

The 24th Westminster Lecture on Transport Safety

Staying Awake, Staying Alive: The problem of fatigue in the transport sector

Dr Robert Hunter
Head of Flight Safety
British Air Line Pilots' Association (BALPA)

4th December 2013, Church House, Westminster, London.

LECTURE

IN PROGRESS

**WARNING
KEEP AWAKE!**

*Pilots admit
dozing off
at the
controls.*

*M-WAY PILE-UP
AS DRIVER FALLS
ASLEEP AT WHEEL.*

Tiredness does kill.

24th WESTMINSTER LECTURE ON TRANSPORT SAFETY & 3RD LECTURE IN THE UN DECADE OF ACTION



Delivered 4th December 2013, Church House,
Westminster, London

*Staying Awake, Staying Alive: The problem of
fatigue in the transport sector*

Dr Robert Hunter, Head of Flight Safety at the British Air
Line Pilots' Association (BALPA)

Dr Robert Hunter is Head of Flight Safety at the British Air Line Pilots' Association (BALPA). He gave evidence to the Transport Select Committee into its *Flight time limitations* inquiry. He was formerly Head of the Civil Aviation Authority's Aviation Health Unit and a consultant specialist working in aviation medicine. During his time at the CAA he trained and secured a commercial pilot's licence and flew on long haul routes for FlyGlobespan on Boeing 767 aircraft. He was also formerly a Non-Executive Director of the Health Protection Agency and has a particular interest in public health. He has the view that, not just in the aviation sector, but more generally, the hazard of human fatigue is underestimated.

1. INTRODUCTION

My lecture addresses the danger of fatigue within the transport sector and by what means it could be measured and managed. I begin by discussing the development of a culture of sleep deprivation within aviation and the impacts this has had on the industry as a whole, before going on to discuss other forms of transport and how they have been affected by both fatigue and Fatigue Risk Management Systems (FRMS). My lecture covers the broader context of fatigue measurement and management, presenting the issue of sleep deprivation as one of the primary factors behind human error that threatens continued safety within a transport environment.

The first section (Chapter 2) comprises a brief overview of the traditional tolerance of fatigue in Great Britain's aviation industry and the medical consequences of sleep deprivation.

The second section (Chapter 3) outlines the performance impacts of fatigue, a sleepiness scale and the risks of involuntary sleep.

The third section (Chapter 4) outlines the recent attempts at fatigue management within the aviation industry, describing the emerging Fatigue Risk Management Systems (FRMS), discussing the positive and negative outcomes that this approach provides.

The fourth section (Chapter 5) goes on to discuss how fatigue and fatigue management have affected other areas of transport ranging from motorists to lorry drivers; maritime to rail.

The fifth section (Chapter 6) looks at the ongoing research into fatigue measurement and the technological developments currently underway to achieve unbiased and scientifically recorded results, for pilots in particular both during and after their periods of duty.

The final section (Chapter 7) includes questions asked at the end of the lecture.

2. AVIATION, FATIGUE AND SLEEP SCIENCE

2.1 The Fatigue Culture

There are numerous hazards within society which are accepted because they developed historically before we became sensitive to the dangers they posed. An example of this would arguably be the approach to fatigue on the flight deck of major airliners in Great Britain and beyond.

The initial development of long haul flights began almost side-by-side with the tradition of sleep deprivation of pilots during World War Two. This was during the period that aircraft were significantly developed with the capability of travelling long distances by day and night, such flights required almost constant awareness from the flight crews due to the nature of their missions and the equipment available to them. In this period the occurrence of sleep deprivation in pilots developed in a manner which would have arguably been contested during peacetime. It would be these planes and their pilots that would become the basis for post war international aviation.

This influence extended beyond hours of duty and impacted upon the evolution of the flight crew in more ways than one. Most notable of these was that during wartime, for these large aircraft each flight crew was made up of five or more crew members with five executive roles with one or more crew member assigned to each role. These executive roles remain in the operation of modern airliners; however, they are now typically distributed between two biological executives (the pilot and co-pilot) and a robotic executive, the autopilots and other automatic systems. However, pilot fatigue has not gone away with the introduction of these automatic systems and the reduction in the numbers of crew has increased the levels of strain on pilots along with their required awareness at certain critical stages of flight.

Furthermore, with the development of our 24-hour society, the invention of artificial light, smart phones that are always by our side, demanding employers and so on, it is now normal for most of us to be in a constant state of sleep deprivation.

2.2 The Medical Approach

Sleep is absolutely vital to human health, with studies suggesting that as much as 10 hours of sleep per night may ideally be required.

Ultimately, sleep deprivation is not a state which the human body can adapt to and without enough sleep there is increasing risk of a variety of medical conditions which are only now being considered to the fullest extent. The study of the consequences of fatigue has seen a massive expansion of medical interest, with academic researchers identifying more and more illnesses which can be associated with or exacerbated by sleep-loss.

These illnesses cover a wide range of areas with more being discovered all the time, and include:

- Depression
- Diabetes
- High Blood Pressure
- Memory impairment
- Eye Disease

There are deepening stages of sleep:

Sleep Stage	Features
Stage 1 (Lightest)	Slow eye movements, reduced muscle activity, muscle jerks, sensation of starting to fall, "nodding off"
Stage 2	Eye movements stop, brain waves slow
Stage 3	Further slowing of brain waves, deep sleep, groggy and disorientated if woken
Stage 4	As above but more so
Stage 5 (Deepest)	Rapid Eye Movement (REM) Paralysed limbs & dreams

3. THE CONSEQUENCES OF FATIGUE

3.1. Performance Decrements of Fatigue

The human performance impacts of fatigue include:

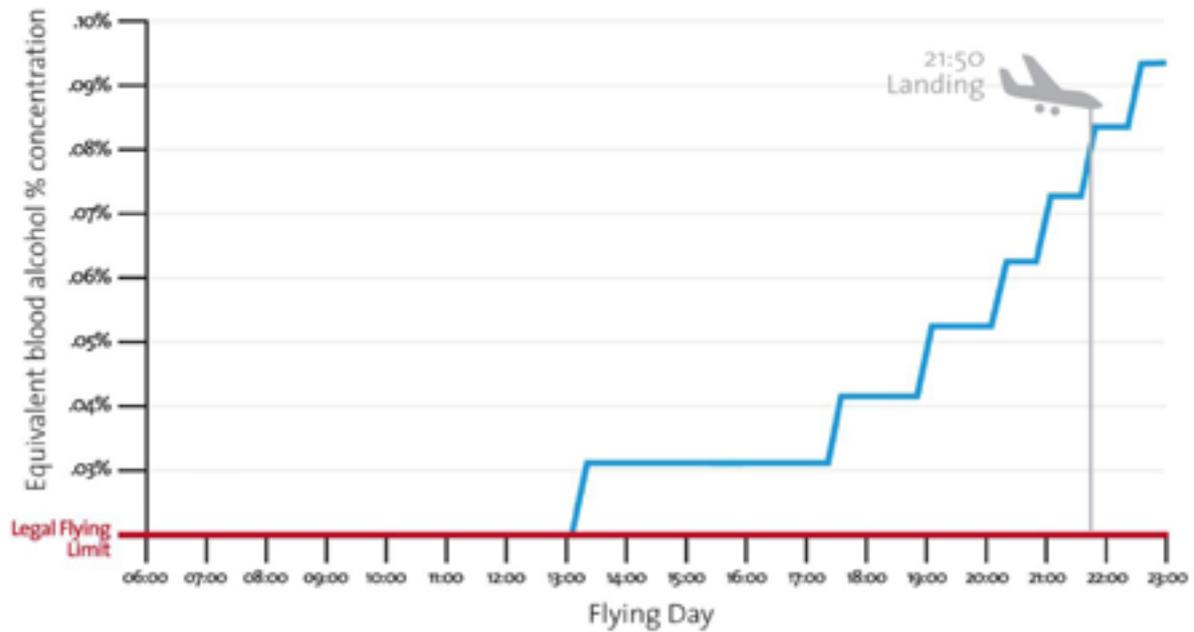
- Reduced reaction time
- Vulnerability to distraction
- Reduced vigilance
- Impaired judgement
- Impaired higher mental functioning
- Inability to deal with the unexpected
- Poor economic decision making
- Greater risk taking, more optimistic.

Perhaps most notable is that fatigued individuals are exceedingly vulnerable to distraction, especially within a closed off and monotonous environment such as the aeroplane flight deck in the cruise phase of flight at night. As a result, the aviation industry has seen a number of notable airline accidents attributed to pilot error which would perhaps have been otherwise avoidable if not for the influences of fatigue.

Vulnerability to sleep deprivation is in part influenced by individual genetics, unique to each person. Therefore, highlighting a vulnerability to sleep deprivation could potentially lead to an entirely new realm of genetic discrimination in modern society as employers seek to hire individuals who are less susceptible to sleep deprivation when working extended hours.

Unfortunately, we are really quite complacent with regards to fatigue in the aviation industry. The risk this poses can be illustrated when considering the fact that the performance decrements of sleep deprivation are similar to those obtained from alcohol consumption. Whilst not identical in effect, there is a well-established academic literature comparing these two effects to one another along with providing conclusions of the impacts that each can cause in situations including aviation.

As a result of these similarities earlier computer programs within the aviation research sector compared fatigue effects to alcohol consumption. The graph below illustrates that pilots with an 18 hour flight duty period (awake at 4 am) can be landing aircraft at an alcohol fatigue equivalence to four times the actual alcohol limit. Generally, with respect to certain human performance parameters, after 17 hours of wakefulness the performance loss is similar to being 2.5 times over the legal alcohol limit for flying.



[Data: SAFE v5 program]

The Karolinska Sleepiness Scale

There are numerous subjective scales for measuring sleep and one of the most common is the Karolinska scale, a subjective scale where the individual scores themselves on a scale of sleepiness from 1 to 9, as seen below:

- 1 Extremely alert
- 3 Alert
- 5 Neither alert nor sleepy
- 7 Sleepy – but no difficulty remaining awake
- 9 Extremely sleepy - fighting sleep

Aviation presentations looking at pilot records have revealed cases of pilots flying with a score of nine, at which point the risk of involuntary sleep is very high and leaves the pilot in a hazardous situation where 'micro-sleeps' occur. An important risk, particularly for long haul flight crew, is the risk of involuntary sleep and particularly the risk that both pilots might fall asleep at the same time.

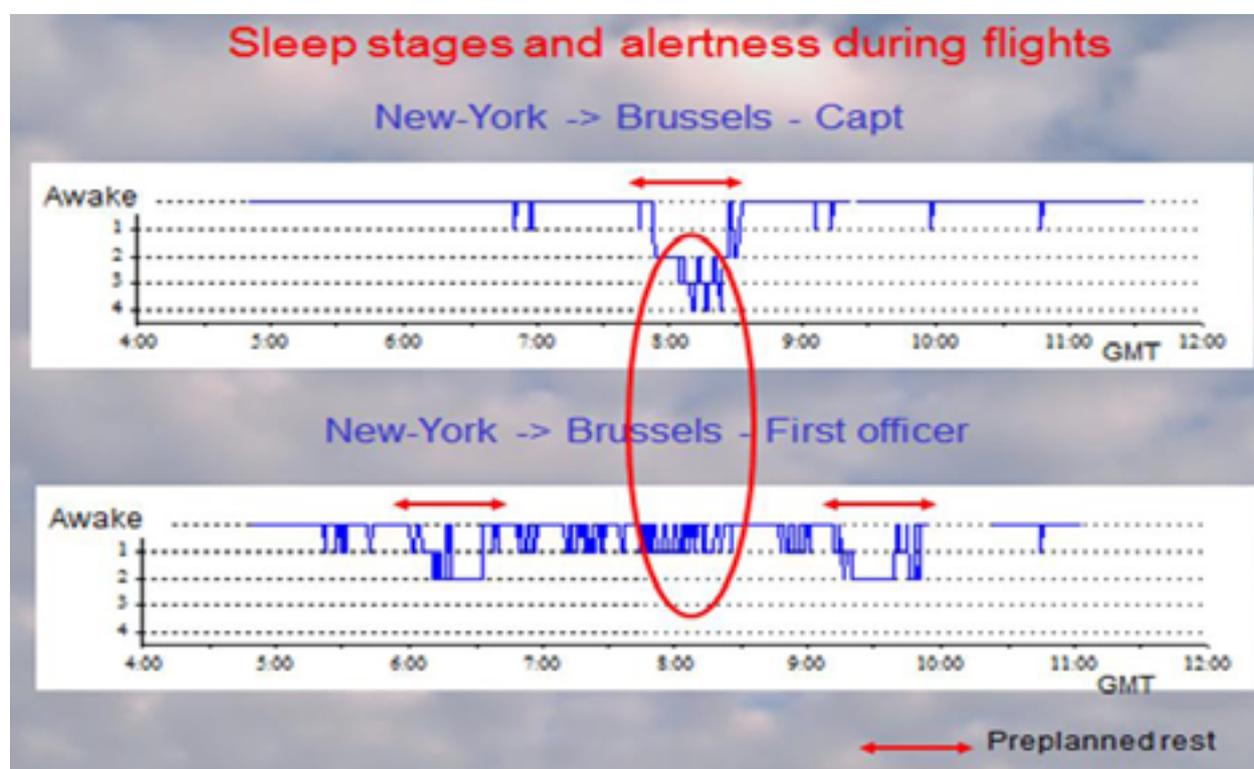
3.2. Involuntary Sleep

One of the greatest recognised threats of fatigue is the risk of involuntary sleep, as revealed by a BALPA commissioned study undertaken by ComRes in September 2011. The BALPA investigation carried out an anonymous poll which questioned 500 airline pilots on how many of them had ever involuntarily fallen asleep on the flight deck during 2 crew operations. This revealed that 43% confirmed that they had. Furthermore, 31% of those pilots who had fallen asleep admitted to waking up to find the other pilot asleep as well.

People don't really remember when they fall asleep; if involuntary sleep was measured objectively it would probably be found that nearly all of the pilots had fallen asleep on the flight deck and the 43% figure only reflects a proportion that had recollection of the incident. People that have had micro sleeps of less than 2 minutes duration generally do not recall their episodes of sleep. The absence of extensive airline accidents attributed to involuntary sleep indicates that the risk of this hazard has been minimised by the automatic systems on the flight deck. However, aircraft automatic systems can fail so we should not be complacent. Furthermore, there are critical stages of flight which demand a pilot's full performance; stages where critical actions cannot be undertaken by the automatic systems.

As a result of this risk there have been recent introductions of 'pre-planned rest' into the flight-deck protocols. The term 'pre-planned rest' is a euphemism for an intentional period of time during which the pilot chooses to fall asleep, when the necessary human input into the aeroplane's systems is minimal and can be assigned to just one of the pilots whilst the other pilot catches up on much needed sleep. As a result the rested pilot can, in theory, be at their most aware and mentally capable for the most critical times later in flight. However, the diagram below reveals the results of an electroencephalography study into 'pre-planned rest' and the data reveals that whilst the Captain took his pre-planned sleep, the First Officer who should have remained awake was in a state of involuntary sleep.

Crew sleep patterns of cockpit napping during transatlantic flights, P. Cabon et al . XVIth International Symposium on Night and Shiftwork, 17- 21 November 2003, Santos, Brazil.



4. FATIGUE RISK MANAGEMENT SYSTEMS

We are soon to have new regulations for the management of pilot fatigue within the United Kingdom, and the pilot associations have the view that these regulations are much more permissive, so we will see an increase in fatigue risks. It is probably true to say that the regulators and the airlines take a different view. But one of the pilot's principal concerns is that the new rules seemed to have been derived industrially, as a type of brokering exercise, rather than being based on science and medicine.

One of the features of these rules is the increasing reliance on FRMS as a type of Safety Management System (SMS). It seems that these systems, without sufficient modification, are being deployed in a number of disparate industries despite the existence of important differences between the industries.

For example when the pilot falls asleep on the flight deck, what is controlling the wakefulness of the other pilot? In the context of aviation there are other issues, because people who sleep on aeroplanes will lower their blood oxygen concentrations and if there is then a loss of cabin pressure their chance of regaining consciousness or to be usefully conscious is much reduced. So it's a much greater hazard for a pilot to sleep on a flight deck in this sense.

In a FRMS, the airline owns its own risks and to some degree sets its own risk levels. A concern about FRMS is that there is no definition of what these levels should be. There is no definition of how "tired is too tired" to safely fly. This system of risk management is heavily reliant on open reporting of fatigue by pilots. The problem is that aviation industry has become iconic of the low cost model and it can be career limiting for a pilot to report fatigue. Pilots probably fall asleep on UK registered aircraft every day, if not more often than that, yet earlier this year the CAA revealed that there had been only 3 reports of this in 30 years.

One of the worries that pilots have about FRMS is that there is a FRMS consultancy bandwagon, with lots of private companies having been set up, offering the managers of the airlines a service. The concern we have is that this service looks much more of a 'blame management system' that would seem to make sure that, if the accident happens, the management aren't blamed for it, rather than a system that is primarily focused on making sure the accident doesn't happen in the first place.

Then there is the historically revisionist aspect of the support for SMS. In this rewriting of history SMS (a form of self-managed risk) is presented as a new and better system that has replaced old prescriptive regulation. However, the history of the development of regulation is in part one of the effects of the failure of self-managed risk, such as in notable transport accidents and incidents, which then led to prescriptive limitations being introduced. The economist Drucker famously said that 'the first duty of an organisation is to survive' so if there is a choice between spending on safety today and not being in business tomorrow, or taking a risk today and being in business tomorrow, most businesses would probably choose the latter. I think that this is the reality of the aviation industry.

5. FATIGUE AND ITS INFLUENCE ON OTHER TRANSPORT SECTORS

5.1 Roads

Within the road user demographic, certain groups of society have been found to have greater vulnerability to fatigue-related accidents on UK roads. These individuals include:

- Overweight and young males.
- Driving in the early hours between 2am and 6am.
- Driving between 2pm and 4pm.
- For pilots and others working extensive shifts they probably have a significant fatigue risk when they drive home after duty periods of up to 18 hours, the longest hours of duty in any of the transport sectors.

There is a very high societal acceptance of sleepiness whilst driving, yet driving is an activity which is desperately intolerant of micro-sleep.

In the driving arena:

- There is seemingly a very high societal acceptance of deaths, injury and road disruption and costs that can reach into the millions of pounds.
- The environment is very intolerant of driver micro sleeps: the sky is big but roads are narrow; and the road environment is *target rich* unlike aeroplanes that are for most of the time widely separated from other aircraft and the ground.
- Unregulated distractions include phones, satellite navigation systems, radios, etc. Unlike pilots who are practiced in the prioritisation of tasks 'aviate, navigate, communicate' a driver is much more at risk to their attention being drawn from the task at hand.
- There are no prescriptive limits for hours of continuous driving or wakefulness for private vehicle drivers.

Sleep Related Vehicle Accidents (SRVAs) have been found to have a greater likelihood of resulting in someone being 'Killed or Seriously Injured' (KSI) than most accidents. This is arguably due to the driver's inability to apply the brakes before impact.

Within the UK in a recent poll, 29% of the driver's surveyed admitted to having been near to falling asleep at the wheel in 2012.

However, the UK national road accident database (STATS19) does not normally record all causal factors. Some accidents, such as those that feature sidewall tyre blow outs caused by driving into the kerb, may actually be related to driver involuntary sleep although they are not recorded as such. Contrastingly, in the United States, study of fatigue as a causal influence on road traffic accidents is a rapidly expanding research area and the US Department of Transportation has estimated that every lorry active within their country will be involved in at least one SRVA in the vehicle's lifetime. This is

a massive number and reveals the extent to which fatigue impacts not only on the aviation industry but is widespread amongst those to whom road-transport is a livelihood. It is likely, however, that within the UK we are less aware of SRVAs and the extent to which the problem is prevalent on our roads.

Motorways in particular offer a great risk of SRVAs due to the monotonous nature of driving on what can often be highly crowded stretches of straight road, an environment which can encourage both distraction and involuntary sleep. It is estimated that 20% of accidents on the United Kingdom's motorways are related to sleepiness, and these accidents have been found to be most common between 02.00-06.00hrs and 14.00-16.00hrs during the day. At 06.00hrs drivers are twenty times more likely to fall asleep at the wheel than at 10.00hrs.

5.2 Bicyclists, pedestrians and alcohol

As a general rule, physical activity has an alerting effect on the human body as, although it is possible to fall asleep standing up, it is difficult to perform much physical activity with a Karolinska score of 7 or higher.

The main fatigue-induced threat with regards to cycling is the reduction of vigilance during a task which requires a constant awareness of the surrounding area and what potential hazards exist within that area. Sleep deprivation could lead to a cyclist running a red light, missing a car door opening or hitting the kerb due to a lack of awareness.

With regards to pedestrians, the main risk of fatigue lies in the combination with alcohol consumption. Alcohol has a natural soporific effect, encouraging tiredness in already sleep deprived individuals, which can leave them drowsy even when they have relatively low blood alcohol concentration and can result in increased risk levels when standing at the roadside or on a railway station platform.

5.3 Rail

Similar to aviation, driving a train can often involve extended periods of monotony whilst requiring a high level of vigilance. Between 2001 and 2009, sleep deprivation was cited in at least 74 railway accidents, revealing the extensive nature of fatigue with the rail industry; a prevalence which has led to a number of highly publicised accidents, including the Clapham Train Crash (1988). As a result of these accidents and the subsequent inquiry there has been a designation of a 12 hour limit on continuous duty in the rail sector. However, these limits can be exceeded under certain circumstances.

Since the *2006 Railways and Other Guided Transport Systems (Fatigue) Regulations*, which set out requirements for undertakings to manage fatigue risks, the rail industry makes use of Fatigue Management Systems and prediction models in order to limit the impact of fatigue. A recent notable fatigue-related incident was the train run back from Shapp, 17 Aug 2010, where on the first night of night shifts the train driver fell asleep after having been awake for more than 18 hours.

5.4 Maritime

Maritime Labour Convention 2006 Regulation 2.3 clearly lays out regulation in terms of hours of work and hours of rest, with a maximum limit on daily duty of 14 hours. Furthermore, the *Standards of Training Certification and Watch keeping 2010 – Section A-VIII/1* focused on a sailor's fitness for duty, maintaining that 14 hours was the maximum daily duty, and that no more than 72 hours was to be worked in 7 days.

6. MEASURING FATIGUE

The difficulty found in fatigue measurement is the subjectivity of the feeling of being fatigued. A pilot questioned on their state of alertness might feel quite alert, but when tested, say with a reaction time test, they might be found to be quite drowsy. The opposite is also true. Moreover, if the means of measuring awareness requires action from the pilot, say by filling in a questionnaire or completing a reaction time test, then undertaking the test itself can be alerting, i.e. the pilot is assessed to be more alert than they really were. To get around these problems BALPA is using eyelid monitoring technology Optalert™ to monitor pilot alertness.

Our research partners are:

- Mark Corbett, Swinburne University
- Philip Cabon, University of Paris
- Andrew Tucker, Optalert

The Optalert equipment has been modified to suit the cockpit environment and makes use of a set of “glasses” which has a transmitter/receiver below the line of sight of the pilot. It transmits infra-red light which, when the eye lid closes, is reflected back to the receiver. The drowsiness calculation is based on the widening distribution of eyelid speeds and accelerations that occur in drowsy states. Whilst originally developed for long distance lorry journeys, BALPA has adapted the technology to make it portable and independently powered, so that the pilot is also able to record their fatigue levels on the journey to and from work which are often during peak fatigue-related accident times.

Detector results of an alert and aware individual:



The detector reading of a drowsy individual:



7. Questions to Dr Hunter following the lecture

Question 1: 'Has anyone ever collated a wider database on industry-based accidents which can be attributed to the consequences of fatigue?'

Answer, Dr Robert Hunter: 'I don't believe that there have been any attempts at what you've described. However, I would agree with you that the fatigue component of fatigue related incidents are almost treated covertly. The fatigue aspects of accidents are often are not directly included in reports and often fade into the periphery, and that's something we have to wake up to.'

Question 2: 'Is there a relation between how tired you are and the complexity of your job? For example can your alertness be increased by hazardous driving conditions such as rain?'

Answer: 'Yes, monotony is a big problem in terms of fatigue, so something that is not related to the operational task can be used to increase alertness, for example, a pilot taking a brief break from their unchanging environment within the cockpit in order to do a crossword could increase overall alertness. However, there comes a point on the scale of fatigue that such things become distraction from the task as the risk of becoming too involved becomes a possibility.'

Question 3: 'Human beings have an odd sleep pattern of being awake for a long time and then asleep for a long time, whilst most animals have a shorter and more frequent sleep pattern. Is this a factor of sleep deprivation and how it happens?'

Answer: 'There have been a variety of studies looking into sleep deprivation and trying to determine what the right amount of sleep is. These studies generally point to the human body requiring more sleep than previously realised.'

Question 4: 'There is an implied criticism of the move from statutory limits to a system of regulation based on preventing harm through the use of management systems within the lecture. However, in the rail industry since 1974 there have been systems focused on removing arbitrary rules that encourage companies to work with and communicate with their employees in order to understand fatigue. This includes the need to be aware of behaviour outside of the workplace and how this can impact upon safety as much as any length of time in the work place'.

Answer: 'I think that in principle, a system of managing a safe limit through a tailor-made approach that is scientifically based is better supported than an arbitrary limit or a limit that is based on some sort of population-generalisation. I think that when that system is deployed into an industry how it pans out, whether a force for good or not depends on a lot of cultural factors which already exist.'

The rail industry reports on their risk management systems appear straight forward and honest, however the aviation industry is already experiencing a great deal of political grumbling where there have been concerns about the misuse of FRMS in aviation.'

Question 5: 'I find the comment on the oxygen levels in the cockpit in case of sudden decompression very interesting. I had always understood that the pilot's cockpit has a higher oxygen level than the rest of the plane? Also, can an analogy be drawn with other industries such as with lorries or cars where the drivers have the windows closed and the heating turned up?'

Answer: 'There has been a study done by Boeing looking at oxygen saturation, the level of oxygen in your blood if you're sleeping in the cabin of an aeroplane, which is notably reduced compared to somebody who's awake. The pilots breathe the same air as the passengers but the main issue for them is that if a sudden decompression takes place in the plane they are required to come to their senses very quickly and put on their oxygen masks at once and then sort out the problem. However, their ability to do so is reduced by lower saturations of oxygen and fatigue. However, the risk of sudden decompression is so rare that it seems to be ignored within much of the aviation industry.'

Question 6: 'What can we do about fatigue besides encouraging more sleep?'

Answer: 'Caffeine in the form of coffee is a well-established solution on the flight deck but use of caffeine in drug form is a different story. There is no official CAA position on the use of stimulants, although military aviation makes use of stimulants. This could potentially be due to the erratic heart-rates that stimulants might rarely cause.'

Question 7: 'Fatigue is starting to include a lot of lifestyle choices, diets and the intensity which people engage with social media. Are there signs that there will be assessment into the other elements of fatigue?'

Answer: 'Fatigue is a hugely expanding area of medicine, there's a greater consciousness of it as a hazard. In the US especially there has been a disproportionately greater focus on the medical implications, whilst Australia has done a lot of work on fatigue tracking. Lifestyle can be regarded as an important factor in each of these aspects.'

Previous Westminster Lectures

The Westminster Lecture is an annual event in which leaders in transport safety address topics of concern to practitioners, researchers and policy makers in the field. It is organised by PACTS.

- 23rd Jeanne Breen, OBE, FRSA, MCIHT
Managing for Ambitious Road Safety Results
- 22nd Dr Jillian Anable, Centre for Transport Research, University of Aberdeen
More haste, less speed: changing behaviour for safety and sustainability
- 21st Danny Dorling, Professor of Human Geography, University of Sheffield
Roads, casualties and public health: the open sewers of the 21st century?
- 20th Fred Wegman, Managing Director, SWOV Institute for Road Safety Research, The Netherlands
Putting People at the Centre: How to Improve Road Safety in the 21st Century
- 19th Professor Oliver Carsten, University of Leeds
Technology: Curse or Cure?
- 18th Professor James Reason CBE, Emeritus Professor, University of Manchester
Recurrent patterns in transport accidents: Conditions and causes
- 17th Professor Phil Goodwin, Professor of Transport Policy at the Centre for Transport and Society, UWE Bristol, Emeritus Professor at University College London
Determination and Denial: The Paradox of Safety Research and Traffic Policy
- 16th Professor Ronan Lyons, Professor for Public Health, University of Wales at Swansea
Connecting Public Health and Transport Safety
- 15th Professor Helen Muir, Director, Cranfield Institute for Safety, Risk and Reliability
In times of crisis how do passengers react?
- 14th Professor David Begg, Chairman, Commission for Integrated Transport
Transport Safety and Integration: putting the two together
- 13th Mr Ken Smart, CBE, Chief Inspector, Air Accidents Investigation Branch
Transport Accident Investigations: a question of trust
- 12th Professor Richard Allsop, Centre for Transport Studies, UCL
Road Safety: Britain in Europe
- 11th Dr Rod Kimber, Director of Science and Engineering, TRL
2010: Getting there in one piece
- 10th Simon Folkard D.SC., Department of Psychology, University of Wales at Swansea
Transport: Rhythm and Blues

- 9th Dr Dianne Parker, University of Manchester
The social psychology of driver behaviour: is it time to put our foot down?
- 8th Professor Frank McKenna, Department of Psychology, Reading University
Death by Accident: the psychology of human error
- 7th Mr Stefan Nillson, Director, Automotive Safety Centre, Volvo
A Holistic View on Automotive Safety
- 6th Sir Alastair Morton, Co-chairman, Eurotunnel
There is no such thing as perfect safety in transport, but life is life, however you travel
- 5th Dr Leonard Evans, Principal Research Scientist, GM R&D Centre
Traffic Safety Measures, Driver Behaviour Responses and Surprising Outcomes
- 4th Mr Brian O'Neil, President, Insurance Institute for Highway Safety
Progress in Transport Safety: the US experience
- 3rd Mr Robert Coleman, Director General, DG VII, European Commission
Transport Safety and the EC
- 2nd Dr Ian Johnston, Executive Director, Australian Road Research Board
Effective strategies for transport safety: an Australian's perspective
- 1st Dr Jan C. Tetlow, Secretary General, European Conference of Ministers of Transport
Transport Safety: European cooperation for the 90's

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