GUIDE

commanders'

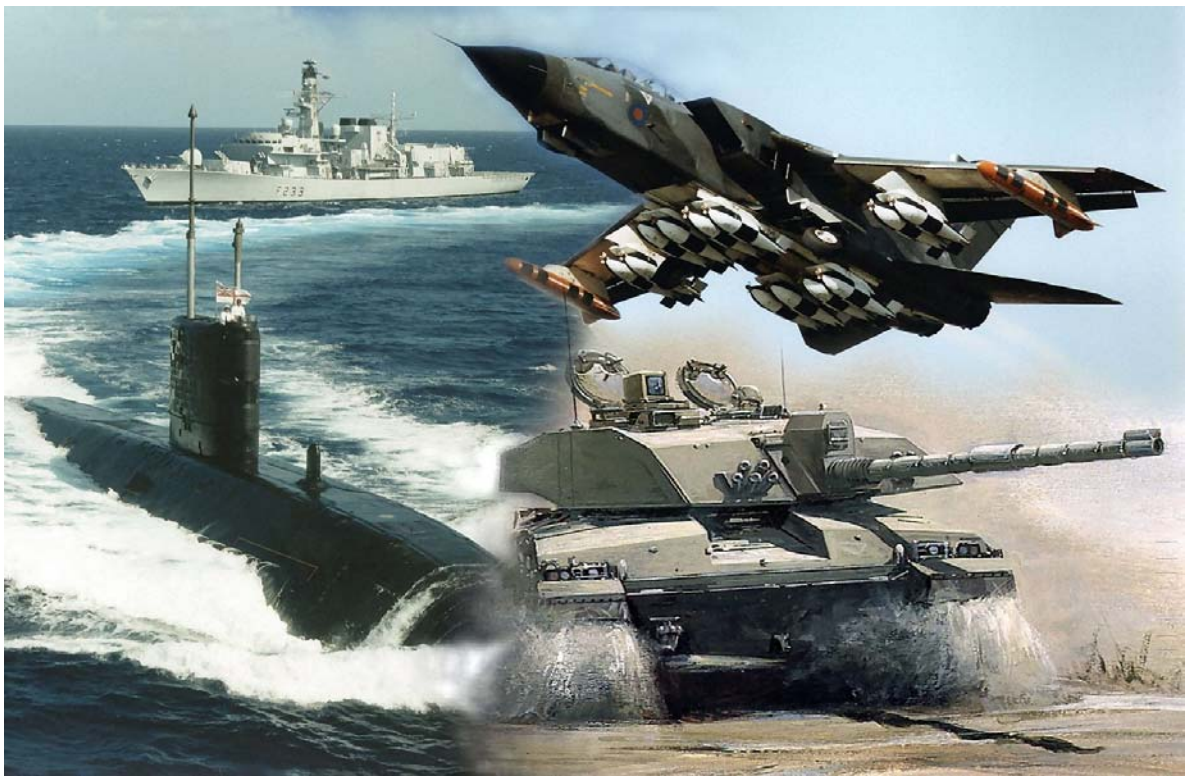
A reference Guide for Commanders

Reducing B Vehicle Driver Fatigue

CG/DRIVERFATIGUE/v1.0/SEPT2002

Authors:
Rogers, A.S.

Contact details
*E-mail: asrogers@dstl.gov.uk



[dstl]

CG/DRIVERFATIGUE/v1.0/SEPT2002

Intentionally blank

Foreword

Recent surveys have highlighted the dangers of driving when tired. Despite installing 'Tiredness kills' signs on motorways, there is little evidence that drivers have woken up to the risks of lack of sleep. They are likely to push on regardless, in the face of increasing levels of fatigue, until possibly falling asleep at the wheel.

The key factors contributing to driver fatigue include, loss of sleep, time of day, long hours of work, irregular hours, lack of breaks, work pressures, individual differences and the vehicle environment.

This guide intends to inform Commanders and their staff on the avoidance of these risk factors, and identify how countermeasures can be employed to improve driver safety. We hope you find it useful.

Alison Rogers, Sept 2002

Preparation of this Guide was funded from the Chemical, Biological & Human Sciences Domain's element of the Ministry of Defence's Corporate Research Programme.

Dstl report number:

Dstl/HB01194

LIST OF CONTENTS

Introduction

" I felt tired. The next thing I remember is someone calling an ambulance"

Driver fatigue is a major contributing factor in road traffic accidents. The DETR has reported that tiredness is the principal determinant in about 10% of all road accidents, and as many as 20% of motorway accidents. Within the MoD, road traffic accidents account for around 30% of all Service deaths, and in some cases, lack of sleep has been recognised as a causal factor [1].

The progressive deterioration of driver performance due to increased sleepiness has serious implications. The safe operation of a vehicle requires alertness as well as quick and accurate perception, judgement and action. As sleepiness increases the driver may be slow to recognise the signs of danger ahead, the ability to take corrective action will diminish, braking distances may be misjudged, and he/she may fall asleep at the wheel.

Sleepy drivers not only risk injury or death to themselves from falling asleep at the wheel whilst driving, but also to their passengers and other road users. Even a loss of attention or slowing of reactions during critical tasks or manoeuvres can result in a road accident. It is, therefore, important that personnel employed as drivers, as well as their commanding officers, are made aware of the risk factors associated with fatigue. It is also necessary to inform personnel, who are not on duty but who may be travelling home from work at different times of the day, on the avoidance of these risk factors.

This guide is divided into 2 sections. Section 1 outlines the key factors contributing to driver fatigue, and thus the increased likelihood of a sleep-related accident. Section 2 documents countermeasures that can be employed to minimise the risk of driver fatigue. For each section key points are listed and specific advice is given in bold print.

Section 1: Causes of Driver Fatigue

1.1 TIME OF DAY

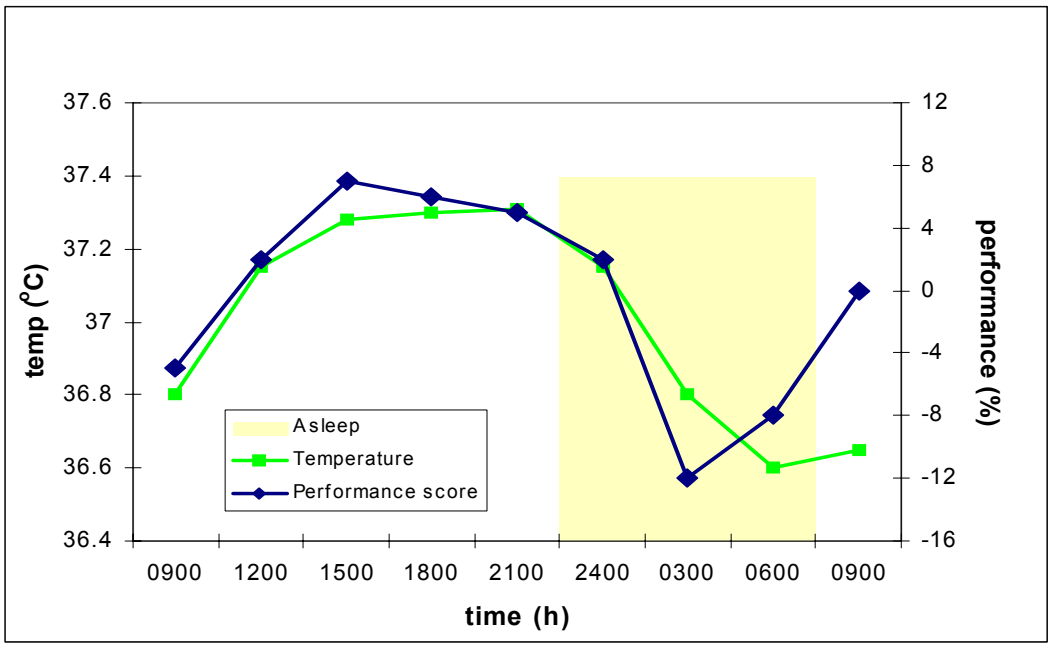
- Alertness and performance follow a circadian pattern, with lowest levels in the early hours of the morning (04:00 – 06:00) and highest values in the late afternoon and early evening (Figure 1).

- This pattern persists even during irregular schedules when sleep is displaced from its normal time. It is due to an in-built circadian rhythm or 'body clock', that normally runs with a period of around 24 hours. The body clock helps to ensure that sleep can be maintained overnight and that individuals can remain alert during the day. The problem with maintaining alertness overnight is that individuals are trying to work at a time normally reserved for sleep and are, therefore, out of phase with their body clock.

- Overnight degradations in performance occur regardless of whether individuals are fully rested prior to commencing duty. Large degradations have been reported in tasks involving vigilance, tracking, and sustained attention [2,3], all of which are involved in driving a vehicle.

- An impairment in performance is sometimes present in the late afternoon. This so-called 'post-lunch dip' occurs irrespective of meal timings [4].

- The influence of the circadian rhythm has been shown in a study of long-haul truck drivers, where episodes of drowsy sleep whilst driving mostly occurred between 23:00 and 05:00 [5].



From Klein et al, 1976

Figure 1: Normal temperature and performance variations over the day (performance scores relate to changes from 24-hour mean)

- Time of day is likely to be an important risk factor for accidents in road transport. Indeed a review of road vehicle accident frequencies has shown that, after correcting for traffic density, accident risk varies as a function of time of day. There is a major peak at around 03:00 when the circadian rhythm of sleepiness is reaching its daily minimum, and a secondary, smaller peak around 15:00 which corresponds to the post-lunch dip in alertness [6,7].

- At around 06:00 drivers are over 20 times more likely to fall asleep at the wheel than around 10:00 [8]. At about 16:00 drivers are three times more likely to fall asleep than at around 10:00 or 19:00. These periods of the day vulnerable to sleep-related accidents are distinct from the peak times for road accidents in the UK, which occur during the commuting periods of around 08:00-09:00 and 17:00-18:00.

- One may argue that the increased risk of accidents around 03:00 is due to the very different driving conditions pertaining at night. However, similar patterns have been observed in industry where shiftworkers have been operating under controlled lighting levels. This is supported by a study of long distance drivers in Sweden

during the spring and autumn [9]. Darkness seemed an unlikely cause of fatigue since the early morning peak in sleepiness occurred several hours after daybreak.

- Alcohol consumed early in the afternoon is about twice as potent in producing sleepiness and driving impairment as the same dose taken in the early evening [10].

KEY POINTS

- **Be aware that driving ability is lowest at night regardless of whether the driver is fully rested prior to commencing the journey.**
- **If possible, avoid driving during the early morning hours.**
- **If it is necessary to drive overnight, ensure drivers try to sleep beforehand, and encourage them to take frequent short breaks throughout the journey.**
- **Be aware that individuals may also feel tired when driving in the mid-afternoon.**
- **Be aware that moderate alcohol consumption around lunchtime, within the legal driving limit, can present an increased risk for driving in the afternoon.**

1.2 LOSS OF SLEEP

- Sleep is a basic need, like thirst or hunger. An individual can only work for a limited period of time without sleep before he/she will experience adverse effects on their behavioural, physiological and cognitive functioning, and no amount of training will prevent this deterioration.

- The amount of sleep required for the maintenance of physiological and psychological health is, on average, 7-8 hours per day.

- Sleep loss is one of the main factors contributing to driver fatigue. It may be due to working long hours, working a night shift or leaving home early in the morning to go to work [11].

- It is important that commanders and individuals recognise the early symptoms of sleep loss, as sleep deprivation will lead to performance decrements and frequent mental lapses. Even though drivers may be aware of their declining level of alertness they do not seem to realise how close they are to falling asleep at the wheel.

a. Physical signs

- The physical signs of sleep loss include:

  - yawning
  - slumped posture
  - blood-shot eyes
  - pale skin tone
  - clumsiness
  - difficulty in focusing
  - increase in blinking
  - slurred speech
  - drooping eyelids

- There are large individual differences in tolerance to sleep loss.

- As sleep loss increases, the symptoms will become more pronounced and will persist.

- There is an increase in hunger disproportionate to the time spent awake. The effects of sleep loss cannot be prevented simply by providing a high-energy diet.

b. Effects on mood

- Negative moods most often reported are:

- tiredness	- decreased willingness to work
- depression	- less cheerful
- irritability	- decreased initiative
- feelings of persecution	- less sociable
- inability to concentrate	- reduced motivation

- Changes in mood will often appear after one night of total sleep loss.

- Interpersonal relationships may deteriorate quickly and there may be a detrimental effect on communication between team members. There may also be an unwillingness to listen to all available information.

c. Effects on driving ability

- Sleep loss will affect those tasks which are uninteresting, of long duration and require sustained attention [12,13], all features which are characteristic of driving a vehicle.

- In some cases accuracy may not be impaired, but reaction times will be slower. In addition, there may be lapses in attention, an inability to concentrate, a failure to take all relevant information into account when making decisions, an acceptance of lower performance standards, increasingly erratic operation of controls and increased risk-taking.

- Mental performance after sleep deprivation still follows the 24-hour pattern of the body clock, with an improvement during daylight hours and a decline at night-time. However, levels of performance will be much lower than usual. No amount of training will prevent this deterioration.

- When overnight sleep is restricted to less than 5 hours per night, performance will deteriorate [14,15]. Even as little as 2 hours sleep loss can result in impairment of performance, reduced levels of alertness and a reduction in the time taken to fall asleep during the day [16,17]. A preliminary study suggested that sleep periods of less than 6 hours were associated with higher levels of sleepiness whilst driving as well as impaired driving ability [18].

- Following a night without sleep, it has been shown that drivers exhibit a safety-critical decline in lane-keeping performance, [19]. This alteration in vehicular control may increase the probability of an accident.

- A relationship between performance decrements associated with reduced levels of alertness and those associated with alcohol intoxication has been derived [20]. It has been estimated that the equivalent blood alcohol concentration to 17 hours of continuous wakefulness, commencing at 07:00, is 0.05%. Although it is not possible at present to evaluate the role of fatigue at the scene of an accident, this approach does highlight that even relatively short periods of sustained wakefulness produce performance impairments that are equivalent to, or even greater than, current legal limits for alcohol intoxication.

- After 48 hours without sleep near vision may be impaired.

d. Sleep disorders

- Driver fatigue may be associated with insomnia which can be transient (e.g. sleep debt associated with a noisy environment) or short term (e.g. response to a life crisis). It may also be associated

with a sleep disorder (e.g. narcolepsy [excessive daytime sleepiness], Obstructive Sleep Apnoea [obstruction of airways during sleep]), and Restless Legs Syndrome.

- Individuals with obstructive sleep apnoea (OSA) have a higher incidence of falling asleep while driving and a high rate of road accidents [21,22,23]. One of the problems with OSA is that individuals may not recognise, or receive very little warning, that they are becoming fatigued, and therefore find it very difficult to compensate for the effects. OSA most commonly affects overweight males, especially between the ages of 40 and 60 years.

KEY POINTS

- **Understand that drivers cannot be trained to cope with the detrimental effects of sleep loss.**
- **Recognise and make other drivers aware of the physical signs of sleep loss and the negative effects on mood. These may be an early indicator of fatigue.**
- **Be aware that a sleep-deprived person is usually a very poor judge of how he/she is being affected. Indeed, drivers are unlikely to gauge accurately their own level of impairment and may be overconfident in their ability.**
- **Be aware that a reduction in sleep duration by as little as 2 hours can impair driving ability.**
- **Achieve temporary alleviation of fatigue (i.e. approximately 15 minutes) by stopping the vehicle and taking a short walk, or winding down the window, but recognise that this will only delay and not prevent the overriding need to sleep.**
- **On long journeys, give the driver a 10-15 minute break every hour (see Section 2.1) and, if possible, rotate driver and passenger (e.g. every 2 hours). The social support of a passenger may, in itself, help to counteract fatigue.**

- **A careful medical assessment of the individual should be carried out if there is a complaint of persistent insomnia and/or excessive daytime sleepiness. This should include assessment by a sleep specialist if a history of heavy snoring and obesity is present.**

1.3 LONG HOURS OF WORK

- Fatigue can build up either during a single prolonged duty period or as a result of a high concentration of working hours over several days or weeks.

- A compressed working week [24], sustained operations [25] and overtime [26] can impair performance on tasks requiring sustained attention.

- A recent study has suggested that a working week of 50 hours or more can lead to increased levels of driver sleepiness on the drive to and from work [18].

- In another study of individuals, who all lived within 30 minutes of their workplace, it was shown that longer duty periods were associated with more difficulties on the journey to and from work [27]. A 12.5 hour duty resulted in more personnel experiencing lapses in attention whilst driving, falling asleep at the wheel and near accidents compared with personnel on a 9-hour duty. The safety of personnel whilst driving home is therefore an important issue, particularly when they are driving home after a long overnight duty.

- For a professional driver, an 8-hour driving period during the day, divided by sufficient rest and meal breaks, should have no adverse implications. However, driving time that extends beyond 8 hours has been associated with an increase in symptoms of fatigue [28] and an increase in the risk of an accident [29,30].

- After 8 hours of driving there is a decrease in the ability to make fine steering adjustments.

- The search for acceptable lengths of duty is further complicated by the influence of time of day. Two factors – time since sleep and time of day – form the basis of a predictive model of alertness (Figure 2) [31]. The first component is equivalent to time on duty if it can be assumed that the individual was fully rested at the start of duty.

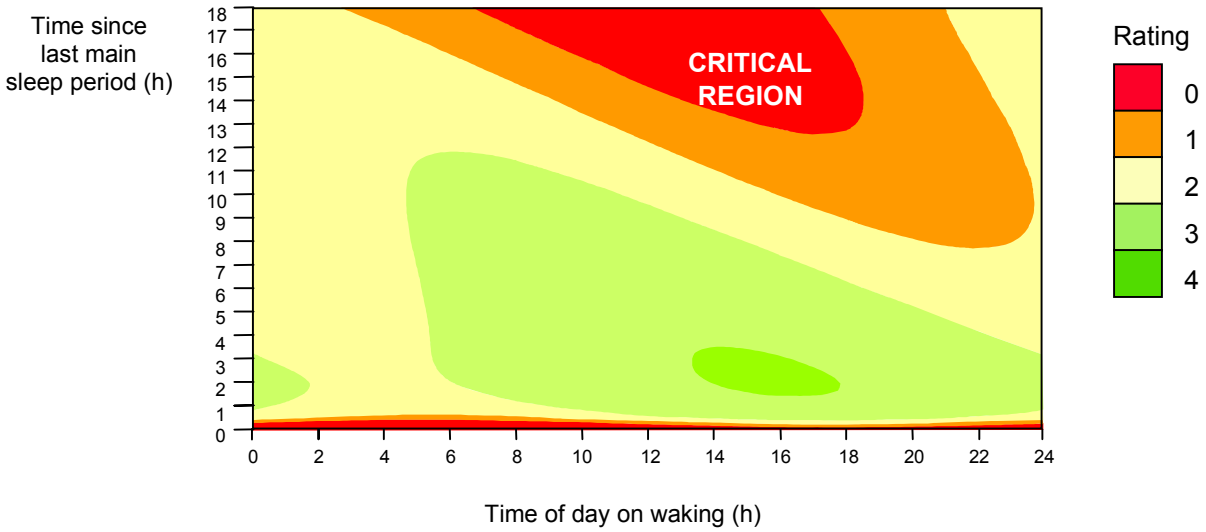


Figure 2: The CHS Alertness Model
(ratings indicate predicted levels of performance (0=lowest, 4=highest))

- The model highlights the earlier onset of fatigue during duty periods that start late in the day and extend through the night. For example, whilst it may be possible to drive for a period of 8 hours during the day, a similar period overnight may not be acceptable.

- Fatigue that builds up during the course of a long duty period, particularly overnight, results in short lapses in attention, or in some cases, 'microsleeps', where for short periods, around 30 seconds, the activity of the brain shows a transition from waking to sleeping. This can result in an increase in reaction time or an increased probability of missing an important sign [32].

- As the work period progresses, drivers may selectively focus their attention on important task features, so that peripheral tasks are ignored. Indeed, throughout a 257-km journey a decline in drivers' detections of certain road signs has been reported [33]. There is insufficient evidence to predict the elapsed driving time, during a period of prolonged driving, when this self-regulatory process will break down and driving will become hazardous, but the risk will be greatest around 03:00 on a quiet motorway.

- Long hours of work may only be acceptable if it is possible to take a short sleep during the duty period (see Section 2.3). This is particularly beneficial overnight when fatigue induced by long periods of work interacts with the circadian dip in alertness.

- A review of accident rates related to time on duty, has shown that there is a 2-4 hour peak in accident risk after the start of duty [6]. This 2-4 hour peak in risk could be related to continuous driving without a break, but the underlying reason can only be determined by further research.

- Studies in air traffic controllers have shown that commuting times in excess of 1 hour can contribute to increased levels of fatigue during a duty period [34]. Whilst there is no information on individuals employed as drivers, it is possible that commuting times of an hour or more could impair driving ability.

KEY POINTS

- **Driving duties should be limited to 8 hours during the day and possibly shorter during the night. This should include breaks for rest and meals.**

- **Be aware that an acceptable length of duty should be a function of the time the work occurs in the 24-hour day.**

- **Microsleeps are a warning sign to stop the vehicle. The driver should not resume control of the vehicle until he/she has taken a sleep and feels fully recovered (see Section 2.3).**

- **Recognise that long shifts often involve increased accident risk, but are tolerable if individuals have sufficient influence over the pace of work, workload and breaks, and are given time off afterwards to recover.**

- **Encourage drivers to take a nap prior to, or during the early hours of, a long overnight drive (see Section 2.3).**

- **It is advisable to base drivers within 1 hours travelling time of their home. If drivers are required to report to a more distant location, the additional travelling time should be included in the duty period.**

1. 4 IRREGULAR HOURS

- The increasing requirement for round-the-clock operations has placed greater emphasis on the need to design optimum work/rest patterns to help maintain human efficiency. It is recognised that the careful design and management of work-rest schedules has an important role to play in ensuring driver safety.

- A Commanders' guide to the management of irregular work-rest schedules [35] has recently been produced. This booklet aims to provide the three Services with an understanding of the human factor aspects that apply to the management of work-rest schedules to maintain operational effectiveness. It includes specific advice on coping with irregular hours of work and, therefore, will not be duplicated in full here.

- Irregular work patterns, particularly those involving night work, require individuals to continue driving through troughs in their circadian rhythm of alertness. In 1996, the National Sleep Foundation in the USA claimed that '20-30% of individuals with irregular work-rest schedules have experienced a fatigue related mishap within the previous year' [36].

- Irregular driving schedules have been shown to produce greater subjective fatigue and performance impairments than regular working hours [37]. Fatigue effects become evident after about 8 hours on regular schedules, but are considerably earlier when the work is irregular.

- Accident risk may be increased by over 30% on the night shift compared with the morning shift [38]. Indeed the risk of falling asleep at the wheel or being involved in an accident on a working day, where the driver is at fault, are greater on the drive home from a night shift.

- Early duties, particularly those commencing before 06:00, are associated with a reduction in sleep time and higher levels of tiredness at the end of the duty [34,39].

- Late shifts, finishing after midnight, are also likely to involve some sleep loss, and be associated with higher levels of fatigue than shifts finishing before midnight [40].

- The problems associated with a single night shift are likely to continue on successive nights while the circadian rhythm of the individual remains synchronised with clock time. It has been estimated that by the end of a week of night shifts, an individual may have lost the equivalent of at least one night's sleep [41].

- Although the effects may not be as great as those associated with the night shift, evidence suggests that there is also a continued disruption of sleep associated with consecutive early starts [42].

- Compared with non-shiftworkers, shiftworkers have reported that they feel more tired on the drive between their home and the workplace and consider that they are more at risk of falling asleep behind the wheel [18]. The main factors contributing to this increased level of sleepiness and associated driving impairments are :
  - night shifts
  - sleep periods of less than 6 hours
  - journeys exceeding 35 minutes in duration

KEY POINTS

- **Recognise that individuals who work irregular hours are more likely to be involved in a road accident.**

- **Avoid long sequences of night duties, or early starts, so as to restrict the accumulation of a sleep debt.**

- **Encourage drivers to compensate for any lack of sleep by attempting to nap before reporting for duty (see section 2.3).**

- **If it is necessary to work an extended period overnight, it is advisable that the driver is allowed to take a short sleep before driving home or is provided with transport.**

1.5 INDIVIDUAL DIFFERENCES

- Differences in age, physiological well-being and general ability to sleep may influence an individual's predisposition towards sleepiness whilst driving a vehicle. Some individuals may be more susceptible to lapses in attention whilst driving than others.

- Individuals differ in their preferred time of day for mental activity. Those who experience peak alertness and activity early in the day have been called 'morning types', as opposed to 'evening types' who perform better later in the day. Although the majority of individuals lie midway between these two extremes, those with a tendency towards 'morningness' may be less tolerant to working irregular hours [43].

- Individuals who find it relatively easy to sleep at unusual times and have no preference for regular sleeping or meal times have shown a better tolerance to working irregular hours [44].

- Adjustment to irregular work tends to become more difficult with age. In most individuals aged between 40-50 years the ability to cope with shifts deteriorates and health problems are more likely to occur [45]. Older individuals generally have a preference for working early shifts.

- Anxieties over domestic and work problems are considered to be a major contributor to sleep problems. They result in poor sleep quality, reduced sleep duration, and consequently sleep loss.

- Fit military personnel may have a better tolerance to working at unusual times.

- Young male drivers are most at risk of being involved in a fatigue-related accident. A greater number of accidents are reported by drivers under 30 years of age compared with those aged over 30 [18,46,47]. This suggests that young drivers, who should resist task and circadian fatigue better than older drivers, may not rest when they should. Younger drivers are also more likely to drive at night, and have less experience of coping with fatigue.

- Younger drivers (18-20 years) tend to have more accidents at night and older drivers (≥ 56 years) tend to have more accidents in the afternoon [48]. However, this may be a reflection of factors such as alcohol consumption and timing of social activities.

- Some skills have been reported to be intrinsically more difficult for older drivers, including those involving vigilance, judgement of speed and distance, and co-ordination [49].

- Professional drivers experienced in working under difficult task conditions are better able to manage their job demands and compensate for some fatigue effects [29]. Thus, although their overall accident risk may be higher than drivers working under less demanding conditions, experienced drivers may be better able to avoid an accident.

- One study has found that high risk drivers had less than 5 years driving experience, whereas low risk drivers had greater than 10 years experience [30].

- Differences in dietary habits may also affect levels of fatigue when driving. One study has shown that the risk of falling asleep was reduced by an intake of sugar [50]. Certain foods that are high in protein (e.g. meat, cheese and eggs) have been reported to alleviate tiredness if foods rich in carbohydrates (e.g. bread and potatoes) are avoided [51]. Although it is generally agreed that a lack of nutritional food or a heavy food intake (>600 kilocalories) will increase fatigue, the research on specific food intake to counteract fatigue is inconclusive.

- The quality of sleep in drivers can be affected by their intake of alcohol. A small amount may help to promote sleep, but as little as 2 units will worsen the quality and quantity of sleep.

- Individuals who have ingested over-the-counter painkillers, antihistamines and decongestants may find that their driving performance is adversely affected.

- There are many other individual characteristics, such as gender, marital status, personality, attitude and health which may influence susceptibility to sleepiness whilst driving a vehicle. In addition,

factors such as type of vehicle, traffic density and driving conditions may also influence driver performance.

KEY POINTS

- **Be aware that tolerance to working irregular hours varies with individuals. Be on the lookout for those drivers who find their schedule particularly demanding.**
- **Circadian type (i.e. morning or evening) and flexibility can be assessed using simple questionnaires. Obtaining this information from drivers may help to optimise the scheduling of work.**
- **Drivers should be provided with a balanced diet. Avoid heavy meals rich in fats during a night duty when the metabolic rate is lower than during the daytime.**
- **Drivers should not use alcohol to aid sleep, although a small amount (i.e. a single unit) is unlikely to have a significant detrimental effect.**
- **Ensure personnel have easy access to health care services and are given guidance on coping with working long and irregular hours.**
- **Fitness for work should be evaluated periodically.**
- **Seek advice from a Medical Officer on possible side-effects of any medications being taken.**

1.6 VEHICLE ENVIRONMENT

- Environmental conditions may influence a driver's performance. Poor ventilation, lack of space, high temperatures, uncomfortable seating and poorly designed control panels have all been cited as factors that contribute to driver fatigue [52].

- The error rate on a tracking task was found to double when the temperature was raised from 20°C to 26°C [53]. Individuals performed similarly under normal conditions but diversified under higher temperatures indicating that a higher temperature may have a different impact on different people.

- The use of cold air (from vehicle air conditioning vents) and listening to a radio or tape have been found to be of marginal benefit [54] and are only sufficient to allow a driver to find a suitable place to take a break.

- Vibration may cause a decrement in cognitive performance. However such effects may be partly attributed to interference with visual and manual control.

- During short operations, adequate rest can be achieved in a vehicle seat, provided that the back angle with the vertical approaches 40º and the legs are supported [55]. However on extended operations, individuals should be able to lie down to ensure adequate and sufficient sleep is obtained.

KEY POINTS

- **Be aware that poor ventilation, lack of space, high temperatures, uncomfortable seating, and poorly designed control panels are all factors which may contribute to driver fatigue.**

1.7 WORKLOAD

- Almost all types of work will involve variations in workload at different times. The variation of workload within a duty period plays an important role in determining the onset of fatigue and the ability to sustain performance.

- Both a low and a high workload can result in poorer performance. Indeed driving ability may be impaired whilst driving on a quiet motorway or through a busy city. Also, adaptation to task demands is particularly relevant in driving, as the task can involve rapid variability of workload.

- The effect of a low workload has been observed during a simulated driving task [56]. Fatigued drivers were able to cope with the increased demands of a task that involved a curved road, but when the task was relatively easy (i.e. a straight road), performance began to deteriorate.

- Decrements in performance are increased by the demands of a high workload, and levels of workload that can be maintained during the day are unlikely to be sustained for the same periods overnight [57]. At high levels of workload, there is a greater impairment of performance on tasks that require continuous sustained attention than those that require discrete responses.

- Driving involves skill in time-sharing multiple task components. Information displays in vehicles may divert the driver's attention away from the road [58]. Since driving is primarily a visual-motor task, any in-vehicle information should, if possible, make use of other modalities.

KEY POINTS

- **Be aware that the level of workload is an important factor in the development of driver fatigue.**

- **Consider the use of facilities for aural messages, so as to reduce the demand for visual processing.**

Section 2: Prevention of Driver Fatigue

2.1 BREAKS

- Although drivers are usually aware of a low level of arousal, there is a tendency to continue driving rather than take a break. If a driver experiences a 'microsleep' but continues to drive, they are likely to fall asleep again within the next 5 minutes [59]. Once this pattern of sleepiness has become established it is very difficult to overcome.

- The practice of incorporating breaks and rest pauses into a work period is well established, and has been shown to reduce fatigue [60,61]. In general, longer breaks have been shown to have a greater and more sustained effect than shorter breaks, and it has been suggested, in the case of the driving task, that the length of breaks should be related to the duration of the journey [62].

- The re-emergence of sleepiness can be extremely rapid when drivers are very tired, and so the frequency of breaks is another important factor that needs to be considered [63]. The optimum frequency and timing of breaks will be influenced by the level of workload and the time of day. The need to take frequent short rest breaks may be of particular importance when driving in an unstimulating environment, such as a motorway or during the night, when the driver is more prone to drifting into an inattentive state.

- A 15-minute rest period is sufficient to overcome the accumulated performance deficits associated with 75 minutes of sustained attention [64]. The beneficial effect of these short breaks has been established during a 12-hour overnight duty (Figure 3).

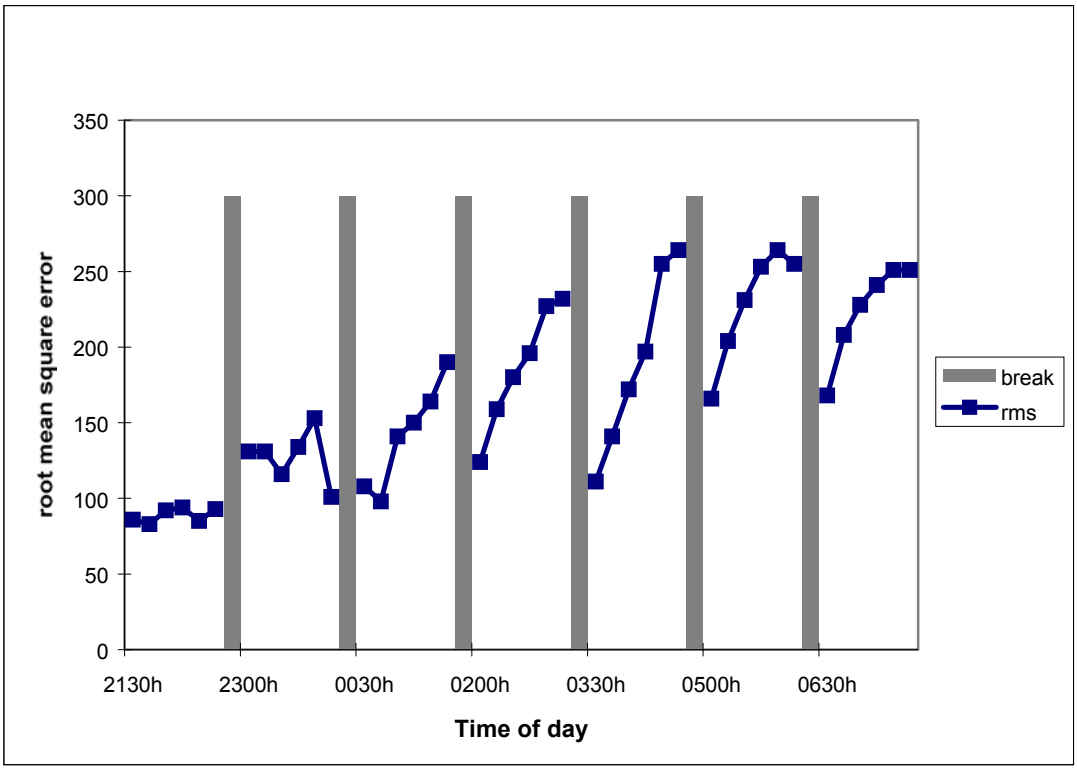


Figure 3: The effect of 15-minute breaks on tracking ability

KEY POINTS

- **Take frequent 15-minute breaks, particularly when driving at night. It is difficult to define a specific time interval, since this will depend on time of day, but certainly during the night a break every 1-1.5 hours would be appropriate.**

- **Breaks are not a substitute for sleep and, although they are a useful countermeasure, if a driver is very tired, he/she should be encouraged to take a short sleep (see Section 2.3).**

2.2 PHARMACOLOGICAL AGENTS

- Caffeine, found in many beverages and over-the-counter medications, improves driver performance [65]. It increases alertness although individuals who drink caffeinated beverages in the latter part of the day, particularly close to bedtime, may experience disturbed sleep. It may also shorten the length of daytime naps. Heavy caffeine users (e.g. 5 or more cups of coffee per day [≥ 350 mg]) may become tolerant and large doses will be necessary to produce an alerting effect. Sudden withdrawal of caffeine from heavy users can produce adverse effects on performance and often results in headaches.

- Drinking three cups of coffee (approximately 200mg caffeine) is effective in reducing sleepiness and driving incidents for up to 30 minutes in drivers who have been awake all night. In drivers, who have taken 5 hours sleep, this same amount of caffeine significantly reduces incidents and subjective sleepiness throughout a 2 hour drive [66].

- As coffee is prepared in many different ways, the caffeine content per cup will vary. Thus, the consistent content of caffeine in recreational drinks (e.g. Red Bull) and pills (e.g. Pro-Plus) may be more appropriate as a countermeasure to performance decrements. The wide availability of these and their convenience are also positive considerations.

- A preliminary study of the effects of Red Bull on levels of sleepiness in caffeine-deprived individuals has recently been carried out [67]. This showed that drinking one can (250ml) containing 75mg caffeine, was effective in reducing moderate levels of sleepiness (e.g. the afternoon dip) for about an hour after being absorbed by the body (i.e. 30 minutes following ingestion). Two cans eliminated moderate levels of sleepiness for about 90 minutes after being absorbed. However, further research is needed to establish any adverse effects. It is not yet known how long after ingestion sleep is impaired, particularly in the middle-aged who have less restful sleep. It must also be borne in mind that high doses of caffeine may lead to tremor and tachycardia.

- Sleeping pills (hypnotics) are available to assist sleep in those individuals involved in driving. If anxiety, heat, noise, time of day effects etc. make sleep difficult, the occasional aid of a short-acting hypnotic may be beneficial [68]. Hypnotics, such as temazepam, have been used in military operations to ensure adequate sleep in critical scenarios, and it is clear that, if used judiciously, they are a significant force multiplier. The development of the ultra-short-acting hypnotic zaleplon opens the possibility of sustained operations being supported by periods of rest of, possibly, only 4 hours duration. However, further work needs to be carried out to explore this possibility, and to establish the usefulness of zaleplon in exacting circumstances.

- Over-the-counter painkillers, antihistamines and decongestants can affect performance adversely.

KEY POINTS

- **Consume caffeine in the form of a tablet (200-250mg), as 3 cups of instant coffee, or 2 cans of 'Red Bull' within the first few hours of a duty to help maintain alertness throughout a long drive. However, avoid such beverages before bedtime, so as not to disrupt sleep.**

- **Consider the use of short-acting hypnotics, such as temazepam (10-20mg), during operations when it is important to avoid sleep loss. Following ingestion, allow individuals to sleep uninterrupted for 6 hours, and not drive for 8 hours. This will ensure there are no residual effects of the hypnotics on performance.**

- **Alternatively, consider ultra-short-acting hypnotics, such as zaleplon (10mg), for use during operations with periods of rest of around 4 hours.**

- **Advice should be given by a Medical Officer on the correct use and possible side-effects of any medications being taken.**

- **The regular use of pharmacological agents should not be advocated, but recognise that they can be of benefit in demanding circumstances.**

2.3 NAPS

- The term 'nap' is usually defined as a short sleep. For the purpose of this guide, a nap will be considered to be a short sleep ranging from about 10 minutes (known as 'power naps') to 4 hours in duration, taken at any time of the day or night, and either in or out of bed.

- In general, naps have a beneficial effect on performance and mood, and may be the most effective countermeasure against driver fatigue. Episodes of sleep as short as 30 minutes can increase levels of alertness towards the end of a duty period [69]. Generally the longer the nap, the greater the benefits on mood, performance and alertness [70,71].

- A nap will be particularly effective if taken as an ‘anticipatory nap’ prior to a period of expected tiredness, rather than if it is delayed until fatigue has become established [72]. A 4 hour daytime nap taken before a night duty will not eliminate completely the normal dip in performance experienced during the early morning hours (i.e. between 04:00 and 06:00) but the degradation in performance will be reduced [73].

- Naps taken after 18 hours without sleep do not have as great or as long-lasting an effect on performance, compared with earlier naps [70]

- Sleep quality and quantity are likely to be optimum when the nap:
  a) follows a reasonable period of wakefulness
  b) coincides with the phase of the circadian cycle during which sleep tends to occur (i.e. 14:00-16:00 and 00:00-06:00)

- It has been suggested that there is also a period in the evening known as the ‘forbidden zone’ for sleep [74]. During this period, which precedes the normal nocturnal sleep by approximately 2-3 hours, (i.e. around 17:00-21:00) sleep initiation and maintenance are thought to be difficult.

- During the day, it is easier to get to sleep in the afternoon (around 15:00). Indeed, napping in the afternoon is traditional in some cultures.

- Following a night without sleep, a nap in the morning improves alertness throughout the rest of the day.

- A long nap may affect subsequent sleep by delaying its onset or disrupting the quality of later sleep periods. This shortening of sleep after a nap is especially prevalent in older individuals who find it difficult to adapt to changes in their sleep pattern.

- Generally, the same individual factors that affect sleep (e.g. age, anxiety) will influence napping ability.

- Napping during a night shift may relate to the sleeping habits of individuals. It is possible to distinguish between 'nappers' who can sleep almost anywhere and 'non-nappers' who report difficulty falling asleep in various environments. Non-nappers are more likely to be disturbed and woken by alerting stimuli such as noise [75].

- A combination strategy using both caffeine and naps could be an effective way to improve performance, but needs further assessment. Caffeine (150mg) taken immediately before a nap of up to 15 minutes (within a 30-minute break) was found to be more effective in maintaining alertness and performance during a 2h monotonous afternoon drive in a car simulator, than caffeine (200 mg) alone [65]. Caffeine in coffee takes approximately 30 mins to have an alerting effect, so a short 15-min nap will not be compromised providing it is taken immediately after the coffee.

- Resting is not a substitute for sleep. The regenerative powers associated with sleep cannot be accomplished by just rest.

Sleep Inertia:

- Sudden awakening from sleep is often accompanied by a state of confusion, impaired performance and mood which can persist for 15-30 minutes [76]. This is known as 'sleep inertia'.

- The transient effects of sleep inertia can give rise to performance levels that are worse than during an overnight period without sleep [77,78].

- Tasks requiring sustained attention, such as driving, are thought to be more susceptible to sleep inertia.

- The severity of sleep inertia appears to be related to the depth of sleep immediately preceding awakening, and the duration of 'deep sleep' [79]. The latter is influence by the amount of sleep loss prior to the nap, the time of day that the nap is taken, and the duration of the nap.

- The effects of sleep inertia are worse and longer lasting among individuals who are sleep deprived [76,77].

- If individuals are awakened after the first few hours of sleep (when sleep is deepest), performance is more likely to be impaired than following a sleep of 4 hours or more. This is therefore an important consideration in situations where naps are used to counteract fatigue, particularly if duties must be resumed immediately after waking.

- If naps are restricted to 10 minutes, deep sleep is avoided and the effects of sleep inertia are not evident. There is an immediate and sustained recovery in alertness, mood and performance [80].

- The use of caffeine following a nap (see Section 2.2) is not a feasible countermeasure to sleep inertia, as it can take 30 minutes from caffeine ingestion until it is effective. Other alerting measures, such as exposure to loud noise (75db(A)) and bright light may also be useful.

- Not all drivers are able to nap in a vehicle, and this coupled with the possible difficulties in waking up, would suggest that in some cases alternative countermeasures are required.

KEY POINTS

- **If the time available for sleep is limited e.g. less than 5 hours in each 24-hour period, encourage personnel to nap when possible. This will reduce the effects of sleep deprivation and attenuate the performance decrement.**

- **Encourage drivers to take a nap prior to an overnight journey and in the early part of a prolonged duty period.**

- **Where possible, ensure 60-90 minutes are available as a napping period. However, so as not to disrupt sleep scheduled for the subsequent night, naps longer than 1 hour should not be taken in the afternoon.**

- **Consider the detrimental effects of sleep inertia when taking naps.**

- **If possible, allow at least 30 minutes between awakening and starting duty. If personnel are required to go on duty immediately, safety critical operations, such as driving, should be avoided.**

2.4 RECOVERY

- An uninterrupted sleep of 8-9 hours is needed after 24 hours awake for a full recovery. However, sleeping for too long (e.g. 10 hours or more) may interfere with the normal sleep-wake schedule.

- A person will usually feel the greatest need to sleep between 24:00 and 06:00 (see section 1.1). Any sleep during this period will have the most recuperative value.

- Although an individual can usually overcome the effects of short term fatigue with a single good recovery sleep, the effects of cumulative fatigue that arise from a series of duties carried out over a 7-day period may take longer to dissipate. Three consecutive overnight sleeps are required to obtain a full recovery [40].

- A period of 8 hours or less between duties is known as a 'quick return'. Quick returns severely restrict sleep duration and exacerbate fatigue [39]. Quick returns at any time of the day are inadvisable, but pronounced sleep deficits are likely to occur when an evening shift follows a night shift.

KEY POINTS

- **Nine hours recovery sleep is sufficient to recover from a period of 24 hours of being awake.**

- **If possible, try to obtain some sleep at night during irregular schedules.**

- **Ensure the rest period between consecutive shifts is 8 hours or more.**

References

1. Defence Annual Road Safety Report, JSP 485, 2001

2. Colquhoun WP. Circadian variations in mental efficiency. In: WP Colquhoun (ed.) Biological Rhythms and Human Performance. Academic Press, London, 1971;pp. 39-107.

3. Folkard S, Monk TH. Shiftwork and performance. Human Factors, 1979;21(4):483-492.

4. Campbell S. Duration and placement of sleep in a 'disentrained' environment. Psychophysiology, 1984;21(1):106-113.

5. Mitler MM, Miller J, Lipsitz JJ, Walsh JK, Wylie CD. The sleep of long-haul truck drivers. New England Journal of Medicine, 1997;337:755-761.

6. Folkard S. Black times: Temporal determinants of transport safety. Accident Analysis and Prevention. 1997;29(4):417-430.

7. Lenne MG, Triggs TJ, Redman JR. Time of day variations in driving performance. Accident Analysis and Prevention. 1997;29:431-437.

8. Horne JA, Reyner LA. Driver Sleepiness. Journal of Sleep Research, 1995;4(suppl. 2):23-29.

9. Kecklund G, Akerstedt T. Sleepiness in long distance truck driving: An ambulatory EEG study of night driving. Ergonomics, 1993;36(9):1007-1017.

10. Horne JA, Baumber CJ. Time of day effects of alcohol intake on simulated driving performance in women. Ergonomics, 1991;11:1377-1383.

11. Fell DL, Black B. Driver fatigue in the city. Accident Analysis and Prevention, 1997;9:463-469.

12. Haslam DR. Sleep loss, recovery sleep and military performance. Ergonomics, 1982;25(2):163-178.

13. May J, Kline P. Measuring the effects upon cognitive abilities of sleep loss during continuous operations. British Journal of Psychology, 1987;78:443-455.

14. Tilley AT, Wilkinson RT. The effects of a restricted sleep regime on the composition of sleep and on performance. Psychophysiology, 1984;21:406-412.

15. Webb WB. Experiments on extended performance: Repetition, age and limited sleep periods. Behavior Research Methods Instruments and Computers, 1985;17:27-36.

16. Caraskadon MA, Roth T. Sleep restriction. In: TH Monk (ed.) Sleep, Sleepiness and Performance. Wiley, Chichester, 1991:pp. 155-167.

17. Rosenthal L, Roehrs TA, Rosen A, Roth T. Level of sleepiness and total sleep time following various time in bed conditions. Sleep, 1993;16:226-232.

18. Rogers AS, Holmes S, Spencer M. The effect of shiftwork on driving to and from work. 2002; accepted for publication in The Journal of Human Ergology.

19. Fairclough SH, Graham R. Impairment of driving performance caused by sleep deprivation or alcohol: A comparative study. Human Factors, 1999;41(1):118-128.

20. Dawson D, Reid K. Fatigue, alcohol and performance impairment. Nature, 1997;388:235.

21. George C, Nickerson P, Hanley P. Sleep apnoea patients have more automobile accidents. Lancet, 1987;2:447.

22. Strohl KP, Bonnie RJ, Findley L. Sleep apnea, sleepiness and driving risk. American Journal of Respiratory and Critical Care Medicine, 1994;150:463-473.

23. Aldrich M. Automobile accidents in patients with sleep disorders. Sleep, 1989;12:487-494.

24. Rosa RR, Colligan MJ, Lewis P. Extended workdays: effects of 8 and 12 hour rotating shift schedules on performance, subjective alertness, sleep patterns and psychosocial variables. Work and Stress, 1989;3(1):21-32.

25. Krueger GP. Sustained work, fatigue, sleep loss and performance: A review of the issues. Work and Stress, 1989;3(2):129-141.

26. Proctor SP, White RF, Robins TG, Echeverria D, Rocskay AZ. Effect of overtime work on cognitive function in automotive workers. Scandinavian Journal of Work and Environmental Health, 1996;22:124-132.

27. Heslegrave RJ, Rhodes W, Gil V. A prospective study examining the changes to worker health and safety after changing to 12-hour shifts. Shiftwork International Newsletter, 1999;16(2):77.

28. Miller JC, Mackie RR. Effects of irregular schedules and physical work on commercial driver fatigue and performance. In: DA Osborne and JA Lewis (eds.) Human Factors in Transport Research. London, Academic Press, 1980;pp. 126-133.

29. Hamelin P. Lorry drivers' time habits in work and their involvement in traffic accidents. Ergonomics, 1987;30:1323-1333.

30. Kaneko T, Jovanis PO. Multiday driving patterns and motor carrier accident risk. A disaggregrate analysis. Accident Analysis and Prevention, 1992;24:437-456.

31. Spencer MB. The influence of irregularity of rest and activity on performance: A model based on time since sleep and time of day. Ergonomics, 1978;30(9):1275-1286.

32. Borland RG, Rogers AS, Nicholson AN, Pascoe PA, Spencer MB. Performance overnight in shiftworkers operating a day-night schedule. Aviation Space and Environmental Medicine, 1986;57:241-249.

33. Näätänan R, Summala H. Road user behavior and traffic accidents. Amsterdam: North Holland.1976.

34. Spencer MB, Rogers AS, Stone BM. A review of the current Scheme for the Regulation of Air Traffic Controllers Hours (SRATCOH), Report No. PLSD/CHS5/CR/97/020, 1997.

35. Rogers AS, Robertson KA, Stone BM. A Commanders' guide on the management of irregular work/rest schedules. CG/WORKAND REST/v2.0/MAR2001.

36. National Sleep Foundation. Drowsy driving fact sheet. Drive Alert Arrive Alive International Forum on Sleepiness and Crashes, 28 May, 1996.

37. Mackie RR, Miller JC. Effects of hours of service, regularity of schedules and cargo loading on truck and bus driver fatigue. Tech. Rep. 1765-F. Goleta, CA:Human Factors Research Inc .1978.

38. Folkard S, Akerstedt T, Macdonald I, Tucker P, Spencer M. Refinement of the three-process model of alertness to account for trends in accident risk. In: S Hornberger, P Knauth, G Costa, S Folkard (eds.) Shiftwork in the 21st Century. Peter Lang, Frankfurt am Main, 2000;pp. 49-54.

39. Rogers AS, Spencer MB. A study of the work and rest schedules of aviation security screeners. DERA report No. DERA/CHS/PPD/CR/97280, 1998.

40. Rogers AS, Spencer MB, Stone BM. Validation and development of a method for assessing the risks arising from mental fatigue. 2000, HSE Contract Research report 254.

41. Tilley AJ, Wilkinson RT, Warren PSG, Watson B, Drud M. The sleep and performance of shiftworkers. Human Factors, 1982;24(6):629-641.

42. Rogers AS, Spencer MB, Stone BM. Sleep patterns of air traffic controllers: The impact of night shifts, and early starts. II European Symposium of Ergonomics, Trioa, June 3-5, 1998.

43. Moog R. Morning-evening types and shiftwork. A questionnaire study. In: A Reinberg, N Vieux, P Andlauer (eds.) Night and Shiftwork: Biological and Social Aspects. Oxford, Pergamon Press, 1981:pp. 481-488.

44. Costa G, Lievore F, Casaletti G, Gaffuri E, Folkard S. Circadian characteristics influencing interindividual differences in tolerance and adjustment to shiftwork. Ergonomics, 1989;32(4):373-385.

45. Monk TH. Shiftwork and safety. Professional Safety, 1989;34:26-30.

46. Baker JS. Single-vehicle accidents on Route 66. Highway Research Record, 1967;188:26-43.

47. Maycock G. Driver sleepiness as a factor in car and HGV accidents. TRL Report 169, 1995.

48. Summula H, Mikkola T. Fatal accidents among car and truck drivers: effects of fatigue, age and alcohol consumption. Human Factors, 1994;36:315-326.

49. Holland CA, Rabbitt PMA. The problems of being an older driver: Comparing the perceptions of an expert group and older drivers. Applied Ergonomics, 1994;25(1):17-27.

50. Hubert S. Effect of driver fatigue. In: T Forbes (ed.) Human Factors in Highway Traffic Safety Research. Wiley, New York, 1972.

51. Ferrer CF, Bisson RU, French J. Circadian rhythm desynchronosis in military deployments: a review of current strategies. Aviation Space and Environmental Medicine. 1995;66:571-578.

52. Holmes SR, Willis A, Rogers AS, Finch M. London Underground Ltd: Track to train closed-circuit television – Human performance shaping factors. DERA Report No. DERA/CHS/PPD/CR98024, 1999.

53. Beshir MH, El-Sabagh AS, El-Nawawi MA. Time on task effect on tracking performance under heat stress. Ergonomics, 1981;24(2):95-102.

54. Reyner L, Horne J. Evaluation of 'in-car' countermeasures to sleepiness: Cold air and radio. Sleep, 1998;21(1):46-50.

55. Nicholson AN, Stone BM. Influence of back angle on the quality of sleep in seats. Ergonomics, 1987;30(7):1033-1041.

56. Desmond PA, Matthews G. Implications of task-induced fatigue effects for in-vehicle countermeasures to driver fatigue. Accident Analysis and Prevention, 1997;29(4):515-523.

57. Rogers AS, Spencer MB, Pascoe PA. Workload and fatigue in single seat operations: a laboratory study. DRA Report No. DRA/CHS/A&N/CR/95/022, 1995.

58. Fisher S, Goodhall J, Wark L. Effects of new technology in cars on driver attitudes and behaviour. Paper presented at the 23rd IAAP International Congress of Applied Psychology, Madrid, Spain, 1994.

59. Lisper HO, Laurell H, Van Loon J. Relation between time to falling asleep behind the wheel on a closed track and changes in subsidiary reaction time during prolonged driving on a motorway. Ergonomics, 1986;29:445-453.

60. Krueger GP. Sustained military performance in continuous operations: combatant fatigue, rest and sleep need. In R Gal and [INITIALS] Mangelsdorff (eds.), Handbook of Military Psychology, Wiley, New York, 1991;pp. 244-277.

61. Alluisi EA, Morgan BB. Temporal factors in human performance and productivity. In: EA Alluisi and EA Fleishman (eds.) Human Performance and Productivity (Volume 3), Lawrence Erlbaum Associates, Hillsdale, NJ, 1982;pp. 165-247.

62. Harris W, Mackie RR, Abrahms C, Buckner DN, Harabedin A, O'Hanlon JF, Stark JR. A study between the relationships among fatigue, hours of service and safety of operations of truck and bus drivers. Human Factors Research Inc. Report 1927-R, Goleta, California, 1972.

63. Landstrom U, Lindblom [INITIALS], Haggqvist S, Lofstedt P. Low frequency noise in lorries and correlated effects on drivers. Journal of Low Frequency Noise and Vibration, 1988;7(3):104-109.

64. Rogers AS, Spencer MB. The recuperative value of short breaks during an overnight period of work. Shiftwork International Newsletter, 1997;14(1):14.

65. Reyner LA, Horne JA. Suppression of sleepiness in drivers: Combination of caffeine with a short nap. Psychophysiology, 1997;34:721-725.

66. Reyner LA, Horne JA. Caffeine (200mg) as a countermeasure to early morning driver sleepiness after nil or restricted sleep. Journal of sleep research, 1998;7(suppl 2):223.

67. Horne J, Reyner L. Arrive alive: Tackling the killer problem of driver sleepiness. Paper presented at the 'Falling Asleep at the Wheel' conference, Market Bosworth, Warkwickshire, November 2000.

68. Nicholson AN. Hypnotics and occupational medicine. Journal of Occupational Medicine, 1990;32(4):335-341.

69. Gillberg M, Kecklund G, Axelsson J, Akerstedt T. The effects of a short daytime nap after restricted night sleep. Sleep, 1996;19(7):570-575.

70. Dinges DF,Orne MT, Whitehouse WG, Orne EC. Temporal placement of a nap for alertness. Contributions of circadian phase and prior wakefulness. Sleep, 1987;10(4):313-329.

71. Opstad PK, Ekanger R, Nummestad M, Raabe N. Performance, mood and clinical symptoms in men exposed to prolonged physical work and sleep deprivation. Aviation, Space and Environmental Medicine, 1978;49:1065-1073.

72. Rogers AS, Spencer MB, Stone BM, Nicholson AN. The influence of a 1h nap on overnight performance. Ergonomics, 1989;32(10):1193-1205.

73. Nicholson AN, Pascoe PA, Roehrs T, Roth T, Spencer MB, Stone BM, Zorick F. Sustained performance with short evening and morning sleeps. Aviation, Space and Environmental Medicine, 1985;56:105-114.

74. Lavie P. Ultrashort sleep-waking schedule III. 'Gates' and 'forbidden zones' for sleep. Electroencephalography and Clinical Neurophysiology, 1986;63:414-425.

75. Dinges DF. Adult napping and its effect on ability to function. In: C Stampi (ed.) Why we Nap. Evolution, Chronobiology and Functions

of Polyphasic and Ultrashort Sleep. Birkhauser, Boston, 1992;pp. 118-136.

76. Muzet A, Nicolas A, Tassi P, Dewasmes G, Bonneau A. Implementation of napping in industry and the problem of sleep inertia. Journal of Sleep Research, 1995;4(s2):67-69.

77. Balkin TJ, Badia P. Relationship between sleep inertia and sleepiness: Cumulative effects of four nights sleep deprivation/restriction on performance following abrupt nocturnal awakenings. Biological Psychology, 1988;27:245-258.

78. Salamé P, Otzenberger H, Ehrhart J, Dewasmes G, Nicolas A, Tassi P, Libert J. Effects of sleep inertia on cognitive performance following a 1 hour nap. Work and Stress, 1995;9(4):528-539.

79. Naitoh P, Angus RG. Napping and human functioning during prolonged work. In: DF Dinges and RJ Broughton (eds.) Sleep and Alertness: Chronobiological, Behavioural and Medical Aspects of Napping. Dinges DF and Broughton RJ (eds.), Raven Press, New York, 1989;pp. 221-246.

80. Tietzel AJ, Lack LC. The recuperative value of brief versus long daytime naps. Sleep, 2000;23(2):A55.

List of Current Commanders' Guides in-issue:

Document ID	Commanders' guide to:
1. CG/NUTRITION/v2.0/MAR2001	Fluid intake for optimal performance during military operations in the heat.
2. CG/WORK&REST/v2.0/MAR2001	Management of irregular work-rest schedules.
3. CG/NUTRITION&PERFORMANCE/ v1.0/JUN2002	Nutrition for health and performance
4. CG/DRIVERFATIGUE/ v1.0/SEPT2002	Reducing driver fatigue

~~~~~~

Forthcoming Commanders' Guides:	***Date planned***
Commanders' guide to ergogenic aids	*2002*
~~~~~~