Fatigue Expert Group

Options for Regulatory Approach to Fatigue in Drivers of Heavy Vehicles in Australia and New Zealand

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Title: **Fatigue Expert Group: Options for Regulatory Approach to Fatigue in Drivers of Heavy Vehicles in Australia and New Zealand**

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Objectives: To provide a consensus report from an expert group on options for the medium term development of regulatory approaches to the management of fatigue in drivers of heavy vehicles.

Abstract: This report was commissioned jointly by the National Road Transport Commission of Australia, the Australian Transport Safety Bureau and the New Zealand Land Transport Safety Authority. The fatigue expert group comprised leading Australian and New Zealand experts in sleep, shiftwork and road safety who collaborated with the participating agencies and industry representatives to construct a set of evidence-based design principles for future fatigue regulatory options.

The group considered that the management of driver fatigue is not a matter for operators and drivers alone, and emphasised the requirements and practices of others in the transport supply chain. The chain of responsibility provisions in road transport legislation are designed to highlight that on-road performance is closely related to the decisions made by customers, consignors and loaders.

The expert group was conscious of the need to provide a flexible and practicable framework in which fatigue could be actively managed by all those who are part of the supply chain.

The group agreed on the following principles for designing better regulations:

- provision for minimum sleep periods, the opportunity for sleep and time of day influences
- taking account of the cumulative nature of fatigue and sleep loss
- taking account of the effect of night work on driving performance and both quality and quantity of sleep
- taking account of duration of working time
- provision for short breaks within working time

The group considered that any policy approach to the management of fatigue in drivers of heavy vehicles must address these factors and proposed a possible model for the application of these design principles.

Key words: fatigue, fatigue management, heavy vehicles, heavy vehicle safety

FOREWORD

The appropriate policy approach to the management of fatigue in drivers of heavy vehicles has long been a difficult issue in Australia, New Zealand and elsewhere in the world.

Prescriptive regulation, focussed on limitations on hours of driving and work, is a feature of road transport policy in developed economies. However, there is widespread agreement that current approaches to prescriptive regulation are not particularly effective in controlling fatigue in drivers of heavy vehicles. There is also a broad consensus that better results (both in terms of safety and productivity) might be obtained from approaches that are more comprehensive, more flexible, and better tuned to current scientific understanding of key factors in fatigue prevention.

Policy on the management of driver fatigue is currently under review in both Australia and New Zealand. In order to stimulate an informed policy debate and to provide a sound research foundation to policy development, the Australia's National Road Transport Commission, the Australian Transport Safety Bureau and the New Zealand's Road Safety Trust have jointly funded a group of fatigue experts to examine the factors leading to fatigue and to develop a policy approach for discussion. These researchers, with extensive experience in the application of fatigue management approaches in road transport operations, were joined by two participants with industry backgrounds to provide an operational perspective during discussions.

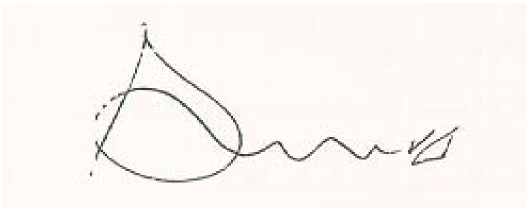
This report of the Expert Group will be discussed with interest by the transport industry on both sides of the Tasman and will be drawn upon by policymakers in Australia and New Zealand in developing revised regulatory approaches to the management of fatigue in truck and bus drivers. Productivity and safety implications of the proposal will be carefully examined by the road transport industry and the wider community.

The focus of the report is on development of a better framework for a regulatory approach to limiting heavy vehicle driver fatigue, but the "design principles" developed by the group could have much broader application. For example, they could be used as a starting point for evaluating driving schedules within a more broadly based fatigue management approach, based on non-regulatory "alternative compliance" principles". The underlying design principles also have potential relevance to other fatigue-exposed occupations.

The participating agencies are pleased to have been able to bring together prominent Australian and New Zealand fatigue experts to provide a valuable input to this process of policy development.

The participating agencies are grateful to the members of the Fatigue Expert Group for the time and effort they have put into the preparation of this report.

The National Road Transport Commission is pleased to have been able to manage the work of the Fatigue Expert Group on behalf of the three agencies.



Stuart Hicks
Chairman
National Road Transport Commission

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Concern about the cost and impact of fatigue in the road transport industry and the effectiveness and relevance of traditional driving hours regulation has made this report of the fatigue expert group especially timely.

The Parliaments of both Australia and New Zealand consider fatigue in the road transport industry important enough to establish committees of inquiry into issues and possible solutions.

In February 2000 the National Road Transport Commission of Australia, the Australian Transport Safety Bureau and the New Zealand Land Transport Safety Authority jointly sponsored the establishment of a fatigue expert group to develop options for the medium term development of prescriptive hours of driving and work in the road transport industry.

The fatigue expert group comprised leading Australian and New Zealand experts in sleep, shiftwork and road safety who collaborated with the participating agencies and industry representatives to construct a set of evidence-based design principles for regulatory options.

The fatigue expert group's approach

The framework proposed by the fatigue expert group needs to be supported by other mechanisms to promote fatigue management. These other mechanisms include education, information, training, road treatments, technological aids and financial incentives/sanctions through workers compensation, vehicle insurance and safety management regimes.

The management of driver fatigue is not a matter for operators and drivers alone and the fatigue expert group emphasised the requirements and practices of others in the transport supply chain. The chain of responsibility provisions in current road transport legislation is designed to highlight that on-road performance is closely related to the decisions made by customers, consignors and loaders.

There are significant incentives in the social and economic profile of the transport industry for scheduling, trip planning and consequent driver practices that increase fatigue related risks. Competitive pressures, payment systems, contracting arrangements and even the unintended consequences of the current driving hours regime combine to create an environment in which fatigue has become an accepted part of industry practice.

The expert group was conscious of the need to provide a flexible and practicable framework in which fatigue could be actively managed by all those who are part of the supply chain.

The model of fatigue used by the expert group was centred on three primary factors that contribute to, and explain driver fatigue:

- the need to ensure that drivers have adequate opportunities to sleep;
- the need to take account of the circadian biological clock, which dictates that drivers cannot work or sleep equally well at all times of the day and night;
- the need to address the fatiguing aspects of work demands, including the duration of work and the availability of breaks during work, which offer the opportunity for temporary recuperation from the effects of fatigue.

These factors are part of a more complex model for understanding fatigue. The core of this model is the need to provide adequate opportunities for restorative sleep and this is a fundamentally different orientation than prescribing limits to driving hours.

Principles for designing better regulations

On the basis of their own research and other national and international research the expert group identified five critical factors or principles that should be incorporated in any regulatory options. The factors are:

- ***Minimum sleep periods, the opportunity for sleep and time of day influences***

  A minimum sleep period in a 24-hour period is required to maintain alertness and performance levels. Continuous and undisturbed sleep is of higher quality and more restorative. The group concluded that the minimum sleep requirement in a single 24-hour period is six consecutive hours of sleep (although the average required on a sustained basis is about seven to eight hours).

  The group then considered the length of break that would enable the six-hour minimum which is necessarily longer than the six-hour sleep minimum period. Breaks need to take account of the activities of daily living including preparation for sleep and return to work. The impact of the circadian biological clock is critical in determining appropriate breaks in which sleep opportunity is possible. The group recommended the minimum sleep opportunity per 24 hours should be sufficient to allow for six consecutive hours of sleep.

- ***The cumulative nature of fatigue and sleep loss***

  Minimum sleep opportunities have to be considered over longer periods because of the cumulative nature of sleep loss and fatigue. The expert group agreed that the six hour minimum sleep requirement is adequate on one day, but not sufficient on an ongoing basis.

  Recovery sleep after an accumulated sleep debt is usually deeper and more efficient, and the lost hours of sleep do not need to be recovered hour-for-hour.

Repaying the debt, to restore normal waking function, usually requires two nights of unrestricted sleep.

As a consequence the group recommended that schedules should permit two nights of unrestricted sleep on a regular basis (preferably weekly) to provide drivers with the opportunity to recuperate from the effects of accumulating sleep debt.

- ***Night work***

  Driving at night was considered an important factor for the expert group as it brings together the elements that generate fatigue risks. Working at night produces an elevated risk of fatigue-related impairment, because it combines the daily low point in performance capacity with the greatest likelihood of inadequate sleep.

  The group concluded that the combination of risk factors associated with night driving should be recognised by ensuring that the length of breaks to enable sleep following night work are suitable and that opportunities for night sleep are available in a seven-day period. Additionally the group proposed a limitation to the number of hours (a limit of 18 hours) that could be driven in the 0000-0600 period after which two nights of unrestricted sleep should be available.

- ***Duration of working time***

  The expert group concluded that a “safe” threshold for daily working time on a sustained basis will vary according to other factors like time of day, but the upper limit is in the 12-14 hours zone. There was evidence that longer trips could be undertaken on a one-off basis but that repeated long trips rapidly escalated fatigue risk factors. Whilst the group believed flexibility for these longer trips should be provided they needed to ensure that long trips were not combined with risks associated with night driving and circadian low points.

  To underpin this short term flexibility, the expert group recommended that any one-off long trips involving over 12 hours work should not extend into the 0000-0600 period and that during a seven-day period there should be no more than 70 hours of working time.

- ***Short breaks within working time***

  The final factor noted by the expert group was making short breaks available as countermeasures to fatigue and the boredom and monotony associated with some driving tasks. These short breaks were not substitutes for the breaks to enable opportunity for minimum continuous sleep.

  Short breaks allow fatigue countermeasures like food, coffee and short naps to be utilised. The expert group agreed that breaks should be taken on a needs basis and that this discretion should be balanced by greater attention in scheduling to account for rest breaks.

The expert group recommended that in a one-day period the driver should take non-work breaks equal to 10% of the total working time; these breaks should be taken at the discretion of the driver but they should not be accumulated to form long breaks. As a minimum, short rest breaks should include a non-work break of 15 minutes after every five hours work.

A less flexible means of achieving non-work breaks equal to 10 per cent of total working time would be to require a 30 minute non-work break to be taken after every 5 hours of work.

Current driving hours regulations do not meet evidence based critical factors

The expert group's evidence-based critical factors are similar to those identified by expert panels in the United States and Canada and when applied to assess the current prescriptive driving hours regime highlight deficiencies including:

- The maximum working (including driving) period in a day does not accommodate circadian patterns (time of day factors);
- The minimum rest periods do not account for cumulative fatigue issues and the variable length of break required for adequate sleep opportunity at different times of the day;
- The minimum rest periods do not accommodate the opportunity for night sleep;
- The short rest breaks are arbitrary and do not allow breaks to be taken when they may be of most benefit.

The expert group's recommendations present challenges for industry and regulators

The expert group's primary focus was on the scientific basis for any regulatory options but it was cognizant of operational, social and economic cost-benefit and compliance dimensions. It gave consideration to a range of factors like journey completion issues, queuing and slotting, availability of rest stations, cost burdens and ease of enforcement.

It was recognised that some of the proposals may create challenges for current operational practices but the expert group was equally clear that improvement and reduced risk is dependent on some of those practices changing to accommodate the state of knowledge about fatigue. The need for change is not limited to the driving task but must encompass the supply chain.

These design principles should be considered in developing prescriptive traditional driving hours regulation or other options such as performance based regulations and codes of practice. To illustrate how the design principles could be applied, an indicative model was prepared by the expert group. The expert group saw this as one way of progressing the better management of fatigue but anticipated there would be other ways of putting the principles into practice.

Whilst the process of developing regulatory options involves robust examination of many factors and inevitable pragmatic compromises, the design principles set out in this report are considered fundamental to improved outcomes.

1 INTRODUCTION

In February 2000 the National Road Transport Commission of Australia, the Australian Transport Safety Bureau and the New Zealand Land Transport Safety Authority jointly sponsored the establishment of a fatigue expert group to develop options for the medium term development of prescriptive hours of driving and work in the road transport industry.

The purpose of this project was to produce a consensus report from an expert group on options for the medium-term development of regulatory approaches to management of fatigue in drivers of heavy vehicles. The options were to include, but not be limited to, options for modifications to prescriptive hours of driving and work.

The group was asked to produce options for medium term development, taking into account:

- the current state of knowledge of requirements for rest;
- the current state of knowledge of effects of circadian rhythms;
- any potentially adverse effects of current prescriptive hours;
- the current state of knowledge of the impact of fatigue on road safety;
- current road transport industry practices in Australia and New Zealand;
- availability of fatigue monitoring and fatigue prediction technology and algorithms;
- expected developments in the treatment of the road transport industry by occupational health and safety authorities.

The group was formed in the context of the work of similar groups in North America:

- Canada: *Options for Changes to Hours of Service for Commercial Vehicle Drivers*, Transport Development Centre, Transport Canada, September 1998;
- United States: *Potential Hours-of-Service Regulations for Commercial Drivers*, Report of the Expert Panel on Review of the Federal Highway Administration Candidate Options for Hours of Service Regulations; prepared for Office of Motor Carriers, Federal Highway Administration, US Department of Transportation; by Transportation Research Centre, The Regents of the University of Michigan, September 1998.

The fatigue expert group comprised researchers and practitioners with extensive knowledge of fatigue and applied work in a range of sectors, including road transport, air transport, air traffic control and maritime industries. Two people with industry backgrounds and a knowledge of fatigue were selected, not as industry representatives, but to provide a "reality check" for the fatigue experts.

Meetings of the fatigue expert group were held in Melbourne (20-21 February 2000), Wellington (12-13 June 2000) and Sydney (10 November 2000). Barry Moore (NRTC) chaired the meetings. Both Chris Foley (LTSA) and Chris Brooks (ATSB) attended most meetings as observers. Bryan Bottomley facilitated the process, co-ordinated written input from the participants and prepared the report.

The expert group comprised:

Fatigue Experts

Professor Drew Dawson, Director, Centre for Sleep Research, University of South Australia

Associate Professor Anne-Marie Feyer, Professorial Research Fellow, Department of Preventive and Social Medicine, University of Otago

Associate Professor, Dr Philippa Gander, Director, Sleep/Wake Research Centre, University of Otago, Wellington School of Medicine

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Chris Foley, Senior Adviser, Land Transport Safety Authority New Zealand

Facilitator and Scribe

Bryan Bottomley, Principal, Bryan Bottomley and Associates

The process to produce a consensus report was to use individual contributions from experts to gradually establish a framework that the group agreed was appropriate. Between meetings supporting evidence was gathered and issues unresolved at meetings were further explored. The facilitator and observers took the role of testing and seeking clarity in the views of the experts and the industry representatives provided advice on the implications of proposals for current practices.

The outcome of the group's considerations is this consensus report on regulatory options for the medium term development of prescriptive hours of driving and work in the road transport industry.

Eliminating and minimising risks to health and safety was the guiding objective of the expert group. Their focus was on road safety, not driver lifestyle, but lifestyle related rules (e.g., 24-hour continuous rest) were proposed to bolster the rest provisions.

The proposed design features should be taken as absolute maximum standards (for working hours) and minimum standards (for hours of sleep). The expert group strongly advocated that a safe and healthy work place would have work practices that improve on these standards in the interests of public safety and drivers' lifestyles. The group does not endorse work practices that consistently reach the limits of the design features proposed here. The group believes the public have the right to expect generally better work practices than are proposed in the limits on the model.

The complexity of the issues and the interaction between fatigue risk factors required the group to balance their specific expertise and available evidence to achieve a safety based consensus report. Some of the evidence is laboratory based and may not always translate to actual on road situations and the expert group recognised this and supplemented their considerations with reference to transport practice.

The most appropriate and current evidence was used, but the group considered that the dynamic nature of the issue and research requires an ongoing review to enable continual improvements to be made to evidence based policy making.

The report represents a consensus view of the group but should not be taken as the view of any one of the contributing experts.

2 CURRENT DRIVING HOURS AND FATIGUE MANAGEMENT ARRANGEMENTS IN AUSTRALIA AND NEW ZEALAND

The considerations of the expert working group were made in the context of current ways of managing driver fatigue through regulation of driving hours.

2.1 Australia

In Australia the National Road Transport Commission has made three sets of complementary recommendations on driving hours:

- The Road Transport Reform (Bus Driving Hours) Regulations were approved in 1994.
- The Road Transport Reform (Truck Driving Hours) Regulations were approved in January 1998.
- The Road Transport Reform (Driving Hours) Regulations, which amalgamated and updated provisions for bus and truck drivers, were approved in January 1999.

These national model regulations have been developed to provide a more uniform driving hours regime in those states working under a prescriptive hours regime.

The "national" provisions approved by Australian Transport Council [ATC] in 1999 have been implemented (with some local variations) in Queensland, New South Wales and South Australia. Victoria has implemented these provisions but has not yet implemented the "extended offences" (chain of responsibility) provisions (though it is understood that legislation is imminent). Tasmania has implemented most of the provisions, but has not implemented the logbook requirements for long-distance drivers. Australian Capital Territory has not implemented the national provisions.

Western Australia and Northern Territory have both implemented Codes of Practice under occupational health and safety legislation. These codes have been developed by transport agencies, in conjunction with the road transport industry.

The regulatory framework approved by ATC applies to vehicles of greater than 12 tonnes gross mass and has three components:

- a regulated driving hours (standard hours) regime;
- a transitional fatigue management scheme (TFMS, not available to bus drivers and operators);
- provision for a full fatigue management scheme.

The standard hours regime is the default system: it applies to drivers/operators who are not covered by the transitional fatigue management or full fatigue management option.

The prescriptive regulations under this regime include:

- maximum of 12 hours of driving and 14 hours of work (including driving) in any 24 hour period
- minimum continuous rest break of six hours in any 24-hour period;
- minimum rest break of 30 minutes (or 2x15 mins) in each period of 5 hrs 30 minutes;
- minimum continuous rest break of 24 hours in each seven-day period (with a variation to cater for bus drivers on long tours);
- maximum hours of work of 72 in any seven-day period.

Drivers operating more than 100 kms from base are required to keep logbook records, though provision is made for electronic recording or auditable management records as alternatives to logbooks.

"Chain of responsibility" offences have been included, which place liability on employers, consigners or other parties who take action which leads to breaches of the provisions.

The transitional fatigue management scheme was designed to encourage movement from a purely prescriptive approach to an approach allowing some increase in flexibility in return for the demonstration of higher levels of responsibility by drivers and operators. This option also had the effect of legitimising a specific trip (Brisbane-Sydney) which requires 14 hours, and which had previously been available under an enforcement moratorium. It was intended as an interim measure; to be phased out when the framework for full fatigue management programs became available.

It provides some relaxation of the limits in the core regulated driving hours regime, in exchange for implementation of auditable processes relating to driver fatigue management training, health and rostering.

The major flexibility offered under the TFMS is:

- 14 hours of driving or work per day;
- the cycle can be operated over a 14-day period (i.e., in any 14-day period: 144 hours maximum driving or work and 2x24 hours continuous rest).

In essence, TFMS is a variant of the core regulated hours approach, whereas full Fatigue Management is a more radical departure. However, TFMS does add some elements of a more comprehensive fatigue management approach to the traditional regulatory core, with increased flexibility as an incentive.

Under the (full) Fatigue Management Scheme, operators with approved programs for managing driver fatigue will be exempt from most driving hours regulations. This option is currently available only as a pilot program, with broader availability subject to results of an evaluation of the pilot.

2.2 New Zealand

In New Zealand, a single set of uniform, prescribed driving hours has been used to manage commercial driver fatigue since the 1930s.

Currently, driving hours apply to drivers of the following vehicle types:

- Any heavy motor vehicle (that is a vehicle with a gross laden weight of 3501 kg, or more), or
- Any vehicle being used in a
  - goods service (<u>except</u> where the goods service vehicle has no more than two axles, a manufacturer's gross laden weight of less than 14 000 kg, is operated within a 50 kilometre radius of the operator's business location, and is not operating for hire or reward),
  - vehicle recovery service (tow trucks), or
  - passenger service (includes taxis and shuttles).

A driver subject to driving hours must:

- Not drive for any continuous period exceeding 5 hours and 30 minutes;
- After a continuous period of 5 hours and 30 minutes driving have at least a 30 minute rest before undertaking any further driving;
- Not exceed 11 hours driving in any 24-hour period;
- Not exceed 14 hours on duty in any 24-hour period;
- Have a minimum continuous off-duty period of at least nine hours in any 24-hour period.

In addition, a driver must have a minimum continuous off-duty period of at least 24 hours after having totalled:

- 66 hours driving, or

- 70 hours on-duty.

The accumulated total to be counted from the last minimum 24 hour off-duty period.

The LTSA is currently reviewing this driving hour system, concentrating on seeking improvements to the current scheme. These include, simplifying the existing system as much as possible and integrating, wherever possible, current scientific understanding of the matter. A policy proposal on driving hours and logbooks was released for public comment late in December 2000 (Land Transport Safety Authority, 2000).

In a corollary exercise, the LTSA will also be overseeing a fatigue management program trial. It may be that, provided the trial is a success, operators could be offered the option of a FMP in place of prescribed driving hours.

2.3 Initiatives in the OHS jurisdiction

The major initiative has been the development of codes of practice in Western Australia and the Northern Territory to provide guidance on fatigue management. The Western Australian code titled Fatigue Management for Commercial Vehicle Drivers was developed by the Department of Transport and given effect under the Occupational Safety and Health Act (1984) of Western Australia.

The code provides guidance to employers on how to meet their general duty of care and has evidentiary status, meaning that while compliance with provisions is not mandatory, failure to follow recommendations may be accepted by a court as a prima facie breach.

3 THE SIZE OF THE COMMERCIAL DRIVER FATIGUE PROBLEM IN AUSTRALIA AND NEW ZEALAND

Fatigue has been recently recognised by both Australian and New Zealand Governments as a major issue. In Australia the Commonwealth House of Representatives Inquiry into Managing Fatigue in Transport has highlighted concern about fatigue and its report “Beyond the Midnight Oil” was released in October 2000. Similarly in New Zealand a House of Representatives Transport Committee Inquiry into Truck Crashes in 1996 reflected the community concern about this issue.

Fatigue is recognised as a significant problem by truck drivers and operators, and by government regulatory and safety agencies, for at least 3 reasons:

- Because of the mass and rigidity of heavy vehicles, collisions with other vehicles tend to be much more severe than other crashes (when a fatigued driver fails to take avoiding action, crash severity is further exacerbated). Multiple fatalities are more common than in other (light vehicle only) crashes, and the risks of injury or fatality are much greater for the occupants of the other vehicle than for the truck driver. Most individual road fatalities attract minimal media attention, but multiple fatalities involving heavy vehicles can be the focus of intensive media coverage. All these factors contribute to strong public concern about heavy vehicle safety, and an expectation that operators and governments should take action to minimise risks.

- Crash data indicate that many other risk factors, such as alcohol use, extreme speeding, and other unsafe driving acts, are generally less common among long-distance heavy vehicle drivers than among other drivers: thus, fatigue becomes a proportionately more important issue in the crashes where heavy vehicle drivers are found to be at fault, and;

- Fatigue is an important occupational health and safety issue for heavy vehicle drivers:

  – because of the amount of time they spend on the road per year,

  – individual heavy vehicle drivers’ exposure to the risk of crash involvement (including fatigue crashes) is considerably greater than that of most other individuals;

  – heavy vehicle driver fatigue appears to be a more common factor in single vehicle crashes than other crashes involving heavy vehicles: thus it is a relatively important factor in crashes involving driver fatalities and injuries;

  – surveys indicate that experience of fatigue (and fatigue impairment) while driving is a regular part of the work experience of many drivers, and;

- surveys also indicate that a significant minority of drivers resort to stimulant drugs as a method of coping with fatigue, and while stimulants can be effective in improving driving performance (and hence safety) in the short term, there are concerns about the longer term health and safety effects of some stimulants and the consequences of the drugs wearing off.

Two main sources of data provide information about the size and nature of the problem of driver fatigue: data on the incidence of fatigue related crashes and data describing the prevalence of fatigue in the commercial driving population.

3.1 The role of fatigue in crashes

Quantitative estimates of the contribution of heavy vehicle driver fatigue to road crashes vary considerably. In part, this is because fatigue is complex, but there are also major practical difficulties in determining whether a driver was impaired by fatigue immediately before a crash occurred.

Fatigue leaves no direct physical evidence at the scene of a crash and thus must be inferred from the circumstances of the crash and potentially unreliable reports from individuals involved (Summala and Mikkola, 1994). Estimates of fatigue involvement in crashes are generally considered to be conservative.

In the US, Knipling and Shelton (1999) estimated the proportion of crashes related to truck driver fatigue through an analysis of police accident reports supplemented by data from four in-depth crash investigation studies to correct for police under-reporting of fatigue as a contributing factor. They found that police under-report by a factor of between 1.4 and 3.1.

Similarly in Australia, Haworth, Heffernan and Horne (1989) estimated that fatigue (either on the part of a truck driver or another driver) was a contributing factor in between 9% and 20% of fatal crashes involving trucks in Victoria, with between 4% and 8% attributable to truck driver fatigue (the lower figure in each range was based on Coroners' findings, and the higher figure on judgements by the authors, taking account of all available information about crash circumstances).

Figures quoted (particularly in secondary sources) sometimes relate to the total contribution of fatigue to heavy vehicle crashes, including fatigue in other road users apart from the truck driver. Where the distinction between "truck driver fatigue" and "other driver fatigue" is made carefully, the latter accounts for more than half of the estimated total contribution of fatigue to heavy vehicle crashes.

Although the absolute frequency of fatigue-related truck crashes cannot be estimated with any certainty, available data do provide useful information about the *relative* incidence of fatigue in different types of crash.

3.1.1 Australia

The following statistics are based on the Federal Office of Road Safety Fatality database for the years 1990, 1992, 1994 and 1996 (the only years for which full coding is available). The estimates of the percentage of crashes involving fatigue are based on all available information in Coroner's records, including police reports. The figures are probably conservative, that is, there may have been a considerable number of cases where fatigue impairment was a factor, but was not attributed in these records (because of lack of direct or circumstantial evidence):

- fatigue was identified as a contributory factor in 496 of the 7,145 fatal crashes in this database (7%). There was a minor change in definition between 1994 and 1996, which may have contributed to the slight increase in reported fatigue between these two years. Overall, there is no clear trend in the number of fatigue crashes as a percentage of all crashes;

- in total, 29 crashes in these four years (0.4% of all fatal crashes) were identified as involving fatigue of a long-distance heavy vehicle driver, and 467 (6.5% of all crashes) as involving fatigue in the driver of a lighter vehicle; and

- fatigue was identified in 10% of the crashes involving at least one long-distance heavy vehicle (articulated truck or long-distance coach), compared with 7% of other crashes. A majority of the fatigue-related crashes involving at least one long-distance heavy vehicle (59%) involved fatigue on the part of another driver, rather than the driver of the heavy vehicle.

The cost of fatigue related crashes has been recently estimated by the Australian Transport Safety Bureau, using updated estimates of total crash costs from the Bureau of Transport Economics:

> *The estimated total cost of road crashes in Australia in 1996 was $15billion (Bureau of Transport Economics 2000). Using mid-range estimates of fatigue involvement, the estimated annual economic cost of all fatigue-related road crashes is of the order of $2.1 billion per year (14% of total road crash costs), and the cost of crashes involving heavy vehicle driver fatigue is of the order of $0.25 billion (about 2% of total road crash costs).*
>
> (Department Of Transport & Regional Services, 1999 [figures updated to Bureau of Transport Economics (2000) cost estimates])

3.1.2 New Zealand

In New Zealand, The House of Representatives Report of the Transport Committee on the Inquiry into Truck Crashes found that: "fatigue is likely to be a significant contributing factor in all types of crashes, not just truck crashes. Despite its importance, however, it is largely unrecognised as a problem in New Zealand" (New Zealand House of Representatives, 1996).

The LTSA statistical statement for motor accidents states: "Driver tired or fell asleep" was a factor in 8.9% of fatal accidents and 3.8% of injury accidents. If the under-reporting was of the same order of magnitude in New Zealand as reported in the US, fatigue is likely to be a contributing factor in approximately 7% to 16% of fatal crashes (all vehicles: cars, trucks etc.) and 8% to 17% of injury crashes based on 1998 reported crashes.

3.2 Prevalence of fatigue among commercial drivers

3.2.1 Australia

Williamson and Feyer (1992) undertook a national survey of the nature and scope of driver fatigue in the long-distance road transport industry in Australia for FORS. The vast majority of truck drivers reported that fatigue was a substantial problem for the industry, with one third reporting it a substantial personal problem. Approximately half of drivers in the sample reported experiencing fatigue on their last trip, and indeed on at least half of trips done.

The vast majority of drivers reported that their driving was worse when they were fatigued:

> *Typically drivers reported feeling fatigued by the fourteenth hour of driving and most particularly in the early hours of the morning.*
>
> (Williamson et al.,1992, p.3).

A more recent national survey undertaken by Williamson and Feyer (2000) confirms the earlier findings: fatigue is widely experienced by and considered to be a substantial problem for commercial drivers.

3.2.2 New Zealand

A major survey recently conducted on the fatigue and fitness for duty of truck drivers has confirmed that there are significant levels of fatigue in the New Zealand transport industry (Charlton and Baas, 2000). One out of four of the drivers' self-ratings of fatigue were in the "tired" range, even though many of them were surveyed at the beginning of their shift. The psychomotor test also indicated a very high level of fatigue in the sample.

Overall, nearly 25% of the sample failed one or more of the psychomotor performance criteria. Psychomotor performance was found to be significantly related to the amount of rest and sleep, shift length, and the number of driving days per week. The findings from the survey data replicated findings from overseas research on the incidence of truck driver fatigue, as well as documenting some attitudes towards fatigue and work activities that were unique to New Zealand drivers.

3.2.3 Overall assessment

Precise estimates of the prevalence of driver fatigue are difficult to establish as the composition of the trucking industry in Australia and New Zealand is not sufficiently well known to permit representative sampling of drivers. However large-scale surveys of the kind reported above suggest the scope of the problem.

The expert group drew the following pragmatic conclusions about the contribution of heavy vehicle driver fatigue to road crashes.

Whatever the “true” figure, it is higher than the public is willing to accept, higher than drivers and responsible operators want, and (almost certainly) higher than it could be if better preventive measures were in place (Moore and Brooks, 2000).

The high prevalence of self-reported fatigue and associated performance decrements among heavy vehicle drivers confirms that the risk of fatigue-related events is considerable.

Hence, fatigue management and prevention is recognised (by both industry groups and government agencies) as a priority issue in the long-distance road transport industry.

4 A FRAMEWORK FOR UNDERSTANDING FATIGUE

The expert group developed a framework for understanding the issue of fatigue in both its broad social context and in terms of its specific nature, causes and interrelationships.

4.1 A brief definition of fatigue and its effects on driving behaviour

There is no universally accepted definition of fatigue, but working conceptual definitions in the transport context typically refer to a combination of symptoms and contributory factors including:

- impaired performance (loss of attentiveness, slower reaction times, impaired judgement, poorer performance on skilled control tasks and increased probability of falling asleep) and subjective feelings of drowsiness or tiredness;

- long periods awake, inadequate amount or quality of sleep over an extended period, sustained mental or physical effort, disruption of circadian rhythms (the normal cycles of daytime activity and night sleep), inadequate rest breaks and environmental stresses (such as heat, noise and vibration).

The early effects of fatigue on driving reflect a tendency of the driver to decrease attention to safety-related tasks and to drive gazing vacantly at one specified point. During this stage vehicle speed is fairly constant but there are often delays in changing speed in response to change in gradients of the road. Studies have shown that drivers may attempt to compensate for slower reactions and impaired visual scanning by slowing down or being less willing to overtake.

When the driver is more fatigued, the driver has little awareness of his/her behaviour and steering responses are slower. The driver tends to zigzag within the lane, sometimes crossing the centre line or running off the side of the road. Falling asleep at the wheel may occur.

Driver fatigue results in an identifiable pattern of deterioration in driver performance. Depending on environmental factors such as the width of the roadway and the presence or absence of other vehicles, the deterioration in driver performance may or may not result in a crash. Haworth (1995, p 45) notes the case of driving in remote areas where the distance travelled and the monotony of the task may increase the probability of a fatigue related incident:

The probability of having a crash would be much higher if it was not for the lack of other vehicles, poles, etc. Thus in remote areas, we have the strange phenomenon that the very characteristics which increase fatigue, reduce the risk of impaired driving resulting in a crash.

4.2 The social, economic and organisational context of fatigue

At a broad social and economic level the factors that have led to the development of working patterns creating lack of sleep and the exposure to fatigue based risks include:

- competitive pressures based on utilisation of assets, reduction in inventory levels and a 24-hour service orientation;
- customer and consumer demands;
- productivity and flexibility methods to reduce workforce numbers and increase intensification of labour process;
- employees' financial and lifestyle expectations.

The road transport industry is typified by these factors (Dawson et al., 2000). In addition there are characteristics of the road transport industry that exacerbate the risks associated with fatigue. Williamson and Feyer (2000) contend that the payment system for drivers is likely to be an indirect cause of fatigue by promoting long working hours. Their survey of drivers showed that nearly two-thirds were remunerated on a payment by results basis, either by kilometre or by load taken. This system is likely to encourage drivers to work long hours in order to maximise their income.

The economic analysis undertaken by Hensher (eg. Hensher et al., 1993) also demonstrates the relationship between economic reward and on-road behaviour of long-distance truck drivers. The relationship between rates of pay and the propensity to speed was a key finding in his work.

Supervision is difficult since drivers are often away from their home base for several days. A consequence of these two factors is that there is a strong temptation to misuse the current inflexible hours of work regulations in order to maximise income, meet deadlines and return home.

The expert group noted these industry characteristics and sought to provide sufficient flexibility to accommodate the reasonable demands of the transport industry's task without compromising the critical factors that must be understood and managed to minimise fatigue. The importance of rethinking the scheduling and trip planning approach taken in the industry was considered both an opportunity and a challenge for the industry. Using a dynamic and balanced approach to providing sleep opportunities, the unintended but negative consequences of inflexibly capped working hours can be overcome.

Matching the transport demand with workforce supply should make it more feasible to consider the fatigue management of the company workforce as a whole. That is, the past working hours of the driver should be taken into account alongside the working hours of other employees in setting future trip schedules for all employees within the guidelines set out by the expert group. Industry characteristics and custom and practice will need to respond to the opportunity provided by a more systematic approach to scheduling.

4.3 A specific model of driver fatigue

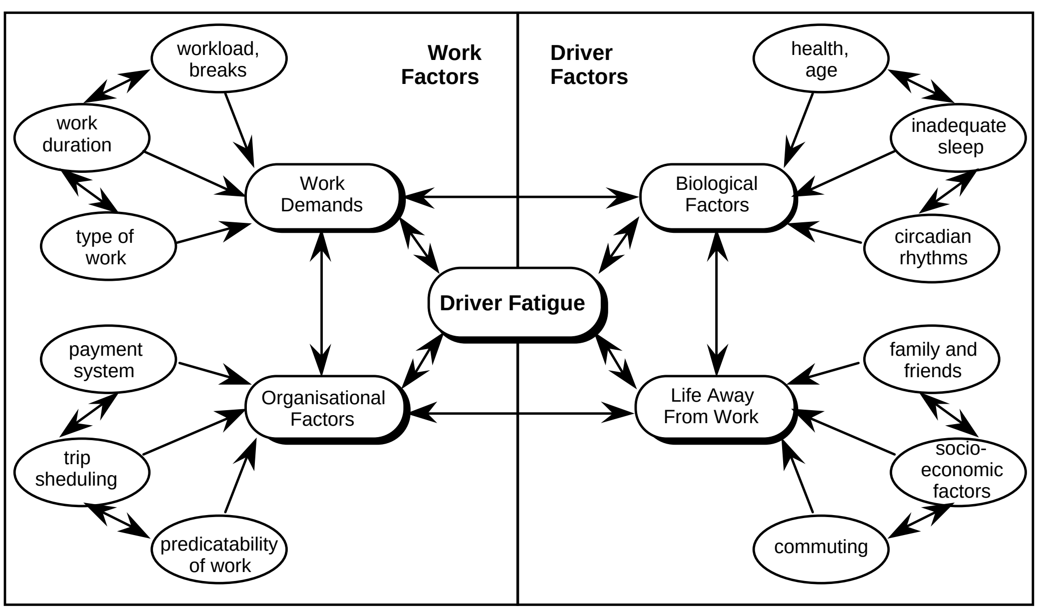
A range of factors can contribute to driver fatigue and these are summarised in the general model below. The research literature suggests that some are more important overall than others.

Not all of these factors can be addressed directly by regulation, and a full fatigue management approach is clearly more comprehensive than a prescriptive approach. Education, information and training are amongst the other means by which the management of driver fatigue can be improved.

At a minimum, a prescriptive approach must aim to do the following:

- ensure that drivers have adequate opportunities to sleep;
- take account of the circadian biological clock, which dictates that drivers cannot work or sleep equally well at all times of the day and night;
- address the fatiguing aspects of work demands, including the duration of work and the availability of breaks during work, which offer the opportunity for temporary recuperation from the effects of fatigue.

Figure 1 Factors Contributing to Driver Fatigue



The expert group emphasised the importance of recognising that a driver's life consists of more than work and sleep. This implies that reasonable time for other activities must be accommodated to minimise the pressure on drivers to sacrifice sleep time for other life activities. It was further recognised that such pressures are likely to be greater when drivers return home at the end of each work period.

Conversely, when drivers are out on multi-day trips, they generally prefer to minimise other activities to continue driving and finish the trip. However, they must still have adequate opportunities for sleep, meals and refreshments, personal hygiene and other non-work demands.

These considerations reinforce the importance of trip scheduling, which must include a sufficient time margin to allow drivers to manage their fatigue appropriately.

The model defines non-work as the opportunity for sleep (recognising that individuals will use this time for their purpose of choice) and work as all task related activity, regardless of driving/non-driving aspects.

4.4 Other fatigue issues

Lack of sleep is not exclusively determined by work-related factors and other non-work activities may be important contributors.

Drivers returning from leave may not necessarily be well rested. In addition, drivers returning from leave to commence night-work may have trouble in adapting from a daytime lifestyle. These factors may result in poorer performance for drivers returning to work after leave.

In addition, the expert group noted other fitness for duty issues that are different in nature to adequate recovery factors (e.g., impairment due to alcohol, other drugs or illness). Work environment (e.g., noise, vibration, heat; and adequacy of sleeper berths) may also be a factor.

Lack of variety and boredom combined with time on task can also contribute to fatigue and performance impairment. Rest periods to counteract this source of fatigue should be distinguished from opportunities for long-term recovery.

The nature of the task is potentially a factor in fatigue (the type of vehicle, the loading and unloading task etc.) but is best considered at the enterprise level in managing fatigue related risk.

Individual difference in tolerance to fatigue was noted, but the expert group emphasised that these differences must be taken as a "given" in managing driver fatigue. A similar position was taken on the impact of the health status of drivers. This is consistent with the philosophy behind health and safety legislation and intervention programs: safe systems of work should take account of human frailty and ensure risk controls are not dependent on a "safe person" approach.

5 DESIGN PRINCIPLES FOR REGULATORY OPTIONS

In the context of the fatigue framework outlined above, the expert group focused on a number of critical factors or principles that underpin the development and assessment of options. These factors are the threshold matters against which the current regime of driving hours should be assessed. The factors are outlined separately below but they are considered by the expert group to be closely interrelated.

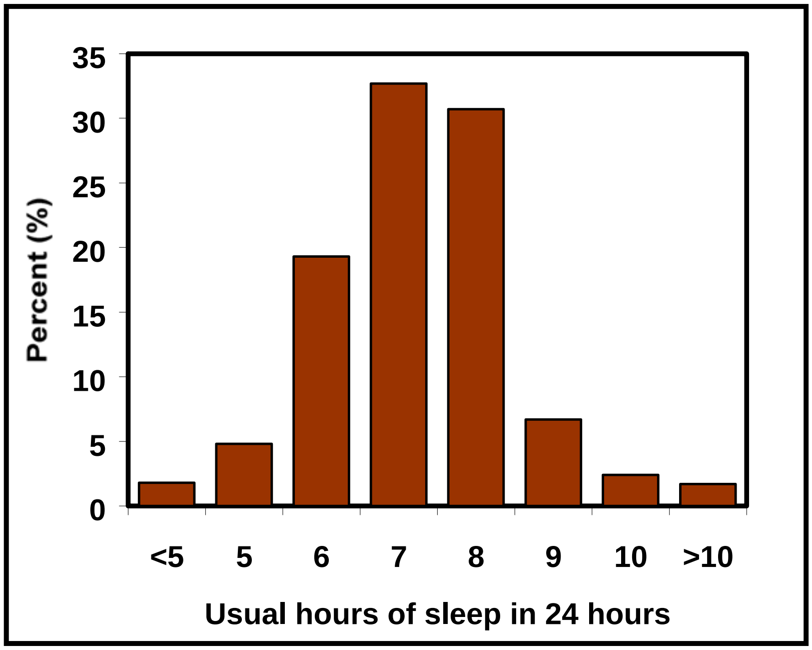
5.1 Minimum sleep periods, the opportunity for sleep and time of day influences

The need for a minimum continuous sleep period in a 24-hour period was considered a cornerstone of the deliberations of the expert group.

To be alert and able to function optimally, each person requires a specific amount of nightly sleep. Figure 2 illustrates the usual sleep in 24 hours of over 7000 New Zealanders aged 30-60 years and selected at random from the electoral rolls (from a nationwide survey with a 70% response rate; Dr Ricci Harris, personal communication). It is important to note that this figure illustrates how much people say that they sleep on average, which is not necessarily as much as they need to be fully rested (37% said they never or rarely got enough sleep). It is generally accepted that the average amount of nightly sleep needed for an adult is about seven to eight hours.

If this individual “sleep need” is not met, the consequences are reduced alertness and performance capacity (mental or physical). For most people, getting two hours less sleep than they need on one night is enough to consistently impair their functioning the next day. Not only the amount of sleep, but also the quality of sleep can have important effects on waking function. Sleep that is restless and fragmented by frequent awakenings can also result in reduced alertness and performance capacity.

Figure 2 Usual sleep in 24 hours



(Source: NZ national survey of 10,000 people aged 30-60, courtesy Dr Ricci Harris.)

Based on this evidence, the expert group agreed that;

> **the minimum sleep opportunity in a single 24-hour period should be sufficient to allow for six consecutive hours of sleep.**

This is consistent with US and Canadian expert panels' views on sleep needs in road transportation.

The duration of breaks to enable a continuous six-hour sleep period requires consideration of the matters set out in the specific fatigue model shown earlier in Figure 1.

At a minimum, breaks must allow adequate time for preparation for sleep, and for return to work, in addition to the six-hour continuous sleep opportunity. The expert group also considered that longer breaks would be needed when drivers returned home to sleep (for commuting and other activities at home), than when they were away on trips.

The time of day that a break occurs is a key factor in determining how long it needs to be to permit an opportunity for six hours of continuous sleep. This is because people are not equally able to sleep at all times of day.

We are innately programmed to sleep at night and be active during the day by the circadian biological clock in the brain. The circadian clock is able to keep the body synchronised to the day/night cycle because it is sensitive to light and darkness, to work/rest patterns and to the patterns of activity of other people. It rarely adapts completely to altered work patterns, because it is constantly being drawn back to its preferred orientation by the unchanged day/night cycle and the activities of the rest of day-active society.

Drivers' performance and safety can be compromised in two ways by this conflict between body time and work time. First, they may be trying to work through the daily low point in alertness and performance capacity (mental or physical), which occurs around midnight to 6am (often slightly later on a night shift). This is when the physiological drive for sleep is greatest.

Drivers who work through this time must then try to sleep when the body and brain are primed for wakefulness. They can face pressures to cut back on sleep in order to participate in family and social activities, and they may also be trying to sleep when environmental disturbances (light, heat, noise) are greatest.

SUPPORTING RESEARCH

Minimum continuous sleep in 24 hours

Numerous studies have confirmed that the average person needs about eight hours of sleep to sustain alertness (e.g., Roehrs et al., 1996; Roehrs et al., 1989).

If this minimum sleep need is not met then alertness and performance levels are reduced (Dinges, D.F. and Kribbs, N.B. in Monk, T.H. (ed.), 1991; Dinges, D.F., Pack, F., Williams, K., Gillen, K.A., Powell, J.W., Ott, G.E., Aptowicz, C. and Pack, A.I., 1997; Carskadon, M.A. and Roth, T. in Monk, T.H. (ed.), 1991; Roth, T., Roehrs, T.A., Carskadon, M.A. and Dement, W.C. in Kryger, M.H., Roth, T. and Dement, W.C. (eds), 1994; Bonnett, M.H. in Kryger, M.H., Roth, T. and Dement, W.C. (eds), 1994).

In laboratory experiments, impairment is particularly marked if less than about five hours sleep is obtained (Carskadon, M.A. and Roth, T. in Monk, T.H. (ed.), 1991; Horne, J.A. in Monk, T.H. (ed.), 1991).

Studies by Hertz (1988) and Dinges (1989) demonstrate the importance of continuous rather than fragmented sleep. These studies highlight the higher recuperative value of continuous sleep.

The quality of sleep is an important factor in the performance of tasks that follow (Roth, T., Roehrs, T.A., Carskadon, M.A. and Dement, W.C. in Kryger, M.H., Roth, T. and Dement, W.C. (eds), 1994).

The consequences of not being able to achieve minimum continuous sleep for road safety outcomes have been examined in a number of studies.

The US National Transportation Safety Board (1995) studied 107 single-vehicle, night time accidents, where the driver survived and in which the previous 96 hours could be reconstructed. Of the total, 58% had fatigue as a probable cause, while the remainder were considered not fatigue-related.

From the analysis the authors concluded that the most critical factors in predicting which night time accidents were fatigue-related were: the duration of the most recent sleep period, the amount of sleep in the past 24 hours, and split sleep patterns. The truck drivers in fatigue-related accidents were found to have obtained an average of 5.5 hours sleep in the last sleep period prior to the accident. This was 2.5 hours less than the drivers involved in non-fatigue-related accidents (8.0 hours).

Hartley et al. (1996) reported that close to one third of Western Australian drivers worked in excess of 72 hours per week, and 11% worked for more than 90 hours a week**.** About 30% of WA drivers obtained less than six hours sleep on at least one day per week.

Among those reporting a fatigue related hazardous event, further analysis of the data indicated drivers who had less than six hours sleep in the previous 24 hours had a three-fold increase in risk of a dangerous incident including crashing.

Stutts, Wilkins and Vaughan (1999) modelled sleep related crash risk and hours of sleep. Persons averaging six to seven hours of sleep were at twice the risk of a sleep related crash. Persons with five to six hours were at three times higher risk.

Length of break to enable sleep opportunity

In order to achieve the minimum sleep period above, a longer block of time needs to be available. This block of time needs to account for the activities of daily living including personal and family needs.

The impact of the circadian biological clock is critical in determining appropriate breaks in which sleep opportunity is possible and this is well established in research findings (for example, United States Congress, Office of Technology Assessment, 1991; Reid, K., Roberts, T. and Dawson, D., 1997; Smolensky, M.H. and Reinburg, A., 1990; Folkard, S. in Colquhoun, W.P., Costa, G., Folkard, S. and Knauth, P. (eds), 1996a; Monk, T.H. in Kryger, M.H., Roth, T. and Dement, W.C. (eds), 1994a).

The impact of conflicts between body time and work time has been examined in a number of industries where shiftwork is a common feature and this research has application to the road transport industry (Folkard, S. in Colquhoun, W.P., Costa, G., Folkard, S. and Knauth, P. (eds), 1996b; Monk, T.H., 1990; Monk, T.H. in Kryger, M.H., Roth, T. and Dement, W.C. (eds), 1994b; Gander, P.H., Gregory, K.B., Connell, L.J., Graeber, R.C., Miller, D.L. and Rosekind, M.R., 1998).

Longer periods between work have been linked to longer periods of sleep (Wylie et al., 1996; Mitler et al., 1997). The Canadian/US Driver Fatigue and Alertness Study (Wylie et al., 1996) stated that eight hours between duty periods was insufficient time to obtain adequate sleep. Dawson (2000) estimates that a 12-hour break from 0000h to 1200h may allow for sleep of seven to eight hours duration whereas a break from 1200h to 0000h may only allow for five to six hours of sleep.

In the US Department of Transportation's (Federal Motor Carrier Safety Administration 49 CFR Parts 350, et al. Hours of Service of Drivers; Driver Rest and Sleep for Safe Operations; Proposed Rule, May 2000) recent review of research it is suggested that total time off duty provisions between 10 and 16 hours may be appropriate.

5.2 The cumulative nature of fatigue and sleep loss

Minimum sleep periods in a 24-hour period can deal with acute fatigue issues but fatigue and recovery have longer-term impacts. The effects of several nights of reduced sleep accumulate into a "sleep debt", with sleepiness, performance and mood becoming progressively worse. Eventually, sleepiness will become overwhelming, leading to the possibility of inadvertently falling asleep at the wheel.

Recovery sleep after an accumulated sleep debt is usually deeper and more efficient, and the lost hours of sleep do not need to be recovered hour-for-hour. Repaying the debt, to restore normal waking function, usually requires two nights of unrestricted sleep. Based on this evidence, the expert group agreed that:

Because the effects of inadequate sleep accumulate, the six hour minimum sleep requirement is adequate for one day, but not sufficient on an ongoing basis.

Schedules should permit two consecutive nights of unrestricted sleep on a regular basis (preferably weekly), to provide drivers with the opportunity to recuperate from the effects of accumulating sleep debt.

SUPPORTING RESEARCH

Lack of opportunity to achieve minimum continuous sleep periods creates a sleep debt that can impair performance (Dinges, D.F., Pack, F., Williams, K., Gillen, K.A., Powell, J.W., Ott, G.E., Aptowicz, C. and Pack, A.I., 1997; Roth, T., Roehrs, T.A., Carskadon, M.A. and Dement, W.C. in Kryger, M.H., Roth, T. and Dement, W.C. (eds), 1994; Carskadon, M.A. and Dement, W.C., 1981).

A single night of sleep is not adequate to compensate fatigue built up over a longer period and research suggests that extended recovery time must be made available at least once every seven days (Rosekind, Neri, and Dinges, 1997; Caldwell, Caldwell and Colon, 1998; Johnson et al., 1998).

Research by Dinges, D.F., Pack, F., Williams, K., Gillen, K.A., Powell, J.W., Ott, G.E., Aptowicz, C. and Pack, A.I., (1997) and by Bonnett, M.H. in Kryger, M.H., Roth, T. and Dement, W.C. (eds; 1994) supports the need to compensate for cumulative sleep loss with two nights of unrestricted sleep.

Further evidence can be found in the work of Johnson and Naitoh (1974); Smiley and Heslegrave (1997) and Vespa et al. (1998b).

The US Department of Transportation's (Federal Motor Carrier Safety Administration 49 CFR Parts 350 et al. Hours of Service of Drivers; Driver Rest and Sleep for Safe Operations; Proposed Rule, May 2000) recent review notes:

> For weekly off-duty periods, the research indicates that to negate the effect of accumulated week-long sleep deprivation and restore alertness to the human body it is necessary to have at least two consecutive nights off-duty that include the periods from midnight to 6.00 a.m. (p. 25555).

5.3 Night work

The issue of night work is illustrative of how these fatigue critical factors are interrelated. Working at night produces an elevated risk of fatigue-related impairment, because it combines the daily low point in performance capacity with the greatest likelihood of inadequate sleep.

Human errors on the night shift have contributed to a number of major industrial disasters, including the Three Mile Island and Chernobyl nuclear power plant accidents, the grounding of the oil tanker *Exon Valdez*, and the explosion of the space shuttle *Challenger*.

The greater demands of night time driving was identified by the expert group as having three dimensions:

- a higher risk of crashes because of environmental conditions (i.e., reduced visibility in darkness);
- a lower level of alertness and higher risk of crashes because of circadian rhythm effects;
- a higher risk of crashes because of the reduced opportunity for restorative sleep.

Many proposals to reduce truck driver fatigue incorporate a reduction in driving at times when the driver is most likely to fall asleep at the wheel. These times are generally acknowledged to be between midnight and 6 a.m. and to a lesser extent about 3 p.m. These proposals have the potential to reduce levels of driver fatigue, both at these critical times and also at other times of the day by encouraging drivers to gain adequate sleep during night time hours.

Yet the early morning hours when truck drivers are most likely to fall asleep at the wheel are the time of day that the volumes of other traffic (both motorised and non-motorised) are lowest. At those times of day, truck drivers benefit from minimal congestion and relatively few other road users are affected by the behaviour of truck drivers. Given these conflicting factors, it is unclear whether the overall effect on road safety of redistributing truck driving hours towards more daytime driving will be positive, negative or neutral.

Restrictions on night time driving were considered by both the US and Canadian expert panels. The view of the US panel that specific limits are, on the basis of current evidence, “somewhat arbitrary” was accepted by the expert group, but like both US and Canadian counterparts they could not ignore the need to address the palpably higher risk of continued night time driving. The US panel recommended a limit of 18 hours between 0000-0600 per seven days and the Canadian panel recommended a two night off-duty period following four nights on duty.

The expert group considered an 18 hour restriction in the 0000-0600 period still allowed some flexibility to manage schedules to meet both safety and transport requirements.

The expert group agreed that:

> **The combination of risk factors associated with night driving should be recognised by ensuring that the length of breaks to enable sleep following night work are suitable and that opportunities for night sleep are available in a seven day period.**
>
> **A maximum of 18 hours night work (0000-0600) can be accumulated before the two consecutive nights of sleep noted earlier above should be taken.**

SUPPORTING RESEARCH

The research providing evidence of the drop in alertness at night is extensive (Bjerner, Holm and Swensson, 1955; Mackie and Miller, 1978; Akerstedt, 1995; Horne and Reyner, 1995; Lavie, 1986; Gillberg, Kecklund and Akerstedt, 1996; Folkard, 1997; Wylie et al., 1996).

The times at which the level of alertness is at its lowest is considered to be between midnight and 6 a.m. (Harris, 1977; Lisper, Eriksson, Fagerstrom and Lindholm, 1979; Prokop and Prokop, 1955) and this is when the drive for sleep is greatest (Dijk, D.J. and Czeisler, C.A., 1995; Knauth, P. and Costa, G. in Colquhoun, W.P., Costa, G., Folkard, S. and Knauth, P. (eds), 1996).

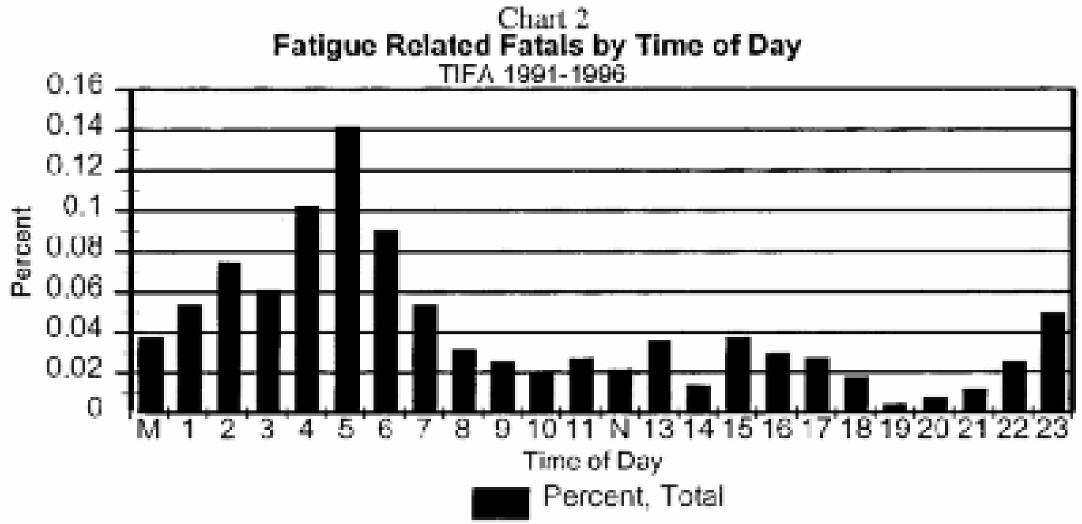
Research findings indicate increased accident risk for night time driving increases independently of the time on task (Mackie and Miller, 1978; Mitler, et al., 1988; Horne and Reyner, 1995; Kecklund and Akerstedt, 1993, 1995; DiMilia, 1998; Vespa et al., 1998b).

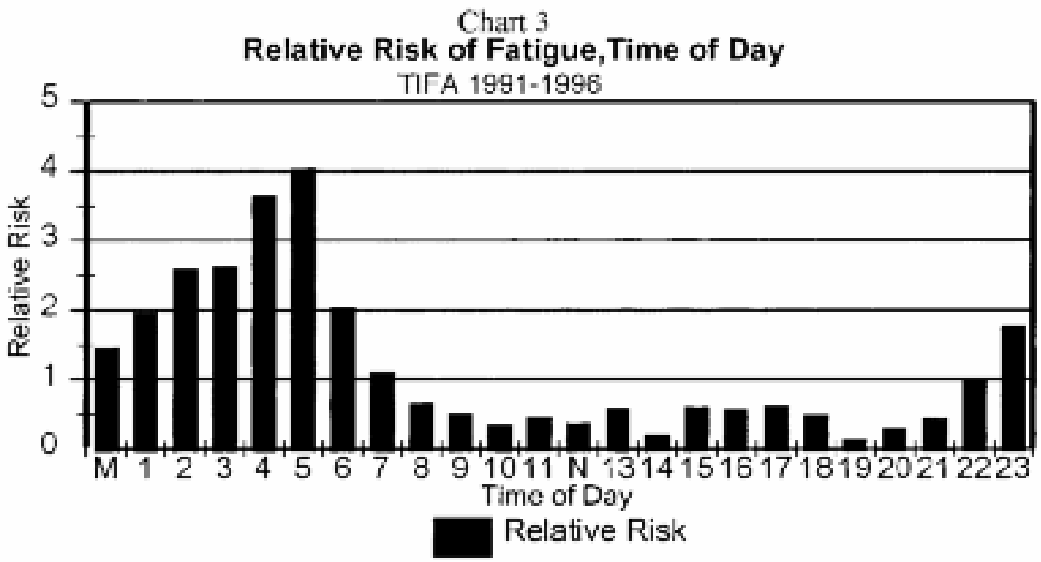
Williamson, Feyer, Coumarelos and Jenkins (1992) undertook a questionnaire-based survey of 960 Australian long-distance drivers. The majority of drivers (77%) reported that between 0000 and 0559 hours they became fatigued.

The issue of night work cannot be divorced from the sleep implications and there is extensive evidence that daytime sleep is less restorative (shorter and sometimes more disturbed) than nocturnal sleep (Keckland, G. and Akerstedt, T., 1993; United States Congress, Office of Technology Assessment, 1991; Monk, T.H. in Kryger, M.H., Roth, T. and Dement, W.C. (eds), 1994; Gander, P.H., Gregory, K.B., Connell, L.J., Graeber, R.C., Miller, D.L. and Rosekind, M.R., 1998).

The evidence of higher risks involved in driving at night noted earlier in the report can be illustrated by US research.

The charts below, based on the University of Michigan Transportation Research Institute's Trucks Involved In Fatal Accidents (TIFA) database and the Bureau Of Census' 1992 Truck Inventory and Use Survey, indicates fatigue peaks between 4 a.m. and 6a.m. compared to the distribution of all trucks in fatals, which has a peak in midafternoon in line with traffic peaks. The relative risk chart incorporates data from the distribution of all trucks in fatals and the fatigue data and confirms the higher risks associated with night driving.





Charts from Department of Transportation Federal Motor Carrier Safety Administration 49 CFR Parts 350, et al. Hours of Service of Drivers; Driver Rest and Sleep for Safe Operations; Proposed Rule, May 2000, p25543.

5.4 Duration of working time

Time on task is another critical factor identified by the expert group that needs to be understood in combination with other factors. The expert group noted that determining what is an acceptable, safe duration of work in the transport industry is a complex issue, despite the fact that restricting hours of work have been the foundation stone for regulating fatigue for many years.

There are many studies which demonstrate that crash risk rises during longer hours of work (see below); some studies report rises after seven, others after 10 and some after 12 hours of work. However, there is no universal agreement on what is the definitive safe duration of work, although there would be few who would argue that working in excess of 14 hours creates a significant risk to safety. The problem of the safe duration of work is that there are several temporal factors interacting to compromise safety over the work period.

First, a most significant factor must be the time the driver has been awake since the last sleep even if it was eight hours long. If the driver has been awake for more than 16 hours there is every likelihood the driver may be sleepy. But a driver might be awake for several hours before commencing a shift. After 12-14 hours of work that driver might be very sleepy.

Second, how sleepy a driver is will also depend on how much sleep the driver had the previous night. If the driver only had five hours of sleep the driver might be sleepy well before the end of a 14 hour shift.

Third, how sleepy drivers are depends on the time of their biological circadian clock. Any driver will feel sleepy in the pre-dawn hours even if they have only completed six hours of work. A driver who has had little sleep will be even sleepier in the pre-dawn hours. A long shift of 14 hours of work could take the driver into the period when the biological clock of alertness is turned down during the night, with attendant safety risks.

A fourth factor affecting sleepiness is job monotony. It has long been known that humans are not good at attending to a monotonous task, which driving sometimes can be. Drivers may be sleepy well before the end of a 14-hour shift if the work is monotonous.

Finally, the demands of some jobs may cause more fatigue than other jobs do; some types of driving may be more tiring than other types of driving.

For these reasons it is hard to set a definitive safe limit for the acceptable duration of work in terms of absolute safety standards. However, it is possible to consider the options for what constitutes an upper bound for the duration of work, beyond which it is normally unreasonable to work. That upper bound is determined by what constitutes an acceptable time off to achieve satisfactory sleep and all the other necessities of life including social activities. That upper bound will lie in the period between 12 and 14 hours of work.

The group noted evidence that found one-off long trips may not generate higher than normal fatigue risks but any repetition of such long trips escalated the fatigue risks significantly. Consequently the group accepted the need for one-off long trips as long as they were limited from extending into night shifts and were compensated by a longer rest period.

The expert group on the basis of its deliberations agreed that:

> **The upper band of daily working time was 12-14 hours but this was best defined by the sleep related criteria already outlined. Any one-off long trips over 12 hours should not extend into the 0000-0600 period. To further provide a safety net, in a seven day period there should be no more than 70 hours of working time.**

SUPPORTING RESEARCH

The research indicates that increased crash risks may be evident after 3-6 hours (Harris and Mackie, 1972), after five hours (Jones and Stein, 1987) or after eight hours the risk is doubled (Mackie and Miller, 1978).

Cumulative hours on duty increase fatigue and performance decrements. Lin, Jovanis and Yang (1993) found that crash risk increases with the hours of driving. Additionally, crash rates have been shown to increase substantially after 12 hours on duty (Folkard, 1997).

Saccomanno et al. (1996) found there was a higher proportion of truck crashes in which no other vehicle was involved on routes typified by long driving times. Hamelin (1987) in his study of lorry drivers indicated that duration of work periods was an important variable in accident risk. Hamelin indicated that accident risk increased substantially after 11 hours of work.

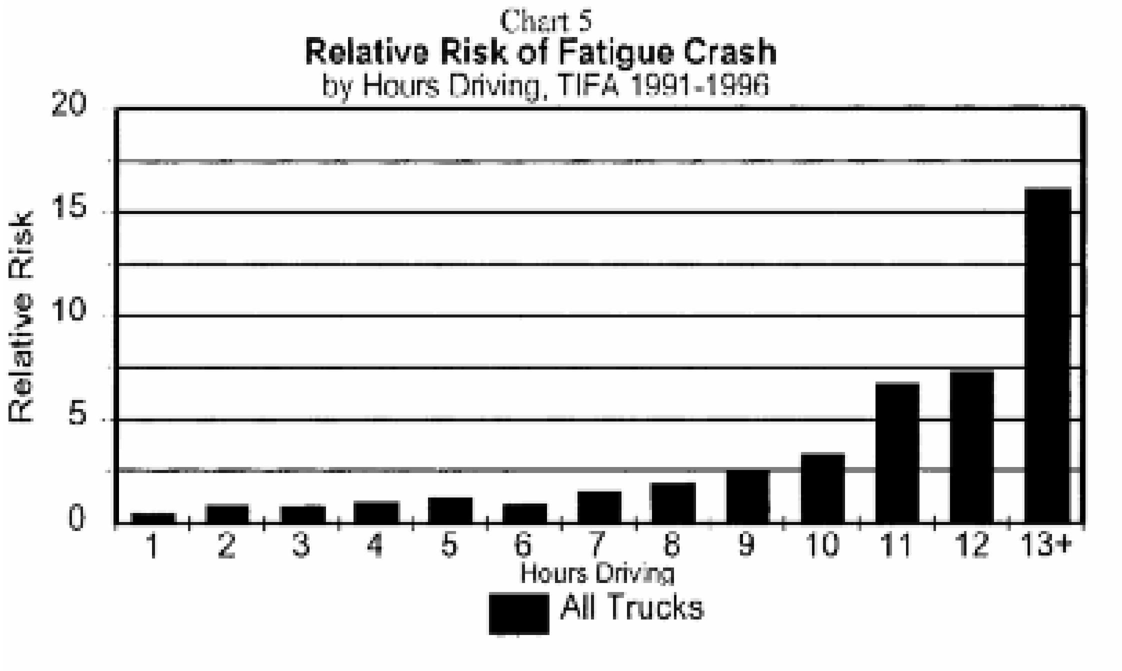
Time of day effects are more pronounced the more time spent on task (Mackie and Miller, 1978; Kaneko and Jovanis, 1992), and thus opportunities for adequate recovery need to be provided over both the short and long term.

An average 12 hour on-duty time is consistent with research showing that risks increase after 12 hour driving shifts (Folkard, 1997; Wylie et al., 1996). Research cited in the current US Department of Transportation Hours of Service Proposed Rule states that:

> *Approximately 20% of the fatal crashes per year where fatigue is coded as a factor involve the driver being behind the wheel for 13 or more hours.*

(Department of Transportation Federal Motor Carrier Safety Administration 49 CFR Parts 350, et al. Hours of Service of Drivers; Driver Rest and Sleep for Safe Operations; Proposed Rule, May 2000, p 25546).

The chart below sets out the data on which this finding is based (p25544).



Some evidence supported the limited use of one-off long trips.

A recently completed study in the US (US FHWA, 1999) which measured cumulative fatigue for drivers operating a 14 hours on/10 hours off schedule for a five-day week, concluded that it did not appear to produce cumulative fatigue.

Williamson, Feyer, Finlay-Brown and Friswell (2000) in their recent evaluation of work-rest schedules concluded that on duty time may be extended for one period but extensions of the pattern create fatigue levels likely to compromise safety.

The study using simulation techniques showed that drivers were able to manage fatigue effectively over the first 16 hours of a schedule if they were rested beforehand. However the ability of drivers to manage fatigue and maintain performance deteriorated significantly by the middle of the second 16 hour period and by the third day of the simulation, after another six hour sleep break, performance deteriorated even more rapidly.

5.5 Short breaks within working time

The expert group considered that the evidence on short breaks as a fatigue prevention measure was not conclusive but that there were other reasons why short breaks should be taken. In particular boredom, monotony and the need for respite from the driving task were the main reasons why breaks should be available. These breaks (even where short naps were taken) were not seen as substitutes or alternatives for the continuous time available to enable the core minimum sleep referred to in 5.1 above.

Evidence to support a specific length and timing of short breaks is inconclusive and the expert group's proposal is designed to provide greater flexibility in taking breaks at times where it is likely to be most beneficial.

The expert group took a similar view to the Canadian expert panel that after five hours of working time a break should be taken. Some other evidence noted by the Canadian panel suggests that short breaks (10 minutes or more) from driving should be taken every two hours to avoid accumulation of fatigue. The 10% of total working time to be taken as short breaks recommended below is a pragmatic response to these findings (10 minutes per two hours and 30 minutes per five hours fit the 10% range).

SUPPORTING RESEARCH

There is relatively little research on the use of short rest pauses on mental task performance. One recent study by Meijman (1997) demonstrated that reaction time slowed in bus drivers after only 3.5 hours of work while accuracy of performance and the amount of effort invested in the task of driving did not change very much.

Performance decrements due to fatigue after relatively short periods of work have been shown to be more likely in tasks involving low levels of demand, such as is common in driving, as tired drivers do not apply effort as effectively as when the task is more demanding, such as on a difficult road (Mathews, Sparks and Bygrave, 1996).

This research suggests that short breaks may be especially important when the task is not very demanding, but that more demanding or interesting tasks can be protected against the effects of mental fatigue because more effort is put into doing them. Problems occur in expending more effort, however, because the amount of effort available to be expended is limited and because expending effort is difficult and can in itself produce fatigue. Breaks will be important for more demanding tasks as well in order to allow drivers to rest after expending effort in doing the task.

The evidence regarding the effectiveness of short breaks is equivocal with Gillberg et al. (1996) showing that 30-minute naps are ineffective in preventing performance deterioration in truck driving at night. Conversely Dinges (1989) and Angus et al. (1987) provide evidence that a two-hour nap is sufficient to promote extended recovery.

Haworth (1998) notes that the effectiveness of rest breaks has been shown to depend on a number of factors including the level of fatigue that may have already developed.

Time of day may also be a factor and Lisper and Eriksson (1980) found that breaks were less effective at night than during the day and were more effective for younger than older drivers.

Many rest breaks taken by drivers include consuming food. The issue of the amount of improvement that relates to the rest break alone versus the food is one that has clear practical significance. Haworth (1998) concluded that the studies of rest breaks suggest that they are most beneficial when taken before the driver is very fatigued and should contain food. Food alone (without a rest break) appears to have some beneficial effects. There is some evidence that a rest break does not lead to an improvement in performance, but rather a reduction in the rate of deterioration of performance.

The expert group proposed that:

> **In a one day period the driver should take non-work breaks equal to 10% of the total working time. These breaks should be taken at the discretion of the driver but they should not be accumulated to form long breaks. As a minimum, short rest breaks should include a non-work should include a non-work break of 15 minutes after every 5 hours of work.**
>
> **A less flexible means of achieving non-work breaks equal to 10 per cent of total working time would be to require a 30 minute non-work break to be taken after every 5 hours of work.**

6 OTHER ISSUES NOTED BY THE EXPERT GROUP

6.1 Sleep disorders

The recent Austroads report 'Heavy Vehicle Driver Health and Sleep Disorders' (Swann, 2000) found chronic excessive sleepiness was a major issue for drivers. Sixteen percent of the drivers surveyed suffered from this complaint and of these 11% had indications of some degree of sleep apnoea.

Management of these disorders constitutes a relatively new area of occupational medicine that needs greater recognition. The expert group agreed it was important that drivers not have an undiagnosed or untreated sleep disorder that significantly impairs their ability to operate a vehicle safely. However the expert group did not agree on the best way to progress the management of sleep disorders.

One view was that a phased approach to screening employees for the presence of an undiagnosed sleep disorder should be used by employers. Initial screening using best available validated screening techniques should be followed by a more detailed assessment for employees identified in this initial stage. Employers should ensure that individuals responsible for screening are suitably trained, use scientifically validated instruments and are aware of the diagnostic criteria for sleep disorders known to adversely affect driving performance.

Where an employee is diagnosed with a sleep disorder that significantly impairs their ability to operate a vehicle safely an employer should ensure that the employee complies with treatment options endorsed by relevant professional groups.

Another view was that until screening techniques were more reliable it was preferable to have policies and procedures for managing people who self-identify as having sleep problems. Employers would be responsible for providing current information on sleep disorders and how to access specialist services. They should also develop criteria for suggesting or requiring specialist diagnosis or treatment and manage individuals with sleep problems using thorough medical assessments of their situation.

Proponents of both positions supported the need for improved screening tools that can be applied in a more cost effective manner than the currently more reliable, but expensive clinical methods.

6.2 Driver fatigue monitoring and technological countermeasures

Examination of developments with performance tests (administered before work or at the roadside) and in-vehicle systems indicates that more work needs to be done before these techniques could be considered as part of a fatigue risk management regime.

According to Dinges and Mallis (1998) different operator-centred fatigue detection technologies can be classified as falling into one of four groups, these are:

- readiness-to-perform and fitness-for-duty technologies;
- mathematical models of alertness dynamics joined with ambulatory technologies;
- vehicle-based performance technologies;
- in-vehicle, on-line, operator status monitoring technologies.

A fundamental problem confronting all of the technologies is their validation. There are two aspects to the problem:

- what to validate the technology against (what is the criterion variable?), and;
- the adequacy of the validation data (what is acceptable validation, what is the safe level of the fatigue index?).

Several authors including Dinges and Mallis (1998) have been cautious about the choice of criterion variable for validation. Often this is a psychomotor vigilance task. There was no validation data available drawn from on-road behaviour or from crashes.

On the adequacy of the validation data, the expert group was not aware of adequate data for many technologies, and only for a handful was adequate data available, although not drawn from on road behaviour or crashes. These data need to be collected before any technology could be considered for licensing for mandatory use.

Dinges (1997) notes that there is a lack of real-world validation of laboratory results and that many claims made by device manufacturers are not supported by scientific validation. He states that technologies are not a substitute for setting community standards for the functional capability of an operator.

A fundamental issue was the use of technologies as safety devices or management systems. The expert group noted the following conclusions from a recent NRTC commissioned review of fatigue detection and prediction technologies (Hartley, L., Horberry, T., Mabbott, N. and Krueger, G.P., 2000):

- Hardware technology output should never be the only input into a management system. Other inputs should at least come from validated software technologies, mutual assessment of fitness for duty and other risk assessments.
- There will be a strong temptation for companies to use them as management systems.
- Hardware technologies generally only function as limited and lower level safety controls.

- The output of hardware technologies could usefully feed into company fatigue management systems to provide real time risk assessment.

Recent research by Campbell, Lang and Smith (1998) on electronic recorders suggests considerable resistance by operators on cost-benefit grounds. A study by Penn and Schoen Associates Inc. (1995) of acceptance of services including technological monitoring found drivers were less favourably inclined towards onboard safety monitoring devices.

6.3 Shift splitting

Split shift operations are those that include two or more separate on-duty periods. Commuter bus drivers who work in morning and afternoon peak periods are one example. Shift splitting becomes a concern where an early morning start and a late evening finish to split shifts compromises the opportunity for continuous sleep. The expert group considered the recommended design principles should be applied to split shifts and that the key priority is the protection of the sleep opportunity available to drivers.

6.4 Delays and journey completion

Problems in scheduling created by delays were noted by the expert group. Flexibility to complete journeys in a way that maximised the opportunity for restorative sleep needs to be incorporated in options.

This matter was addressed by the Canadian expert panel which noted excessive driving time without rest and speeding was used to “beat” the problem of having to take rest close to the journey’s end. The Canadian panel proposed a two hour on duty extension on the condition that two hours rest was taken in order to enable trips to be completed. This 2/2 proposal was also conditional on time of day factors and adequate prior sleep periods.

An extension of this concept to cater for situations where cumulative delays cannot be accounted for in the 2/2 24-hour period was also defined by the Canadian panel. An eight hour extension conditional on an eight hour off-duty period was proposed to deal with these circumstances. The 8/8 option could only be taken at the end of a work cycle and would be followed by two nights rest.

The expert group considered that the flexibility provided in its principles to allow one-off long trips was adequate to address these situations and consequently did not consider it appropriate to define special circumstance extensions.

6.5 Two up driving

The two-up driving pattern has some clear advantages from a fatigue management perspective. The potential advantages of two-up driving (compared to single driving) include reduced driving time and generally shorter continuous driving shifts per driver, more frequent napping opportunities and reduced pressure for a driver to keep driving when temporarily fatigued (provided the two-up partnership is working effectively). These advantages need to be considered in light of the following typical two-up features:

- reduced sleep quality in a moving sleeper berth (compared to stationary rest);
- driving during circadian low points;
- split sleep patterns, with at least part of the daily sleep opportunity occurring during parts of the circadian cycle when sleep is difficult;
- constraints on continuous sleep, because of limits to the duration of the co-driver's shift and difficulty maintaining continuous sleep in-transit. particularly during the day.

Two-up operations thus need to be used to better manage long trips and not as a means of completing even longer trips.

The study of two-up driving conducted by Feyer, A.M., Williamson, A.M. and Friswell, R. (1995) found that whilst regular access to part sleeps is effective in the short term, extended periods of broken rest undermines the restorative value of the rest.

The Canadian Expert Panel noted evidence about the poorer quality of sleep obtained in a moving truck. The panel reported findings that the driver's lack of confidence in their partner's driving (and willingness to stop if fatigued) is a major reason for difficulty in sleeping.

There are also issues concerning the design of vehicles that need consideration for the best quality sleep to be achievable.

Taking into account the factors listed above, the expert group considered that the important principles for managing fatigue in two-up driving are to:

- limit the period for which continuous two-up driving is permitted, before both drivers are required to take a long stationary sleep break (preferably overnight);
- ensure that both night sleep opportunities and night work are shared roughly equally between the two drivers;

- provide adequate opportunities for full recuperation: at least two consecutive stationary night sleep opportunities per week.

Providing these basics are addressed, prescription of minimum continuous break periods (or maximum continuous driving shifts) during the on-road part of a two-up operation is probably undesirable: limiting flexibility in this area could produce the undesirable result of forcing the less-fatigued driver to rest, while the more-fatigued driver takes the wheel.

6.6 Supply chain issues

The schedules that can lead to fatigue are often imposed by the demands of customers and recent legislation has recognised this by incorporating “chain of responsibility” provisions. Longer term strategies to reduce fatigue risk factors will need to address these commercial constraints.

Earlier approaches to road transport law in Australia generally applied responsibility for operating safely to drivers and, in some cases (particularly for mass offences in some states), owners or operators.

The principle behind the “chain of responsibility” concept is that any party who has control in a transport operation can be held responsible and may be made legally liable. Under chain of responsibility, control = responsibility = legal liability.

An example of a simple transport chain is:

Consignor => loader => transport operator => driver => receiver.

Chain of responsibility applies both inside and outside a road transport company. Within the company, any person with control over road transport operations could be held responsible. Examples would include directors who set general policies and managers who set rosters or schedules. Outside the company, it also applies to consignors, customers and potentially any other party in the transport chain who places unreasonable demands on others in the transport chain.

Chain of responsibility provisions have already been included in national driving hours and dangerous goods laws. The form of chain of responsibility provisions will vary with the nature of the application.

The full implications of chain of responsibility will not be apparent until there has been a series of successful prosecutions. However, the ability to prosecute parties other than drivers and operators is expected to be a strong deterrent and will also have implications for the insurance liability of those parties. These factors alone are expected to result in an overall improvement in compliance.

7 OVERALL CRITERIA FOR ASSESSING OPTIONS

The project brief suggested three broad criteria for assessing options:

- effects on road safety;
- effects on road transport productivity;
- ease of enforcement and road authority administration.

The expert group further developed their criteria by examining:

- science or evidence based criteria (e.g., time of day effects);
- operational based criteria (e.g., journey completion issues);
- social and economic impact criteria (e.g., cost of reducing maximum on-duty hours);
- compliance criteria (e.g., ability to measure fatigue or enforce standards).

The focus of the expert group was science or evidence based criteria but reference was made to the other criteria.

Section 5 outlines the core elements of the evidence based design principles. In addition the expert group identified flexibility and practicability as criteria.

Evidence based	· Minimum sleep periods, the opportunity for sleep and time of day influences · The cumulative nature of fatigue and sleep loss · Night work · Working time · Short breaks within working time
Flexibility	· Option enables flexibility for operator/driver to achieve best fit system for managing fatigue risks
Practicability	· Option able to be implemented · Option able to be able complied with and effectively enforced

8 APPLYING THE DESIGN PRINCIPLES: A POSSIBLE MODEL

In order to redress the deficiencies of current driving hours regimes and to address the evidence from research the expert group developed an indicative model based on a number of “working rules”.

The model was prepared as one example of how the design principles could be applied but the group recognised there were other ways of operationalising these principles. As noted throughout the report, fatigue management cannot be addressed by regulatory measures alone and needs to be part of broader effort to reduce risks.

The nature of the model allows significant internal flexibility and allows a number of combinations of work-rest modules each underpinned by fatigue/adequate recovery minimum standards. The elements of the model are summarised in table 1 below.

The expert group considered the issue of when the " scheduling clock starts" in this model and emphasised that the critical issue is the pattern of rest and work over periods of varying length, ranging from one day to 14 days. Effectively these rules operate on the basis that the first "day" is a period of 24 hours beginning at the initial start of work after a long break of two days or more. The second "day" is the next 24-hour period, and so on. Similarly, the first two-day period is a period of 48 hours from the initial start of work. Following a long break of two days or more the scheduling clock can be reset, starting a new sequence of "one-day", "two-day" "seven-day" and 14-day"periods.

Table 1 Summary of the Fatigue Expert Group Indicative Model

Working Rule	Justification	Design Principle
1. In a one day period, a seven hour minimum continuous break is required to allow six hours sleep and;	*The seven hour break is considered the minimum period to enable six hours sleep which in turn is considered the minimum sleep period in a 24 hour period.*	**Minimum sleep periods, the opportunity for sleep and time of day influences**
a) for every hour worked between 0000-0600 an extra ½ hour should be added to the base seven hour break and;	*The additional ½ hour weighting for every hour worked in the midnight to 6am period recognizes that the break required to allow the minimum sleep will need to be greater to compensate for the reduced opportunity for, and quality of day sleep.*	

Working Rule	Justification	Design Principle
b) if sleep is taken at home, an extra one hour should be added to the break in order to protect the six hour sleep minimum.	*The additional hour break for sleep taken at home recognizes the impact of daily living tasks including commuting on the available time for sleep.*	
2. In a two day period the opportunity for two minimum continuous breaks to allow 14 hours sleep is required. These breaks are exclusive of any short breaks taken in the period.	*This provision extends principle 1 to the 2 day period and enables some catch-up to be achieved over this period in cases where the minimum rest had been taken on the previous day.*	**Minimum sleep periods, the opportunity for sleep and time of day influences** **The cumulative nature of fatigue and sleep loss**
3. In every two day period there should be at least one consolidated block of nine hours non-work.	*This provision ensures that flexibility to work longer hours is balanced by a requirement that provides an opportunity for sleep.*	**The cumulative nature of fatigue and sleep loss** **Minimum sleep periods, the opportunity for sleep and time of day influences**
4. In a 14 day period there should be continuous 24 hours periods free of work available twice.	*This provision ensures that longer continuous breaks are available for recovery.*	**The cumulative nature of fatigue and sleep loss**
5. In a seven day period there should be two consecutive nights where sleep is possible between 0000-0600.	*This provision, in line with evidence about cumulative fatigue, ensures that two consecutive nights opportunity to maximize restorative sleep can be taken.*	**The cumulative nature of fatigue and sleep loss**

Working Rule	Justification	Design Principle
6. A maximum of 18 hours night work (0000-0600) can be accumulated before the two consecutive nights of sleep noted earlier above should be taken.	*This provision is designed to limit the use of schedules that require excessive driving hours at the most risky time and also restrict the opportunity for night sleep.*	**Night work**
7. The length of work shifts should not be extended beyond 12 hours where hours extend into the 0000-0600 period.	*The model whilst allowing one-off long shifts where adequate compensatory rest opportunities follow such shifts must account for circumstances where long shifts end in the circadian low point. The provision is designed to prevent individual risk factors like time on task and circadian low points compounding to create even higher and more unacceptable risks. The expert group considered the alternative of allowing 14 hours as the threshold but considered the 12 hour limit was more consistent with available evidence.*	**Night work**
8. In a 7 seven day period there should be no more than 70 hours of working time.	*This capping of working time is designed to enable flexibility but still protect the opportunity for sleep and to enable drivers to carry on the normal tasks of living.*	**Duration of working time** **Minimum sleep periods, the opportunity for sleep and time of day influences** **The cumulative nature of fatigue and sleep loss**

Working Rule	Justification	Design Principle
9. In a one day period the driver should take non-work breaks equal to 10% of the total working time; these breaks should be taken at the discretion of the driver but should not be accumulated to form long breaks. A minimum 15 minute break should be taken after 5 hours work. **As a simpler, but less flexible alternative, a 30 minute break should be taken after every 5 hours of work.** **These short breaks would not count as "working time.**	*This provision enables flexibility for the driver in using short respite breaks and prohibits the accumulation of short break time as a substitute for appropriate continuous breaks to allow sleep.*	**Short breaks within working time** **Duration of working time**

Special provisions to accommodate two-up driving

1. **Driving time to be shared and each driver to do no more than 12 hours each in a 24-hour period.**
2. **Night work and day work to be equally shared between the drivers.**
3. **No more than 36 hours driving before a stationary rest period of at least nine hours.**
4. **At least two consecutive nights sleep opportunities per week.**

APPENDIX 1: COMPARISON WITH US AND CANADIAN CRITERIA

The table below indicates a similar approach by the respective expert groups. The critical issues for each panel represent the evidence based factors that options were based on. In some cases the factor underpinned the approach as is the case with circadian (time of day) factors or was implied by the approach.

Sleeper berth use and split shift driving were bigger issues in the US report than in Australia and New Zealand.

Table 2 Comparison of expert group critical issues

US HOS Expert Panel	Canadian Panel	Aust-NZ Expert Group
Night-time differential	Night versus day driving	Night work
Adequate recovery time	Fatigue recovery periods	Minimum sleep opportunities
Limits on cumulative on-duty time	*Implied criterion*	Working time
Continuous time off duty daily	Cumulative fatigue and crash risk	The cumulative nature of fatigue and sleep loss
Not dealt with	Other fatigue factors	Short breaks within working time
Underpins criteria	Circadian rhythm, sleep and performance	*Underpins criteria*
On duty time versus driving time	*Underpins criteria*	*Underpins criteria*
24-hour cycle	*Underpins criteria*	*Underpins criteria*
Split shift drivers	*Not dealt with*	Shift splitting
Sleeper berth use	*Not dealt with*	Two-up driving

APPENDIX 2: ASSESSMENT OF CURRENT REGIME AGAINST EXPERT GROUP REGULATORY DESIGN PRINCIPLES

The brief assessment of the current regulated hours of driving regime against the design principles in Table 3 identifies significant deficiencies.

Table 3 Assessment of driving hours regulation against design principles

Current Heavy Vehicle Driving Hours			**Aust-NZ Expert Group Assessment Against Principles**
Period	**Maximum Driving or Working**	**Minimum Rest**	
5.5 hours	5 hours driving	30 minutes, either as one period or as two separate periods of 15 minutes.	The driving hours do not account for circadian patterns/time of day factors, especially night work.
24 hours	12 hours driving 14 hours working	10 hours, including one continuous period of six hours and any 15 or 30 minute rest breaks taken during driving/working time.	The maximum working (including driving) period in a day is within the expert group's upper limits but does not allow the flexibility for one-off longer working periods. The maximum working (including driving) period in a day does not account for circadian patterns/time of day factors. The minimum rest periods do not account for cumulative fatigue issues and the variable length of break required to enable sleep opportunity. The minimum rest periods do not account for the opportunity for night sleep. The short rest break regime does not allow breaks to be taken when they may be of most benefit.
168 hours (7 days)	72 hours driving or work	96 hours, including one continuous period of 24 hours.	As above.

APPENDIX 3: THE FATIGUE EXPERT GROUP

FATIGUE RESEARCHERS AND PRACTITIONERS

Professor Drew Dawson

Prof. Dawson completed his PhD (Psychology) at Flinders University, Adelaide. He has had extensive experience as a shiftwork consultant, both in Australia and overseas. He as worked at Harvard University in Boston and Cornell University in New York as a Research Fellow. He is currently director of the Centre for Sleep Research at The University of South Australia and principal consultant for Circadian Consulting. Prof. Dawson is a well known and respected authority on shiftwork, its management and effects. He has been invited to speak at numerous international and national symposiums. He is also the author of an extensive listing of publications in international journals.

Associate Professor Anne-Marie Feyer

Associate Professor Anne-Marie Feyer completed her PhD (Psychiatry) at the University of New South Wales. Her research interests have been focused on the impact of work organisation on health, safety and performance. In particular, her work has examined the impact of hours of work on operator performance in a range of settings, including the aviation and road transport settings. While working as a Senior Research Scientist at the National Institute of Occupational Health and Safety in Sydney, she and Ann Williamson developed a major programme of work examining fatigue and work/rest patterns in the long distance road transport industry from an employee health and safety perspective. This work included the first national survey of the nature and prevalence of the problem among Australian drivers and some of the first examinations of the impact of fatigue under Australian operational conditions. She has published widely on the subject, and has presented papers at numerous national and international conferences, including both scientific symposia and industry conferences. She is currently a professorial research fellow based in New Zealand where she directs the national research group in environmental and occupational health research.

Dr Philippa Gander

Dr Gander's scientific interests are in sleep, the circadian biological clock and the impact of shift work on occupational health, safety and productivity. She completed her doctoral thesis in chronobiology at Auckland University and was granted a Senior Fulbright Fellowship at the Harvard Medical School in 1980. From 1983, she worked in the NASA Fatigue Countermeasures Program developing fatigue-management strategies for the aviation industry. Now a Professorial Research Fellow based in New Zealand, Philippa directs the Sleep/Wake Research Centre at the Wellington School of Medicine. Projects include fatigue countermeasures research and development in transport and health industries, and work on the epidemiology of sleep disorders in New Zealand.

Associate Professor Laurence Hartley

Laurence Hartley completed his PhD at University College London and then was employed by the UK Medical Research Council's Applied Psychology Unit in Cambridge to work on the effects of sleep loss and noise on people. He is currently Associate Professor at Murdoch University and Director of the Institute for Research in Safety & Transport and Fellow of the Australian Psychological Society. He is the author of over 100 papers and numerous reports on road safety, driver fatigue and drugs and driving. He is on the editorial boards of Accident Analysis and Prevention, and Transportation Research; a member of the executive of the International Congress of Traffic and Transport Psychologists; and convenor of the Conferences on Managing Fatigue in Transportation

Dr Narelle Haworth

Dr Haworth was the first Research Follow appointed to MUARC in 1987, shortly after completing a PhD in Psychology at Monash University. Together with Professor Tom Triggs and Elizabeth Grey, she wrote a major review of the driver fatigue literature for the Federal Office of Road Safety. Currently employed as a Senior Research Fellow at the Centre, Narelle has conducted extensive research on fatigue in driving, particularly truck driving. This has included an examination of the role of fatigue in fatal truck crashes in Victoria, experimental studies of factors affecting the development of driver fatigue and interviews of truck drivers.

She has also conducted research into seat belt wearing by truck drivers, road user behaviour in developing countries, development of data collection methodologies, evaluation of graduated licensing, coin-operated breath testing and motorcycle crash injuries to children and adolescents. Recently Narelle managed two major case-control studies: one of motorcycle crashes and the other, the single vehicle crashes study.

Dr Ann Williamson

Dr Ann Williamson has a PhD in Psychology from LaTrobe University. She has worked in the area of occupational health and safety since the early 1980's, first as a Research Scientist at the NSW Department of Industrial Relations, then as Head of the Human Factors and Ergonomics Unit at the National Occupational Health and Safety Commission. She is currently Executive Director of the NSW Injury Risk

Management Research Centre at the University of New South Wales. Ann has been working on the issue of fatigue and driving for more than 10 years. Together with Anne-Marie Feyer, she has produced a number of reports on fatigue in the long distance road transport industry. These have included national surveys of drivers and company representatives and on-road evaluations of existing and alternative approaches to fatigue management. She has also worked on the development of methods for assessing the effects of fatigue on performance. Ann's research interest in fatigue also extends to the issue of irregular working hours and shiftwork in other industries and she has also produced research papers and reviews on these issues.

INDUSTRY PARTICIPANTS

Peter Baas:

Peter Baas has been involved in many of the heavy vehicle safety initiatives that have occurred in New Zealand over the last 20 years. He was the Technical Advisor to the New Zealand House of Representatives Transport Committee Inquiry into Truck Crashes and recently completed major reviews of truck safety for the Road Transport Forum of NZ and the NZ Land Transport Safety Authority (LTSA). Peter is the Managing Director and a principal researcher at Transport Engineering Research New Zealand Limited (TERNZ). TERNZ is a leader in transport research in New Zealand with human factors, vehicle and road safety expertise. Current and recent research projects Peter has been involved in include the development of industry standards for the proposed NZ Safety Rating Scheme for transport operators, a major survey of driver fatigue and fitness for duty, a review of international compliance and enforcement practices, analysis of vehicle travel data, vehicle stability analysis, and the development of countermeasures aimed at reducing the incidence of logging truck rollover crashes.

Darren Nolan

Darren Nolan is the Risk Manager of Nolan’s Interstate Transport, and has been involved directly with the development of a number of government and industry accreditation programs successfully implementing these into working operation. These include the Queensland Department of Transport and the Australian Trucking Association joint Fatigue Management Pilot scheme, industry recognised trucksafe program, ISO 9002, HACCP Certification and taking up the Greenhouse Challenge.

Darren Nolan has also made written submissions and provided evidence to the Federal Parliamentary Inquiry into “Managing Fatigue in Transport”, and the NSW Inquiry by the Motor Vehicle Accident Authority into “Safety into the Lang Haul Trucking Industry”. In his roles as Risk Manager for Nolan’s Transport he has made presentation to a number of committees, including the Australian Trucking Association Annual Conference.

OBSERVERS

Barry Moore

Barry Moore has worked with the NRTC since July 1992. He has held the positions of Senior Economist, Manager Economic Policy and now Director – Strategy. Barry has managed the development of the compliance and enforcement provisions module of the national road transport law. He has been closely involved in the development of the Commission's policies on operator performance, accreditation and industry self-regulation. He chaired the Alternative Compliance Co-ordinating Committee and is a member of the steering committee for the Queensland Transport/Road Transport Forum Fatigue Management project. Barry is currently managing projects on a review of regulatory approaches to heavy vehicle driver fatigue project on the development of a health and safety code for road transport.

Chris Brooks

Chris is Team Leader, Research Management and Strategy at the Australian Transport Safety Bureau (ATSB). He is responsible for planning and managing external research projects on a range of road safety issues (including heavy vehicle driver fatigue) and providing policy advice based on this and other research. He worked in the Federal Office of Road Safety (FORS) until this became part of the ATSB in July 1999.

He has given evidence to a number of state and federal parliamentary enquires on road safety in Australia, and has been involved in the development and review of the National Road Safety Strategy and associated action plans. Prior to joining FORS in 1990, he worked on program planning and evaluation at the Federal Public Service Commission.

Chris Foley

Chris Foley has been involved in transport policy and compliance issues since 1986, when he joined the Policy section of the NZ Ministry of Transport. He has also spent six years as a licensed transport industry investigating and compliance officer based in Christchurch with the Ministry and, in 1993, the newly created LTSA. Since 1996 he has been a senior adviser in the LTSA's policy group based in head office, concentrating on commercial driver fatigue – including a current review of NZ's driving hour system.

FACILITATOR AND SCRIBE

Bryan Bottomley

Bryan Bottomley has undertaken a number of senior executive roles in the OHS field including Deputy General Manager of the Health and Safety Organisation (Vic) and Senior Manager Strategic Policy WorkCover (Vic). In these positions he had responsibility for state-wide operations including OHS inspection, audit, prosecution and legislative reform. He now manages his own consultancy practice and has undertaken a wide range of projects in the OHS and regulatory reform field. He has had involvement in a number of fatigue projects including the preparation a code of practice for the AMA on working hours for doctors. He holds a BA (Hons) and MA specialising in organisational change, job satisfaction and work design and spent 10 years lecturing in these fields.

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