Published Project Report
PPR438

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Analysis of police collision files for pedal cyclist fatalities in London, 2001 - 2006

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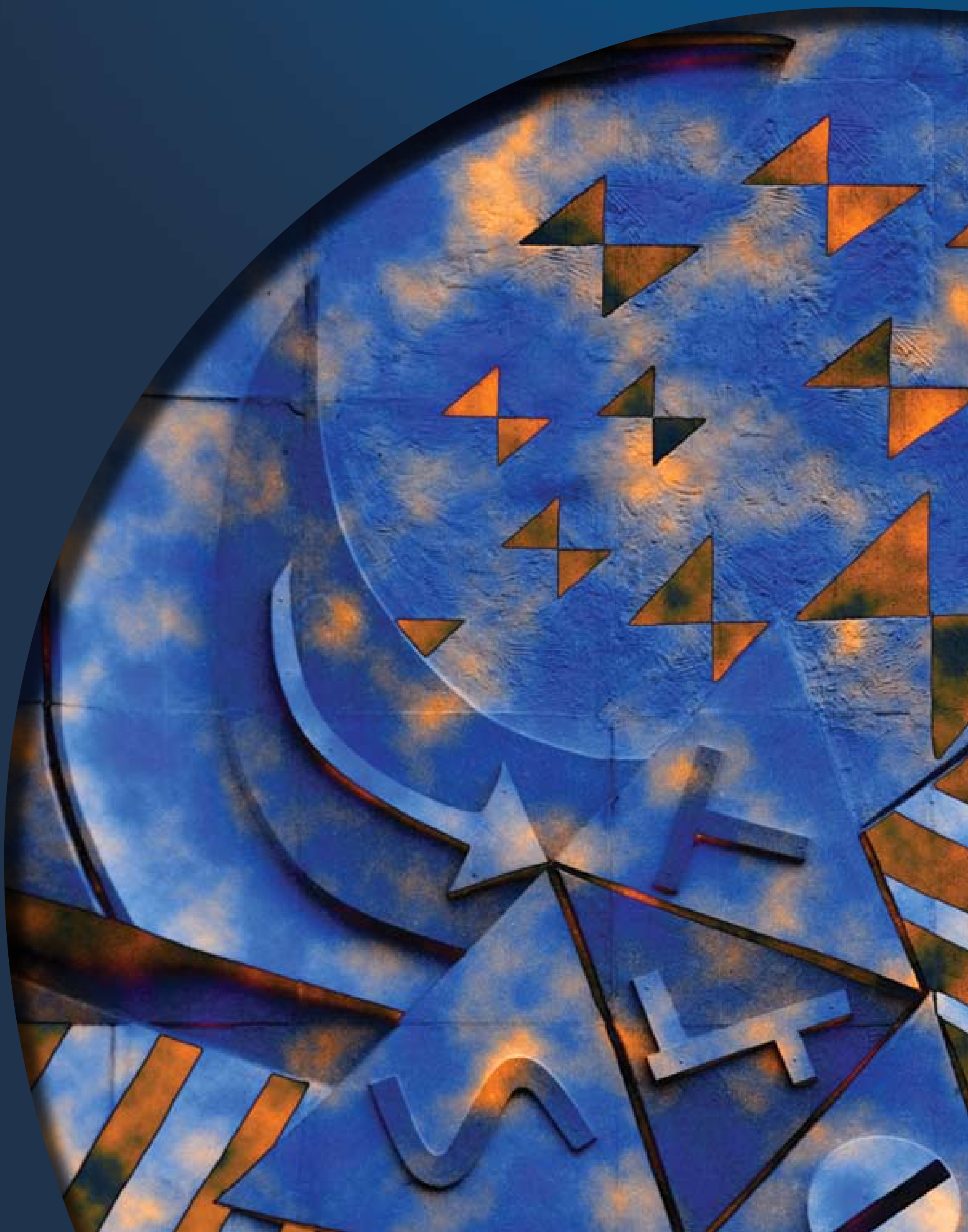

Transport Research Laboratory

PUBLISHED PROJECT REPORT PPR438

Analysis of police collision files for pedal cyclist fatalities in London, 2001 - 2006

by M Keigan, R Cuerden and A Wheeler (TRL)

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		Analysis of police fatal collision files
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Executive summary

The numbers of pedal cyclist fatalities in London have varied over the years from 1986 to 2006; averaging 18 per year, the maximum was 33 in 1989 and the minimum was 8 in 2004. There has been a substantial increase in cycling, particularly in central and inner London. The London Travel Report 2007 (Transport for London, 2007a) reported that in 2006 the cycle flows on London's major roads were almost twice as many as in 2000. During the period January 2001 to December 2006 a total of 108 pedal cyclists were killed in London.

This study has described the in-depth characteristics of 92 fatal pedal cyclist collisions in London between 2001 and 2006. These small numbers are not statistically reliable; however, this study provides very detailed qualitative data. An almost complete set of police collision investigation files were located (85%) which has reduced the potential for selection bias to distort analysis and findings.

The fatal files used for this research are a rich source of information. They contain much greater detail about the collisions, vehicles and casualties than are routinely available from other sources such as collision and casualty STATS19 data.

A content analysis of the collision files was carried out using the systematic approach to looking at collisions and the factors involved that contributed to the event, using Haddon's Matrix. This illustrates the interaction of the human, the vehicle and the environment during the three phases of the collision; pre event, event and post event. The research methods were peer reviewed by the University of Nottingham.

The following research questions were considered:

- Primary prevention: What factors contributed to the collision? How could the collision have been prevented?
- Secondary and tertiary prevention: What factors contributed to the fatal injury? How could the fatal injury have been prevented?

The analysis considered the pedal cyclist fatalities, the environmental factors, and the other vehicles and drivers (or riders) involved. A collision typology was developed to categorise the collisions and propose interventions. The collisions were categorised into 11 types. The most common (23) of these was when the pedal cyclist fatality was struck by a large vehicle changing lane to the left or turning left. The potential interventions that might have reduced the number or severity of fatalities of pedal cyclists in London are based on the expectations of the research team. Some interventions have a reasonably strong research evidence base, others less so, while for other interventions there is currently no research evidence at all. Reported efficacy is sometimes conflicting and cannot necessarily be expected to be repeated in London where the circumstances (profiles of pedal cyclists, infrastructure etc.) may be different to elsewhere.

The process of reviewing the fatal files and considering the interventions that might have been expected to have reduced their number or injury severity has led to a number of recommendations to reduce cyclist fatalities in London. They do not explicitly take account of the wider context in which decisions about cyclist safety must be made. Transport for London already undertakes varying levels of activity along the lines of some of the interventions described here.

The interventions proposed following the review of the fatal files are neither exhaustive nor presented in any order, but are directly relevant to the collisions investigated in this study. The proposed interventions relate to engineering, education (including training and publicity) and enforcement. Examples of vehicle engineering interventions are improving and installing side guards on all heavy goods vehicles and improved mirror

configuration on heavy goods vehicles. Both of these vehicle engineering interventions have particular relevance to collisions involving a pedal cyclist fatality and a heavy goods vehicle turning left.

The proposed interventions relating to education (including training and publicity) are to raise awareness of pedal cyclists by drivers and close the gap of opinion that road users hold of themselves and each other as being competent to be walking, riding and driving. These could take the form of education on the need for all road users to be more considerate of the needs of others and the skills required by each class of road user to complete their journey safely. The existing driver training included in driving lessons could be extended. Other potential opportunities for training drivers could be during professional driver training, driving lessons and other driving courses, for example speed awareness courses. Training is an important strand in the wider safety strategy for pedal cyclists. It must go hand in hand with measures to create a safer cycling environment and measures to improve the behaviour of motorists. There is anecdotal evidence that those who have received good cycle training become better drivers.

The improved conspicuity of cyclists was also proposed. Various sources recommend that pedal cyclists wear light-coloured or fluorescent clothing in daylight and poor light, and reflective clothing and/or accessories (belt, arm or ankle bands) in darkness. Further research is required to determine if increasing conspicuity does prevent serious injury and fatalities.

With respect to injury prevention, cycle helmets were identified as a potential intervention in approximately one third of the cases investigated. This work has identified the target population or those who may have been saved if they had worn a cycle helmet. However, without a forensic study of each collision and the associated injury mechanisms, which would involve consideration of impact speeds and likely biomechanical tolerance under given loading conditions, it is not possible to say how effective cycle helmets would have been for these 26 pedal cyclist fatalities. Nonetheless, it is noteworthy that cycle helmets have the potential at least, to reduce the severity of head injury. Whilst it is not compulsory to wear a cycle helmet, it is important that this information is available to cyclists so that they can consider this in conjunction with evidence available from other sources to make an informed personal choice on wearing a helmet.

Speed management was proposed relating to highway engineering and enforcement. The highway engineering intervention was the introduction of 20mph limit on residential roads which could produce a 50% reduction in pedal cyclist killed and seriously injured casualties. Increased levels of enforcement could lower the incidence of speeding and reduce the severity of injury.

Further research is needed to understand the possible benefits from the interventions put forward here on lower injury severity pedal cycle casualties. This study has shown that the fatal collision police investigation files are a valuable source of information that may not be available elsewhere. It may be appropriate to consider research for other road user fatalities, for example, pedestrians and powered two wheeler users in London.

1 Introduction

The numbers of pedal cyclist fatalities in London have varied over the years from 1986 to 2006; averaging 18 per year, the maximum was 33 in 1989 and the minimum was 8 in 2004. There has been a substantial increase in cycling, particularly in central and inner London. The London Travel Report 2007 (Transport for London, 2007a) reported that in 2006 the cycle flows on London's major roads were almost twice as many as in 2000. During the period January 2001 to December 2006 a total of 108 pedal cyclists were killed in London.

STATS19 (Department for Transport, 2008) is the national database of records of road casualties involving personal injury. This database holds details of the attendant circumstances (e.g. date, time, location and weather), details of the vehicles (e.g. vehicle type, vehicle manoeuvres and vehicle location) and casualties (e.g. age, gender and casualty severity) involved. For some years a more detailed set of data in the police fatal collision files has been collected at TRL from the police forces in England and Wales for the Department for Transport (Archive of Police Fatal Road Traffic Collision Files). Police fatal road traffic collision reports provide a unique insight into how and why fatal collisions occur on our roads. This archive preserves valuable information and enables research to be carried out into the causes and consequences of fatal collisions. The fatal files in the archive have been linked to STATS19 for this project.

These very comprehensive files include reports by collision investigation and vehicle examination specialists, sketch plans showing pre-impact trajectories and post-impact positions of vehicles, photographs of the scene and vehicles involved, transcriptions of interviews with drivers and witnesses and post mortems and contributory factors (ACPO, 2007). This detailed information is not available from any other source and can be used to gain a fuller understanding of the causes of a collision. Through understanding the nature and causes of the collisions it is then possible to investigate how they could have been prevented. This project has sought to identify the factors or primary interventions which if they had been in place may have prevented the collision occurring. Further, the project has considered the causes of the injuries and where practical identified the secondary interventions which if they had been in place may have reduced their severity. Finally, each case was evaluated with respect to any tertiary interventions such as earlier medical care, which if it had been available may have prevented the loss of life.

This study has analysed a total of 92 police fatal files that were available to the researchers, which represents a sample size of 85%. These files were for the period 2001 to 2006, where a pedal cyclist was fatally injured in a collision, within the Metropolitan and the City of London Police Force areas.

The following research questions were considered:

- Primary prevention: What factors contributed to the collision? How could the collision have been prevented?
- Secondary and tertiary prevention: What factors contributed to the fatal injury? How could the fatal injury have been prevented?

This report supersedes Webster (2006) for pedal cyclist fatalities involving goods vehicles. Webster analysed 49 collisions using STATS19 data from January 1999 to May 2004, the enhanced vehicle registration data and information received from police collision files. Whereas, this study had direct access to the police fatal collision files.

This report begins by setting the context for pedal cyclist fatalities in London and introducing the methods for applying the pedal cyclist safety interventions. This is followed by the research methods used to conduct the content analysis of the information found in the police files for 92 pedal cyclist fatalities in London during the period 2001 to 2006 and for the 95 'other' vehicles involved in the collisions. The research methods presented here do not attempt to repeat the collision investigation carried out by the police. The research method reported in section 2.2 used a systematic approach based on Haddon's Matrix (Haddon, 1999) and the results in section 3 are reported following its structure. The collisions have been categorised into types (see Section 3.1 and Appendix A) and interventions (see section 4, Appendix B and Appendix C) are proposed under the headings of education (including training and publicity), enforcement and engineering.

1.1 Investigation of a road traffic fatality

The steps involved in the investigation of a road death are detailed in the Road Death Investigation Manual (ACPO, 2007). The main stages in an investigation are:

- Notification of the incident
- Identify and secure the scene
- Full scene investigation
- Post scene considerations
- What does the investigation now know?

The manual provides guidance for the dealing with fatal or potentially fatal collisions and is intended as a guide. The logical sequence should mean that all avenues are covered and the investigation produces clear outcomes.

1.2 Comparison of pedal cyclist fatalities in London and Great Britain.

To set this research in context, the pedal cyclists killed in London have been compared to those killed on built-up[1] roads in Great Britain for the period 2001 to 2006 using data from the national road casualty database, STATS19 (Department for Transport, 2008). Table 1-1 presents the distribution of pedal cyclist fatalities, by gender, and shows that a higher proportion of female pedal cyclists and a lower proportion of male pedal cyclists were killed in London compared to Great Britain (although the distributions are not significantly different using chi-sq test at 5% significance level).

Table 1-1: The distribution of pedal cyclist fatalities by gender in London and Great Britain.

Gender	Great Britain	London
Male	81%	74%
Female	19%	26%
Sample size (=100%)	532	108

Using the same dataset the proportion of pedal cyclist fatalities by age group is shown in Table 1-2. This shows that the pedal cyclist fatalities in London tended to be older compared to Great Britain (the age distributions in London are significantly different compared to Great Britain using chi-sq test at 5% significance level).

[1] Built-up roads have a speed limit of 40mph or less.

Table 1-2: The distribution of pedal cyclist fatalities in London and Great Britain by age group.

Age group	Great Britain	London
under 16	22%	11%
16-29	19%	26%
30-59	37%	49%
60+	22%	14%
Sample size (=100%)	532	108

It is important to note that we do not know the exposure data for pedal cyclists in London by age, by gender, by distance travelled, by number or time of trips or by trip characteristics (leisure, commuter etc).

The type of vehicle involved in the collision with the pedal cyclist fatalities in Great Britain and London is shown in Table 1-3. The STATS19 variable that records the 'first contact between each vehicle' has been used to determine the type of other vehicle involved.

Table 1-3: The distribution of pedal cyclist fatalities in London and Great Britain by type of other vehicle involved.

Other vehicle involved	Great Britain	London
Motorcycle	3%	5%
Car / taxi	56%	35%
Light goods vehicle, <=3.5t[2] mgw[3]	8%	11%
Heavy goods vehicle >3.5t and <7.5t mgw	3%	3%
Heavy goods vehicle >=7.5t mgw	23%	39%
Bus or Coach	6%	7%
Others	2%	1%
Sample size (=100%)	532	108

The distributions for London and Great Britain shown in Table 1-3 are significantly different (chi-sq test at 5% significance level). The most frequent type of vehicle in collision with the pedal cyclist fatalities in Great Britain was a car / taxi and in London this was a heavy goods vehicle >=7.5t mgw.

In summary, the pedal cyclist fatalities in London were principally male, but compared with pedal cyclist fatalities in built-up areas of Great Britain there were proportionally more females (26% killed). The age distribution of pedal cyclists killed in London was different to Great Britain. Fewer older (aged 60+) and younger (aged under 16) pedal cyclist fatalities were recorded in the capital. Heavy goods vehicles (>=7.5t mgw) accounted for 23% of pedal cyclist fatalities in Great Britain and 39% in London. Sixty percent of London's pedal cyclist fatalities had a collision with a goods vehicle or large passenger vehicle (bus or coach), compared with 40% for Great Britain.

2 t=tonnes
3 mgw = maximum gross weight

This section has shown that there are differences between pedal cyclist fatalities in London and Great Britain. This has motivated the need for further understanding of the fatal collisions in London and the following section explains the methods used to do this.

1.3 Interventions for pedal cyclist safety

The evidence from the fatal collision files was reviewed and suitable pedal cyclist safety interventions suggested from the catalogue in Appendix C. The interventions included in this catalogue are based on published work, readily available grey literature and inputs from TRL and Transport for London cycling and road safety experts.

The interventions are grouped into Engineering, Education (including training and publicity), and Enforcement – the 3 E's. Some interventions include activity in more than one of the three E's.

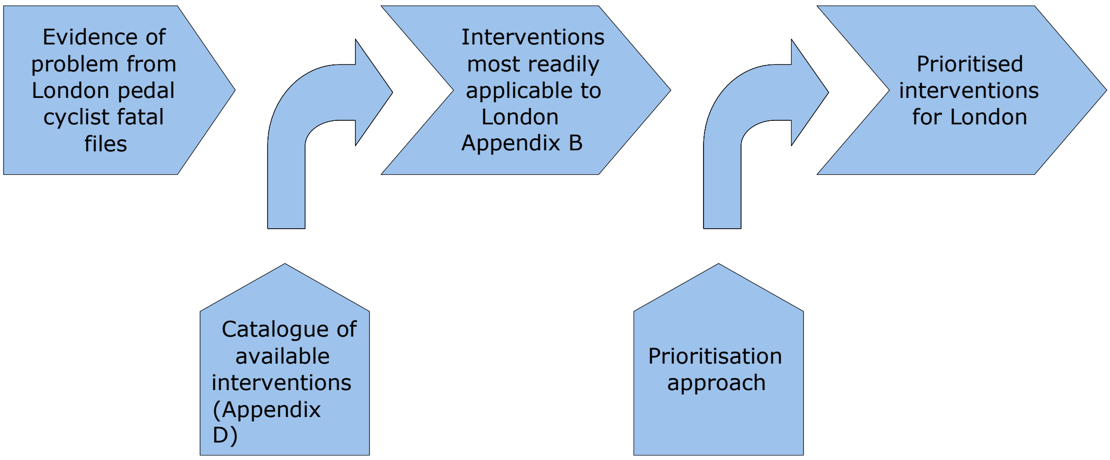

Figure 1-1: The process used to apply the interventions.

More detail on the potential interventions that have been proposed from the analysis of the police collision files are found in section 4 and those thought to be beneficial based on the evidence in the fatal files in Appendix B.

2 Research methods

The first stage of the project was to obtain a sample of fatal collision files that were as complete and up to date as possible. Of the total of 108 files for the years 2001 to 2006 85% (92) were available for analysis. This represents a fairly complete sample and the number of files that were unavailable is broadly similar for each year giving a small selection bias. The remaining 16 files were unavailable as they had not been sent to the TRL archive. This could be for a number of reasons, for example, when there was a complex or criminal investigation being carried out and the file was not closed or because the file had been recalled by the Metropolitan Police for further investigation. The circumstances for each of these collisions were different and this means that each fatal collision investigation is unique. The level of detail within the files is high. However, some of the items that were recorded within the file would only be recorded when pertinent to the collision. For example, there is no provision for knowing if the pedal cyclist was for example, wearing a helmet, not wearing a helmet or that it was unknown if a helmet was being worn if it is not mentioned explicitly in the file. This should not however diminish the rich amount of data that has contributed to road safety research.

The second stage in the research method was to analyse the files using the approach described in section 2.2.

2.1 Finding the files

The files for the years 2001 to 2006 were chosen giving 108 files for analysis. Table 2-1 gives the numbers of pedal cyclist fatalities and the number of police files that have been analysed, by year. Of the 108 fatalities 102 were from the Metropolitan and 6 from the City of London Police Force areas.

Table 2-1: Number of pedal cyclist fatalities and police fatal files found by year of collision.

Year	Number of pedal cyclist fatalities	Number of police fatal files analysed	Number of files not available
2001	21	18	3
2002	20	17	3
2003	19	16	3
2004	8	8	0
2005	21	18	3
2006	19	15	4
All years	108	92	16

The majority (73) of the Metropolitan police fatal files were located in the Archive of Police Fatal Road Traffic Collision Files stored at TRL where the content analysis was carried out. Some of the more recent files were difficult to obtain, usually because there was an outstanding criminal investigation. The police do not release the files for at least one year and possibly two to allow for these investigations to be completed. The Metropolitan Police Traffic Criminal Justice Unit was visited at Marlowe House, Sidcup, Kent to carry out the analysis of a further 13 files.

The City of London Police Force does not send its files to TRL for storage so Wood Street Police Station was visited to carry out the analysis of all six of their files. During the visit one of the collision investigators provided useful insight into some of their cases, particularly in describing the collision location.

All of the interpretation and coding of the police fatal road traffic collision files followed strict data handling and confidentiality guidelines defined in the Department for Transport protocol for accessing the fatal collision files. No personal information was collected or retained by this work programme.

2.2 File analysis approach and development

Haddon (1999) proposed a systematic approach to looking at collisions and the factors involved that contributed to the event, producing what is known as Haddon's Matrix. This illustrates the interaction of the human, the vehicle and the environment during the three phases of the collision; pre event, event and post event. This is illustrated in Table 2-2 using some general items to exemplify what is considered in each cell.

Table 2-2: Generic Haddon's Matrix.

	Human	Vehicle	Environment
Pre - event	Education, impairment	Roadworthiness,	Road design, road maintenance
Event	Use of safety devices	Safety systems fitted	Roadside furniture in place - safety barriers
Post - event	First aid available	Vehicle damage	Traffic congestion

More recently Haddon's Matrix (HM) has been used (ACPO, 2004 and World Bank, 2003) to offer a framework for data collection and analysis that adds a chronological aspect, i.e. before, during and after the event, for road collision investigators. After discussion with Transport for London, the decision was taken to use the HM to guide the content analysis of the police fatal files for this project. The HM would detail the items to record from the files. In addition, several text description fields were included in the database to enrich the findings and provide a narrative of the collision.

The structure of HM for this content analysis of police files for pedal cyclist fatalities has been developed after consultation with the project team, Transport for London and other project stakeholders and is reproduced in Table 2-3.

Table 2-3: Haddon's matrix for pedal cyclist fatalities.

	Pedal Cyclist	Other vehicle involved		Environment
		Vehicle	**Driver**	
Pre event	*Personal characteristics:* Age, gender, socio-economic status, ethnicity, postcode, cycling AND driving experience, impairment, relevant personal circumstances. *Situation:* journey purpose, knowledge of route/location, distractions (phones/earphones), speed, manoeuvres, compliance law/highway code/good practice, communication with other road user (e.g. signalling, eye contact) *Vehicle/equipment etc:* type/condition bicycle, equipment/clothing (e.g. helmet, lighting, high visibility), carrying luggage/load.	*Vehicle/s etc:* type, size, age, load, vehicle make/model, vehicle status (insurance, tax), condition (e.g. lights) *Situation:* Type of company, business sector, size of company, is it a London based company, route type, own account or third party, company policy for Heavy Goods vehicles in particular. For Heavy goods vehicles details of mirrors fitted.	*Personal characteristics:* Age, gender, socio-economic status, ethnicity, postcode, driving AND cycling experience, licence status/previous convictions, if professional driver (regular company driver, self-employed, remuneration), impairment, relevant personal circumstances. *Situation:* journey purpose (e.g. private, work, freight), duration of journey (i.e. start/finish shift), type of route (e.g. number of drops), knowledge of route/location, distractions (phones/passengers), number of occupants, speed, manoeuvres (e.g. over/under-taking), communication with other road users (e.g. signalling, eye contact), compliance law/highway code/good practice, compliance company policy.	*Situation*: Time, date, day, weather, location, land use and features (e.g. residential, commercial, school), visibility and sight lines, parked vehicles. Traffic conditions (e.g. congested, other road users around, including pedal cyclists and pedestrians), other vehicles involved/contributing to collision (e.g. opening doors), speed limit, vehicle speeds. *Road layout:* road layout (e.g. confusing road layouts/signing/marking), bus lane, traffic controls, guard rails, cycle infrastructure (e.g. cycle lane, advance stop line, London cycle route network). Road humps.
Event	*Situation:* Manoeuvres (e.g. evasion, change – including intended manoeuvres), cycling position, speed, accompanied, impairment, distractions, collision /impact with objects (e.g. vehicle, guard railing). *Vehicle etc:* Cycle lighting/cycle defects, helmet worn (or came off in collision), clothing (colour, reflective).	*Vehicle etc:* condition, roadworthiness (e.g. tyres, brakes), vehicle design, relevant features or modifications (e.g. wheel configuration, mirrors, side protective guards, over-run, bull bars)	*Situation:* Impairment, distractions, seatbelt worn, collision /impact with what, speed, manoeuvres, location/direction of impact, number of impacts, number and types of vehicles involved.	*Situation:* Speed limit, vehicle speeds, if using crossing facility, road surface (quality, state inc. contamination, wet), site maintenance (e.g. potholes, ironwork), scene plan.
Post Event	*Outcome:* Type and extent of injuries incurred, cause of death. .Immediate first aid at scene, qualified emergency personnel attended, time taken to arrive at scene, access to appropriate care facilities, hospital treatment. Legal, social/counselling for all involved. Significant comments / statements	*Outcome:* vehicle damage Ease of access for emergency vehicles. Company debriefing and reaction	*Outcome:* Type and extent of injuries incurred. Extent of investigation (e.g. duration), legal advice, social/counselling, prosecution, conviction (outcome coroner's court), driver education, other consequences (e.g. company policy). Significant comments / statements	Congestion, emergency vehicle access, facilities available in close vicinity, preserve the scene.

During this file analysis phase of the study frequent team meetings were held to discuss the availability of the desired information. Other topics were discussed to clarify information to be included in the database.

The meetings continued to be held regularly throughout the project to discuss various aspects of the files and to ensure good levels of reliability of the coding by the members of the team. Nine of the files were coded by all three members of the team to assess reliability and ensure that the coding was being done in a similar and consistent manner. The team meetings and the topics that were raised for clarification led to the decision to include three descriptive items that would be helpful when placing the cases into 'collision types'. The descriptive items are:

- What was the pedal cyclist doing?
- How did the pedal cyclist and the other vehicle interact?
- What happened next?

The team meetings also provided a useful forum to discuss any areas of concern raised by the team about the nature of information presented within the files. For example, the photographs, the post mortem reports and descriptions of the mechanism of injury could be distressing. This was managed by offering counselling to the team members.

A TRL specialist classified the injuries from the post mortem reports. This was done using the Abbreviated Injury Scale (AIS) (Gennarelli and Wodzin, 2005), which is an internationally recognised method of measuring injury severity. The AIS is based on threat to life.

Each injury description is assigned a unique six digit numerical code in addition to the AIS severity score. The first digit summarises the body region; the second digit identifies the type of anatomical structure; the third and fourth digits identify the specific anatomical structure or, in the case of injuries to the external region, the specific nature of the injury; the fifth and sixth digits identify the level of injury within a specific body region or anatomical structure. Finally, the digit to the right of the decimal point is the AIS severity score.

The AIS code (851812.3) shown in Figure 2-1 represents a fracture of the femur, where the AIS severity score is 3 (serious). This study specifically uses the AIS code for the body region injured and the AIS severity score (see section 3.4.1.1).

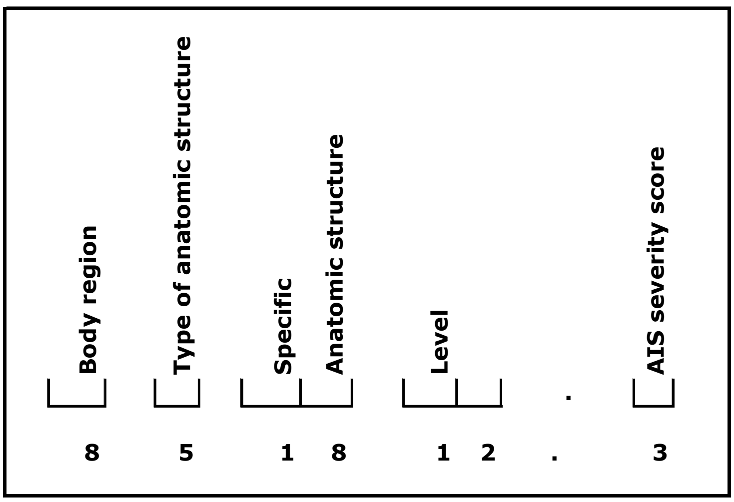

Figure 2-1: Example of an AIS code

The AIS severity score classifies individual injuries by body region on a six point ordinal severity scale ranging from AIS 1 (minor) to AIS 6 (currently untreatable), shown in Table 2-4.

Table 2-4: Description of AIS severity scores

AIS severity score	Description
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximum

MAIS denotes the Maximum AIS severity score of all injuries sustained by a casualty. It is a single number that attempts to describe the seriousness of the injuries suffered by a casualty. The AIS system therefore allows injuries to be coded by their type and severity in terms of threat to life.

The potential factors, based on the information available in the file, contributing to the collision were considered and recorded in the database. Then the possible road safety interventions were reviewed. The Haddon's Matrix was useful in this respect because the evidence from the files may suggest interventions that could apply to pedal cyclist fatalities, the other road users, the vehicles or the road environment or any combination of these.

Each file was different containing elements key to the investigation, for example the collision investigator's report, a plan of the collision scene and witness statements. These documents were not in a specific order within the file. Sometimes information was missing from the files about the pedal cyclist fatalities, for example, their intended direction of travel and journey purpose. This would have created some reporting bias in this work. This valuable information helps to build a complete picture of the circumstances around each of the collisions and is useful when carrying out this type of content analysis. A simple check list included in the files would assure the researcher that the information was sought but could not be found. However, this analysis of the fatal collision files has exploited a source of information that enriches the data available in STATS19 and any reporting bias is not considered to have biased the results. The investigations undertaken by the police during this period followed consistent protocols.

2.3 A peer review of the research methods

The University of Nottingham (UoN) have been reviewing fatal collision files for a number of years and have produced research reports on vehicle occupants (Clarke et al., 2007) and motorcyclists (Clarke et al, 2004). TRL have also carried out research using the fatal collision files into such topics as adolescent pedestrian and cyclists (Sentinella and Keigan, 2005) and motorcyclists (Lynam et al. (2001). The UoN were chosen to conduct a peer review of their methodology and the methodology used by TRL for this project. Both the UoN and TRL reviewed the same three files chosen at random from this sample of 92 and a meeting was held at the UoN to discuss the findings.

2.3.1 *TRL's method and findings*

An overview of the project was given followed by detailed analysis for the three chosen cases under review with the opportunity for discussion and finally a summary of 'collision types' and injury patterns. TRL have identified and accessed 92 police files of pedal cyclist fatalities and analysed their content using Haddon's matrix.

A summary of the research methodology detailed in section 2.2 and the three cases were presented. A scanned image of the collision investigator's sketch plan, photographs taken shortly after the collision, a list of key points and recommended interventions were shown for each case.

2.3.2 *The Nottingham group's method and findings*

The method used by the UoN to analyse the police fatal files was presented by Professor David Clarke. Although the UoN have not looked specifically at pedal cyclist fatalities it was thought that the methodology used for motorcyclist fatalities (Clarke et al., 2004) would be most suitable. A member of the University of Nottingham team visited TRL and carried out a review of three chosen cases of the Metropolitan police fatal files currently under review by TRL. Figure 2-2 represents the steps that researchers typically take to move from data on individual cases (top left) to general conclusions (bottom right). Conventional projects follow path A, while the essence of the UoN approach is to follow path B, analysing individual cases and aggregating the conclusions. The TRL methodology is similar since it also follows path B.

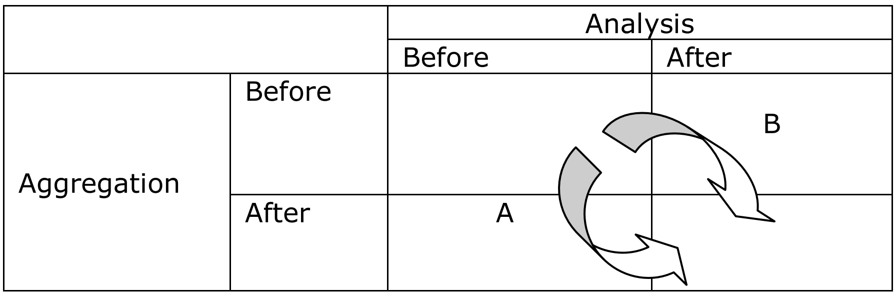

Figure 2-2: Research method showing the analysis process

The UoN team have developed their method of dealing with the cases over a number of years. The UoN entered objective data into the FileMaker Pro database, for example, date and time of the collision and class of road user. A prose account of each of the three collisions was produced and entered into the database. This prose account uses consistent terms to provide a step-by-step description of the collision from the viewpoint of the pedal cyclist. The prose account also summarises information available from witness statements and other sources within the police fatal file. Examples of these are the vehicle damage reports and the collision investigator's report. It is possible to search the database for topics of interest using the information within the prose account. An example of this type of search could be 'all collisions in the rain on a Tuesday'. The contributory factors are entered into the database using the system currently adopted by the Police. A schematic diagram of each collision is drawn and included in the database. The coders also determine suitable interventions (up to a total of 30) for each of the drivers involved. These interventions relate to prevention or mitigation of the collision and often refer to driver behaviours. The information is anonymised in order to abide by the principles of the data protection act.

2.3.3 *Discussion of approaches*

The three cases fell into the following broad categories;

- a collision at a complex junction where the exact path of the pedal cyclist was under some doubt,
- a heavy goods vehicle turning left that struck a pedal cyclist who was going ahead, and
- a collision with a car, whose driver was speeding through a traffic light controlled junction, that struck the pedal cyclist who was turning right.

During the presentations of the three cases various discussions were held which are noted under the following points:

- *Consistency of coding the information*

  TRL have assessed the reliability of the coding at several points in the course of the study. Regular meetings were held to discuss the files. Some of the topics for discussion led to improved definitions for recording in the database. There was good agreement between the coders.

  UoN reported that they had done this in the early days and do not find it necessary now. They tend to proceed with extra caution in cases where ambiguity is found.

- *Problems of reporting qualitative research*

  In general, this has led to building a matrix of 'collision types' or using a sequence of events (Sentinella and Keigan, 2005) prior to the collision and using these to suggest interventions.

- *Vehicle engineering interventions that may be suitable for pedal cyclists*

  At present, vehicle safety standards similar to the NCAP standards (NCAP, 2008) for pedestrians and vehicle occupants do not exist for pedal cyclists. Impact kinematics for pedal cyclists can be different when compared to pedestrians. Some discussion followed on the possible use of exterior airbags, raising the bonnet height and also the consideration of the effect on drivers of being involved in a collision and their subsequent quality of life.

- *Collision types*

  The collision types proposed by TRL in the presentation were thought to cover the most common scenarios.

- *Interventions - other*

  Ways of using a targeted approach to improve knowledge of the Highway Code (DSA, 2008) for the road users involved in the most frequent collision types were discussed.

- *Time taken to go through a file*

  Both TRL and UoN took around one to two hours per case, recognising that the processes involved are labour intensive. Selection of suitable cases for a project would sometimes be hypothesis led, although the UoN approach has typically focussed on particular manoeuvres, such as right turns, where collision mechanisms tend to be homogeneous, and then been data-driven.

- *Exposure measures*

  There was a general discussion considering using pedal cyclist exposure data from travel surveys etc., examples from other projects could be the casualty reduction target baseline. UoN have used some statistical techniques in the past for larger samples. In this case (92 files) the results will be reported numerically.

The more general discussion held during the meeting raised the following points:

The different methods produced good agreement on the events before, during and after the collision for all three cases. There were similar uncertainties in the first case.

The main difference was that the UoN method was more data driven than hypothesis driven. However, TRL were analysing these cases for a specific project. The Haddon's Matrix enabled a sequential account of the collision, and the inclusion of open fields to record 'what the pedal cyclist was doing', 'what the other vehicle was doing' and 'how did they interact' extended the scope of the data. The method used could be adapted for a different focus, for example, pedestrian fatalities.

Table 2-5 lists the sources of information in the police fatal files; they have not been ranked in an order.

Table 2-5: Data sources within the police files.

University of Nottingham	TRL
Collision investigator's report	Collision investigator's report
Police photographs	Police photographs
Police interview with the driver	Collision investigator's scene plan
Witness statements	Post Mortem report

Although the list of sources appears different it should be borne in mind that the collision investigator's report often includes information taken from the witness statements and the police interview with the driver. Therefore it is concluded that there was general agreement between UoN and TRL on the most reliable data sources within the files.

2.4 Finding

The UoN method has been developed over time. The TRL method was developed for this particular study and benefited from using Haddon's Matrix to drive the content analysis and propose potential interventions. It is recommended that for the future a fatality database at a national level should be created using the TRL method and enhancing it with the use of diagrams and illustrations of the collision scenarios similar to those that are used by the UoN.

3 Results

This section of the report summarises the findings for 92 pedal cyclist fatalities in London. Section 3.1 gives a general overview of the collisions by broad collision type. This is followed by results presented according to the format of the Haddon's Matrix, as described earlier in section 2.2. These results are presented under the main headings for the pre-event (see Section 3.2), the event (see Section 3.3) and the post event (see Section 3.4). Within each of these main headings the results are described for the pedal cyclist fatalities, the other vehicles involved in the collision and their drivers and the road environment.

3.1 Collision Types

This section gives a general overview of the 92 collisions involving a pedal cyclist fatality. The narratives describing the sequence of events for each collision have been reviewed and the collisions have been classified into 11 very broad collision types. These collision types are shown in Table 3-1. Further narrative details for each of the collisions by type are presented in Appendix A.

Table 3-1: Broad collision types.

	Broad collision type	Number of collisions
A	Heavy goods vehicle or bus or coach was turning left or changing lane to left and struck pedal cyclist	23
B	Pedal cyclist lost control or wobbles or makes possible slight contact with the other vehicle	11
C	Pedal cyclist was riding across the road	11
D	The other vehicle struck the pedal cyclist struck from rear	11
E	Pedal cyclist moves out to pass parked vehicles or veers to the right or is turning right	8
F	Other vehicle changing lane or has turned across the pedal cyclists' path or has lost control	7
G	Pedal cyclist against automatic traffic signal	6
H	Other vehicle door opened	4
I	Pedal cyclist entering main road	2
J	Other vehicle against automatic traffic signal	1
O	Other	8
All collision types		92

The most common (23) of these collision types (A) is when the pedal cyclist fatality was struck by a large vehicle changing lane to the left or turning left. Twenty-two of these large vehicles were heavy goods vehicles and one was a coach.

For 11 collisions the pedal cyclist 'lost control' and for 11 the pedal cyclist was struck by the other vehicle from behind. A further 11 collisions (Type C) occurred when the pedal cyclist was riding across the road at the time.

Eight of the pedal cyclists were either moving out to pass parked vehicles, veering to the right or turning right. Seven of the collisions involved a vehicle that was changing lane, or turning across the pedal cyclists' path or had lost control. In six of the collisions the pedal cyclist was riding against the automatic traffic signal.

There were four collisions where the occupant of the other vehicle opened a door into the pedal cyclist' path. In two collisions the pedal cyclist was entering the main road and in one collision a car disobeyed the red light at an automatic traffic signal and struck the cyclist. The circumstances for a further eight collisions were various and details are in Appendix A.

The following sections report on the collisions using the structure of Haddon's Matrix (1999) according to the pre – event, the event and post event for the pedal cyclist fatalities, the other vehicles and their drivers and the road environment. The collision types introduced here are used in relation to whether the collision occurred at or away from a junction, in sections 3.3.3.2, the collisions at automatic traffic signals, in section 3.3.3.3, and in relation to potential interventions in section 4.

3.2 Pre-event

3.2.1 *The pedal cyclist fatalities*

3.2.1.1 Demographics

The majority (82/92) of the pedal cyclist fatalities in the sample were adults, of which 57 were male and 25 female. Only one of the 10 children in the sample was female as shown in Table 3-2.

Table 3-2: Age and gender of the pedal cyclist fatalities.

Age group	Male	Female
<16	9	1
16-29	16	8
30-59	27	17
60+	14	-
All fatalities	66	26

The occupation of the pedal cyclist fatality was found in the file in 39 cases, 14 were students or school pupils, 8 were retired (previous occupation unknown), 3 were middle management, 8 were junior management, 3 were skilled manual, 3 were semi-skilled or unskilled and 1 was unemployed. This is in contrast to the occupation of the other vehicle drivers who were mostly semi-skilled (see Section 3.2.2.4).

The ethnicity was recorded for 74 of the pedal cyclist fatalities using the 16+1 Ethnic classification system as used in the 2001 census for England and Wales (ONS, 2001).

The numbers of pedal cyclist fatalities have been grouped into the 'major categories' of this system and are shown in Table 3-3.

Table 3-3: Fatal file description of the ethnicity of the pedal cyclist fatalities.

Ethnicity	Number of pedal cyclists
Asian or Asian British	8
Black or Black British	3
Chinese or other ethnic group	7
Mixed	1
White	55
Not stated	18
All fatalities	92

Care should be taken when using these data since the groupings have been achieved using a number of sources within the file. These included the descriptions used by the pathologist on the post mortem reports and those in the collision investigators' reports; neither of which is an ideal method for recording this information.

3.2.1.2 Cycling experience

There was some evidence of the level of cycling experience for 31 of the pedal cyclists. This was most often found in the witness statements and the collision investigator's report. Some examples of the comments noted for the more (27) experienced pedal cyclists included:

- "Regular cycle user" – witness statement.
- "Experienced" - police investigator's report.
- "Experienced cyclist, (non-UK resident), had been in the UK for over a year now and cycled everywhere" – partner.
- Had been witnessed cycling this route on number of occasions by a bus driver (witness).

Some examples of the comments noted for the less experienced cyclists were:

- "Had ridden bike when accompanied by parent, first time with guardian" - guardian.
- "Inexperienced, had borrowed bike" – collision investigator's report.

The cycling experience of the pedal cyclist fatalities was one of the items of information that was particularly challenging to find within the fatal collision files. This could contribute to a reporting bias as it may have only been noted in the file if thought relevant to the investigation.

3.2.1.3 Type of bicycle and safety equipment

The type of bicycle was known for 88 of the pedal cyclist fatalities. All (10) of the children were riding either a child's bike, a BMX or a mountain bike. Forty - three of the adults were riding a mountain bike, 12 were riding a racing / touring bike, 15 were riding a traditional town bike, two were riding a BMX and six were riding an 'other' style bike.

In terms of pedal cyclists' safety equipment 10 were reported to be wearing a helmet (in one of these instances the helmet came off during the collision). Only four of the pedal cyclist fatalities were reported to be wearing a fluorescent item, for example a vest or jacket or back pack and none were reported to be wearing fluorescent clothing. From the files reviewed it was difficult to determine the influence of clothing on the conspicuity of the pedal cyclist fatality because the evidence was unclear.

The roadworthiness of the bicycles was reviewed. Where recorded, for the vast majority of bicycles the brakes were working (67/70) and reflectors were present (50/63).

Information on whether the pedal cyclist fatality was carrying a load was recorded for 55 and the different types of load are shown in Table 3-4. This is important to consider as it may sometimes lead to the pedal cyclist becoming unbalanced and falling off.

Table 3-4: Types of load carried by the pedal cyclist fatalities.

Carrying luggage or load	Number of pedal cyclist fatalities
No load	13
Panniers	4
Rear rack	1
Front basket / handlebar bag	7
Rucksack	20
Other rider held/worn (e.g. across body)	4
Bag over handlebars	6
All types of load	55

For most of the pedal cyclist fatalities who were carrying a load this was a rucksack, which is a common type of bag and a sensible choice for a pedal cyclist. However, it is possible that this item is more likely to have been recorded in the police file when a load was being carried and thought relevant to the collision investigation. One interpretation of this is that whenever it was not recorded in the file that the pedal cyclist fatality was not carrying a load, however it is impossible to know the number of occasions when this was unknown.

3.2.1.4 Journey details

The journey purpose was recorded for 42 of the pedal cyclist fatalities. Fourteen were riding for leisure or exercise, 11 were riding either to or from their place of work or school and five were riding as part of their work.

Twenty–three of the pedal cyclist fatalities were known to have regularly travelled the route where the collision occurred and in three cases this frequency was occasionally or the first occasion. This item was not recorded for 66 of the pedal cyclist fatalities.

The speed of the pedal cyclist was described in the files using a number of terms, for example; "fast", "slow", "riding briskly", "riding very slowly" and "cycling normally". In a small number of cases (4) the speed of the pedal cyclist could be calculated. One speed was calculated from CCTV (23mph) and three were calculated from police evidence; these speeds were 11mph, 14mph and 9 mph. This limited evidence makes it impossible to comment upon the role of the speed of the pedal cyclists in the fatal collisions. Some reporting bias could be attributed to the lack of this type of information in the fatal collision files.

3.2.2 *The other vehicles and their drivers*

3.2.2.1 Types of other vehicles involved

A total of 95 motor vehicles were involved in these 92 collisions. The majority (85) of the collisions in this study involved two vehicles (the pedal cycle and one motor vehicle); five collisions involved three vehicles (the pedal cycle and two motor vehicles) and two were single vehicle collisions (the pedal cycle). The configurations of the vehicles involved in the collisions are shown in Table 3-5**.**

Table 3-5: Combinations of vehicles involved in collisions with the 92 pedal cyclist fatalities.

Vehicles involved in the collisions	Number of pedal cyclist fatalities
No other vehicle	2
Motorcycle	4
Car or taxi	26
Light goods vehicle <=3.5t mgw[4]	11
Heavy goods vehicle >3.5t and <7.5t mgw	1
Heavy goods vehicle >=7.5t mgw	35
Bus or Coach	8
Car + car	2
Car + Light goods vehicle <=3.5t mgw	2
Car + Heavy goods vehicle >3.5t and <7.5t mgw	1
All collisions	92

The circumstances of the single vehicle collisions were as follows:

- The pedal cyclist was cycling at night, without lights, downhill on the footway of a poorly lit road. The pedal cyclist hit one of a line of wooden posts on the footway. The posts did not have reflectors.
- The pedal cyclist was cycling in a bus lane where pedal cyclists were not permitted. His head was down and although braking hard he struck a 'bus driver controlled' barrier.

A large vehicle (light or heavy goods or a bus or coach) was involved in over half (55) of the collisions with the pedal cyclist fatalities and over one quarter (26) involved a car or taxi.

The steering side was known for 71 of the vehicles and of these 69 were right hand drive and 2 were left hand drive; one car and one heavy goods vehicle (over 7.5t mgw).

[4] mgw = maximum gross weight, t = tonnes

3.2.2.2 Heavy goods vehicles' mirrors

A number of different types of mirrors may be fitted to heavy goods vehicles to improve the field of vision for the drivers. These are intended to reduce blind spots in the immediate area surrounding the vehicle. Over recent years there has been some European legislation requiring different types of mirrors to be fitted to goods vehicles (Fenn et al., 2005). In 2003, a new EU Directive (2003/97/EC) on rear view mirrors to reduce blind spots to a minimum was issued. The vehicles covered by the new Directive are goods vehicles of over 3.5t maximum gross weight and passenger vehicles with more than 17 seats. The new Directive builds on the existing provisions to ensure that the field of vision is extended for new vehicles manufactured from 2003. Implementation of its rules commenced in 2005 and will be completed by early 2010.

The new requirements principally relate to:

- An increase in the compulsory minimum field of vision for certain vehicles.
- The installation of supplementary devices for indirect vision in certain vehicles (e.g. front mirrors on heavy goods vehicles).
- Adaptations to technical progress (e.g. the curvature of the surface of rear-view mirrors).
- The replacement of some rear-view mirrors with other indirect vision systems (e.g. camera-monitor devices).

An additional Directive 2007/38/EC has been issued to allow the retrofit of devices to the entire existing fleet of heavy goods vehicles. It is estimated that the entire fleet of heavy goods vehicles already in circulation in the EU will not have been fully replaced until 2023. In the interim vehicles already in circulation must be retrofitted with rear-view mirrors reducing the lateral blind spots while fulfilling the technical requirements of Directive 2003/97/EC (see Figure 3-1).

Heavy goods vehicles of over 3.5 tonnes and registered after 1 January 2000 should be fitted with lateral rear-view mirrors reducing the blind spot by 31 March 2009. Heavy goods vehicles must be fitted with rear-view mirrors that comply with Directive 2007/38/EC to pass the compulsory annual roadworthiness test imposed by Directive 96/96/EC.

The types of mirrors fitted to vehicles over 3.5t mgw fall into five categories:

- Class I – interior rear-view mirror (optional if unable to provide rearward vision, e.g. in a van with no rear windows)
- Class II – large main exterior mirror compulsorily fitted one on the driver's side and one on the passenger's side
- Class IV – wide angle mirror compulsorily fitted one on the driver's side and one on the passenger's side on vehicles over 7.5t mgw (optional on vehicles between 3.5t mgw and 7.5t mgw).
- Class V – Close-proximity mirror compulsorily fitted on the passenger's side and optional on the driver's side on vehicles over 7.5t mgw (optional on either side on vehicles between 3.5t mgw and 7.5t mgw)
- Class VI – Front mirror to cover blind spot below windscreen (since January 2007 mandatory on new vehicles over 7.5t mgw and optional on vehicles between 3.5t mgw and 7.5t mgw).

A class III (small exterior mirror) is not permitted on goods vehicles over 3.5t mgw. Class V and VI mirrors must be mounted at least 2m above ground and a class VI mirror should be visible within the area swept by a windscreen wiper. The different types of mirrors fitted to vehicles and illustrations of the field of view are reproduced in Fenn (2005).

Fresnel lenses are easy to fit lenses that stick on to the passenger window of a truck cab, improving lorry drivers' vision of cyclists who come within close proximity of their vehicles.

The improved field of view achieved after fitting these additional mirrors to a right hand drive heavy goods vehicle is shown in Figure 3-1.

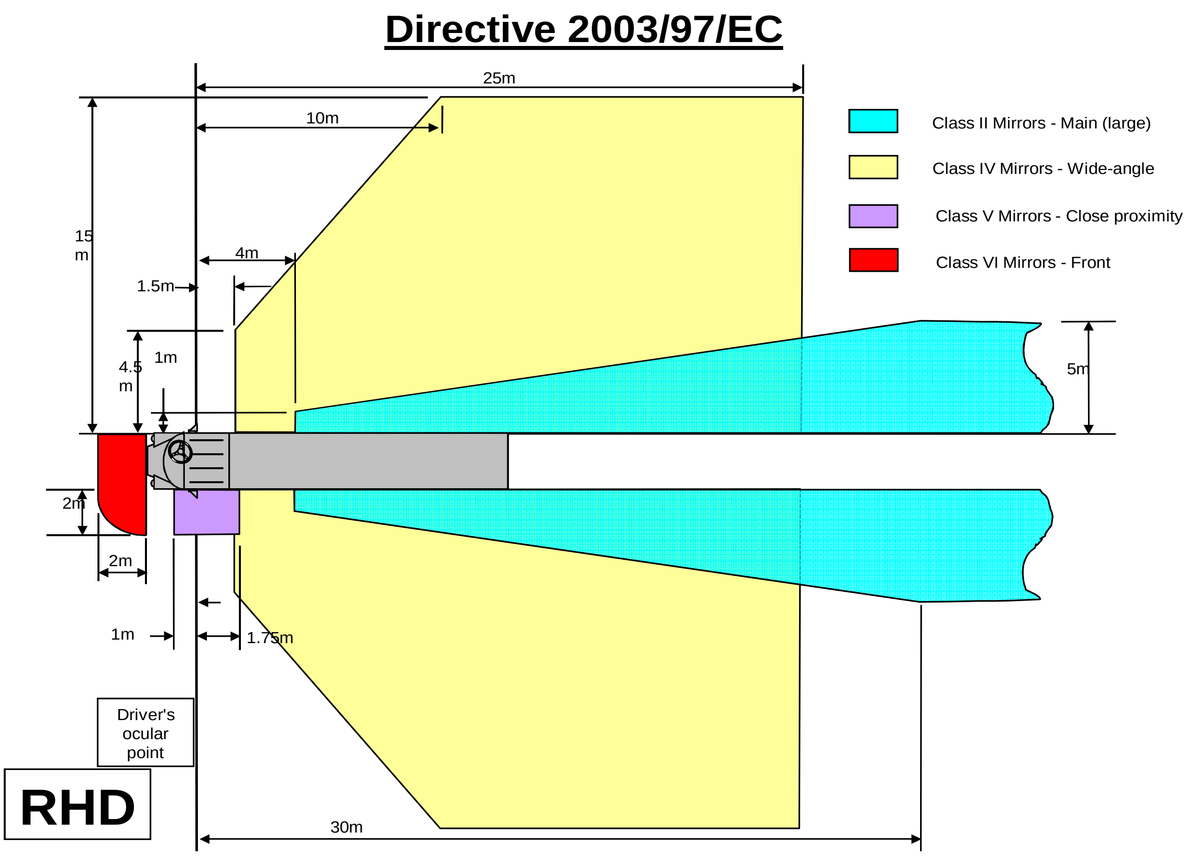

Figure 3-1: Improved field of view by additional mirrors fitted to a right hand drive vehicle

Using the photographs of the vehicles in the police files it was possible to determine the types of mirror fitted to 34 of the goods vehicles. The configurations are shown in Table 3-6.

Table 3-6: Mirror configuration where it was known for 34 goods vehicles

Mirror configuration	Vehicle type		
	Light goods vehicle, <3.5t mgw	Heavy goods vehicle >3.5t and <7.5t mgw	Heavy goods vehicle >=7.5t mgw
Class II both sides	3		5
Class II and Class IV			2
Class II and Class V			2
Class II, class IV and Class V*		2	20
All vehicles where the mirror configuration was known.	3	2	29

* *one of these vehicles was left hand drive and the sides of the vehicle where the mirrors were fitted was reversed in comparison to that of right hand drive vehicles.*

Twenty of the 29 heavy goods vehicles >= 7.5t mgw were fitted with class II, IV and V mirrors. These mirrors provide the means for a driver to check the blind spots but are dependent on being adjusted by the driver before driving the vehicle and on the driver looking at the moment when a pedal cyclist is close to the vehicle. The collision investigator's report often included details from questioning the driver on when he used the mirrors fitted to heavy goods vehicles. For one of the collisions, where CCTV was available, there was a reconstruction to show for how long the pedal cyclist would have been in view of the driver. The drivers' responses were usually that they had used their mirrors but not seen the pedal cyclist.

3.2.2.3 Condition of the heavy goods vehicles

The condition of the vehicle was recorded in 90 cases. The majority of the vehicles (84) did not have any defects that contributed to the collision. For the remaining six, one was a motorcycle (over 500cc) where the rear tyre pressure was low which made the suspension harsh and one was a goods vehicle (3.5t mgw and under) where the glass in the driver's door mirror was missing and the brake lights were not working. The remaining four cases applied to goods vehicles over 7.5t mgw and were:

- Blemish on nearside close proximity/down mirror; dirty mirrors and window.
- Defective brakes.
- Defective brakes and tyre.
- No wide angle mirror and the mirrors were incorrectly adjusted. The vehicle was badly maintained; low braking efficiency, cracked windscreen, no tachograph and a defective tyre.

Further information about prosecution of the drivers is in section 3.4.2.

3.2.2.4 Driver demographics

The majority of the drivers of the vehicles involved in the collisions with the pedal cyclist fatalities were male (85) and Table 3-7 shows the distribution of gender and age group for the 95 drivers.

Table 3-7: Age group and gender of the drivers.

Age group of driver	Male	Female	Unknown
<25	9	4	0
26-45	43	1	0
46+	25	3	0
Unknown	8	0	2
All drivers	85	8	2

Almost half (43/85) of the male drivers were aged between 26 and 45 and about one quarter were aged over 45. There were 8 female drivers involved in the collisions and the gender was unknown for two drivers. The ethnicity of the driver has been determined from the police collision investigators' report for 63 of the drivers and may be subjective. Table 3-8 gives the drivers' ethnicity and the same note of caution as applied to Table 3-3 should be applied.

Table 3-8: Fatal file description of the ethnicity of the drivers of the other vehicles.

Ethnicity	Number of drivers
Asian or Asian British	15
Black or Black British	2
Chinese or other ethnic group	0
Mixed	2
White	44
Not stated	32
All drivers	95

The occupation of the drivers was noted in the file more frequently than for the pedal cyclist fatality (see Section 3.2.1.1). It was known for 71 drivers; 5 were senior or middle management, 6 were junior management, 48 were skilled manual, 10 were semi-skilled or unskilled, 1 was retired (previous occupation unknown), and 1 was unemployed. In contrast to the pedal cyclist fatalities, over half were classified as skilled manual. This is probably because over half of the collisions involved a taxi or a bus or coach or a heavy goods vehicle and licensed drivers of these vehicles are classified as skilled manual. None of the drivers were students.

3.2.2.5 Driving experience and insurance

Fifty–two of the drivers had a valid driving licence, five were known to not have a valid driving licence and for the remainder this was unknown (35). Two of the drivers were known to be quite inexperienced (less than six months with this type of vehicle) and two admitted to not being familiar with the vehicle they were driving. The drivers cycling experience was not recorded in the fatal files. Further information on driving experience is reported in Section 3.3.2.5. Information on insurance was recorded for 62 of the drivers; 54 were insured and 8 were not insured.

3.2.2.6 Journey details

The drivers were most frequently travelling alone in the vehicle (64 out of 82 cases where this was recorded). The journey purpose was recorded for 82 of the drivers; for 54 of the drivers the journey was part of work, 18 of the drivers' journeys were for leisure or other purposes and 10 drivers were on their way to or from work. The journey purpose for the drivers of each type of vehicle is presented in Table 3-9.

Table 3-9: Journey purpose of the drivers by type of vehicle.

Journey purpose	Motor-cycle	Car	Taxi	Light goods vehicle, <3.5t mgw	Heavy goods vehicle, >3.5t mgw and <7.5t mgw	Heavy goods vehicle, >=7.5T	Bus or coach	All vehicles
Journey as part of work	0	2	3	7	2	32	8	54
Commuting to/from work	2	7	0	1	0	0	0	10
Leisure / Exercise	1	7	0	0	0	0	0	8
Other	0	7	0	2	0	1	0	10
Unknown	1	7	0	3	0	2	0	13
All types of journey	4	30	3	13	2	35	8	95

The car drivers' journey types were known for 23; they were usually driving in their local area for leisure or commuting to or from work and on only two occasions driving for work. General examples of the types of journey being undertaken are:

- "Just left home, going to friends" (9)
- "Dropping son or daughter off" (3)
- "On my way to" or "on my way from work" (6)

Unsurprisingly, the taxi, bus, coach and goods vehicle drivers were most often driving as part of their work.

A breakdown of the work sector for the 41 goods vehicles whose journey was part of work is shown in Table 3-10

Table 3-10: The work sector for the 41 goods vehicles whose journey was part of work.

Work sector	Light goods vehicle, <3.5t mgw	Heavy goods vehicle, >3.5t mgw and <7.5t mgw	Heavy goods vehicle, >=7.5t mgw	All
Construction	0	1	6	7
Delivery - retail	2	0	2	4
General haulage / distribution	0	0	16	16
Skilled trade/craft	2	0	0	2
Vehicle leasing delivery	0	1	1	2
Recycling	0	0	2	2
Delivery – building materials	1	0	1	2
Other	2	0	0	2
Unknown	0	0	4	4
All	7	2	32	41

One half (16) of the heavy goods vehicles (over 7.5t mgw) were in the general haulage / distribution sector and six were in the construction sector.

There is far more complete information in the fatal collision files for the driver than for the pedal cyclist fatality. This is because the drivers were frequently uninjured and able to be interviewed by the collision investigator at the time of the collision and to make a statement. This was not possible for the pedal cyclists because the severity of these collisions caused them to die very soon afterwards or they were too severely injured to be interviewed. Inevitably, this leads to greater detail being available in the file for the drivers of the other vehicles than for the pedal cyclist fatalities.

3.2.3 *The road environment*

3.2.3.1 Time, location, weather and lighting

The distribution of the collisions by calendar month is shown in Figure 3-2. Over one-third (33) of the pedal cyclist fatalities occurred during the three-month period May to July when the days are longer. The month when the most (13) collisions occurred was July.

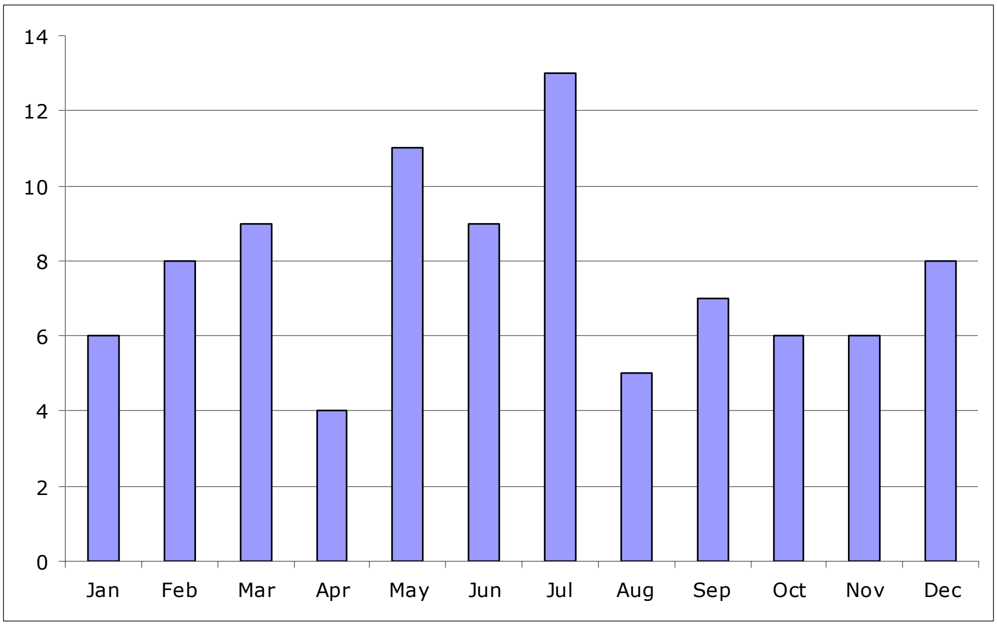

Figure 3-2: The number of pedal cyclists killed by month.

The number of pedal cyclist fatalities by hour of the day and during daylight or darkness for the years 2001 to 2006 combined is shown in Figure 3-3. The majority (72) of the pedal cyclist fatalities happened in daylight hours.

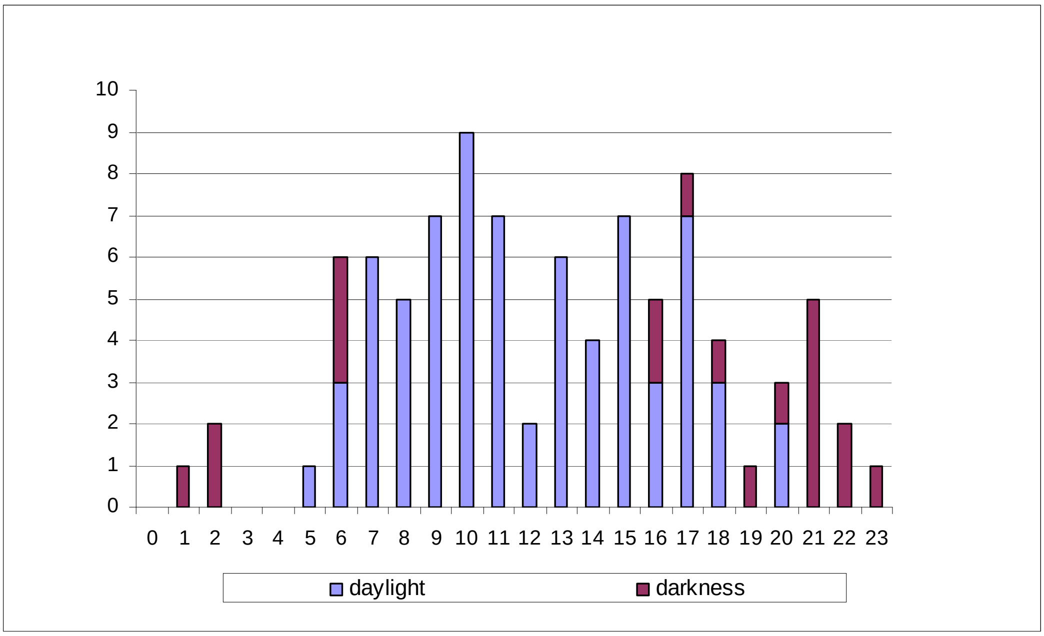

Figure 3-3: The number of pedal cyclists killed by hour of the day and daylight or darkness.

Sixty six of the pedal cyclist fatalities occurred during the 12 hour period of 0700 to 1900. There were 27 pedal cyclist fatalities during the morning peak hours of 0700 to 1000 and 18 pedal cyclist fatalities during the hours 1600 to 1900. There does not seem to be an obvious pattern to pedal cyclist fatalities occurring during the intervening hours apart from a drop at mid-day.

There were street lights present and lit at the locations where all of the 20 pedal cyclist fatalities were killed during hours of darkness. Of these 20 pedal cyclist fatalities 14 were not using cycle lights, three were using cycle lights (two flashing rear light only and one was using a front light only and for three it was unknown if cycle lights were being used.

At the time of the collision the weather was usually fine (86). The presence of obstructively parked vehicles was recorded in eight cases.

3.2.3.2 *Speed limit and traffic conditions*

The speed limit at the collision site was recorded as being 30 miles per hour (mph) for 86, 40mph for 3 cases and 50mph for 3 cases. The traffic conditions were noted in the collision investigator's report for 69 of the cases and have been summarised as light (30 cases), moderate (14 cases), busy (12 cases), heavy (12 cases), congested (1 case).

3.2.3.3 *Infrastructure*

The collision location was most frequently described as either a combination of residential and commercial (57) or residential (19). The visibility and sight lines were often described as 'good' (51).

Specific cycling infrastructure was recorded in the file for 28 of the collision sites as shown in Table 3-11.

Table 3-11: Cycling infrastructure at collision site

Cycling infrastructure at collision site	ALL
Cycle lane on the road	16
Shared bus and cycle lane	11
Shared pedestrian and cycle path	1
None	59
Unknown	5
Total	92

There was a cycle lane on the road at 16 sites. On one occasion the cycle lane (which was on the carriageway) was reported as being 0.9 metres wide, which is less than the normal recommended width of 1.5m (Transport for London 2005a). At 11 collision sites there was a shared bus and cycle lane and at one site a shared pedestrian and cycle path.

There were Advanced Stop Lines (ASL) present at 3 collision sites; the location of the pedal cyclist fatality was away from the ASL at the time of the collision (one in the cycle lane, one on the wrong side of the road and one in the centre of the lane).

A bus lane was present at 17 sites, guard rails at 25 and both guard rails and a bus lane at 6 sites. There was one occasion where the pedal cyclist fatality was trapped by the guard rails and knocked under a heavy goods vehicle that was turning left.

A 'confusing' road layout at the time of the collision was noted by the police???in 22 cases and some examples of these are:

- Multiple junction where confusion could arise over which 'arm' is straight ahead and which is the left turn.
- Narrow junction where a large vehicle needs to move to the right in order to turn left.
- A 2-way cycle lane in a one-way street.

- A pedestrian crossing was located just after the junction causing a risk of drivers / riders confusing the junction signal phase with the crossing signal phase.
- Unusually, a with-flow 'Bus Only' lane that was not shared with pedal cyclists. A bus / cycle lane in the centre of the road between two lanes of traffic.
- The bus lane terminated at the junction.

There are recommendations that after a fatal collision the road layout should be checked and improved where appropriate and it is possible that this has been done at these sites since the fatal collisions.

3.3 The Event

3.3.1 *The pedal cyclist fatalities*

3.3.1.1 Impairment

Information in the files regarding impairment of the pedal cyclist fatality has been grouped under the following headings; alcohol and / or drugs, illness or incapacity and other personal circumstances. The impairment could have influenced the pedal cyclists' reaction to the event. This information, for 17 cases, was most often found in the collision investigator's report and the toxicology report. Since this information was not routinely found in the files it may have been included in the files only when considered relevant by the collision investigator.

Alcohol or drugs

Seven pedal cyclist fatalities were known to have been drinking alcohol prior to the collision and of these, two were known to have exceeded the drink / drive limit of 80mg of alcohol /100ml blood (BAC). Traces of medicinal drugs were found in the urine of one pedal cyclist fatality. Two of the pedal cyclist fatalities were found to have taken illicit drugs as well as alcohol. These were one pedal cyclist fatality where Cannabinoids were present and another where a high concentration of heroin and traces of cannabis were found in the blood. Another pedal cyclist fatality was noted as having 'drug and alcohol dependency'. It is unknown if the presence of these drugs was a contributory factor in the collisions.

Illness or incapacitated

There were three pedal cyclist fatalities who were reported to have been unwell or possibly incapacitated at the time of the collision. These pedal cyclists were observed to be cycling 'erratically' or cycling while 'unwell' and against advice.

Other personal circumstances

There were four occasions (including 3 children) when comments under this heading were found which may have been a contributory factor at the time of the collision. The children were cycling with friends or on a paper round and the fourth was an elderly pedal cyclist who had previously fallen from his bicycle.

3.3.1.2 Distractions

Specific distraction was found in the collision investigator's report for five of the pedal cyclist fatalities; 3 were using earphones and two a mobile phone. Whether the pedal cyclist was using these devices at the time of the collision was not routinely recorded in the file.

3.3.2 *The other vehicles and their drivers / occupants*

3.3.2.1 Door opening

There were four collisions where the pedal cyclist fatality was struck by the occupant of a parked vehicle opening the door. On one occasion the passenger of a right hand drive light goods vehicle opened the door. On three occasions it was the driver who opened the door. Two of these vehicles were light goods vehicles (less than 3.5t mgw), one was a car and one was a taxi.

3.3.2.2 Speed of the other vehicle

The speed of the other vehicle involved will have a significant bearing on the outcome of the severity of injury suffered by the pedal cyclist. As has already been mentioned in section 3.2.3 the speed limit at the majority (86) of the collision sites was 30mph or less. The speed of the other vehicle at the time of the collision was recorded in 62 cases and this is shown in Table 3-12 with the source of this information. The groupings for the speed of the vehicle have been chosen because very often the vehicle speed was recorded in this way in the collision investigator's report and rarely as an exact value.

Table 3-12: Speed of the other vehicles at the time of the collision

Speed limit at collision site	Source of speed	Speed of other vehicle (mph)					
		0-15	5-20	15-30	20-40	40+	All
30mph or less	Calculated from evidence	2	1	5	6	3	17
	Estimated from evidence	5	2	0	5	0	12
	Tachograph	11	4	1	0	0	16
	Witness	4	1	2	0	0	7
	Other	1	0	2	1	0	4
	All sources	23	8	10	12	3	56
Over 30mph	Calculated from evidence	0	2	1	0	0	3
	Estimated from evidence	1	0	0	0	0	1
	Tachograph	0	0	0	1	0	1
	Witness	0	0	0	1	0	1
	Other	0	0	0	0	0	0
	All sources	1	2	1	2	0	6

The speed of the vehicle was most frequently calculated from evidence (20). In 17 cases the vehicle's tachograph indicated the vehicle speed and for 13 vehicles the speed was estimated from evidence. The majority (41/56) of the drivers were driving within a 30mph speed limit (using the ranges 0-15, 5-20 and 15-30 mph in Table 3-12). Although the drivers were driving within the speed limit, the collisions were so severe that the pedal cyclist was killed. Some of these collisions involved large vehicles turning slowly. For others speed could have been a contributory factor.

3.3.2.3 Impairment

There was one instance where the driver of the vehicle was over the drink-drive limit, the car was also being driven at speed without the owner's consent. There was no other evidence of impairment for the drivers of the other vehicles in the files.

3.3.2.4 Distraction

There was little evidence in the files regarding distraction of the vehicle driver and it may be the case that this was only recorded when thought relevant by the investigating officer. Some examples of potential distraction of the driver that were recorded in the files were:

- May have been concentrating on taxi to the offside of the vehicle that was in conflict with his bus for occupancy of the centre lane.
- The driver admitted that he was reaching for paperwork and was also distracted by a pedestrian on the central traffic island.
- While driving, the driver was suspected of possible illegal mobile phone use and consuming the contents of a 'take-away' meal.
- The taxi driver opened the door to go and help an approaching disabled passenger.
- Possibly using a mobile phone.

These five examples show the potential for distraction from driving which could have been a contributory factor in the collisions.

3.3.2.5 Driving experience and familiarity with the route

In addition to the information reported about driving experience above (see Section 3.2.2.5) some examples of comments by the vehicle driver that indicated a lack of driving experience are:

- "I was taking a family member out for ride after purchasing the car that day"
- "I was not used to driving that size of van". (A blind spot in centre of the rear of the vehicle was recorded by the police inspection of the vehicle. The vehicle was approximately one year old.)
- "It was a family member's car; the first time I had driven it".

There were a couple of examples of rather more unusual circumstances. A driver, who was known to be mentally ill, stole a van and was subsequently involved in a number of incidents including the collision with the pedal cyclist fatality. In another example the presumed driver of a hire vehicle alleged that the vehicle had been stolen from him at knifepoint; the vehicle was found abandoned.

Familiarity with the route was known for 26 of the vehicle drivers, 23 had travelled the route regularly, two had travelled the route occasionally and one was travelling the route for the first time.

3.3.3 *The road environment*

3.3.3.1 Road surface

The condition of the road surface was recorded as being in “a good state of repair” for 44 of the collision sites and was unknown for 48. An “anti-skid surface” was recorded at 24 collision sites. There was one instance of “debris” and one where there was a “raised drain cover in the cycle lane”.

3.3.3.2 At a junction

Negotiating junctions poses particular challenges for pedal cyclists. The location of the collisions by junction detail and by gender of the pedal cyclist fatality is shown in Table 3-13.

Table 3-13: Junction detail and gender of the pedal cyclist fatality

Junction detail	Female	Male	All
Not at or within 20m of a junction	3	20	23
Roundabout		2	2
T or staggered junction	11	27	38
Slip road		2	2
Crossroads	9	11	20
Multiple junction	2	1	3
Using private drive or entrance		1	1
Other junction	1	2	3
All	26	66	92

Sixty-nine of the 92 collisions occurred at a junction. A higher proportion of female pedal cyclists were killed at a junction. The collisions occurred most often at a T or staggered junction and these were in similar proportions for the male and female pedal cyclist fatalities. The two collisions that occurred at a roundabout involved male pedal cyclists.

The combinations of the vehicles involved (see Table 3-5) in the 69 collisions occurring at a junction are shown in Table 3-14.

Table 3-14: The combinations of vehicles involved and gender of the pedal cyclist fatalities where the collision occurred at a junction.

Vehicles involved in the collisions	Female	Male	All
No other vehicle		1	1
Motorcycle		3	3
Car or taxi	4	14	18
Light goods vehicle <=3.5t mgw		3	3
Heavy goods vehicle >3.5t and <7.5t mgw		1	1
Heavy goods vehicle >=7.5t mgw	18	15	33
Bus or Coach		7	7
Car + car		1	1
Car + Light goods vehicle <=3.5t mgw		1	1
Car + Heavy goods vehicle >3.5t and <7.5t mgw	1		1
All collisions	23	46	69

A total of 45 collisions involved one large vehicle (a goods vehicle >3.5t mgw or a bus or a coach) and the pedal cyclist fatality (see Table 3-5). Forty-one of these collisions occurred at a junction. Thirty-three of these involved a heavy goods vehicle (>7.5t mgw) and of these 18 involved a female pedal cyclist fatality. Eighteen collisions that occurred at a junction involved a car and for the majority of these the pedal cyclist fatality was male. At a junction, a higher proportion of female pedal cyclist fatalities were in collision with a heavy goods vehicle. At a junction, similar proportions of male pedal cyclist fatalities were in collision with a car or taxi as with a heavy goods vehicle.

The broad collision types (see Table 3-1) for the 69 collisions that occurred at a junction are shown in Table 3-15.

Table 3-15: Collision type for the collisions that occurred at a junction and gender of the pedal cyclist fatalities.

	Broad Collision type	Female	Male	All
A	Heavy goods vehicle or bus or coach was turning left or changing lane to left and struck pedal cyclist	11	11	22
B	Pedal cyclist lost control or wobbles or makes possible slight contact with the other vehicle	4	5	9
C	Pedal cyclist was riding across the road	1	6	7
D	The other vehicle struck the pedal cyclist struck from rear	1	7	8
E	Pedal cyclist moves out to pass parked vehicles or veers to the right or is turning right	1	2	3
F	Other vehicle changing lane or has turned across the pedal cyclists' path or has lost control	1	4	5
G	Pedal cyclist against automatic traffic signal	1	4	5
H	Other vehicle door opened	1	2	3
I	Pedal cyclist entering main road		2	2
J	Other vehicle against automatic traffic signal	1		1
O	Other	1	3	4
All collision types		23	46	69

The majority of the collisions that occurred at a junction involved a heavy goods vehicle turning left or changing lane to the left (type A). At a junction almost one half of the female pedal cyclist fatalities and about one quarter of the male pedal cyclist fatalities were involved in a type A collision.

Further details for collisions occurring at a junction where an Automatic Traffic Signal was present are in section 3.3.3.3.

3.3.3.3 Automatic Traffic Signals

From looking at the collision investigator's plan of the collision scene and photographs (if in the file) an Automatic Traffic Signal (ATS) was known to be present at 34 of the locations. Fifteen of the pedal cyclist fatalities at an ATS controlled junction were female and 19 were male. The junction detail and gender of the pedal cyclist fatality is shown in Table 3-16.

Table 3-16: The junction detail and gender of the pedal cyclist fatality for the 34 collisions that occurred where an ATS was present.

Junction detail	Female	Male	All
T or staggered junction	5	9	14
Slip road		1	1
Crossroads	7	7	14
Multiple junction	2	1	3
Other junction	1	1	2
All	15	19	34

Fourteen of the collisions at an ATS controlled junction occurred at a T or staggered junction and fourteen at a crossroads. At an ATS controlled junction there was a higher proportion of female pedal cyclist fatalities at a T or staggered junction and a higher proportion of male pedal cyclist fatalities at a crossroads. The combinations of the types of vehicles involved in these 34 collisions are shown in Table 3-17.

Table 3-17: The combinations of vehicles involved and gender of the pedal cyclist fatalities where the collision occurred at an ATS controlled junction.

Vehicles involved in the collisions	Female	Male	All
No other vehicle	0	1	1
Motorcycle	0	0	0
Car or taxi	3	7	10
Light goods vehicle <=3.5t mgw	0	1	1
Heavy goods vehicle >3.5t and <7.5t mgw	0	1	1
Heavy goods vehicle >=7.5t mgw	11	9	20
Bus or Coach	0	0	0
Car + car	0	0	0
Car + Light goods vehicle <=3.5t mgw	0	0	0
Car + Heavy goods vehicle >3.5t and <7.5t mgw	1	0	1
All collisions	15	19	34

Twenty one of the 34 collisions involved a pedal cyclist fatality and a heavy goods vehicle. Of the collisions at an ATS controlled junction 11 involved a car or taxi, one involved a car and a heavy goods vehicle (>3.5t and <7.5t mgw), one involved a light goods vehicle and one was a single vehicle collision. At an ATS controlled junction a higher proportion of female pedal cyclist fatalities were in collision with a heavy goods vehicle. At an ATS controlled junction the proportion of male pedal cyclist fatalities in collision with cars or taxis and heavy goods vehicles was broadly similar.

The collision type (see Table 3-1) for the collisions that occurred at an ATS controlled junction are shown in Table 3-18. Fourteen of the heavy goods vehicles were turning left (collision type A).

Table 3-18: Collision type for the collisions that occurred at an ATS controlled junction and gender of the pedal cyclist fatalities.

	Broad Collision type	Female	Male	All
A	Heavy goods vehicle or bus or coach was turning left or changing lane to left and struck pedal cyclist	7	7	14
B	Pedal cyclist lost control or wobbles or makes possible slight contact with the other vehicle	3	4	7
C	Pedal cyclist was riding across the road	1	1	2
D	The other vehicle struck the pedal cyclist struck from rear	0	0	0
E	Pedal cyclist moves out to pass parked vehicles or veers to the right or is turning right	1	1	2
F	Other vehicle changing lane or has turned across the pedal cyclists' path or has lost control	1	1	2
G	Pedal cyclist against automatic traffic signal	1	4	5
H	Other vehicle door opened	0	0	0
I	Pedal cyclist entering main road	0	0	0
J	Other vehicle against automatic traffic signal	1	0	1
O	Other	0	1	1
All collision types		15	19	34

Eleven (see Table 3-17) of the female pedal cyclist fatalities who were in a collision at an ATS controlled junction were struck by a heavy goods vehicle and seven of these heavy goods vehicles were turning left(collision type A see Table 3-18).

Ten (see Table 3-17) of the male pedal cyclist fatalities who were in collision at an ATS controlled junction were struck by a heavy goods vehicle and seven of these heavy goods vehicles were turning left (collision type A see Table 3-18).

When a collision at an ATS controlled junction occurred involving a pedal cyclist and a heavy goods vehicles the manoeuvres of the heavy goods vehicles were similar for both male and female pedal cyclist fatalities.

Table 3-19 gives further details of the pedal cyclist fatality and heavy goods vehicle's manoeuvres for the 21 collisions that occurred at an ATS controlled junction. This table uses the narratives from the collision files to describe the vehicle manoeuvres and should be read from top to bottom, i.e. each row is a subset of the one above. Four of the female pedal cyclist fatalities struck by a heavy goods vehicle turning left were thought to be intending to go straight ahead, two were thought to be intending to turn left and for one the intended direction of travel was unknown.

Four of the male pedal cyclist fatalities struck by a heavy goods vehicle turning left were thought to be intending to go straight ahead and two were thought to be intending to turn left and for one the intended direction of travel was unknown.

Table 3-19: Vehicle manoeuvres for the 21 collisions that occurred at an ATS controlled junction and involved a large vehicle and gender of the pedal cyclist fatalities.

Vehicle manoeuvres	Female	Male
All collisions	11	10
Heavy goods vehicle or bus or coach was turning left or changing lane to left and struck pedal cyclist	7	7
Cyclist going ahead and heavy goods vehicle or bus or coach was turning left or changing lane to left	4	4
Cyclist turning left and heavy goods vehicle or bus or coach was turning left or changing lane to left	2	2
Cyclist manoeuvre unknown and heavy goods vehicle or bus or coach was turning left or changing lane to left	1	1

This table show that at an ATS controlled junction, the manoeuvres for male and female pedal cyclist fatalities are similar.

From the evidence in the fatal files it is not possible to state explicitly the status of the signals at the time the collision occurred. However, there were six instances when it was known that the pedal cyclist fatality had disobeyed a red signal and one where the driver had disobeyed a red signal (see Table 3-1).

3.3.3.4 Away from a junction

Twenty-three of the collisions occurred away from a junction. The combinations of the vehicles involved in these collisions by gender of the pedal cyclist fatality are shown in Table 3-20.

Table 3-20: The combinations of vehicles involved and gender of the pedal cyclist fatalities where the collision occurred away from a junction.

Vehicles involved in the collisions	Female	Male	All
No other vehicle	0	1	1
Motorcycle	0	1	1
Car or taxi	0	8	8
Light goods vehicle <=3.5t mgw	1	7	8
Heavy goods vehicle >3.5t and <7.5t mgw	0	0	0
Heavy goods vehicle >=7.5t mgw	1	1	2
Bus or Coach	1	0	1
Car + car	0	1	1
Car + Light goods vehicle <=3.5t mgw	0	1	1
Car + Heavy goods vehicle >3.5t and <7.5t mgw	0	0	0
All collisions	3	20	23

The majority of the 23 pedal cyclist fatalities involved in a collision away from a junction were male. The type of other vehicle that was most often involved in a collision, away from a junction, with the male pedal cyclist fatalities were cars, taxis or light goods vehicles. The collision types for the 23 collisions that occurred away from a junction are shown in Table 3-21.

Table 3-21: Collision types for the 23 collisions that occurred away from a junction and gender of the pedal cyclist fatalities.

	Broad Collision type	Female	Male	All
A	Heavy goods vehicle or bus or coach was turning left or changing lane to left and struck pedal cyclist	1		1
B	Pedal cyclist lost control or wobbles or makes possible slight contact with the other vehicle		2	2
C	Pedal cyclist was riding across the road	1	3	4
D	The other vehicle struck the pedal cyclist struck from rear	1	2	3
E	Pedal cyclist moves out to pass parked vehicles or veers to the right or is turning right		5	5
F	Other vehicle changing lane or has turned across the pedal cyclists' path or has lost control		2	2
G	Pedal cyclist against automatic traffic signal		1	1
H	Other vehicle door opened		1	1
I	Pedal cyclist entering main road			
J	Other vehicle against automatic traffic signal			
O	Other		4	4
All collision types		3	20	23

The most frequent collision type for the 23 pedal cyclist fatalities involved in a collision away from a junction was type E, where the pedal cyclist fatality moved out to pass parked vehicles or veered to the right or was turning right. This highlights the 'turning right' manoeuvre that is viewed as one of the most risky for pedal cyclists.

3.4 Post event

3.4.1 *The pedal cyclist fatalities*

3.4.1.1 Injuries

The most severe impact to the pedal cyclist fatality was most frequently recorded as 'runover' (39) and this was usually by the first or second axle of the other vehicle involved. The pedal cyclist fatality suffered the most severe impact from striking the other vehicle in 23 cases, from hitting the ground in 16 cases and from multiple contacts in 9 cases. The most severe impact can be difficult to ascertain when the pedal cyclist has experienced a significant collision with the vehicle and the ground or road side object(s), because of this the most severe impact for 6 pedal cyclist fatalities was unknown. The category 'runover' was always associated with a bus or coach or goods vehicles, often with relatively low impact speeds (less than 15 mph). The injury mechanisms described for the 'runover' collisions involved crushing injury.

For 66 of the pedal cyclist fatalities it was possible to AIS code each injury they sustained. The AIS coding system allows each injury to be scored with respect to threat to life and is correlated with a body region. The pedal cyclist fatalities were grouped with respect to the pattern of severe injury they sustained by each of these body regions (Gennarelli and Wodzin, 2005). Severe injury was defined as any life threatening injury (AIS score 3 or greater) and the pedal cyclist fatality groups are presented in Table 3-22.

The most common Injury Classification Group was head injury only (18) used in Table 3-22 and Table 4-4; followed by severe injuries (AIS 3+) both to the head and thoracic body regions (13). The majority of the pedal cyclist fatalities (41) sustained life threatening injury to multiple body regions. Table 3-22 shows that the majority of the pedal cyclist fatalities with known injury data (AIS 3 or greater injury) suffered life threatening trauma to the head (47) and thorax (41).

Table 3-22: Pedal cyclist fatalities' body regions injured – Injury Classification Groups

Injury Classification Group	Body region injured at AIS 3 or greater severity					Total (pedal cyclist fatalities)
	Head	Thorax	Abdomen	Spine	Lower Extremity	
1. Head only	18					**18**
2. Thorax only		5				**5**
3. Lower extremities only					2	**2**
4. Head and thorax	13	13				**13**
5. Head, thorax and abdomen	1	1	1			**1**
6. Head, thorax, abdomen and lower extremities	3	3	3		3	**3**
7. Head, thorax and lower extremities	5	5			5	**5**
8. Head, thorax and spine	2	2		2		**2**
9. Head and spine	1			1		**1**
10. Head and lower extremities	4				4	**4**
11. Thorax and abdomen		4	4			**4**
12. Thorax, abdomen and lower extremities		3	3		3	**3**
13. Thorax and lower extremities		5			5	**5**
Body region total	47	41	11	3	22	**66**

The pattern of injuries sustained is more complex when all injuries are considered, but for simplicity Table 3-22 only details injuries with AIS scores of 3 or higher.

Injury Classification Group 1 (Head only) comprised 18 pedal cyclist fatalities who died from their head injury. Fifteen of this group were male. The ages in this group ranged from 6 to 74 years, with a median of 40 years. The injury mechanisms assigned by the TRL investigators to these 18 pedal cyclist fatalities were principally correlated with impact with the ground (10). Two were identified as crush injury caused by being 'runover'. Excluding the two pedal cyclists who were 'runover', five were believed to have suffered their head injury from contact with the ground, another vehicle or a combination of these and sustained internal head injury with no skull fractures. The remaining pedal cyclists all suffered skull fractures and internal organ injury (including those who were 'runover').

Only one in this group was known to have been wearing a cycle helmet (see section B.2.2.2). The pedal cyclist fatality who was wearing a helmet was involved in a collision with a car and he was thrown from his bike. The car is believed to have turned right across his path and there was damage to the near-side rear wing, rear door and the window was smashed.

There were 18 pedal cyclists in Injury Classification Group 1 who sustained life threatening injuries to the head only, of which 15 were neither 'runover' nor already wearing a helmet. These 15 form a target population, where a cycle helmet may have prevented or reduced the severity of their injuries. However, from the information available it is not possible to categorically judge whether or not cycle helmets would have mitigated the head injury they experienced and potentially saved their life.

The life threatening injuries sustained to the thorax, abdomen, spine and lower extremities were caused either as a result of 'runover' collisions (crushing injury) or were the result of blunt impact trauma, normally involving higher impact speeds (> 20 mph). There was a diverse range of injuries experienced by the pedal cyclist fatalities.

3.4.1.2 Emergency care

There was immediate first aid provided at the scene for 69 of the cases. The time taken for qualified emergency personnel to arrive at the scene of the collision was recorded for 65 of the cases and this was most frequently (58) within fifteen minutes. The Helicopter Emergency Medical Service (HEMS) helicopter or emergency response car arrived for 26 cases. The time taken to arrive at a hospital or specialist unit was recorded for 25 cases and for 11 this was within half an hour of the time of the collision. Despite medical care thirty-four of the pedal cyclists died at the scene of the collision.

3.4.1.3 Coroners' verdict

The Coroner's verdict was found in the files for 46 of the cases. These were: accidental death, 39; traumatic road death, 5; one death by misadventure and for one case an open verdict was recorded. The Coroners' verdict by the types of vehicle involved in the collisions is shown in Table 3-23. Of the 39 pedal cyclist fatalities where the Coroner's verdict was accidental death 15 were hit by a car, 14 by a heavy goods vehicle, four by a bus or coach, three by a light goods vehicle, two by a car and a light goods vehicle and one by a motorcycle.

Table 3-23: The Coroners' verdict by the types of other vehicles involved in the collision.

	Coroners' verdict					
Vehicles involved in the collisions	**Accidental death**	**Traumatic road death**	**Death by misadventure**	**Open verdict**	**Unknown**	**ALL**
None					2	2
Motorcycle	1		1		2	4
Car or taxi	15				11	26
Light goods vehicle <=3.5t mgw	3	2		1	5	11
Heavy goods vehicle >3.5t and <7.5t mgw					1	1
Heavy goods vehicle >=7.5t mgw	14	1			20	35
Bus or Coach	4	1			3	8
Car + car		1			1	2
Car + Light goods vehicle <=3.5t mgw	2					2
Car + Heavy goods vehicle >3.5t and <7.5t mgw					1	1
All collisions	39	5	1	1	46	92

3.4.1.4 Other comments

Significant comments / statements from the family of the victim were rarely recorded in the files. Two examples were that "the death had had a severe impact on the victim's family" and in another instance "the victim's family were not keen to prosecute the driver".

3.4.2 *The other vehicles and their drivers*

Many (42) of the drivers of the other vehicles involved in the collisions were recorded as suffering from shock; for three drivers this was recorded as serious and for three it was recorded as slight.

There was limited information on prosecution in the files. Some of the files were subject to continuing investigation. However, 40 of the 95 drivers involved in these collisions were prosecuted. The most frequently recorded types of offence were driving without due care and attention (15 drivers) and causing death by dangerous driving (13 drivers). Of the 40 drivers who were prosecuted 28 were convicted.

Three of the four drivers who were driving a heavy goods vehicle over 7.5t mgw where a vehicle defect was recorded (see section 3.2.2.3) were prosecuted.

Two of the prosecutions were for driving without due care and attention and both drivers were found guilty. One was fined with a disqualification and the other was fined and received six points on his driving licence.

The third driver did not stop and was prosecuted for causing death by dangerous driving, found guilty and sentenced to imprisonment for one year and ordered to sit an extended driving test. There was insufficient evidence for a prosecution of the fourth driver.

Involvement in these collisions had a profound impact on many of the drivers and a couple of examples of comments found in the files are:

- "I have never driven a heavy goods vehicle since"; and
- "I have disposed of the car".

3.4.3 *The road environment*

Following the guidance in the Road Death Manual (ACPO, 2004) it was known from the evidence in the fatal files that the road was closed for 68 of the collisions. There was no evidence in the files to suggest that congestion following event had any impact on the care of the pedal cyclist fatality.

4 Interventions for pedal cyclist safety

This section proposes interventions for prevention of the collisions (see section 4.1) and the fatal injury (see section 4.2). A method for giving the interventions a priority for pedal cyclist fatality collisions in London is discussed in section 5. Some interventions have a reasonably strong research evidence base, others less so, while for other interventions there is currently no research evidence at all. The interventions discussed in the following section relate only to those collisions investigated in this study

4.1 How could the collision have been prevented?

During the analysis of the police fatal collision files the evidence has been assessed and the research team have suggested potential interventions. More detail on the suggested interventions is given in Appendix B. The interventions have been grouped into three categories; those relating to engineering, education (including training and publicity) for the road users and enforcement. The following three tables (Table 4-1, Table 4-2, and Table 4-3) show the interventions by their category linked to the collision types described in Table 3-1 and Appendix A. In these tables the numbers in the 'all' column denote the total number of collisions where the intervention was considered appropriate. For example, in Table 4-1 for two of the type B collisions (there were 11 in all) it was suggested that intervention B.1.1.2 – 'Propose changes to junction layout' would be worth considering. The numbers in the tables do not total to the number of collisions by their type because there may have been more than one suggested intervention for each collision.

It should be remembered that the collisions and their outcome are determined by *multiple* factors which coincide. The proposed interventions may address one of these factors but may not always be effective in preventing a collision.

4.1.1 *Engineering interventions*

The group of suggested engineering interventions (see section B.1 for further details) for the 92 fatal collision files are shown in Table 4-1. The interventions numbered B.1.1.1, B.1.1.2, B.1.1.3 and B.1.2.1 relate to highway engineering and the interventions numbered B.1.1.5 and B.1.1.6 relate to vehicle engineering.

Table 4-1: Engineering interventions by collision type

Engineering intervention	Collision Type, where N = number of collisions											
	A **N=23**	**B** **N=11**	**C** **N=11**	**D** **N=11**	**E** **N=8**	**F** **N=7**	**G** **N=6**	**H** **N=4**	**I** **N=2**	**J** **N=1**	**O** **N=8**	**All** **N=92**
Highway engineering												
B.1.1.1 - Introduce or improve cycle lanes	1	4			1							6
B.1.1.2 - Propose changes to junction layout		2	1									3
B.1.1.3 - Change Automatic Traffic Signal (ATS) priority					1	1					1	3
B.1.2.1 - Introduce other cycling infrastructure		3	2	1								6
Vehicle engineering												
B.1.1.5 - Improve field of view for heavy goods vehicle drivers - mirrors	9	1	2	1		1					1	15
B.1.1.6 - Improve field of view for heavy goods vehicle drivers - sensors and CCTV	20	5				1						25

The infrastructure related engineering interventions suggested mainly raise issues that segregate or decrease the frequency of interaction of the pedal cyclists and other modes. This may not always be possible where road space is limited. Consideration could be given to providing a shared space for road users as is being planned for Exhibition Road in the London Borough of Kensington and Chelsea. Others mention maintenance of the road environment, for example, defects in the road surface and the vegetative growth at the roadside.

The most frequent vehicle related engineering interventions related to collision type A, a heavy goods vehicle or a bus or coach turning left or changing lane to the left and struck the pedal cyclist. In these circumstances it is suggested that close proximity sensors (B.1.1.6) may have helped to prevent 20 of the 23 collisions occurring. However, at present there is no research evidence that these devices work or that they would help to prevent collisions in London. It is possible that these devices would overload the driver with information and make the driving task too complex.

The various types of mirror have been described in Section 3.2.2. Also, for collision type A there were 9 collisions when it was thought that an improved mirror configuration may have helped to prevent the collision from happening.

There were some instances (3) where the mirror configuration could have been improved, for example, when only a Class II mirror was fitted and also occasions (9) where a Class VI mirror would have helped the driver to see the blind spot below the windscreen. These interventions could improve the ways that the driver may be alerted to the presence of a pedal cyclist and are dependent on being used effectively at the appropriate moment while driving.

4.1.2 *Education interventions*

The education (including training and publicity) interventions (see Section B.2) have been suggested for pedal cyclists and for the drivers of the other vehicles and are shown in Table 4-2.

Table 4-2: Education (including training and publicity) interventions for each collision type

Education, training and publicity intervention	**Collision Type, where N = number of collisions**											
	A N=23	**B** N=11	**C** N=11	**D** N=11	**E** N=8	**F** N=7	**G** N=6	**H** N=4	**I** N=2	**J** N=1	**O** N=8	**All** N=92
B.2.1.1 - Improve pedal cyclists' awareness of other road users and their intentions	22	6	7	4	4	3	5	1	2	1	3	58
B.2.1.2 - Cycle training			3									3
B.2.1.3 –Improve drivers' awareness of pedal cyclists	23	8	1	3	3	3		1		1	1	44
B.2.2.1 –Reduce impaired cycling					2		1				3	6
B.2.2.3 – Improve pedal cyclists' conspicuity			1	2	3	1	1				2	10
B.2.2.4 – Address carrying loads on bicycles		1										1
B.2.2.5 - Roadworthiness of bicycles		1										1
B.2.2.6 - Roadworthiness of vehicles									1			1

The potential for education, training and a publicity campaign aimed at pedal cyclists to encourage good practice that could prevent all collision types is evident in Table 4-2. The evidence from the collision files suggests that areas to focus on could include:

- Remind pedal cyclists to look and signal before making manoeuvre.
- Education and training for pedal cyclists to obey traffic signals and check that road is clear before executing manoeuvre.
- Pedal cyclists should not use sections of the road prohibited to pedal cyclists.
- Pedal cyclists to be taught not to use devices that can distract / impair hearing.
- Pedal cyclists to be vigilant when passing occupied parked vehicles.
- Training should include module on not riding alongside large vehicles especially when entering junctions and roundabouts and at ATS.
- The dangers of drinking alcohol and then riding a bicycle.

In addition, an education campaign focused towards the drivers of the other vehicles involved could encourage them to become more aware of the pedal cyclists. Areas of particular focus, sourced from the collision files, should include:

- Be more 'cyclist aware' at all times and especially when turning across an off-road (segregated) cycle lane which crosses mouth of a junction.

- Keeping within the speed limit.
- Look in mirrors and look behind before opening door of vehicle.
- Not to park in bus lanes.

Heavy goods vehicle driver training and monitoring could include cycle awareness (see B.2.1.3).

The education programmes for both the drivers and the pedal cyclists should lead to good practice that would be followed by enforcement strategies.

4.1.3 *Enforcement interventions*

The enforcement interventions (see Section B.3) have been suggested for each collision type and are shown in Table 4-3.

Table 4-3: Enforcement interventions by collision type

Enforcement intervention to address:	**Collision Type, where N = number of collisions**											
	A N=23	**B** N=11	**C** N=11	**D** N=11	**E** N=8	**F** N=7	**G** N=6	**H** N=4	**I** N=2	**J** N=1	**O** N=8	**All** N=92
B.3.1.1 - Speed enforcement			4		1	1						6
B.3.2.1 - Drinking and driving or riding				3			1				3	4
B.3.3.1- Parking near junctions or within bus lanes	3		1	1		1			1			7

These suggested enforcement interventions would employ standard enforcement tactics, as well as new technology and changes to road traffic law. They would follow extensive education, training and publicity campaigns. At present, for example, a pedal cyclist may be judged to be impaired using observation only, whereas the police have breath testing powers for drivers. The speed enforcement interventions would, by reducing speeds, mitigate the severity of injury.

4.2 How could the fatal injury have been prevented?

The analyses of each pedal cyclist fatality involved consideration of how the fatal injury outcome could have been prevented, assuming that the collision itself has already occurred. The pedal cyclist fatalities with detailed AIS (see Table 2-4) coded injury descriptions (66) were grouped according to their pattern of life threatening injury (see Table 3-22) and cross tabulated against their collision types (see Table 3-1), and are shown in Table 4-4.

The pedal cyclist fatalities with a head injury at AIS 3 or greater (see Table 3-22) experienced a diverse range of collision types with no dominant scenario.

Collision type A, where a heavy goods vehicle or a bus or coach was turning left or changing lane to the left struck the pedal cyclist fatality, was most frequently associated with complex multi-body region trauma. Thirteen of the 16 pedal cyclist fatalities involved in a type A collision suffered an injury of AIS 3 or greater to their thorax and to at least one other body region. These were often crush injuries caused by the vehicle's wheels driving over the pedal cyclist.

Nine of the 11 pedal cyclist fatalities involved in a collision type B, where the pedal cyclist lost control or wobbles or makes possible slight contact with the other vehicle, suffered an injury of AIS 3 or greater to their thorax and to at least one other body region.

No other obvious patterns were found correlating collision type and pattern of overall injury.

Table 4-4: Injury Classification Groups (AIS 3+) by collision type

	Collision Type, where N = number of collisions											
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**O**	**All**
Injury Classification Group	**N=16**	**N=11**	**N=9**	**N=6**	**N=7**	**N=5**	**N=4**	**N=3**	**N=1**	**N=0**	**N=4**	**N=66**
1. Head only	1	1	2	3	3	2	2	2			2	18
2. Thorax only	2	2									1	5
3. Lower extremities only						1					1	2
4. Head and thorax	5	2		1	2	1	1		1			13
5. Head, thorax and abdomen	1											1
6. Head, thorax, abdomen and lower extremities	1	1	1									3
7. Head, thorax and lower extremities	1	1		1	1			1				5
8. Head, thorax and spine			1		1							2
9. Head and spine							1					1
10. Head and lower extremities		1	3									4
11. Thorax and abdomen	1	2				1						4
12. Thorax, abdomen and lower extremities	1		1	1								3
13. Thorax and lower extremities	3	1	1									5

All the pedal cyclists’ injury interventions were then considered with respect to their collision types (Table 4-5). The interventions were flagged if they were believed to have had the potential to prevent the fatality outcome. Cycle helmets were identified as a key intervention. There were 26 pedal cyclists who had a head injury which was the most severe, or equal to the most severely injured body region and where the research team identified a cycle helmet as an intervention which could have prevented the fatality. The 15 pedal cyclist identified in section 3.4.1.1 are a subset of this 26.

Therefore, this work has identified the target population or those who may have been saved if they had worn a cycle helmet. However, without a forensic study of each collision injury mechanism involving consideration of impact speeds and likely biomechanical tolerance under given loading conditions, it is not possible to say how effective cycle helmets would have been for these 26 pedal cyclist fatalities. Nonetheless, it is noteworthy that cycle helmets have the potential at least, to reduce the severity of head injury.

Reducing vehicle speeds may prevent collisions, but could also reduce the energy of any traffic collisions that do occur and the subsequent injury risks. Further, ensuring good roadworthiness of bicycles, especially the brakes could assist the pedal cyclists to slow down and again lessen the impact severity.

Table 4-5: Fatal injury interventions by collision type

Intervention	**Collision Type, where N = number of collisions**											
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**O**	**All**
	N=16	**N=11**	**N=9**	**N=6**	**N=7**	**N=5**	**N=4**	**N=3**	**N=1**	**N=0**	**N=4**	**N=66**
B.2.2.2 - Cycle helmet use		3	5	3	6	1	3	2	1		2	26
B.3.1.1 - Speed enforcement			3									3
B.1.1.4 - Speed limit reduction			2		1							3
B.2.2.5 - Roadworthiness of bicycles		1										1
B.1.1.7 - Improve side guards on heavy goods vehicles	15	5										20

Finally, there were 20 cycle collisions where it was identified that if the heavy goods vehicle involved had had side guards fitted or they were more effective (typically covered a larger area), then they could have changed the pedal cyclist collision kinematics and subsequently prevented the fatal injuries. Collision types A (a heavy goods vehicle or a bus or coach turning left or changing lane to left struck the pedal cyclist) and B (Pedal cyclist lost control or wobbles or makes possible slight contact with the other vehicle) were associated with this intervention and the potential for benefit is believed to be significant. Side guards are not required to be fitted to all goods vehicles and there is a good argument that this should be reviewed given the lives that could potentially be saved.

5 Discussion

This study has described the in-depth characteristics of 92 fatal pedal cyclist collisions in London between 2001 and 2006. An almost complete set of files were located (85%) which has reduced the potential for selection bias to distort analysis and findings.

Through the use of Haddon's Matrix (Haddon, 1999), a structured database was created. This describes each collision with respect to the pre-event, event and post-event factors. This database was used to analyse, compare and categorize the collisions by their nature and type. A collision typology was developed to categorise the collisions. The research methods were peer reviewed by the University of Nottingham. The dataset included only pedal cyclist fatalities in London. It did not consider other severities of collision or casualty, nor did it consider damage only collisions or account for exposure to risk.

The fatal files used for this research are a rich source of information. They contain much greater detail about the collisions, vehicles and casualties than are routinely available from other sources such as collision and casualty STATS19 data. However, not all information which would have been relevant for this research was held in the fatal files.

In London in 2007, STATS19 data show that there were 15 pedal cyclist fatalities, 446 seriously injured and 2,509 slightly injured. The analysis used in this study cannot ascertain whether application of the interventions aimed at reducing pedal cyclist fatalities might also yield casualty saving benefits amongst seriously and slightly injured pedal cyclists. Further work to establish the potential impact of the interventions proposed on seriously and slightly injured pedal cyclist casualties could help to support the case for prioritising and investing in cycle safety interventions.

The analysis considered the pedal cyclist fatalities, the environmental factors, and the other vehicles and drivers (or riders) involved. There was far more complete information in the fatal collision files for the driver than for the pedal cyclist fatality. This is because the drivers were frequently uninjured and so able to be interviewed by the collision investigator at the time of the collision. The pedal cyclists could not be interviewed because the severity of these collisions caused them to die very soon afterwards. In some cases, the drivers were also unaware of the cyclist prior to the collision and so were unable to provide much reliable information about the cyclist's actions prior to the collision.

From a research perspective, there are some gaps in the information available from the fatal files. For example, evidence was rarely found relating to helmet use, the driving experience of the pedal cyclist, the cycling experience of drivers or any interaction or communication between those involved prior to the collision. It was also difficult to find information about the behaviour of the pedal cyclist before the collision occurred, particularly if the only witness was the driver of the other vehicle. Occasionally, there were other witness statements available. This evidence was sometimes contradictory, however, and if the behaviour of the pedal cyclist prior to the collision was clear then this was taken into account.

A catalogue of available interventions is reported in Appendix C. This catalogue was used to produce a list of interventions available for consideration in London and this is shown in Appendix B. Sections 4.1 and 4.2 describe a selection of the potential interventions that might have reduced the number or severity of fatalities of pedal cyclists in London based on the expectations of the research team. These necessarily rely on interpreting the efficacy of the intervention and its applicability to the particular collision. This interpretation is limited in that the evidence basis for the interventions described in Appendix B is variable. Some interventions have a reasonably strong research evidence base, others less so, while for other interventions there is currently no research evidence at all. Reported efficacy is sometimes conflicting and cannot necessarily be expected to be repeated in London where the circumstances (profiles of pedal cyclists, infrastructure etc.) may be different to elsewhere.

Notwithstanding the mixed quality of the evidence base and the interpretation issues, an attempt has been made to prioritise the interventions. This is based on an estimation of the efficacy range of each intervention. Where available, this estimate is drawn from published work. Where no relevant published evidence is readily available, an estimate based on experience is suggested. This efficacy range has then been applied to the number of pedal cyclist fatalities where it was thought the intervention could have prevented the collision or mitigated the severity of the fatal injury. This process allowed the interventions to be ranked in terms of potential for reducing the number of pedal cycle fatalities. Given the limitations, these priorities are indicative in that the relative ranks of the interventions may be misleading, but it is likely that the interventions with the highest ranks are nevertheless likely to have a greater impact on reducing pedal cycle fatalities compared to those with the lowest ranks, all else being equal.

Given the limitations of the evidence base, there are interventions for which the range has been estimated without published evidence or where the evidence may not be pertinent to London. The cost for implementing the interventions has not been considered in this suggested prioritisation process. The absence of a readily available and reliable evidence base for the efficacy of interventions aimed at improving cyclist safety suggests that further work to establish the efficacy of interventions and a fuller review of the evidence base have merit.

The process of reviewing the fatal files and considering the interventions that might have been expected to have reduced their number or severity has led to a number of recommendations. These are described in the following section.

6 Recommendations

The following recommendations to reduce cyclist fatalities in London are put forward from the work conducted through this study. They do not explicitly take account of the wider context in which decisions about cyclist safety must be made.

The following interventions should be considered for action or further evaluation. This list of interventions is neither exhaustive nor presented in any order.

1. *Improve and/or install side guards on heavy goods vehicles*. Regulations exist that require spray suppression, side guards, rear under-run and front under-run protection to be fitted to heavy goods vehicles. These are considered to be effective in reducing the likelihood of an impact or the severity of injury when a heavy goods vehicle is overtaking a pedal cyclist. Currently, some heavy goods vehicles are exempt from these regulations. Fitting these with the encouragement of FORS (Transport for London, 2008b) could mitigate the injury severity of pedal cyclists particularly for the collision where a heavy goods vehicle is turning left. There are currently some vehicles which are exempt from fitting side guards and this could be reconsidered by Transport for London and the Department for Transport.

2. *Retrofit mirrors - Improve mirror configuration*. A number of different types of mirrors (Fenn et al., 2005) should be fitted to heavy goods vehicles to improve the field of view for the drivers. These are intended to reduce blind spots in the immediate area surrounding the vehicle. Fitting these with the encouragement of FORS (Transport for London, 2008b) could mitigate the injury severity of pedal cyclists particularly when a heavy goods vehicle is turning left and the pedal cyclist is positioned on their nearside. The scope for this intervention relies on the driver adjusting the mirrors before starting the journey and using the mirrors at the significant moment during for example, a left turn manoeuvre. Transport for London has recently introduced a scheme to distribute free safety lenses, known as "Fresnel" lenses, to freight companies operating vehicles in London. These easy to fit lenses stick on to the passenger window of a truck cab, improving lorry drivers' vision of cyclists who come within close proximity of their vehicles.

3. *Raise awareness of cyclists by drivers*. There is a clear need for interventions to close the gap of opinion that road users hold of themselves and each other as being competent to be walking, riding and driving. These could take the form of education on the need for all road users to be more considerate of the needs of others and the skills required by each class of road user to complete their journey. More campaigns aimed at drivers in London to raise their awareness of pedal cyclists are needed. A review of the effectiveness of previous campaigns and literature, for example Transport for London (2008a); RoSPA/CEMEX (2006); London Cycling Campaign (2008) would inform on the focus and style of future campaigns. In particular, awareness initiatives for both drivers and cyclists need to continue to draw attention to the problem of collisions involving cyclists at junctions, especially those involving heavy goods vehicles turning left.

4. *Driver Training.* Driver training to ensure London drivers deal safely with pedal cyclists on the road. The existing training included in driving lessons could be extended. Other potential opportunities for training drivers could be during professional driver training, driving lessons and other driving courses for example speed awareness courses.

5. *Cycle training*. Training is an important strand in the wider safety strategy for pedal cyclists. It must go hand in hand with measures to create a safer cycling

environment and measures to improve the behaviour of motorists (RoSPA, 2008a). The UK's national Cyclists Touring Club (CTC) also highlight that there is anecdotal evidence that those who have received good cycle training become better drivers. Transport for London already carry out cycle training and this could be offered to employers as part of work related road safety. Some emphasis could be placed on negotiating junctions in London. Ideally, all pedal cyclists should undertake cycle training before cycling in London. The cycle training could be assessed to ensure all general principles are covered and that the more difficult manoeuvres and types of locations are included.

6. *Improve Cyclist conspicuity*. Various sources recommend that pedal cyclists wear light-coloured or fluorescent clothing in daylight and poor light, and reflective clothing and/or accessories (belt, arm or ankle bands) in darkness. The bicycle should be fitted with front and rear lights, which should be lit in the dark and a red rear and white front reflector. A Cochrane review (Kwan, 2008) of interventions for increasing pedestrian and pedal cyclist visibility for the prevention of death and injuries was undertaken. This looked at various studies of using fluorescent materials in yellow, red and orange colours to improve detection and recognition in the daytime and lamps, flashing lights and retro-reflective materials in red and yellow colours to increase detection and recognition at night. The finding was that, although these visibility measures do help drivers to see pedestrians and pedal cyclists, further research is required to determine if this increased visibility does prevent serious injury and fatalities. During 2008 Transport for London gave away environmentally friendly wind-up powered secondary lights to help cyclists improve their visibility.

7. *Cycle helmets.* With respect to injury prevention, cycle helmets were identified as a potential intervention in 26 of the 66 fatal collisions where injury information was available. Therefore, this work has identified the target population or those who may have been saved if they had worn a cycle helmet. However, without a forensic study of each collision and the associated injury mechanisms, which would involve consideration of impact speeds and likely biomechanical tolerance under given loading conditions, it is not possible to say how effective cycle helmets would have been for these 26 pedal cyclist fatalities. Nonetheless, it is noteworthy that cycle helmets have the potential at least, to reduce the severity of head injury. Whilst it is not compulsory to wear a cycle helmet, it is important that this information is available to cyclists so that they can consider this in conjunction with evidence available from other sources to make an informed personal choice on wearing a helmet.

8. *Speed management*.

    a. *Speed reduction - Introduce 20mph limit on residential roads*. Recently it has been proposed (Crawford, 2008) that a 20mph speed limit could be applied to all residential areas. This could be achieved by the use of average speed cameras and traditional traffic calming measures. Webster and Layfield (2003) found a 50% reduction in pedal cyclist killed and seriously injured casualties after 20mph zones had been applied.

    b. Increased levels of enforcement could lower the incidence of speeding and reduce the severity of injury (Crawford, 2008). More effective enforcement may be achieved by the use of average speed cameras which would encourage drivers to maintain their speed within the limit rather than slow down in the vicinity of a traditional safety camera. Speed awareness course for drivers could include an element that deals with awareness of pedal cyclists and their behaviours.

9. The following are research recommendations:

a) Transport for London should consider research to understand the possible benefits from the interventions put forward here on lower severity pedal cycle casualties.

b) Transport for London should consider collection of more behavioural data of pedal cyclists', and possible other road users', in London. For example, observing behaviour at junctions where pedal cyclists are turning left.

c) Transport for London, the Police and Department for Transport should consider whether and how a more systematic dataset of key variables can be collected during fatal collision investigation. This could encourage the collection of data on, for example, cycle helmet wearing.

d) Transport for London should consider ways to improve the evidence base for cyclist safety interventions.

e) Should further studies using the fatal files be taken forward, consideration should be given to pilot work to determine a protocol for handling the content analysis of the data.

f) This study has shown that the fatal collision police investigation files are a valuable source of information that may not be available elsewhere. It may be appropriate to consider research for other road user fatalities, for example, pedestrians and powered two wheeler users.

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Appendix A More detail on broad collision types used in Table 3-1

Broad collision type	More detail from collision narrative	Total
A (Heavy goods vehicle or bus or coach was turning left or changing lane to left and struck pedal cyclist)	The cyclist and the heavy goods vehicle were both stationary, they pulled away as the traffic lights changed and the driver was distracted	1
	The heavy goods vehicle was turning left and struck the cyclist who was going straight ahead	8
	The heavy goods vehicle cut 'short' an overtaking manoeuvre	1
	The heavy goods vehicle was turning left and struck the cyclist	12
	The bus or coach was turning left	1
A Total		23
B (Pedal cyclist lost control or wobbles or makes possible slight contact with the other vehicle)	The cyclist's load or bicycle made contact with other vehicle and cyclist starts to fall	3
	The cyclist clipped, lost control and was run over	1
	The cyclist lost control and fell	4
	The cyclist wobbled possible that the other vehicle was too close	1
	The cyclist wobbled and fell under the heavy goods vehicle	1
	The cyclist and the heavy goods vehicle were alongside at a junction, too close and the cyclist fell under the rear of a heavy goods vehicle	1
B Total		11
C (Pedal cyclist was riding across the road)	The cyclist was riding across the road	11
C Total		11
	The cyclist moved across the front of a heavy goods vehicle to turn left and was struck from rear	1
	The cyclist was struck from behind by a speeding vehicle	2
	The cyclist was struck from rear by a car	1
	The cyclist was struck from rear by a heavy goods vehicle	1
D	The cyclist was struck from rear by a motorcycle	1
(Pedal cyclist struck from rear by other vehicle)	The cyclist was struck from rear by a bus or coach	2
	The cyclist was struck from rear by a speeding motorcycle	2
	The cyclist was struck from rear in bus/cycle lane	1
D Total		11
E	The cyclist was changing lane	1
	The cyclist was changing lane and struck by speeding vehicle from	1

Pedal cyclist moves out to pass parked vehicles or veers to the right or is turning right	opposite direction	
	The cyclist was changing lane and was struck by vehicle from behind	1
	The cyclist lost control, moved to the right and was struck by a car travelling in the same direction	1
	The cyclist was turning right when struck by a speeding car at ATS junction	1
	The cyclist veered to the centre of the road and was struck by car travelling in the same direction	1
	The cyclist veered to centre of road and was struck by a taxi travelling in the same direction	1
	The cyclist moved out to overtake parked vehicles and was struck from behind	1
E Total		8
F (Other vehicle changing lane or has turned across the pedal cyclists' path or has lost control)	A car turned right across the cyclist's path	1
	The cyclist was overtaking a queue of traffic and was struck by a van turning right	1
	A heavy goods vehicle was changing lane to avoid a car and struck the cyclist who was alongside it	1
	The other vehicle was changing lane	1
	The other vehicle was speeding or lost control and struck the cyclist	2
	A bus or coach turned right into path of cyclist	1
F Total		7
G (Pedal cyclist against lights)	The cyclist against lights	1
	cyclist crossing road against lights struck by car 'on green'	1
	cyclist crossing road against red light	2
	cyclist rode over junction against red light	2
G Total		6
H (Other vehicle door opened)	Parked car - door opening	4
H Total		4
I (Pedal cyclist entering main road)	cyclist emerging from side road and parked vehicles	1
	cyclist emerging onto road	1
I Total		2
J (Other vehicle against lights)	cyclist struck by car that disobeyed red light	1
J Total		1
O	cyclist entered road to pass parked van, heavy goods vehicle could not	1

(Other)	pass, van reversed into cyclist	
	cyclist hit parked vehicle	1
	cyclist on pavement cycleway struck by stolen light goods vehicle	1
	cyclist riding in wrong direction along coned off lane struck by motorcycle	1
	Cyclist hit oncoming car	1
	cyclist struck by car carrying out a U-turn in front	1
	heavy goods vehicle turning right	1
	Cyclist on pavement and hits wooden post	1
O Total		8
All		92

Appendix B Interventions considered beneficial to cases studied

This appendix describes interventions to improve pedal cycle safety. These have been included based on published work, readily available grey literature and inputs from TRL and Transport for London cycling experts.

The interventions listed and described in this section are only those which were thought to be beneficial based on the evidence in the fatal files. Further interventions were considered by the research team and the full list is in Appendix C, including a repeat of those shown in Appendix B.

The interventions are grouped into Engineering, Education (including training and publicity), and Enforcement – the 3 E’s. Some interventions include activity in more than one of the three E’s. The three E’s are commonly understood areas of activity within road safety. The funding, resources, skills and people charged with delivering each of these types of activity are often distinct. Sometimes, the interventions themselves are not so distinctly categorised. In such cases, the intervention has been assigned to one category (Engineering, Education or Enforcement), but the relevance to other categories has been noted. Working across these boundaries is strongly encouraged and can be expected to lead to improved delivery. For example, publicity advising of changes to enforcement practices is expected to lead to greater compliance, and therefore improved safety, than would be achieved with enforcement alone.

In addition to grouping the interventions into the 3E’s, the reliability and nature of the readily available evidence base for the efficacy of each intervention has been reviewed. This has led to a further categorisation of the interventions within each of the Es as follows:

- those that have a strong level of evidence supporting efficacy (usually based on experimental trial and published sources);
- those which are guidance or good practice (usually design guidance and Traffic Advisory Leaflets etc.); and
- those that can be thought of as potentially good ideas for safety, but for which little or no evidence supporting their efficacy has been found.

For the interventions in the second group (good practice), it can be the case that safety considerations form only part of the reasoning behind particular recommendations or good practice approaches put forward.

The interventions are presented in Table B-1 identifying how they are categorised within this framework (the 3E’s and the nature of the evidence-base).

Table B - 1: The Engineering, Education and Enforcement interventions

	Engineering	Education	Enforcement
Evidence based	▪ B.1.1.1 Introduce or improve cycle lanes ▪ B.1.1.2 Propose changes to junction layout ▪ B.1.1.3 Change Automatic Traffic Signal (ATS) priority ▪ B.1.1.4 Speed limit reduction ▪ B.1.1.5 Improve field of view for heavy goods vehicle drivers - mirrors ▪ B.1.1.6 Improve field of view for heavy goods vehicle drivers - sensors and CCTV ▪ B.1.1.7 Improve side guards on heavy goods vehicles	▪ B.2.1.1 Improve pedal cyclists' awareness of other road users ▪ B.2.1.2 Cycle training ▪ B.2.1.3 Improve drivers' awareness of pedal cyclists	▪ B.3.1.1 Speed enforcement
Good Practice	▪ B.1.2.1 Introduce other cycling infrastructure	▪ B.2.2.1 Reduce impaired cycling ▪ B.2.2.2 Cycle helmet use ▪ B.2.2.3 Improve pedal cyclists' conspicuity ▪ B.2.2.4 Address carrying loads on bicycles ▪ B.2.2.5 Roadworthiness of bicycles ▪ B.2.2.6 Roadworthiness of vehicles	▪ B.3.2.1 Drinking and driving or riding
Other interventions			▪ B.3.3.1 Parking near junctions or within bus lanes

Another way to consider particularly the Education and Engineering interventions is whether they are targeting cyclists, or whether they are targeting other road users. This distinction is made to emphasise the point that all road users are responsible for the safety of themselves and others.

Educational interventions can further be thought of as those that are aimed at changing the levels of Awareness, Behaviour or Competence of road users – both cyclists and other road users. The distinction between these aims can be helpful in that the channels or methods through which changes can be made might be different. The table below uses the problem of collisions involving pedal cycles and left-turning heavy goods vehicles as an example.

Change	Target	Approach	Desired Outcome
Awareness	**Pedal cyclists** unaware that left turning heavy goods vehicles are often positioned as if going straight ahead when they are turning left	**Ad- campaigns** making cyclist aware of this issue so that they are more likely to consider what heavy goods vehicles are likely to do at junctions	**Pedal cyclists** aware of the positioning of left turning heavy goods vehicles. Knowledge of the risk will empower them to consider their action to mitigate it
Behaviour	**Pedal cyclists** not wearing cycle helmets and high visibility clothing	**Education** to inform pedal cyclists of importance of wearing helmets and high visibility clothing and include in cycle training	**Pedal cyclists** wear high visibility clothing and cycle helmets
Competence/skills	**Pedal cyclists** waiting at lights alongside heavy goods vehicles without making efforts to make themselves more visible	**Pedal cycle training** to include specifically the positioning when alongside a heavy goods vehicle	**Pedal cyclists** moving forward at junctions or otherwise making themselves more visible to heavy goods vehicle drivers
Competence/skills	**Heavy goods vehicle drivers** unaware of the presence of pedal cyclists when making left turning manoeuvre	**Vehicle checks** of side guards and mirrors are fitted and used correctly	**Heavy goods vehicles** with suitable mirrors and side guards that are fitted and used correctly

Transport for London already undertakes varying levels of activity along the lines of some of the interventions described here.

B.1 Engineering interventions

There is a wide variety of engineering interventions available to make cycling safer and more convenient. These range from cycle-specific measures, including completely segregated paths, through to measures such as speed reduction that are not specifically targeted at cyclists but which can be very beneficial to them. Recent guidance from Cycling England on cycle friendly infrastructure recognises the latter as "invisible" cycling infrastructure.

Separate provision for cyclists is often assumed to be preferable, but as well as being impractical to introduce in many locations, especially where space is constrained, it can also introduce problems of its own. These include conflict with pedestrians on shared-use paths, loss of priority at side road crossings adding delay and inconvenience for cyclists and conflicts with other vehicles at crossings and junctions. In addition, cycle lanes can restrict the ability of cyclists to position themselves correctly for turning right, and passing obstacles and, if of insufficient width, can encourage drivers to pass too close.

For these reasons best practice guidance on cycle infrastructure usually refers to a 'hierarchy of measures' which advocates traffic and speed reduction before off-road provision. The hierarchy, as set out in Department for Transport Local Transport Note LTN 1/04 - Policy, Planning and Design for Walking and Cycling, recommends:

Consider first	Traffic reduction
↓	Speed reduction
	Junction treatment, hazard site treatment, traffic management
	Redistribution of the carriageway (bus lanes, widened nearside lanes etc)
	Cycle lanes, segregated cycle tracks constructed by reallocation of carriageway space, cycle tracks away from roads
Consider last	

This approach is reflected in Cycling England's Design Checklist (Cycling England, 2007) and it is recommended that the interventions discussed below are all considered within these overall principles.

Furthermore the interventions discussed below often refer to the London cycling design standards (Transport for London, 2005a).

B.1.1 Evidence based

B.1.1.1 Introduce or improve cycle lanes

This intervention is largely aimed at pedal cyclists. Cycle lanes can help pedal cyclists by providing a clear route so that they can maintain progress in congested traffic and by providing a marked route through a junction increasing the awareness of pedal cyclists by other road users. However, the road layout in London is often such that it is not possible to allocate dedicated road space to cycles (or buses). Where provided, cycle lanes should be a minimum of 1.5m wide (Transport for London, 2005a). Cycle lanes can also restrict or at least discourage correct road positioning when cyclists are turning right or need to change lanes. Where cycle lanes (Transport for London, 2005a) are introduced, the cost of remedial measures to the carriageway surface should be included within the scheme budget.

Cycle lanes should be continuous and made conspicuous across side roads at junctions, for example at right turning lanes.

A mandatory cycle lane, from which motor vehicles are excluded by Traffic Regulation Order, should be continued across the mouths of side roads. At these locations, however, the lane should be advisory because other traffic needs to cross it. Colour is useful to reduce blockage by emerging vehicles. Advisory lanes are otherwise used where mandatory lanes are unsuitable e.g. where vehicles park regularly. However, blockage by parked vehicles will force cyclists into the traffic stream.

Alongside vehicle parking bays, if space permits, the cycle lane should be routed along the offside of the bays and separated by an edge strip at least 0.5m wide (Transport for London, 2005a) such that an opening door does not endanger a cyclist.

On bends and corners, long vehicles can encroach on a cycle lane. If possible the carriageway should be widened or the number of traffic lanes reduced. Although a cycle lane was not present, one of the collisions studied involved a cyclist colliding with the side of a heavy goods vehicle pulling away from signals on a bend. The risk of such a collision occurring could have been reduced if the kerb had been realigned to reduce the curvature.

B.1.1.2 Propose changes to junction layout

This intervention is largely aimed at pedal cyclists. A disproportionate number of cycle collisions take place at junctions, so interventions that reduce conflict at junctions can have a very beneficial effect on safety. Best practice in cycle infrastructure guidance recommends that this is done in accordance with the hierarchy of measures, with speed reduction being an important aspect of safety improvement (Transport for London, 2005a). Common conflicts at junctions occur when cyclists are:

- Changing lanes, for example to continue straight ahead when approaching a left-turn filter lane;
- Pulling out into the path of faster traffic, for example to avoid parked vehicles, drain covers, road build outs, as well as to turn right;
- Merging into fast traffic, or having fast traffic merging from the left, a particular problem at large roundabouts and gyratories;
- Being positioned next to turning vehicles, especially long vehicles;
- Using ghosted right turning spaces and lanes, and potentially being exposed to fast traffic passing on the left.

It is possible to use dedicated lanes and crossing points to try to separate the flows of cyclists from other vehicles using the junction, however care must be taken not to add new conflicts and potential confusion, as well as added delay and discontinuity for cyclists. If cyclists have to make turning manoeuvres at places where motorists are not expecting them, there is a risk of conflicts.

It is recommended that junctions are assessed on an individual basis, using an appropriate audit methodology such as Cycle Audit and Review (Transport for London, 2007b) and that any changes are designed in accordance with the hierarchy of measures. Cycling England's Design Checklist (Cycling England, 2007) provides a useful summary of approaches to improving junctions for cyclists.

For collisions involving cyclists emerging from a side road, making parking illegal within 50m of a junction, along with kerb realignment to improve visibility and reduction of vehicle speeds would be beneficial. However, kerb realignment can produce a pinch point for cyclists on the main road, which can reduce safety for them unless traffic flows are very low. Installing a raised table at the junction would also reduce speeds but create an obstacle for cyclists to ride over. The design standards for junctions are covered in (Transport for London, 2005a) and there is a recommendation for a safety check to be carried out at the location of a fatal collision. If a new junction is installed or a junction is amended then a road safety audit will be carried out. For example, the design and introduction of a new cycle scheme for Blackfriars bridge after a cycle review which was carried out for Transport for London by TRL (Transport for London, 2005b).

B.1.1.3 Change Automatic Traffic Signal (ATS) priority

This intervention is largely aimed at pedal cyclists. In addition to ASLs, engineering measures to improve pedal cyclists' safety at signalled junctions are covered in the guidance produced by Transport for London (2005a), Cycling England (2007) and the Dutch publication Design Manual for Bicycle Traffic produced by CROW (Information and Technology Platform for Transport, Infrastructure and Public Space (CROW,2007)). Collisions between left-turning large vehicles and pedal cyclists going ahead or turning left could be avoided by, for example, the use of:

- Cycle bypasses (designed as a short length of cycle track)
- A separately signalled slip lane placing the cyclist ahead of the traffic queue
- An 'early green' facility on a separately signalled short length of cycle track at the junction.

Although not permissible in the UK, detectors specifically for pedal cyclists can be used to detect slow-moving pedal cyclists clearing a junction and create an 'all red' period (Cycling England, 2008). This avoids potential conflict with other traffic pulling away.

Button operated signal filters could be introduced for right-turning pedal cyclists, a practice used in Western Australia when no other vehicles are present (Government of Western Australia, 2008).

B.1.1.4 Speed limit reduction

It has been proposed in recently (Crawford, 2008) that a 20mph speed limit could be applied to all residential areas, which could be achieved by the use of average speed cameras and traditional traffic calming measures. Webster and Layfield (2003) found a 50% reduction in pedal cyclist killed and seriously injured casualties after 20mph zones had been applied in London.

B.1.1.5 Improve field of view for heavy goods vehicle drivers - mirrors

This intervention is largely aimed at heavy goods vehicle drivers. A number of different types of mirrors are fitted to heavy goods vehicles to improve the field of view for the drivers. These are intended to reduce blind spots in the immediate area surrounding the vehicle. One of these types of mirror is the Type V, close proximity mirror. These mirrors are particularly relevant for collisions occurring at junctions that involve a heavy goods vehicle turning left or changing lane to the left with and a pedal cycle alongside the inside of the vehicle. Fenn et al. (2005) concluded that the cost of fitting these mirrors is small but there would be limited annual potential casualty saving to pedal cyclists. Fenn also reported that 90% of heavy goods vehicle drivers surveyed agreed that the use of close proximity mirrors generally contributes to the reduction of heavy goods vehicle collisions, with 61% of drivers claiming that use of this mirror had helped them to avoid a potential collision in the past 12 months. The report raised the concern that some drivers do not realise the purpose of this mirror and are failing to use it correctly.

The intention of providing these mirrors to improve the field of view for the drivers depends on them being adjusted correctly and being used before and during the turning manoeuvre. It is the driver's responsibility to adjust the vehicle mirrors correctly before each journey and to use them while driving. Consideration could be given to encourage compulsory retro fitting of mirrors, where feasible, to meet current design standards for new vehicles and to promote familiarity and use of such mirrors.

B.1.1.6 Improve field of view for heavy goods vehicle drivers - sensors and CCTV

This intervention is largely aimed at heavy goods vehicle drivers. Proximity or collision avoidance sensors can supplement mirrors by warning a heavy goods vehicle, bus or coach driver of moving objects close to the vehicle. The sensors start working as soon as the engine is started and the vehicle starts moving. They can work by ultrasound, radar or infrared, continuously sending and receiving signals from and to the moving object. As soon as a colliding object is detected, the driver receives an audible alarm and could possibly take appropriate avoidance action.

Instead of using proximity sensors, CCTV can be used to cover blind spots. They have an advantage over proximity sensors in that the driver can see what is going on rather than having to rely on an audible warning. Cameras would have to be mounted in a position where accumulation of dirt on the lens would be minimal. The cameras should provide full coverage of the front, rear and sides of the vehicle.

An alternative to the class VI mirror (see section 3.2.2.1 and Fenn, 2005) positioned to cover the blind spot below the windscreen) has been trialled using close-range obstacle detection by the use of stereo CCTV cameras on the front of a heavy goods vehicle to investigate the presence of obstacles in blind spot areas in front of the vehicle (Bertozzi *et al.*, 2006; Broggi *et al.*, 2007). The system is able to prevent a vehicle starting off when a pedestrian or cyclist close to the front of the cab is detected.

Using sensors as an intervention may be highly effective in alerting the driver to the presence of a pedal cyclist. However the complexity of the driving task may mean that this would overload the driver with information.

B.1.1.7 Improve side guards on heavy goods vehicles

This intervention is largely aimed at heavy goods vehicle drivers. Regulations exist that require spray suppression, side guards, rear under-run and front under-run protection to be fitted to heavy goods vehicles. These are considered to be effective in reducing the likelihood of an impact or the severity of injury when a heavy goods vehicle is overtaking a pedal cyclist. An example of the sequence of events for this type of collision is that the pedal cyclist falls sideways into the side of the heavy goods vehicle between the front and rear axles and is run over by the rear wheels. This suggests that side guard design could be improved to give better protection to pedal cyclists and other vulnerable road users.

A project carried out by TRL for the Department for Transport studied the integration of safety guards and spray suppression for heavy goods vehicles (Knight et al., 2005). Under consideration was the development of a stronger and lower integrated structure all the way round the lower part of a heavy goods vehicle. This presents a smooth uninterrupted surface to the pedal cyclist or vulnerable road user and is usually flush with the outer edge of the vehicle and covers the wheels with very low ground clearance. The smooth surface of this structure, originally intended to enhance aerodynamic performance, has been shown through test work to prevent violent head strikes on the side of the vehicle body and the load hooks, and also prevents heavy chest strikes on the outer edge of the rear tyre as the cyclist tends to slide down the side panel. An additional benefit is that clothing and limbs are less likely to get caught or dragged by the vehicle and the pedal cyclist is not thrown to the ground with as much force. Computer simulation showed that smooth flat panelled side guards did offer potential for improved protection for vulnerable road users. Although, in simulation, the cyclist ends up very close to the wheels and there may be a risk of limbs being run over, this design may reduce the risk of head/thorax/abdomen being run over. Analysis of collision data did suggest that these would translate to real world casualty reductions.

B.1.2 Good practice

B.1.2.1 Introduce other cycling infrastructure

This intervention is largely aimed at pedal cyclists. It is thought that a pedal cyclist's crossing facility or an alternative cycle route to avoid a complex road system could be beneficial, though this should be done in accordance with best practice in cycle infrastructure design, and having regard for the desire lines and the need for routes to avoid introducing excessive detour and delay.

B.2 Education (including training and publicity) interventions aimed at raising Awareness, Behaviour and Competence of road users – both pedal cyclists and other road users.

B.2.1 Evidence based

B.2.1.1 Improve pedal cyclists' awareness of other road users and their intentions

This intervention is aimed at pedal cyclists. Steer et al. (2008) reported that pedal cyclists in London view themselves as competent but that they also view other cyclists as less competent. It also reported that amongst cyclists themselves there is a feeling of being the "least protected" of all road users.

Pedal cyclists need to have sufficient skill to deal competently with the dynamic situations posed by pedestrians, other pedal cyclists and motor vehicles using the roads. This can be achieved through education, cycle training and publicity campaigns. Cycle Training UK Ltd (2004) assessed cycle training and found that, after training, people cycle more confidently, for longer journeys and more frequently. RoSPA (2008a) recommend that cycle training should go hand in hand with measures to create a safer cycling environment and measures to improve the behaviour of motorists. The competence of a cyclist is integral to the awareness of other road users. Steer et al. (2008) conducted a postal survey of people who received one to one training in London and found that 81% of trainees cycle more or more confidently as a result.

The intervention promoted here would be to encourage all cyclists to become familiar with the Highway Code, particularly the rules for pedal cyclists, and to undertake cycle training. The types of training available in London range from specific courses for children to individual training for adults (Transport for London, 2008d). This could be promoted by schools and colleges, employers and cycle retailers in conjunction with other stakeholders. Cycle training is being advocated at a national level following the development of the National Standards for Cycle Training for both child and adult cyclists. Child cycle training, promoted as Bikeability, is now being supported by Cycling England, with funding available to local authorities to set up cycle training schemes in their areas.

Heavy goods vehicles pose a major threat to cyclists. In London between 1999 and 2004, 56% of cyclists killed were involved in a collision with a goods vehicle (Webster, 2006). Also in London between 1985 and 1992 there were 40 heavy goods vehicles, out of a total of 108 vehicles, involved in a fatal collision with a pedal cyclist (McCarthy and Gilbert, 1996).

Regular education campaigns about the dangers of cycling alongside heavy goods vehicles, especially when approaching junctions and roundabouts are worth considering and updating. In 2002, the need for more mutual awareness was highlighted with the slogan 'there are two sides to every story'. This was an initiative launched by Transport for London Street Management, in partnership with the London Cycling Campaign and the Freight Transport Association. The campaign aimed at both cyclists and drivers of commercial goods vehicles. This campaign encourages cyclists and drivers to be more aware of the way each other uses the available road space, particularly at turns and junctions (Local Authority Road Safety Officers Archive, 2002).

Examples of other material already available are the Highway Code (DSA, 2008) and the DfT's THINK! Road Safety Campaign (Department for Transport, 2008b). These include advice on cycling near heavy goods and other large vehicles. There are free road safety resources available from RoSPA (2008b) including a film about 'pedal cyclists and lorries'. A lot of the information is freely available on the internet but for some people this resource is not easily accessible. Television / radio / cinema advertisements may reach more people.

A prominent notice on the back of a heavy goods vehicle warning pedal cyclists not to go alongside the vehicle or informing the pedal cyclist that if they cannot see the mirrors on the vehicle then the driver cannot see them are recommended.

B.2.1.2 Cycle training

This intervention is aimed at pedal cyclists. The need for training to improve pedal cyclists' skills and behaviour has been mentioned earlier (B.2.1.1) and in other sources (Basford, 2002, Steer et al., 2008). Through Cycling England the Government has supported the development of National Standards for Cycle Training for both adults and children. National Standard cycle training is based on teaching the skills needed to cycle on the road with other traffic and helps to give pedal cyclists the confidence to avoid conflicting manoeuvres through correct positioning and planning.

Cycling safety could be taught in schools from as early an age as possible. This is particularly relevant on residential streets without traffic calming measures, especially those that can be used by through traffic.

Bikeability (2008) is a Government supported scheme that delivers outcomes at three award levels to provide basic skills, an introduction to on-road cycling and advanced cycle training, which includes familiarity with the Highway Code.

The www.bikeforall.net website (recommended by DfT's THINK! Road Safety Campaign) has a section on cycle training providing links to training schemes and providers specific to London. For example:

- Cycle Training UK (www.cycletraining.co.uk) which claims to be the largest independent provider of on-road cycle training and cycle maintenance training in London.
- The London School of Cycling (www.londonschoolofcycling.co.uk) which provides instruction and information for adults on riding and maintenance.
- The London Cycling Campaign (www.lcc.org.uk) which provides links to information on training from specialist organisations and through local borough groups for adults and children.
- Training available through some London boroughs, particularly for children (e.g. the Redbridge Cycling Centre, opened in 2008).

B.2.1.3 Improve drivers' awareness of pedal cyclists

This intervention is largely aimed at other vehicle drivers. There is evidence that, in London, road users other than pedal cyclists perceive cycling as dangerous and that pedal cyclists are a nuisance on the road (Steer Davies Gleave, 2008). This view is supported by Basford et al. (2002). This research surveyed the attitude and behaviour of drivers towards pedal cyclists using various techniques including virtual reality equipment to simulate encounters between drivers and pedal cyclists. Basford recommended that the education of drivers should not only focus on helping them to predict pedal cyclist behaviour but to help them understand the circumstances that will influence that behaviour. The intention is to encourage drivers to not regard pedal cyclists as a 'nuisance' and to recognise that the road environment affects the pedal cyclist's behaviour. Basford also recommended that drivers' education, for example in the Highway Code, should include advice on how to respond when encountering pedal cyclists at certain types of road feature, both those explicitly for pedal cyclists and other highway features. This would enable drivers to respond considerately and resist social pressure from other drivers to force their way past pedal cyclists.

Integrated Educational and Awareness raising is recommended to improve driver awareness of pedal cyclists. In March 2008, Transport for London launched a campaign to cut collisions between cyclists and goods vehicles distributing 10,000 free safety lenses to freight companies to improve lorry drivers' vision of cyclists. This lens is one of the tools of the Freight Operator Recognition Scheme (FORs), which encourages operators to ensure best practice both for driving standards and vehicle safety. This initiative was coupled with a driver awareness campaign.

More education is required for all types of road user to emphasise the need to be more considerate of others while using the roads in London and to follow the rules in the Highway Code (DSA, 2008).

It is possible that a simple first step that could be considered would be handing out free copies of the Highway Code by high profile enforcement or cycling personnel, for example, our Olympic cycling athletes / Police Officers.

B.2.2 Good practice

B.2.2.1 Reduce impaired cycling

This intervention is aimed at pedal cyclists. Impaired riding can arise through the use of alcohol, drugs (including medicine), and the use of earphones or a mobile phone. The use of alcohol and drugs is covered specifically by Section 30 of the Road Traffic Act

(RTA) 1988 and constitutes an offence. However, reckless and careless cycling (Section 28 - amended to 'dangerous cycling' in RTA 1991) and inconsiderate cycling (Section 29) both constitute an offence and can arise from impairment.

Wearing earphones can make a pedal cyclist less able to hear other traffic (Highway Code Rule 148), and the use of a mobile phone can distract and reduce control of the bicycle (Highway Code Rule 149 – riders).

Interventions aimed at impaired cycling would need to educate pedal cyclists on the rules in the Highway Code relating to impairment followed by enforcement measures.

B.2.2.2 Cycle helmet use

This intervention is aimed at pedal cyclists. Much research has been carried out on the effectiveness of helmet. Some of the findings are contradictory, in some cases because of the different research approaches used (The Cochrane Library 2006, 2008a and 2008b). Towner et al. (2002) provided a critical review of research and evidence on the efficacy of cycle helmets. The review looked at the impact of compulsory cycle helmet use on cycling and safety with the intention of identifying gaps in existing knowledge and research. The conclusions reached by Towner were that there is a considerable amount of scientific evidence that cycle helmets are effective at mitigating head, brain and upper facial injuries to pedal cyclists, particularly for children. Also, cycle helmet promotion and legislation needs to be seen as part of a broader package to enhance cycling safety and that barriers to cycle helmet use can be overcome. There are many public sources, including the Cochrane reviews regarding the use of cycle helmets. There is often controversy surrounding their conclusions.

However, there is also evidence from countries that have introduced cycle helmet wearing legislation that compulsion may have resulted in lower levels of cycling. For example in Australia there are reports that the reduction in overall cycle use was greater than the reduction in head-injury achieved.

There is some evidence that lower rates of cycling and helmet wearing by women may be due to comfort (Cycling England, 2008b). Specific publicity campaigns for women would need to take this into account.

The intervention would consider promotion of wearing cycle helmets to mitigate the severity of injury, particularly for children. It is important to recognise that even if they are effective at reducing head injury, helmets will only be able to benefit those who do not also suffer fatal injuries to other parts of the body.

B.2.2.3 Improve pedal cyclists' conspicuity

This intervention is aimed at pedal cyclists. Highway Code rule 59 recommends that pedal cyclists wear:

- light-coloured or fluorescent clothing in daylight and poor light, and
- reflective clothing and/or accessories (belt, arm or ankle bands) in darkness.

Highway Code rule 60 and Road Vehicle Lighting Regulations 13, 18 and 24 (1989, amended 1994 and 2005) state that at night a bicycle must have white front and red rear lights lit. The bicycle must be fitted with a red rear reflector (and amber pedal reflectors, if manufactured after 1/10/85). White front reflectors and spoke reflectors are recommended and flashing lights are permitted. The Highway Code recommends that cyclists who are riding in areas without street lighting use a steady front lamp.

There is a Cochrane (Kwan, 2008) review of interventions for increasing pedestrian and cyclist visibility for the prevention of death and injuries. This looked at various studies of using fluorescent materials in yellow, red and orange colours to improve detection and recognition in the daytime and lamps, flashing lights and retro-reflective materials in red and yellow colours to increase detection and recognition at night.

A study (Mills, 1989) of 776 pedal cyclist casualties who attended hospital, recommended that cyclists should be encouraged to wear more protective clothing and head gear.

B.2.2.4 Address carrying loads on bicycles

This intervention is aimed at pedal cyclists. Carrying loads on bicycles is likely to affect the balance and control of the bicycle. Long, heavy or large items are unsuitable and advice on the safest method would be useful. This may include using appropriate bags securely fixed to the bicycle, for example, cycle panniers. This intervention could be considered with cycling competency and cycle training (see section B.2.1.2).

B.2.2.5 Roadworthiness of bicycles

This intervention is aimed at pedal cyclists and is linked to Engineering and Enforcement interventions. The Highway Code applies to England, Scotland and Wales. All road users should be aware of the Code and behave considerately towards other road users. Many of the rules in the Code are legal requirements, and if disobeyed a criminal offence is committed. These rules are identified by the use of the words **'MUST/MUST NOT'**.

The following is taken from the Highway Code rules for cyclists. These rules require pedal cyclists to ensure that they are confident in their ability to ride safely on the road. The rules for their bicycles are the following:

- Choose the right size and type of cycle for comfort and safety.
- Keep lights and reflectors clean and in good working order.
- Tyres should be in good condition and inflated to the pressure shown on the tyre.
- Ensure gears are working correctly.
- Keep the chain properly adjusted and oiled
- Adjust the saddle and handlebars to the correct height

It is recommended that a bell is fitted to your bicycle.

You **MUST**

- Ensure your brakes are efficient.
- At night, use lit front and rear lights and have a red rear reflector.

Interventions highlighting these rules from the Highway Code for bicycles could be in the form of roadside checks. Also, bicycle maintenance workshops could be incorporated into training courses. Employers could be encouraged to supply copies of the Highway Code to their employees (see Section B.2.1.1). The roadworthiness of bicycles is also linked to section B.2.2.3 which deals with bicycle lighting.

B.2.2.6 Roadworthiness of vehicles

This intervention is aimed at other vehicle drivers and is linked to Engineering and Enforcement interventions. The Highway Code applies to England, Scotland and Wales. All road users should be aware of the Code and behave considerately towards other road users. Many of the rules in the Code are legal requirements, and if disobeyed a criminal

offence is committed. These rules are identified by the use of the words **'MUST/MUST NOT'**.
The Highway Code provides rules for vehicle maintenance regarding vehicle lighting, steering, brakes, the exhaust system, demisters, wipers and washers. There is a requirement for seat belts to be adjusted correctly and that luggage is secured before starting out on a journey. The rules for tyre pressures and tread depths are listed together with other rules for regular checks and maintenance of vehicles. General rules are given regarding penalties, first aid on the road, vehicle security and work related road safety.

Interventions that ensure the roadworthiness of vehicles on the road should reduce the likelihood that a vehicle will respond adversely when involved in a collision, for example, very low brake fluid may result in brake failure which could affect the severity of a collision.

B.3 Enforcement interventions

B.3.1 Evidence based

B.3.1.1 Speed enforcement

This intervention is largely aimed at other vehicle drivers. More effective enforcement may be achieved by the use of average speed cameras which would encourage drivers to maintain their speed within the limit rather than slow down in the vicinity of a traditional safety camera. Speed awareness course for drivers could include an element that deals with awareness of pedal cyclists and their behaviours. Increased levels of enforcement could lower the incidence of speeding and reduce the severity of injury (Crawford, 2008).

B.3.2 Good practice

B.3.2.1 Drinking and driving or riding

This intervention is aimed at other vehicle drivers. In the UK the legal drink-drive limit for motor vehicle drivers and riders is 80 milligrams of alcohol per 100 millilitres of blood (equivalent to 35 micrograms of alcohol per 100 millilitres of breath). In London, there were 886 screening breath tests carried out in 2006 per 100,000 population compared to 1,127 for the whole of England and Wales (Ministry of Justice, 2008). For some of the Police Forces in England and Wales this number is much higher, for example, in Cheshire it is 3,599 and in Hampshire it is 1,920. A recent article in Road Casualties Great Britain (Department for Transport, 2008) shows that, generally, when the number of breath screening tests carried out increases, the number of positive / refused breath tests decreases, i.e. the number of drink drive collisions. This is probably closely linked to the perception of potential drink drivers as to whether they will be caught or not. Research (Broughton, 2003) has also shown that drivers who committed several non-motoring offences were far more likely than non-offenders to also commit offences such as drink driving or dangerous driving.

Consideration should be given to (a) increasing the breath testing rate and consequently discouraging potential drink drivers or (b) using the breath testing powers of the Police to identify drink drivers; this could reduce the load on Police resources.

B.3.3 Other interventions

B.3.3.1 Parking near junctions or within bus lanes

This intervention is largely aimed at other vehicle drivers. Other uninvolved vehicles parked near junctions mask the pedal cyclist from moving traffic. Consideration should be given to whether parking should be made illegal within a certain distance of a junction. The advice in the Highway Code restricts parking within 10m of a junction and increasing this distance seems like an important consideration.

Appendix C The catalogue of available interventions

This appendix describes interventions to improve pedal cycle safety. These have been included based on published work, readily available grey literature and inputs from TRL and Transport for London cycling experts. It provides a comprehensive list of interventions including those considered by the researchers to be appropriate for the cases investigated, which are repeated from Appendix B.

The interventions are grouped into Engineering, Education (including training and publicity), and Enforcement – the 3 E's. Some interventions include activity in more than one of the three E's. The three E's are commonly understood areas of activity within road safety. The funding, resources, skills and people charged with delivering each of these types of activity are often distinct. Sometimes, the interventions themselves are not so distinctly categorised. In such cases, the intervention has been assigned to one category (Engineering, Education or Enforcement), but the relevance to other categories has been noted. Working across these boundaries is strongly encouraged and can be expected to lead to improved delivery. For example, publicity advising of changes to enforcement practices is expected to lead to greater compliance, and therefore improved safety, than would be achieved with enforcement alone.

In addition to grouping the interventions into the 3E's, the reliability and nature of the readily available evidence base for the efficacy of each intervention has been reviewed. This has led to a further categorisation of the interventions within each of the Es as follows:

- those that have a strong level of evidence supporting efficacy (usually based on experimental trial and published sources);
- those which are guidance or good practice (usually design guidance and Traffic Advisory Leaflets etc.); and
- those that can be thought of as potentially good ideas for safety, but for which little or no evidence supporting their efficacy has been found.

For the interventions in the second group (good practice), it can be the case that safety considerations form only part of the reasoning behind particular recommendations or good practice approaches put forward.

The interventions are presented in Table C-1 identifying how they are categorised within this framework (the 3E's and the nature of the evidence-base).

The references for this appendix are also included here.

Table C - 1: The Engineering, Education and Enforcement interventions

	Engineering	Education	Enforcement
Evidence based	▪ C.1.1.1 Introduce or improve cycle lanes ▪ C.1.1.2 Propose changes to junction layout ▪ C.1.1.3 Advanced Stop Lines ▪ C.1.1.4 Change Automatic Traffic Signal (ATS) priority ▪ C.1.1.5 Speed limit reduction ▪ C.1.1.6 Shared use zebra crossing ▪ C.1.1.7 Improve field of view for heavy goods vehicle drivers - mirrors ▪ C.1.1.8 Improve field of view for heavy goods vehicle drivers - sensors and CCTV ▪ C.1.1.9 Improve side guards on heavy goods vehicles	▪ C.2.1.1 Improve pedal cyclists' awareness of other road users ▪ C.2.1.2 Unexpected opening of vehicle door ▪ C.2.1.3 Route planning guidelines ▪ C.2.1.4 Cycle training ▪ C.2.1.5 Improve drivers' awareness of pedal cyclists	▪ C.3.1.1 Speed enforcement
Good Practice	▪ C.1.2.1 Pedestrian guard railsB.1.2.1 Introduce other cycling infrastructure ▪ C.1.2.4 Improve condition of the road surface ▪ C.1.2.5 Improve heavy goods vehicle lighting	▪ C.2.2.1 Reduce impaired cycling ▪ C.2.2.2 Cycle helmet use ▪ C.2.2.3 Improve pedal cyclists' conspicuity ▪ C.2.2.4 Address carrying loads on bicycles ▪ C.2.2.5 Roadworthiness of bicycles ▪ C.2.2.6 Driving while impaired ▪ C.2.2.7 Driving while uninsured ▪ C.2.2.8 General driving skills ▪ C.2.2.9 Roadworthiness of vehicles ▪ C.2.2.10 Work related road safety	▪ C.3.2.1 Drinking and driving or riding ▪ C.3.2.2 Impairment and cycling ▪ C.3.2.3 Driving while uninsured
Other interventions	▪ C.1.3.1 Vehicle design standards ▪ C.1.3.2 Advance emergency brake systems ▪ C.1.3.3 Black spot mirrors	▪ C.2.3.1 Left turn on red at automatic traffic signals (ATS) for pedal cyclists ▪ C.2.3.2 Changing driving behaviours that affect cycling safety ▪ C.2.3.3 Drivers' behaviour - change presumptions of liability and/ or insurance cover	▪ C.3.3.1 Parking near junctions or within bus lanes ▪ C.3.3.2 Heavy goods vehicle construction and use offences ▪ C.3.3.3 Compliance at traffic lights

Another way to consider, particularly the Education and Engineering interventions, is whether they are targeting cyclists or other road users. This distinction is made to emphasise the point that all road users are responsible for the safety of themselves and others.

Educational interventions can further be thought of as those that are aimed at changing the levels Awareness, Behaviour or Competence of road users – both cyclists and other road users. The distinction between these aims can be helpful in that the channels or methods through which changes can be made might be different. The table below uses the problem of collisions involving pedal cycles and left-turning heavy goods vehicles as an example.

Change	Target	Approach	Desired Outcome
Awareness	**Pedal cyclists** unaware that left turning heavy goods vehicles are often positioned as if going straight ahead when they are turning left	**Ad- campaigns** making cyclist aware of this issue so that they are more likely to consider what heavy goods vehicles are likely to do at junctions	**Pedal cyclists** aware of the positioning of left turning heavy goods vehicles. Knowledge of the risk will empower them to consider their action to mitigate it
Behaviour	**Pedal cyclists** waiting at lights alongside HGVs without making efforts to make themselves more visible	**Pedal cycle training** to include specifically the positioning when alongside a heavy goods vehicle	**Pedal cyclists** moving forward at junctions or otherwise making themselves more visible to heavy goods vehicle drivers
Competence	**Heavy goods vehicle drivers** unaware of the presence of pedal cyclists when making left turning manoeuvre	**Vehicle checks** of side guards and mirrors are fitted and used correctly	**Heavy goods vehicles** with suitable mirrors and side guards that are fitted and used correctly

Transport for London already undertakes varying levels of activity along the lines of some of the interventions described here.

C.1 Engineering interventions

There is a wide variety of engineering interventions available to make cycling safer and more convenient. These range from cycle-specific measures, including completely segregated paths, through to measures such as speed reduction that are not specifically targeted at cyclists but which can be very beneficial to them. Recent guidance from Cycling England on cycle friendly infrastructure recognises the latter as "invisible" cycling infrastructure. It provides a comprehensive list of interventions including those considered by the researchers to be appropriate for the cases investigated, which are repeated from 0.

Separate provision for cyclists is often assumed to be preferable, but as well as being impractical to introduce in many locations, especially where space is constrained, it can also introduce problems of its own. These include conflict with pedestrians on shared-use paths, loss of priority at side road crossings adding delay and inconvenience for cyclists and conflicts with other vehicles at crossings and junctions. In addition, cycle lanes can restrict the ability of cyclists to position themselves correctly for turning right, and passing obstacles and, if of insufficient width, can encourage drivers to pass too close.

For these reasons best practice guidance on cycle infrastructure usually refers to a 'hierarchy of measures' which advocates traffic and speed reduction before off-road provision. The hierarchy, as set out in Department for Transport Local Transport Note LTN 1/04 - Policy, Planning and Design for Walking and Cycling, recommends:

Consider first	Traffic reduction
↓	Speed reduction
↓	Junction treatment, hazard site treatment, traffic management
↓	Redistribution of the carriageway (bus lanes, widened nearside lanes etc)
↓	Cycle lanes, segregated cycle tracks constructed by reallocation of carriageway space, cycle tracks away from roads
Consider last	

This approach is reflected in Cycling England's Design Checklist (Cycling England, 2007) and it is recommended that the interventions discussed below are all considered within these overall principles.

Furthermore the interventions discussed below often refer to the London cycling design standards (Transport for London, 2005a).

C.1.1 Evidence based

C.1.1.1 Introduce or improve cycle lanes

This intervention is largely aimed at pedal cyclists. Cycle lanes can help pedal cyclists by providing a clear route so that they can maintain progress in congested traffic and by providing a marked route through a junction increasing the awareness of pedal cyclists by other road users. However, the road layout in London is often such that it is not possible to allocate dedicated road space to cycles (or buses). Where provided, cycle lanes should be a minimum of 1.5m wide (Transport for London, 2005a). Cycle lanes can also restrict or at least discourage correct road positioning when cyclists are turning right or need to change lanes. Where cycle lanes (Transport for London, 2005a) are introduced, the cost of remedial measures to the carriageway surface should be included within the scheme budget.

Cycle lanes should be continuous and made conspicuous across side roads at junctions, for example at right turning lanes.

A mandatory cycle lane, from which motor vehicles are excluded by Traffic Regulation Order, should be continued across the mouths of side roads. At these locations, however, the lane should be advisory because other traffic needs to cross it. Colour is useful to reduce blockage by emerging vehicles. Advisory lanes are otherwise used where mandatory lanes are unsuitable e.g. where vehicles park regularly. However, blockage by parked vehicles will force cyclists into the traffic stream.

Alongside vehicle parking bays, if space permits, the cycle lane should be routed along the offside of the bays and separated by an edge strip at least 0.5m wide (Transport for London, 2005a) such that an opening door does not endanger a cyclist.

On bends and corners, long vehicles can encroach on a cycle lane. If possible the carriageway should be widened or the number of traffic lanes reduced. Although a cycle lane was not present, one of the collisions studied involved a cyclist colliding with the side of a heavy goods vehicle pulling away from signals on a bend. The risk of such a collision occurring could have been reduced if the kerb had been realigned to reduce the curvature.

C.1.1.2 Propose changes to junction layout

This intervention is largely aimed at pedal cyclists. A disproportionate number of cycle collisions take place at junctions, so interventions that reduce conflict at junctions can have a very beneficial effect on safety. Best practice in cycle infrastructure guidance recommends that this is done in accordance with the hierarchy of measures, with speed reduction being an important aspect of safety improvement (Transport for London, 2005a). Common conflicts at junctions occur when cyclists are:

- Changing lanes, for example to continue straight ahead when approaching a left-turn filter lane;
- Pulling out into the path of faster traffic, for example to avoid parked vehicles, drain covers, road build outs, as well as to turn right;
- Merging into fast traffic, or having fast traffic merging from the left, a particular problem at large roundabouts and gyratories;
- Being positioned next to turning vehicles, especially long vehicles;
- Using ghosted right turning spaces and lanes, and potentially being exposed to fast traffic passing on the left.

It is possible to use dedicated lanes and crossing points to try to separate the flows of cyclists from other vehicles using the junction, however care must be taken not to add new conflicts and potential confusion, as well as added delay and discontinuity for cyclists. If cyclists have to make turning manoeuvres at places where motorists are not expecting them, there is a risk of conflicts.

It is recommended that junctions are assessed on an individual basis; using an appropriate audit methodology such as Cycle Audit and Review (Transport for London, 2007b) and that any changes are designed in accordance with the hierarchy of measures. Cycling England's Design Checklist (Cycling England, 2007) provides a useful summary of approaches to improving junctions for cyclists.

For collisions involving cyclists emerging from a side road, making parking illegal within 50m of a junction, along with kerb realignment to improve visibility and reduction of vehicle speeds would be beneficial. However, kerb realignment can produce a pinch point for cyclists on the main road, which can reduce safety for them unless traffic flows are very low. Installing a raised table at the junction would also reduce speeds but create an obstacle for cyclists to ride over. The design standards for junctions are covered in (Transport for London, 2005a) and there is a recommendation for a safety check to be carried out at the location of a fatal collision. If a new junction is installed or a junction is amended then a road safety audit will be carried out. For example, the design and introduction of a new cycle scheme for Blackfriars bridge after a cycle review which was carried out for Transport for London by TRL (Transport for London 2005b).

C.1.1.3 Advanced Stop Lines

This intervention is largely aimed at pedal cyclists. Advanced Stop Lines (ASLs) were originally introduced to reduce conflict between pedal cyclists and motorists when pulling away from rest at signal controlled junctions (Transport for London, 2006). The conflicting movements generally occur where pedal cyclists go ahead and motorists turn left, and motorists go ahead and pedal cyclists turn right. Their installation should be considered at all signal controlled junctions. The reservoir between the motorists' and pedal cyclists' stop lines is normally accessed by a nearside cycle lane and should be designed to take account of the numbers of pedal cyclists and the manoeuvres they need to make. Its depth should preferably be 5m and not less than 4m (Allen et al., 2005).

The main benefits of ASLs are that:

- Pedal cyclists are given a visible and practical advantage at signalled junctions.
- Pedal cyclists can bypass queuing traffic to get to the front of the queue via the lead-in lane.
- Pedal cyclists are placed in a safer and more visible location, ahead of traffic rather than in the blind spot to the left of traffic; this is especially important where there are appreciable numbers of heavy goods vehicles.
- Pedal cyclists can wait in an area relatively free from exhaust fumes.
- They make it easier for right turning pedal cyclists to position themselves in the best location.
- They make pedestrian crossing movements at the junction more visible, safer and more comfortable by setting back the line of waiting vehicles.

A non-nearside lead-in cycle lane would have to be installed where there is a left-turn only lane for vehicles but if possible this would need to be positioned to avoid the section of road where there are weaving movements, particularly those from left to right. This may mean that the lane needs to be made shorter than intended. Research on the effectiveness of non-nearside lead-in lanes is reported in Ryley (1996).

Allen (2005) also reported a high number of red light violations (17%) at all types of junctions. This was highlighted at ASLs leading onto a roundabout where 30% of pedal cyclists carried out this manoeuvre.

C.1.1.4 Change Automatic Traffic Signal (ATS) priority

This intervention is largely aimed at pedal cyclists. In addition to ASLs, engineering measures to improve pedal cyclists' safety at signalled junctions are covered in the guidance produced by Transport for London (2005a), Cycling England (2007) and the Dutch publication Design Manual for Bicycle Traffic produced by CROW (Information and Technology Platform for Transport, Infrastructure and Public Space (CROW,2007)). Collisions between left-turning large vehicles and pedal cyclists going ahead or turning left could be avoided by, for example, the use of:

- Cycle bypasses (designed as a short length of cycle track)
- A separately signalled slip lane placing the cyclist ahead of the traffic queue
- An 'early green' facility on a separately signalled short length of cycle track at the junction.

Although not permissible in the UK, detectors specifically for pedal cyclists can be used to detect slow-moving pedal cyclists clearing a junction and create an 'all red' period (Cycling England, 2008a). This avoids potential conflict with other traffic pulling away.

Button operated signal filters could be introduced for right-turning pedal cyclists, a practice used in Western Australia when no other vehicles are present (Government of Western Australia, 2008).

C.1.1.5 Speed limit reduction

It has been proposed in recently (Crawford, 2008) that a 20mph speed limit could be applied to all residential areas, which could be achieved by the use of average speed cameras and traditional traffic calming measures. Webster and Layfield (2003) found a 50% reduction in pedal cyclist killed and seriously injured casualties after 20mph zones had been applied in London.

C.1.1.6 Shared use zebra crossing

This intervention is largely aimed at pedal cyclists. A recent study for Transport for London looked at the shared use of zebra crossings (Greenshields et al., 2006). At present, the law does not give pedal cyclists the same rights as pedestrians at zebra crossings. Pedal cyclists do not have precedence over vehicles when riding across a zebra crossing. As bicycles are technically vehicles, pedal cyclists should give precedence to pedestrians at zebra crossings. Changes to the law would be required to give cyclists similar rights to pedestrians and changes to Regulations to give cyclists priority over other vehicles at Zebra crossings. In addition, appropriate signing would need to be agreed by the Department for Transport.

A shared-use crossing could be implemented under existing laws however, cyclists would not have precedence over other vehicles. The local highway authority may be held liable should the design of a shared-use zebra crossing lead a cyclist to reasonably conclude that they did have precedence and this leads to an incident.

The research found that 87.8% of cyclists at the observed sites ride over some or the whole of the Zebra crossing. The key concerns involved the safety of cyclists being involved in conflict situations with other vehicles, other cyclists, and pedestrians (especially mobility impaired people). This intervention could improve the links for pedal cyclists when route planning (see C.2.1.3) and if introduced all road users would need to be informed and changes to signing would need to be implemented.

C.1.1.7 Improve field of view for heavy goods vehicle drivers - mirrors

This intervention is largely aimed at heavy goods vehicle drivers. A number of different types of mirrors are fitted to heavy goods vehicles to improve the field of view for the drivers. These are intended to reduce blind spots in the immediate area surrounding the vehicle. One of these types of mirror is the Type V, close proximity mirror. These mirrors are particularly relevant for collisions occurring at junctions that involve a heavy goods vehicle turning left or changing lane to the left with and a pedal cycle alongside the inside of the vehicle. Fenn et al. (2005) concluded that the cost of fitting these mirrors is small but there would be limited annual potential casualty saving to pedal cyclists. Fenn also reported that 90% of heavy goods vehicle drivers surveyed agreed that the use of close proximity mirrors generally contributes to the reduction of heavy goods vehicle collisions, with 61% of drivers claiming that use of this mirror had helped them to avoid a potential collision in the past 12 months. The report raised the concern that some drivers do not realise the purpose of this mirror and are failing to use it correctly.

The intention of providing these mirrors to improve the field of view for the drivers depends on them being adjusted correctly and being used before and during the turning manoeuvre. It is the driver’s responsibility to adjust the vehicle mirrors correctly before each journey and to use them while driving. Consideration could be given to encourage compulsory retro fitting of mirrors, where feasible, to meet current design standards for new vehicles and to promote familiarity and use of such mirrors.

C.1.1.8 Improve field of view for heavy goods vehicle drivers - sensors and CCTV

This intervention is largely aimed at heavy goods vehicle drivers. Proximity or collision avoidance sensors can supplement mirrors by warning a heavy goods vehicle, bus or coach driver of moving objects close to the vehicle. The sensors start working as soon as the engine is started and the vehicle starts moving. They can work by ultrasound, radar or infrared, continuously sending and receiving signals from and to the moving object. As soon as a colliding object is detected, the driver receives an audible alarm and could possibly take appropriate avoidance action.

Instead of using proximity sensors, CCTV can be used to cover blind spots. They have an advantage over proximity sensors in that the driver can see what is going on rather than having to rely on an audible warning. Cameras would have to be mounted in a position where accumulation of dirt on the lens would be minimal. The cameras should provide full coverage of the front, rear and sides of the vehicle.

An alternative to the class VI mirror (see section 3.2.2.1 and Fenn, 2005) positioned to cover the blind spot below the windscreen) has been trialled using close-range obstacle detection by the use of stereo CCTV cameras on the front of a heavy goods vehicle to investigate the presence of obstacles in blind spot areas in front of the vehicle (Bertozzi *et al.*, 2006; Broggi *et al.*, 2007). The system is able to prevent a vehicle starting off when a pedestrian or cyclist close to the front of the cab is detected.

Using sensors as an intervention may be highly effective in alerting the driver to the presence of a pedal cyclist. However the complexity of the driving task may mean that this would overload the driver with information.

C.1.1.9 Improve side guards on heavy goods vehicles

This intervention is largely aimed at heavy goods vehicle drivers. Regulations exist that require spray suppression, side guards, rear under-run and front under-run protection to be fitted to heavy goods vehicles. These are considered to be effective in reducing the likelihood of an impact or the severity of injury when a heavy goods vehicle is overtaking a pedal cyclist. An example of the sequence of events for this type of collision is that the pedal cyclist falls sideways into the side of the heavy goods vehicle between the front and rear axles and is run over by the rear wheels. This suggests that side guard design could be improved to give better protection to pedal cyclists and other vulnerable road users.

A project carried out by TRL for the Department for Transport studied the integration of safety guards and spray suppression for heavy goods vehicles (Knight et al., 2005). Under consideration was the development of a stronger and lower integrated structure all the way round the lower part of a heavy goods vehicle. This presents a smooth uninterrupted surface to the pedal cyclist or vulnerable road user and is usually flush with the outer edge of the vehicle and covers the wheels with very low ground clearance. The smooth surface of this structure, originally intended to enhance aerodynamic performance, has been shown through test work to prevent violent head strikes on the side of the vehicle body and the load hooks, and also prevents heavy chest strikes on the outer edge of the rear tyre as the cyclist tends to slide down the side panel. An additional benefit is that clothing and limbs are less likely to get caught or dragged by the vehicle and the pedal cyclist is not thrown to the ground with as much force. Computer simulation showed that smooth flat panelled side guards did offer potential for improved protection for vulnerable road users. Although, in simulation, the cyclist ends up very close to the wheels and there may be a risk of limbs being run over, this design may reduce the risk of head/thorax/abdomen being run over. Analysis of collision data did suggest that these would translate to real world casualty reductions.

C.1.2 Good practice

C.1.2.1 Pedestrian guard rails

This intervention is largely aimed at pedal cyclists. The positioning of guard rails, although well intended for pedestrian safety, may mean that a pedal cyclist is 'trapped' between them and a vehicle to their right. Cycle bypasses described in section C.1.1.4 can avoid this problem at signalled junctions. Another solution, if space permits, would be to install or reposition guard rails further away from the kerb edge.

C.1.2.2 Cycle super highway

This intervention is largely aimed at pedal cyclists. Cycle Superhighways will provide cyclists with safe, fast, direct routes into central London from outer London. (Based on information on TfL web site at: http://www.tfl.gov.uk/roadusers/cycling/11901.aspx) The first two routes will open in Summer 2010 with ten more being introduced as part of a rolling programme.

They will be direct and continuous, with the routes clearly marked and easy to follow. There will be new signage and road markings, and information about journey time and links to other cycling routes.

TfL will be improving road surfaces and minimising obstructions along the routes so cyclists can pedal more comfortably.

Each Cycle Superhighway will have a clear and unique identity. Blue surfaces will also increase driver awareness.

The Cycle Superhighways will be at least 1.5m wide and provide continuous cycle lanes at junctions; advanced stop boxes; and signals to help cyclists keep safe.

The Cycle Superhighways project is one of TfL and the Mayor's main ways of bringing about a London cycling revolution, aimed at increasing cycling in London by 400 per cent by 2025 (compared to 2000 levels).

C.1.2.3 Introduce other cycling infrastructure

This intervention is largely aimed at pedal cyclists. It is thought that a pedal cyclist's crossing facility or an alternative cycle route to avoid a complex road system could be beneficial, though this should be done in accordance with best practice in cycle infrastructure design, and having regard for the desire lines and the need for routes to avoid introducing excessive detour and delay. This intervention could be linked to the cycle super highway (see C.1.2.2).

C.1.2.4 Improve condition of the road surface

This intervention is largely aimed at pedal cyclists. All ironworks, for example, drain covers, should be flush with the road surface, especially where cyclists are mostly likely to use the carriageway. The design of gulley gratings to eliminate the risk of a bicycle wheel being caught could possibly be achieved by changing the orientation. Roadside shrubbery should also be cut to ensure it is not an obstruction to pedal cyclists and does not compromise their sight lines.

Regular checks should be made for potholes and other defects, supplemented with an easy means of reporting them. Repairs should be carried out without delay. Consideration could be given to using an antiskid road surface, which can be used to cover drain covers.

C.1.2.5 Improve heavy goods vehicle lighting

This intervention is largely aimed at heavy goods vehicle drivers. Heavy goods vehicles should be fitted with side and marker lights for all corners of the vehicle and especially repeater indicator lights on the side of the vehicle. This intervention is important when a large vehicle is at a junction and intends to turn left. The vehicle is indicating and the pedal cyclist, either alongside or moving up the inside of the vehicle, does not notice the indicators because of the lack of repeaters along the side of the vehicle. A left turning heavy goods vehicle often needs to be positioned towards the centre of the road to complete the manoeuvre. The pedal cyclist assumes the vehicle is travelling straight ahead or turning right because of the position of the vehicle, potentially leading to a collision. This intervention is considered to help communicate to the pedal cyclist the intended manoeuvre of the heavy goods vehicle. However, it depends upon the driver using the indicators appropriately.

C.1.3 Other intervention

C.1.3.1 Vehicle design standards

This intervention is largely aimed at vehicle design regulators. Fatal collisions involving an impact with a car often result in the pedal cyclist's head striking the windscreen or bonnet. In the European New Car Assessment Programme (Euro NCAP, (NCAP,2008)) tests for pedestrians have been carried out replicating child and adult pedestrian collisions at 25mph. The new cars are awarded a star rating from one (least safe) to four (most safe).   However, as corresponding tests for pedal cyclists' protection are not carried out it is possible that the results for pedestrian impact testing may be used as a guide for pedal cyclists' safety. There is potential for a test to be devised to assess new cars with respect to the safety of pedal cyclists and possibly extend this rating system to all types of vehicle, including buses, coaches and heavy goods vehicles.

C.1.3.2 Advance emergency brake systems

This intervention is largely aimed at vehicle designers and vehicle owners and drivers. Collision avoidance systems capable of detecting pedestrians and pedal cyclists as well as vehicles that use a combination of radar and camera technology are available. These succeed a first generation system which detected vehicles and lane departure; its main application was the prevention of rear-end collisions due, for example to slow driver reaction time or inattentiveness. This intervention would alert the driver to the presence of the cyclist and may allow more time for avoidance action. This could also be linked to Work Related Road Safety procedures (see Section C.2.2.10).

C.1.3.3 Black spot mirrors

This intervention is largely aimed at highway engineers. Recent reports in the media (Bikeportland, 2009) highlight a convex mirror placed on a traffic signal, for example below 'the green light' on traffic lights. These mirrors are called 'black spot mirrors' or 'dead angle mirrors'. The mirror is heated for all weather use. They have been installed at over 100 locations in Amsterdam and are placed where the driver is already looking while waiting for the lights to change or to proceed through the junction. These could be considered useful at junctions controlled by Automatic Traffic Signals where pedal cyclists may be turning left or going straight ahead.

C.2 Education (including training and publicity) interventions

C.2.1 Evidence based

C.2.1.1 Improve pedal cyclists' awareness of other road users

This intervention is aimed at pedal cyclists. Steer et al. (2008) reported that pedal cyclists in London view themselves as competent but that they also view other cyclists as less competent. It also reported that amongst cyclists themselves there is a feeling of being the "least protected" of all road users.

Pedal cyclists need to have sufficient skill to deal competently with the dynamic situations posed by pedestrians, other pedal cyclists and motor vehicles using the roads. This can be achieved through education, cycle training and publicity campaigns. Cycle Training UK Ltd (2004) assessed cycle training and found that, after training, people cycle more confidently, for longer journeys and more frequently. RoSPA (2008a) recommend that cycle training should go hand in hand with measures to create a safer cycling environment and measures to improve the behaviour of motorists. The competence of a cyclist is integral to the awareness of other road users. Steer et al. (2008) conducted a postal survey of people who received one to one training in London and found that 81% of trainees cycle more or more confidently as a result.

The intervention promoted here would be to encourage all cyclists to become familiar with the Highway Code, particularly the rules for pedal cyclists, and to undertake cycle training. The types of training available in London range from specific courses for children to individual training for adults (Transport for London, 2008d). This could be promoted by schools and colleges, employers and cycle retailers in conjunction with other stakeholders. Cycle training is being advocated at a national level following the development of the National Standards for Cycle Training for both child and adult cyclists. Child cycle training, promoted as Bikeability, is now being supported by Cycling England, with funding available to local authorities to set up cycle training schemes in their areas.

Heavy goods vehicles pose a major threat to cyclists. In London between 1999 and 2004, 56% of cyclists killed were involved in a collision with a goods vehicle (Webster, 2006). Also in London between 1985 and 1992 there were 40 heavy goods vehicles, out of a total of 108 vehicles, involved in a fatal collision with a pedal cyclist (McCarthy and Gilbert, 1996).

Regular education campaigns about the dangers of cycling alongside heavy goods vehicles, especially when approaching junctions and roundabouts are worth considering and updating. In 2002, the need for more mutual awareness was highlighted with the slogan 'there are two sides to every story'. This was an initiative launched by Transport for London Street Management, in partnership with the London Cycling Campaign (London Cycling Campaign, 2008a and 2008b) and the Freight Transport Association. The campaign aimed at both cyclists and drivers of commercial goods vehicles. This campaign encourages cyclists and drivers to be more aware of the way each other uses the available road space, particularly at turns and junctions (Local Authority Road Safety Officers Archive, 2002).

Examples of other material already available are the Highway Code (DSA, 2008) and the DfT's THINK! Road Safety Campaign (Department for Transport, 2008b). These include advice on cycling near heavy goods and other large vehicles. There are free road safety resources available from RoSPA (2008b) including a film about 'pedal cyclists and lorries'. A lot of the information is freely available on the internet but for some people this resource is not easily accessible. Television / radio / cinema advertisements may reach more people.

A prominent notice on the back of a heavy goods vehicle warning pedal cyclists not to go alongside the vehicle or informing the pedal cyclist that if they cannot see the mirrors on the vehicle then the driver cannot see them are recommended.

C.2.1.2 Unexpected opening of vehicle door

This intervention is aimed at pedal cyclists. Pedal cyclists should be aware that occupants of parked vehicles may open a door into their path (Transport for London, 2008c) and take action to overtake safely. When opening a door the vehicle occupants need to check for the presence of pedal cyclists before opening the door. A cyclist who is easily seen (see section C.2.2.3) increases the chance of being noticed by a driver in this situation.

Although this advice is included in cycle training it is worth considering using publicity to highlight the potential dangers of cycling near parked vehicles and advise on ways to overtake.

C.2.1.3 Route planning guidelines

This intervention is aimed at pedal cyclists. Several cycling organisations provide information and mapping of safer routes for cyclists that are either part of the London and National Cycle Networks or are other signed on-road and traffic free routes. Examples are as follows:

- The London Cycling Campaign (London Cycling Campaign, 2008c) and Transport for London have jointly produced a series of guides covering Greater London. The guides are available from Transport for London and compliment the London Cycle Network Plus which is will be completed in 2009/10 with 900km of route.

- The Cyclists' Touring Club website (www.ctc.org.uk) contains information on recommended routes and designated cycle routes. They are regularly updated and are available for each county, including Greater London.

- Sustrans (www.sustrans.org.uk) includes interactive mapping of both on-road and traffic-free routes for each region of the UK and Ireland, including Greater London. Links are available to local news and information on developments of the network.

- Review of procedures associated with the development and delivery of measures designed to improve safety and convenience for cyclists (see C.1.1.2) and Transport for London, 2005b).

Clear signing and greater publicity of these routes in London would raise awareness and promote their use by more pedal cyclists. This is linked to the Engineering Interventions (see section C.1).

C.2.1.4 Cycle training

This intervention is aimed at pedal cyclists. The need for training to improve pedal cyclists' skills and behaviour has been mentioned earlier (C.2.1.1) and in other sources (Basford, 2002, Steer et al., 2008). Through Cycling England the Government has supported the development of National Standards for Cycle Training for both adults and children. National Standard cycle training is based on teaching the skills needed to cycle on the road with other traffic and helps to give pedal cyclists the confidence to avoid conflicting manoeuvres through correct positioning and planning.

Cycling safety could be taught in schools from as early an age as possible. This is particularly relevant on residential streets without traffic calming measures, especially those that can be used by through traffic.

Bikeability (2008) is a Government supported scheme that delivers outcomes at three award levels to provide basic skills, an introduction to on-road cycling and advanced cycle training, which includes familiarity with the Highway Code.

The www.bikeforall.net website (recommended by DfT's THINK! Road Safety Campaign) has a section on cycle training providing links to training schemes and providers specific to London. For example:

- Cycle Training UK (www.cycletraining.co.uk) which claims to be the largest independent provider of on-road cycle training and cycle maintenance training in London.
- The London School of Cycling (www.londonschoolofcycling.co.uk) which provides instruction and information for adults on riding and maintenance.
- The London Cycling Campaign (www.lcc.org.uk) which provides links to information on training from specialist organisations and through local borough groups for adults and children.
- Training available through some London boroughs, particularly for children (e.g. the Redbridge Cycling Centre, opened in 2008).

C.2.1.5 Improve drivers' awareness of pedal cyclists

This intervention is largely aimed at other vehicle drivers. There is evidence that, in London, road users other than pedal cyclists perceive cycling as dangerous and that pedal cyclists are a nuisance on the road (Steer et al., 2008). This view is supported by Basford et al. (2002). This research surveyed the attitude and behaviour of drivers towards pedal cyclists using various techniques including virtual reality equipment to simulate encounters between drivers and pedal cyclists. Basford recommended that the education of drivers should not only focus on helping them to predict pedal cyclist behaviour but to help them understand the circumstances that will influence that behaviour. The intention is to encourage drivers to not regard pedal cyclists as a 'nuisance' and to recognise that the road environment affects the pedal cyclist's behaviour. Basford also recommended that drivers' education, for example in the Highway Code, should include advice on how to respond when encountering pedal cyclists at certain types of road feature, both those explicitly for pedal cyclists and other highway features. This would enable drivers to respond considerately and resist social pressure from other drivers to force their way past pedal cyclists.

Integrated Educational and Awareness training is recommended to improve driver awareness of pedal cyclists. In March 2008, Transport for London launched a campaign to cut collisions between cyclists and goods vehicles distributing 10,000 free safety lenses to freight companies to improve lorry drivers' vision of cyclists. This lens is one of the tools of the Freight Operator Recognition Scheme (FORs), which encourages operators to ensure best practice both for driving standards and vehicle safety. This initiative was coupled with a driver awareness campaign.

More education is required for all types of road user to emphasise the need to be more considerate of others while using the roads in London and to follow the rules in the Highway Code (DSA, 2008).

It is possible that a simple first step that could be considered would be handing out free copies of the Highway Code by high profile enforcement or cycling personnel, for example, our Olympic cycling athletes / Police Officers.

C.2.2 Good practice

C.2.2.1 Reduce impaired cycling

This intervention is aimed at pedal cyclists. Impaired riding can arise through the use of alcohol, drugs (including medicine), and the use of earphones or a mobile phone. The use of alcohol and drugs is covered specifically by Section 30 of the Road Traffic Act (RTA) 1988 and constitutes an offence. However, reckless and careless cycling (Section 28 - amended to 'dangerous cycling' in RTA 1991) and inconsiderate cycling (Section 29) both constitute an offence and can arise from impairment.

Wearing earphones can make a pedal cyclist less able to hear other traffic (Highway Code Rule 148), and the use of a mobile phone can distract and reduce control of the bicycle (Highway Code Rule 149 – riders).

Interventions aimed at impaired cycling would need to educate pedal cyclists on the rules in the Highway Code (DSA, 2008) relating to impairment followed by enforcement measures.

C.2.2.2 Cycle helmet use

This intervention is aimed at pedal cyclists. Much research has been carried out on the effectiveness of helmet. Some of the findings are contradictory, in some cases because of the different research approaches used (The Cochrane Library 2006, 2008a and 2008b). Towner et al. (2002) provided a critical review of research and evidence on the efficacy of cycle helmets. The review looked at the impact of compulsory cycle helmet use on cycling and safety with the intention of identifying gaps in existing knowledge and research. The conclusions reached by Towner were that there is a considerable amount of scientific evidence that cycle helmets are effective at mitigating head, brain and upper facial injuries to pedal cyclists, particularly for children. Also, cycle helmet promotion and legislation needs to be seen as part of a broader package to enhance cycling safety and that barriers to cycle helmet use can be overcome. There are many public sources, including the Cochrane reviews regarding the use of cycle helmets. There is often controversy surrounding their conclusions.

However, there is also evidence from countries that have introduced cycle helmet wearing legislation that compulsion may have resulted in lower levels of cycling. For example in Australia there are reports that the reduction in overall cycle use was greater than the reduction in head-injury achieved.

There is some evidence that lower rates of cycling and helmet wearing by women may be due to comfort (Cycling England, 2008b). Specific publicity campaigns for women would need to take this into account.

The intervention would consider promotion of wearing cycle helmets to mitigate the severity of injury, particularly for children. It is important to recognise that even if they are effective at reducing head injury, helmets will only be able to benefit those who do not also suffer fatal injuries to other parts of the body.

C.2.2.3 Improve pedal cyclists' conspicuity

This intervention is aimed at pedal cyclists. Highway Code rule 59 recommends that pedal cyclists wear:

- light-coloured or fluorescent clothing in daylight and poor light, and
- reflective clothing and/or accessories (belt, arm or ankle bands) in darkness.

Highway Code rule 60 and Road Vehicle Lighting Regulations 13, 18 and 24 (1989, amended 1994 and 2005) state that at night a bicycle must have white front and red rear lights lit. The bicycle must be fitted with a red rear reflector (and amber pedal reflectors, if manufactured after 1/10/85). White front reflectors and spoke reflectors are recommended and flashing lights are permitted. The Highway Code recommends that cyclists who are riding in areas without street lighting use a steady front lamp.

There is a Cochrane (Kwan, 2008) review of interventions for increasing pedestrian and cyclist visibility for the prevention of death and injuries. This looked at various studies of using fluorescent materials in yellow, red and orange colours to improve detection and recognition in the daytime and lamps, flashing lights and retro-reflective materials in red and yellow colours to increase detection and recognition at night.

A study (Mills, 1989) of 776pedal cyclist casualties who attended hospital, recommended that cyclists should be encouraged to wear more protective clothing and head gear.

C.2.2.4 Address carrying loads on bicycles

This intervention is aimed at pedal cyclists. Carrying loads on bicycles is likely to affect the balance and control of the bicycle. Long, heavy or large items are unsuitable and advice on the safest method would be useful. This may include using appropriate bags securely fixed to the bicycle, for example, cycle panniers. This intervention could be considered with cycling competency and cycle training (see section C.2.1.4).

C.2.2.5 Roadworthiness of bicycles

This intervention is aimed at pedal cyclists and is linked to Engineering and Enforcement interventions. The Highway Code (DSA, 2008) applies to England, Scotland and Wales. All road users should be aware of the Code and behave considerately towards other road users. Many of the rules in the Code are legal requirements, and if disobeyed a criminal offence is committed. These rules are identified by the use of the words **'MUST/MUST NOT'**.

The following is taken from the Highway Code rules for cyclists. These rules require pedal cyclists to ensure that they are confident in their ability to ride safely on the road. The rules for their bicycles are the following:

- Choose the right size and type of cycle for comfort and safety.
- Keep lights and reflectors clean and in good working order.
- Tyres should be in good condition and inflated to the pressure shown on the tyre.
- Ensure gears are working correctly.
- Keep the chain properly adjusted and oiled
- Adjust the saddle and handlebars to the correct height

It is recommended that a bell is fitted to your bicycle.

You **MUST**

- Ensure your brakes are efficient.
- At night, use lit front and rear lights and have a red rear reflector.

Interventions highlighting these rules from the Highway Code for bicycles could be in the form of roadside checks. Also, bicycle maintenance workshops could be incorporated into training courses. Employers could be encouraged to supply copies of the Highway Code to their employees (see Section C.2.1.1). The roadworthiness of bicycles is also linked to section C.2.2.3 which deals with bicycle lighting.

C.2.2.6 Driving while impaired

This intervention is largely aimed at other vehicle drivers. Drink driving is illegal and enforcement interventions are already in place (see section C.3.2.1). Further publicity in London highlighting the dangers of drink driving followed by enforcement could be considered. The use of alcohol interlocks in cars and commercial vehicles together with Work Related Road Safety (see section C.2.2.10) recommendations could be considered by employers.

C.2.2.7 Driving while uninsured

This intervention is largely aimed at other vehicle drivers. A review (Greenaway, 2004) for the Department for Transport of the extent and costs of uninsured driving in the UK reported that 5% of vehicles are being driven without insurance, uninsured drivers are more likely to be involved in a collision, more likely to be non-compliant with other road traffic requirements and obligations and potentially to be involved in other criminal activity. Education, training and publicity addressing uninsured driving could be considered with the corresponding enforcement intervention (see Section C.3.2.3).

C.2.2.8 General driving skills

This intervention is largely aimed at other vehicle drivers. Annual TRL reports monitoring the progress towards the casualty reduction targets for 2010 have been produced for the Department for Transport, the most recent of which is Broughton and Buckle (2008). Analysis of contributory factor data has shown a decline in driving standards since 1999 with a prevalence of the factors 'loss of control' and 'excessive speed' in fatal and serious car collisions. One interpretation of this is that driving standards have declined, particularly in urban areas, and the increase since 2002 in pedal cyclists who were hit by cars may mean that they have begun to suffer from the deteriorating behaviour of drivers. Education, training and publicity addressing driving standards or skill might focus on the needs of pedal cyclists to encourage drivers to drive safely, competently and considerately on the roads in London.

C.2.2.9 Roadworthiness of vehicles

This intervention is aimed at other vehicle drivers and is linked to Engineering and Enforcement interventions. The Highway Code applies to England, Scotland and Wales. All road users should be aware of the Code and behave considerately towards other road users. Many of the rules in the Code are legal requirements, and if disobeyed a criminal offence is committed. These rules are identified by the use of the words **'MUST/MUST NOT'**.

The Highway Code provides rules for vehicle maintenance regarding vehicle lighting, steering, brakes, the exhaust system, demisters, wipers and washers. There is a requirement for seat belts to be adjusted correctly and that luggage is secured before starting out on a journey. The rules for tyre pressures and tread depths are listed together with other rules for regular checks and maintenance of vehicles. General rules are given regarding penalties, first aid on the road, vehicle security and work related road safety (see Section C.2.2.10).

Interventions that ensure the roadworthiness of vehicles on the road should reduce the likelihood that a vehicle will respond adversely when involved in a collision, for example, very low brake fluid may result in brake failure which could affect the severity of a collision.

C.2.2.10 Work related road safety

This intervention is largely aimed at heavy goods vehicle drivers. The Freight Operator Recognition Scheme (FORS) has been developed by Transport for London (2008b) to promote safe, efficient and environmentally friendly freight delivery in London. The scheme requires FORS members to run a safe, legally compliant operation and that they have the processes, systems, risk management procedures and records in place. The focus is on the following areas; drivers and driver management, vehicle maintenance and fleet management, transport operations and managing the performance of these operations.

It is possible that freight deliveries could be carried out during the night as fewer cyclists are around at that time, particularly during the 0200 to 0500 hours. However, care should be exercised since fatigue is likely to be an issue during these hours. Also, parts of London are a 24hour city and there could be a negative impact on pedestrian safety.

The preparations for the London Olympics in 2012 are increasing the numbers of heavy goods vehicles in London. These are mainly construction vehicles and it is possible that the procurement chain could demand that the operators sign up to FORS.

Employers often provide suitable storage for cyclists' equipment at work and facilities such as showers. However, it is also in the best interests of the employers to ensure the safety of their employees when commuting to and from the workplace and when using a bicycle for work related journeys. This could embrace cycle training, for example as provided by the London Boroughs (Transport for London, 2008c).

C.2.3 Other intervention

C.2.3.1 Left turn on red at automatic traffic signals (ATS) for pedal cyclists

This intervention is largely aimed at pedal cyclists. The problem of heavy goods vehicles turning left across the path of pedal cyclists has been mentioned earlier, see section C.2.1.1. It has been suggested that a possible intervention for this scenario would be to allow pedal cyclists to turn left on red at ATS (GLA, 2008). While this could allow the pedal cyclist to advance away from the junction ahead of any heavy goods vehicle, and perhaps remove them from danger, there are a number of considerations:

- This would bring pedal cyclists into conflict with comparatively fast moving (typically 30-40mph) traffic and if the pedal cyclist was alongside a large vehicle then their vision of cross traffic would be hindered as would their visibility to oncoming traffic.
- If the pedal cyclists decide that it is unsafe to move on red at the ATS or they wish to travel straight ahead then they would still be alongside the heavy goods vehicle when the lights change.
- Understanding the attitudes of pedal cyclists' wish to take on any additional risk that this might involve would be important.
- There would be increased threats to pedestrian safety through greater conflict between pedestrians and pedal cycles.
- There is the potential for a rise in violation of other traffic signals and stop lines by pedal cyclists.
- There could be a loss of positive signal confidence and predictability amongst pedestrians.
- There would be a loss of priority and space for pedestrians.

Furthermore, allowing a left turn on red might not necessarily be the best way of dealing with this problem, which may be concentrated at particular junctions in which case they can be reviewed individually. For example, left-turn cycle lanes by-passing the lights could be considered, providing the same benefit without having to change the law. A recent initiative (GLA, 2008) by Transport for London, who have applied to the Department for Transport to run trials of the scheme, has been reported in the media (for example, Evening Standard, 2008).

C.2.3.2 Changing driving behaviours that affect cycling safety

This intervention is largely aimed at other vehicle drivers. These would include such measures as using the cameras in buses to alert parking regulators of vehicles parked in bus lanes, review the practice of bus lanes being shared by cyclists and to monitor cyclist use at ATS, for example by fitting red light cameras, and carrying out surveys to measure cyclist behaviours at different types of junctions. Another possibility would be to consider research that would collect data from cameras fitted to pedal cycles or helmets to obtain the cyclists' perceptions of riding in London. This is forming part of a review of pedal cyclists' safety currently being carried out for the Department for Transport by TRL.

C.2.3.3 Drivers' behaviour - change presumptions of liability and/ or insurance cover

This would require extensive education, training and publicity measures to ensure that all road users are aware of any changes to current practice in line with that in place in other countries for example, Holland.

C.3 Enforcement interventions

C.3.1 Evidence based

C.3.1.1 Speed enforcement

This intervention is largely aimed at other vehicle drivers. More effective enforcement may be achieved by the use of average speed cameras which would encourage drivers to maintain their speed within the limit rather than slow down in the vicinity of a traditional safety camera. Speed awareness course for drivers could include an element that deals with awareness of pedal cyclists and their behaviours. Increased levels of enforcement could lower the incidence of speeding and reduce the severity of injury (Crawford, 2008).

C.3.2 Good practice

C.3.2.1 Drinking and driving or riding

This intervention is aimed at other vehicle drivers. In the UK the legal drink-drive limit for motor vehicle drivers and riders is 80 milligrams of alcohol per 100 millilitres of blood (equivalent to 35 micrograms of alcohol per 100 millilitres of breath). In London, there were 886 screening breath tests carried out in 2006 per 100,000 population compared to 1,127 for the whole of England and Wales (Ministry of Justice, 2008). For some of the Police Forces in England and Wales this number is much higher, for example, in Cheshire it is 3,599 and in Hampshire it is 1,920. A recent article in Road Casualties Great Britain (Department for Transport, 2008) shows that, generally, when the number of breath screening tests carried out increases, the number of positive / refused breath tests decreases, i.e. the number of drink drive collisions. This is probably closely linked to the perception of potential drink drivers as to whether they will be caught or not. Research (Broughton, 2003) has also shown that drivers who committed several non-motoring offences were far more likely than non-offenders to also commit offences such as drink driving or dangerous driving.

Consideration should be given to (a) increasing the breath testing rate and consequently discouraging potential drink drivers or (b) using the breath testing powers of the Police to identify drink drivers; this could reduce the load on Police resources.

C.3.2.2 Impairment and cycling

This intervention is largely aimed at pedal cyclists. The Highway Code states that pedal cyclists must not ride when under the influence of drink or drugs, including medicine (Highway Code, 2008d). However, there is no legal limit for alcohol for pedal cyclists and the Police do not have breath testing powers for cyclists. A method used by Police Forces to assess whether a pedal cyclist is impaired is similar to the impairment tests used for drivers when under suspicion of impairment but have passed a breath screening test. An example of one of these tests is the walk and turn test. The police office determines a suitable location and the driver is required to take nine heel-to-toe steps along the line, to turn keeping the toe of one foot on the ground and take small steps with the other foot and return. The driver must keep their hands by their sides throughout and count the steps out loud to the police officer (Department for Transport, 2004).

Future consideration could be given to setting a legal limit for alcohol for pedal cyclists. Some research would need to be done to determine a suitable level but the current drink-drive limit would be a good starting point. Other forms of riding while impaired, for example, using a mobile phone or earphones could also be considered.

C.3.2.3 Driving while uninsured

This intervention is largely aimed at other vehicle drivers. Driving while uninsured indicates a lack of competence by the driver. A review of the extent and costs of uninsured driving in the UK (Greenaway, 2004) estimated that 5% drivers in the UK were uninsured. Greenaway reported that an uninsured driver is more likely to be involved in a collision, more likely to be non-compliant with other road traffic requirements and obligations and potentially to be involved in other criminal activity.

Consideration could be given to monitoring of vehicles and real time checks against insurance databases combined with links to the enforcement of general Road Traffic Law.

C.3.3 Other interventions

C.3.3.1 Parking near junctions or within bus lanes

This intervention is largely aimed at other vehicle drivers. Other uninvolved vehicles parked near junctions mask the pedal cyclist from moving traffic. Consideration should be given to whether parking should be made illegal within a certain distance of a junction. The advice in the Highway Code restricts parking within 10m of a junction and increasing this distance seems like an important consideration.

C.3.3.2 Heavy goods vehicle construction and use offences

This intervention is largely aimed at other vehicle drivers. Operation Mermaid is a multi-agency operation carried out by the Metropolitan and other Police Force areas to check goods vehicles for defects and other offences, which could adversely impact road safety. The agencies that are involved include the Department of Transport, Vehicle and Operator Services Agency (VOSA), HM Customs Investigation Branch, the Benefits Agency and Trading Standards. Representatives from the different agencies check vehicles for offences, which could impact on road casualties in London, for example, driver hours, excess weight and mechanical defects.

This operation could include an additional check, which could be viewed as an intervention linked to the safety of cyclists, on correct fitting and adjustment of mirrors on goods vehicles and that their indicators are present and working correctly.

C.3.3.3 Compliance at traffic lights

This intervention is largely aimed at pedal cyclists. Red light violations by all road users at ASLs have been reported by Allen (2005) and Webster (2006).

A recent manual survey carried out for Transport for London in June 2007 measured pedal cyclists' compliance with traffic lights on every arm of each of five selected sites in central London on a weekday. A violation was defined as a cyclists crossing though a red light, and continuing over or turning at a junction. As such, a violation was not merely deemed to be crossing the stop line. However, the results may be subjective to judgement of individual surveyors. The findings were:

- The majority of cyclists (84%) obey red traffic lights.
- Violation is not endemic, but 1 in 6 (16%) of cyclists do jump a red light, and at this level may encourage more to do so in the future.
- A much greater number of men cycle during the morning and evening peaks. When a comparison is made of the behaviour of male and female cyclists it can be concluded that men are slightly more likely to violate red lights (17% compared to 13%).
- In general cyclists who ride through red lights are more likely to do so whilst travelling straight ahead at a junction. They are least likely to do so when turning right.
- Red light violations are most common by cyclists travelling towards central London in the morning, and away from central London in the evening.

Consideration to methods for changing this behaviour of pedal cyclists at traffic lights and perhaps changes to the phasing at traffic light controlled junctions.

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Analysis of police collision files for pedal cyclist fatalities in London, 2001 - 2006

The numbers of cyclist fatalities in London have varied over the years from 1986 to 2006; averaging 18 per year, the maximum was 33 in 1989 and the minimum was 8 in 2004. There has been a substantial increase in cycling, particularly in central and inner London. The London Travel Report 2007 (Transport for London, 2007a) reported that in 2006 the cycle flows on London's major roads were almost twice as many as in 2000.

This study has described the in-depth characteristics of 92 fatal cyclist collisions in London between 2001 and 2006. These small numbers are not statistically reliable; however, this study provides very detailed qualitative data. An almost complete set of police collision investigation files were located (85%) which has reduced the potential for selection bias to distort analysis and findings.

The process of reviewing the fatal files and considering the interventions that might have been expected to have reduced their number or injury severity has led to a number of recommendations to reduce cyclist fatalities in London. They do not explicitly take account of the wider context in which decisions about cyclist safety must be made. Transport for London already undertakes varying levels of activity along the lines of some of the interventions described here.

The interventions proposed following the review of the fatal files are neither exhaustive nor presented in any order, but are directly relevant to the collisions investigated in this study. The proposed interventions relate to engineering, education (including training and publicity) and enforcement.

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