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National Rail Safety Guideline

Management of Fatigue in Rail Safety Workers

This national guideline is one of a series of six containing guidance for rail safety regulators, industry stakeholders and other parties about aspects of rail safety legislation.

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NTC AUSTRALIA
National Transport Commission

Rail Safety Regulators' Panel

National Guideline for Management of Fatigue in Rail Safety Workers

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Prepared by: National Transport Commission in conjunction with the Rail Safety Regulators Panel

Foreword

The National Transport Commission (NTC) is an independent body established under Commonwealth legislation and an inter-governmental agreement, and funded jointly by the Commonwealth, States and Territories. In accordance with its duties, the NTC has developed a national model *Rail Safety Bill 2006* and *Rail Safety Regulations 2006* to achieve a nationally consistent approach to regulating rail safety in Australia. The model legislation was developed in conjunction with representatives of all jurisdictions, the rail industry and rail unions and was approved by the Australian Transport Council in 2006. The national model Bill and Regulations will receive legal effect when enacted in State and Territory law.

National Guidelines

National guidelines are intended to assist rail safety regulators, industry stakeholders and other relevant parties with duties under the rail safety legislation to understand and comply with the new legislative requirements. National guidelines are administrative documents that are intended to provide practical advice. Guidelines do not extend, add to or modify legislative obligations contained in the *Rail Safety Bill 2006* or *Rail Safety Regulations 2006*. Depending on the subject matter, guidelines may:

- articulate how rail safety regulators will behave when undertaking their functions to ensure that their processes are transparent to the duty holders (e.g. *National Guideline for Compliance and Enforcement for Rail Safety*);
- provide nationally consistent and/or integrated processes by which rail safety regulators will make decisions (e.g. *National Guideline for Uniform Administration of Accreditation*); or
- assist duty holders with the interpretation of legislative provisions and provide practical guidance for satisfying these requirements (e.g. *National Guideline for Accreditation of Rail Transport Operators*, *National Guideline for the Requirements of a Rail Safety Management System*).

National guidelines impose no legal duties or requirements. Failure to comply with a national guideline does not give rise to any civil or criminal liability. Where actions or outcomes are described as being mandatory in the guidelines, this is because those actions or outcomes reflect provisions in the *Rail Safety Bill 2006* or *Rail Safety Regulations 2006*.

The advice provided in the national guidelines has been expressed in general terms. Rail transport operators and other duty holders should not assume that the advice and any examples provided automatically apply to the operating conditions and environmental circumstances of their railway operations. They should be used as a guide only.

Acknowledgements

Within each State and Territory, the rail safety regulators are responsible for administering rail safety legislation and in some jurisdictions, this responsibility extends to the preparation of rail safety guidelines. Rail safety regulators' national activities are coordinated through their collegiate body, the Rail Safety Regulators Panel (RSRP) which together with the NTC is responsible for the development of this guideline.

The NTC and Rail Safety Regulators Panel (RSRP) would like to thank the members of the Rail Safety Package Steering Committee for their guidance and advice during the development of this guideline. Appreciation is also extended to those who made contributions during the public comment period. In particular, the NTC and RSRP acknowledges the contributions of Frank Hussey, Keith Wheatley and members of the reference group involved in the development of this guideline. Finally, the work of the NTC officers Tim Eaton and Jan Powning is acknowledged.

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1. Introduction

1.1 Purpose

The national model *Rail Safety Bill 2006* sets out requirements for rail transport operators to manage the fatigue of rail safety workers who carry out railway operations in relation to rail infrastructure or rolling stock. Specifically, Section 57 of the Bill requires rail transport operators to have a safety management system that includes, among other things, the preparation and implementation of a fatigue management program for rail safety workers in accordance with Section 67.

The purpose of this guideline is to assist industry, workers and their representatives, regulators and other stakeholders in understanding good practice with regard to fatigue management, and thus assist them in meeting their duties under Section 67 of the *Rail Safety Bill 2006*, and under existing /interfacing legislation.

1.2 Content and status

A growing body of scientific knowledge and informed operational experience across a range of industries, has seen a move away from prescribed approaches to working hour restrictions, towards a more systematic approach to managing fatigue-related risk. Through the establishment of fatigue management programs, organisations take a broader approach to fatigue management by addressing the principal causes of fatigue. Implicit in this approach is the recognition that factors outside the workplace can impact on fatigue, and that fatigue management involves rail transport operators, and individual rail safety workers or their representatives.

The objective of a fatigue management program is to reduce the likelihood of errors, incidents and accidents in which fatigue is a contributing factor.

A systematic approach to the management of fatigue-related risks is expected to lead to improved safety, efficiency, productivity and operational flexibility, while also satisfying the company's duty of care to its employees and the public.

This guideline provides practical guidance for establishing a fatigue management program and to adopting a systematic, consultative approach to identifying, assessing, controlling and monitoring the risk factors associated with fatigue. It includes advice by which rail transport operators can improve the management of fatigue-related rail safety risk thereby minimising the risk of the impairment of rail safety workers by fatigue;

The guideline identifies and provides advice on a range of issues that should be considered in implementing a fatigue management program. Safety is an extremely important issue, but there are also industrial, social, family, and productivity considerations to be taken into account.

Definitions provided by rail safety legislation apply within this guideline.

Use of the word ‘consider’ or ‘may’ indicates an option however the rail transport operator is free to follow a different course of action provided that it complies with the legislation.

Use of the word ‘should’ indicates a recommendation of the Rail Safety Regulators Panel, however the rail transport operator is free to follow a different course of action provided that it complies with the legislation.

Use of the words or terms such as ‘must’ or ‘mandatory’ indicates a legal requirement exists with which compliance is necessary.

Where terms are not defined within legislation the Macquarie Dictionary definition applies.

The fatigue management for rail safety workers guideline should be read in conjunction with the *National Guideline for the Preparation of a Rail Safety Management System*.

1.3 Context – the national model rail safety legislation

1.3.1 The national model rail safety legislation

The Inter-governmental Agreement for Regulatory and Operational Reform in Road, Rail and Intermodal Transport requires the development of a framework to improve and strengthen the co-regulatory system for rail safety. The national model Rail Safety Bill was developed by the National Transport Commission in accordance with the requirements of the inter-governmental agreement.

The model Rail Safety Bill was developed by the National Transport Commission (NTC) following an extensive review of the current co-regulatory approach to rail safety in Australia. It was developed in conjunction with representatives from the rail safety regulators and transport agencies of all states, territories and the Commonwealth, the rail industry and rail unions and other relevant regulatory agencies.

The model Bill is accompanied by regulations and both will be given legal effect when their provisions are reproduced in the legislation of each State and Territory.

The objectives of the model Bill place a high value on the effective management and control of risk to improve safety in railway operations and to promote public confidence in the safety of rail transport.

The model Bill brings rail safety legislation in Australia into line with modern regulatory approaches for safety. The key features include:

- general duties that apply to responsible parties and establish a ‘chain of responsibility’ for rail safety;

- risk management criteria based on the requirement to ensure so far as is reasonably practicable, that rail operations are safe;
- detailed requirements for the development and contents of safety management systems;
- clear criteria for the accreditation of rail infrastructure managers and rolling stock operators;
- clearer responsibilities for the Rail Safety Regulator and strengthened audit and enforcement powers; and
- a hierarchy of sanctions and penalties where breaches of rail safety requirements occur.

The meaning of *railway operations* to which the model Bill applies is very broad. It includes the operations and movement of rolling stock by any means; the construction of rolling stock or a railway, tracks or associated track structures; and the management, commissioning, maintenance, repair, modification, installation, operation or decommissioning of rail infrastructure and similarly, of rolling stock.

1.3.2 National guidelines for rail safety

This guideline is one of a suite of National Rail Safety Guidelines which are intended to assist rail safety regulators, industry stakeholders and other relevant parties with duties under the rail safety legislation to understand and comply with the new legislative requirements.

National guidelines are administrative documents that are intended to provide practical advice. Guidelines do not extend, add to or modify legislative obligations contained in the *Rail Safety Bill 2006* or *Rail Safety Regulations 2006*. Depending on the subject matter, guidelines may:

- articulate how rail safety regulators will behave when undertaking their functions to ensure that their processes are transparent to the duty holders (e.g. *National Guideline for Compliance and Enforcement of Rail Safety*);
- provide nationally consistent and/or integrated processes by which rail safety regulators will make decisions (e.g. *National Guideline for Uniform Administration of Accreditation*);
- assist duty holders with the interpretation of legislative provisions and provide practical guidance for satisfying these requirements (e.g. *National Guideline for Accreditation of Rail Transport Operators*, *National Guideline for Requirements for Safety Management Systems*).

National guidelines impose no legal duties or requirements. Failure to comply with a national guideline does not give rise to any civil or criminal liability. Where actions or outcomes are described as being mandatory in the guidelines, this is because those actions or outcomes reflect provisions in the *Rail Safety Bill 2006* or *Rail Safety Regulations 2006*.

1.4 Historical Context

A well formed platform of knowledge and practical experience in managing fatigue related risks has developed in the rail industry over the past decade or more.

Much of this expertise was derived from participation in the 'Rail Industry Shiftwork and Workload Studies' research consortium with the University of South Australia where considerable time and resources were invested in the research and development of innovative tools to manage fatigue. Between 1995 and 2005 all major operators, a number of specialist operators and the Rail Tram and Bus Union funded and participated in a variety of fatigue-related research projects which have contributed substantially to practice.

During 2003 to 2005 the Australasian Railways Association (ARA) developed a draft Code of Practice for Fatigue Management. Subsequently the National Transport Commission undertook a review of a range of fatigue management proposals including the draft ARA Code of Practice. This work has formed a strong basis for ongoing development of guidance, including the development of this guideline.

2. Fatigue and Rail Safety Workers

Fatigue has been identified as a causal factor in accidents and incidents on railway systems and is therefore an operational concern.

The degradation in the performance capacity of fatigued rail safety workers can be gradual and insidious, and effectively impairs or restricts the physical and mental resources that an individual has available to meet their job requirements.

Typical outcomes include reduced vigilance and alertness, impaired decision-making and a general deterioration in mood and motivation. Unusual or high workload situations and situations where people are under time pressure can contribute to fatigue related incidents.

2.1 Defining fatigue

Fatigue is a human condition primarily caused by prolonged wakefulness and/or insufficient or disturbed sleep. It includes physical, cognitive, psychological and physiological dimensions that interact with each other to reduce human performance and lead to uncontrollable sleep onset. The symptoms of fatigue include being sleepy, feeling physically or mentally tired, weary or drowsy; feeling exhausted or lacking energy; and behaving in a way that is consistent with these examples.

Fatigue may be caused by a range of factors, both work and non-work related, including:

- physical or mental exertion;
- long periods awake;
- not enough sleep or not enough restorative sleep;
- not enough rest breaks,

These factors may be compounded by person's circadian rhythm ('body clock'); environmental stress, age and personal health and fitness.

The endpoint of fatigue is sleep and will power will not overcome the biological pressure to fall asleep uncontrollably.

2.2 Factors affecting fatigue

There are five primary factors recognised as contributing to fatigue-related performance degradation, and good practice suggests that each needs to be included in any fatigue management system:

(a) the duration of a duty[1] period (time on task), and the rest breaks within and between shifts;

(b) inadequate sleep (or sleep debt), which results from inadequate duration and quality of prior sleeps;

(c) circadian effects, which involve working and sleeping against natural body rhythms that normally program people to sleep at night and be awake and work during the day;

(d) the type or nature of the task being undertaken (workload); and

(e) the work environment.

These factors are discussed below.

2.2.1 Time on task and workload

Time on task involves both physical and mental exertion. Research indicates that physical fatigue accumulates in a linear manner with respect to time[2]. However, estimating the level of fatigue accrued through mental exertion is linked more to the timing and duration of sleep and wake between shifts. Work shifts and schedules should therefore be reviewed collaboratively to ensure that adequate opportunity for sleep is provided during time away from work, including employer provided facilities for resting between shifts in 'barracks' and or relay vans.

Rather than *causing* fatigue in the traditional sense, workload has been described as a factor, which can either mask or augment the effects of fatigue. The relationship between workload and fatigue can be thought of as a u-shape, with increased likelihood of fatigue-related error when workload is either very high, or very low. Specifically, tasks that have a very low mental workload can result in loss of interest and boredom, sometimes referred to as an underload. Those tasks with a very high mental workload are sometimes described as presenting an overload for the attentional system. In situations of over and underload, the risk of poor performance is increased[3].

2.2.2 Sleep loss

To be alert and able to function well, every individual requires a specific amount of nightly sleep. The average for a normal adult is about 7-8 hours, but there are individuals who require more or less than this average.

When this individual 'sleep need' is not met, performance and alertness during periods of wakefulness are degraded. For most people, getting one to two hours less sleep than they need on one night (an acute sleep loss of one to two hours) is sufficient to degrade their performance and alertness the next day. This reduction is particularly marked if less than about 6 hours sleep is obtained. The effects of consecutive nights of reduced sleep accumulate into a sleep debt, with alertness and performance becoming progressively worse.

Recovery from the effects of sleep loss generally requires two nights of undisturbed sleep although recent experiments suggest that it can take longer to recover full waking function. Recovery sleep is usually deeper and more efficient, and the lost hours of sleep do not need to be recovered hour-for-hour.

Over the course of time, it becomes increasingly difficult to maintain task set, and performance can be impaired. In regards to driving, for example, literature has shown that symptoms of fatigue can develop within an hour of continuous driving (van der Hulst et al., 2001). In a study examining the time-on-task effects in driving, van der Hulst and colleagues (2001) found that fatigue and sleepiness increased as a function of time-on-task. It was also found that as fatigue increased, the aversion to continue driving and deterioration of performance also increased.

A study of Japanese high-speed train drivers showed an increase in physical signs of drowsiness as workload decreased (Endo & Kogi, 1975). These signs included increased yawning and change of the sitting position, as well as poorer performance on a secondary auditory task.

In practical terms, any work pattern that requires a person to change the timing of their sleep, and in particular night work, is likely to cause sleep loss. Because of the cumulative effects of sleep loss, it is important in roster design to consider the rate at which sleep loss is likely to be accruing across the roster. This should determine the number of consecutive shifts before a scheduled opportunity for recovery (at least two full nights off).

2.2.3 Circadian rhythms

People do not function, physically or psychologically, at a steady, unchanging level across the 24-hour day. All of the body's organs cycle through daily peaks and troughs of efficiency, known as circadian rhythms, which are coordinated by a biological clock in the brain.

The biological clock keeps the body 'in-step' with the day/night cycle by being sensitive to light and darkness, to work/rest patterns, and to the patterns of activity resulting from the influence of other people. The clock is genetically-based, and effectively programs the body for sleep at night and wakefulness during the day. It does not usually adapt much to shiftwork[4], because it is constantly being drawn back to its preferred (or default) orientation by the unchanged day/night cycle and the activities of the rest of day-active society.

With respect to rail safety workers, there are two aspects of circadian rhythms that are directly relevant to fatigue management and safety. There are circadian rhythms in alertness and performance capacity that can affect how a person responds to job demands during the course of the day and night.

Alertness reaches its daily low-point in the early hours of the morning (about 3-5am, or slightly later on the night shift), when the physiological drive for sleep is greatest. There is a second drop in alertness, and increase in sleepiness, in the mid-afternoon, corresponding to the nap time in siesta cultures. The urge to fall asleep at these times occurs even in rested people but is much stronger when prior sleep has not been adequate.

Both physical and mental performance capacity reach a daily low point at a similar time in the early morning (about 3-5am, or slightly later on the night shift). People working under time pressure, or with a high workload, are most likely to make errors at this time of day. Particularly for tasks that require vigilance, there is also a secondary slump in performance capacity in the mid-afternoon.

The time-of-day of best performance depends on the nature of the task. For example, people usually perform best around noon on tasks that require complex mental processing. On the other hand, they generally perform best in the early evening on tasks requiring physical coordination and vigilance.

In practical terms, the circadian rhythms in performance capacity mean that people cannot be expected to function equally well at all times of the day, and that they are likely to have most difficulty on the night shift.

There are also circadian rhythms that influence the ability to sleep. In other words, people simply cannot sleep 'at will'. As already mentioned, the physiological drive for sleep is strongest in the early hours of the morning (about 3-5am, or slightly later on the night shift). The physiological drive for waking up is strongest about 6 hours later. As a result, after a night shift, people frequently wake up spontaneously after only a few hours of sleep. The daytime sleep of night workers is consistently found to be about one third shorter and of poorer quality (and consequently less restorative) than their night time sleep.

In practical terms, the circadian rhythms in sleep propensity mean that it is possible to obtain more sleep in a night time rest period[5] than in a daytime rest period of the same length. Thus, compared with day work, night work is associated with a double negative effect of possibly less sleep during the day (with its attendant lowering of performance) and of working during the natural daily low-point in performance capacity during the early hours of the morning.

2.3 Managing fatigue risks

Traditionally, in a number of industries, a prescriptive regulatory approach to fatigue management specified maximum duty periods and minimum rest periods. This approach is seen as a simple administrative mechanism to provide some basic concepts to employers and workers alike. The prescriptive requirements have at times been supplemented by a system of exemptions to provide scope for flexibility in allowing services to operate safely.

However, the prescriptive approach did not address all of the known causes of fatigue affecting the workplace. By way of example, the recovery value of a specified minimum rest period depends on how much sleep a person is able to obtain. This in turn depends on the duration of the rest period and its adequacy in allowing sufficient time for sleep and other essential life activities. It also depends on a conscious decision of the individual to set aside sufficient time for sleep and on how much of the rest period coincides with the time of day when the brain and the body are primed for sleep by the circadian biological clock.

A well formed platform of knowledge and practical experience in managing fatigue related risks has developed in the rail industry. Much of this expertise was derived from participation in the 'Rail Industry Shiftwork and Workload Studies' research consortium with the University of South Australia where considerable time and resources were invested in the research and development of innovative tools to manage fatigue. Between 1995 and 2005 all major operators and a number of specialist operators and the Rail Tram and Bus Union funded and participated in a variety of fatigue-related research projects.

During 2003 to 2005 the Australasian Railways Association (ARA) developed a draft Code of Practice for fatigue management.

The National Transport Commission undertook a review of a range of fatigue management proposals including the draft ARA Code of Practice. The subsequent development of this guideline will assist the industry and rail safety workers (and their representatives) to manage fatigue related risks.

Industries generally have started to adopt a more systematic approach to managing fatigue-related risk by employing what are often referred to as fatigue management programs based on this growing body of scientific knowledge on the development of fatigue, its effects on human performance, potential countermeasures and informed operational experience.

These programs take a broader approach to fatigue management by addressing the principal causes of fatigue. Implicit in this approach is the recognition that factors outside the workplace can impact on fatigue, and that fatigue management involves rail transport operators, and individual rail safety workers or their representatives.

The fatigue management program applies to all rail safety workers. Safety critical work can be undertaken on a transport system at any time, day or night, in sometimes difficult circumstances and, at times, with demanding work schedules. The potential for fatigue should be foreseeable in such circumstances.

The rail industry employs a wide range of rail safety workers whose duties vary considerably in terms of the impact a fatigue related occurrence will have on them individually, on other rail safety workers, the public and the railway network as a whole.

It is up to rail transport operators to assess the extent to which fatigue will impact on different rail safety workers, involving those rail safety workers (and their representatives) and in consultation with them to develop their fatigue management programs accordingly.

Contractors and others who carry out railway operations are responsible for demonstrating how they will comply/are complying with all contractual and regulatory requirements (see section 2.4.1).

Risk analyses need to assess the likelihood for fatigue and the likely impact of fatigue impairment on all rail safety workers. The key criteria will be the extent to which the loss of performance due to fatigue impairment may impact on the safety of the rail network and the public. The nature of the task and the engineering controls available are both considered in the risk assessment[6]. Rail safety workers such as drivers, signallers, signal and train maintenance technicians, shunters, track workers and train controllers are examples of those that could be involved in a serious occurrence.

The Australian rail industry operates on the principle of eliminating risks so far as is reasonably practicable, and if it is not reasonably practicable to eliminate them, then to reduce them as far as is reasonable practicable.

The adoption of fatigue management programs by industry and the workforce has taken place within the existing regulatory safety environment. All industries have a general duty under occupational health and safety legislation to protect the safety of their workers.

These duties are at times defined in specific industry based legislation or regulations, by specific hours of work and rest requirements, or by guidelines.

Industry, or individual companies in consultation with industry unions often takes the initiative to develop fatigue management programs rather than rely solely on minimum regulatory requirements. This risk based approach ensures legislative obligations are met, workers and the general public are protected to the greatest degree possible, and that the costs of fatigue related occurrences are minimised.

2.4 Fatigue and the new regulatory framework

Arrangements for managing fatigue in the Australian rail industry involve management and employees. They comprise a mixture of regulation (transport and occupational health and safety), industry-based initiatives, company policies and industrial negotiation between companies, employees and rail unions. The arrangements also involve standardised health assessment programs in the National Health Assessment Standard for Rail Safety Workers.

2.4.1 National model Rail Safety Bill 2006

The new national model *Rail Safety Bill 2006* sets out requirements on rail transport operators to manage the fatigue of rail safety workers who carry out railway operations in relation to rail infrastructure or rolling stock. Section 57 of the Bill requires rail transport operators to have a safety management system that includes, among other things, the preparation and implementation of a Fatigue Management Program for rail safety workers in accordance with Section 67.

Section 57 (2) of the Bill requires rail transport operators, before establishing or reviewing or varying a safety management system, to consult as far as reasonably practicable with persons affected by the system, health and safety representatives, and unions representing affected persons.

Therefore the programs for the management of fatigue required under Section 67 will be developed by rail transport operators following consultation between the rail transport operator and rail safety workers and/or their representatives. The Fatigue Management Programs would then be included in the safety management system.

The *Rail Safety Bill* makes provision for the development of regulations, guidelines and compliance codes to assist in the implementation of its primary requirements. The fatigue management for rail safety workers guideline should be read in conjunction with the *National Guideline for the Preparation of a Rail Safety Management System*.

2.4.2 Interaction with other legislative requirements

Some health and corporate safety programs interact, to varying degrees, with rail safety worker fatigue management requirements. Such programs or initiatives may have a legal basis or be implemented as part of a rail transport operator's human resources policy. Where there is such interaction, each instance should be identified and managed in order to increase the effectiveness of the Fatigue Management Programs and to reduce duplication.

In this regard, when implementing their Fatigue Management Programs, rail transport operators need to consider legislation and programs that address such areas as health, drugs and alcohol and occupational health and safety. Where there is such an interaction, such documentation as the National Health Assessment and occupational health and safety standards should be consulted and appropriate reference made to them in Fatigue Management Program material.

The National Standard for the Health Assessment of Rail Safety Workers provides a sound basis for identifying and managing medical conditions associated with sleep disorders that impact on fatigue such as sleep apnoea. Similarly, it is envisaged the proposed National Guideline on Drug and Alcohol Management will have provisions that minimise the risks of impairment that can also impact on fatigue.

Occupational health and safety legislation integrates with rail safety legislation by placing a general duty of care responsibility on both the rail transport operator and the rail safety worker. Equally, management has an obligation to take account of each safety report in a 'just culture' work environment and not to make decisions that involves an unacceptable risk to safety.

Part 2 of the *Rail Safety Bill 2006* explains how the Bill fits in with occupational health and safety legislation and creates additional protections, rights and obligations necessary because of the special risks associated with railway operations. Sections 12 to 16 of the Bill outline the protection the Bill adds to occupational health and safety legislation, where occupational health and safety legislation prevails, the defences available in relation to the provisions of the *Rail Safety Bill*, and the inability of an offender to be punished twice for an offence. Section 70 sets out the specific duties of rail safety workers.

3. Fatigue Management Programs

The objective of a fatigue management program is to reduce the likelihood of errors, incidents and accidents in which fatigue is a contributing factor.

A systematic approach to the management of fatigue-related risks is expected to lead to improved safety, efficiency, productivity and operational flexibility, while also satisfying the company's duty of care to its employees and the public.

3.1 Framework for a fatigue management program

A fatigue management program is part of an overall framework for fitness for duty and a safeworking environment for rail safety workers, their organisations and the general public. The fatigue management program is an integral part of a rail transport operator's safety management system that provides a means of ensuring that employees' alertness and performance (including contractors and subcontractors) is not degraded to an unacceptable level as a result of fatigue.

Under the new national model *Rail Safety Bill 2006*, all rail transport operators will have a fatigue management program. However, the extent of detail required for the various elements of the fatigue management program will be scalable based on the results of the risk assessment undertaken, as occurs with safety management systems.

The diagram below summarises the proposed overall structure of a fatigue management program as part of the rail transport operators safety management system. The means of integrating the fatigue management program within the safety management system should be considered in terms of the guidance provided in the *National Guideline for the Preparation of a Rail Safety Management System*.

The level of detail of a fatigue management program might vary for different workforce groups within an organisation, and among different sized organisations.

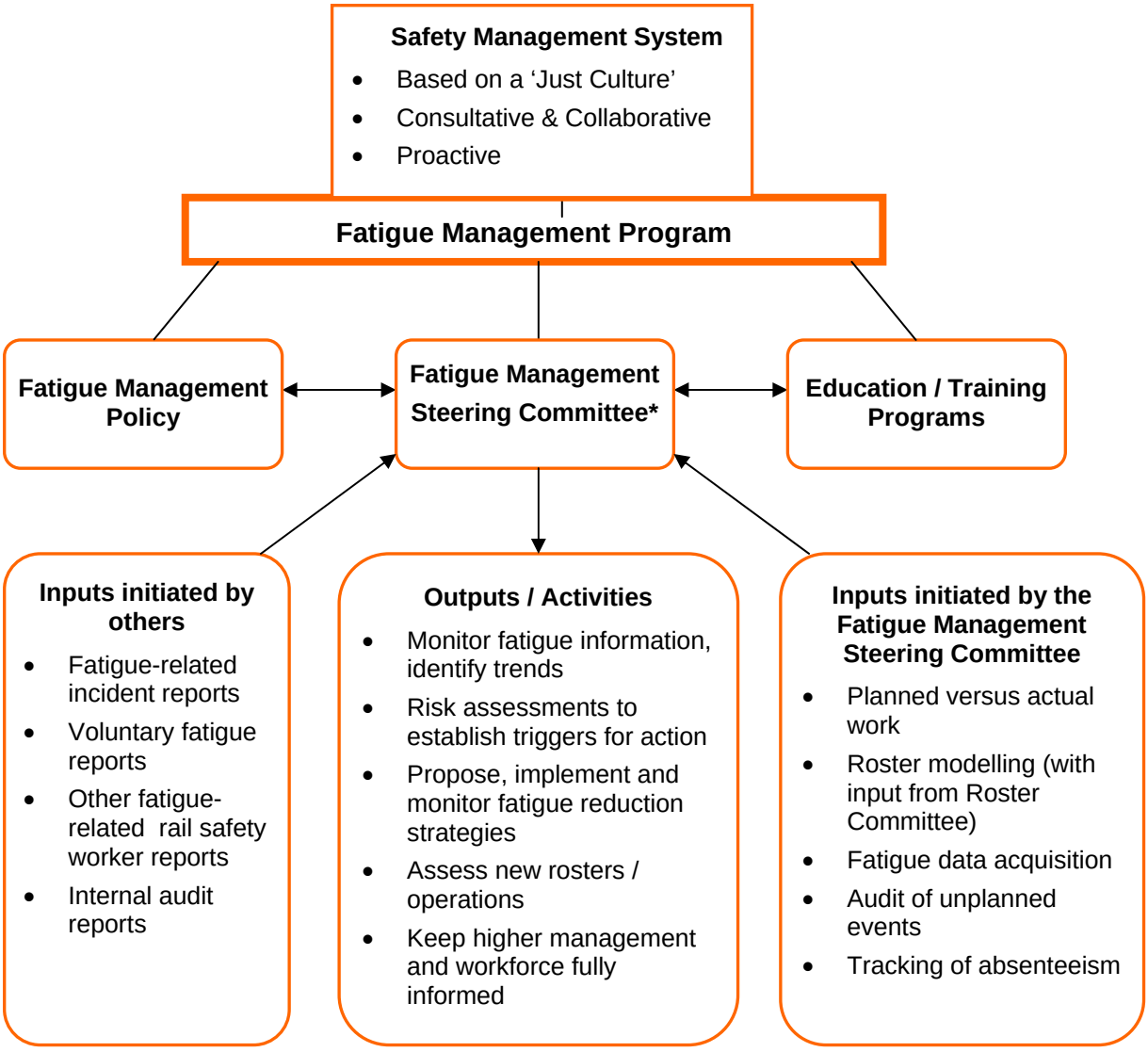
3.1.1 Fatigue management steering committee

While fatigue is one of a range of important risks to be managed within the overall safety management system, benefits can be achieved by the establishment of a Fatigue Management Steering Committee which can provide a focal point for strategically coordinating all fatigue management activities within the organisation. Its functions include monitoring fatigue information sources, investigating fatigue-related issues, consulting with rail safety workers and their representatives and making recommendations on priorities for targeting fatigue management resources, etc.

The committee may be a specially convened group for this purpose, or it may be a function of an existing management committee, roster committee or safety committee, at organisational, divisional or workplace level, depending on the size and nature of the rail transport operator, or it may work closely with such existing committees. Representatives of employees (elected by employees) should be included on the committee(s).

The composition of the Fatigue Management Steering Committee should include balanced representation from the company (including people responsible for such areas as workforce planning/rostering, including roster committee where applicable, training, safety and operations). The Committee should also include rail safety workers and their representatives, with scientific/specialist advice available as needed.

Figure 1. Fatigue Management Program Structure



3.2 The elements of a fatigue management program

The fatigue management program should include elements such as:

- a fatigue management policy[7];
- limits on hours of work, and provisions for adequate rest breaks;
- rostering design and management of work patterns;
- fatigue risk assessments and subsidiary assessments such as specific task/decompositions;
- 'competency based' education or 'awareness training' programs as appropriate;
- a rail safety worker fatigue reporting mechanism with associated feedback;
- procedures and measures for assessing/monitoring the fatigue management program;
- procedures for reporting, investigating, and recording incidents that are attributable wholly or in part to fatigue; and
- a process for review of the fatigue management program and its risk treatments/controls.

These elements are discussed individually below.

3.2.1 Fatigue management policy

The company's fatigue management policy is an integral part of its safety policy. The policy should be displayed as a statement of commitment and intent by the rail transport operator and signed by the CEO or other corresponding authority. It should be distributed to all employees, and include the following elements:

- commitment to the fatigue management policy from the highest levels of the organisation;
- commitment to provide as appropriate units of competency or awareness training (to meet the requirements of Section 68 of the national model *Rail Safety Bill 2006* and to provide resources in support of the fatigue management policy;
- definition of the shared responsibilities of the company management, employees and, where appropriate, contractors; and
- assurance to act so far as reasonably practical on any corrective actions regarding fatigue management arising from audit findings.

3.2.2 Tourist and heritage rail transport operators

Tourist and heritage rail transport operators' do not generally operate at night and their fatigue management policy may reflect the consequent lowered risk of work related fatigue arising from this aspect of their operations. However many of their workers and volunteers have primary employment outside this sector and may in fact be using rest and recreation time from that employment to engage in activities with the tourist and heritage rail transport operator.

Hence these operators fatigue management policy should include provisions for the management of their workers and volunteers total working hours in primary and secondary employment, together with commuting times to the tourist and heritage operation, to ensure their fitness for safety critical duties.

Section 2.4.2 provides some guidance on situation where night work is encountered.

3.2.3 Limits on working hours and fatigue management planning

Limits on working hours are established as part of the overall mix of commercial, industrial and safety objectives of a rail transport operator. Rail transport operators should identify those rail safety workers for whom the working hours and work patterns need to be controlled and in consultation with rail safety workers, set limits to control the hours that rail safety workers work, and their rest periods.

In assessing the maximum limits for hours worked by rail safety workers the following issues would at least be addressed:

- factors that might affect the onset of fatigue such as job design; workload and working environment; i.e. tasks requiring sustained vigilance, or low levels of workload, (e.g. repetitive routes), time of day, insufficient rest before starting night or early morning work, staffing/train crewing levels, control of overtime, quality of company provided rest and recovery facilities, time spent travelling while on shift and commuting home after long shifts, poor timing of meal breaks in early shifts, the timing of breaks);
- the maximum length of any work shift or period of duty (operating limits)[11];
- the minimum rest period between any periods of duty[12];
- the maximum number of hours to be worked in any seven-day and/or 14 day period;
- the minimum frequency of rest periods (continuous time off)[13];
- the maximum number of consecutive shifts[14]; and
- the maximum number of consecutive night shifts[15].

In situations where there are medium to high probabilities of risk, it is very important to give consideration to the adequacy or otherwise of control measures already in place or planned to mitigate the effects of fatigue such as vigilance systems, automatic train protection systems and crewing levels. As fatigue risk increases so should the number and effectiveness of control measures. Control measures should also be considered for rail safety workers on permanent night, afternoon and early morning shifts when setting their limits.

Attachment 1(a) provides further information on methods available to control fatigue risks.

The design of working patterns, in consultation with the rail safety workers concerned, should attempt to:

- minimise the buildup of fatigue by restricting the number of consecutive night and/or early morning shifts[16, 17];
- allow fatigue to dissipate by ensuring adequate rest periods before, and breaks during, a period of duty to reduce the likelihood of fatigue, and between blocks of consecutive shifts[18];
- ensure that shift rotations and shift changes are planned in order to allow adequate sleep opportunities and to minimise sleep disturbance[19];
- take into account the process of circadian rhythm adaptation when rail safety workers return to work after a period of extended leave -the first shift after leave should not be rostered as a night or early morning shift; and
- take account of staffing/train crewing levels, job design, tasking and workload, the working environment, the shift system in operation, overtime, the frequency of breaks/ recovery time during periods of duty, etc.

Arrangements to cover emergencies / unforseen circumstances and/or rail safety workers being called in for duty in addition to rostered shifts will help to manage the consequent increased levels of fatigue-related risk. See section 2.6. In addition, post-incident reviews of occasions where limits have been exceeded, and of the circumstances, will help to prevent and/or minimise the consequences of similar occurrences in the future.

Practical tips: Inclusion in Fatigue Management Policy

(a) A specified line of accountability for managing fatigue risks in the organisation

(b) Identification of the work groups covered by the Fatigue Management Program

The following should be considered:

- the safety consequences if the rail safety worker should become impaired (task risk analysis);
- the nature of those consequences (public safety, injuries, damage to equipment, financial);
- if the rail safety worker works alone or with a team, or works alone at night;
- the arrangements for managing and accountability for the Fatigue Management Program;
- identification of fatigue reporting mechanisms;
- requirements for managing the risk arising from unforseen circumstances[8] and circumstances where approved maximum limits may need to be exceeded in an emergency[9];
- fatigue management operating procedures and standards for different work areas, regions and different types of rail safety work (e.g. single operator) where applicable; and
- a 'just culture'[10] that encourages honest reporting of essential safety related information and errors while establishing clear accountability for actions supported by a systematic way of reporting errors and where necessary following up recommended safety actions.

Practical tips: Establishing limits on working hours and rest

The key issues for a fatigue management system are to focus on managing fatigue and its pre-cursors, to ensure that they are well managed, and to focus on key design principles for developing a regulatory system based on managing fatigue. In the design of schedules, providing continuous rest opportunities for sleep to manage the fatigue risk is paramount.

The actual requirements for individual classes of rail safety workers will depend on the outcomes of the risk assessments undertaken for them. Those rail safety workers who occupy positions with a low likelihood of fatigue related risks will be able to have less onerous requirements placed on the management of their fatigue levels – though still be within reasonable bounds. As the likelihood of fatigue related risks increase, so will the need to manage the risks more closely. This does not just mean having more restricted working hours, but examining the total management of rest, time at work, breaks, starting times etc in the light of the risk profiles and other environmental, social and health factors.

It means balancing potentially greater fatigue risk by compensatory time for rest and recovery as well as by introducing control measures to offset possible increases in fatigue levels (more details are set out in Attachment 1(a)).

Determine limits on working hours and work patterns

Different limits may be set for different situations; for example, a greater number of consecutive day shifts may be allowed than night or early morning shifts. Where it can be foreseen that the limits are likely to be exceeded more than occasionally, for example where hours of work are already close to the limits, organisations should plan accordingly and make any necessary contingency provision to ensure that the limits are not exceeded.

Shifts where a rail safety worker is engaged in training or safety briefing should not be a reason for non-compliance with the limits on hours of work. These should be regarded as working shifts as they are not opportunities for sleep.

Similarly the existence of long standing vacancies, or a block of maintenance work extending over a few days (e.g. plant shut down or blockade working), training delays or organisational changes in the company should be foreseeable problems, and are to be managed in accordance with providing adequate sleep opportunities for the rail safety workers affected.

In managing fatigue any local agreements on rostering and working hours that have been made should be compatible with the stated maximum limits and any organisational policy. The risks associated with fatigue can be minimised when there is commitment to act from the rail transport operator, workers and their representatives.

Length of periods of duty

There is evidence that human performance deteriorates significantly when people have been at work for more than 12 hours, and current industrial instruments set a limit of up to 12 hours work. Rail transport operators need to ensure shifts for safety critical workers do not exceed that length except in the case of emergencies and unforseen circumstances where they must consider the nature of the work those workers could be carrying out after the twelfth hour. (See 2.6)

Below 12 hours, the extent to which fatigue occurs may depend on other aspects of the working time pattern such as the adequacy of breaks taken during the shift and the length of interval since the previous duty (as well as on other factors such as the nature of the work and the working environment). Even shifts of 8 hours or less can be fatiguing if the work is very intense or demands continuous concentration, or there are inadequate breaks.

The traditional daytime work period of 8 hours is increasingly being challenged with shifts up to 12 hours being introduced. The effects of these changes have been the subject of considerable debate. Currently, the evidence indicates that 12 hour shifts have benefits for social and leisure time (Johnson & Sharit, 2001; Kaliterna & Prizmic, 1998; Smith et al, 1998; Tucker, Smith, Macdonald, Folkard, 1998) as they result in a compressed work week which allows longer continuous periods away from work between the compressed blocks of work shifts. However, there is other evidence that suggests that longer work shifts have adverse effects on performance.

Practical tips: Establishing limits on working hours and rest (cont)

It seems that the 50 percent longer work period of the 12 hour shift can result in greater fatigue, (Macdonald & Bendak, 2000) lowered arousal (Rosa, 1991) and poorer safety-related performance (Baker, Olson, & Morisseau, 1994; Tucker, Smith, Macdonald, Folkard, 1998) towards the end of the shift.

In practical terms this means that work load allocation, especially for safety-related work, needs to take these potential effects on fatigue and performance into account. Consideration should be given to avoiding or eliminating safety-critical activities towards the end of long work shifts.

There is very little guidance in the research literature on the scheduling of breaks within shifts. While there is agreement that rest breaks during shifts have significant benefits with respect to managing fatigue, the precise timing of breaks in order to obtain the best benefits is unclear. There is evidence that short breaks around every two hours can reduce the risk of industrial accidents although further research is needed to confirm these findings (Tucker, 2003). Other research indicates that caffeine consumption combined with short naps may enhance the benefits of breaks, especially during the later stages of a long shift or night work (Horne & Reyner).

In practical terms, there is very little guidance on the timing within the shift and the duration of breaks. However, a responsible approach should encourage rail safety workers to take breaks in response to the onset of feelings of fatigue and should ensure that breaks are scheduled regularly within each shift. Details of the references are provided in the endnotes.

Intervals between duties

The daily rest interval for safety critical workers needs to be adequate to enable them to return to work rested after a full sleep. The general standard in the rail industry is a minimum time off between shifts of 12 hours. If rest intervals less than agreed in the fatigue management program occur when workers are operating away from home or in emergency or other circumstances (this situation minimises the time available for sleep) - it is important to ensure that other daily rest intervals in the shift pattern are of adequate length and that breaks during the shift after the short interval are adequate.

Arrangements where workers rest away from home in specially provided accommodation, or rest vans on relay work, the provision and arrangements of such facilities must ensure the maximum sleep in the time available, in order to reduce the likelihood of fatigue.

The quality and quantity of sleep in rest vans (associated with relay working) has been the subject of recent studies (How Well Do Train Driver's Sleep in Relay Vans?, Lamond, Darwent and Dawson (2005); Train Drivers' Sleep Quality and Quantity during Extended Relay Operations; Jay, Dawson and Lamond (2006)). While quality was found to be comparable with home sleep, quantity of sleep showed a distinct circadian effect (lower during the day) resulting in the accumulation of sleep debt.

There is evidence that time spent travelling to and from work does not provide rest in the same way as time spent at home. It is important to monitor long travelling times to and from work and consider how this can reduce the opportunity for daily rest and thus increase the risk of fatigue. Where a large proportion of a group of safety critical workers have long travelling times, this ought to be taken into account when considering changes to working time patterns.

Recovery time

There is clear evidence about the value of rest days in enabling workers to 'recharge their batteries' and to maintain their work performance. The planning of rest day arrangements for safety critical workers needs to take account of the length of shifts and of daily rest intervals. The frequency of rest days and the length of the recovery time are both relevant.

Workers will benefit from regular (at least fortnightly) recovery periods where they can have at least two full nights sleep. These are particularly important for shift workers and most especially those working nights. This is because shortened or interrupted sleep over a period can result in them spending part of their rest day sleeping.

Practical tips: Establishing limits on working hours and rest (cont)

Shift work

It is in the nature of the railway business that many safety critical workers work rotating shifts, and that these may include night work. Workers may have difficulty in adjusting to varying sleep patterns, or to daytime sleep; this is an effect of the internal 'body clock' regulating sleep and wakefulness, which corresponds to the natural cycle of night and day.

In addition, despite the responsibility of the rail safety worker to obtain rest, it may be difficult at certain times to find the right conditions at home for daytime sleep. As a result there may be reductions in the quantity and quality of sleep, and the effects can build up over a period. On average a person may lose 2 hours[20] sleep for each night shift worked.

The resulting fatigue, which safety critical workers may experience, is likely to be most noticeable on the night or early morning shift, and to be more marked the more monotonous or repetitive the task.

Whilst people prefer to work more consecutive shifts in order to take a block of days off afterwards this needs to be balanced with the risk of higher levels of fatigue from the greater number of shifts worked. Research shows that a shift pattern that changes about once a week is likely to be more difficult to adjust to than a more rapidly or more slowly changing one.

Current thinking suggests that starting a shift later than the previous one (forward rotation) may be less of a problem than starting a shift earlier than the last one (backward rotation). Some shift patterns can result in a short daily rest interval of perhaps only 8 hours[21]; a pattern that included such a short interval would be particularly unfavourable for safety critical workers.

For safety critical workers who are on call, or whose starting time frequently varies with very little notice given, the uncertainty makes it difficult to plan suitable sleep time and as a result fatigue is more likely. A particular example is drivers on a 'spare turn' who can have large variations (up to 4 hours) in their duty start time. If consecutive duty start times vary by 5 hours or more, then fatigue is highly likely to be a problem.

As far as possible, shift start times and on call duties should be planned to avoid variations of more than 2 hours[22]. Where this is not possible then additional control measures such as additional rest breaks within a period of duty or a shorter shift length should be considered if feasible. A series of consecutive rostered duties with large variations in start times should not be planned. Further guidance on work patterns that require attention can be found in Attachment 2.

3.2.4 Rostering considerations

Roster development incorporates a wide range of commercial, social, family, industrial and safety objectives – fatigue is only one aspect of this mix. While rail transport operators need to consider the broader aspects of rail safety workers' duties in roster development, from a fatigue safety point of view, rosters should take account of the following:

- ***Work-related fatigue***

  Rostering rules and work arrangements should take account of such considerations as:

  - prior work history, location, work environment, tasking, staffing/train crewing levels, single person operation etc.
  - the previous and current work history of volunteers and/or contract labour should be recorded.
  - roster stability (planned versus actual time worked) and changes in rosters by staff should be monitored.

- **Non-work-related fatigue**

  Assigning individuals to lines on rosters and/or operational work schedules should, where practicable, be performed at local/depot level where rosterers and/or supervisors/driver coordinators may have personal knowledge of those individuals in respect of:

  - difficulties with sleep at home because of family circumstances;
  - the time required for employees to commute to/from work;
  - secondary employment (it is important to ensure that such activities do not compromise the safety of their primary employment or infringe fatigue management policies and procedures).
  - Additionally the individuals themselves can be assisted in managing non work related fatigue through:
  - implementation of a self-reporting program based on a 'just culture';
  - education and training aimed at ensuring that all employees are aware of their responsibilities with respect to fatigue management and can make informed decisions to ensure fitness for duty.

  Work related fatigue can impact on non-work related fatigue. If the number of working hours and/or consecutive shifts are sufficiently high an individual may sacrifice sleep in order to fulfil domestic and social responsibilities.

- **Non-standard work, variable start and finish times, staff rostered on-call and contractors**

  In some sectors of the rail industry it is not possible to roster work to a standard pattern of work. There may be variable start and finish times, irregular and non-rostered hours of work, staff rostered on - call and the use of contractors whose previous hours of duty may not be known.. In sectors of the industry involved in the movement of bulk products, blank line rostering may be used whereby unpredictable start and finish times are caused by port and shipping schedules.

  The employees' fatigue management is controlled by provisions in industrial instruments and increasingly, by the use of bio mathematical models. However, structural changes in the rail industry have seen the engagement of casual/contractors to undertake a wide range of rail safety work, where the prior work history of the contractor is unknown. In these circumstances, the rail transport operator should implement a system, which will allow the organisation to utilise as appropriate, alternative methods to assess the risk of fatigue. Where these bio mathematical models are used, results should be treated with caution as the efficacy and accuracy of the models are the subject of ongoing research.

One such method could be to assess the amount of sleep obtained in the 24 and 48 hour periods prior to commencing work (a minimum of 6 hours sleep in the preceding 24 hours and 14 hours in the preceding 48 hours respectively). These would be indicative and would set minimum levels that might be acceptable on an occasional basis, but should not be used as an indicator on a continuous basis. It should also be recognised these indicators relate to the amount of **sleep**, **NOT** breaks between shifts (for example to obtain six hours **sleep** during daylight hours might require a break of up to10 hours).

Another method might be to implement a system to assess if a worker is exhibiting symptoms and behaviours indicative of the effects of fatigue (Attachment 1(b) has some examples though they may not be exhaustive).

There may also be opportunities to review the fatigue management programs in this part of the industry to improve the family and social life of the employees and further research is recommended.

Contractors are required to work in accordance with the safety management system of a rail transport operator (as well as their own safety management system), including their fatigue management program (see clause 71 of the national model *Rail Safety Bill 2006*).

3.2.5 Fatigue risk assessment

Risk assessments form the fundamental basis for a sound fatigue management program. A properly constructed and completed risk assessment undertaken in conjunction with those who perform the rail safety tasks provides the underpinning of a program that will address the risks and provide controls that will either eliminate or minimise fatigue related risks.

As outlined in the national model *Rail Safety Bill 2006* and associated guidelines, the principles of *AS/NZ4360:2004 Risk Assessment*, *HB 436:2004 Risk Management Guidelines*, *HB205:2004 OHS Risk Management Workbook* should be used for undertaking risk assessments and include the following main steps:

- identification of the sources of risk associated with fatigue;
- an assessment of the level of risk (likelihood and consequence) associated with these factors;
- identification of appropriate risk treatments to address these risks including timeframes and accountabilities for implementation; and
- evaluations of the effectiveness of these risk treatments, once implemented.

If there are unanticipated negative consequences of the fatigue management program, the risk assessment should be reviewed, and appropriate adjustments to controls implemented. Should there be a change in operating conditions, or any evidence of a change in risk, such that the operating conditions are no longer valid, the risk assessment should be reviewed.

Practical tips: Rostering Principles

General

Each rail transport operator should develop, in consultation with their rail safety workers and their representatives, a set of rostering principles that seek to minimise fatigue related risk. The rostering principles should include:

- the process to be followed for roster development including reference to the inclusion of rail safety workers and their representatives in this process, (including roster committees where relevant) and the provision of relevant data;
- design principles underlying roster development such as work/life balance;
- a framework that facilitates the assessment and review of rosters for their potential to lead to work-related fatigue. This may involve utilising an accepted mathematical algorithm that evaluates the roster using an evidence based methodology;
- workforce planning to ensure there are adequate rail safety workers to cover rostered and other planned work requirements without recourse to excessive amounts of overtime;
- staff contingency planning, for example sick leave coverage or unplanned maintenance;
- overtime and call-out procedures; and
- a strategy for managing rail safety workers who have returned from an extended period of absence from the workplace such as annual leave.

Design principles for rosters

Scheduling the work of rail safety workers to eliminate or minimise potential health and safety risks to all stakeholders is essential. Fatigue experts consider that the following performance-based principles should underline the design of work schedules:

- minimise the occasions on which rail safety workers are required to work in rail safety duties of long periods (i.e. from sign on to sign off);
- ensure adequate rest and recovery periods after night shift working;
- ensure that any rostered period of extended hours is compensated with a longer break before resuming a shift;
- avoid rapid shift changes that do not provide opportunity for adequate sleep (especially from night shift to day shift);
- ensure rail safety workers have a minimum of number of hours free of work in a 14-day period to aid in fatigue recovery, including two nights sleep;
- minimise consecutive night shifts in order to limit reductions in performance levels caused by circadian disruption, fatigue and reduced alertness; and
- take into account the process of circadian rhythm adaptation when rail safety workers return to work after a period of extended leave.

Roster development

Organisations should consider the questions below in designing work patterns:

- overall, is the proposed working time pattern likely to increase the risk of accidents arising from fatigue?; and
- does the proposed working time pattern have any particular feature, which could give rise to fatigue risks?

Further guidance to features of work patterns that require attention can be located in Attachment 2.

Practical tips: Identifying the sources of risk associated with fatigue

It is necessary to gain an understanding of the exact nature and extent of the problem. In the case of fatigue, this can be achieved by applying a systematic approach to the identification of all risk factors that have the potential to contribute to a rail safety worker or group of rail safety workers experiencing fatigue. It is essential that rail safety workers and/or their nominated representatives are consulted as part of this process. Risk factors can be identified through:

- findings from occurrence investigations;
- discussions with rail safety workers and/or their representatives;
- rail safety worker surveys or questionnaires;
- research reports and articles;
- trends in safety related data;
- inspections and task analyses; and
- audit results.

Rail transport operators need to be aware of the factors which affect the onset of fatigue, and design tasks and the working environment to maximise alertness so far as is reasonably practicable. (See attachment 1(b)).

Any risks which might arise with a significant change of working patterns, relevant recognised good practice, or from changed operating standards should be identified and assessed.

Practical tips: Assessing the Level of Risk

Risk assessment involves considering all reasonably foreseeable events, managing the likelihood that injury or harm to any person's health (workers or public) can occur, and/or damage to company equipment/ services and the environment, and the consequences of exposure to a hazard. Risks are then ranked in order of significance to allow risk treatments to be appropriately implemented, so far as is reasonably practicable to ensure safe operations. A risk assessment can be conducted for each of the risk factors identified below and incorporated into the Fatigue Risk Management Plan.

The risk assessment should relate to each operational area for which a proposal is being developed. If there are significantly different operating conditions, tasks or work patterns within different divisions of the organisation, it may be necessary to prepare more than one risk assessment and/or obtain more specific expertise and tools. Operators can build on existing risk assessments where there are comparable elements.

Simple questions that might help work through the process

Is there a problem?

- Do the rail safety workers work at night?
- Do they work long periods at night or a number of continuous night shifts? (higher probability)
- Do they work alone at night?
- Do they commence work in the early hours of the morning?
- Are their hours of work likely to introduce a fatigue problem (refer Section 2.10)
- Are the proposed schedules likely to increase the risk of occurrences from fatigue or have any particular feature that could give rise to fatigue risks?

If the answer to each of these questions was 'Yes', what risk is involved?

- What tasks are these workers undertaking – job design, workload and working environment, repetitive routes, etc?
- Has a task risk analysis been done?
- Have the relevant rail safety workers been identified from the task risk analysis?
- What could go wrong if one of these suffered an involuntary sleep episode of 1-5 minutes?

Simple questions that might help work through the process (cont)

Are any controls in place that would reduce the risk to acceptable levels?

- Working time and recovery/breaks limits set by awards, agreements, regulations.
- Use of mathematical models or other tools to assess rosters and work schedules.
- Technical devices to ensure vigilance, or to minimise errors.

If there is still an unacceptable risk, can it be measured by data to support the need to act?

- Incident or accident data indicating fatigue as a contributing factor.
- Employees reporting fatigue (is there a non-jeopardy arrangement to do so?)
- Are the patterns and levels of absenteeism indicative of fatigue causes?

Further guidance on the risk assessment process can be found in Attachment 1(a) – ' risk based approach to fatigue management'.

Practical tips: Identifying appropriate risk treatments to address these risks including timeframes and accountabilities for implementation

Upon completion of the risk assessment process, it will be possible to identify priorities for developing risk treatments. Risk treatments should be developed for each of the risks identified and incorporated into the fatigue management program.

In addition, the nature of the controls can become more rigorous in the sense of documentation, monitoring and review frequency and audit processes as the risk increases. While risk treatments will vary from rail transport operator to rail transport operator, they could include but not be limited to such strategies as:

- implementation of rostering principles;
- assessment of all rosters to determine that they provide adequate sleep opportunity;
- assessing fitness for work of rail safety workers prior to commencement of a shift;
- assessment of alertness of rail safety workers through subjective means during a shift using observation by other rail safety workers and monitoring communications where practicable, and other means such as the response to vigilance devices;
- provision of adequate rest/meal breaks to help prevent build up of fatigue during a shift, and ensuring they are taken;
- implementation of local call-out procedures;
- provision of rest or sleep facilities that provide adequate rest in instances where rail safety workers are required to work away from home and/or engage in relay working. These facilities will be subject to minimum noise levels, be well ventilated and have the ability to control levels of light and temperature;
- mandatory attendance at a competency based fatigue management training course and refresher courses;
- giving consideration to the effect of commuting time when managers prepare or adjust rosters and workers prepare themselves for duty;
- providing resting facilities after long shifts and/or alternative transport to reduce the risk associated with commuting home;
- assessment of master and working/daily rosters, as well as actual working time to ensure changes do not create fatigue related risks; and
- any indication of sleep disorders in medical assessments or notification by rail safety worker.

3.2.6 Fatigue management training

The development and implementation of a training program is a critical element of the rail transport operator's Fatigue Management Program. The purpose of the training program is to ensure that the rail safety workers and staff have the competence to implement and comply with the rail transport operator's Fatigue Management Program in a manner that is appropriate to and commensurate with their roles and responsibilities.

Requirements for the rail transport operator to ensure that each rail safety worker on their railway operations has the competence to carry out their work are addressed under clause 68 of the national model *Rail Safety Bill 2006*.

These requirements state also that in assessing the competence of the rail safety worker (or causing the assessment) the rail transport operator must make reference to any applicable units of competence recognised under the Australian Quality Training Framework (AQTF).

Units of competence and/or qualifications which are recognised by the AQTF have been defined by industry through an industry skills council. They contain descriptors of workplace outcomes to be achieved, the criteria for performance and guidelines for assessing competence - combined they form an industry training package.

Rail safety work is most extensively covered by the Transport and Distribution Training (TDT) Package which is developed by the Transport and Logistics Industry Skills Council. The TDT Training Package contains a number of units of competence for fatigue management. They are designed respectively for individuals undertaking rail safety work, those who are responsible for administering the Fatigue Management Program and staff with responsibilities for the management, supervision and rostering of rail safety work.

A fatigue management training program intended for rail safety workers, including those with rostering responsibilities, should as a minimum provide the skills and knowledge required to:

- identify the causes and understand the risks associated with fatigue;
- recognise and act upon the signs and the symptoms associated with fatigue;
- understand the rail transport operator's Fatigue Management Program, implementation plan, strategies and procedures; and
- apply fatigue management strategies to minimise fatigue during work activities and to maintain or enhance sleep opportunities and sleep quality.

Where the rail transport operator has staff with responsibilities for administering the Fatigue Management Program, or where consultative committees are established to address rostering/ fatigue issues training should be provided of a level that is aimed at ensuring they have the competence to undertake this role.

This would include for example, the skills and knowledge to:

- develop, implement and monitor a fatigue management implementation plan, strategies and related procedures;
- participate effectively in consultative committees
- assess rail safety workers' competence in fatigue management; providing feedback on any shortcomings in their fatigue management skills and knowledge;
- recognise breaches of fatigue management policies, procedures and regulations; and
- report to management on the implementation of the fatigue management plan.
- assess the application of bio mathematical models in the particular circumstances.

Staff with responsibilities for the management and/or supervision of rail safety workers should also receive the appropriate level of training for fatigue management. This is to ensure they have the appropriate skills and knowledge with respect to fatigue management in order for example, that they have the competence to:

- establish, manage and/or improve the fatigue management implementation plan and organise adequate resources and operational systems;
- facilitate the training and assessment of staff competencies in relation to fatigue management;
- act appropriately upon reports on the implementation of the plan and any identified breaches of fatigue management regulations;
- ensure that the rail transport operator's systems are compliant with fatigue management regulation and identify legal requirements and liabilities and their own and others' responsibilities in relation to the rail transport operator's Fatigue Management Program.

In particular, fatigue management training should be a high priority requirement for any rail safety worker or staff who are directly involved in the preparation or implementation of rosters. It should focus on rostering principles set out in these guidelines, the ways in which tools are to be used in the processes and the strengths and limitations of the tools used.

Where practicable, family members or partners of rail safety workers should be encouraged to participate in a fatigue awareness program or be provided with awareness raising or educational materials.

Practical tips: Fatigue management training

For rail safety workers whose work has a low likelihood of serious fatigue risks, training programs might comprise an awareness package. As a minimum, the training process should enable these rail safety workers to:

- identify the impacts associated with fatigue on safety and health;
- understand the symptoms associated with fatigue;
- understand sleep and how to enhance its quality;
- understand the rail transport operator's fatigue management policy, as well as its local organisational procedures in relation to other employment; and
- identify and implement appropriate strategies for minimising fatigue-related risk.

For other rail safety workers with a higher likelihood of fatigue risk, a minimum, training process should be competency based and enable rail safety workers to:

- identify the risks associated with fatigue;
- understand the Rail transport operator's fatigue management risk policy, procedures and Fatigue Management plan;
- fully participate in the risk assessment process and development of fatigue management programs, work rosters and changes to working arrangements;
- maximise rest and recovery opportunities between shifts;
- identify and implement appropriate strategies for minimising fatigue-related risk at work; and
- assist in judging whether their behaviour is consistent with safe practices and relevant fatigue management policies.

Specific training should be a high priority requirement for any staff who are directly involved in the preparation or implementation of rosters. It should focus on rostering principles set out in these guidelines, the ways in which tools are to be used in the processes, and the strengths and weaknesses of the tools used. Depending on the level of risk, this may involve competence at levels beyond TLISC 'Apply Fatigue Management Strategies'. The education of these workers is critical to the successful implementation of fatigue programs.

3.2.7 Fatigue reporting

Good safety management practice ensures all hazards and occurrences are identified and recorded. The more hazard data are captured, analysed, and resultant safety actions deployed, the more robust the safety management system will be. Fatigue management is no different and fatigue related occurrences should be identified and recorded through the organisation's normal methods. It is important to ensure that:

- rail safety workers are encouraged to be open about reporting fatigue and incidents;
- supervisors capture and record fatigue related hazards and actions;
- the resultant rail transport operator's fatigue data base is used to improve its fatigue management program; and
- information is provided regularly to the fatigue management program steering committee where established, or appropriate committees.

Rail transport operators should take care to ensure that, so far as is reasonably practicable, rail safety workers who report for duty when they are unfit owing to fatigue, or who, through the course of their work shift, report or are reported impaired due to fatigue, do not carry out, or continue to carry out, rail safety work. (See attachment 1(b))

Any reporting of fatigue should be undertaken in a non-punitive 'just culture'. In the event of a rail safety worker being unfit due to fatigue, appropriate control measures (such as providing sufficient rest) are to be applied before the rail safety worker commences or recommences rail safety work.

3.2.8 Procedures and measures for assessing / monitoring the fatigue management program

It is also important to use the information collected to monitor and assess the outcomes of the fatigue management program. This can be done by putting in place arrangements for monitoring and managing fatigue to assess how effectively they are controlling the fatigue-related risks. Recording and monitoring actual hours worked and specific exceedences against the agreed limits in the fatigue management program, and particularly those set by industrial instruments, will provide evidence of compliance with the applicable requirements, and the effectiveness of relief and workforce planning arrangements. (see also paragraphs 2.2.8 and 2.2.9).

3.2.9 Procedures for occurrence reporting, recording and investigation

Where fatigue may be a contributory factor to a safety-related occurrence, the collection of following information, where available, will help establish if that is the case and if there are any underlying problems in the system:

- time of day of accident (consider circadian rhythms – did the accident occur during a period of high or low alertness);
- time on task;
- time on duty (against the relevant policy limits);
- work history over the last 14 days including night work, variations in start times, number of consecutive shifts, breaks;
- time elapsed since last worked, and amount of wakefulness prior to the occurrence, etc.;
- sleep history of the individual(s) involved over the past week to determine their fatigue likelihood – have their sleep patterns involved poor, average or above average quality of sleep;
- the role(s) of the individual(s) involved in the occurrence and their degree of impairment;
- if available, any documented or self-reported medical history of sleep disorders (e.g. sleep apnoea or insomnia) – the privacy provisions of the *National Standard for the Health Assessment of Rail Safety Workers* will apply; and

- work conditions that have the potential to increase or decrease feelings of fatigue: for example, temperature, humidity and other weather conditions.

The information from this system should be made available to the FMP Steering Committee where established and other appropriate committees.

3.2.10 Review of the fatigue management program and its risk treatments / controls

Periodic reviews of fatigue management programs are essential, as are reviews after an occurrence in which fatigue was a contributing factor, and where risk treatments have been implemented. They need to be evaluated to ensure they are effective in managing fatigue risk and are not creating subsequent issues or hazards.

Meaningful fatigue management programs are designed in such a way that mechanisms are in place to evaluate the program in terms of strategies that are working well and to identify any areas for improvement.

Reviews of these arrangements would be best undertaken when:

- the frequency/routine of work patterns is changed;
- the maximum limits are increased;
- there has been an occurrence, or series of occurrences indicating a trend in which fatigue has been determined to be a causal or contributing factor; and/or
- there has been any other change, which could give reason to doubt the effectiveness of the existing arrangements.

Rail transport operators should act upon recommendations arising from reviews related to the management of fatigue risks.

Practical tips: Evaluating the effectiveness of risk treatments

The evaluation process can be undertaken in a range of ways including:

- inclusion in a rail transport operator's compliance audit plan;
- reviewing actual hours worked against rostered hours , and the rail transport operator's policy in this respect;
- involving safety representatives in periodic inspections;
- management safety tours or inspections;
- direct feedback from rail safety workers and other relevant stakeholders; review of occurrence data. Reviews should also be undertaken to ensure the currency of the program, measuring deviations of actual hours worked from planned hours of work and reviewing these against the rail transport operator's benchmark levels. Rostering is to be reviewed when these levels are consistently exceeded, as consistent exceedences are a probable indication of rosters that result in work related fatigue;
- reviewing occurrence data. Fatigue should be included as a potential causal factor in the investigation of occurrences;
- monitoring changes in rosters by staff and ensure that these do not result in risks beyond those predicted and ensure those monitoring are fully educated in the methods used.
- use procedures for assessing the fatigue levels of individual workers that assists in identifying Rail Safety Workers in the workplace or presenting for work that are not fit for duty due to fatigue (see attachment 1(b));
- self-reporting through a 'Just Culture' policy;
- the effectiveness of the consultative process in assigning appropriate responsibilities and behaviours to rail safety workers their supervisors;
- using external or internal consultants for expert technical advice;
- obtaining feedback from rail safety workers including occupational health & safety representatives where appointed;
- using a standard shift work survey;
- including fatigue as a standard agenda item for discussion at management safety meetings, occupational health and safety committee meetings or other forums; and
- keeping records of the percentage of staff deemed competent in 'Applying Fatigue Management Strategies'.

Fatigue management information is to be made available to rail safety workers and their representatives to assist the evaluation process.

3.3 Performance requirements and audits

Section 57 (1) (d) of the Rail Safety Reform Bill 2006 requires rail transport operators to specify the controls (including audits) that are to be used to manage risks and monitor safety, and prioritise safety actions accordance with the level of risk. Rail transport operators operating at a higher level of probability of fatigue risk assume the burden of responsibility for demonstrating to the relevant regulatory body that an appropriate fatigue management program has been developed, implemented and is being actively managed. In relation to the audit of fatigue management programs, the following advice is provided:

(a) Internal Audits

Each rail transport operator accepts responsibility for conducting an audit of the application of the fatigue management program in accordance with the rail transport operator's audit schedule and determined frequency, (including the assessment of the performance of contractors).

The minimum reporting standards for audit purposes might include:

- risk assessment methodology;
- standards, operating limits/rules[24], threshold points and outer limits;
- procedures and controls employed for operating circumstances above threshold points and outer limits;
- evidence of surveillance of actual hours of work.;
- the effectiveness of the training and education program;
- documentation and action required regarding instances where limits have been exceeded.
- evidence of monitoring actual performance against FMP policy and programs and;
- evidence of investigation and monitoring of fatigue related factors in occurrences.

The results of internal audits should be made available to the Fatigue Management Steering Committee (where established) and to other appropriate committees.

(b) External Audits

A compliance audit of the application of the fatigue management program may be undertaken at any time, and/or included within the external annual rail safety regulator compliance audit in accordance with the provisions of each State and the *Northern Territory Rail Safety Act* and the national model *Rail Safety Bill 2006*.

3.4 Rail safety workers covered under a fatigue management program

A rail transport operator is to prepare and implement a fatigue management program for rail safety workers who carry out rail safety operations on their rail infrastructure or rolling stock (section 67 of the national model *Rail Safety Bill 2006*).

3.4.1 Contractors

Contractors play an important part in the operations of infrastructure and rolling stock of many rail transport operators. Under the *Rail Safety Bill* rail transport operators are required to take responsibility for managing their contractors and ensuring that contractors meet their responsibilities for the management of fatigue-related risks amongst their own rail safety workers. In addition to complying with their own safety management system requirements, contractors must comply with the rail transport operator's safety management system and fatigue management program whilst engaged in the rail transport operator's operating environment. (Section 71) Contractors are responsible for demonstrating how they will comply/are complying with all contractual and regulatory requirements – and in some cases this may mean contractors demonstrate they have effective control to a level equal to or superior than the rail transport operator.

3.4.2 Volunteers

Volunteers are a highly valued resource in the tourist and heritage sector. However, the provisions of a Fatigue Management Program will apply equally to these rail safety workers as those employed in the industry.

While many are not directly associated with the rail industry in their normal employment, a significant number are employed as rail safety workers and as such are subject to the fatigue management policies of their employer(s). Volunteers working for rail transport operators in the tourist and heritage sector whose primary employment is as a rail safety worker with another rail transport operator should at all times (including when working as a volunteer) be compliant with the working arrangements for which they are primarily employed.

Volunteers who do not normally work for a rail transport operator should be subject to the requirements incorporated in the tourist and heritage organisation's fatigue management program which have been determined from the organisation's risk assessment of its volunteer workforce.

For some volunteers, their employer's obligations may be as detailed, if not more detailed, than those who work in the rail industry. For many volunteers, their work on a tourist railway may require significant amounts of travel prior to and after their volunteer work. This impacts on time available for recovery prior to volunteering, and prior to returning to work. The social aspect of volunteering, a key reason why many volunteer, is a potential factor that may impact on time available for sleep.

Whilst most heritage railways do not operate at night, a number of safety critical tasks may be undertaken in the higher risk period of 4-7am. The work to light up and prepare a locomotive, or a train, is usually done at this time. Errors here may have extreme consequences later in the day. Working at these times compounds the ability for workers who may already be tired from a full weeks work to complete their activities safely, and the ability for workers to safely complete a task for which there may already be a decay in skills and abilities because of the infrequency of the activity.

3.5 Consultation

Consultation with rail safety workers and their representatives is essential for the success of the fatigue management program process and its outcomes.

Section 57 (2) of the national model *Rail Safety Bill 2006* and in section 15 of the *National Guideline for the Preparation of a Rail Safety Management System* set down the requirements for a rail transport operator to consult, as far as is reasonably practicable, before establishing or varying a safety management system with people likely to be affected, health and safety representatives within the meaning of occupational health and safety legislation, unions representing persons affected, and other transport operators. These requirements apply to fatigue management programs developed in association with these guidelines.

Obligations to consult also exist under OHS legislation.

3.6 Emergencies and unforseen occurrences

Emergencies and unforseen occurrences will arise in the operation of rail services. Fatigue management planning needs to anticipate the issues so that the organisation will know how to plan for them and to address them when they occur. Procedures should be in place that cover emergencies and unforeseen occurrences which cause a planned shift to be extended, or rail safety workers to be called in for duty in addition to their rostered shifts. This will ensure that rail safety workers are not asked to undertake duties that may place themselves or others at unacceptable levels of risk.

An ‘emergency’ could include an event due to an actual or imminent occurrence (such as fire, flood, storm, earthquake, explosion, accident, epidemic, or warlike action) which endangers or threatens to endanger, the safety of persons or destroys or damages, or threatens to destroy or threaten to destroy or damage property. When an emergency situation occurs, rail transport operators should make every effort to avoid or limit such extended hours on duty and implement rules and procedures (contained in the fatigue management program) to allow appropriate recovery by the affected rail safety workers.

An ‘unforeseen occurrence’ could include a situation which occurs during the shift, which requires a rail safety worker to continue working if he or she is fit for duty to avoid serious dislocation to train services. For example, ‘unforeseen occurrences’ might include equipment and infrastructure failures as well as notifiable occurrences defined by the Rail Safety Act and Regulations.

They do not include situations that were, or should have been foreseeable, such as a breakdown in scheduling/rostering caused by staff absences, or general late running of trains. Strategies should be put in place to manage the consequent increased level of fatigue risk which might occur in the event of when the above occurrences arise.

Such strategies may involve:

- the establishment of limits of numbers of consecutive shifts or call outs;
- limiting the number of times an additional shift may be permitted in a roster period;
- prescribing duties and responsibilities of rail safety workers following a shift extension; and
- limiting the availability of the rail safety worker for subsequent shifts following additional hours of work.

Where extended working has been necessary, all reasonable steps should be taken to relieve a rail safety worker whose hours of work are already close to the limits as soon as possible and to ensure that they have sufficient time to be fully rested before their next period of duty. In addition, a policy should be established whereby a rail safety worker required for emergencies or unforeseen occurrences is subject to a ‘never exceed’ limit of 14 hours working.

Planned training or safety briefings for rail safety workers should not be a reason for exceeding the limits established in the fatigue management program. Neither should other circumstances such as the existence of long-standing job vacancies, a block of maintenance work extending over a few days (e.g. plant shut down or blockade working) training delays or planned organisational changes that affect the numbers of available rail safety workers.

All of these circumstances should be reasonably foreseeable and suitable action should be taken in planning or altering rosters based on the following:

- no rail safety work should be performed without a risk assessment first being conducted in accordance with the organisation’s policy;
- the risk assessment should include consideration of the rail safety workers capacity to extend/continue to work safely, including the rail safety workers own view of their capacity to continue (see Attachment 1(b)) Can we discuss?; and
- for reasons other than an emergency, rail safety workers may decline to work beyond agreed limits.

Operators should notify breaches of limits they establish in their fatigue management program for normal shift rosters to their fatigue management steering committee where established, and/ or any other relevant safety committee. Where applicable, such breaches of limits should also be reported to the rail safety regulator.

Considerations in managing fatigue

The considerations in managing fatigue in the workplace should include:

- ensuring that rail safety workers have an adequate opportunity for sleep (quantity and quality) particularly addressing the 'time of day' or 'circadian rhythm' effect[25] and where the sleep is taken;
- ensuring that the numbers of consecutive shifts (in particular night shifts) shift lengths and rest periods between shifts are considered in roster compilation, again addressing time of day considerations[26];
- understanding that rail safety workers have a need to balance the competing requirements of their jobs with their social and domestic responsibilities;
- rail safety workers should be included in a consultation process when designing, implementing and evaluating rosters and work schedules as intended by the provisions of the *Rail Safety Bill 2006*;
- using appropriate limits on numbers of consecutive shifts and direction of shift rotations[27] (forward rotation cycles are preferred)[28];
- minimising irregular and unpredictable work schedules; and
- undertaking workforce planning to ensure adequate numbers of rail safety workers are engaged for the tasks without resorting to long or extra shifts.

Practical control measures

Operators will find that there are a range of practical measures that can be adopted to suit their circumstances. They will combine a mixture of the best practice flowing from research, risk assessments and industry practical experience. However, the best practices will be the ones that, in combination, most suit the operators' and employees' needs. They will be able to be adapted as research evolves to provide better ways of managing fatigue related risks. Good practice will encompass the following:

- ensure rail safety workers are provided with working conditions and working time arrangements which enable them to report for duty unimpaired by fatigue and that they do not become fatigued to such a degree at work that rail safety is jeopardised;
- manage contractors[29] and ensure that contractors meet their responsibilities for the management of fatigue risks of their rail safety workers;

- ensure, so far as it is reasonably practicable, that rail safety workers who report for duty where they are unfit owing to fatigue, or who, through the course of their work shift report or are reported as impaired due to fatigue, do not carry out or continue to carry out rail safety work. In the event of a rail safety worker being unfit, appropriate control measures, such as providing sufficient rest, should be considered and applied before the rail safety worker commences or recommences rail safety work;
- demonstrate that those responsible for managing these responsibilities have a thorough understanding of the causes of fatigue-related risks in railway operations; and / or
- establish policy about any secondary employment working arrangements that may affect fitness for duty and advise rail safety workers about their obligations in this respect.

Rail safety legislation requires rail safety workers to take reasonable care for their own safety and the safety of people who may be affected by the rail safety workers acts or omissions at work, and to cooperate with the rail transport operator to comply with a requirement imposed by rail safety legislation.

Hence rail safety workers must ensure that:

- they attend for duty in a fit and well rested condition to enable them to commence and complete their shift unimpaired by the effects of fatigue;
- if they consider themselves unfit to attend or continue to work, they should exercise their duty of care and advise the rail transport operator. Rail transport operators should have a policy and procedures in place to deal with these circumstances and rail safety workers should not be disadvantaged by such actions.

Industrial agreements and awards cover many aspects of hours of work and rest and are legally enforceable. As the new fatigue management program arrangements of the national model *Rail Safety Bill 2006* are implemented, there should be a greater harmonisation between the arrangements negotiated out of the provisions and industrial instruments.

Controls for other eventualities

The fatigue management program should provide clear criteria for the controls that are to be implemented to cater for eventualities such as:

- covering sickness and unplanned short notice absences of rail safety workers;
- the action(s) required if a RSW reports fatigued and therefore is unfit to work or continue to work safely as rostered;
- the action(s) required if a supervisor/manager or another worker determines that a rail safety worker is too fatigued and therefore unfit to work safely as rostered;
- unavailability of transport to accommodation;

- the above circumstances occurring at remote location operations; and
- calling in on-call personnel.

From the point of view of development of fatigue management programs, ‘work’ consists of all activities that are incompatible with rest or sleep. The arrangements should take into account all periods of work (both safety critical and non-safety critical) if time spent on the latter (such as safety briefings, training days) could have a bearing on a person’s ability to undertake safety critical work.

The factors most relevant of these are the total number of working hours, the length of the shift, the opportunity for sleep between shifts and the amount of night work.

The fatigue management program may include the specific limits on work and rest times established by rail transport operators in consultation with rail safety workers or their representatives, industrial instruments or those set in legislation. (See section 2.2.3)

While all rail transport operators will need to prepare a fatigue management program the extent of detail required for the various elements of the fatigue management program will be scalable based on the results of the risk assessment undertaken, as occurs with safety management systems. (See section 2.2.4).

Appendix 1: An Approach to Fatigue Management

This attachment sets out an approach to assist rail transport operators manage fatigue related risks, by the use of multiple layers of controls. It expands on the concepts outlined in these guidelines and provides additional tools to assist the rail industry manage fatigue related risks within that framework.

This approach is provided as information only and not an alternative to the framework developed in the body of these guidelines.

The fatigue risk trajectory approach draws heavily on the theories of James Reason[30] and has been adapted for the rail industry and fatigue related risks by the Centre for Sleep Research of the University of South Australia. It provides a means by which rail transport operators do not have to rely solely on hours of work and rest provisions to manage fatigue risks, but can implement a range of controls to minimise risks while at the same time maintaining productivity and meeting the needs of its workforce. This approach allows the industry as a whole to benefit from a multi-dimensional approach rather than an approach based on a limited number of controls.

This material should also be considered in reference to the human factors section (Part A section 18) in the *National Guideline for the Preparation of a Rail Safety Management System*.

1. The regulatory framework of the *Rail Safety Bill* (Model Provisions) 2006 conceptualises fatigue as a hazard to be managed within a rail transport operator's Safety Management System

2. By adapting Reason's (1997) general hazard control framework, a fatigue-related occurrence can be seen as the end point of a causal chain of events at each level of the fatigue risk trajectory (see Figure 1). The incident trajectory is 'blocked' by means of defensive layers/systems that are designed to protect against error. Examples of a defensive system might include, but are not limited to, measures such as training and education, vigilance control systems, standard operating procedures etc.

   There are multiple layers that precede a fatigue-related occurrence, for which there are identifiable hazards and controls.

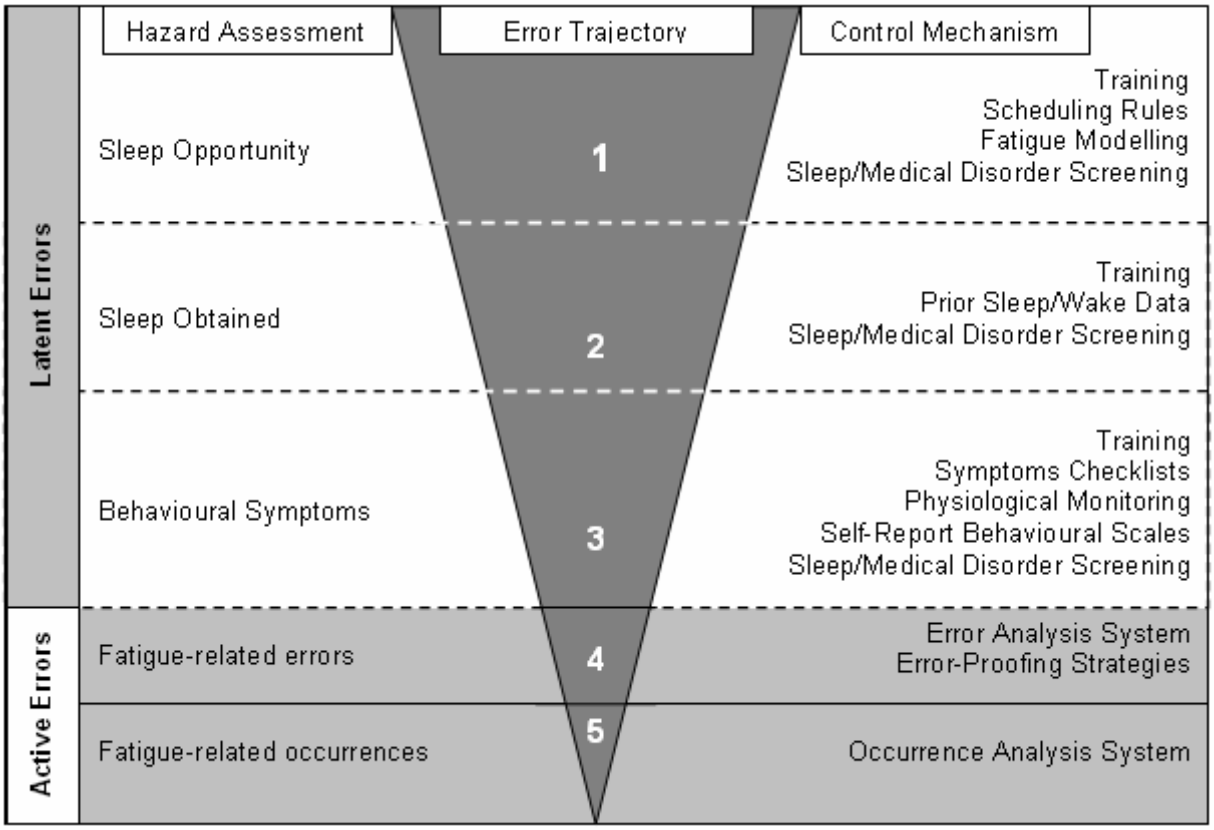
3. Operators may choose to manage fatigue-related risk with multiple levels of control. Such risk may be controlled by a variety of mechanisms including limits for hours of work, particularly night work, rest periods between shifts and, consequently, opportunities for sleep.

4. For those rail safety workers working in an operation where risk of fatigue is high, there needs to be a more structured way of ensuring that rail safety work is controlled in order to minimise fatigue-related occurrences.

5. Where this differs from other fatigue-related safety measures (i.e. general rules of rostering) is the obvious assumption that:
   - every defensive countermeasure is imperfect; and
   - effective hazard control requires a systematic integration of defensive countermeasures in a task and organisationally appropriate manner.

6. Every occurrence (Level 5 in the Fatigue Risk Trajectory in Figure 1) is always preceded by a common sequence of event classifications that lead to an actual occurrence. Thus, a fatigue-related occurrence is always preceded by a failure at Level 4, that is, a fatigue-related error. Each error will, in turn, be associated with an individual(s) in a fatigued state, exhibiting fatigue-related symptoms or behaviour (Level 3). The fatigued state in the individual(s) will have been preceded by

Figure 2. Fatigue Risk Trajectory



insufficient recovery sleep or excessive wakefulness and other possible factors such as time on task and workload.

7. Insufficient sleep or excessive wakefulness will be caused by either:

   A Level 1 failure - that is, an inadequate rest period (e.g. the roster or schedule did not provide an adequate opportunity for sufficient sleep), or

   A Level 2 failure - that is, insufficient recovery sleep during an adequate rest period (e.g. failure to obtain sufficient sleep for reasons beyond their control (poor sleeping environment or undiagnosed sleep disorder), or those over which they may have control (choosing to engage in non-sleep activities).

8. Each of the four pre-occurrence levels in the Fatigue Risk Trajectory for a fatigue related occurrence provides the opportunity to identify potential precursor or leading indicators and, more importantly, the presence (or absence) of appropriate and effective hazard control mechanisms in the system. Figure 1 also implies that we can reduce the incidence of fatigue related errors by more co-ordinated or integrated control of the preceeding events or actions that constitute potential or 'latent' failures of the safety management system.

9. Effective management of fatigue-related risk requires a fatigue management program that implements task and organisationally appropriate control mechanisms at each point in the Fatigue Risk Trajectory illustrated in Figure 1. Where a rail transport operator fails to develop appropriate controls at each level of the hierarchy it is unlikely that, overall, the system will be well defended against fatigue-related occurrences and the rail transport operator will be exposed to increased risk of a fatigue-related occurrence.

10. Level 1 controls - ensuring adequate sleep opportunity

Research indicates that physical fatigue accumulates and discharges in a broadly uniform manner with respect to time. Similarly activities involving mainly mental activity (both demanding and boring) can soon lead to mental exhaustion. Therefore, from a perspective of purely recovering from the effects of fatigue, providing a rest period of at least 10 hours is both desirable and practical. However, estimating the level of fatigue accrued through mental exertion is linked more to the timing and duration of sleep and wake within a rest period, rather than the duration of the rest period alone. Work shifts and schedules should therefore be reviewed to ensure that adequate opportunity for sleep is provided during time away from work.

The degree of work-related fatigue associated with a given task on a given schedule is linked to the degree to which a schedule precludes sleep of sufficient quality and duration to ensure fitness for work (in relation to fatigue). In essence, a schedule will produce higher levels of work-related fatigue if it requires employees to work more frequently during times when they are socially or biologically predisposed for sleep.

Assessing rosters for susceptibility to fatigue-related risk should be based on the amount of sleep opportunity it provides. The assessment of rosters can be carried out by fatigue modelling, other indices designed to help measure risks associated with proposed shift patterns, or by using the rostering considerations identified in part 2.

Examples of tools and models to assess work schedules

Rail transport operators wishing to use any of the tools discussed in this section should obtain professional advice on the use of the models to ensure they are appropriate for the desired tasks and they are used in accordance with the capacities of the tools. The tools are primarily support mechanisms for systems that use rostering principles discussed in part 2.

It should be recognised from the outset that these are tools to assist rail transport operators make an assessment of the proposed shifts and work schedules and should be used in accordance with the limits built into each tool.

Fatigue modelling or indexes can be used as a supplementary Level 1 tool to assess rosters once they have been constructed according to the Rail transport operator's rostering parameters. Bio-mathematical fatigue models are mathematical algorithms that use the duration of sleep and wake and time-of-day (circadian time) obtained during the overall pattern of work and non-work periods to predict the average level of sleep opportunity associated with a given schedule. At present, there are two general classes of bio-mathematical models.

The first, referred to as One Step Models, use the observed timing of sleep, wake and circadian measures derived from an individual to predict surrogate measures of fatigue.

The second class of model used is referred to as a Two Step Model. Two Step Models use the timing and duration of the work-rest period to estimate the most likely timing and duration of sleep and wake. The estimated sleep-wake pattern is then used subsequently to estimate likely sleep wake behaviour and provide a probabilistic estimate of the likelihood of work related fatigue based on sleep opportunity (as per the One Step Models).

It is generally thought that Two Step Models are likely to be inherently less accurate for a specific individual or event since work-related fatigue predictions are based on estimates of average behaviour and do not generally account for individual differences. While One Step Models attempt to predict the level of fatigue experienced by an individual, Two Step Models cannot do so. That is Two Step Models only predict the average sleep opportunity associated with a pattern of work.

Two Step Models have sometimes been used (erroneously) to predict proxy or surrogate measures of fatigue. However, technically, it cannot determine what a given individual does on a specific occasion with a sleep opportunity. An adequate sleep opportunity may not have been used to obtain sufficient actual sleep. Conversely, a restricted sleep opportunity might have resulted in an adequate amount of sleep because an employee preferred to sleep than undertake family and social responsibilities. It is extremely important to note that Two Step Models can only ever predict what is likely to happen to people on average.

While a Two Step Model is a means of assessing average opportunity for sleep over a particular period for an organisation at the aggregate level it is of minimal use at the individual level. As a consequence, Two Step Models are suitable for determining whether a Rail transport operator is providing an adequate sleep opportunity or the degree to which work-related fatigue may have contributed to overall fatigue. Whether an individual is actually fatigued requires additional information on the timing and duration of their sleep and wake rather than estimated average values. On the other hand, it may be entirely more reasonable to use one step models as a part of the analysis of individual events where the timing of sleep and wake is known with a fair degree of certainty.

Importantly, some studies have sought to validate and calibrate biomathematical models. Validation shows that a model is a reliable predictor of fatigue-related errors. Calibration provides a link between the model and the level of risk. The United States Department of Transportation (Hursh et al 2006) collected 30-day work histories of locomotive crews prior to 400 human factor and 1000 nonhuman factor accidents to determine validation of several models. Very strong validation was demonstrated and some level of calibration was made. For example, an identifiable increase in human factor accidents was identifiable at an effectiveness score below 70, and by linking this with other research, the score of 70 was equated with a blood alcohol reading of 0.08.

Given the emerging research on this issue, prior to using a biomathematical model, it is important to determine its level of validation and calibration.

A number of other tools are available, but the following two methods have been developed for rail regulators in either the United Kingdom or the United States of America.

(a) <u>UK Health and Safety Executive (HSE) Fatigue and Risk Calculator</u>

Some time ago, the UK Health and Safety Executive developed a method of assessing the risk arising from fatigue associated with work patterns for safety critical workers. The methodology involved the calculation of a ‘Fatigue Index’. The index was intended to be used to provide an assessment of changes in work patterns and to determine whether any particular aspect of the work pattern was likely to increase levels of fatigue.

The initial Fatigue Index included six factors associated with the development of fatigue, namely: the length of the shift, the interval between shifts, the number of rest days, the quality of the rest breaks, the variability of the shifts, and the time of day. Each of the six factors was scored independently and the composite score was used to provide an overall index of fatigue.

A recent review was undertaken to develop an up to date version of the Fatigue Index, which would take account of current knowledge and understanding of factors associated with the development of fatigue in the shift work environment. A further development, since the release of the previous version of the Fatigue Index, was the increase in information concerning trends in risk related to shiftwork. For the construction of a new index, therefore, it was proposed to investigate the extent to which the output of the index could be expressed in terms of the relative risk associated with different patterns of work.

The new index (available as a spreadsheet) consists of two separate individual indices, one related to fatigue (the 'Fatigue Index') and one related to risk (the 'Risk Index'). While the two indices are similar in many respects, they diverge in others. The main differences are due to the different time of day effects: the peak in risk occurs close to midnight whereas the peak in fatigue occurs some five hours later in the early morning. Assessments of patterns of work need to be reviewed in terms of both indices.

In the spreadsheet, both risk and fatigue indices are expressed in terms of three individual components:

- A cumulative component. This relates to the way in which individual duty periods or shifts are put together to form a complete schedule. The cumulative component associated a particular shift depends on the pattern of work immediately preceding that shift.
- A component associated with duty timing, i.e. the effect of start time, shift length and time of day throughout a shift.
- A job type/breaks component. This relates to the content of the shift, in terms of the activity being undertaken and the provision of breaks during the shift.
- Details are set out in the following three documents which are found on the HSE website http://www.hse.gov.uk/research/RRhtm/rr446.htm
- Spencer MB, Robertson KA and Folkard S The development of a fatigue/risk index for shiftworkers. Research report 446 (2006). HSE Books (also available on HSE website at ttp://www.hse.gov.uk/research/rrhtm/rr446.htm).
- Fatigue and Risk Index Version 2.2, User Guidance
- Fatigue Index Calculator

(b) United States Department of Transportation Work Schedule Representation and Analysis Software.

This software was designed for the US Department of Transportation Human Factors Coordinating Committee. It has been developed to assist managers and schedulers understand and objectively evaluate work schedules with regard to those characteristics that promote on-duty alertness.

The tool attempts to recognise the diversity of flexible and irregular hours and that working hours differ from one week to the next and from one employee to another. It compares actual flexible hours of work, sleep and other activities of individual employees in two ways. First, by automatically calculating a high number of features, users can easily compare actual flexible hours in various ways. Such comparison is supported by calculating numbers as well as powerful visuals. Second, it transfers and applies existing knowledge about the effects of night and shiftwork.

More information on this program can be obtained in the following documents on the Human Factors Coordinating Committee website (http:scitech.dot.gov/research/ human/ofm./html)

- Work Schedule Representation and Analysis Software Setup for Windows 2000 and higher. Written by Ximes, GmbH, (ZIP< 18.7MB); and
- Introductory Tutorial.

Caveats on the use of bio-mathematical models

To ensure the appropriate use of bio-mathematical models operators should ensure:

- models should not be used for purposes beyond their validity;
- detailed information on prediction error of models and the circumstances where prediction error is more likely is obtained;
- that bio-mathematical models are only used in conjunction with rostering principles;

- that users have information on how to use rostering principles in conjunction with model outputs. This is particularly critical for operators that apply the model to master rosters and do not employ controls to manage variations due to roster changes, shift swapping or overtime; and
- that users have basic information about how the model works, including how many days are analysed by the algorithm.

11. Level 2 controls – ensuring individuals obtain adequate sleep

    Since the primary physiological determinants of fatigue for any given employee undertaking a given task are the timing and duration of prior sleep and wake, these physical states are the most appropriate criteria for judging whether an employee is likely to be fit for work. Level 2 controls typically focus on setting minimum sleep and maximum wake thresholds to ensure that employees are not fatigued. While minimum thresholds for prior sleep and maximum thresholds for prior wake will vary according to the risk profile for a specific task or work group, by setting them we provide simple, practical, easily observable external indices that can be used to determine whether someone has obtained sufficient sleep and, by inference, is fit for work.

    Level 2 controls should be able to answer the following two questions:

    - has the employee had sufficient sleep before commencing a period of duty; and
    - if so, for how long are they able to work at an acceptable level of safety before becoming too fatigued (in relation to the risk profile for their task) to continue?

    A number of tools may be used to determine whether a rail safety worker can be considered fit-for-work in relation to fatigue risks. One such tool which might be used proposes that rail safety workers should have obtained a minimum of 6 hours sleep in the 24 hours, and 14 hours sleep in the 48 hours, prior to commencing work. This will give an indication of whether the individual has had enough sleep in order to start work. . It should also be recognised these indicators relate to the amount of sleep, NOT breaks between shifts - rest breaks or time in bed does not equate to actual time asleep. For example, to obtain six hours sleep during daylight hours might require a break of up to 10 hours.

    The allowable length of that shift will be indicated by the amount of sleep obtained in the last 48 hours being equal to, or greater than, the period of time from when the rail safety worker awoke until the expected end of that shift.

    A rail safety worker could use the above rules as a simple self-assessment tool. This may help rail safety workers to determine when their individual risk of fatigue is increased and thereby assist them in planning fatigue countermeasures. The countermeasures may include sleep planning, strategic napping, caffeine, breaks task rotation, etc.

    Under some conditions a stronger Level 2 control mechanism may be required (for example an employee request to be permanently rostered on early morning starts). The employer and the employee might reach agreement to report actual sleep obtained on a daily basis to their employer as a documented fatigue risk mitigation strategy.

12. Level 3 controls – observing fatigue-related symptoms and behaviour

    There are many reasons why an individual may exhibit fatigue-related symptoms or behaviour. The primary cause would normally be insufficient sleep. If the fatigue management program were operating effectively, this cause should be screened out by Levels 1 (the provision of sufficient sleep opportunity) or Level 2 (actually obtaining sufficient sleep) controls as outlined in Figure 1. There may, however, be additional factors that could cause fatigue-related symptoms or behaviour.

The nature of the work itself is another possibility in causing fatigue. That is, the scheduled work may be particularly demanding in a mental or physical sense. Therefore, individuals may require a decreased time on task, or an increased time for recovery between shifts. These factors should be considered in the risk assessment of work tasks so that, where warranted, scheduling parameters can be set for different organisational sections or work tasks. The presence of fatigue-related symptoms or behaviour in specific work periods or tasks can be effective in determining whether risk profiles of tasks and work schedules need to be re-addressed.

The observation and reporting of fatigue-related symptoms and behaviour as a Level 3 control is important in an effective fatigue management program on several levels to:

- advise whether the minimum sleep requirements set by the fatigue management programs are appropriate;
- advise whether task scheduling processes are appropriate;
- indicate whether non-work activities are impacting upon the risk of workplace fatigue;
- indicate whether individuals have a sleep disorder; and
- identify behavioural indicators of fatigue associated with a significant increase in the risk of a fatigue-related error or occurrence.

An example of one way of identifying the typical behavioural symptoms of fatigue is attached at Attachment 1 (b).

In addition to generic symptoms of fatigue, most rail safety workers are aware of task-specific indicators of fatigue. These should be identified on a task-specific basis by individual work groups and included in a table of reportable symptoms developed by the rail transport operator.

13. Training to use Levels 1, 2 and 3 fatigue control mechanisms

In addition to the control mechanisms described above, as shown in Figure 1, training for all relevant personnel and screening of sleep and medical disorders should be undertaken. The latter may include identifying whether medications are being used that may affect alertness, fatigue, sleep and the circadian system.

14. Levels 4 and 5 controls – reporting fatigue-related errors and occurrences

The first three levels of control outlined in Figure 1 are concerned with measures to minimise the likelihood of a fatigue-related error or occurrence. The final two levels of control in the fatigue risk trajectory are concerned with identifying fatigue-related errors and occurrences that have 'slipped' through the first three levels of control. In this way, levels 4 and 5 of the fatigue risk trajectory provide the opportunity to identify potential pre-cursor or leading indicators and, more importantly, the presence (or absence) of appropriate and effective hazard control mechanisms in the system.

To be defined as a fatigue-related error or occurrence, an event would have:

- occurred with the likelihood of fatigue being a causal factor; and
- been consistent with fatigue-related error (e.g. caused by individual falling sleep, inattention, delayed reaction time, etc.)

Defining an event as a fatigue-related error or occurrence requires a review of the first three Levels of control outlined in Figure 1, to determine whether:

- the work schedule provided sufficient sleep opportunity for the employee(s);
- the employee(s) actually obtained sufficient sleep; and
- whether the event was preceded by the presence of fatigue-related behaviours or symptoms.

In any organisation, there would be a greater frequency of fatigue-related errors than occurrences. This offers greater opportunity to analyse the effectiveness of the fatigue management program, and determine areas of weakness in the system that require greater management efforts. In doing so, a rail transport operator can determine the root causes of any fatigue-related risk, and implement appropriate control strategies, before the error becomes an occurrence. As such, the documentation and review of fatigue-related errors would be particularly useful in the review process, to determine flaws or gaps in Levels 1, 2 and 3 in Figure 1, and be used for improvement.

Mechanical/technological devices are also examples of Level 4 controls such as vigilance controls, Automatic Train Protection systems, 'dead-man' devices etc. In addition the use of appropriate software systems at this level will provide a more systematic way of reporting errors, and where necessary, following up recommended safety actions.

15. Summary

Ideally a full fatigue management program should comprise all the elements outlined in the fatigue risk trajectory outlined in Figure 1. The depth and detail associated with each element will vary according to the degree of fatigue-related risk and the relative emphasis placed on each level of control by the rail transport operator. For example, rail transport operators that assigned primacy to Level 1 controls based on bio-mathematical fatigue models would be required to demonstrate that appropriate software was embedded within day-to-day operations, used accurate and reliable input data and was reported on a regular basis for both proposed and actual work patterns.

Similarly, rail transport operators that choose to emphasise Level 3 controls would need to demonstrate a significant commitment to technologies for identifying fatigue-related symptoms and behaviour in the workplace and ensuring that rail safety workers designated as impaired were not able to continue working.

The management of any hazard is achieved through a hierarchy of controls. Effective management of fatigue-related risk requires a fatigue management program through which appropriate control mechanisms are implemented at each point in the Fatigue Risk Trajectory in Figure 1. Where a rail transport operator fails to develop appropriate controls at each level of the hierarchy, it is unlikely that, overall, the system will be well defended against fatigue-related errors and thus the rail transport operator will be exposed to increased risk of a fatigue-related occurrence.

Appendix 2: Link Between Fatigue and the Unsafe Act / Decision

Table 1. Establishing the Link Between Fatigue and The Unsafe Act / Decision

Performance impairment	Indicators
Attention	• Overlooked sequential task element • Incorrectly ordered sequential task element • Preoccupied with single tasks or elements • Exhibited lack of awareness of poor performance • Reverted to old habits • Focused on a minor problem despite risk of major one • Did not appreciate gravity of situation • Did not anticipate danger • Displayed decreased vigilance • Did not observe warning signs
Memory	• Forgot a task or elements of a task • Forgot the sequence of task or task elements • Inaccurately recalled operational events
Alertness	• Succumbed to uncontrollable sleep in form of microsleep, nap, or long sleep episode • Displayed automatic behaviour syndrome
Reaction time	• Responded slowly to normal, abnormal or emergency stimuli • Failed to respond altogether to normal, abnormal or emergency stimuli
Problem-solving ability	• Displayed flawed logic • Displayed problems with arithmetic, geometric or other cognitive processing tasks • Applied inappropriate corrective action • Did not accurately interpret situation • Displayed poor judgment of distance, speed, and/or time
Mood	• Was less conversant than normal • Did not perform low-demand tasks • Was irritable • Distracted by discomfort
Attitude	• Displayed a willingness to take risks • Ignored normal checks or procedures • Displayed a ‘don’t care’ attitude
Physiological effects	• Exhibited speech effects - slurred, rate, content • Exhibited reduced manual dexterity - key-punch entry errors, switch selection

Source: Fatigue Expert Group March 2006 based on Transportation Safety Board of Canada. A Guide for investigating fatigue. (TSB Internal Document)

Appendix 3: Summary of Features of Work Patterns

Features of work patterns to consider are summarised in Table 2. Table 2 provides guidance in the right hand column on when to review controls in place to manage the risks from fatigue. These are given as good practice suggestions and should not be taken as being the only reasons for a review of controls.

These examples are not exhaustive as varied situations will arise in the workplace and from site to site. However, they should provide users of the guidelines with an indication of the types of issues to be considered.

Table 2. Features of Work Patterns

Feature	Options	Think about	Questions to consider
Timing of shift start	Day, evening, night, early or late	Night and early shifts can cause reduced sleep and fatigue.	• Are night and very early shifts involved? • How long do they last? • Are any controls available to be put in place to reduce the risk to an acceptable level?
Length of shift	8, 10, 12hrs or split shift	Shorter shifts can cause less fatigue for night and early shifts. The risk of accidents rises more rapidly after 12 hours on shift. Long split shifts are a problem area.	• Is a long shift planned? • How long is it? • Is overtime involved after a long planned shift (including the long break within the shift)? • Is a shift of this length essential? • What controls are available to be put in place to reduce the risk to an acceptable level? • Is expert advice required to assist in making decisions?
Weekly work-rest ratio	Number of workdays to rest days Overtime workdays Weekend working	Minimise the number of consecutive night shifts and early shifts worked and allow 2 rest days after a block of such shifts After overtime ensure sufficient time for sleep, travelling, and meal breaks before the start of the next shift. Plan some free weekends	• Is the number of consecutive night shifts or very early shifts more than 4 in a rotating shift pattern or 6 when working a permanent shift pattern? • How much rest is planned after any number of night shifts or very early shifts? • Is the number of consecutive day shifts excessive? • What controls are available to be put in place to reduce the risk to an acceptable level? • Is expert advice required to assist in reaching a decision?
Shift rotation	Permanent shift times (no rotation)	Individuals may have a preference for working permanent shift times. This can avoid problems with shift exchange and improve work life balance.	• Do these arrangements suit all rail safety workers? • Do they lead to unacceptable levels of fatigue in Rail safety workers working night, early morning, or afternoon shifts?

Table 2. Features of Work Patterns (cont)

Feature	Options	Think about	Questions to consider
Shift rotation (cont)	Permanent shift times (cont)		• Are tasks of high safety importance involved during, or at the end of these shifts? • What controls are available to be put in place to reduce the risk to an acceptable level?
	Rotating speed	Rotating speed refers to the number of workdays before a shift change. Rapid rotation is 2 days per shift type; slow rotation is 21 days per shift. Rapid rotation or slow rotation is easier to adjust to then a shift pattern that rotates about once a week	• Are there sound reasons for slow rotation shifts? • Do workers prefer slow instead of fast rotating shifts? • Do slow rotating shifts lead to an unacceptable rise in the levels of fatigue? • What controls are available to be put in place to reduce the risk to an acceptable level?
	Direction of rotation	Clockwise rotation from day to evening to night shift is usually preferable to counter clockwise change from day to night to night to evening.	• Are there any changes in the direction of rotation of shifts between shifts? (For example a person works 2 nights, 3 early shifts, and then 2 more nights. Here the shift start times are first advancing forwards and then being put backwards.) • Are there sound reasons for changing the directions of the shifts? • Does the shift pattern result in unacceptable levels of fatigue – and what proof exists of this?
Predictability	Emergency or call duty	All these can affect any other part of the work pattern and will impact on levels of workers fatigue.	• Does your roster planning involve unplanned or on call shifts that have a start time that vary by more than 2 hours or late notice is given of additional or altered duties? (For example a person is told at 10am that they are requested to work an evening on call shift). • Are these shifts a low percentage of your operations? • Are they essential for the type of operation involved? • What special arrangements are in place to ensure that rail safety workers are fit for duty before they commence work? • What arrangements are in place to ensure they obtain sufficient rest between shifts? • What arrangements are in place to ensure those rail safety workers whose work involves the probability of medium or high fatigue risks have their fatigue risks monitored?

Table 2. Features of Work Patterns (cont)

Feature	Options	Think about	Questions to consider
Predictability (cont)	Unplanned overtime	Restrict unplanned work and allow workers adequate rest before their next planned shift. The performance of workers who have been awake for more than 17 hours is likely to have more errors.	• What controls are in place to monitor if a worker who has a medium or high probability of fatigue risks because of less than the normal rest break arising from an on call or emergency working?. • Are roster planners well trained in fatigue management planning? Have they attended the appropriate courses? Have they been formally instructed in company policy for the management of rail safety workers who may be seriously fatigued? • Do internal procedures warn of the dangers of planning or allowing work and overtime to reach or come close to agreed weekly, 14 day or 28 day limits? • Are clear control measures in place to guide roster staff of what has to occur in such circumstances?

Appendix 4: Further Information

Akerstedt, T. (1995). Work hours, sleepiness and the underlying mechanisms - Journal of Sleep Research, 4(2); 15-22.

Akerstedt, T, Torsvall L, & Gillberg M. (1982) Sleepiness and shiftwork: Field studies. Sleep; 5, 95-106.

Åkerstedt, T. & Landstrom, U. (1998). Workplace countermeasures of night shift fatigue. International Journal of Industrial Ergonomics; 21, 167-178.

Barton, J & Folkard S. (1993) Advancing versus delaying shift systems. Ergonomics; 36, 59-64.

Barton, J, Spelten, E, Totterdell, P, Smith, L, & Folkard, S. (1995) Is there an optimum number of night shifts? Relationship between sleep, health and well-being. Work Stress, 9 (2); 109-123

Belenky, G. et al. (2003). Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: a sleep dose-response study. Journal of Sleep Research, 12; 1-12.

Dawson, D & McCulloch, K. (2005). Managing Fatigue: It's about sleep. Sleep Medicine Reviews, 9(5); 365-380.

Dinges, D F. (1995). An overview of sleepiness and accidents. Journal of Sleep Research 4 (suppl 2); 4-14.

Folkard, S. & Akerstedt T. (2004). Trends in the risk of accidents and injuries and their implications for models of fatigue and performance. Aviation, Space and Environmental Medicine, 75(3 Suppl); A161-7.

Folkard, S. (1992). Is there a best compromise shift system? Ergonomics, 35(12), 1453-1463.

Human Fatigue Research in Railroad Operations (FRA), http://scitech.dot.gov/research/human/ofm.html

Jay S, Dawson D, Lamond N, Train Drivers' Sleep Quality and Quantity during Extended Relay Operations Chronobiology International Volume 23 Issue 6 October 2006 , pages 1241 - 1252

Kecklund L, (December 2001) Final Report on the TRAIN – Project, Risks and proposals for safety enhancing measures in the train driver system

Kecklund, G & Akerstedt T. (1995). Effects of timing of shifts on sleepiness and sleep duration. Journal of Sleep Research, 4 (Suppl 2); 47-50.

Knauth, P. (1993). The design of shift systems. Ergonomics, 36; 15-28.

Lack, L. C. & Lushington, K. (1995). The rhythms of human sleep propensity and core body temperature. Journal of Sleep Research, 5, 1-11.

Lamond, N. & Dawson, D. (1999). Quantifying the performance impairment associated with fatigue. Journal of Sleep Research, 8; 255-262.

Lamond N , Darwent D and Dawson D How Well Do Train Driver's Sleep in Relay Vans? Industrial Health 2005, 43, 98–104

Lamond N , Darwent D and Dawson D Train drivers' sleep and alertness during short relay operations. Applied Ergonomics May 2005 36(3):313-8

McCulloch K, Sletten T, Baker A, et al. (2002). The management of workplace fatigue. Safety in Australia, 24(2); 8-13.

Monk, T. H. (1989). Shiftwork and Safety. Professional Safety, 34; 26-30.QinetiQ Centre for Human Sciences & Simon Folkard Associates Ltd (2006) The development of a fatigue/risk index for shift workers. Health and Safety Executive, London

Railtrack PLC, Safety Standards Directorate, (January 2003), Impact of Shiftwork and Fatigue on Safety

Reason, J. (1997). Managing the risks of organisational accidents. Aldershot: Ashgate Publishing Ltd.

Reinberg, A., Vieux, N., & Andlauer, P (1981). Night and shift work: Biological and social aspects. Oxford, Pergamon Press.

Rogers, AS, Spencer, MB and Stone BM. Validation and development of a method for assessing the risks arising from mental fatigue. Contract research report 254/1999 HSE Books. (also available on HSE's website: www.hse.gov.uk/research/content/crr/1999/crr99254.pdf

Smith L, Folkard S, & Poole CJM. (1994). Increased injuries in the night shift. Lancet; 244, 1137-1139.

Tilley, A. J., Wilkinson, R. T., Warren, P. S. G., Watson, B. & Drud, M. (1982). The sleep and performance of shiftworkers. Human Factors; 24(6), 629-641.

Totterdell P, Spelten E, Smith L, Barton J, Folkard S. (1995). Recovery from work shifts: How long does it take? Journal of Applied Psychology, 80(1); 43-57.

W S Atkins Ltd. Assessing the risks associated with fatigue in railway safety-critical tasks. Contract research report 188/1998. HSE Books.

Appendix 5: Other Relevant Fatigue Management Guidelines / Codes

- Rail Safety and Standards Board (2006) Human factors study of fatigue and shiftwork
- Main report : Guidelines for the management and reduction of fatigue in train drivers
- Appendix one : Working patterns for train drivers : Implications for fatigue and safety
- Appendix two : review of coping strategies to mitigate fatigue of train drivers
- Appendix three : Fatigue and shiftwork study : rail rostering culture : interview findings
- Appendix four : Fatigue and shiftwork study : Evaluation of current tools and techniques used for estimating risk associated with shift patterns.
- Health and Safety Executive (UK) – The development of a fatigue risk index for shift workers – research report 446
- Health and Safety Executive (UK) – Assessing the risks associated with fatigue in railway safety critical tasks. Contract research report 188/1998.
- Tasmanian Minerals Council (October 2004), Fatigue Risk Management Guide and Toolkit Suggestions
- Worksafe Victoria (2004), Fatigue Management Guidelines for the Forestry Industry
- Queensland Department of Industrial Relations, (Feb 2005), Fatigue Management Guide
- Western Australian Commission for occupational safety and health (2006), Code of Practice, Working Hours
- Australian Medical Association (Dec 2002), National Code of Practice: Hours of work, Shiftwork and Rostering for Hospital Doctors
- Australian Medical Association & Australian Healthcare Association (Aug 2003), Best Practice Rostering: Training Resource Kit (Practical Tools for Rostering Doctors)

Appendix 6: Endnotes

[1] Duty / Period of Duty/or duty period is the period of time between the start and end of a working shift and includes all duties applicable to the work, including (but not limited to) paid travel time, safety briefings, training and paid meal breaks.

[2] Over the course of time, it becomes increasingly difficult to maintain task set, and performance can be impaired. In regards to driving, for example, literature has shown that symptoms of fatigue can develop within an hour of continuous driving (van der Hulst et al., 2001). In a study examining the time-on-task effects in driving, van der Hulst and colleagues (2001) found that fatigue and sleepiness increased as a function of time-on-task. It was also found that as fatigue increased, the aversion to continue driving and deterioration of performance also increased.

[3] A study of Japanese high-speed train drivers showed an increase in physical signs of drowsiness as workload decreased (Endo & Kogi, 1975). These signs included increased yawning and change of the sitting position, as well as poorer performance on a secondary auditory task.

[4] Shiftwork is an arrangement of work that can be performed in shifts commencing and finishing during any of the 24 hours of the day and any of the 7 days of the week.

[5] Rest period is a break between each successive shift.

[6] Risk Assessment means the overall process of risk analysis and risk evaluation.

[7] Fatigue Management Policy means a policy developed by the Rail transport operator to establish the broad initiatives the organisation will undertake to meet its commitments to minimise the risks of fatigue impairment for rail safety workers

[8] Contingencies mean the measure(s) necessary to deal with unforeseen operating problems that are inherent in railway operations that do not constitute an 'emergency'. These include but are not limited to: (a).unforeseen crew absence; (b) locomotive malfunctions; (c) equipment failure; (d) broken rails; and (e) train crossing delays.

[9] Emergency means a sudden or unforeseen situation where injury or harm has been sustained, or could reasonably be sustained to employee(s), passenger(s), the public or the environment such as those involving a casualty or unavoidable accident, an Act of God, severe storms, major earthquakes, washouts, derailments or where there has been a delay resulting from a cause not known to the railway company at the time employees leave the terminal and which could not have been foreseen.

[10] Just Culture means an environment that acknowledges human fallibility and encourages honest reporting of essential safety related information and errors while establishing clear accountability for actions.

[11] Evidence from research suggests that the comparison between 8 and 12-hour shifts can be complex and contradictory (Smith et al., 1998). Shift workers and managers prefer 12-hour shifts, however some studies have shown that shifts extending beyond eight hours may cause fatigue and degrade performance (Mascord & Heath, 1992; Nagatsuka, 1996). Other studies suggest that the risk of accidents is greater between the second and fourth hour of a shift rather than between the 8th and 12th hour (Rosa et al., 1989). Thus, maximum shift length must be considered in relation to work demands and time of shift.

[12] The rest period between the end of one shift and the start of the next should be long enough to enable adequate sleep for recovery, usually 8-hours. Some research shows that to achieve 8-hours sleep, 12 hours rest is required before a 14:00 start, 14 hours before a 16:00 start and 16 hours before a 19:00 start (Kecklund & Akerstedt, 1995; Kurumatani et al., 1994; Rogers et al., 2000).

[13] A study of shift-workers in the UK suggest that at least two days off are required to recover from two consecutive night shifts, three days off after four to five night shifts, and three to four days off after seven night shifts (Rogers et al., 2000).

[14] A questionnaire study conducted within British industry showed an increase in subjective fatigue over seven days was found for all shift types (early, afternoon and night) (Rogers et al., 2000). A more detailed analysis indicated that afternoon shifts finishing after midnight were associated with higher levels of fatigue than shifts that finished before midnight, and this effect was significant from the fifth afternoon shift. Folkard (1992) recommends that a span of successive morning or day shifts including 32 or more hours of work that start before 07:00 should be limited to four.

[15] Due to the result showing that, relative to the first night shift, the risk is increased by about 15% on the second night shift, by about 30% on the third night shift and 50% on the fourth night shift; Folkard (1992), recommended that a span of successive night shifts should be limited to 6 for shifts up to 8 hours long, 4 shifts of 8.1 to 10 hours long and 2 for shift of 10.1 hours or longer.

[16] Regular rest breaks are an effective means of controlling the accumulation of risk during prolonged task performance. Following research on shiftwork and fatigue, and as part of the Drivers Restructuring Initiative, Folkard (1991) suggested the following as the most effective break structure:

1. The length of any break should not be less than four minutes for each 30 minutes, or part thereof, since the last break or start of duty. However;
2. All turns of duty in excess of five hours should include at least one break of 30 minutes, while no scheduled break should be less than 20 minutes long, and;
3. No period of continuous duty should exceed five hours before either the provision of a break or the start of a period of off-duty.

[17] As well as often taking very little sleep during the day before the first night shift (Knauth et al., 1980), sleep at home between night shifts can be shortened by up to one third compared to a normal night's sleep, thus no more than two or three consecutive night shifts is recommended. In a study on the work hours of aircraft maintenance, Folkard (2003) comments that an early start to the morning/day shift can also result in a substantial truncation of sleep. In light of this, Folkard recommends that a span of successive morning or day shifts including 32 or more hours of work that start before 07:00 should be limited to four.

[18] Rogers et al. (1995) found that the inclusion of a 15 minute break at the end of each 75 minute of continuous work had a considerable beneficial effect, overcoming some of the performance deficits associated with time on task. The recuperative value of these breaks was evident throughout a 12-hour duty period, both during the day and overnight. Moreover, Folkard's (2003) study of the working hours of aircraft maintenance personnel led to the recommendation that a maximum of four hours is worked before a break, with the minimum break period being ten minutes plus five minutes for each hour worked since the start of the work period or the last break.

[19] Rapidly rotating schedules, involving no more than two or possibly three night shifts are generally viewed as minimising the disruption of the individuals' body clocks. These systems have been associated with lower sleep disturbance, problems of circadian adaptation and performance decrements (Folkard, 1992; Knauth & Hornberger, 1995).

[20] In a review of the literature, Kecklund and Ackerstedt (1995) found that nightshift workers daytime sleep was, on average, 2 to 4 hours less per day than their dayshift counterparts. Ackerstedt and Gillberg (1981) also showed that even under controlled laboratory conditions, eliminating all environmental influences, day sleep was shortened in nightshift workers. This is primarily due to the fact that these workers are sleeping at times of

circadian peaks when their bodies are primed for wakefulness. Work or shift patterns mean the working period scheduled between any significant break away from work. For example, 5 shifts of work, followed by 2 shifts off.

[21] Shifts can rotate in clockwise (morning, afternoon, night) or anti-clockwise directions (night, afternoon, morning). It has been shown that a clockwise direction (delaying system) has less ill-effects on shiftworkers than the anti-clockwise direction (advancing system) and the advancing system often results in rest periods of less than 8 hours (Akerstedt, 2003).

[22] Muecke (2005) found that nurses who had continuing changes to start times experienced greater fatigue and exhibited poorer performance than their permanent duty peers.

[23] The Electro-technology and Utilities Industry Skills Council (EE-OZ) has developed and maintains the Transmission Distribution and Rail Training Package.

[24] Operating limits are the maximum hours that are planned (rostered) and to be actually worked as far as reasonably practical.

[25] Humans are diurnal, such that they remain active by day and at rest at night. This sleep/ wake cycle is referred to as a circadian rhythm (Glazner, 1991). Due to the fact that internal circadian mechanisms are robust and only adjust slowly, such changes to the normal sleep/ wake schedule cause desynchronisation of bodily rhythms relative to the outside world (Folkard et al., 1985). As daytime sleep is shortened due to the fact that night workers are sleeping at times when their bodies are primed for wakefulness and as environmental disturbances (e.g. noise) often disrupt their sleep (Akerstedt and Gillberg, 1981), slightly longer rest periods between shifts is required.

[26] The problems associated with lack of sleep before single night shifts are likely to escalate over successive nights if the internal body clock does not adjust. For example, in a study involving 12 male shift workers, Tilley et al (1982) demonstrated that by the end of a week of night shifts the shift workers had lost the equivalent of at least one night's sleep. Additionally, studies have found that the risk of accidents becomes greater after nine hours on a shift (Fletcher, 1999), and if less than 12 hours of rest is given between shifts (Rogers et al., 2000).

[27] Successive night shifts result in a cumulative sleep debt that may get worse as more night shifts are worked (Folkard, 1999). A number of studies done in industry have reported increases in accident risk over at least four successive night shifts (Folkard et al, 2000). For safety-critical operations, such as public transport, it may be preferable to limit the number of consecutive night shifts worked to no more than two or three in order to restrict the accumulation of a sleep deficit associated with successive daytime sleeps (Folkard, 1992). Slowly rotating shift systems, such as those involving a weekly rotation, are generally regarded as the most fatiguing since any benefit accruing from the partial adaptation to a new shift will be immediately lost by the switch to another shift (Knauth & Hornberger, 1995).

[28] Shifts can rotate in forward (early, late, night) or backward directions (night, late, early). It has been considered that the forward direction (delaying system) has less ill-effects on shiftworkers than the backward direction (advancing system). A study that involved more than 300 industrial shift-workers on a range of advancing and delaying continuous systems, found better physical and psychological health, less chronic fatigue, less social disruption, fewer sleep difficulties and more job satisfaction among workers on delaying systems (Barton & Folkard, 1993).

[29] A contractor is a person who is engaged by or on behalf of any body that has been accredited under a jurisdiction's rail safety legislation to provide goods or services to such a body.

[30] Reason J 1990, Human Error and Reason J 1997 Managing the risks of Organisational Accidents

Endnotes Reference Sources

Akerstedt, T. (1991). Sleepiness at work: effects of irregular work hours. In Monk, T. H. (Ed). Sleep, Sleepiness and Performance: 131-152.

Akerstedt, T. (2003). Shiftwork and disturbed sleep/wakefulness. Occupational Medicine, 53, 89-94.

Akerstedt, T. & Gillberg, M. (1981). Sleep disturbances and shift work. In Reinberg, A., Vieux, N., & Andlauer, P (Eds). Night and shift work: Biological and social aspects. Oxford, Pergamon Press.

Barton J, Folkard S. (1993). Advancing versus delaying shift systems. Ergonomics, 36: 59-64.

Clissod, G, Smith, P, Accutt, B, Di Milla, L. (2002). A study of female nurses combining partner and parent roles with working a continuous three-shift roster: the impact on sleep, fatigue and stress. Contemp Nurse.

Endo, T. & Kogi, K. (1975). Monotony effects of the work of motormen during high-speed train operation. J Human Ergology 4:129-140.

Fletcher, A. (1999). Measurement and Management of Work Related Fatigue: Development and Preliminary Validations of a Predictive Model.

Folkard, S. Drivers Restructure Initiative, Final Report, 1991.

Folkard S. (1992) Is there a best compromise shift system? Ergonomics, 35(12): 1453-1463.

Folkard, S. (1999). Transport: Rhythm and Blues. 10th Westminster Lecture on Transport Safety. Parliamentary Advisory Council for Transport Safety.

Folkard S. (2003) Report to the Civil Aviation Authority on Work Hours of Aircraft Maintenance Personnel. Swansea, Wales: Body Rhythms and Shiftwork Centre.

Folkard S, Akerstedt T, MacDonald I, Tucker P, Spencer MB (2000). Refinement of the three-process model to account for trends in accident risk.

Folkard, S., Hume, K. I., Minors, D. S., Waterhouse, J. M. & Watson, F. L. (1985). Independence of the circadian rhythm in alertness from the sleep/wake cycle. Nature 313: 678-679.

Glazner, L. K. (1991). Shiftwork: Its effect on workers. AAOHN Journal 39(9): 416-421.

Hursh S, Raslear T, Kaye S, Fanzone J (2006) Validation and Calibration of a Fatigue Assesment Tool for Railroad Work Schedules, Summary Report.

Jay S, Dawson D, Lamond N, Train Drivers' Sleep Quality and Quantity during Extended Relay Operations Chronobiology International Volume 23 Issue 6 October 2006 , pages 1241 - 1252

Kecklund, G. & Åkerstedt, T. (1995). Effects of timing of shifts on sleepiness and sleep duration. J Sleep Res 4(suppl 2): 47-50.

Kecklund G, Akerstedt T, Lowden A, Von Hederberg C. (1994). Sleep and early morning work. J. Sleep Res., 3(Suppl 1): 124.

Knauth P, Hornberger S. (1995) Changes from weekly backward to quicker forward rotating shift systems in the steel industry. Shiftwork Int. Newsletter, 12(1): 34.

Knauth P, Landau K, Droge C, Schwitteck M, Widynski M, Rutenfranz J. (1980). Duration of sleep depending on the type of shiftwork. International Archives of Occupational and Environmental Health, 46:167-177.

Kurumatani N, Koda S, Nakagira S, Hisashige A, Sakai K, Saito Y, Aoyama H, Dejima M, Moriyama T. (1994) The effects of frequently rotating shiftwork on sleep and the family life of hospital nurses. Ergonomics, 37: 995-1007.

Lamond N , Darwent D and Dawson D How Well Do Train Driver's Sleep in Relay Vans? Industrial Health 2005, 43, 98–104

Mascord, D.J. & Heath, R.A (1992). Behavior and physiological indices of fatigue in a visual tracking task. Journal of Safety Research, 23, 19-25.

Muecke, S. (2005). Effects of rotating night shifts: Literature review. Journal of Advanced Nursing, 50(4), 433-439.

Nagatsuka, Y. (1996). Deteriorations of performance and its recovery in prolonged work: An effect of active rest. In: Proceedings of the second international conference of fatigue and transportation: Engineering, enforcement and education solutions. Fremantle: Western Australia.

Rogers AS, Spencer MB (1998). A study of the work and rest schedules of Aviation Security Screeners (UKR). DERA Report No. DERA/CHS/PP5/CR/97280/1.0.

Rogers AS, Spencer MB, Pascoe PA. (1995). Workload and fatigue in single seat air operations: a laboratory study. DERA Report No. DRA/CHS/A&N/CR/95/22.

Rogers AS, Spencer MB, Stone BM. (2000). Validation and development of a method for assessing the risks arising from mental fatigue. HSE Contract Research Report.

Rosa RR, Colligan MJ, Lewis P. (1989). Extended workdays: effects of eight hour and 12 hour rotating shift schedules on performance, subjective alertness, sleep patterns and psychosocial variables. Work and Stress, 3(1): 21-32.

Smith L, Folkard S, Tucker P, MacDonald I. (1998) Work shift duration comparing 8h and 12h shift systems. Occup. Environ. Med., 55: 217-229.

Tilley, A. J., Wilkinson, R. T., Warren, P. S. G., Watson, B. & Drud, M. (1982). The sleep and performance of shiftworkers. Human Factors 24(6): 629-641.

UK office of Rail Regulation: Managing fatigue in safety critical work regulations

van der Hulst, M, Meijman, T. & Rothengatter, T. (2001). Maintaining task set under fatigue: A study of time-on-task effects in a simulated driving. Transportation Research Part F, 4, 103-118.

Zulley J, Campbell S. (1985) Napping behaviour during 'spontaneous internal desynchronisation': Sleep remains in synchrony with body temperature. Human Neurobiol., 4: 123-126.

Appendix 7: Rail Safety Regulator Contacts

Answers to specific queries about the legislation relevant to a particular State or Territory can be obtained directly from the relevant rail safety regulator.

New South Wales: Independent Transport Safety and Reliability Regulator.
http://www.transportregulator.nsw.gov.au/

Northern Territory: Department of Planning and Infrastructure, Rail Safety
transport.dpi@nt.gov.au

Queensland: Queensland Transport
http://www.transport.qld.gov.au/Home/Safety/Rail/

South Australia: Department for Transport, Energy & Infrastructure
http://www.transport.sa.gov.au/safety/rail/

Tasmania: Department of Infrastructure, Energy & Resources
http://www.dier.tas.gov.au/

Victoria: Public Transport Safety Victoria
http://www.doi.vic.gov.au/doi/internet/vehicles.nsf/headingpagesdisplay/public+transport+safety+victoria

Western Australia: Department for Planning & Infrastructure
http://www.dpi.wa.gov.au/

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