accident report. This could include features such as the weather and road surface conditions at the time, location and direction of travel of the participants, speed and behaviour and the presence or absence of temporary features such as roadworks. More importantly, however, is the potential role of the images to help the accident researcher build up a picture of the factors which contributed to the accident. It is in this area where the images have the most potential to improve understanding of why accidents occur and hence inform the development of remedial measures. The following sections examine each of the key groupings of the currently operational contributory factor scheme in Britain to ascertain the areas where video images could most usefully contribute. Figure 5 show the key factor classifications used in this scheme which has been in operation since 2005, while Table 1 indicates the relative importance of the different factors in accidents which occurred in Leeds during the year 2005.

Figure 5 about here.

Table 1 about here.

5.1 Road environment contributed

Presence of a feature does not necessarily mean it contributed to the accident and in some cases this is likely to be difficult to discern from video evidence. For example, it is easy to see that a road is slippery or wet, but it does not necessarily mean that it contributed to the accident and in some cases a driver may even use such a feature as an excuse for poor driving technique or behaviour. The video record may nevertheless be useful to confirm or deny something which has been claimed by one of the accident participants and will usefully permit knowledge of things such as the traffic signal settings at the time of the accident and the possible influence of other road users, who may not initially have been recorded as being involved in the accident (for example Southwell et al (1990), in their in-depth study of contributory factors in road accidents, showed that 2.1% of the explanatory factors assigned to their sample of 1254 accidents in Leeds involved a ‘phantom’ vehicle which was not otherwise recorded in the accident data.

On the whole it is unlikely that video records of accidents will contribute much additional information on accident causation where a road environment feature is involved, though this category of factor accounts for less than 5% of the total in Leeds.

5.2 Vehicle defects

The majority of factors related to vehicles (defective tyres, brakes, lights, mirrors, steering or suspension) are unlikely to be identifiable on a video unless, for example, a tyre exploded, though it may be possible to observe a sudden deviation of course or direction, which might reinforce existing information. A video is likely to be of less help for these factors compared to subsequent investigation of the vehicles by an expert, though it is important to note that this group of factors accounts for less than 1% of those observed in Leeds.

5.3 Injudicious action

This category of factors is potentially the easiest to observe on a video as they correspond to violations and thus often to observable vehicle movements. It is also notable that they make up nearly a fifth of the contributory factors identified in Leeds. However, in many cases other background information will be required to confirm some of the factors. The disobedience of signs or markings can only be identified if those signs or markings are in the field of view. The disobedience of automatic traffic signals is a bit more difficult to determine if not all signal heads are in view and requires knowledge of the signal sequencing and settings. Three of the 10 factors in the injudicious action category are related to distance or speed ("exceeding speed limit", "traveling too fast for conditions" and "following too close"), so distance and speed ideally should be measured, or at least estimated, from the video. This could be facilitated by putting known distance markers on the road, to tie in with a time signal on the video.

5.4 Driver/rider error or reaction

Some factors included in this category are similar to those in the previous category as they refer to observable actions, including: "junction overshoot", "junction restart", "poor turn or manoeuvre", "passing too close to cyclist, horse rider or pedestrian", "sudden braking", "swerved" and "loss of control". These factors can relatively easily be identified from a video and in total make up more than 40% of the factors identified in Leeds. A failure to signal properly or a misleading signal may also be observed provided that the indicators are visible on the video. "Failure to look properly" may be possible to observe for pedestrians, cyclists and motorcyclists (though helmets will not help here), but it is unlikely to be possible for drivers within vehicles, even if the camera is pointed by chance in the exact direction towards the car window, as the cameras are usually fitted with a window blanking system which prevents them looking through glass. The other factor in this category, “failed to judge other person’s path or speed”, cannot be identified solely from video, although if this is identified by a participant, then the video may provide corroborative evidence.

5.5 Impairment or distraction

The factors related to impairment (alcohol, drugs, fatigue, defective eyesight, mental or physical disability) are unlikely to be observed on video, except perhaps a physical disability if the driver leaves the vehicle or where pedestrians and cyclists are involved. They may sometimes be ‘guessed’ but a confirmation from the police files or the persons involved is needed. It is probably better on the whole to get this kind of information from the police or hospital report form. In total this category account for just under 6% of the Leeds factors, though it is possible that, given the density of places of entertainment within the city centre area, the figure might be slightly higher if only those accidents occurring in the city centre were considered.

Not displaying lights at night or wearing dark clothes for cyclists are identifiable factors. Distraction is difficult to identify: an object or event that could distract the driver/rider may be observed but it does not mean that distraction actually took place. Moreover, what happened inside a vehicle is not generally observable, so “distraction in vehicle” and “driver using mobile phone” are unlikely to be identified solely from video evidence.

5.6 Behaviour or inexperience

Among the factors included in the category “behaviour or inexperience”, only a few are potentially observable on a video: “aggressive driving” and “driving too slow”, provided that speed and distances can be estimated and perhaps in some instances “careless/reckless/in a hurry”. A learner may also be identified by the ‘L’ on his/her vehicle, depending on the angle and the zoom of the camera, though it is unlikely that other aspects of inexperience could be picked up as easily. The other factors in that group, such as “nervous/uncertain/panic” are only likely to be detected following an interview with the driver or rider.

5.7 Vision affected

As for distraction and road environment, an obstacle like a parked car or a tree may be seen without necessarily implying that it affected the vision of the driver. However, such information should aid in understanding what happened and provide a degree of verification of statements from those involved. The last 2 factors (“visor or windscreen dirty or scratched” and “vehicle blind spot”) are unlikely to be observable.

5.8 Pedestrians

The group of factors related to pedestrians contains some factors already cited for drivers/riders. The possibility of identifying them is slightly higher as pedestrians are not inside a vehicle. Factors related to impairment (alcohol, drugs, mental disability), behaviour (“careless, reckless or in a hurry”) or failure to judge vehicle’s path or speed are still very difficult to observe, but a physical disability or a failure to look are more likely to be identifiable than for a driver. Other factors, mainly related to behaviour and injudicious actions could be observed on a video.

5.9 Special codes

This category comprises 4 unusual factors and an “other” factor. It is possible to see that a vehicle door has been opened or closed negligently. A vehicle followed by a police car may indicate that this vehicle is in the course of criminal activity and an emergency vehicle with a siren could be on a call, but these 2 factors need confirmation. The last factor, “stolen vehicle” can not be identified only using video, and in particular the fact that it is stolen would not necessarily be a contributory factor in the accident.

5.10 Summary

The majority of factors which are most likely to be identifiable from video are of one particular type: violations. They correspond mainly to the first level of causation factors in the system devised by Carsten et al (1989), i.e. the factors that led directly to the accident. But video does not necessarily permit an assessment of why these violations happened, for example whether an individual failed to look properly or why they did not.

Nevertheless, the additional information a video may provide is useful since such information is not always available from normal data sources. Indeed, even if researchers have access to detailed police files they can be incomplete for a wide range of reasons. This is particularly likely if the accident scene is not attended by police officers, but rather the accident is reported some time later at a police station by one or more of those involved. In 2002-2004, 31% of the accidents were reported ‘over the counter’, therefore accident data may be partial in almost one third of the reported accidents. The same problem can also arise in a smaller number of cases where drivers fled the scene of the accident. It can also sometimes be difficult to figure out how an accident happened when the statements of participants and witnesses conflict. Such divergence may occur deliberately or due to misinterpretation. In these situations a video record of the accident could be a very useful tool to clarify some of the conflicting issues.

Other advantages of video records potentially include having more information on speeds and on some details that are not always reported by the Police such as the presence of parked cars.

6. DISCUSSION

Overall, in terms of the types of factors which have been identified in Leeds in the first year of operation of the contributory factor recording scheme, it appears that if the accidents were observable, a substantial proportion of the contributory factors would also have been potentially identifiable from the CCTV video record. The kinds of factors which occur most frequently (injurious action and driver/rider error or reaction) are also those which are most likely to be observable from such records.

The existing UTMC cameras in Leeds potentially permit the recording of 27% of the accidents, assuming the cameras are used solely for the purpose of accident recording. It would be relatively easy to set up a system whereby once an accident is reported within one of the camera ‘zones’, the relevant video tape is extracted and stored for further study. What remains uncertain is the time between an accident occurring and notification to the authorities. Almost a third of the Leeds accidents were reported at a police station sometime after the event. This indicates that to be reasonably sure of retaining all the useful video footage a system of continuous recording is required, along with appropriate storage of each tape until it is certain that it is safe to delete the contents.

The assessment of the potential of video evidence to help determine contributory factors indicates that such a system can be very beneficial to accident researchers, especially in terms of the identification of immediate violations. It also has the potential to help to disentangle some of the evidence (often conflicting) that is collected from more normal sources such as the participants, witnesses and from the site itself.

The cost and benefits of installing such a system in Leeds are complicated by the range of options available. An easy option would be to use the existing UTMC camera system, though this would obviously detract from its main intended purpose. Adding new dedicated cameras is likely to cost around £20,000 per installation, however, with careful siting these could be expected to provide a greater useable coverage of potential accidents than the existing cameras.

A comparison of different systems of recording using digital video recorders showed that it is possible to install a system recording continuously for around £600 per equipped camera. Adding this to the cost of installing a further 20 dedicated cameras for the centre of Leeds gives a total cost of £412,000. The average cost of an accident in Leeds in 2004 was roughly £59,000. Whilst the videos themselves will not prevent accidents, it is likely that the extra information gained about some of the accidents at some sites will enable a more comprehensive analysis of accident causation to be undertaken and hence a better development of appropriate remedial measures. Given the cost of accidents the camera system described will rapidly pay for itself and could easily be applied more widely in other urban areas.

7. CONCLUSIONS

This paper has shown that use of CCTV type cameras has considerable potential as a means of developing a greater understanding of the factors which contribute to road accidents. With relatively little investment in addition to the camera systems which exist in many city centres, it would be possible to be reasonably sure of having video records of a substantial proportion of road accidents. Such a system is probably suited most to city centre areas where there is normally a high density of roads and traffic, though it could also usefully be extended to other areas of a city, particularly where it was known that there was a high frequency of accidents - indeed such systems could be set up on a temporary basis and then moved on once the required information had been collected.

It is not intended that the use of CCTV images replaces the need for the information which is currently collected on accidents, through systems such as STATS 19 in Britain, rather that it complements what already exists and provides a source of independent information about an accident which in some cases will extend what is already known, in others merely provide corroboration. It is expected that CCTV records will increase both the quality and quantity of information on accidents available to the safety researcher and enhance their ability to accurately assess the best course of corrective action to improve safety.

The key recommendations from this research are that local highway authorities should consider how such accident recording systems could be set up in their areas and how best to develop the system of notification of accident occurrence to ensure maximum retention of relevant video records. This paper focuses on a system making use of cameras which are commonly available in urban areas. An alternative would be to focus on fewer locations to get a more complete coverage and understanding of accident causation at those locations.

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Captions

Figure 1: Part of the Leeds City Council road network showing the usable coverage by UTMC cameras and the study area boundary

Figure 2: Examples of obstruction of camera views

Figure 3: Accidents in the usable coverage area of camera L108

Figure 4: Accident locations in relation to camera coverage area

Figure 5: List of contributory factors

Table 1: Contributory factors assigned to casualties resulting from road accidents in Leeds in 2005[1]

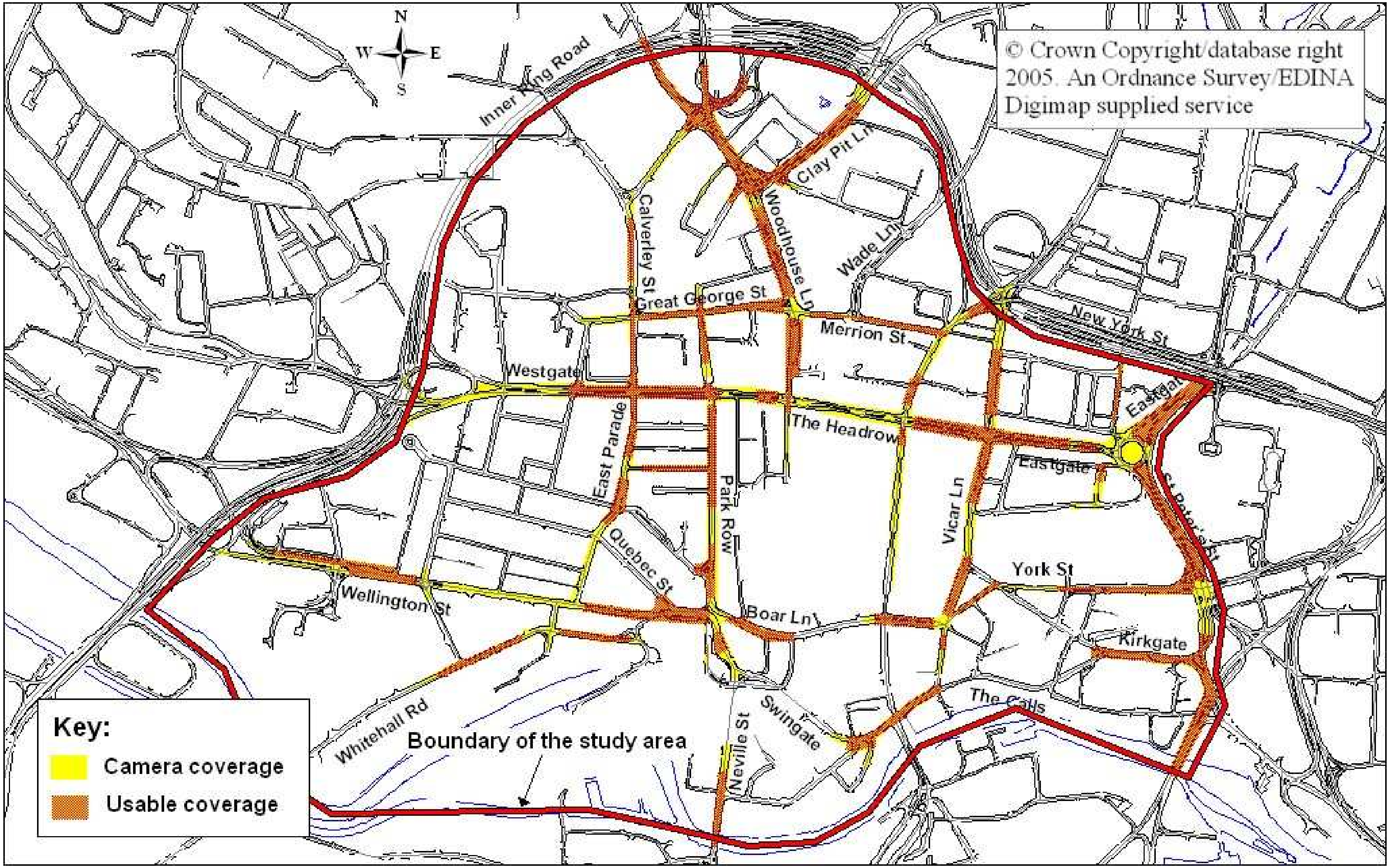

Figure 1: Part of the Leeds City Council road network showing the usable coverage by UTMC cameras and the study area boundary

Figure 2: Examples of obstruction of camera views

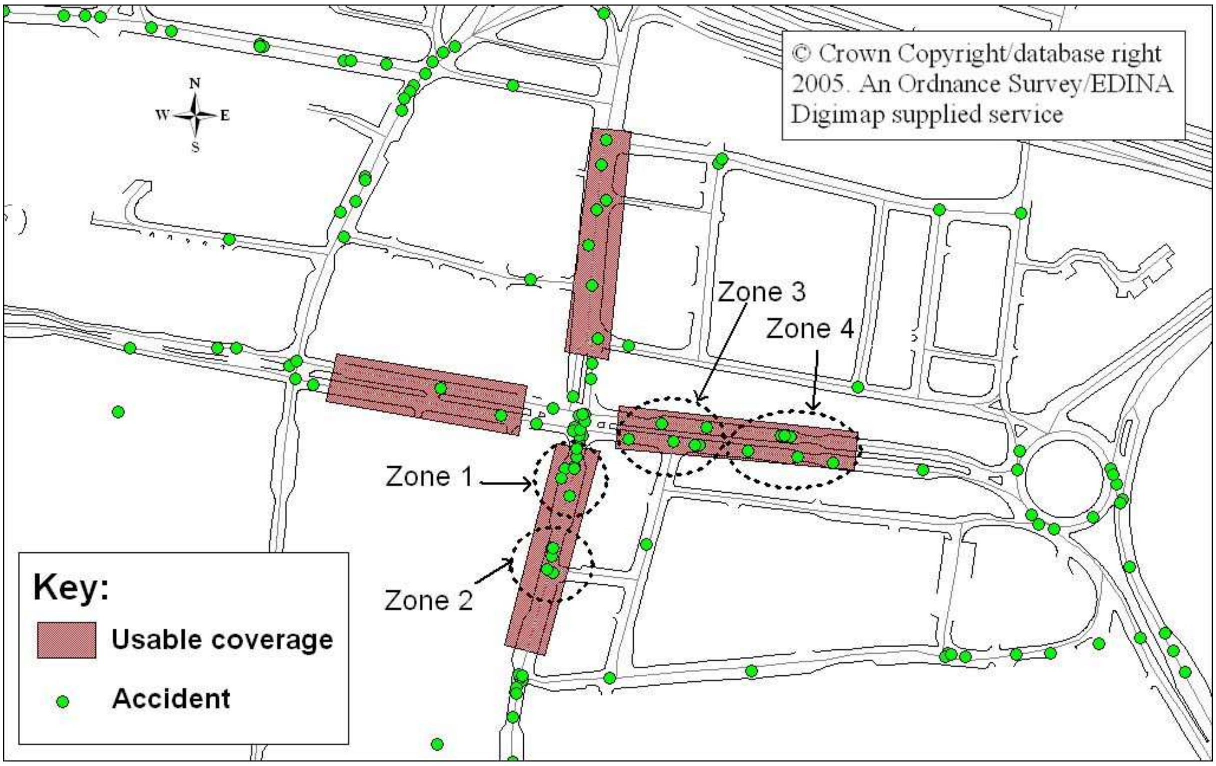

Figure 3: Accidents in the usable coverage area of camera L108

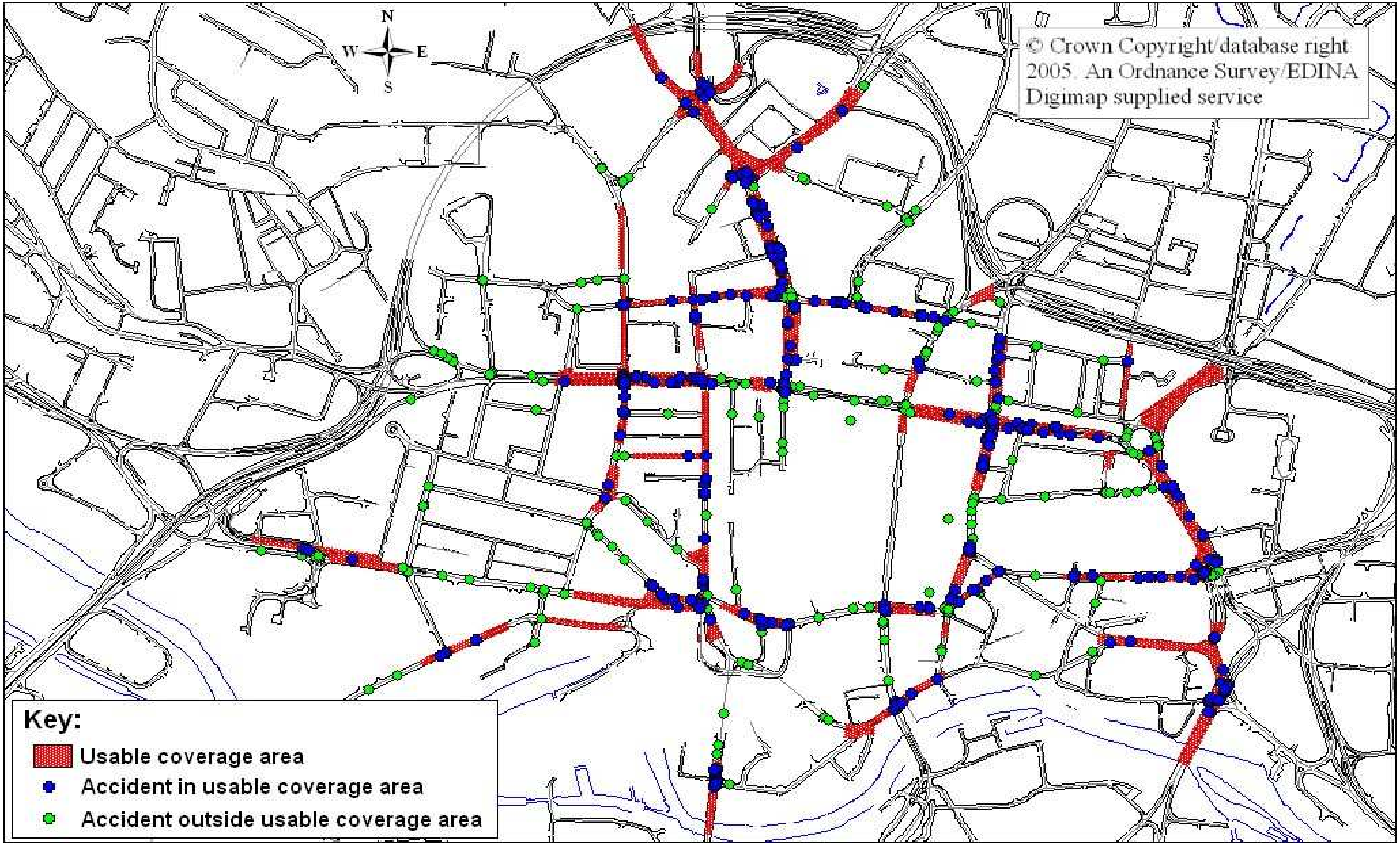

Figure 4: Accident locations in relation to camera coverage area

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

Figure 5: List of contributory factors (Source DfT, 2004).

Table 1: Contributory factors assigned to casualties resulting from road accidents in Leeds in 2005[1].

Category	*Number of factors assigned to casualties*[2]	*Percent*
Road environment contributed	256	4.6
Vehicle defects	27	0.5
Driver/rider only		
Injudicious action	1034	18.7
Driver/rider error or reaction	2351	42.5
Impairment or distraction	304	5.5
Behaviour or inexperience	565	10.2
Vision affected by	260	4.7
Pedestrian only	553	10.0
Special codes	78	1.4
Other	98	1.8
Total	5526	100.0

Source: Data provided by Leeds City Council.
[1] – note that these figures are missing a small proportion of the casualties occurring in 2005 as at the time of reporting these are still being added to the database.
[2] – note that a given casualty may be assigned more than one factor.