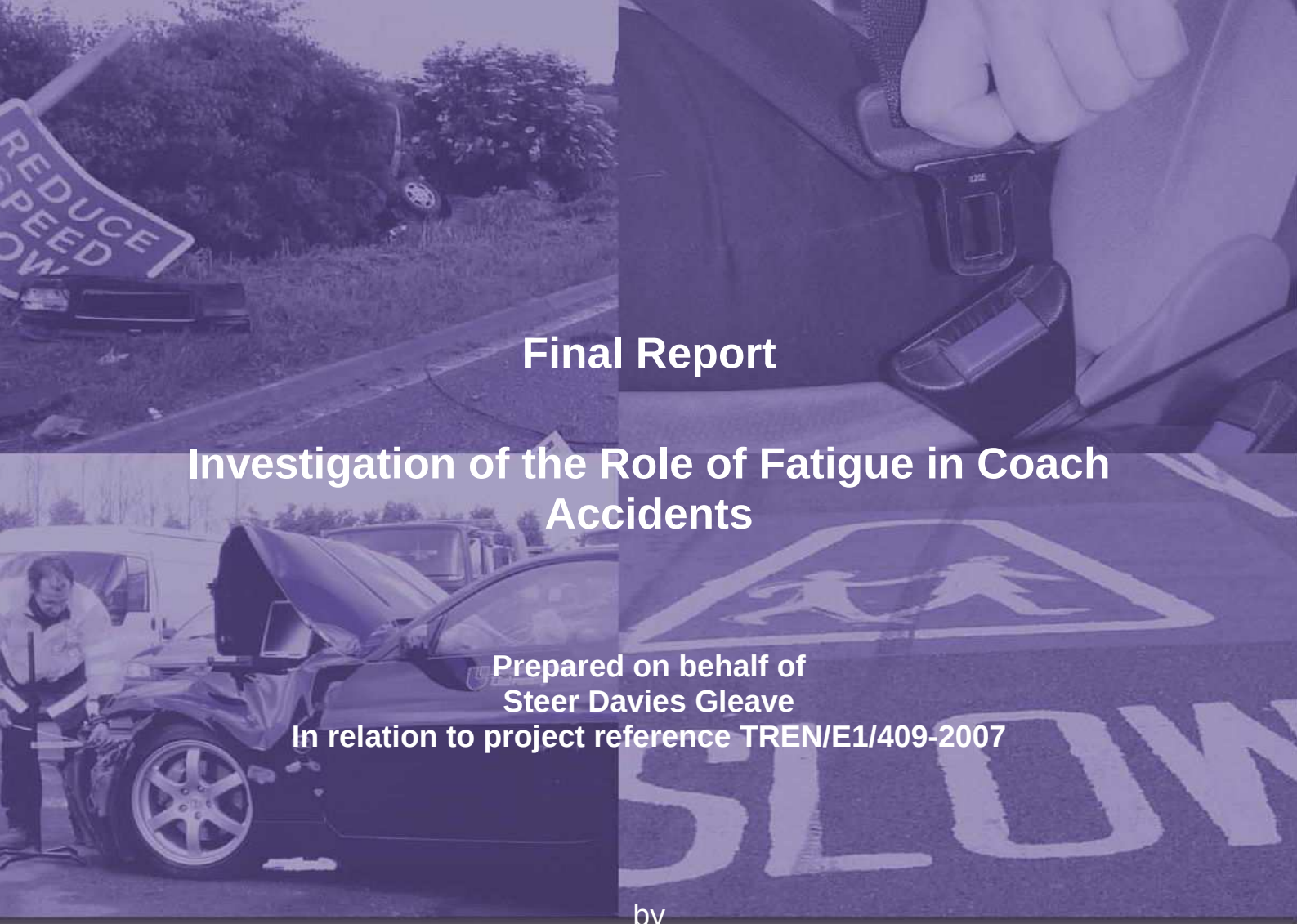

Final Report

Investigation of the Role of Fatigue in Coach Accidents

Prepared on behalf of
Steer Davies Gleave
In relation to project reference TREN/E1/409-2007

by

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EXECUTIVE SUMMARY

This report has been prepared as part of a wider study into passenger transport by coach in Europe - reference number TREN/E1/409-2007. The objectives of this small study are to understand the main causes of coach accidents with respect to understanding the role of driver fatigue and to consider the accident data with regard to drivers' hours and the 12 day derogation. The work started on the 12th November 2008 and has been undertaken by the Vehicle Safety Research Centre of Loughborough University according to the proposal dated the 30th October 2008.

The report includes a review of the literature concerned with the issues associated with driver fatigue with particular reference to coach driving and crashes. Work undertaken by the Sleep Research Centre at Loughborough University has been reviewed, along with work by other expert groups such as the European Transport Safety Council, the US National Highway Transportation Safety Administration and the US National Transportation Safety Board. This research represents the current 'State of the Art' in fatigue related accident research, not just in Europe, but also in America and Australia. The literature highlights the difficulty of isolating fatigue as the cause of an accident, but identifies specific factors which increase the risk. Certain times of day (02.00, 06.00 and 16.00 hours) and certain road types (motorways and other monotonous inter-urban routes) are known to be associated with increased risk, but other factors which are important are lack of sleep, physical fitness, shift patterns and age. Time spent driving is generally not considered to be a good indicator of accident risk.

A review has also been undertaken of accident data published from the European CARE database (Community Road Accident Database) and also other existing European data sources. This report includes a summary of the various data sources and a description of the data available in them. In all the data examined it is difficult to separate coaches from a broader vehicle type description. In most cases 'bus or coach' is a single variable, in other cases other public service vehicles such as trams or trolley buses are also included. Accidents involving buses or coaches are responsible for only a small proportion of total road accident fatalities in Europe (2.5% in 2006). The published figures suggest that there is some evidence to support the findings of earlier studies looking at fatigue, an apparent increase in fatal accidents in the early morning and towards the end of the working day can be observed. This increase is more noteworthy on motorways than other road types. However, the published data are not sufficiently detailed to assess the effect on accident risk of shift patterns, time spent driving and rest periods, so are not well-suited to addressing the question of the 12 day derogation.

A review and analysis of the national accident data for Great Britain (STATS19) has been undertaken. Permission has been obtained from the UK Department for Transport for the analysis of data for the years 2005/2006/2007, using make/model and accident causation data fields. The results of this analysis indicate that the STATS19 database is not ideally suited to addressing the question of the likely impact of the 12 day derogation on road safety due to the difficulty of identifying the vehicle type of interest and the small sample of cases with fatigue identified as a causation variable. However, the overview of bus and coach accidents on motorways by time of day shows the same pattern as that

identified through the CARE analysis. Using the accident causation variables for fatigue, detailed analysis of the relevant fatigue cases (n=24) does not give a clear picture of the types of accident or accident scenario expected for these accidents. Despite the very small number of cases, the in-depth accident review (n=4) indicates that accident time could be an indicator for fatigue accidents. This supports the findings of the literature review, where time of day was identified as a major indicator of fatigue accidents.

A review has also been undertaken of a number of recent coach crashes in the UK and Europe. These crashes were reported in the media and/or came to the attention of the VSRC through its routine accident investigation work. As far as is possible, information has been gathered in relation to the circumstances of the crash, the causes of the crash and the recommendations. Of the 26 cases from the UK and Europe which were reviewed in detail, 12 (46%) cases were considered to be caused by factors other than fatigue and 1 of these cases occurred at a peak time for fatigue (16.00hrs). However, 4 cases (15%) had a specific reference to fatigue or had strong evidence that fatigue was a cause. In addition, 1 of these cases occurred at a peak time for fatigue (16.00hrs). In a further 10 cases (39%) fatigue may have been a contributory factor as the time of the crash, or the nature of the crash circumstances or journey type, are consistent with the main indicators of fatigue related accidents. In addition, 1 of these cases occurred at a peak time for fatigue (06.00hrs). As it is equally likely that fatigue did not play a part in a number of these 10 crashes, no firm conclusions can be drawn regarding the actual role of fatigue.

As can be seen from these in-depth cases the causes of crashes are complex and in many cases it is difficult to determine if fatigue played a role. However, whilst the number of cases is small, these findings support the indication from the literature that fatigue related accidents are more prevalent than the available statistical data might otherwise suggest.

Whilst the literature demonstrates that fatigue is a contributory factor in road accidents involving coaches, it is not possible to quantify this contribution with the available accident data. The European data are not sufficiently detailed regarding the number of coach crashes or the information that is necessary to determine the role of fatigue. Using the national data for Great Britain (STATS19) the data are not sufficiently detailed regarding the number of coach crashes, even when using the make/model information. Using the accident causation field for fatigue, the number of cases that can be confirmed and investigated is so small that reliable conclusions cannot be drawn. However, analysis of both the European data and the data for Great Britain, gives some indications that fatigue might be a contributory factor when the time of the accident (small hours of the morning and late afternoon) and the type of road (motorway) are considered. The review of a small number (26) of detailed crash reports of coach accidents in Europe and the UK also demonstrate that fatigue is evident as a contributory factor in some of these cases.

Therefore, in terms of addressing the specific question of the safety implications of reinstating the derogation of the drivers' hours, the data that are currently available are not sufficiently detailed to address this issue.

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1. INTRODUCTION

1.1. Background

This report has been prepared as part of a wider study into passenger transport by coach in Europe reference number TREN/E1/409-2007. The objectives of this small study are to understand the main causes of coach accidents with respect to understanding the role of driver fatigue. The work started on the 12th of November 2008 and has been undertaken by the Vehicle Safety Research Centre of Loughborough University according to the proposal dated the 30th of October 2008. The work programme included 4 research activities and the presentation of the findings in a final report.

1.2. Vehicle Safety Research Centre (VSRC)

The VSRC is one of two research centres at the Ergonomics and Safety Research Institute (ESRI) at Loughborough University. Established in 1983, the VSRC has 30 experts in the field of road accident research, including vehicle, highway and human factors, with special emphasis on real world accident investigations. VSRC is an independent research and consultancy centre producing information and recommendations to governments, the European Commission and industry. An objective data-driven approach, based on in-depth investigations of numerous real-life crashes, provides fundamental information for legislators and road-user safety strategy engineers. Together with the Applied Ergonomics Centre at ESRI, experts across the wider Loughborough University community and a network of partners across Europe, the Centre is able to bring a very wide range of expertise concerning road safety issues, active and intelligent vehicle safety systems, crashworthiness and casualty reduction strategies. The Centre has 4 PhD students studying different aspects of active safety. The significance of research undertaken by the VSRC, together with research conducted by the Sleep Research Centre, has recently been recognised by the joint award of a 2007 Queen's Anniversary Prize for work in vehicle, road and driver safety research.

The VSRC has undertaken a number of research projects of direct relevance to this study. They include:

- The EC 5th Framework Programme funded project ECBOS (Enhanced Coach and Bus Occupant Safety). As Leader of Task 1.1 this involvement included an investigation of collision and 'non collision' casualties on local buses in Great Britain and the consolidation and reporting of the national casualty data analysis of 7 other participants.

- The UK Department for Transport funded project 'Seatbelts: requirements for minibuses and coaches' in whch the VSRC was a subcontractor to TRL Limited. The VSRC contributed analysis of the issues of exposure and child injury data on coaches and minibuses at national and local level. Practical issues of fit and use of seatbelts and child restraints were investigated through user trials and observations.
- The participation in a study with the Cranfield Impact Centre in a dedicated call from the European Commission on the Safety Consideration of Longitudinal Seating Arrangements in Buses and Coaches.
- The SafetyNet project is a 6th framework Integrated project co-funded by the European Commission, Directorate-General Transport & Energy. The project began on the 1st of May 2004 and is nearing completion. The project Consortium consists of 21 partners from 14 EU member states and 3 non EU countries. This partnership brings together many of the most experienced organisations in the field of road and vehicle safety. In its 2001 White Paper the European Commission identified the need for a "Road Safety Observatory" and it is the intention of this project to provide the EC with the building blocks for such an Observatory. The VSRC is the co-ordinator of SafetyNet. The TRACE project was funded under the EC 6FP Programme. The 16 full partners were from 8 EU countries and included vehicle manufacturers, universities, research laboratories and insurance companies. The overall aim was to provide the scientific community, stakeholders, suppliers, vehicle industry and other Integrated Safety Program participants with an overview of road accident causation in Europe, by analysing existing databases. The project identified, characterised and quantified the nature of risk factors, groups at risk, specific conflict driving and accident situations and estimated the safety benefits of a selection of technology based safety functions.
- The On-The-Spot accident research project (OTS) takes teams of crash investigators to the scenes of accidents alongside emergency services, to collect data on causation. It began in 2000 and is funded by the Department for Transport (DfT) and the Highways Agency and is now in its third phase.

Using this wealth of previous research and expertise in the analysis of European, National and in-depth data the VSRC has been able to determine a work programme that is realistic with the available information and which was achievable in the short time frame of the study.

1.3. Overview of the Work Programme Undertaken

1.3.1. Review of literature and existing accident databases

A literature review has been undertaken regarding the issues associated with driver fatigue and with particular reference to coach driving and crashes. Work undertaken by the Sleep Research Centre at Loughborough University has been reviewed, along with work by other expert groups such as the European Transport Safety Council, the US National Highway Transportation Safety Administration and the US National Transportation Safety Board. This research represents the current 'State of the Art' in fatigue related accident research, not just in Europe, but also in America and Australia. The findings of this review are presented.

A review has also been undertaken of accident data published from the European CARE database (Community Road Accident Database) and also other existing European data sources. Given the limitations of these datasets with regard to the analysis of accident causation and selection of target vehicles it has been possible to draw only general conclusions with regard to the contribution of fatigue. The report includes a summary of the various data sources and a description of the data available in them.

1.3.2. Review of accident data collected as part of the wider activity in Project reference TREN/E1/409-2007

Accident data collected as part of the wider activity in Project TREN/E1/409-2007 has been included. This data has been considered in the context of the wider accident data.

1.3.3. Review of accident data for Great Britain (STATS19)

Permission has been granted by the UK Department for Transport for the analysis of the national accident data for Great Britain (STATS19) for the years 2005/2006/2007. Permission has been specifically given to use the make/model and accident causation variables and a review and analysis of this data has been undertaken with particular reference to coaches.

1.3.4. Investigation of specific coach crashes

A number of coach crashes have been reviewed. This search has included high profile crashes from the UK and Europe which were reported in the media and crashes which have come to the attention of the VSRC through its routine accident investigation work. Information has been compiled, predominantly from media sources, in relation to the circumstances of the crash, the causes of the crash, where relevant the legal outcome and any recommendations. Case summaries for these crashes are presented and the findings discussed.

2. REVIEW OF LITERATURE

2.1. The importance of coach trips as a transport mode

There is currently little robust statistical data regarding passenger transport by coach in the European Union. In countries where data exist it is often difficult or impossible to separate short distance urban public transport, such as buses and trams, from long distance coach travel (LeJeune et al, 2007). It is especially hard to find reliable figures for occasional transport by coach, for example as represented by tourist travel.

As sustainability and “green” policy objectives have an increasingly high profile at both national and European level, coach travel could potentially play an important role in reducing car-dependence.

It is therefore desirable to know more about the contribution of coach travel to vehicle and passenger kilometres within Europe, and also to understand the potential safety issues that should be addressed.

Fatigue is one such issue. It has been suggested that professional drivers are particularly susceptible to fatigue because of the higher incidence of medical conditions such as Obstructive Sleep Apnoea (Rodenstein et al, 2008). In addition, accidents where fatigue is a factor tend to occur at higher speeds (Horne and Reyner, 2001). This greater speed combined with the greater size and mass of coaches and the (possibly) high number of vehicle occupants means that coach accidents with driver fatigue as a factor have the potential to lead to severe consequences in both human and financial terms.

The European Road Safety Observatory (2008) has recently published a detailed analysis of existing literature on the subject of driver fatigue, looking at definitions, causes, consequences and possible counter measures. This document is a thorough review of the topic of fatigue and the conclusions suggest that important measures to address the issue include:

- Further improvement in legislation concerning driver fatigue. The current EU legislation does not take into account all factors relevant to fatigue and EU Member States legislations are highly variable in terms of legal rules for driving fitness for persons with a sleeping disorder.
- Publicity and education campaigns to increase awareness of the problem of fatigue and possible countermeasures. The provision to drivers of clear and practical

messages, which make clear the importance of preventing fatigue rather than trying to overcome it is essential.

- Within transport companies, fatigue management plans may be successful in combating driver fatigue provided they are endorsed at all company levels and part of a more general safety culture.
- In the future, driving assistance systems may warn the driver when the driver or vehicle show signs of fatigue-induced behaviour.
- Knowledge about cost-benefit of various countermeasures is needed.
- It is clear that current knowledge about the scale and costs of fatigue as a road safety issue is inadequate for the purposes of designing legislation. According to ERSO (2008) "a well-designed, large-scale epidemiological study on the risk-increasing effects of fatigue could be an important contribution to knowledge about this problem".

2.2. Fatigue and safety

There is no clear definition of fatigue. It can have a physical meaning (for example resulting from physical exertion), a neurobiological meaning (determined biologically by rhythms of sleep/wakefulness) and a mental/psychological meaning (a subjectively experienced reluctance to continue with a task) (SWOV, 2006). The term describes a range of states and symptoms including drowsiness, lack of concentration, increased reaction time, decreased awareness and poorer coordination, with the most serious potential consequence being actually falling asleep at the wheel.

There is some research evidence which addresses general questions about fatigue and traffic safety, and literature which examines specific categories of road user (coach drivers, truck drivers, car drivers). This study considers all of the available evidence in order to draw relevant conclusions; however there are few research publications which specifically link fatigue to number of days worked or weekly rest (the studies which have been undertaken are discussed in section 2.4 below).

One would expect that drivers experiencing fatigue would suffer a reduction in their ability to drive safely. According to Maclean et al (2003) studies suggest that the most common changes in driving performance attributable to sleepiness include increased variability of speed and lateral lane position. Higher order functions such as judgement and risk-taking may deteriorate.

The Australian Transport Safety Bureau (2003) suggests that three general factors influence fatigue:

- Lack of sleep,
- Time of day,
- Time spent on task.

These general factors are augmented by specific individual factors such as the driver's age, physical fitness and certain medical conditions.

According to Horne and Reyner (2001) sleep-related vehicle accidents are typically characterised by vehicles running off the road or colliding with the rear of another vehicle, with no attempt to apply the brakes beforehand, resulting in high impact speed.

SWOV (2006) state that,

"The next question is whether fatigue also plays a role in the occurrence of road crashes. The answer is an unambiguous yes."

According to RoSPA,

"*Driver fatigue is a serious problem resulting in many thousands of road accidents each year"*

However, obtaining accurate data regarding the extent of the problem is not easy, as a result of the difficulty of identifying whether or not fatigue was a factor in a specific accident.

According to Rodenstein (2008),

"*Awareness that sleepiness causes many road accidents may be hampered by the lack of questions about sleepiness in police accident report forms, especially when there is death or serious injury. Whereas in many countries these forms refer to alcohol or drugs they omit references to acute or chronic sleepiness*."

A number of studies have attempted to quantify the problem. Horne and Reyner (1995) attempted to assess the incidence, time of day and driver morbidity associated with accidents where the driver falling asleep was the most likely cause. They identified "sleep-related accidents" by the following criteria:

- Blood alcohol levels below the legal limit,
- The vehicle either runs off the road or collides with the back of another vehicle,
- There is no attempt to apply the brakes beforehand (hence no skid marks),
- There is no mechanical defect (for example, tyre blow-out),
- Good weather and visibility,
- Elimination of speeding or driving too close as causes,
- Police officers at the scene suspected sleepiness as the prime cause,
- For several seconds immediately before the accident the driver could have seen clearly the point of run off or the vehicle hit.

They concluded that,

"sleep related vehicle accidents are largely dependent on time of day and account for a considerable proportion of vehicle accidents, especially those on motorways and other monotonous roads."

Their results indicate that such accidents accounted for 16% of road accidents in general and over 20% of motorway accidents, with distinct peaks at 02.00, 06.00 and 16.00 hours.

Research from other countries suggests a similar incidence of fatigue or sleep-related accidents. In Australia 16.6% of fatal crashes in 1998 involved driver fatigue. The Northern Territory had the highest rate of fatigue-related crashes per 100 million vehicle kilometres travelled (0.66). However, within individual States and Territories, New South Wales had the highest percentage of fatal crashes involving driver fatigue (22.0%). Between 1990 and 1998 the proportion of fatal crashes involving driver fatigue increased from 14.9% in 1990 to 18.0% in 1994, after which there was a decline to 16.6% in 1998 (Australian Transport Safety Bureau, 2003).

While not targeted research on coach drivers, comparable research on truck drivers has been conducted in the USA, where a series of studies by the National Transportation Safety Board (NTSB, 1999, 1995) concluded that 52% of 107 single-vehicle accidents involving heavy trucks were fatigue-related. In nearly 18% of the cases, the driver admitted to falling asleep. Summarising the findings of this research, the extent of fatigue-related fatal accidents is estimated to be around 30%. More recently, the "100 Car Naturalistic Driving Study" (NHTSA, 2003) found that 22 – 24% of crashes and near-crashes had driver drowsiness as a factor.

According to the European Transport Safety Council (ETSC) the situation in Europe is less well researched and many of the studies are likely to underestimate the extent of the problem. ETSC (2001) refers to a number of relevant studies which have attempted to quantify the problem:

- In Finland, the percentage of fatal accidents involving fatigue or falling asleep fluctuates between 16-19% (Hantula, 2000),
- In a UK survey, "tiredness" was reported by the drivers questioned as being a factor in 7.3% of the accidents they had been involved in during the three years preceding the study (Maycock, 1995),
- A German study estimated fatigue to be a factor in 7% of accidents according to lorry and bus drivers (Garo et al, 1997),

- A Bavarian study found that 24% of the fatal accidents (irrespective of road users categories) that had occurred on motorways in 1991 (204 in total) were the result of sleepiness at the wheel (Langwieder and Sporner, 1994).

Looking specifically at the case of HGV drivers, ETSC (2001) cites two studies:

- A Dutch survey found that 7% of HGV drivers attributed their accident involvement to having fallen asleep at the wheel (van Ouwerkerk, 1987),
- A more recent French study showed that 10.5% of HGV drivers stated that fatigue had contributed to their road crash involvement (Monfrin et al, 1996), Langwieder and Sporner (1994).

The European Truck Accident Causation Study (IRU, 2007) was an in-depth study, the aim of which was to "fill-in" current gaps in knowledge about accidents involving large goods vehicles. Fatigue was highlighted as a factor in some of the 624 accidents included in the final database. Results indicated that:

- Fatigue was a factor in only 6% of the total accidents,
- 37% of the accidents where fatigue was a factor were fatal,
- 29% of the cases with fatigue as a factor were single truck accidents,
- Two time periods were identified as being important; 02.00 to 02.59 (when the driver's biorhythm is at a low point), and from 15.00 to 15.59 (when it is nearly the end of the working day),
- Nearly 90% of fatigue accidents happen on highways or on inter-urban roads. Fatigue as an accident cause plays only a minor role in cities.

According to SWOV (2006) police reports indicate a 1- 4% incidence of sleep related crashes out of all crashes. However, this is assumed to be an under-representation of the problem, caused by a lack of awareness amongst police of the issue. Questionnaire studies and in-depth crash analyses suggest that the true extent of the problem is 10 - 25% higher.

Studies from the Australian Transport Safety Bureau (2002), SWOV (2006) and Horne and Reyner (2001) highlight factors which place an individual driver at increased risk including:

- Shift work,
- Solitary work,
- Disturbed sleep,
- Age,
- Presence of sleep disorders,
- Physical fitness.

Some of these factors are particularly relevant to professional drivers, though the consequences will vary between different vehicle types and journey types.

2.3. Legislation

It is not a specific offence to drive whilst tired, though it may be that a tired driver is more susceptible to committing other offences. The main approach of strategies to limit fatigue in professional drivers has been to limit the hours worked. In Europe, drivers' hours are governed by two sets of regulations, the purpose of which is to ensure that excessive hours are not driven. Within the EU the relevant legislation is Regulation (EC) No 561/2006. Outside the EU it is the "European Agreement on the Work of Crews of Vehicles Engaged in International Road Transport" (AETR) which sets out the relevant limits. In addition, some countries have their own national legislation for purely domestic operations. The regulations cover two elements of the drivers' schedule; driving time and rest periods. Rest periods are categorised as either daily or weekly rest.

Driving time

Weekly driving time shall not exceed 56 hours or the maximum working time laid down in the Working Time Directive No. 2002/15. Maximum 90 hours in any two consecutive weeks.

Not more than 4 hours without taking a break of 45 minutes or several breaks of at least 15 minutes taken over the 4 hours. The daily driving limit is 9 hours but this can be extended to 10 hours twice a week.

Driving Breaks

After four and half hours, a driver shall take an uninterrupted break of not less than 45 minutes unless he takes a rest period. This break may be replaced by a break of at least 15 minutes followed by a break of at least 30 minutes each distributed over the 4½ hour driving period. (Art 7)

Daily rest

11 hours in the 24 hour period commencing at the end of the last daily or weekly rest period. This may be reduced to 9 hours no more than three times between any two weekly rest periods.

Weekly rest

Must start after six 24 hour periods from the end of the previous weekly rest period. A driver may extend a daily rest period into either a regular weekly rest period of at least 45 hours or a reduced weekly rest period of less than 45 hours but at least 24 hours.

> In any two consecutive weeks a driver shall take at least two regular weekly rest periods, or one regular weekly rest period and one reduced weekly rest period of at least 24 hours. However the reduction shall be compensated by an equivalent period of rest taken en bloc before the end of the third week.

Regulation 561/2006 came into force in April 2007 and was intended to harmonise and simplify the existing regulations. One of the most controversial features of this legislation was the removal of the "12 day derogation". In effect this was an exemption which allowed drivers engaged in occasional international coach tours to drive for up to 12 consecutive days before taking a weekly rest period. A number of arguments have been put forward in support of the reinstatement of the derogation, including:

- No evidence has been put forward to demonstrate that driving for more than 6 days increases accidents,
- From a scheduling point of view, such tours are very different from other types of commercial road transport, as drivers frequently have long breaks while passengers visit tourist sites,
- Forcing drivers to take additional overnight breaks away from home could affect the quality of the sleep they get, hence impacting on safety,
- It may be necessary in some instances to hire local drivers to cover some days. These will have a lower level of knowledge of the vehicle and will be harder for coach companies to monitor and train, so may have a higher likelihood of accident involvement.

The removal of the 12 day derogation has not yet been applied to the AETR, which means that the two sets of legislation are not currently harmonised.

Under EU rules a tachograph must be used to record hours of driving, other work, breaks and rest periods. These must be regularly inspected by an approved calibration centre every two years.

2.4. The effect of driving hours on the onset of fatigue

As discussed above, the relationship between crash risk and time spent driving is not generally one which has been well-researched. However, some studies do exist.

Hanowski at al (2009) undertook a naturalistic driving study, the aim of which was to examine the effect of change in drivers' hours regulations in the US to permit an additional hour of driving (from ten to eleven hours). The study found no consistent significant increase in

incidents between hours two and eleven spent driving, but an elevated accident risk during the first hour.

According to Hanowski et al (2009) time on task is;

" a poor predictor of crashes and safety-related traffic events. In fact, a significant spike in the rate of critical incidents was found during the 1st driving-hour. These results are not consistent with the contention that crash risk increases as hours of driving increase…."

Whilst the context of these results were amendments to US drivers' hours regulations, similar findings have also been generated in Australia, where a study looking at the onset of fatigue in long distance drivers found that natural (circadian) rhythms had a greater impact on fatigue than time on driving task

"These findings raise questions about the validity of the assumption underlying work hour regulations for long-distance drivers which, currently, are universally based on duration of work." (Feyer and Williamson, 1995)

This study did, however also conclude that drivers who were able to arrange breaks flexibly when they began to feel fatigued were better able to manage the problem.

It is difficult to establish a direct relationship between time spent on the (driving) task and accident risk. Time of day is an additional important factor because of the effect of circadian rhythms on alertness. Circadian rhythms control sleep and wakefulness. During daytime they generate a drop of vigilance in the mid-afternoon and a very alert period towards the end of the afternoon (Philip et al, 2007).

For coach drivers there are a number of other important factors which will affect their likelihood of suffering from fatigue. These can be divided into three categories; personal factors, journey type factors and external factors, which are discussed in turn. No studies have been found which specifically address the question of the effect of number of days spent driving on fatigue.

2.4.1. Personal factors

According to Horne and Reyner (2001) whilst the drivers' hours regulations refer to "adequate rest" there is little guidance on what is meant, and no acknowledgment of the fact that "adequate rest" is not the same as adequate sleep. The amount of sleep needed is highly dependent on individual circumstances, varying with factors such as age and general fitness level. Other personal factors which will affect fatigue include shift patterns, with drivers being particularly vulnerable during their first night working a nightshift and early in the morning after a long night shift (Horne and Reyner 2001). Physical fitness is also

important, with some medical conditions having a known association with fatigue accidents. Obstructive Sleep Apnoea is one such condition, and whilst it is covered by some countries' Physical Fitness to Drive regulations, it is not covered in all countries (Rodenstein, 2008). In a sector like coach travel, where drivers may cross national boundaries, this is a factor which could warrant further research.

2.4.2. Journey type factors

In the case of long-distance tourist travel by coach, there are a number of factors which could work together to compound the potential problem of fatigue. Whilst the schedule over the duration of the tour may incorporate a diverse range of journeys and incorporate scheduled stops for visits, meals etc, these will not necessarily mitigate the risks. It is likely that there will be long stretches of driving on motorways or other inter-urban routes, which are known to have a higher incidence of fatigue accidents due to the lower mental stimulation and lower levels of concentration required. If working to a set itinerary which requires the coach to be at specific destinations by certain times, the opportunity to take breaks may be limited by the schedule that is being worked to. In addition, any stop involves the safety, welfare and wishes of the passengers. The coach driver may not be able to make an unscheduled stop and would not be able to expect the passengers to sit and wait whilst they take a break. This is likely to make it more difficult for the driver to have any flexibility over decisions about when and where to take breaks, making it more likely that drivers would feel forced to continue even if they began to feel tired. The breaks that are scheduled in will not necessarily be at a time, location or duration that fits in with the driver's need to rest.

2.4.3. External factors

Related to journey type factors, there are other factors over which neither the coach driver nor coach company has any control over, which could affect the extent to which the driver may feel pressured to continue to drive despite being fatigued. These include delays caused by bad weather (for example by affecting ferry crossings) and accidents (which may lead to congestion and other traffic disruption).

These factors can work together to compound the effect of time of day and time on task in causing the driver to suffer from tiredness.

In the light of the importance of other factors, and because of the general lack of information in the accident databases about length of time spent driving, the analysis of European and international accident data will focus on time of day, rather than time on task as an indicator of fatigue.

2.5. Conclusions

Road accidents are complex phenomena which generally result from the interaction of a number of factors. It is hard to prove that fatigue is the main cause of an accident, or that it has contributed. There are various stages of consciousness, from slight fatigue to sleeping, making it difficult to ascribe fatigue as a cause. This is compounded by the fact that fatigue may be mistaken for other factors such as excess speed or lack of attention.

It is likely that the incidence varies by a number of factors with lack of sleep and time of day being key factors, but with others such as shift patterns, age and physical fitness being important. These factors are not generally recorded in national accident databases. Fatigue accidents are likely to also be influenced by the road environment, with monotonous motorway and trunk roads being more problematic than urban roads where drivers have more mental stimulation. Accurate estimates of fatigue-related vehicle accidents are very difficult to make with any certainty because of a lack of reliable evidence. However, the estimates in the literature vary from 1 - 4% (SWOV, 2006) to 24% (NHTSA, 2003) depending on the precise conditions specified in the study (whether all road types, road-user types and times of day are considered, for example).

Although not directly addressed in the literature, factors are highlighted that are relevant to coach drivers, who are more likely to be affected by fatigue if:

- It is night time
- They are using long, straight roads,
- They are at the beginning or end of a long journey,
- They have relevant personal factors such as existing medical conditions.

These factors are not specifically related to the 12 day rule, and will not be applicable to all driving on international coach tours. There are specific regulatory provisions designed to minimise the risk of driving at night.

Current legislation aims to manage the incidence of fatigue-related accidents by controlling the length of time which professional drivers can work for and the amount of time they spend resting. There is evidence that factors other than time spent on task will have an important effect on the likelihood of a driver experiencing fatigue. These include factors over which drivers and employers have some degree of control (physical fitness, journey scheduling and shift patterns), and factors over which they have none (traffic conditions and weather). However, there is no information in existing national accident databases about these additional factors. This makes the drawing of definite conclusions regarding the contribution of these factors problematic. Time of day and road type can be used as indicative factors to

produce some estimates of the likely incidence of fatigue related accidents involving coach travel, but it is unlikely that clear evidence will be available.

Having identified factors which will affect the likelihood of coach drivers suffering from fatigue it is worth considering these in comparison to the drivers of cars and trucks, particularly when considering the regulation of drivers' hours. The personal factors (amount of sleep, shift patterns, physical fitness, etc) will affect drivers of all vehicles. The journey type factors associated with long distance travel will again affect all drivers. However, the effect of a travel itinerary and a large number of passengers means that, whilst the car and truck driver is likely to be able to decide to stop and take a break or have a short sleep, this is unlikely to be the case for the coach driver. Any stop involves the safety, welfare and wishes of the passengers both on and off the coach. The coach driver may not be able to make an unscheduled stop and may not be able to expect the passengers to sit and wait whilst the driver takes a break. Thus coach drivers will have much less personal control of their ability to stop driving when tired than the drivers of cars and trucks. Regarding external factors (ferry crossings and traffic congestion) will affect drivers of all vehicles. However, the implications of delays and the choices about how to address them are a matter for the drivers of cars and trucks to decide. However, the coach driver must again consider the safety, welfare and wishes of the passengers and may therefore have less flexibility over the choices and decisions made.

Thus the drivers' hours regulations will have differing impacts on the drivers of different vehicle types and coach drivers have additional limitations as a result of the passengers they are carrying.

Review of Literature: Summary	
Information source	Results/research finding
The importance of coach trips as a transport mode (Section 2.1)	Data about the importance of coach travel as a transport mode is limited. Currently available data concerning the scale and costs of fatigue as a road safety issue is inadequate for the purposes of designing legislation

Fatigue and safety (Section 2.2)	There is no single definition of fatigue. Fatigue is influenced by time of day, time on task and amount of sleep, though these factors can be augmented by other factors dictated by individual circumstances. There is evidence that fatigue leads to crashes, but the extent of this is difficult to quantify from national statistics. Both the European Transport Safety Council and European Road Safety Observatory have published extensive reviews of studies into the scale of the problem. Estimates range from 1 – 4% to over 50%, depending on the criteria used.
Legislation (Section 2.3)	Legislation exists to govern drivers' hours, though it is not a specific offence to drive while tired.
The effect of driving hours on the onset of fatigue (Section 2.4)	There is little scientific evidence linking time on (driving) task to accident risk, with other factors such as time of day known to be more significant. The literature suggests a number of other factors which are likely to be relevant to the specific case of coach drivers. Coach drivers have additional limitations as a result of the passengers they are carrying and the drivers' hours regulations will have a different impact on the drivers of coaches from, for example, truck drivers.

3. REVIEW OF EXISTING ACCIDENT DATABASES

3.1. Availability of data for analysis

There are a number of databases which contain information about road crashes and casualties in European countries and EU member states.

Most European countries maintain a national database of road accidents, based on accident report forms completed by police officers attending the scene. The European Road Safety Observatory (ERSO) has additional information about this national data.

There are several issues that must be borne in mind when using this data for analysis of a specific road safety issue such as the effect of fatigue on the accident involvement of coaches:

- Both buses and coaches are recorded in one vehicle group (bus or coach) and it is not possible to separate them in analysis,
- Definitions of vehicle types and accident types may vary from country to country. This will affect the extent to which different countries' data can be considered to be comparable. Different methods of collecting and collating data may also affect both comparability and compatibility (for example, if two different countries group casualties into age groups, but do not use the same groupings, it may not be possible for the data to be analysed together),
- When looking only at a specific vehicle type (in this case, coaches) for a specific type of accident (fatigue accidents, which typically occur on certain road types at certain times of day) it is likely that even in relatively large countries the number of relevant accidents for study will be so small as to preclude meaningful statistical analysis,
- Information about the risk exposure of coaches in different European countries is sparse, so rates in different countries cannot be calculated in a meaningful, comparable way.

A number of international data sources also exist, most notably CARE, UNECE, IRTAD and Eurostat, which are discussed in turn in the following section.

CARE (Community Road Accident Database) is the European Community database on road accidents resulting in death or injury. It is maintained by the European Commission and the main difference between CARE and other similar international databases is the high level of disaggregation possible. This makes analysis of a specific issue such as bus and coach accidents somewhat easier than with more aggregated databases, though some limitations

remain. The CARE database has data from a number of European countries, though availability varies with different years. The most recent year for which data is available is 2007, and for this year it is available for the Czech Republic, Denmark, Estonia, Greece, Spain, France, The Netherlands, Austria, Portugal, Finland, Sweden and Great Britain (but not Northern Ireland, hence not the UK). For the newer member states data are generally only available from 2005 onwards, and there is no recent data for Germany. This clearly limits the degree to which findings from CARE can be generalised to the whole of Europe. The Traffic Safety Basic Fact Sheets, available via the website of the European Road Safety Observatory (www.erso.eu) provide general analysis of road accidents across Europe using the CARE data.

The United Nations Economic Commission for Europe (UNECE) maintains a database of transport statistics which includes figures on road traffic accidents overall. There are 56 countries which have membership of UNECE. For details of which countries supply data see UNECE Website.

In 1988, the OECD Road Transport Research Programme established the International Road Traffic and Accident Database (IRTAD). This can be useful for comparing road safety measurements between various developed countries. At present the following countries are included: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea (South Korea), Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, Sweden, Switzerland, Spain, Slovakia, Slovenia, Turkey, Hungary, the USA, and the UK.

Eurostat is the statistical office of the European communities. Eurostat also publishes fatality figures and fatality rates for road accidents in Europe. However, the sources of the Eurostat data are CARE (where countries have data in CARE) and UNECE. It is therefore not expected that analysis of this data would add any additional information, hence this source will not be exploited.

In addition, data collected as part of the wider activity in Project TREN/E1/409-2007, will be discussed alongside the European databases previously mentioned.

The databases vary in their inclusion of countries and the level of disaggregation of data which is possible. In addition, countries differ in the variables, values and definitions used in the collection and processing of national data. Care must be used when comparing countries, especially when it is not clear that data are compatible. For this reason, the data used refer only to fatalities and fatal accidents, in order to minimise the effect of such differences on the totals.

A further significant limitation of both national and European databases is the difficulty of distinguishing between coaches and buses. According to Albertsson (2004) there is no universal definition of buses and coaches. In general terms a bus is defined by its use, being primarily geared for the short term transportation of people (seated and standing) on urban roads. Coaches generally serve seated passengers on longer journeys using non-urban roads. However, coaches are routinely used for local transport services (for example, the journey to/from school). So whilst buses and coaches are recorded in accident data as one vehicle type, in practice their journey type differs. This affects crash types and casualty patterns, making analysis difficult. Seat belt use is generally not recorded for coaches, so it is not possible to determine what effect on casualty reduction there has been since the 2006 seat belt directive.

Comparing risk rates at a European level is a task made more complex by the theoretical and practical limitations which present themselves when trying to collect exposure data. Yannis et al (2005) provide a detailed analysis of the current "State of the Art" on risk and exposure data, concluding that;

"A series of problems, namely poor data availability, insufficient reliability, inappropriate desegregation… and limited accessibility are the main limitations to the full exploitation of RED at European level."

3.2. Context

According to the European Road Safety Observatory (www.erso.eu) the number of people killed in accidents involving buses and coaches in EU-14 fell from 1,018 in 1997 to 660 in 2006. For accidents involving Buses or Coaches, the EU-18 average fatality rate was 2.8 per million population, ranging from 0.5 in Ireland to 9.7 in Estonia.

Only 19.6% of those killed in bus or coach accidents were occupants of buses or coaches, indicating that the greater size of these vehicles generally makes accidents more severe for the occupants of other (probably smaller) vehicles than for the occupants of the buses and coaches themselves.

General analysis of the role of buses, coaches and other large vehicles in fatal accidents across Europe can be found in the Traffic Safety Basic Fact Sheets (Andreu et al, 2008). The information presented includes fatalities, for all bus and coach accidents in the CARE database, by the types of vehicle occupants, road type, time of day, day of the week etc.

According to Albertsson and Falkmer (2005) the risk of being killed in a bus or coach crash is seven to nine times lower for bus and coach occupants than for car occupants.

Given the suggested differences between coach and bus operation, it may be possible to identify to some extent those accidents which are *likely* to be coach accidents by selecting accidents which occurred outside urban areas. According to the CARE database, slightly over half of all bus and coach accidents occurred on rural roads or motorways. In the UK, fatalities since 1991 in accidents involving buses or coaches in non-urban areas vary between a maximum of 41 in 1995 to a low of just 5 in 2007. The relatively small numbers of such fatalities leads to a large amount of variability year on year, making statistical analysis problematic. A further issue to consider when analysing bus and coach accidents is the relationship between crash numbers and casualty numbers. Bus and coach accidents can result in casualties both inside the vehicle and to the occupants of other vehicles, or to pedestrians or cyclists. In the case of coach accidents the number of casualties could potentially be very high due to the number of passengers it is possible for a coach to carry. Depending on the type of crash, a high number of serious or fatal injuries can be sustained.

In the following sections casualty and collision figures from available data sources will be analysed. The data sources which will be considered are the CARE, UNECE and IRTAD databases, and the data collected as part of the wider activities of Project TREN/E1/409-2007. The aims will be:

- To attempt to quantify the significance of fatigue as a safety issue for coach operation at the European level,
- To highlight the factors that are likely to affect the accuracy of conclusions,
- To determine the degree to which the conclusions drawn can be applied at a European level,
- To assess the suitability of currently available data sources to address this issue.

3.3. CARE data

As has been stated, the CARE database is maintained by the European Commission and contains details of injury accidents in a number of, but not all, EU member states.

The data are generally more disaggregated than data from other similar sources, making more detailed analysis possible. Only data regarding fatalities and fatal accidents is presented here, in order to minimise the effect of different data collection methodologies and definitions across countries. Table 1 shows the number of fatalities resulting from accidents in which at least one bus or coach was involved. It should be borne in mind that these figures seem relatively high. This is because;

1. Data are for both buses and coaches under the variable name “Bus or Coach”
2. Data includes casualties on buses and coaches, but also all other road users who sustained an injury in an accident in which a bus or coach was involved.

Table 1: Fatalities in "Bus or Coach" accidents in the Member States 2003 – 2006
Source; CARE database

	2003	2004	2005	2006
Belgium	29	31	19	31
Czech	-	-	-	34
Denmark	26	15	11	14
Estonia	-	-	7	13
Greece	94	48	53	36
Spain	126	80	108	100
France	97	99	91	76
Ireland	2	-	-	-
Italy	122	125	-	-
Luxembourg	-	-	-	-
Hungary	71	58	62	64
Malta	-	-	1	0
Netherlands	21	-	-	-
Austria	20	24	10	19
Poland	-	-	252	-
Portugal	26	41	23	13
Finland	13	29	13	19
Sweden	33	16	13	36
UK	160	154	140	164
Total (all)	29,243	26,919	26,060	24,684
TOTAL (coach/bus)	840	720	803	619

Even drawing limited conclusions such as whether coach accidents have increased or decreased over time is difficult, for two reasons. Firstly, the numbers are relatively small, so will be subject to fluctuations year on year. Secondly, different countries' data are available for different years, making it difficult to monitor trends over a long period of time. However, it can be seen that bus and coach accidents make a relatively small contribution to fatalities, being involved in only 619 (2.5%) of fatalities out of a total of 24,684 in 2006.

In order to try to limit the analysis to coaches and their occupants only, Table 2 further disaggregates the accidents according to area type. This is because, as has been explained, coaches predominantly run services which are inter-urban.

Table 2: "Bus or Coach" occupant fatalities in the member states, listed by inside/outside urban area
Source; CARE database

Year	Inside	Outside	Total
1991	37	159	196
1992	43	203	246
1993	41	141	182
1994	39	98	137
1995	47	152	199
1996	22	107	129
1997	32	137	169
1998	35	132	167
1999	34	117	151
2000	26	123	149
2001	35	156	191
2002	30	84	114
2003	25	170	195
2004	31	105	136
2005	31	106	137
2006	34	94	128
2007	18	94	112
Total	560	2,178	2,738

As can be seen in Table 2, the majority of bus or coach occupant fatalities occur outside urban areas. It is likely that road type (hence higher vehicle speeds) will be a factor in this.

Table 3 shows the fatalities disaggregated by motorway/non-motorway area type, since it is not possible using STATS19 to separate urban and non-urban areas in the same way.

Table 3: Fatalities in 'Bus or Coach' accidents in the member states, listed by motorway/non-motorway area.
Source; CARE database

	Motorway	No motorway	Unknown	Total
1991	88	1,057	51	1,196
1992	143	1,139	48	1,330
1993	94	957	48	1,099
1994	65	891	50	1,006
1995	99	894	44	1,037
1996	65	731	92	888
1997	103	824	91	1,018
1998	70	836	100	1,006
1999	63	738	105	906
2000	65	704	92	861
2001	65	750	68	883
2002	78	602	69	749
2003	67	712	63	842
2004	54	610	60	724
2005	44	714	79	837
2006	54	521	60	635
2007	44	463	68	575
Total	1,261	13,143	1,188	15,592

It is reasonable to assume that the vehicles involved in motorway accidents are much more likely to be coaches than buses. However, for the non-motorway crashes it is not possible to make any assumptions about the relative involvement of buses and coaches.

It can also be seen that there is a high number of cases recorded as being unknown. Since in some years the "unknown" value is higher than the value for motorways, the figures must be interpreted with some caution.

As has previously been highlighted, fatigue accidents are known to vary according to time of day as well as by area type. In order to examine this factor, Table 4 records fatalities in bus and coach accidents by time of day, and fatalities in bus and coach accidents in non-urban areas by time of day.

Whilst there are significant numbers of accidents occurring outside of the times specifically highlighted as a factor in fatigue accidents, the role of exposure in this must be considered. It is likely that bus and coach traffic peaks during the morning and evening rush hours. Certainly the volume of other types of traffic is heaviest at this time. This will have an effect on the conditions in which buses and coaches are operating, and hence will affect their

chances of being involved in an accident and influence the nature of the accident. Unfortunately, the limitations in available exposure data (highlighted in section 2.1) mean that it is not possible to draw conclusions about the size of the effect of exposure.

Table 4: Fatalities in bus and coach accidents 2005 - 2007, by time of day. Source; CARE database

Time of day	All fatalities	Non-urban	Urban	Non-motorway	Motorway
00:00 - 00:59	37	8	15	28	8
01:00 - 01:59	26	1	14	25	1
02:00 - 02:59	22	10	8	11	10
03:00 - 03:59	24	5	6	18	5
04:00 - 04:59	28	7	8	20	7
05:00 - 05:59	39	2	13	34	2
06:00 - 06:59	107	3	29	96	3
07:00 - 07:59	113	18	43	90	18
08:00 - 08:59	114	6	36	97	6
09:00 - 09:59	104	1	52	95	1
10:00 - 10:59	84	12	48	65	12
11:00 - 11:59	84	11	60	77	11
12:00 - 12:59	99	0	55	85	0
13:00 - 13:59	92	6	60	94	6
14:00 - 14:59	116	4	57	104	4
15:00 - 15:59	124	8	65	116	8
16:00 - 16:59	142	1	79	125	1
17:00 - 17:59	150	1	62	119	1
18:00 - 18:59	128	8	49	104	8
19:00 - 19:59	120	17	61	98	17
20:00 - 20:59	130	3	45	60	3
21:00 - 21:59	69	3	32	38	3
22:00 - 22:59	50	2	27	52	9
23:00 - 23:59	63	4	37	48	4

It should be noted that motorway/non & urban/non are not mutually exclusive categories (i.e. motorways could also be inside or outside an urban area), hence columns total to more than all fatalities. In general it can be seen that urban accidents are generally (but not exclusively) higher than non-urban accidents, and non-motorway accidents out-number motorway accidents. However, looking specifically at the peak times for fatigue-related accidents, (Horne and Reyner, 1995) highlighted in the table (02.00, 06.00 and 16.00 hours) it can be seen that between 02.00 and 03.00 hours non-urban accidents exceed urban accidents. In

addition, non-motorway accidents exceed motorway accidents by a smaller proportion at this time of day than at any other time. Between 04.00 and 05.00 hours urban and non-urban accidents are broadly similar in number, and whilst motorway accidents are responsible for only roughly one third of the fatalities of non-motorway accidents, this is still a higher proportion than at other times of the day. This could be seen as an indication of the role of fatigue at these times of day. However, without additional information about exposure, it is difficult to draw firm conclusions. At 16.00 hours it is difficult to see any evidence of a fatigue effect. However, it is likely that at this time of day there will be high numbers of buses, carrying large numbers of passengers on busy roads. This may mask the effect on the accident statistics of fatigue.

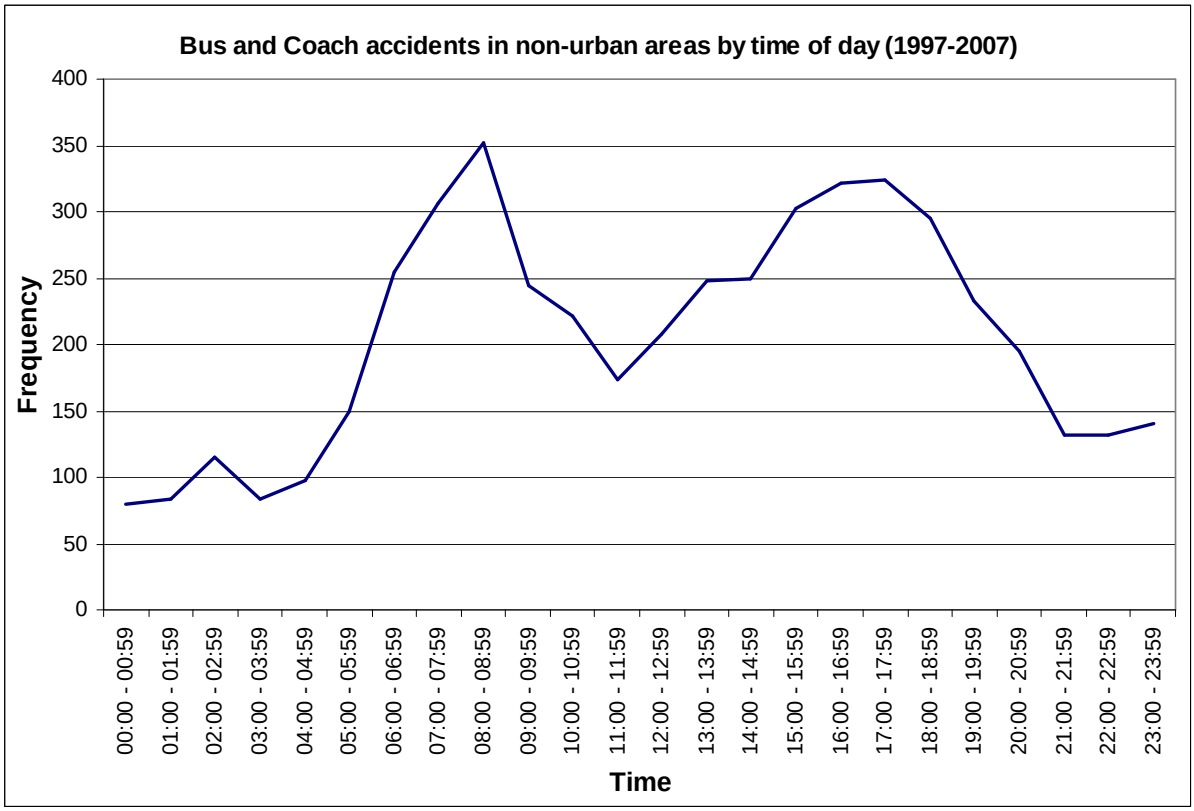

Figure 1: Bus and coach accidents in non-urban areas by time of day
Source – CARE

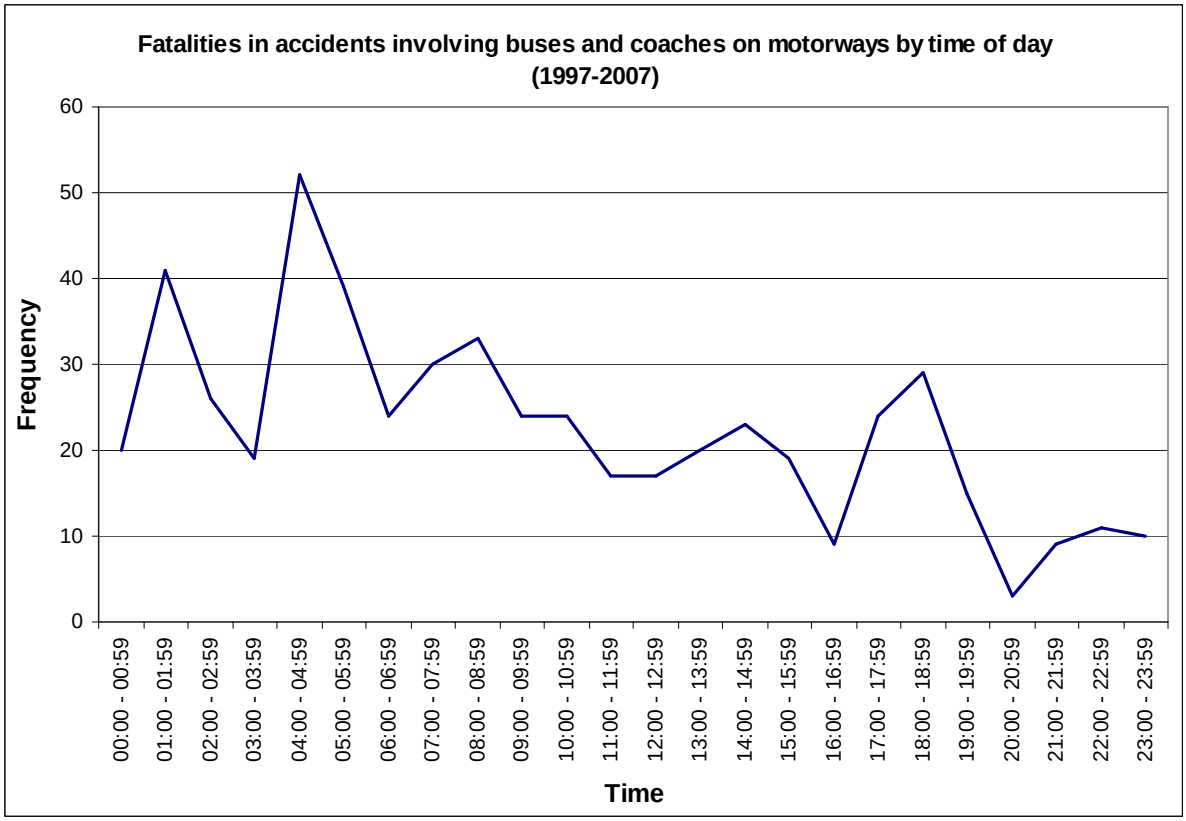

Figure 2: Fatalities in accidents involving buses and coaches on Motorways by time of day Source – CARE

Figure 1 and Figure 2 illustrate these variations according to time of day, and show fatalities in accidents involving buses and coaches in non-urban areas and motorways respectively. In the case of non-urban areas there are two distinct peaks in the data which appear to correspond to the morning and evening rush hour (08.00 to 08.59 hours and 17.00 to 17.59 hours). However, the data for motorways shows several peaks. The biggest of these occur in the early hours of the morning (02.00 to 02.59 hours and 05.00 to 05.59 hours), with a smaller peak early in the evening. This broadly supports the conclusions drawn from the literature review about the times of day most strongly associated with fatigue related accidents.

In conclusion, whilst there is evidence in the CARE data to support the idea that some coach accidents have an element of fatigue as a causal factor, it is difficult to make any firm recommendations on the basis of this evidence. There is a lack of supporting evidence such as:

- The proportion of the total represented by coach as opposed to bus accidents,
- Exposure data (coach journeys),
- Information about the length of time on the driving ask prior to the accident.

In addition, there are more general limitations, such as the relatively low numbers of accidents, making statistically robust analysis difficult.

3.4. UNECE data

The UNECE on-line database does not allow the same level of disaggregation as the CARE database. Whilst it is possible to separate urban and non urban accidents in the publicly-available online database, it is not possible to do this whilst looking only at a specific vehicle type (coaches and buses in this case). Also, definitions of fatal casualties vary across countries (for example, death on the spot, death within 3 days, and death within 30 days). In the CARE database, data are transformed to provide figures for fatalities at 30 days in order for different countries' data to be comparable. In the UNECE database this may not be done, so care must be taken when comparing the fatality total for different countries. It is also not possible to identify different time periods, in order to highlight those accidents which are most likely to have an element of fatigue involved.

Table 5 "Bus or Coach" occupant fatalities in 2003.
Source; UNECE database

Country	fatalities
Belgium	0
Czech	29
Denmark	10
Estonia	3
Greece	38
Spain	27
France	44
Ireland	0
Italy	-
Luxembourg	0
Hungary	39
Malta	1
Netherlands	0
Austria	1
Poland	24
Portugal	2
Finland	0
Sweden	10
UK	11
Total	228

As can be seen from Table 5, the numbers of fatalities occurring on the buses and coaches themselves is very small indeed. This may reflect the fact that they are generally large vehicles, whose occupants will be relatively well protected in collisions with smaller vehicles

or vulnerable road users. Using the online database it does not appear to be possible to select all casualties in an accident in which a bus or coach is involved, making it difficult to compare the data with those in CARE. However, it is clear that compared to total fatalities, which according to Table 1 were over 29,000 in 2003 (across all vehicle types), bus and coach occupant fatalities are relatively few.

In conclusion, the publicly-available UNECE database is not sufficiently detailed for estimates of fatigue related accidents to be drawn from it.

3.5. IRTAD

The publicly accessible sections of the IRTAD database contain only fatality totals. These are not disaggregated by vehicle type, time of day or road type, so it has been concluded that analysis of this data is unlikely to add anything further to that possible using CARE and STATS19.

3.6. Additional data collected as part of the wider activity in Project reference TREN/E1/409-2007

A sample of accident data has been collected from a number of countries across Europe as part of the wider activity in Project reference TREN/E1/409-2007. There are a number of limitations with this data, which include:

- Low number of cases (zero in some countries), making statistically robust analysis difficult,
- Inclusion in some (but not all) countries' data of trolley buses,
- Lack of clarity about whether fatalities refer to coach/bus occupants or to all road users injured in accidents involving buses and coaches,
- Data are not for the same years for all countries,
- In some cases data are the same as those provided for CARE, meaning additional information cannot be obtained from the data.

These data are provided in Table 6 for information, though no estimates of fatigue related coach accidents have been derived from them. A further, more detailed, set of data from a study in Austria does however provide estimates of the percentage of fatal accidents caused by fatigue. These are presented in Table 7.

Table 6: Summary of data collected as part of the wider activity in project reference TREN/E1/409-2007

Country	Year	Fatalities	Comments
Albania	6 months 2008	Bus 5 Microbus 5 Minibus 1	2008 data not yet available for other countries, therefore compatibility of data likely to be an issue
Bulgaria	2007	22	No data on fatal accident numbers. Data refer to buses.
Croatia	2003 - 2005	1	Data include buses and trolleybuses. Small numbers (1 fatality) robust conclusions difficult to draw.
FYROM (Former Yugoslav Republic of Macedonia)	2007	0	No fatalities.
Iceland	Not known	1	No data on fatal accident numbers
Latvia	Not known	11	No data on fatal accident numbers. Data include trolleybuses and tramcars.
Lithuania	2004	24	No data on fatal accident numbers. Data include trolleybuses and tramcars.
Luxembourg	2002	4	Data provided is from CARE
Moldova	2001 - 2004	1	Data include buses and trolleybuses. Small numbers (1 fatality) robust conclusions difficult to draw
Morocco	2007	142	No data on fatal accident numbers
Norway	Not known	0	Data refers to passengers only
Romania	2007	2,712	No data on accident numbers. Data cannot be split by mode
Slovakia	2007	7	Data not comparable as includes only accidents judged to have been caused by the bus.
Slovenia	2004	0	Data include buses and trolleybuses. Small numbers (0 fatalities) robust conclusions difficult to draw
Switzerland	2007	0	Small numbers (0 fatalities) robust conclusions difficult to draw
Turkey	2006/2007	196 (2006) 206 (2007)	No data on fatal accident numbers
UK (GB only)	2007	19	Fatal accident numbers refer to accidents involving buses and coaches, fatalities refer only to those on the bus/coach.

Table 7: Austrian data

YEAR	% fatal accidents caused by fatigue (estimated)	% fatal accidents caused by innatention (estimated)
2003	4.2%	9.4%
2004	6.0%	8.3%
2005	4.8%	7.3%
2006	6.0%	10.7%
2007	3.0%	10.6%

The estimates reported in this study are very much at the lower end of the range reported in the literature. This may be an outcome of the particular methodology used as it seems that the source of these estimates may be a study looking at the role of impairment in accidents which result in legal proceedings. Such a study would be likely to yield low estimates due to the likelihood of drivers not wanting to report fatigue and thereby incriminating themselves, and the level of evidence that would be required to prove fatigue in the context of the judicial process.

3.7. Conclusions

The stated aims of the data analysis were:

- to attempt to quantify the significance of fatigue as a safety issue for coach operation at the European level,
- to highlight the factors that are likely to affect the accuracy of conclusions,
- to determine the degree to which the conclusions drawn can be applied at a European level,
- to assess the suitability of currently available data sources to address this particular issue.

Using the CARE and other data the following conclusions can be drawn.

It is difficult to quantify the significance of fatigue as a safety issue from the existing national and European databases because of limitations in the collected data. Whilst the literature review highlights some estimates of the likely scale of the problem, these vary according to a number of key factors, so would be difficult to apply directly to aggregated European accident data.

A number of factors that might affect the accuracy of estimates of the significance drawn from the databases have been highlighted. These include the difficulty of identifying fatigue

accidents, the differences in variables, values and definitions across countries and the relatively low numbers of cases of coach fatalities in the databases.

As a result of the issues highlighted above drawing conclusions that can be applied to the whole of Europe is problematic. The data sources currently available are not well-suited to addressing the issue of fatigue accidents because of a lack in the databases of the relevant variables.

The CARE data for fatal accidents involving buses and coaches does support some of the findings from the literature study. The literature suggests that fatigue accidents peak at certain times of day and are a more significant issue on motorways and other non-urban routes. Analysis of the CARE data shows that there are peaks in the accident totals at certain key times of (early hours of the morning and early evening) and these peaks are more pronounced on motorways. However, in terms of addressing the specific question of the safety implications of reinstating the derogation, the data are not sufficiently detailed to address this issue.

Review of Existing Accident Databases: Summary	
Information source	Results/research finding
Availability of data for analysis (Section 3.1)	A number of sources of European road accident data exist, but some limitations must be borne in mind when analysing the data. The journey types, crash types occupant injury and restraint requirements differ between buses and coaches. However it is not currently possible to quantify these differences within the data sets available. It is generally not possible to separate coaches from buses and other similar vehicle types. A lack of data about exposure to risk also makes comparisons problematic.
Context (Section 3.2)	The accident rate for buses and coaches is low, with the risk of being involved in a fatal accident being seven to nine times lower for bus or coach accidents than for car occupants. The Traffic Safety Basic Facts provide general statistics about road accidents across Europe.
CARE data (Section 3.3)	The CARE database contains details of injury accidents in a number of EU member states. Analysis indicates that bus and coach accidents represent under 3% of all fatalities in Europe. Data show discernable peaks in accidents at certain times of day. Some of these may be related to fatigue, others to exposure.
UNECE data (Section 3.4)	The UNECE database does not have the same level of disaggregation as CARE, though data suggest the contribution to European road fatalities of coaches is very small.

4. REVIEW OF ACCIDENT DATA FOR GREAT BRITAIN (STATS19)

4.1. An overview of the national data for Great Britain

National Accident Data for Great Britain are collected by police forces and collated by the UK Department for Transport (DfT). The data are made available to the Vehicle Safety Research Centre at Loughborough University by the UK Department for Transport. An analysis of this national road accident injury data for Great Britain (commonly called 'STATS19' due to the name of the form that the Police complete) has been undertaken to examine fatigue related coach accidents.

The data fields used for analysis in this report are not those that are generally available to the research community but include make/model and accident causation fields, for which specific permission has been granted by DfT. The national accident dataset has included records regarding causation factors since 2005, using the Contributory Factors system.

For each accident, there are three types of records: accident, vehicle and casualty. The overall criteria for an accident to be included in the national accident records are that a person must have been injured in an accident on a public highway. An accident record is completed for each accident. A vehicle record is completed for every vehicle involved in the accident, even if there are no injured occupants. A casualty record is completed for every injured person in the accident.

To provide a context to the subject of fatigue an overall analysis of the national STATS19 data for the years 2005 to 2007 inclusive was conducted to establish the number of bus and coach accidents and to determine the scale of fatigue related crashes. A selection was made on the vehicle type of ‘Bus or Coach (17 or more passenger seats)’ from the complete dataset containing 569,978 accidents involving all vehicle types. STATS19 data for the three years shows a total of 27,680 buses and coaches involved in all accident types, this breaks down to 9,988 accidents in 2005, 9,133 accidents in 2006 and 8,559 in 2007.

It is not practicable to differentiate between a bus and a coach in a sample this large as a case by case review would have been necessary. This is due to a large number of absences and errors in the data collection relating to vehicle make and model type. For example all vehicles in the 27,680 sample are recorded as a vehicle type of ‘bus or coach’, however the detailed make and model information includes data which is clearly a passenger car or motorcycle. These need to be individually assessed and removed/recoded if necessary,

however the large case sample precludes this activity on a task with a short time span. A way around the problem outlined above would be to select on just the make and models which can be verified as a coach. This technique also has problems as it is common to only have a make recorded. For example, a record of Volvo for vehicle make could be either a bus or a coach with a Volvo drive train. The large number of unknowns using this technique coupled with the already mentioned errors makes this unreliable. It was therefore decided to reduce the case numbers by first investigating the causative effect of fatigue, an in depth review of make and model could then be completed more reliably on a smaller subset.

Causative factors associated with the accident are recorded in STATS19 for each road user in each accident. These cover a range of causation factors such as vehicle defects, driver error, impairment and injudicious actions or behaviour. One of these codes under the impairment and distraction tab covers fatigue and this was selected alongside buses and coaches to provide a dataset of relevant cases.

These relevant cases include all accident types: single vehicle accidents, multiple vehicle accidents on all road and location types; motorway, urban dual carriageway, rural A-road, unclassified city centre road and at all times of day in all weather conditions; darkness, daylight, early morning, rain, fine weather conditions. Accidents with either coach occupants injured or accidents with only other road users injured were included. No other case selection was used to maximise case numbers.

Accidents in which the causative effects of fatigue for the drivers of buses and coaches based on the selection described above shows that for the same three years a total of 34 vehicles are recorded. This breaks down to 8 cases in 2005, 10 cases in 2006 and 16 in 2007.

The number of cases returned from this selection is very small compared to the whole bus and coach accident population. The difference can be explained by a number of reasons. A large but unquantifiable number of cases in the sample of 27,680 cases may be associated with buses. This vehicle type, due to risk exposure and the type of journey, are likely to be involved in many more small accidents. Both bus and coach drivers report more accidents as they are commercial operators with a duty to the public, and also for insurance purposes, especially if the accidents are non-fault or small bumps. However, it is possible that drivers do not report fatigue as this may compromise them. Finally the recording of causations in the STATS19 database may not be comprehensive as it is often not possible to determine all causative factors in an accident so especially as an officer doesn't always attend the scene.

As a proportion of the accidents where causation factors are recorded, fatigue plays a very small part in these accidents. The proportion of buses and coaches where the fatigue

causation code is recorded is as low as 0.12% of the total number of vehicles. The truck vehicle class (>3.5t) shows a higher rate of fatigue related accidents at 1.44% of total vehicles. This vehicle class has driving restrictions relating to driving hours and statutory breaks. Car drivers record a proportion of 0.62% fatigue related accidents. There are no driving restrictions relating to driving hours and statutory breaks for car drivers, although some companies may have best practise guidelines for their professional drivers. A breakdown of the numbers involved is shown below:

Table 8: Proportion of fatigue related accidents by vehicle type
Source; STATS19

Year	Bus or Coach		Trucks		Cars	
	Freq	Fatigued	Freq	Fatigued	Freq	Fatigued
2005	9,988	8	12,120	165	275,130	1,599
2006	9,133	10	11,336	177	261,459	1,562
2007	8,559	16	10,688	149	249,642	1,693
Total	27,680	34	34,144	491	786,231	4,854
% Fatigued	0.12%		1.44%		0.62%	

It is worth noting that the figures presented above are the total number of bus and coach accidents and the number of coaches will be smaller than these figures. This is due to STATS19 categorising buses and coaches under one heading. It is not practical to split this group in large scale analyses where thousands of cases are considered. However, every effort has been made to separate the group in the subsequent in-depth analysis using make and model variables, to ensure a more reliable group of fatigue related coach only accidents.

Considering the limitations with separating coaches from buses it is possible that a figure of fatigue of 0.12% could be an under-representation when considering coaches on their own. As it is not possible to determine the precise number of bus and coach accidents, or the distribution of each according to severity, journey type, time of day, etc., it is not possible to calculate whether coaches might account for a higher proportion of the 0.12% fatigue related accidents than buses.

A number of other factors exist which may help explain the differences in the figures displayed above. The use the different vehicle classes are being put to may explain why a truck driver has a higher exposure to fatigue; early pick up and drop off times, driving through the night to avoid heavy traffic or travelling to and from ports to meet late/early ferries all could explain why fatigue accidents are comparatively higher for trucks. Even in cars the differences between drivers can have a significant bearing on the likelihood of fatigue. An older driver may be more susceptible to fatigue than a driver in their early twenties or a company driver travelling for work may attempt longer journeys than a commuter or someone

travelling for pleasure. All of these differences may affect the proportion of fatigue related accidents by vehicle type. However these differences are not determinable through STATS19 so further analysis of the exact circumstances behind each accident is impossible and generalisations cannot be supported with figures.

Another issue to consider is the reporting of fatigue by the investigating police officer. For all 3 vehicle groups given, the instances of fatigue are surprisingly low when compared with what would be expected from the literature. This level of reporting may be due to several factors. These include the difficulty for the police officer in determining fatigue as a factor and drivers being unwilling to admit to being fatigued as admission might compromise their insurance claim, legal defence or employment.

Another overview of coach accidents where fatigue may play a part can be conducted using the complete dataset for the years 2005 to 2007 by modifying the selection criteria. As mentioned above, the type of journey could have an affect on the risk of fatigue, this is particularly evident according to Horne and Reyner (1995) when long journeys on motorways are concerned. Using the bus and coach category from STATS19 it is reasonable to make the assumption that when using a motorway the majority of this vehicle type are coaches. This makes the basic assumption that a vehicle of this class travelling on this road type is doing so for extended periods and is being used, irrespective of body shape, as a coach.

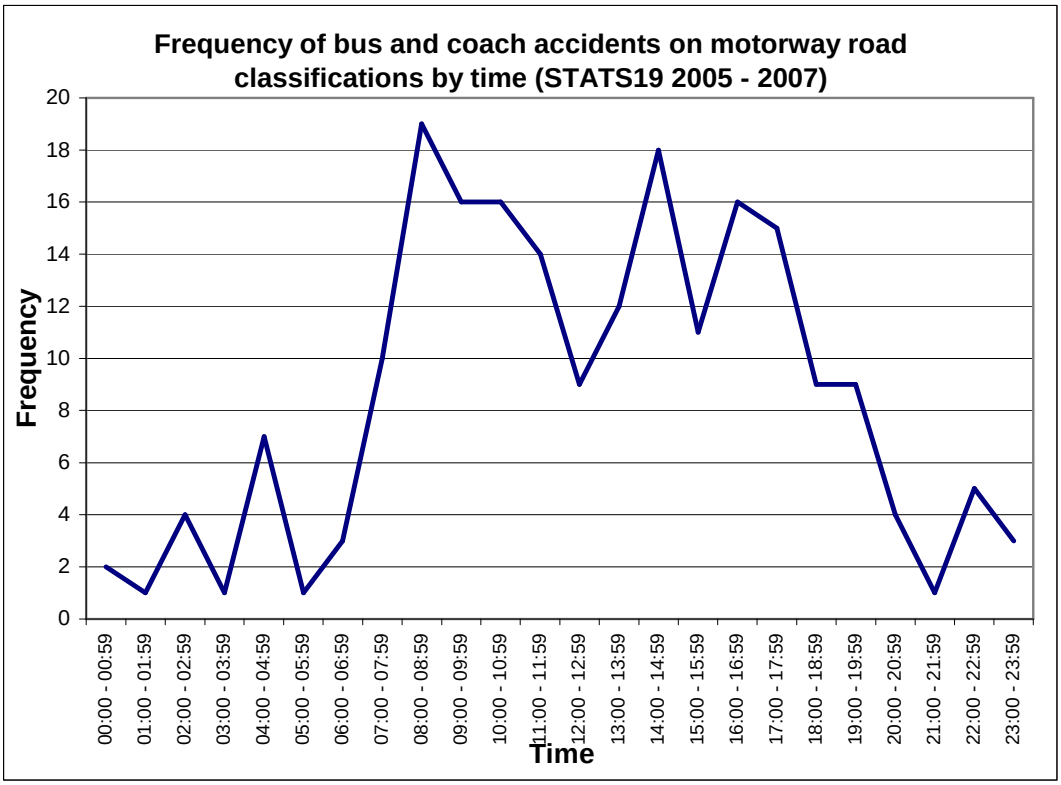

Figure 3: Bus and Coach accidents on motorways by time of day (2005-2007)

Figure 3 shows the frequency of bus and coach accidents occurring on motorways by time of day. The total number of these accidents is 206 of the total sample of 27,680.

The results show a similar pattern to that displayed by the CARE results in Section 3.3.

Figure 3 shows peaks of accidents at mid-morning (during the hours 08.00 to 11.00) and mid-afternoon (during the hours of 14.00, 16.00 and 17.00). These peaks are due mainly to exposure, more coach journeys are expected to be underway at these times and more traffic shares the road space with them. Areas of interest for fatigue analysis are the very early morning and late at night, and here small peaks are present (at 22.00, 02.00 and 04.00 hours). These peaks are likely to be more significant than they appear in Figure 3 as they could represent a much higher proportion of the total number of coaches on the road at those times, despite their low numbers (e.g. over 3 years n=7 at 04.00).

4.2. Analysis of coach accidents with fatigue causation

To derive a dataset where only accidents involving coaches exist a review of the 34 fatigue related cases was made. A process of elimination was employed using detailed vehicle type, make, model and variant data alongside bus and coach manufacturers' information to determine exact vehicle classification.

To summarise, these cases were selected from the complete dataset for 2005 to 2007 as:

- Fatigue recorded as causative – selected for both 'very likely' and 'possible'.
- A coach - determined using vehicle type, make and model variables. A process of elimination was employed using bus and coach manufacturers information to determine exact vehicle type.

In total 24 cases were returned which included all accident types: single vehicle accidents, multiple vehicle accidents on all road and location types; motorway, urban dual carriageway, rural A-road, unclassified city centre road and at all times of day in all weather conditions; darkness, daylight, early morning, rain, fine weather conditions, coach occupants and other road users.

The results of a descriptive analysis of the 24 fatigue related coach accidents are shown in Table 9.

Table 9: STATS19 Coach accidents with fatigue causation by year

Accident Year	Frequency	Percent
2005	5	21%
2006	8	33%

2007	11	46%
Total	24	100%

In total, 49 casualties were recorded for the 24 coach accidents. Of these 35 (71%) were recorded as either a coach driver or passenger, a further 10 (20%) were occupants of other vehicles involved in the crash and the remaining 4 (8%) were pedestrians.

A breakdown of the casualty severities for the three casualty classes: coach occupants, the occupants of other vehicles and pedestrians, all involved in fatigue related coach accidents, is shown below in Table 10.

Table 10: STATS19 coach accidents with fatigue causation – casualty profile

Severity	Casualty class			
	Coach occupant	Other vehicle	Pedestrian	Total
Fatal	1	0	1	2
Serious	7	1	0	8
Slight	27	9	3	39
Total	35	410	4	49

Coaches, by design, can carry large numbers of passengers and in the event of an accident this could very quickly lead to multiple casualties. The data shown in Table 11 covers the number of casualties by vehicle for the 24 fatigue related coach accidents.

Table 11: Coach accidents with fatigue - Number of casualties by coach

Accident #	Number of casualties	Max Severity	Number of accidents
1	1	Slight	12 accidents
2	1	Slight	
3	1	Slight	
4	1	Slight	
5	1	Slight	
6	1	Slight	
7	1	Slight	
8	1	Slight	
9	1	Slight	
10	1	Serious	
11	1	Serious	
12	1	Fatal	
13	2	Slight	4 accidents
14	2	Serious	
15	2	Serious	
16	2	Serious	
17	3	Slight	3 accidents
18	3	Slight	
19	9	Serious	1 accident
20	No coach casualties	Not applicable	
21	No coach casualties	Not applicable	
22	No coach casualties	Not applicable	
23	No coach casualties	Not applicable	
24	No coach casualties	Not applicable	

There were a total of 35 injured occupants in the 19 accidents in which coach occupants were injured. In the 5 remaining accidents a total of 14 other road users were injured, 10 in other vehicles and 4 pedestrians.

Of the 35 injured coach occupants, 10 were drivers and 25 were passengers. Of the 19 crashes in which coach occupants were injured, only 1 crash had a large number of injured occupants (n=9). There is no evidence, therefore, that large numbers of casualties occur in coach accidents involving fatigue from this particular sample.

As is demonstrated in the subsequent analysis of road type and speed limits the types of accident seen are more likely to be slight and therefore caused only injury to limited numbers

of passengers. A limitation of the data that could also explain the low numbers of casualties per coach is that only injured occupants are recorded. There is no way of determining whether a single injury on a coach applies to the only occupant or one of 60 for instance.

Table 12: Coach accidents with fatigue – vehicle manoeuvre by junction

Manoeuvre	Junction Location				Total
	Not at or within 20m of junction	Approaching junction or parked at junction approach	Entering roundabout	Mid junction	
Parked	1	0	0	0	1
Waiting to go ahead - held up	1	0	0	0	1
Slowing or stopping	2	0	0	0	2
Moving off	1	2	0	0	3
Turning left	0	0	0	1	1
Changing lane to right	1	0	0	0	1
Left hand bend - going ahead	2	0	0	0	2
Straight ahead	6	5	1	1	13
Total	14	7	1	2	24

Just over half of the coaches were involved in accidents while continuing straight ahead. Of these 13 accidents occurring while travelling straight ahead only 6 were not within 20m of a junction.

The types of manoeuvre shown in Table 12 can be split into two main groups. The first group, shown un-shaded, are slow speed manoeuvres expected in mainly urban areas, and include manoeuvres such as slowing or stopping and moving off. The second group (grey shading) shows the type of manoeuvres we would expect to see in faster flowing traffic on A or B roads classes. These results give an indication of what would be expected from the literature review, where monotonous road sections and higher speed are cited as indicators of fatigue related crashes.

To understand where the accidents take place and on what type of road the following tables describe the road environment in terms of Class, Type, Speed limit and junction type.

Table 13: Coach accidents with fatigue – road class by road type

Road Type	Road Class					Total
	M	A	B	C	Unclassified	
Roundabout	0	1	0	0	0	1
One way	0	1	0	0	1	2
Dual carriageway	2	4	0	0	0	6
Single carriageway	0	7	1	2	5	15
Total	2	13	1	2	6	24

Table 13 displays the road class by road type, and road type is differentiated by the general carriageway layout. Dual carriageway designates any road type with more than one lane in each direction, this will include dual carriageways (2 lanes in each direction) and motorways (2 + lane in each direction).

Table 14: Coach accidents with fatigue – speed limit by road class

Road Class	Speed Limit				
	30	40	60	70	Total
M	0	0	0	2	2
A	10	1	2	0	13
B	1	0	0	0	1
C	2	0	0	0	2
Unclassified	6	0	0	0	6
Total	19	1	2	2	24

Only 2 accidents were recorded as occurring on motorways. This does not support the literature which indicates that motorways, particularly monotonous sections, show a higher proportion of fatigue related cases.

Speed limits are also lower than the literature review would suggest. Monotonous road sections such as dual carriageway road types would generally have a higher posted speed limit. The results shown above however would indicate that 30mph roads of all classes (although particularly A or unclassified) have a higher occurrence of fatigue related cases (80% n=19). This might be partly explained by road types with lower speed limits 'bookending' long journeys, for example a long motorway journey between major cities. In these cases the drivers could be entering the destination in their most fatigued state. STATS19 unfortunately has no data on the length of journey undertaken or the time driving before the accident occurred, making a review of this hypothesis impossible.

The literature indicates that time of day is a major indicator of fatigue related accidents [Horne and Reyner, 1995]. The table below shows the time of day recorded for all fatigue related coach accidents by road class.

Table 15: Coach accidents with fatigue – road class by time of day

Time	Road class					Total
	M	A	B	C	Unclassified	
00:00 - 00:59	-	-	-	-	-	-
01:00 - 01:59	-	1	-	-	-	1
02:00 - 02:59	-	1	-	-	-	1
03:00 - 03:59	-	-	-	-	-	-
04:00 - 04:59	-	1	-	-	-	1
05:00 - 05:59	-	-	-	-	-	-
06:00 - 06:59	1	2	-	-	-	3
07:00 - 07:59	-	-	-	1	-	1
08:00 - 08:59	-	-	-	-	-	-
09:00 - 09:59	-	1	-	-	-	1
10:00 - 10:59	-	-	-	-	-	-
11:00 - 11:59	1	1	-	-	-	2
12:00 - 12:59	-	1	-	-	1	2
13:00 - 13:59	-	2	1	-	1	4
14:00 - 14:59	-	1	-	-	-	1
15:00 - 15:59	-	-	-	-	1	1
16:00 - 16:59	-	1	-	-	2	3
17:00 - 17:59	-	1	-	1	-	2
18:00 - 18:59	-	-	-	-	-	-
19:00 - 19:59	-	-	-	-	1	1
20:00 - 20:59	-	-	-	-	-	-
21:00 - 21:59	-	-	-	-	-	-
22:00 - 22:59	-	-	-	-	-	-
23:00 - 23:59	-	-	-	-	-	-
Total	2	13	1	2	6	24

The times of day suggested by Horne and Reyner (1995) as having a higher risk associated with fatigue accidents are 02.00, 06.00 and 16.00 hours and are shown above (highlighted sections in Table 15) alongside the overall results for the 24 fatigue related coach accidents.

The times of 06.00 and 16.00 hours do show a number of coach accidents where fatigue may be a factor. Although not the significant peaks associated with the Horne and Reyner research, the numbers do still indicate that fatigue at these times may play a role in coach

accidents. The number of accidents between 15.00 and 17.59 hours represent one quarter of all fatigue related coach accidents and while exposure may play a part this is still a noticeable peak in the data that reflects accepted knowledge on the subject of fatigue.

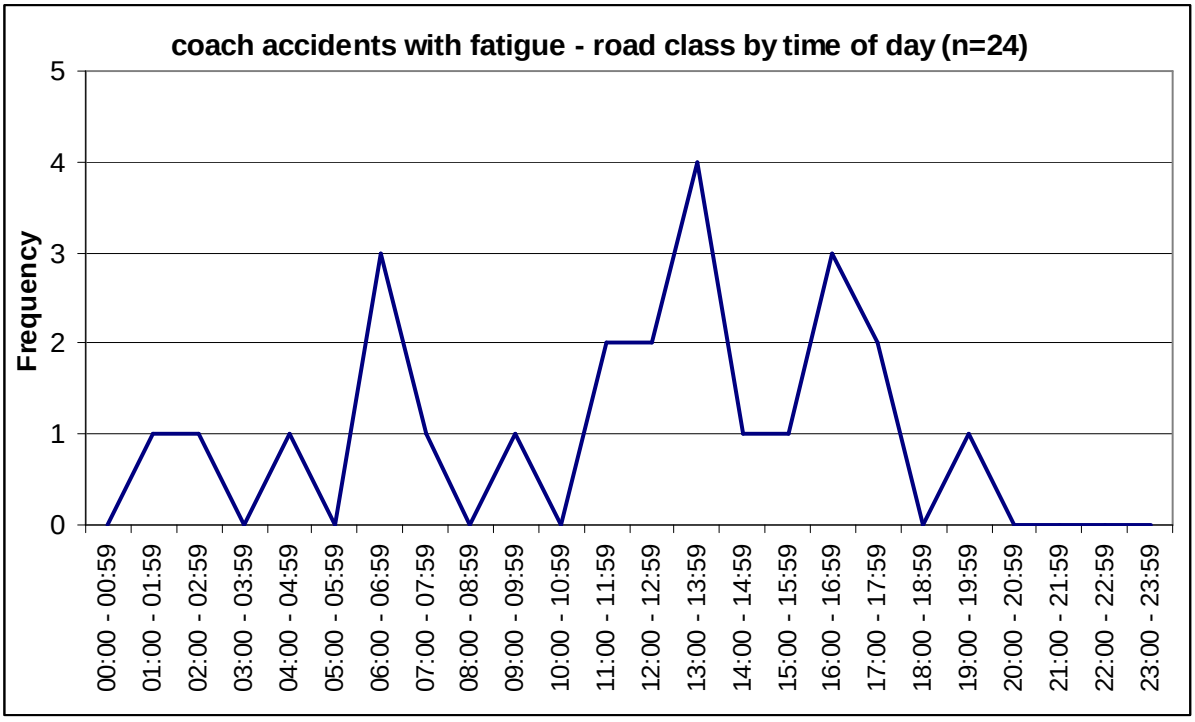

Figure 4: Coach accidents with fatigue – road class by time of day

Figure 4 more clearly shows the peaks in fatigue related accident numbers by time of day. A larger peak is evident at approximately 13.00 hours which could be due to risk exposure rather than pure fatigue as more vehicles will be occupying the road space during this 'lunch time' period, increasing the risk of accidents.

Considering the traffic conditions in the early morning (02.00 and 06.00 hours) and the associated effects on risk exposure could mean that the accidents recorded at these times are more significant than they initially seem. Although it is not possible to determine the exact effect of quieter roads on risk exposure for these particular accidents, it is reasonable to assume that traffic volumes would be significantly reduced from the peaks recorded at morning and evening rush hour, in turn reducing the risk of the coach being involved in an accident with another vehicle.

4.3. Accident causation factors

In STATS19 it is possible to record up to 6 causation or contributory factors which are relevant to the accident. If there is more than 1 factor they may be shown in any order but an indication must be given of whether each factor is 'very likely' (A) or 'possible' (B).

Out of the 24 coach accidents the fatigue causation code is recorded as 'very likely' in 9 accidents and 'possible' in 15 accidents.

Another measure of how important fatigue is to the causation of the accident is to look at how great a part it played in the total causation records. This is simply how many causation codes were recorded for each accident containing a fatigue record.

The table below shows the total number of causation factors associated with the 24 fatigue accidents. The fatigue causation factor is included in the number of recorded codes.

Table 16: Number of causation factors for the 24 fatigue accidents

	Number of Causation Factors for accident (CF)											
	1 CF		2 CF		3 CF		4 CF		5 CF		6 CF	
Freq	4		8		5		1		4		2	
Fatigue **Very likely (A)** **Possible (B)**	A	B	A	B	A	B	A	B	A	B	A	B
Freq (n=24)	3	1	3	5	2	3		1		4	1	1

From the table above in 4 cases fatigue was the only reported accident cause. In 8 cases fatigue plus one other factor such as exceeding speed limit or aggressive driving was reported. In the remaining 12 cases fatigue was one of 3 or more causation factors.

4.4. Accidents with indicators of fatigue

The overview of the national dataset indicated that the proportion of accidents involving a bus or coach where fatigue was recorded as a causative factor was very small at 0.12% of all accidents. Subsequent analysis of the 24 fatigue related accidents selected on detailed vehicle type data and causation factor data did, however, indicate that fatigue of coach drivers follows a similar pattern to the Horne and Reyner research in terms of the times that these crashes occur. However this does not give the whole picture for a number of crucial reasons.

These reasons include confounding factors contained in the accident scenario or causation factors, all of which could make the causative effects of fatigue more or less significant. Accidents do not often have one simple cause and there are many different but associated factors which may lead to the occurrence of an accident. As an example an accident may have three suspected causes, fatigue being one of these. If all causation codes have the 'very likely' code this does not mean that fatigue is the primary cause or that the two other confounding factors (excess speed and alcohol impairment for example) are. Similarly, the difficulty in using a case where a lot of causation factors exist is that some or all may be linked very closely. For example a behavioural causation code of 'Careless, Reckless or in a Hurry' may be associated quite strongly with fatigue as a driver may be anxious to finish the

driving task. However just being seen as ‘careless’ in the eyes of the police may be due to a deterioration in driving due to fatigue. The previous section of analysis derived a number of pure fatigue accidents from the existing 24 fatigue related cases.

In order to create a sample of fatigue relevant accidents it was decided to remove the cases where confounding factors could have influenced the accident causation or circumstances. The decisions taken in this process were supported by studying literature on the subject of fatigue to help guide the analysis.

It is necessary to understand that the removal of a case does not indicate that it was not in some way related to fatigue but rather that the accident causation could be attributed to a number of different factors.

Horne and Reyner (1995) identified ‘sleep related accidents’ by developing a list of criteria that described the signature of a fatigue accident. A filter based on these criteria was applied to remove cases where confounding factors existed. These criteria are shown below:

- Blood alcohol levels below the legal limit,
- The vehicle either runs off the road or collides with the rear of another vehicle,
- There is no attempt to apply the brakes beforehand (hence no skid marks),
- There is no mechanical defect (for example, tyre blow-out),
- Good weather and visibility,
- Elimination of speeding or driving too close as causes,
- Police officers at the scene suspected sleepiness as the prime cause,
- For several seconds immediately before the accident the driver could have seen clearly the point of run off or the vehicle hit.

Cases involving injured passengers who were either alighting or boarding were also removed as these were considered slow speed manoeuvring accidents where a number of confounding factors could exist.

A number of cases also indicated causation factors of fatigue combined with an unspecified driver illness or medical condition. In these cases the role played by both causations is unknown and therefore the case was removed from the sample.

The remaining cases after this filter totalled 4, 1 from 2005, 1 from 2006 and the remaining 2 cases from 2007. These In-depth cases indicate that accident time could still be an indicator for fatigue accidents as there are 2 cases which occur between 01.00 and 03.00 hours in the identified literature as or near a time of day that is an indicator of fatigue accidents and also occurr on low speed (30mph) A-roads.

The other 2 cases do not fit so easily into the expected results from earlier research. Neither occur particularly late at night/early in the morning (although one is in darkness), nor in the mid afternoon time band (16.00 hours). Both occur on lower speed roads away from monotonous sections of dual carriageway.

This information again goes to demonstrate that fatigue accidents are not as simple or as predictable (by road type and time of day for example) as previous research would suggest.

4.5. Conclusions

The number of cases presented for both the overview of the fatigue related coach accidents and the in-depth case review is most probably an under-representation of the total fatigue related cases. This is due to a number of factors but centres around the reporting and recording of such accidents. It is understood that many causative factors associated with accidents are not admitted by the driver during the police interview. Fatigue may be one of these causative factors that a driver is less inclined to attribute to the accidents occurrence. Unless evidence exists (eg. from tachographs or witness reports) the police may indicate fatigue based on time of day or length of journey using only the ‘possible’ code or not record fatigue at all.

The analysis of bus and coach accidents on motorways by time of day shows the same pattern as that identified through the CARE analysis. This analysis shows peaks of accidents at mid-morning and mid-afternoon due mainly to risk exposure as more coach journeys are underway at these times. Small groups are also present late at night and in the early morning. These are likely to be more significant than they appear in the results as they probably represent a much higher proportion of the total number of coaches and other vehicles on the road.

Using the accident causation variable for fatigue, detailed analysis of the relevant coach fatigue cases (n=24) does not give a clear picture of the types of accident or accident scenario expected for these accidents. This is most probably due to the number of confounding factors that exist in even a basic accident scenario. However the fact that no clear picture emerged from the analysis does not mean that it is not possible to use the information. In fact understanding that a number of interlinked and confounding causation factors exist indicates that fatigue, and its role in the accidents, is not simple. It is therefore difficult to imagine countermeasures that could prevent these accidents where fatigue could play only a small part.

Despite the very small number of cases, the in-depth accident review (n=4) indicates that accident time could be an indicator for fatigue accidents. This follows on from the literature

review on the subject where time of day was identified as a major indicator of fatigue accidents. Out of the 4 cases returned 3 were in darkness and 2 in the early hours of the morning.

The STATS19 database is also not ideally suited to addressing the question of the role of fatigue in coach accidents. The difficulty of separating buses and coaches is a significant limitation. This is something which is fundamental to the understanding of fatigue crashes due to the different uses these vehicles are put to and the type of crashes they have.

Review of Accident Data for Great Britain (STATS19): Summary	
Information source	Results/research finding
Overview (Section 4.1)	Of the 27,680 bus and coach accidents no selection can be made for coach only. Cannot identify coaches with sufficient confidence due to information recorded however from 3 years of national accident data 27,680 buses and coaches were recorded – 34 have fatigue as possible causation factor. 34 accidents from the total of 27,680 bus and coach crashes equates to 0.12% with fatigue identified as a possible causation factor, Trucks recorded at 1.44% and cars 0.62%. Accidents on motorways by time of day shows accidents peaks at mid-morning and mid-afternoon due possibly to risk exposure. Small groups of accidents are present late night and early morning. Unable to normalise this result based on exposure as data do not exist.
Analysis of coach accidents with fatigue (Section 4.2)	24 cases selected based on detailed make and model information. 1 accident recorded as fatal, 7 recorded as serious and 27 as slight. 35 injured were coach occupant including the drivers, 10 were in other vehicles and 4 were pedestrians. 10 of the 35 injured coach occupants were drivers, 25 were passengers. Of the 19 crashes in which coach occupants were injured, only 1 crash had a large number of injured occupants (n=9). 2 accidents occurred on motorways, 13 on A roads, 1 on a B road, 2 on a C road and 6 recorded on unclassified roads. Speed limits were low with 20 of the 24 accidents occurring on 40mph or slower roads. Data shows similar peaks in accidents at the expected fatigue related times of 02:00-03:00, 06:00-07:00 and 16:00-17:00 identified in the literature.

Review of Accident Data for Great Britain (STATS19): Summary contiued	
Accident causation factors (Section 4.3)	Out of 24 fatigue related coach accidents the causation is recorded as 'fatigue very likely' in 9 accidents and 'fatigue possible' in 15 accidents. In 4 cases fatigue was the only reported accident cause. In 8 cases fatigue plus one other factor (e.g. aggressive driving) was reported. In the remaining 12 cases fatigue was one of 3 or more causation factors. A total of 3 cases were selected after in-depth review as fitting the signature of a fatigue related crash.
Conclusions (Section 4.5)	The number of cases presented for the overview of the fatigue related coach accidents and the in-depth case review is most probably an under-representation of the total fatigue related cases. The causations factors reported are most probably an under-representation of the national picture In general fatigue tends to play a part in a complex array of other causations factors; these may influence the accident scenario more or less than fatigue itself. The number of cases presented for both the overview of the fatigue related coach accidents and the in-depth case review is most probably an under-representation of the total fatigue related cases. This is due to a number of factors but centres around the reporting and recording of such accidents. The STATS19 database is also not ideally suited to addressing the question of the role of fatigue in coach accidents. Longstanding difficulties exist in the separation buses and coaches; this remains the most significant limitation to this study.

5. INVESTIGATION OF SPECIFIC COACH CRASHES

5.1. Methodology

A number of coach crashes have been reviewed. This search has included high profile crashes from the UK and other European Member States which were reported in the media. In addition, a number of crashes have come to the attention of the VSRC through its ongoing accident investigation work either as special cases of interest or as part of the UK OTS project. Information has been compiled in a case summary, in relation to the circumstances of each crash, the causes of the crash, where relevant the legal outcome and any recommendations, in order that a thorough review of the crash information could be made

In total 26 crashes have been considered in detail, of which 13 occurred in the UK and a further 13 which occurred in other European countries. The information in these cases was considered in the light of the main indicators of fatigue related accidents as discussed in section 2.2 in Horne and Reyner (1995).

- Certain times of day (peaks at 02.00, 06.00 and 16.00 hours),
- Motorways and Non-urban driving (urban roads are generally more stimulating).

Other factors:

- Typically involves run off road,
- Absence of skid marks or other indications of braking,
- For several seconds prior to the accident the driver could have seen clearly (implying prolonged inattention),
- Other causes (e.g. mechanical defect) have been eliminated,
- Witnesses report lane-drifting.

Case summaries for these crashes are provided to accompany this report via the links in the tables.

5.2. UK Crashes

A search for coaches involved in crashes was carried out in the UK media and the VSRC's ongoing special accident investigation work. In a number of the incidents further investigation confirmed the vehicle to be a bus, public service vehicle or minibus and they were discounted. A list of 13 cases was ultimately compiled.

In addition the UK OTS database was examined and a total of 110 cases in Phases 1 and 2 (77) and Phase 3 to date (33) were identified as involving a bus or coach. Further analysis of these cases confirmed that none of them had fatigue coded as a causation variable and

none occurred during the peak hours identified in the literature. Ultimately 1 OTS case was identified which occurred outside of these time periods (early afternoon) but on a stretch of motorway. This was the only case in which fatigue might possibly have made a contribution to the crash. Permission to provide information for this case must be obtained from the UK DfT.

An approach was made to the Vehicle and Operator Services Agency (VOSA) in order to establish whether they could provide information about crashes relevant to the study or whether the information gathered in the media search could be corroborated against the records held by VOSA. Such information might be available following the granting of permission by the UK DfT but would be limited to those cases in which legal proceedings would not be conducted or were already completed, thus excluding the more recent cases. It was not possible within the time frame of this study to follow up this line of enquiry with DfT and VOSA but this avenue of obtaining relevant information is worthy of consideration for any future research.

In total 13 UK cases were followed up in order to ascertain the possible causes of the crash and the possible contribution of fatigue. For each of the in-depth cases a conclusion has been made and the findings are summarised in Table 17.

Table 17: UK Coach Crashes

	Fatigue cited or circumstances of the crash consistent with fatigue being a contributory factor.		Time identified in the literature as a peak for fatigue related crashes 02.00hrs, 06.00hrs and 16.00hrs

Case No.	UK	Date	Time	Location	Cause of crash/Possible role of fatigue
SDG01UK	**M25 nr Slough**	16/11/2002	23.00hrs	Between J15-J16 of M25	**Fatigue cited as a cause of the crash**.
SDG02UK	**A483 Wrexham**	14/07/2003	00.15hrs	Northbound carriageway of A483 on outskirts of Wrexham	Other road user. Fatigue not a cause apart from the time of the crash.
3SDG03UK	**M4/M25 London**	03/01/2007	23.45hrs	Slip road off junction 4B of M4 onto junction 15 of M25	Loss of control. Fatigue not cited.
SDG04UK	**M1 Newport Pagnall**	03/09/2007	16.00hrs	Slip road to Newport Pagnall services on M1	Dangerous driving and drinking with excess alcohol. *Driver had been drinking all night* – **fatigue may have been a contributory factor**.
SDG05UK	**A429 Bourton-on-the-water**	05/12/2007	No time given	A429 Bourton-on-the-Water	Driving without due care and attention. Fatigue not cited as a cause but may have been a possible contributory factor.
SDG06UK	**M4 Newbury**	04/03/2008	19.10hrs	Between junction 14 and Membury services	No reason cited. Nature of crash was such that fatigue may have been a contributory factor.
SDG07UK	**A429 Coventry**	15/07/2008	16.50hrs	A429 Barford Road, ½ mile from junction 15 of M40	No reason cited. Nature of crash was such that fatigue may have been a contributory factor.
SDG08UK	**Alton Towers**	18/08/2008	About 18.00hrs	Station Road, Alton, Staffs 0.5 miles from Alton Towers	Likely cause weather conditions and road type. No reason to consider that fatigue was a contributory factor.
SDG09UK	**A64 North Yorkshire**	20/09/2008	09.00hrs	A64 Staxton Hill nr Scarborough	Possible brake failure. No reason to consider that fatigue was a contributory factor apart from likely time of departure and length of journey.
SDG10UK	**M42 Worcs**	26/09/2008	Shortly after 14.00hrs	North-bound carriageway between junctions 3 and 3a	No cause given. Nature of crash was such that fatigue may have been a contributory factor.
SDG11UK	**A429 Stow**	10/10/2008	15.10hrs	A429 at Fountain crossroads	Details not available. No reason to consider that fatigue was a contributory factor apart from the time in the afternoon.
SDG12UK	**A51 Chester**	11/11/2008	03.05hrs	A51 Tarporley Road, Tarvin	No cause given. Time and length of journey such that fatigue may have been a contributory factor.
SDG13UK	**Crawley, Sussex**	18/11/2008	07.55hrs	Ifield Wood, off Charlwood Road, just outside Crawley	Details not available. It is not possible to draw a conclusion regarding the role of fatigue as a possible cause.

5.3. European crashes

A similar media search for coaches involved in crashes in other European Member States was undertaken. The cases identified again included some buses, public service vehicles and minibuses. Crashes included European vehicles and coaches registered in the UK but travelling in Europe. A list of 12 of these cases was ultimately compiled.

In addition the SafetyNet Accident Causation and Fatal Databases were interrogated. From the in-depth crashes involving a bus or coach 3 cases were identified in which fatigue was recorded as an accident causation variable. Every effort was made to obtain information from the investigating organisation but ultimately only 1 of these cases could be included in the final selection. Indeed, closer investigation identified that this case involved a large minibus, as opposed to a coach, but it was decided to leave the case in as an example.

In total 13 European cases were followed up in order to ascertain the possible causes of the crash and the possible contribution of fatigue. For each of the in-depth cases a conclusion has been made and the findings are summarised in Table 18.

Table 18: EC Coach Crashes

	Fatigue cited or circumstances of the crash consistent with fatigue being a contributory factor.		Time identified in the literature as a peak for fatigue related crashes 02.00hrs, 06.00hrs and 16.00hrs

Case No.	European	Date	Time	Location	Case Summary
SDG14EU	**Hungary 2002**	06/01/2002 not checked	Just after 01.15hrs	Lake Balaton, Hungary	Excessive speed. Fatigue not included in court outcome. The road type, the time of the crash and the nature of the journey are all consistent with fatigue being a contributory factor.
SDG15EU	**France 2002**	27/06/2002	04.40hrs	Bierre-les-Semur near Dijon, in central France	Involuntary manslaughter and involuntary injury by driving without due care and attention. Speeding and loss of control. **Strong evidence that fatigue was a contributory factor.**
SDG16EU	**Turkey 2002**	25/09/2002 Not checked	03.15hrs	Dogusbelen	No cause given. The time of the crash is such that fatigue cannot be ruled out as a contributory factor.
SDG17EU	**Greece 2003**	15/04/2003	No time	Near Tempi	Other vehicle. Fatigue not a cause.
SDG18EU	**France 2003**	17/05/2003	05.00hrs local time	A6 Northern suburbs of Lyon	Likely to be loss of control and excessive speed. However, the time and nature of the crash suggest that fatigue may have been a contributory factor.
SDG19EU	**Germany 2003** (SafetyNet)	13/07/2003 not checked	04:52hrs	Hannover region	NB large minibus. Case in SafetyNet 5.1 where **fatigue mentioned as an impairment**. Case complied by MUH. Time and nature of accident also consistent with fatigue related crash.
SDG20EU	**Belgium 2003**	20/12 2003	05.00hrs local time	French-Belgian border near Hensies	Loss of control - possibly due to the driver falling asleep. The time, road and nature of the crash and the journey are all consistent with fatigue being a contributory factor.
SDG21EU	**Austria 2004**	10/08/2004	16.30hrs local time	Bad Dürnberg, nr Hallein, South of Salzburg	Other vehicle. Fatigue not a cause (even though time of crash can be associated with fatigue accidents).
SDG22EU	**Greece 2004**	27/09/2004	No time	Maliakos Bay	Other vehicle. Fatigue not a cause.
SDG23EU	**Belgium 2007**	10/06/2007	11.10hrs	Between the towns of Middelkerke and Nieuwpoort	Reaction to other vehicle. No reason to consider that fatigue was a contributory factor.
SDG24EU	**France 2007**	22/07/2007	11.00hrs	Near Vizille, close to Grenoble	Loss of control. Fatigue not a cause.
SDG25EU	**Spain 2008**	19/04/2008	19.50hrs	Benalmadena	Other vehicle. Fatigue not a cause.
SDG26EU	**Croatia 2008**	07/09/2008	06.00hrs local time	Zir	Loss of control. The road type and the time of the crash in relation to the length and nature of the journey are all consistent with fatigue being a contributory factor.

5.4. Discussion

Considering all of these crashes, 4 (15%) of the 26 cases had fatigue cited as a cause of the crash or there was strong evidence that fatigue was a contributory factor. In 10 cases (39%) there were variables that are considered to be the main indicators of fatigue related accidents i.e. where the time, road and/or nature of the crash indicate that fatigue might be a possible contributory cause of the crash. In the remaining 12 cases (46%) the cause was determined to be something other than fatigue.

Of the UK cases 1 had fatigue cited as a cause of the crash (SDG01UK). In a further case (SDG04UK) 'dangerous driving' and 'excess alcohol' were stated as the causes of the crash but fatigue is likely to have been a factor as the driver was reported as being 'up all night drinking' the night before the crash. This case also occurred at one of the peak times for fatigue (16.00hrs). In a further 5 cases fatigue may have been a contributory factor as the time of the crash or the nature of the crash circumstances or journey type are consistent with the main indicators of fatigue related accidents. In the remaining 6 cases the cause was determined to be something other than fatigue.

Of the cases in other European Member States, 1 (SGD15EU) had strong evidence that fatigue was a contributory factor. In a further case (SGD19EU), identified in the SafetyNet 5.1 database, fatigue was mentioned as an impairment (of the driver). In fact this case involved a large minibus but it was originally coded as a coach. In a further 5 cases fatigue may have been a contributory factor as the time of the crash or the nature of the crash circumstances or journey type are consistent with the main indicators of fatigue related accidents. Only 1 of these crashes occurred at one of the peak times for fatigue (06.00hrs). In the remaining 6 cases the cause was determined to be something other than fatigue and 1 of these crashes occurred at one of the peak times for fatigue (16.00hrs).

The distribution of crashes by time is given in Figure 5 for both the UK and EC crashes. The grouping of crashes between the peak times of 02.00 and 06.00hrs can be seen which supports the suggestion that in crashes during this time period, fatigue may play a role.

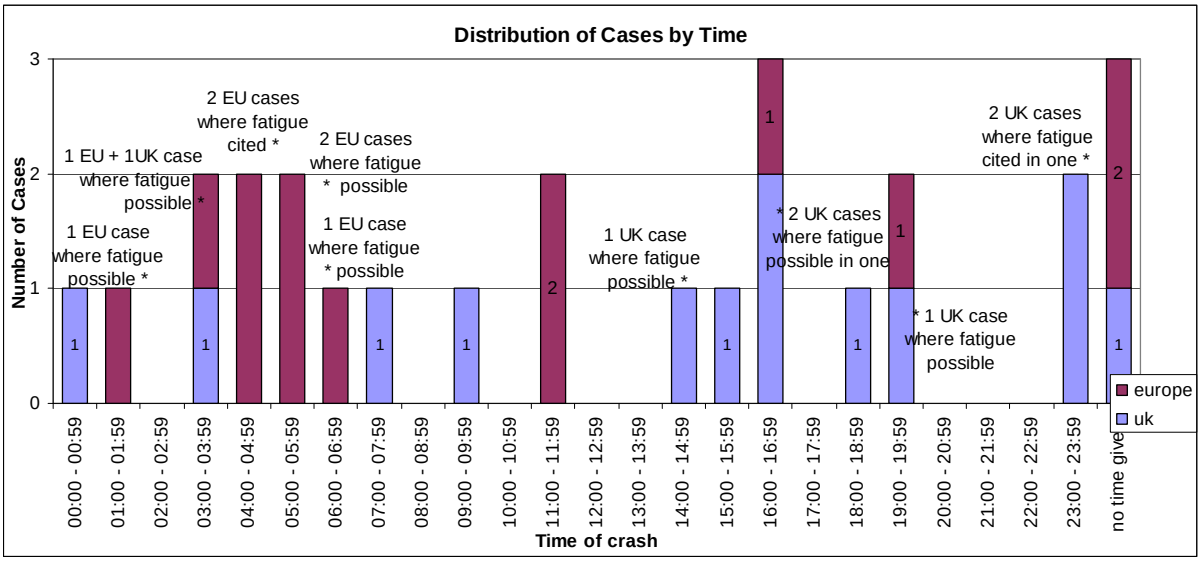

Figure 5: Distribution of UK and European in-depth crashes by time (n=26)

With the relatively small number of crashes both available and feasible to be followed up in the timeframe of the study, it is not possible to give an undertaking that the selected cases are representative of the coach crash population in either the UK or Europe. The cases selected for in-depth analysis represent those crashes which are of media interest, relevant to the research question and for which it is possible to obtain sufficient information. The accuracy, quality and consistency of this information cannot be guaranteed but is reported in good faith.

5.5. Conclusions

Of the 26 cases from the UK and other European Member States which were reviewed in detail, 12 (46%) cases were considered to be caused by factors other than fatigue and 1 of these cases occurred at a peak time for fatigue (16.00hrs). However, 4 cases (15%) had a specific reference to fatigue or had strong evidence that fatigue was a cause. In addition, 1 of these cases occurred at a peak time for fatigue (16.00hrs). In a further 10 cases (39%) fatigue may have been a contributory factor as the time of the crash or the nature of the crash circumstances or journey type are consistent with the main indicators of fatigue related accidents. In addition, 1 of these cases occurred at a peak time for fatigue (06.00hrs). However, as it is equally likely that fatigue did not play a part in a number of these 10 crashes, no firm conclusions can be drawn regarding the actual role of fatigue.

As can be seen from these in-depth cases the causes of crashes are complex and in many cases it is difficult to determine if fatigue played a role.

Whilst the number of cases is small, these findings support the indication from the literature that fatigue related accidents are more prevalent than the statistical data might otherwise suggest.

Investigation of Specific Coach Cashes: Summary	
Information source	Results/research finding
Reviewed coach crashes identified in the media and through VSRC work (Section 5.1 & 5.5)	26 cases presented from UK and Europe. **Sample not representative of all coach crashes.** 4/26 (15%) had fatigue cited as cause or considered a possible contributory factor; 10/26 (39%) fatigue not mentioned but in circumstances (road/crash type, etc) which may be associated with fatigue; 12/26 (46%) had no mention of fatigue.
Summary of 13 UK cases (Section 5.4)	1 case fatigue cited as cause; 1 case fatigue considered a possible contributory factor and occurred at 16.00hrs; 5 cases fatigue not mentioned but in circumstances (road/crash type, etc) which may be associated with fatigue; 6 cases had no mention of fatigue.
Summary of 13 European cases (Section 5.4)	1 case strong evidence that fatigue was a contributory factor; 1 case fatigue mentioned as an impairment; considered a possible contributory factor and occurred at 16.00hrs; 4 cases fatigue not mentioned but in circumstances (road/crash type, etc) which may be associated with fatigue; 1 case fatigue not mentioned but in circumstances (road/crash type, etc) which may be associated with fatigue and at time associated with fatigue; 6 cases had no mention of fatigue and 1 of these occurred at time associated with fatigue.
26 cases presented from UK and Europe (Section 5.5)	As can be seen from these in-depth cases the causes of crashes are complex and in many cases it is difficult to determine if fatigue played a role.
26 cases presented from UK and Europe (Section 5.5)	Whilst the number of cases is small, these findings support the indication from the literature that fatigue related accidents are more prevalent than the statistical data might otherwise suggest.

6. DISCUSSION

6.1. Background

The objectives of this study have been to understand the main causes of coach accidents, with a particular emphasis on understanding the role of driver fatigue. The context of this work includes recent changes to rules on the drivers' hours (regulation EC 651/2006 and the so-called "12 day rule").

Specifically, the activities have included:

- Reviewing the relevant literature in order to understand the factors that influence fatigue accidents and to inform the data analysis,
- The analysis of existing international databases (for example CARE, UNECE and IRTAD),
- The review of additional data collecting by Steer Davies Gleave,
- The review of national data for Great Britain (STATS19),
- More detailed analysis of recent accidents in Europe.

The conclusions that have been drawn as a result of these activities are discussed in turn.

6.2. Literature

Road accidents are complex phenomena which generally result from the interaction of a number of factors. From the literature it is clear that it is hard to identify those accidents where fatigue has been the main or a contributory cause. Since there are various stages of consciousness, from slight fatigue to sleeping, it is difficult to ascribe fatigue as a cause. This is compounded by the fact that fatigue may be mistaken for other factors such as excess speed or lack of attention.

The literature suggests that the incidence varies by a number of factors with lack of sleep and time of day being key ones, but with others such as shift patterns, age and physical fitness being important. These factors are not generally recorded in national accident databases. Fatigue accidents are likely to also be influenced by the road environment, with monotonous motorway and trunk roads being more problematic than urban roads where drivers have more mental stimulation. Accurate estimates of fatigue-related vehicle accidents are very difficult to make with any certainty because of a lack of reliable evidence. However, the estimates in the literature vary from 1 – 4% (SWOV, 2006) to 24% (NHTSA, 2003) depending on the precise conditions specified in the study (whether all road types, road-user types and times of day are considered, for example).

Coach drivers are likely to be affected by fatigue if:

- It is night time,
- They are using long, straight roads,
- They are at the beginning or end of a long journey,
- They have relevant personal factors such as existing medical conditions.

Current legislation aims to manage the incidence of fatigue-related accidents by controlling the length of time which professional drivers can work for and the amount of time they spend resting. There is evidence that factors other than time spent on task will have an important effect on the likelihood of a driver experiencing fatigue. These include factors over which drivers and employers have some degree of control (physical fitness, journey scheduling and shift patterns), and factors over which they have none (traffic conditions and weather). However, coach drivers have additional limitations as a result of the passengers they are carrying and the drivers' hours regulations will have a different impact on the drivers of coaches from, for example, truck drivers. Currently, there is no information in existing national accident databases about these additional factors. This makes the drawing of definite conclusions regarding the contribution of these factors problematic. Time of day and road type can be used as indicative factors to produce some estimates of the likely incidence of fatigue related accidents involving coach travel, but it is unlikely that clear evidence will be available.

6.3. Data analyses (European sources)

The stated aims of the analysis were:

- To attempt to quantify the significance of fatigue as a safety issue for coach operation at the European level,
- To highlight the factors that are likely to affect the accuracy of conclusions,
- To determine the degree to which the conclusions drawn can be applied at a European level),
- To assess the suitability of currently available data sources to address this issue.

Using the CARE, UNECE and IRTAD data the following conclusions can be drawn.

It is difficult to quantify the significance of fatigue as a safety issue from the existing national and European databases because of limitations in the collected data. Whilst the literature review highlights some estimates of the likely scale of the problem, these vary according to a number of key factors, so would be difficult to apply directly to aggregated European data.

A number of factors have been highlighted that might affect the accuracy of estimates of the significance drawn from the databases. These include the difficulty of identifying fatigue

accidents, the differences in variables, values and definitions across countries and the relatively low numbers of cases of coach fatalities in the databases. The data sources currently available are not well-suited to addressing the issue of fatigue accidents because of a lack in the databases of the relevant variables. As a result of the issues highlighted above, drawing conclusions that can be applied to the whole of Europe is problematic.

The CARE data for fatal accidents involving buses and coaches does support some of the findings from the literature study. The literature suggests that fatigue accidents peak at certain times of day and are a more significant issue on motorways and other non-urban routes. Analysis of the CARE data shows that there are peaks in the accident totals at certain key times of (early hours of the morning and early evening) and these peaks are more pronounced on motorways. However, in terms of addressing the specific question of the safety implications of reinstating the derogation, the data are not sufficiently detailed to address this issue.

As is also the case for existing European databases, the data collected by Steer Davies Gleave is not well suited to addressing the question of the role of fatigue in coach accidents in Europe. It also lacks the necessary detail to inform a decision about the reinstatement of the 12 day derogation.

6.4. Analysis of STATS19

The STATS19 database is not ideally suited to addressing the question of the likely impact of the 12 day derogation on road safety. The most significant limitation is the difficulty of identifying the vehicle type of interest. Whilst it is possible to identify some vehicles through the make/model data, coaches and buses generally operate in very different circumstances with respect to the road environment, the traffic conditions, the fact that passengers may be standing on buses but seated and restrained on coaches, and not least the length of the journey that is being undertaken. The fact that only some different vehicle models can be identified, and the use to which the vehicles are put cannot be determined, limits the extent to which the relevant cases can be highlighted. This is something which is fundamental to the understanding of fatigue crashes. In addition, variables describing the factors which are of most interest, namely, the length of time spent driving and the amount of rest taken in the days leading up to the accident simply do not exist in the database. These factors make it difficult to address questions about the incidence of fatigue accidents in Great Britain.

However, the overview of bus and coach accidents on motorways by time of day shows the same pattern as that identified through the CARE analysis. There are peaks in the number of accidents at mid-morning and mid-afternoon which may be related to higher risk exposure at these times. There is evidence of a smaller grouping of accidents late at night and early in the

morning. These may be more significant, however, a lack of suitable risk exposure data makes it difficult to draw firm conclusions.

Selecting by the accident causation variables for fatigue detailed analysis of the relevant fatigue cases (n=24) does not give a clear picture of the types of accident or accident scenario expected for these accidents. This is likely to be due to the number of confounding factors that exist in even a simple accident scenario. However the fact that no clear picture emerged from the analysis does not mean that it is not possible to use the information. In fact understanding that a number of interlinked and confounding causation factors exist indicates that fatigue, and its role in accidents, is not simple.

Despite the very small number of cases the in-depth accident review (n=4) indicates that accident time could be an indicator for fatigue accidents. This supports the findings of the literature review, where time of day was identified as a major indicator of fatigue accidents. Out of the 4 cases returned 3 were in darkness and 2 in the early hours of the morning.

It is likely that the number of cases presented as having fatigue as a causal factor is an understatement. It is likely to be the case that a professional driver would be unwilling to admit to being tired or falling asleep because of the potential consequences for his career. Unless evidence exists (eg. from tachographs or witness reports) the police may indicate fatigue based on time of day or length of journey using only the ‘possible’ code or not record fatigue at all.

6.5. Specific coach crashes

Of the 26 cases from the UK and other European Member States which were reviewed in detail 12 (46%) cases were considered to be caused by factors other than fatigue and 1 of these cases occurred at a peak time for fatigue (16.00hrs). However, 4 cases (15%) had a specific reference to fatigue or had strong evidence that fatigue was a cause. In addition, 1 of these cases occurred at a peak time for fatigue (16.00hrs). In a further 10 cases (39%) fatigue may have been a contributory factor as the time of the crash or the nature of the crash circumstances or journey type are consistent with the main indicators of fatigue related accidents. In addition, 1 of these cases occurred at a peak time for fatigue (06.00hrs). However, as it is equally likely that fatigue did not play a part in a number of these 10 crashes, no firm conclusions can be drawn regarding the actual role of fatigue.

As can be seen from these in-depth cases the causes of crashes are complex and in many cases it is difficult to determine if fatigue played a role. Whilst the number of cases is small, these findings support the indication from the literature that fatigue related accidents are more prevalent than the statistical data might otherwise suggest.

7. CONCLUSION

The data indicate that the total contribution to fatalities of accidents where a coach is involved is relatively small. As is shown in table 1, bus and coach accidents account for only 2.5% of fatalities in 2006 and coaches only account for an indefinable proportion of these due to the way the vehicles are recorded. Within this relatively small number of fatalities, the studied literature suggests that somewhere between 4 and 24% may have fatigue as a contributory factor. However it is not possible to make estimates of the total contribution of fatigue with the data currently available. The European data are not sufficiently detailed regarding the exact number of coach crashes or the information that is necessary to determine the role of fatigue.

Recommendations to define a common Accident Data Set (CADaS) which formed part of the SafetyNet project (www.erso.eu) include a variable to indicate fatigue as a causal factor in accidents. However, adoption by the member states of this set of variables is voluntary at the current time. In any case, in those countries which do adopt this set of variables, data will still be collected by police officers at the scene and will continue to be subject to the difficulties previously highlighted in identifying the presence of impairment due to fatigue.

Using the national data for Great Britain (STATS19) the data are not sufficiently detailed regarding the number of coach crashes, even when using the make/model information. Using the accident causation field for fatigue, the number of cases that can be confirmed and investigated is so small that reliable conclusions cannot be drawn.

Analysis of both the European data and the data for Great Britain, gives some indications that fatigue might be a contributory factor when the time of the accident (small hours of the morning and late afternoon) and the type of road (motorway) are considered. However, limitations in the available exposure data make it very difficult to separate the effect of variations in traffic conditions at different times of the day.

The exposure data that is currently collected across Europe generally uses simple measures. The Safetynet project identified deficiencies in current exposure data and also made proposals for the future collection of exposure data to better address questions relating to the scale of specific safety issues such as this one. However, it is likely to be several years before all countries can collect comparable and compatible exposure data. In the short term it is only the simplest indicators (population, registered drivers, registered vehicles) that are likely to be considered feasible for all countries to collect. However, it is detailed data on the more complex indicators (time spent in traffic, number of trips) that would be the most useful in addressing the particular question of the role of fatigue. These are unlikely to be available on a European level for some years.

It is unlikely that suitable exposure data are currently available in sufficient countries to make a representative sample possible. Indeed, it is likely that such data would be highly variable, with factors such as local customs, latitude and social and economic factors having a significant impact on variations in traffic conditions throughout the day, making it problematic to generalise to the whole of Europe.

The review of a small number (26) of detailed crash reports of coach accidents in Europe and the UK also demonstrated that fatigue is evident as a contributory factor in some of these cases. However, this sample is small and cannot be considered as representative of all coach crashes in either the UK or Europe, and it is not therefore possible to use this information to determine estimates for the number of cases in which fatigue may have played a role in crashes across Europe.

However, it is important to note that coach drivers have additional limitations as a result of the passengers they are carrying. The drivers' hours regulations will have a different impact on the drivers of coaches from, for example, truck drivers.

Therefore, in terms of addressing the specific question of the safety implications of reinstating the derogation of the drivers' hours, the data that are currently available in Europe are not sufficiently detailed to address this issue.

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This report uses make/model and accident causation data from STATS19 by permission of the Department for Transport.