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Title: Heavy Vehicle Driver Fatigue Advanced Fatigue Management - Summary of Fatigue Management Programs and Research in Australia.
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Objectives: The heavy vehicle driver fatigue (HVDF) review is a key component of the third heavy vehicle reform package. The aim of this review is to improve road safety through the implementation of policies and practices addressing the management of fatigue in the road transport supply chain.
NTC Programs: Fitness for Duty.
Key Milestones: This document is being released at this date for public information only. Public consultation on both the draft legislation and revised policies developed for the heavy vehicle driver fatigue reform will take place later in 2006 upon receipt of the draft legislation.
Abstract: The report discusses the fatigue information that has been used in developing the advanced fatigue management option policy proposal. This report presents a summary of this data and provides discussion about the key issues in developing the advanced fatigue management option.
Purpose: For information purposes only.
Key words: Heavy vehicle driver fatigue, advanced fatigue management.
Comment by: Not applicable.
The National Transport Commission (NTC) is a body established under an intergovernmental agreement with a charter to develop, monitor, and maintain uniform or nationally consistent regulatory and operational reforms relating to road transport, rail transport, and inter-modal transport. The NTC is funded jointly by the Australian Government, States and Territories.

Fatigue is one of the main causes of crashes involving heavy vehicle drivers. The Heavy Vehicle Driver Fatigue Review is a key component of the Third Heavy Vehicle Reform Package. The aim of this review is to improve road safety through the implementation of policies and practices addressing the management of fatigue in the road transport supply chain.

This report provides supporting information for the report: Advanced Fatigue Management Option Policy Proposal. Stakeholders should note that the views expressed are those of the NTC which have been informed by discussions with industry, regulators and relevant experts. These views have not been endorsed by any other organisations including the Transport Agencies Chief Executives or industry peak bodies.

While NTC is not formally seeking comment on this paper, the project manager is happy to consider any written or verbal responses and may be able to attend meetings or seminars to discuss the issues. Contact details are below. NTC plans to release the package of revised policy papers, regulatory impact statement and draft legislation in August 2006 for a six week period. Formal comment will be sought at that stage. Comments will then be analysed and a final package will be sent to the Australian Transport Council for endorsement in December 2006.

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Michael Deegan
Acting Chairman
SUMMARY

The advanced fatigue management (AFM) option is the third tier of the multi option approach to heavy vehicle driver fatigue. The multi option approach recognises the diversity of the road transport industry and the need for flexibility. The AFM option is based on risk management, accreditation and quality assurance approaches.

This report discusses the fatigue information that has been used in developing the AFM option policy proposal.

Section 2 presents a discussion of the key issues for the development of the AFM option, including the criteria parameters in the AFM model.

Section 3 presents the fatigue management programs and research studies in detail which are relevant to the AFM option. This includes fatigue management practices in the Australian transport industry and reports that have been commissioned for the fatigue reform.
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1  INTRODUCTION

The National Transport Commission is in the process of finalising the Heavy Vehicle Driver Fatigue Reform. As part of this reform, a three tier fatigue management system has been put forward. The proposed regime will comprise three options:

- **Standard Hours** – a default option prescribing minimum rest and maximum working hours;
- **Basic Fatigue Management (BFM)** – an optional more permissive set of minimum rest and maximum working hours requirements with increased fatigue management and compliance-assurance responsibilities imposed on operators; and
- **Advanced Fatigue Management (AFM)** – an optional approach based on risk management, accreditation and quality assurance approaches. Operators will adhere to agreed standards and operating limits in return for maximum work and minimum rest hours defined by the regulatory agency according to the operator’s specific fatigue risks and fatigue management system.

This report focuses on the fatigue information that has been used in developing the advanced fatigue management option. This report presents a summary of this data (section 3) and provides discussion (section 2) about the key issues in developing the advanced fatigue management option.

2  DISCUSSION

This section provides discussion of the key issues for the development of the advanced fatigue management option.

2.1 Managing Fatigue Rather than Driving Hours

Traditional prescriptive regulatory regimes have focused in managing driving hours. The Fatigue Expert Group (FEG) report (see section 3.1.1) concluded that the key issues for a regulatory system are to focus on managing fatigue and its pre-cursors. The FEG report focused on key design principles for developing a regulatory system based on managing fatigue. The report put forward a range of design principles that have been used to develop the three tiers including the AFM option.

There are examples of current fatigue management programs of use in Australia that show that managing fatigue rather than driving hours can lead to less fatigue for drivers.

An evaluation of the fatigue management program (section 3.2.1), which is a flexible regime based on managing fatigue, concluded that these drivers are exposed to significantly less fatigue risk.

An evaluation of the Western Australian transport industry in 1997 (see section 3.2.2) which at the time had unregulated driving hours showed that the safety record for Western Australia was comparable to the other States that has regulated driving hours.

2.2 Critical Parameters in the AFM Model

The advanced fatigue management option has a range of parameters that need to be managed. The two critical parameters are the short term 24 hour parameters as identified by the group of fatigue practitioners that examined operating limits (see section 3.2.2).
This had led to a slight refinement of the advanced fatigue management option from the original policy proposal (January 2004) to enhance the advanced fatigue management system by providing additional counter measures to ensure that these two parameters are not traded off to the detriment of fatigue. These changes include:

1. a focus on the two key short term fatigue parameters (‘minimum continuous sleep opportunity in 24 hours’ and ‘maximum work in 24 hours’) to ensure that rest and work are not traded off; and

2. incorporating mandatory fatigue counter measures to aid fatigue recovery, which is in addition to other fatigue counter measures the operator may propose.

The subsequent benefit of these changes has been a slightly simplified model which is consistent with the original design principles for developing the advanced fatigue management option. This will allow the transport industry to easily understand what is required in the advanced fatigue management option. It will also enable the audits to focus on any non-compliances and ways to improve fatigue management.

2.3 Ranges of Possible Work Practices under Flexible Fatigue Management Regimes and the Fatigue Counter Measures

Under flexible fatigue management regimes, the available data shows that a range of work practices are possible. The critical issue is to ensure that fatigue precursors are well managed. In the design of schedules, providing continuous rest opportunities for sleep to manage the fatigue risk is paramount.

A study of driving performance of drivers by Horberry (see section 3.2.4) on a specific schedule illustrates an example of the possible range of work where fatigue pre-cursors are well managed. The study showed no reported decline in the performance of drivers before and after the work shift. The shift length, including a four hour minimum continuous rest opportunity between driving, was 21 hours. The counter measures for managing the fatigue risk included large blocks of time off between work (27 hours) that allows for sleep opportunities, a rest opportunity in the middle of the work shift of four hours and an established norm for drivers to take an afternoon nap to prepare themselves for the later drive. Note that this schedule would not be possible under the advanced fatigue management option as it provides a four hour minimum continuous rest opportunity.

A study by Williamson et al (see section 3.2.5) examining possible alternative compliance driving hours regimes (flexible fatigue regimes like AFM) concluded that it is possible to increase trip length to 16 hours (equivalent to a 17¼ hour shift) and still maintain good performance levels.
3 SUMMARY OF FATIGUE MANAGEMENT PROGRAMS AND RESEARCH STUDIES

This section contains the fatigue management studies and programs in further detail.

3.1 Reports from Groups about the Fatigue Reform

There have been two groups convened to provide advice for consideration in developing the fatigue reform in Australia. These reports are detailed below.

3.1.1 Fatigue Expert Group Report

The Fatigue Expert Group (2001) 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 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, quantity of sleep;
- taking account of duration of working time; and
- 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.

3.1.2 Operating Limits Report

In developing further information to assist the assessment of the operating limits in accreditation proposals submitted by operators, data was sought about the associated fatigue risk for the operating limits. NTC convened a group of three fatigue practitioners (Associate Professor Ann Williamson of Injury Risk Management Research Centre - University of NSW, Dr Philip Swann of VicRoads, and Dr Narelle Howarth of Monash University Accident Research Centre) to provide advice about the operating limits under the AFM option and the associated fatigue risk. This advice was based on available literature and showed that managing the short term parameters is paramount for managing driver fatigue. It was recognised by the fatigue practitioners that their advice provided

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1 This section was reproduced from Austroads (2005).
cannot cover all scenarios. For situations where an accreditation proposal is beyond the operating limit advice provided by the fatigue practitioners, they suggested that the accrediting agency may need to seek more specific advice on the implications of the limits for fatigue management. The full report is presented in Appendix A.

3.2 Fatigue Management Practices in the Australian Transport Industry

3.2.1 Queensland Fatigue Management Program

The Queensland Department of Transport has been managing a fatigue management program (FMP) on behalf of the NTC for several years (Mahon and Cross 2000). The program allows industry and government to better manage heavy vehicle driver fatigue under alternative compliance arrangements instead of the prescriptive driving hours regime. It was concluded that fatigue management safety issues do not meet the criteria for successful implementation of counter measures based on learning and habitually memorising rules.

Burgess-Limerick and Bowen-Rotsaert (2002) assessed the Queensland fatigue management program (FMP) and concluded that the overall pattern of results support a conclusion that the drivers surveyed in 2001 and 2002, while working under FMP conditions, are exposed to significantly less fatigue related risk than those drivers surveyed in 1996/97.

The report also drew the following comparisons between pre-FMP drivers and the FMP drivers.

Compared to the pre-FMP drivers, the FMP drivers were more likely to report:

- greater involvement in determining schedules and rosters;
- that sufficient time was allowed in their schedule for breaks and non-driving work;
- a reduced frequency of fatigue indicators overall, and particularly of performance related fatigue indicators;
- greater knowledge of fatigue management;
- that management played their role in managing fatigue; and
- that their company’s fatigue management policy was effective.

Compared to the pre-FMP drivers, the FMP drivers were less likely to report:

- speeding to meet a deadline;
- feeling tired; and
- difficulty in concentrating.

In addition, the business survey results indicate that businesses operating under FMP conditions were:

- more likely than the industry comparison group companies to be well aware of the range of commonly recognised causes of stress and other fatigue inducing factors;
- more likely than before adopting the FMP to respond to fatigue problems, and achieve a positive outcome for drivers;
- more likely than before adopting the FMP to take a proactive role in managing their drivers’ fatigue;

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2 This section was reproduced from Austroads (2005).
likely to be more viable than before adopting the FMP, with three of the six companies better off, two the same, and one indeterminate; and likely to state that their expectations of the FMP have been realised.

All responding FMP operators found the FMP to be appropriate and effective in reducing driver fatigue. Three of the six operators found the FMP to be efficient in practice and two suggested enhancements to improve its business efficiency in operation.

The report also concluded that the additional profitability of some FMP operators cannot be solely or directly attributed to the FMP. However indications are that FMP appeared to be having a net positive effect on company profitability, while minimising fatigue risks to drivers.

The authors considered that while the net improvement to driver fatigue risk factors was positive, the overall incidence of undesirable driving behaviours and fatigue risk taking by drivers and operators was still of concern. However, the companies and drivers taking part in the FMP demonstrated a significant improvement over the conditions existing before the FMP and also show results that are generally better than the industry comparison group.

3.2.2 Study on Fatigue in the Western Australian Transport Industry

A study on fatigue in the Western Australian transport industry by Hartley et. al. (1996), which at the time had unregulated driving hours, showed that the safety record for Western Australia was comparable to the other States including those with driving and related working hours regulations. On no single indicator does Western Australia stand out as having a worse fatigue related crash problem than other States. These findings do not suggest that introducing driving and related working hours regulations to Western Australia would benefit road safety. This conclusion is qualified by the several driving and road environment differences, such as traffic density, between the States.

3.2.3 Current Western Australian Fatigue Management for Commercial Drivers

Western Australian introduced a fatigue management regime in July 2003 under the Occupational Safety and Health Act 1984. A Code of Practice – Fatigue Management for Commercial Drivers has been developed to provide practical advice on preventive strategies and a practical means of achieving any code, standard, rule, provision or specification relating to occupational safety and health in Western Australia. The section of the code of practice for solo drivers is reproduced in Appendix B.

3.2.4 Study of Driving Performance by Horberry

A study undertaken by Horberry (2000) examined the driving performance of six drivers who undertook driving from Perth to Kalgoorlie, having a night break and then driving back to Perth. The approximate work schedule was:

- leave Perth at approximately 17:00 and arrive in Kalgoorlie at 02:00 (a nine hour shift including rest breaks);
- a 4 hour in-cab rest between 02:00 – 06:00;
- leave Kalgoorlie at 06:00 and arrive in Perth at around 14:00 (a eight hour shift including rest breaks);
- 27 hours off work before undertaking the Perth-Kalgoorlie-Perth trip again; and
the driving schedule was undertaken six times over a 12 day and then the drivers had two days off.

The drivers’ performance was tested using a driving simulator before they commenced work and immediately after they returned. The intention of the study was to assess if any decline in driving performance had occurred. Six drivers were involved in the study and each driver was tested three times before their shift and three times after. The results found no overall decline in driving performance after their shift compared with before the shift.

One explanation the report offers for no reported decline in performance is the fatigue counter measures employed. The drivers only worked one nightshift in a row, there was a large block of time (27 hours) off between work to allow plenty of sleep opportunities, no driving was undertaken in the ‘high risk’ hours of 02:00 to 06:00 and it was the established norm for the drivers to take an afternoon nap to prepare themselves for the later drive.

3.2.5 Fatigue Management Study by Williamson et. al.

Williamson et. al. (2000a) undertook a series of three studies looking at the development of model work-rest schedules for managing driver fatigue in the long distance road transport industry. The studies were summarised in a fourth document (Williamson et. al. 2000b). The purpose of these studies was to help the industry in designing work-rest schedules to provide additional flexibility for companies and drivers to meet their operational needs but also manage fatigue most effectively. The report provided an overview of the findings of each of the three studies.

The first study (Williamson et. al. 2000c) developed a set of fatigue-sensitive performance measures and alcohol-equivalent standards for each of them. The results also demonstrated sleep deprivation of 17 hours or more produced decrements in performance capacity equivalent to the community-accepted standard of 0.05 percent blood alcohol concentration. They also showed that long distance drivers appeared to cope with the demands of sleep deprivation better than non-professional drivers.

The second and third reports (Williamson et. al. 2000a and 2000d) detailed the evaluation of four work-rest schedules, two of which complied with the current working hours regulations and two that were alternative schedules that did not comply with the regulations. The evaluations were carried out on the road while drivers were doing their normal trips. The exception was one of the alternative compliance schedule evaluations, which was done with professional long distance drivers in a simulation mode rather than on-road. The results of the regulated hours evaluations showed that so long as drivers were rested before their trips, the regulated regime produced increased fatigue and produced some performance decrements at the end of a work period between long 24 hour breaks. The level of effect was not significantly high however, relative to alcohol-equivalent standards.

In contrast, the alternative compliance schedule (FMP) evaluations demonstrated that it is possible to introduce flexibility in scheduling such as by extending the length of work periods, but only if an adequate balance is maintained between work and rest.

The schedule used under the alternative compliance evaluation was a three day work-rest regime of 16 hours work (17¼ shift) followed by a six hour rest opportunity. The following is general conclusion is reproduced from the study (Williamson et al 2000b):

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3 This section was reproduced from Austroads (2005).
The results show clearly that it is possible to increase trip length to 16 hours [17¼ hour shift], say, and still maintain good performance levels. It is not possible, however, to continue to do 16 hour trips without a longer break than is usually allowed, even in the regulated regime.

The study found that work periods of up to 16 hours (17¼ hours shift length) can be undertaken without compromising the safe performance provided that drivers are sufficiently rested before they begin. The study found that, with a multi-day schedule comprising of 16 hours work with a six hour minimum rest opportunity, the performance of professional truck drivers deteriorated significantly by the middle of the second 16 hour work period. This study demonstrates that for this specific work-rest schedule, a minimum sleep opportunity of six hours is not sufficient to manage fatigue. Note that this schedule would not be possible under the advanced fatigue management option as it long work periods are managed by additional rules that provide for longer minimum rest opportunities and subsequent shorter work periods after a longer work period is undertaken.

The general conclusions from these three studies are reproduced in Appendix C.
4 REFERENCES


APPENDIX A – OPERATING LIMITS REPORT

The operating limits report was developed using the original advanced fatigue management model that was outlined in the Heavy Vehicle Driver Fatigue: Policy Proposal 2004. The AFM model now contains mandatory counter measures which are consistent with good fatigue management practices. The previous advanced fatigue management model with three limits (normal limits, flag points and outer limits) has been replaced with two limits (operating limits and outer limits) with the final advanced fatigue management proposal. The operating limits for the new AFM model is equivalent to combining the normal limits and flag points under the original AFM model proposed in 2004. The operating limits provide the basis around which the business is planned and organised and must take into account all reasonable foreseeable circumstances.

Background

The Heavy Vehicle Driver Fatigue: Policy Proposal 2004 was considered by ATC in 2004 and clarification of various issues in the Advanced Fatigue Management (AFM) component was sought. Some jurisdictions are seeking more specific advice on the parameters that they will be asked to assess. The NTC has asked the Reference Group to assist in this process. The Reference Group was:

- Ann Williamson;
- Philip Swann; and
- Narelle Haworth.

The process was facilitated by Bryan Bottomley and John Gordon from Queensland Transport also provided input on the AFM Calculator.

Jurisdictions have sought greater clarity about the interaction of parameters and the suitability of countermeasures that are included in applications for accreditation. AFM covers a comprehensive management system approach but this expert review focused only on the operating limits aspect.

The core agenda of the Reference Group was to:

- identify and assess suitable countermeasures for possible individual operating limit parameters included in applications for accreditation;
- identify and assess the impact of several parameters in combination as included in applications for accreditation and the availability of suitable countermeasures; and
- make recommendations on any matters that may impact on the management of fatigue under the AFM model.

In doing so the group has taken into account the following:

- state of current knowledge in relation to limits/frequencies; and
- state of current knowledge in relation to countermeasures.

The group provided advice on the basis of available knowledge on fatigue related crash risk particularly in relation to the 24 and 48 hour periods. The impact of accreditation requirements (e.g. training, audit, monitoring) was not considered but it is expected that at normal and flag points the management of fatigue will be enhanced by the measures required under the accreditation scheme.

The Reference Group’s advice was framed in the context of the following issues:
• The relationship of the three elements of the scheme (Standard limits, Basic Fatigue Management and Advanced Fatigue Management) was difficult to ignore but it was agreed to consider AFM independently.

• The Standard option introduced some measures that made significant progress in aligning the law with evidence on the management of fatigue.

• The operating limits for BFM are of concern and the scope of limits in the BFM model has left AFM setting outer limits that are difficult to justify from the fatigue literature.

• The treatment of limits must make clear that the notion of a shift includes work and rest breaks. The period of wakefulness is the critical factor rather than distinction between work, driving and short rest breaks.

• The relevance of overall road safety factors in addition to the specific experience of fatigue in determining the overall road safety outcome. If the objective is to reduce harm then some other mitigating factors could be considered such as area of operation and shared or divided roadways. It was decided that these issues may be relevant in assessing the overall road safety effects of a proposed operation, but that they would not be included in the countermeasures discussed by the Reference Group. Accrediting agencies may wish to consider these factors when assessing applications.

• The scope of countermeasures to be considered could include both the limits themselves and other measures such as napping. It was agreed that the use of short term measures such as napping is best considered in relation to the opportunity in proposed operating limits for such measures to be used.

• The distinction between short rest breaks and the opportunity for sleep need continual emphasis in AFM.

• The group thought that the most important parameters were those that control the build up of fatigue within each 24 hour period as this will also reduce the potential for longer term build up of fatigue.

• Discussion of the 24 hour period resulted in agreement to use the definition in the Fatigue Management Guide. This defines a 24 hour period as commencing at the end of a continuous sleep opportunity. If two 24 hour periods overlap the first 24 hour period still applies. This was seen as essential to prevent the development of highly disrupted circadian rhythms due to work-rest combinations being shorter than 24 hours which have the effect of making sleep time occur progressively earlier each day. If a different definition was used the advice of the Reference Group would have to be reconsidered.

• The following advice on limits has been provided on the basis of broad application and the group has not subjected specific schedules to any rigorous scrutiny to enable them to assess the suitability of any specific schedule.
Advice on operating limits in AFM

The advice that follows is presented in the following format:

Normal limits and flag points

Normal limits and flag points are suggested on the basis of the Reference Group’s consideration of fatigue evidence.

These limits can be used by agencies in assessing applications for accreditation as an AFM operator.

The different limits in the AFM scheme need to be considered in totality, but for purposes of giving advice, they have been considered as separate parameters. The two core parameters are considered to be the minimum sleep opportunity in 24 hours, and the maximum hours work in 24 hours. These are interdependent and the Reference Group believes that time of day factors should be included in the assessment of these limits.

Time of day factors are important in all parameters, but in some cases the interaction of parameters creates better opportunities for sleep and recovery. The Reference Group’s recommendation is to keep the 24 hour parameters as standalone in any assessment and consider all the other parameters with regard to the opportunity they provide for regular recovery from short term or accumulated sleep debt.

An evidence based rationale for setting the limits

Available evidence to support the operating limit is drawn from sources suggested by the Reference Group. The Fatigue Expert Group Report published in 2001 and more recent research is used to support the case for particular limits.

The factors to consider in managing the interdependencies between the parameters

The factors that should be kept in mind in assessing operating limits are the time of day, the time on task and related time awake and the likelihood of build up of sleep deprivation.

The generic countermeasures are to:

- minimise long continuous work periods;
- minimise the need for night work; and
- minimise long runs of consecutive work shifts without opportunity for a significant sleep break.

Advice cannot cover all scenarios

As noted earlier the application of this advice to all the possible operating limits that may be forwarded for approval has not been tested. The advice has to be considered against the particular details of an application. It is suggested that where an application is beyond the normal and flag points suggested here that the accrediting agency may need to seek more specific advice on the implications of the limits for fatigue management.
MINIMUM SLEEP OPPORTUNITY IN A 24 HOUR PERIOD

This parameter is aimed at providing an opportunity for continuous undisturbed sleep to meet individual sleep needs. It is considered important not only to recuperate from the immediate working day but to provide a platform to prevent the build up of sleep debt over longer periods.

The Reference Group recommended that normal limits for sleep opportunity should be assessed with a time of day risk factor in mind:

Normal limits

The Reference Group recommended that for 90 percent of operations:

- where able to be taken mainly at night, a minimum of seven hours continuous sleep opportunity; and
- where able to be taken mainly during the day, a minimum of nine hours continuous sleep opportunity.

Flag Points

For the 10 percent of cases where variation from the normal limit to a flag point is required to meet special circumstances the Reference Group recommended:

- where able to be taken mainly at night, a minimum of seven hours continuous sleep opportunity; and
- where able to be taken mainly during the day, a minimum of eight hours a continuous sleep opportunity.

Where less than a seven hour continuous sleep opportunity (but more than the outer limit of six hours) was available, the Reference Group recommended that no more than 12 hours work (13 hour shift) should precede such a limited opportunity and that the sleep opportunity should be available in the 0000-0600 period. This limited sleep opportunity is only to be used a maximum of once in three days.

Rationale and factors to consider

The normal limits range is based on evidence that while sleep need varies among individuals most people on average need seven to eight hours of night sleep. Sleep taken during the day is less restorative and requires a longer sleep opportunity to achieve the same number of hours of actual sleep. Consequently a basic time of day factor has been included in the assessment of normal limits and flag points. Combined with time required to meet the requirements of daily living, the time of day factor means that the sleep opportunity in most circumstances must be at least seven to eight hours, even in the most advantageous circumstance (i.e. sleep able to be taken at night).

Any application that indicates that a flag point is to be set at between six and seven hours (six hours is the outer limit) should be closely scrutinised in relation to time of day, the

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available opportunity for sleep and the length of working hours preceding the sleep opportunity.

The conditions recommended by the Reference Group are based again on countermeasures to protect minimum sleep opportunity. The best time for this limited opportunity for sleep to translate into actual restorative sleep would be the midnight to dawn period. The evidence indicating that two hours sleep less than needed in one night is enough to consistently impair functioning the next day is the basis for limiting the flag point frequency to once in three days.⁵

**Broken sleep limits**

This parameter is inconsistent with all the evidence about the need for continuous minimum sleep opportunity⁶. The Reference Group did not think it appropriate to encourage the notion of normal limits and only suggested an alternative that retained a core minimum sleep opportunity.

A possible flag point was suggested as ten hours in two parts with a minimum of six in one part. The one in three days maximum frequency is also recommended for this limit.

**Rationale and factors to consider**

As in previous advice by fatigue experts broken sleep is considered to create an unacceptable fatigue risk. The proposed limit continues to protect a six hour minimum continuous sleep opportunity. The FMP evaluation involving broken rest demonstrated this practice was not effective in managing fatigue.⁷

**MAXIMUM HOURS WORK IN A 24 HOUR PERIOD**

This parameter is linked to the minimum sleep opportunity parameter and should be seen as a way of ensuring that the opportunity for sleep is not compromised rather than only as a means of limiting working hours.

The Reference Group recommended that normal limits for maximum hours work should be assessed with a time of day risk factor in mind. Secondly, the Reference Group has considered these limits in relation to actual shift lengths to highlight the need to consider how long a driver has been awake. Consequently an equivalent shift length is included in brackets to emphasise the reason why the Reference Group has assessed the risks associated with long periods of wakefulness.⁸

**Normal limits**

The Reference Group recommended that for 90 percent of operations:

- where operations involve working hours outside the midnight to dawn period a maximum of 12 hours work (i.e. shift of 13 hours); and

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⁵ Ibid, p.27.
⁸ Apart from the 16.5 hours in 24 calculation explained below, the rest of the shift equivalents are based on 12 hour working periods. For example a 12 hour working period with the addition of two 30 minute short breaks becomes a 13 hour shift. A 72 hour period based on 6x12 hours becomes a 78 hour shift equivalent.
• where operations involve working hours within the midnight to dawn period a maximum of 10 hour (i.e. shift of 11 hours) hours work.

Flag Points

For the 10 percent of cases where variation from the normal limit to a flag point is required to meet special circumstances the Reference Group recommended:

• where operations involve working hours outside the midnight to dawn period a maximum of 14 hours work (i.e. shift of 15 hours) in 24 hours; and
• where operations involve working hours within the midnight to dawn period a maximum of 12 hours working (i.e. shift of 13 hours) in 24 hours.

In exceptional circumstances the Reference Group saw up to 15 hours work (16.5\textsuperscript{9} hour shift) in a 24 hour period only being acceptable where the following conditions applied:

• no work in the 0000-0600 period;
• longer rest (greater than seven hours) prior to shift; and
• longer rest (greater than seven hours) after shift.

The frequency to be a maximum of once every three days if required.

Rationale and factors to consider

The evidence about time on task and fatigue has to be read in conjunction with the impact of time of day factors. Some research suggests that time of day is a greater influence on crash risk than duration of work\textsuperscript{10} and this is the reason the Reference Group has included a time of day variable in the normal and flag point ranges.

The Fatigue Expert Group Report refers to research showing that crash risk increases significantly after 11 to 12 hours on duty\textsuperscript{11} (or an 11-12 hour shift as expressed by the Reference Group). Consequently the end of the range for normal limits where work includes the midnight to dawn period is suggested at an 11 hour shift or ten hours work.

The rationale for the flag point range is the increased crash risk after 12 hours working\textsuperscript{12} and the upper bounds suggested in the Fatigue Expert Group Report of 14 hours. On the basis that the 14 hours is working hours the Reference Group flag range at a 15 hour shift for predominantly daytime work is consistent.

The exceptional shift length of 16.5 hours is bounded by much more restrictive conditions on time of day and readiness and recuperation opportunities. Australian research using measures to establish equivalence with Blood Alcohol Concentration concluded:

\textsuperscript{9} The calculation of 16.5 hours is based on the group’s view that continuous work periods of 5 hours should utilise the 30 minutes break in a way that the trip is not shortened by saving the break to the end (“the short rest breaks must be taken throughout the shift and cannot be used to shorten a trip”. This is a different notion to the proposed 6 hours continuous work definition.

\textsuperscript{10} E.g. Hamelin, 1987 cited in FEG.
\textsuperscript{11} FEG op. cit p. 37.
\textsuperscript{12} E.g. Folkard, 1997;Wylie et al 1996 cited in FEG, p. 37
“that after around 16 to 19 hours without sleep, performance capacity has deteriorated sufficiently to be of concern to the community due to an increased potential safety risk.”

Consequently, the Reference Group considered this range as presenting a heightened fatigue risk.

As noted, the hours worked in 24 are important in the opportunity they provide for sleep, and all the same evidence as noted under minimum continuous sleep opportunity applies.

**MAXIMUM HOURS WORK IN SELECTED PERIODS**

These parameters combine operating limits for 48 hour, seven day, 14 day and 28 day periods. The evidence basis for fatigue related crash risk has not been based on periods such as 14 and 28 days. The parameters are relevant to the extent that they afford the opportunity for scheduling sleep opportunities, night sleep opportunities and days free of work.

**Normal limits**

The Reference Group recommended that for 90 percent of operations:

- total working hours in 48 hours should be no more than 24 hours (i.e. equivalent to total times for shifts of 26 hours);
- total working hours in seven days should be no more than 60 hours (i.e. equivalent to total times for shifts of 65 hours);
- total working hours in 14 days should be no more than 120 hours (i.e. equivalent to total times for shifts of 130 hours); and
- total working hours in 28 days should be no more than 240 hours (i.e. equivalent to total times for shifts of 260 hours).

**Flag Points**

For the 10 percent of cases where variation from the normal limit to a flag point is required to meet special circumstances the Reference Group recommended:

- total working in 48 hours should be no more than 27 hours (i.e. equivalent to total times for shifts of 29 hours);
- total working hours in seven days should be no more than 70 hours (i.e. equivalent to total times for shifts of 76 hours);
- total working hours in 14 days should be no more than 140 hours (i.e. equivalent to total times for shifts of 152 hours); and
- total working hours in 28 days should be no more than 280 hours (i.e. equivalent to total times for shifts of 304 hours).

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Where averaging over 14 days was used, the Reference Group considered that a longer week of up to 78 hours (84 hour shift equivalent) was acceptable when used once per month. The longer week would be countered by a shorter second week.

**Rationale and factors to consider**

*Working hours in 48 hour period*

The evidence about time on task and fatigue has to be read in conjunction with the impact of time of day factors. This parameter allows averaging and a longer shift needs to be followed by a shorter working day that affords an opportunity for a longer sleep. As noted the hours worked in 48 are important in the opportunity they provide for sleep and all the same evidence as noted under minimum continuous sleep opportunity applies.

*Working Hours in a seven day period*

The Reference Group considered limits in relation to the opportunity for sleep. The normal limits would provide for the kind of opportunity recommended in the first parameter. The FEG report saw 70 hours as a limit to working longer shifts on a regular basis and compromising sleep opportunities. The 72 hours standard is still a very long week compared to practices in the rest of the community.

A recent study \(^{14}\) of an 84 hour shift (7x12) in the construction sector showed there were no signs of reduced test performance and elevated fatigue in the study group. However, this schedule was seven days on and seven days off, not a condition of the AFM limit. Secondly, the shifts were inclusive of rest breaks and were day shifts.

The 78 hours conditional flag point limit was proposed on the basis that it was balanced with a significantly shorter second week. Applications for longer weeks in an averaging period should be scrutinised to ensure that increased risks are balanced with the most beneficial sleep opportunities.

*Working Hours in a 14 day period*

The Reference Group considered these limits from the standpoint that they did not extend hours to a point where the opportunity for sleep is likely to be continually compromised. The group was not convinced that front loading or back loading of a 14 day period close to the outer limits proposed would lead to acceptable fatigue outcomes.

Averaging at close to outer limits was not seen as providing a clear enough balance of extended rest to recover from extended work. The maximum 84 hour week (a 91 hour shift equivalent) would only be compensated by a 70 hour week under the averaging concept. From the group’s point of view this is just less than the current maximum working hours in a week (i.e. 72 hours) and so does not provide the shorter work week that is needed to balance the previous very long work week.

The alternative proposed allows a long week up to 78 hours work (an 84 hour shift equivalent) but a consequently shorter week 60 hours work (a 66 hours shift equivalent) at the limit.

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Applications for longer weeks in an averaging period should be scrutinised to ensure that the compensating shorter week is well within the normal limits range for seven days suggested.

*Working Hours in a 28 day period*

The 288 hour cap was seen as acceptable given it incorporated the 72 hour threshold.

**MINIMUM OPPORTUNITY FOR A NIGHT SLEEP IN A SEVEN DAY PERIOD**

This parameter is related to the restorative value of night sleep in managing both acute and cumulative sleep deprivation.

**Normal limits**

The Reference Group considered for 90 percent of operations, two consecutive nights sleep opportunities of at least seven hours continuous between 10pm - 8am in a seven day period as an acceptable limit.

**Flag Points**

The Reference Group considered for 10 percent of operations, two night sleep opportunities enabling sleep between 10pm - 8am in a seven day period was an acceptable limit.

In exceptional circumstances the Reference Group accepted one night sleep opportunity in seven days only on the condition that it is available once per 14 days and that in the following week at least two night sleep opportunities are available.

**Rationale and factors to consider**

The case to maximise night sleep opportunities is drawn from evidence about the biological drive for sleep at night and wakefulness during the day.

Sleep at night enables the body’s circadian clock to be kept synchronised to the night/day cycle and also maximises the possibility of continuous, undisturbed sleep. Sleep at night is the most effective way of discharging any accumulated sleep debt.

The normal limit is suggested to be at least three night sleep opportunities. This ensures that regular opportunities for restorative sleep are available in a week. The alternative of fewer but consecutive night sleeps is based on the evidence that a single night sleep is not adequate to compensate for fatigue built up over a longer period and that an extended period needs to be made available at least once every seven days^{15}. The value of two consecutive night sleeps in compensating for cumulative sleep debt is also supported in the FEG report.

The reduced night sleep opportunities at the flag points are limited and always followed by a week in which two night sleep opportunities are available. The operation of the limit for 36 long and night hours in combination is expected to operate as a counterbalance to schedules that reduce the opportunity for night sleep.

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^{15} E.g. Rosekind, Neri and Dinges, 1997 cited in FEG, p. 32.
24 HOURS OFF IN A 28 DAY PERIOD

This parameter has no intrinsic link to fatigue except in relation to the timing and opportunity for non work days in which the opportunity for sleep, particularly night sleep, is available.

Normal limits

The Reference Group considered for 90 percent of operations regularly taken 24 hour breaks grouped at two or more per week within the 28 day period represented an acceptable normal limit.

Flag points

The Reference Group considered for 10 percent of operations two 24 hour breaks spread over a 14 days was a suitable limit.

The major concern of the Reference Group was the saving up of days to the back end of a schedule but considered there were some circumstances in which grouping did not necessarily result in adverse consequences.

The Reference Group accepted as a flag point four days off taken as a group in a 28 day period where the following conditions applied:

a. shift lengths shorter than 12 hours; and
b. no night work

Rationale and factors to consider

The rationale for the normal limits is the opportunity that two days, and particularly two consecutive days, gives for night sleep opportunity.

The flag point rationale is similarly that two night sleeps, possibly consecutive, are available in a 14 day period to enable recovery from accumulated sleep debt.

Grouping of days off would be an unacceptable fatigue risk where long shifts and night work combined to compromise the opportunity for more than the minimum night sleep in any one week. The exceptions related to work within normal limits for the 24 hour parameter and regular opportunity for night sleep and grouping in this situation was not seen as accelerating fatigue risk.

MAXIMUM HOURS NIGHT WORK IN SEVEN DAYS

There is extensive research indicating a drop in alertness at night and an increase in crash risk for drivers working at night. The Reference Group considered the 36 long and night hours in combination concept that is incorporated in the BFM option to be a suitable safety net that would moderate potentially high risk schedules and facilitate the opportunity for some night sleep opportunities.

As other parameters have emphasised a time of day dimension the Reference Group did not think that normal and flag points for this parameter would be meaningful.

LENGTH OF SHORT BREAKS

This is not a formal parameter in the AFM model but the standard definition of 30 minutes break in a trip of up to six hours is expected to apply. The Reference Group could not identify any improvement in fatigue management afforded by lengthening the period before a break must be taken from the current five hours.
The evidence about the timing and impact of short breaks is not conclusive and the Fatigue Expert Report\textsuperscript{16} noted research suggesting that:

- breaks after two hours may combat fatigue;
- short breaks may be more important for tasks with low mental demands;
- the effectiveness of short breaks may be related to the level of fatigue already developed and the time of day that the break is taken.

Despite the lack of conclusive evidence a precautionary approach should be taken and that suggests the current threshold is more suitable.

Importantly, the Reference Group considered that the extension of the continuous period of work before a break encouraged the possibility that these breaks would be used as a substitute for the absolute requirement for continuous sleep opportunities.

The issue for assessing applications is not whether applicants outline whether they may use short term measures such as napping, but how the limits they propose afford the opportunity for suitable sleep opportunities and opportunities to maximise the effectiveness of measures such as napping.

\textsuperscript{16} FEG, p.39.
APPENDIX B – CURRENT WESTERN AUSTRALIAN HEAVY VEHICLE DRIVER FATIGUE MANAGEMENT FRAMEWORK

The following section is reproduced from the Code of Practice – Fatigue Management for Commercial Drivers which provides the commercial vehicle operating guide.

Solo drivers

Solo commercial vehicle drivers are drivers who do not have another commercial vehicle driver in the cab of the vehicle to take over the driving from time to time. In the regulations, this is referred to as driving without a relief driver.

Solo drivers must, so far as practicable, have at least 20 minutes of breaks from driving for every 5 hours of work time, including one break of at least 10 minutes during or at the end of every 5 hours.

The regulations are written in such a way that a driver cannot drive for more than 5 hours without stopping the vehicle.

These are breaks from driving. The breaks may include other activities that are included in “work time” such as toilet stops, rest, and meals. However, it should be remembered that the breaks are designed to minimise the risk of fatigue. Experts in the fatigue area believe that breaks from driving should be of at least ten minutes duration to be effective. It is not intended that breaks be accumulated to shorten the trip or added on to the end of the trip.

So far as practicable, the work time for solo drivers must not be more than 168 hours in any 14 day period. The 14 day period must include at least two periods of 24 continuous hours of non-work time.

This means that the 168 hours will usually be spread over 12 days.

It is acceptable to work according to a 28 day schedule instead of the 14 day arrangement described above. However, this is on the condition that the hours of work time do not exceed 144 hours in any 14 day period within the 28 days.

To comply with requirements for 28 day schedules, drivers must have at least four periods of 24 continuous hours of non-work time in any 28 day period. The hours of non-work time may accumulate but they must be taken in minimum 24 hour lots. They cannot be split into half days.

The 28 day roster means that a driver could work for 24 out of any 28 days and there could be up to 24 days of work before a driver has days off. If a driver works every day for 24 days, the driver must stop driving the commercial vehicle or operating the item of mobile plant for four continuous days.

It is preferable that days of work time do not accumulate and the driver has days of non-worktime spread throughout each 28 day period.

There is some flexibility in the way that solo drivers can organise their work time. Each day can have a varied number of hours as long as the total for each period is not exceeded and the driver has the minimum amount of non-work time set out in the standard.

In any 72 hour period (three days) there must be a total of at least 27 hours of non-work time including three breaks of at least 7 continuous hours. The remaining non-work time can be made up of other continuous breaks of 30 minutes or more. This non-work time cannot include breaks from driving of less than 30 minutes as they are counted in work time.
For practical purposes, to determine whether a driver has met the requirement for three breaks of at least 7 continuous hours in any 72 hour period, the 72 hours is counted from the end of a long break of 7 continuous hours or more.

In well managed circumstances, a solo driver can work for up to 17 hours, but there must be a break of at least 7 continuous hours immediately before and after the 17 hour period. These breaks of 7 continuous hours would be included in the 27 hours of non-work time referred to above. The 17 hours will include breaks from driving of 20 minutes for every 5 hours, which would add up to at least one hour of breaks from driving.

It is important to remember that the limits on the number of hours that can be worked in a 14 or 28 day period mean it is not possible to continuously work 17 hour days.

Solo drivers can work through the night, but it is recommended that night work be kept to a minimum to guard against the risk of fatigue.

Solo drivers who do continuous rotating shift work for 5 or more days in a row, should, as far as practicable, have at least 24 continuous hours of non-work time between shift changes (for example, going from day shift to night shift).

**Table 1. Operating Standard for Solo driving**

<table>
<thead>
<tr>
<th>OPERATING STANDARD FOR SOLO DRIVING</th>
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<tbody>
<tr>
<td>At least 20 minutes of breaks from driving for every 5 hours of work time including a break of at least 10 consecutive minutes during or at the end of 5 hours.</td>
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<tr>
<td>No more than 168 hours of work time in any 14 day period.</td>
</tr>
<tr>
<td>At least 27 hours of non-work time in any 72 hour period, including at least 3 periods of at least 7 continuous hours of non-work time.</td>
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<tr>
<td>No more than 17 hours between non-work periods of at least 7 continuous hours.</td>
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<tr>
<td>If there is shiftwork on 5 or more consecutive days, at least 24 continuous hours of non-work time between shift changes.</td>
</tr>
<tr>
<td>Note: All of the items above and one of the options below must be complied with, so far as is practicable.</td>
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<tr>
<td>EITHER</td>
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<tr>
<td>At least 2 periods of 24 continuous hours non-work time in any 14 day period.</td>
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<tr>
<td>OR</td>
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<tr>
<td>At least 4 periods of 24 continuous hours non-work time in any 28 day period (provided hours of work do not exceed 144 hours in any 14 day period within the 28 days).</td>
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APPENDIX C – CONCLUSIONS FROM WILLIAMSON ET AL (2000A)

These studies were important for three reasons. Most notably, these findings provide evidence about the effectiveness of two different work-rest regimes and suggest some general principles for the management of fatigue. The results showed that trips that are conducted under the current working hours regime of up to 14 hours allowable in each trip, do not produce significant levels of fatigue nor significant adverse effects on performance. The results of both studies show, however, that increasing hours of work produce both fatigue and poorer performance, even over the week. Further work is needed to be specific about how many hours work can be done and still remain safe. The simulation study suggests that up to 16 hours of work may be done without producing significant adverse effects on performance, but that such a long trip cannot be sustained for longer than one trip. This finding needs to be replicated on the road as overall performance levels in this simulation were considerably poorer than expected.

These studies also showed the importance of taking into account the effects of accumulation of fatigue over consecutive trips. The simulation revealed that recovery from fatigue is dependent on the accumulated level of fatigue and that recovery may not even occur when too much fatigue has accumulated. The on-road study showed that even at relatively low levels of fatigue, the amount of sleep and the number of breaks determine fatigue and performance. The results imply that management of chronic fatigue will be achieved best by controlling the amount and pattern of rest breaks rather than simply the number of working hours permitted.

The second reason that these findings are important is that the observed performance effects are of relevance to driving. Performance functions, such as reaction speed and the ability to consistently react quickly, and the ability to detect infrequent signals, were affected most by work-rest experiences and fatigue. Decrements in these types of functions are certainly likely to affect driving ability. It is also significant that the same performance effects, increases in the number of missed signals in the Mackworth Vigilance test and more variable reaction speed in the Simple Reaction Time test, were found across work periods in both studies. This suggests that these functions are most sensitive to fatigue.

Lastly, these studies are important because they demonstrate a method for systematically evaluating the effects of different work-rest patterns on fatigue and performance. One of the major problems for management of fatigue in the long distance road transport industry has been a lack of scientific evidence for recommending effective limits for work or patterning of rest. The results of these studies and of the previous laboratory study demonstrate a method that is sensitive enough to pick up effects of variations in the work-rest schedule and variations in fatigue levels. This method will therefore enable informed judgements to be made about how work and rest can be arranged to reduce the problem of driver fatigue. This method can be applied to assess other work-rest schedules, to evaluate their effectiveness for managing fatigue and to develop alternative schedules where a particular schedule is shown to be ineffective.