



# JHC

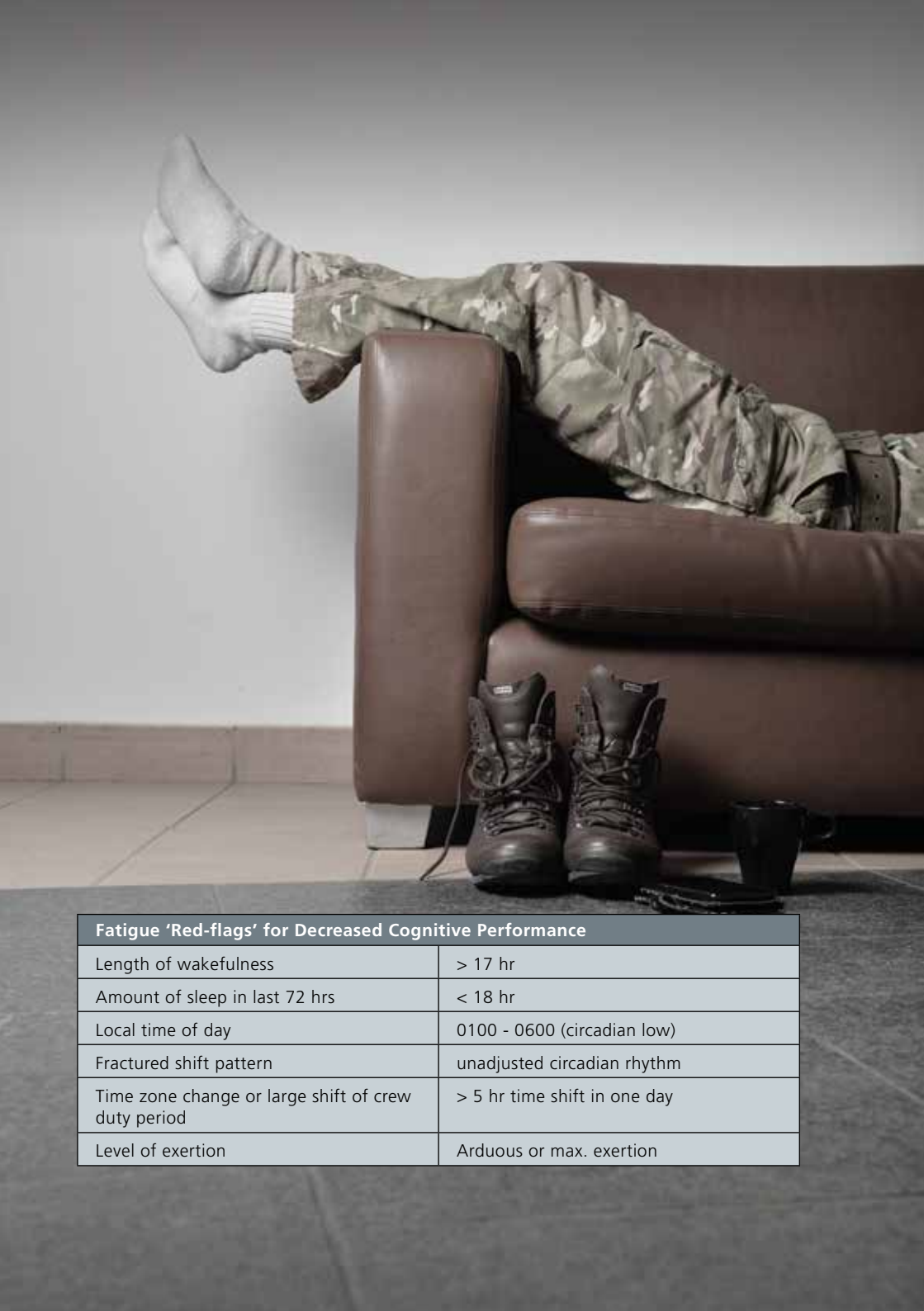
## Commanders' Guide to Fatigue Management





## COMMANDERS' GUIDE TO FATIGUE MANAGEMENT

*The first quality of a soldier is constancy in enduring  
fatigue and hardship. Courage is only second.*  
Napoleon



#### Fatigue 'Red-flags' for Decreased Cognitive Performance

Length of wakefulness	> 17 hr
Amount of sleep in last 72 hrs	< 18 hr
Local time of day	0100 - 0600 (circadian low)
Fractured shift pattern	unadjusted circadian rhythm
Time zone change or large shift of crew duty period	> 5 hr time shift in one day
Level of exertion	Arduous or max. exertion

#### Definitions and Manifestations

Fatigue is often separated into physical and mental categories with acute, chronic, and cumulative parameters:

- Acute: can be alleviated by a single sleep period
- Chronic: requires multiple sleep periods to recover
- Cumulative: builds across multiple duty periods where there is inadequate recovery between; requires multiple sleep periods to recover

Fatigue is not just some uncomfortable sensation to be endured but includes reduced human performance. With fatigue there is very often a penalty to pay with respect to efficiency, performance and safety. The manifestations can be subtle, insidious and often not fully appreciated by the individual.

To highlight the impact on performance, it helps to think of these deficits within the context of alcohol since many of deficits are comparable. In fact, in some neuroscience tests, individuals with sleep restriction perform on par with subjects that are legally alcohol-impaired: one study for example demonstrated 24 hrs of sleep deprivation to be equivalent in performance to a 100 mg/dl alcohol level<sup>1</sup>. How many times have you heard the phrase, "It's ok, I'm just really tired today. I'll be fine." and not thought much of it. But what if your co-worker said "It's ok, I'm just a little drunk today. I'll be fine."

Physical	Mental	Emotional
Slowed reaction time	Decreased concentration and vigilance	More quiet and withdrawn
Poor energy level	Omissions, carelessness	Irritability
Micro-sleeps or 'spacing out'	Failure to anticipate	Poor motivation and attitude
Headache, nausea, upset stomach	Mistakes even on well-practiced tasks, calculations	Unstable or labile mood
Repeated yawning	Poor decision making	Strained personal relationships
Varied task performance	Impaired memory	
	Poor communication, even with important information	
	Decrease in learning and problem-solving	
	Greater tolerance for error	

<sup>1</sup> UK legal limit for driving is 80 mg/dl of blood alcohol.

Fatigue contributes to poor health as well. Research has demonstrated associations between short sleep periods and a host of medical conditions including high blood pressure, diabetes, obesity, heart disease, and some types of cancer.

At present state, 70-80% of aircraft accidents are attributed to human factors...often implicating fatigue. Historically, human factors (including fatigue) have gone hand-in-hand with aviation-often with tragic results. There is now little doubt within the scientific community that fatigue contributes to poor health, lower productivity & worker efficiency, and a higher risk of accidents.

**Complexity of the Issue**

Fatigue is complex and multi-factorial. We understand some things reasonably well such as sleep and circadian rhythm. But there are multiple factors at play: inadequate sleep, circadian rhythms, high workload, extended duty periods, psychosocial factors, environmental factors, and others. There is also considerable individual variability. It’s important to emphasize that there is no simple, universal solution to the problem. The first step is education and respect for fatigue-related consequences. The second is to recognize (and plan for) conditions that are conducive to aircrew fatigue. You must work fatigue management into the plan, both in training and on operations. The last is to implement strategies, where possible, to mitigate fatigue. It must be a part of risk management decisions across the 4 Worlds. Commanders already do this for a number of other threats; conceptually, this is no different.

**Root Causes & Major Factors**

The human operating system has an optimal performance envelope just like an aircraft- exceeding this often comes at a cost. Furthermore, scientific studies have consistently shown that sleep-restricted individuals are unable to reliably judge their level of impairment and performance deficits. There are multiple risk factors to consider:

Fatigue Risk Factors	
Sleep deprivation	Inefficient or broken sleep
Circadian misalignment	Time awake and duty period
Health factors (medications, illness, sleep disorders, hypoxia, dehydration, others)	Environmental issues (temperature extremes, light, noise, vibration, others)
Workload and time on task	Stress and psychosocial factors
Time since last break	Others

**Sleep deprivation and efficiency**

The human system is optimized for a largely diurnal existence with periods of activity and periods of rest. Sleep is a fundamental physiological requirement, just like oxygen, water, and food. You must sleep- there is no substitute. As a general benchmark, it is estimated that individual performance declines approximately 30% with every 24hr period without sleep. Sleep is the remedy for acute fatigue.



Sleep is not just a period of unconsciousness; it's a critical biologic imperative whereby the body, and especially the brain, undergoes many vital processes. Two key contributors to fatigue include insufficient sleep and disruptions in normal sleep cycle.

Most individuals require 7-9 hrs of sleep a night. If an individual doesn't obtain the required amount, he will incur 'sleep debt.' Even very modest but consistent sleep loss over time can have cumulative significant consequences. This is the type most often seen in operational settings. Studies have demonstrated that 2hrs of sleep loss per night over a one week period can result in the same performance as subjects who had remained awake for 24 continuous hours. Both current (i.e. last night) and cumulative sleep history are important.

Efficiency and quality of sleep are important, as well. The body cycles through different levels in a predictable fashion:

Sleep Cycles	
Stage 1	Slowing brain activity. Individuals easy to arouse (and many will believe they were never asleep).
Stage 2	Further slowing of brain activity and progression to deeper sleep.
Stage 3 & 4	Deep (slow-wave) sleep. Individuals very difficult to arouse, and will feel very drowsy and sluggish when awoken. Very brief transition back through Stage 2 then to REM sleep.
REM sleep	Rapid Eye Movements and dreaming occurs. Muscle tone relaxes. Very active brain wave patterns.
Cycle repeats approximately every 90 minutes with progressively less time in deep (Stage 3 & 4) sleep.	

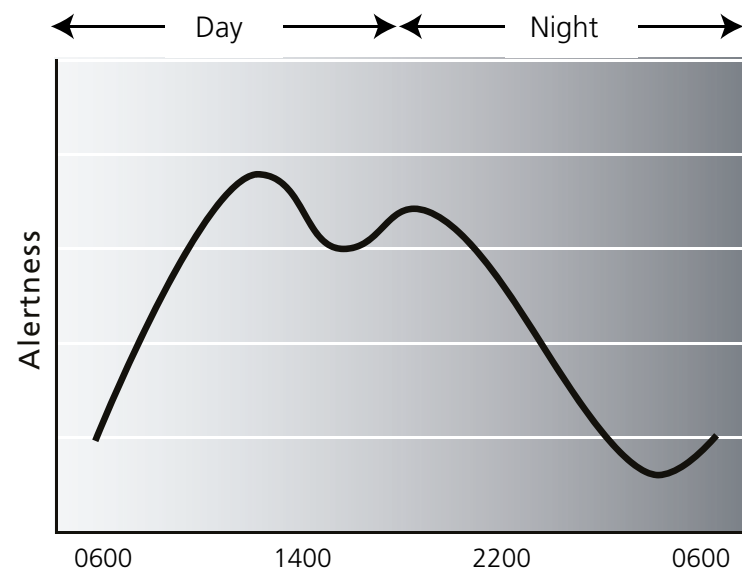
Studies have demonstrated that it is important to cycle through sleep stages and obtain uninterrupted sleep in order for the sleep period to be restful and restorative. Every effort must be made to preclude interruptions and awakenings during sleep to prevent fatigue. One study, for example, demonstrated that four 15min awakenings over an 8hr sleep period resulted in only marginally better performance than 4hrs of total sleep.

#### **Circadian dysrhythmia**

Most aircrew are somewhat familiar with the concept of the body's internal time clock. To date there have been over 300 physiological rhythms identified that are tied to this including such things as core body temperature, alertness, urine output, hormone release, and many others. This cycle is quite predictable and highly resistant to change. Light exposure (especially sunlight) is a very strong driver for the body's internal clock. There are other less important drivers such as social cues.

Frequent crossing of multiple time zones is not usually an issue for helicopter or UAS operations. The culprit is usually shift work and night shifts in particular. If schedule





change causes wake-up times and daylight exposure to vary significantly (usually  $\pm 5$ hrs), the body will receive input similar to crossing multiple time zones. Studies of night-shift workers consistently demonstrate reduction in work efficiency and increased risk of accidents. Studies have also shown that aviators flying during night-shifts have reduced hand-eye coordination, lower vigilance, worse problem-solving, and overall impaired flight performance when compared to day pilots. It is, of course, possible to shift the body's circadian rhythm to a new schedule, but this takes time (and the internal clock resists change). In general, it is easier to accept westward time-zone travel or advancing shifts when shifting circadian rhythm. Most experts cite that it takes one day for every time zone shift to fully accommodate, but many individuals can be reasonably functional before full accommodation.

#### Duty periods and work-rest scheduling

Length of duty period, time on task, and time since last break have all been shown to affect worker productivity and increase accident risk. There are multiple studies within industry that have demonstrated increasing relative accident risk with successive work shifts without a day off, successive number of hours on shift, and increasing work time without a break. Generally speaking accident risk remains relatively stable for an 8-10 hr duty period, then increases markedly after 12hrs.

#### Nutrition and fitness

Much can be said about the role of good physical fitness and proper nutrition with respect to health and performance. The body will withstand any insult-including fatigue-when it is optimized. A well-balanced diet to 'fuel' your body appropriately is important. Likewise, proper physical fitness optimizes the human operating system, even for tasks that don't necessary involve physical activity.





### Stress

In general, there are four types of stressors frequently encountered in military operations: biologic, emotional, mental, and environmental. They can all contribute to fatigue in different ways. Stress can be life saving in some instances providing the body with adrenaline, energy, and alertness but this response is best suited for intermittent and short-term application.

Within the context of chronic stress, the results can be very unhealthy. Physical ailments such as high blood pressure, irregular heartbeat, compromised immune function, stomach upset, back pain, and others have all been tied to chronic stress. Clearly stress can also impact the individual's ability to get restful sleep, as well. Stress can be cumulative, so even moderate improvements in a few (real or perceived) stressors (avoid, adapt, alter, accept) can help to reduce chronic stress to manageable levels and mitigate its impact on fatigue.

### Environmental factors

Environmental factors that contribute to fatigue may include thermal extremes, altitude, noise, vibration, weather conditions, poor air quality, substandard hygiene conditions, crowding and others. Overall, elimination or improvement of these factors not only reduces fatigue but generally supports better health and increased productivity and safety as well.

### Regulation

NATO guidance on aircrew flying/rest periods is located in STANAG 3527. Aircrew Fatigue Management is governed by MAA Regulatory Article 2345 and the Joint Helicopter Command Order 2345.

### Controls and countermeasures

Fatigue controls, countermeasures, and risk mitigation strategies should be part of an overall Fatigue Risk Management System (FRMS) and apply to the 4 Worlds. Leaders can assess many aspects of fatigue through evaluation of the mission environment, personnel and equipment available, type of duty, work scheduling and rest periods, sleep environment, and other pertinent factors. There is no universal solution, and countermeasures should be employed where possible and workable.

### Work-rest scheduling

This is a challenging problem without a template solution. Commanders must wrestle with 'mission first' but also within the context of efficiency and safety. Aircrew are generally well-protected by operating within the regulations of a crew duty period and flight time limitations (essentially providing a 'safe box' of operations), but pay special attention to those ground trades, still in mission and safety critical positions, that are not governed by such parameters. Expect less work productivity and efficiency from night shifts, encourage more frequent breaks, and (when possible) defer safety-critical or complex tasks to day shifts. Cross-checking procedures, checklists, and closer supervision become more important with fatigued teams.

There are a number of tools available to assist with managing shift work schedules. These include the Fatigue Audit Interdyne Tool, Prior Sleep and Wake Model, Fatigue Avoidance Scheduling Tool, and many others (see J3/CI/23 Fatigue Risk Management for more detail). Indeed, volumes have been written on the subject and the 'right solution' may vary on many factors.

As a very general guide, most safety experts agree that

- a single wake period should not exceed 17hrs
- daily off-times should be at least 10hrs to protect restorative and uninterrupted sleep
- you should have one full day off per week
- night shift workers should retain the same schedule of wake and sleep to remain circadian shifted if continuing on night shifts after an off day.

### **Sleep Hygiene**

While there are some medical disorders that interfere with restful sleep, by far the largest obstacle is ourselves. There are many strategies and guidelines to facilitate better sleep. Avoid stimulants (caffeine and nicotine) 4-5 hr before bed. Avoid alcohol; while it may make you drowsy and fall asleep faster, alcohol metabolism can interfere with normal sleep cycling and sleep architecture. Physical activity is important, but avoid strenuous activity 2-3 hrs before bed. To the extent that we are all creatures of habit and respond to 'conditioning,' try to maintain the same schedule and routines before bed. Avoid reading, watching television, or using a smart phone or tablet in bed. Cooler temperatures are better, and use the background noise of a fan or similar 'white noise' if noise is a problem. When on operations, respect the 'Quiet-Shift Workers Sleeping' signs for even brief awakenings can be detrimental.

### **Napping**

Napping is now widely accepted within the aviation community and used regularly by aircrew on long-haul flights, for example. It is effective because one of the core causes of fatigue is sleep deprivation. When the pace of operations and staffing permit, the following guidelines are considered best practices: Utilize your circadian low (if known) for napping. Sleep as long as conditions permit-even naps of 15 minutes can be helpful. Plan for sleep inertia-that grogginess or sluggishness that occurs with first awakening (which will depend on the amount of sleep deprivation and phase of sleep when awoken). This usually lasts about 15min, but can be much longer if sleep deprivation is severe. It is not practicable to plan to awake in a certain phase of sleep (e.g. the 90min cycle) since sleep deprived individuals will drop into deep sleep more quickly. If you must return to work immediately, a brief period of exercises can help shorten sleep latency.

### **Stimulants**

Stimulants are not permitted for use by aircrew with the exception of caffeine (or nicotine which is discouraged). An important point to note is that if you are relying on stimulants, you are already 'behind the fatigue power curve'. Caffeine is actually a very effective stimulant, and many studies have demonstrated that it performs very well when compared with some prescription stimulant drugs-but there's a catch. To derive maximum benefit, it must be used 'strategically.' Most caffeine users quickly become tolerant to the stimulant effects with regular daily consumption (sometimes in as little as a week depending on dose). It is best to reserve caffeine for times when its stimulant effects will be necessary. It is well-established that caffeine improves performance in sleep deprived individuals who are not regular consumers. Side effects (usually dose-dependent) may include nausea, upset stomach, anxiety, tremor, urinary frequency and others which may impair task performance.



Onset of caffeine effects generally occur within 15-30 mins. It has a relatively short effect window of 4-6 hrs depending on a number of factors.

Be cognizant that different coffees and teas as well as differing preparations can result in vastly different caffeine levels (a fresh cup of coffee can vary between 80-350mg, for example). An optimal level for stimulant effects is generally accepted to be 200 mg every 4-6hrs (not exceeding 1,000mg/day) for short periods.

Approximate Caffeine Content		
Item	Caffeine	Notes
Coffee, instant	60-100 mg/cup	Depends on quantity in your cup
Coffee, fresh	80-350 mg/cup	Depends upon type beans, method, and strength of brew
Coffee, decaf	2-4 mg/cup	Caffeine content usually marked on packaging
Tea	8-90 mg/cup	Depends upon strength of brew
Cola drinks	35 mg/250 ml	Also contains lots of sugar
Chocolate bar	20-60 mg/200 g	Also contains lots of sugar
"Energy drink"	80-300 mg/can	Caffeine content varies widely by product and size

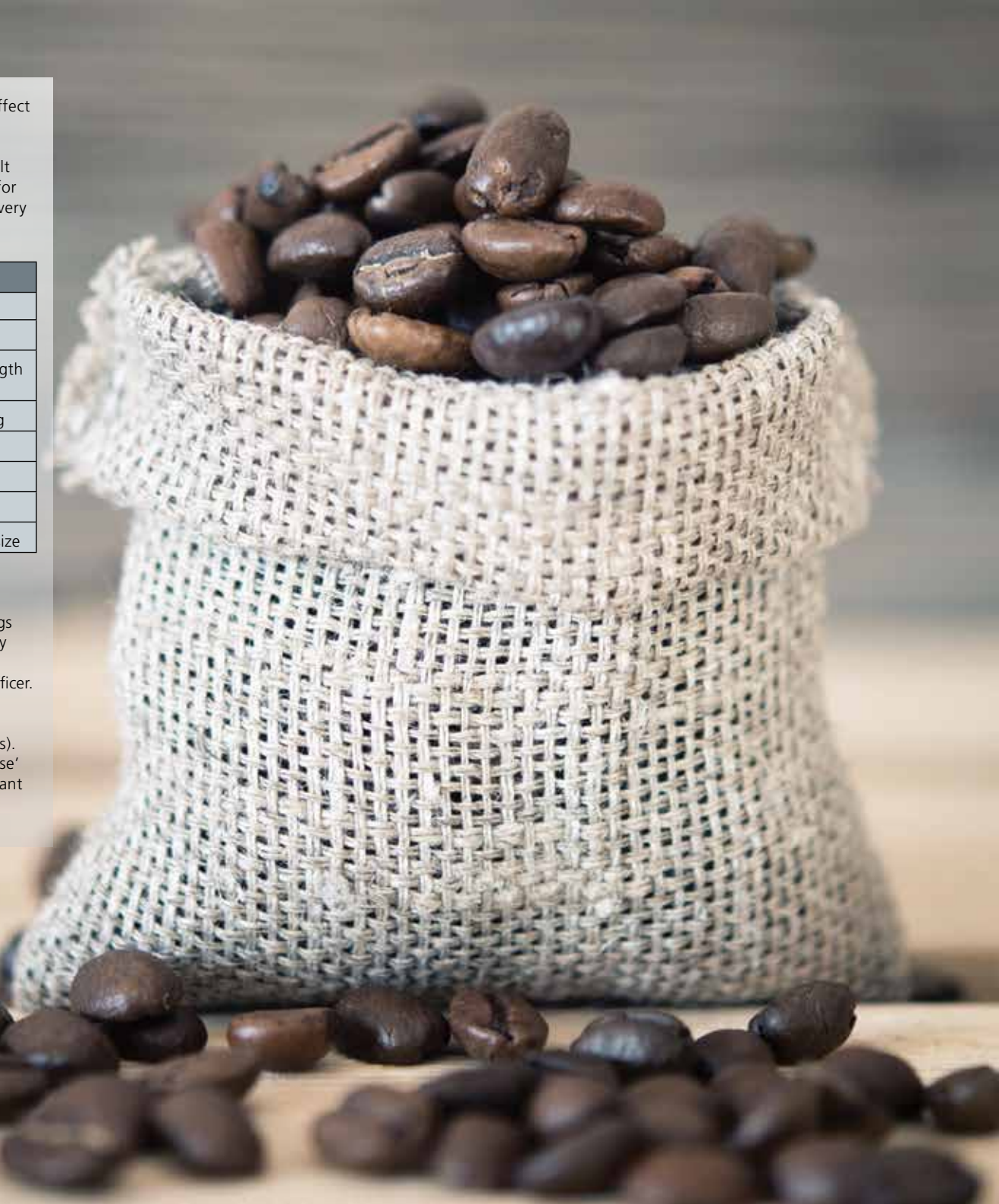
#### Rest agents

Sleep can be difficult in operational environments, even when given adequate time.

UK military aviation permits the use of the drug Temazepam in certain instances. It belongs to a class of drugs called benzodiazepines which have sedating properties. Its use, like any medication, is associated with intended benefits as well as side effects. Aircrew are never **required** to use hypnotic rest agents; use is voluntary in consultation with the medical officer.

Its use is intended for sustained operations, but is also authorized for exercises.

The recommended dose is 20mg (though 10mg may be adequate for some individuals). Aircrew must coordinate with their Military Aviation Medicine Examiner for a 'trial dose' no less than three days before anticipated flight. Use must be authorized by the relevant Aviation Duty Holders and unit commander.



**Key concepts review**

Fatigue is ubiquitous in our fast-paced 24/7 society and pervasive among hard-pressed military operations. It affects just about everyone at some point or another.

Fatigue is challenging because it affects individuals differently, there is no easy objective test for it, and the manifestations can be insidious. Fatigue is a key safety issue. It can contribute to significant performance deficits and crucial safety lapses. Individuals are not good at predicting their level of fatigue-related impairment.

Although there are certainly times to "press the fight," many aspects of fatigue control and countermeasures are under the operator's control. Employ countermeasures and mitigating strategies wherever possible.

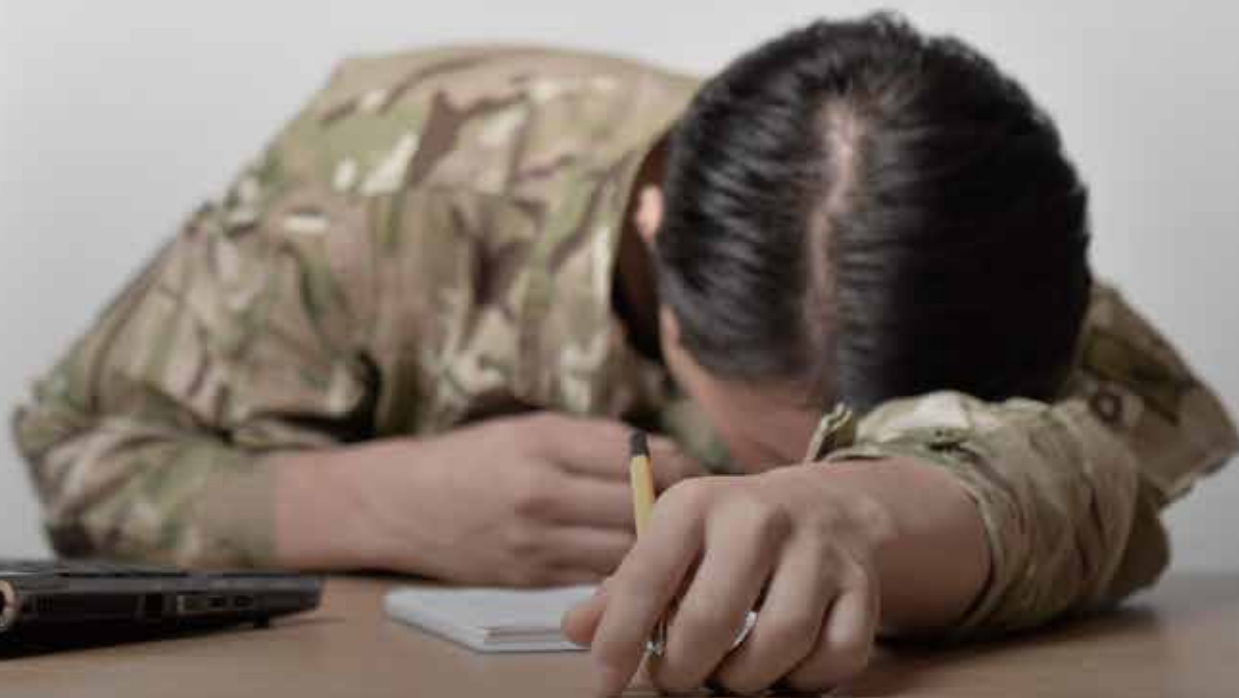
Respect fatigue and discard the traditional military macho associations with sleep deprivation and excessive workload.

It is impractical to generate an inclusive checklist for fatigue risk factors or fatigue-related risk management. Commanders and safety officers must tailor their Fatigue Risk Management and mitigation strategies. At its most basic level, consider the following 'red flag' high-risk factors adapted from Dr. J. Miller's fatigue checklist:

Fatigue 'Red-flags' for Decreased Cognitive Performance	
Length of wakefulness	> 17 hr
Amount of sleep in last 72 hrs	< 18 hr
Local time of day	0100 - 0600 (circadian low)
Fractured shift pattern	unadjusted circadian rhythm
Time zone change or large shift of crew duty period	> 5 hr time shift in one day
Level of exertion	Arduous or max. exertion

Education - about the dangers of fatigue, the causes of sleepiness, and the importance of sleep and proper sleep habits - is one of the keys to addressing fatigue in operational contexts.

Caldwell, et al.  
"Fatigue Countermeasures in Aviation."



Comments and suggestions for improving this document  
are welcomed. Designed by CMD, Andover 01264 382188

© Crown Copyright

**The sponsor of this publication is:**

**SO1 AVN MED**

JHC, IDL 417  
HQ Land Forces,  
Marlborough Lines, Monxton Road,  
Andover Hampshire SP11 8HT

<b>T</b>	03067 70 1074
<b>Smart</b>	96770 1074
<b>DII</b>	JHC-CI-AVNMED-SO1
<b>Millie</b>	091LAN0





<b>CI Title:</b> Fatigue Risk Management	<b>Author:</b> SO1 Avn Med	
<b>CI No:</b> J3/CI/23	<b>Last Updated:</b> 05 Jan 15	<b>Next Review:</b> 05 Jan 16
<b>Classification:</b> RESTRICTED	<b>E-Mail Address:</b> JHC–CI-AvnMed-SO1	<b>Tel No:</b> 96770 1074

## **FATIGUE RISK MANAGEMENT**

1. The JHC's Fatigue Policy is in place to ensure that we maximise Aviation Safety by appropriately managing the working patterns of all personnel. The MAA requires that JHC policies, standards and practices are, as far as reasonably practicable, at least good as those required by legislative provisions on fatigue that apply to civilian operators, whether or not the Armed Forces are bound by those provisions.

### **Responsibilities of Duty Holders**

2. Duty Holders (DH) are pivotal in the JHC Safety Management System (SMS); in terms of fatigue they should:

- a. Enhance Flight Safety by reducing the number of fatigue related accidents and or incidents.
- b. Encourage a safe working environment by minimising the hazards and risks associated with fatigue.
- c. Ensure fatigue related risks associated with extended working hours are minimised.
- d. Ensure personnel on operational duty comply with this policy, where reasonably practicable.
- e. Ensure that where there is a requirement to operate outside this policy, personnel communicate the increased risk of fatigue through the safety chain to the appropriate DH.
- f. Be responsible for the implementation of measures to minimise fatigue-related risk.
- g. Ensure that their personnel are trained and fully understand their responsibilities relating to fatigue management.
- h. Ensure there is a clear and unambiguous ownership of fatigue management when personnel are deployed on operations.
- i. Define the maximum flying times, cockpit alerts, standby duties, crew duty periods and compulsory rest periods for aircrew, within the limits of STANAG 3527<sup>1</sup> which gives guidance on aircrew flying times and rest periods. The procedures for granting extensions or exceptions to these limitations should also be defined in DH orders and guidance.

3. The scope of the JHC Fatigue Risk Management Strategy (FRMS) is detailed below and encompasses:

- a. FRMS Policy and Objectives.

<sup>1</sup> STANAG 3527 – NATO Aircrew Fatigue Management

- b. FRMS Accountabilities and Responsibilities.
- c. Fatigue Awareness.
- d. Fatigue Training.
- e. Communication and Promotion.
- f. Controls and Tools.
- g. Risk Assessment, Hazard Management and Safety Assurance.

## **Responsibilities of Personnel**

4. Personnel shall:
  - a. Make appropriate use of their rest periods (between shifts or periods of duty) to obtain good quality sleep.
  - b. Avoid activities detrimental to the next crew duty period (including non-military flying hours).
  - c. Report fatigue-related hazards and incidents through ASIMS<sup>2</sup>.
  - d. Inform their chain of command prior to, or during work if:
    - i. They are aware or suspect that they, or another personnel, are suffering from unacceptable levels of fatigue; or
    - ii. They have any doubt about their, or another individual's, capability to accomplish their duties.
  - e. Participate in fatigue risk management training and be aware of local fatigue management policies.

## **FATIGUE AWARENESS**

### **What is Fatigue?**

5. Fatigue is an experience of physical or mental weariness that results in reduced alertness. For most people, the major cause of fatigue is not having obtained adequate rest and recovery from previous activities. In simplistic terms, fatigue largely results from inadequate quantity or actual quality of sleep. This is because both the quantity and quality of sleep are of equal importance to recover from fatigue and maintaining normal alertness and performance. Furthermore, the effects of fatigue can be exacerbated by exposure to harsh environments (e.g. operations) and prolonged mental or physical work.

6. Inadequate sleep (quality and quantity) over a series of nights causes a sleep debt which results in increased fatigue that can sometimes be worse than a single night of inadequate sleep. Sleep debt can only be recovered with adequate recovery and sleep. When personnel work outside the normal routine of Monday to Friday 0800 hrs to 1700 hrs, this can limit the opportunity for sleep and recovery in each twenty four hour period. This is partly due to the disruption of the body's clock/circadian rhythms.

### **Cumulative Fatigue**

---

<sup>2</sup> Air Safety Information Management System

7. Flight time, duty periods, duty period limitations and rest requirements are established to enable our personnel to perform at an adequate level of alertness for safe flight and ground/support operations. Fatigue can be divided into two types, transient and cumulative fatigue. Transient fatigue is described as fatigue that is dispelled by a single sufficient period of rest or sleep. Whereas, cumulative fatigue occurs after incomplete recovery from transient fatigue over a period of time. Personnel on operational duty are at greater risk of cumulative fatigue due to the working environments and work rate. Commanders should consider the cumulative fatigue effect against the requirements of operational commitments, especially where personnel are often expected to work for consecutive periods without adequate rest periods. Commanders should ensure that where there is an extension of working time that deviates from DH orders, this is to be elevated to the appropriate DH.

### Symptoms of Fatigue

8. Fatigue-related symptoms can be divided into three categories: physical, mental and behavioural. Table 1 depicts examples of each of these types of fatigue. If a person is experiencing **three or more** of the symptoms outlined below, there is an increased chance that they are experiencing some level of fatigue or reduced alertness. It should be remembered that fatigue may not be the only cause of the symptoms presented below but if they occur together, it is a good indication that an individual is fatigued.

Personnel who present three or more symptoms in a short period of time are likely to be experiencing fatigue-related impairment.		
Physical Symptoms	Mental Symptoms	Behavioural Symptoms
Yawning Heavy eyelids Rubbing Eyes Head drooping Microsleeps	Irrational decision making Difficulty concentrating on tasks Lapses in attention Difficulty remembering what they are doing Failure to communicate important info Failure to anticipate events or actions Accidently doing the wrong thing	More quiet or withdrawn than usual Lacking energy Lacking in motivation to do a task well Irritable or grumpy with peers, family or friends Irrational reactions

**Table 1.**

### Causes and Consequences of Fatigue

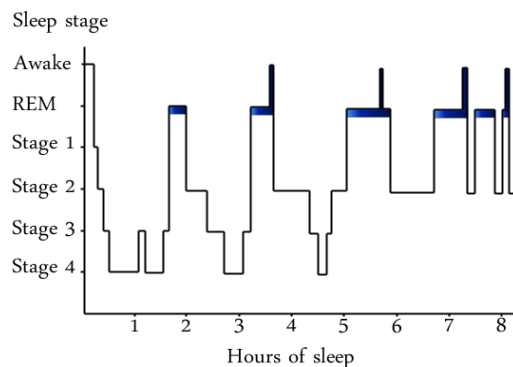
9. Fatigue affects all personnel in the form of physical, mental and emotional tiredness. The result of this tiredness is reduced alertness which may have a negative impact on performance. The fatigue associated with tiredness and reduced alertness is different from physical fatigue or weariness which is caused by long hard physical work. In this case, fatigue may be more accurately defined as mental fatigue although it certainly affects physical performance as well, especially tasks that require mental-physical interactions like hand-eye coordination, reaction time and fine motor skills. Other skills that are impaired by fatigue include attention, vigilance, concentration, ability to communicate information clearly and accurately, and decision-making. Impairment can lead to fatigue-related errors, which in turn can lead to incidents or an accident.

### Sleep Science

10. Sleep is defined as a state of partial or full unconsciousness during which voluntary functions are suspended and the body rests and restores itself<sup>3</sup>. It is believed that during sleep, the body recovers from the stresses imposed on it that day and subsequently prepare for the next

<sup>3</sup> Fatigue Risk Management System for the Canadian Aviation Industry, Chapter 3, pg 14.

day's stresses. Prolonged sleep deprivation leads to reduced mental and physical performance and symptoms such as hand tremors, slurred speech and increased sensitivity to pain. Both the quality and quantity of sleep are equally important and are determined by the timing of sleep within a twenty four hour day. Sleep cycles vary throughout the night and are not uniform; Figure 1 displays these stages. It is important to ensure you receive sufficient of these stages as they follow each other and can last between 90 and 120 minutes.



**Fig 1.**

- a. Stage 1 is where we fall asleep. During this initial stage you may occasionally experience muscle twitches.
- b. Stage 2 is a light sleep where we can be easily be woken.
- c. Stage 3 & 4 are deep sleep cycles. These are the stages where it is considered the body regenerates and it is usually a difficult stage to be woken up from. Sleep scientists now refer to stages 3 & 4 together as Slow Wave Sleep (SWS).
- d. Rapid Eye Movement (REM) sleep is the stage where we dream and is important for learning and memory consolidation.

11. Depending on the level of fatigue, a sleep deprived person will generally fall asleep more quickly and move rapidly from light sleep (stages 1/2) to deep sleep (stages 3/4). Unwanted sleep and fatigue can be considered a hindrance and under certain circumstances it can be dangerous if for example, in the process of driving a car or piloting an aircraft. Whilst there are many colloquial strategies to reduce the effects of sleep deprivation and fatigue, they are only a temporary fix no matter how effective they appear to be. At some point you must sleep to ensure proper physical and mental recovery. The amount of sleep required will vary between individuals but it is generally between around 7 and 9 hours. Naturally the body is programmed by their circadian clock to sleep between approximately 2200 and 0800.

## **Sleep Inertia**

12. Sleep Inertia is a physiological state characterised by a decline in motor dexterity and a subjective feeling of grogginess immediately following an abrupt awakening. There is always a certain amount of sleep inertia, even when waking from a short nap, yet the amount will be fairly limited compared to be woken from slow wave or deep sleep. While both long sleeps and napping are highly beneficial in combating fatigue, it is important to be aware that performance and alertness may be impaired for a short period when an individual is woken suddenly. In essence the longer the nap, the longer the period of sleep inertia. Therefore, you should minimise critical tasks that would be sensitive to sleep inertia for at least 20 minutes after been woken. Areas such as Quick Reaction Alert (QRA) and Search and Rescue (SAR) are considered 'High Risk' areas, in which personnel may be on standby for 24 hrs with a strong likelihood of being woken suddenly and a requirement to react immediately. This particular risk should either be addressed or managed within the appropriate Group risk register.

## **Napping**

13. One of many combatants of fatigue is napping. Short sleeps can deliver some of the benefits of longer sleeps but over a shorter period. Benefits can be seen in areas such as improved short-term memory, increased performance, alertness and improved reaction times. It should be remembered that the benefits of naps are short lived compared to a full night's sleep. Naps are considered as lasting up to 35 minutes in duration. However, the longer the nap, the greater the benefits will be in terms of recovery and improvements in performance. An individual's ability to take a nap will depend on work shifts and fatigue level, but taking a nap in the evening can have a negative effect on the ability to sleep later in the evening. The advantage of the nap being short is to enable the body to awake fully prior to entering a deeper sleep stage, which would otherwise cause an increase vulnerability to sleep inertia.

## **Jet Lag**

14. When an individual travels across a number of time zones the circadian clock eventually reacts to the change in light levels plus other factors to adjust the body's daily cycle to the new time zone. Before this adaptation is complete, individuals are said to suffer from 'jet lag'. The adaptation process is affected by a number of factors:

- a. Number of time zones crossed.
- b. Travel adaptation is usually quicker following westward travel than eastward travel across the same number of time zones. This is because most people have a circadian body clock that has an innate cycle slightly longer than 24-hours, therefore it is easier to adapt to a westward shift (day stretch).
- c. After eastward flights across 6 or more time zones, the circadian body clock may adapt by shifting in the opposite direction (antidromic effect), i.e. shifting 18 time zones west rather than 6 time zones east. When this occurs, some rhythms shift eastward and others westward and overall adaptation may be slowed.
- d. Adaptation is usually faster when the circadian body clock is more exposed to the time cues that it needs in the new time zone. Therefore, the earlier you can adopt the eating and sleeping cycle in the new time zone, the less effect jet lag will have upon you.
- e. Increased fatigue levels are likely if a person does not adapt to the new time zone and continues to eat and sleep under their previous time zone. This may result in degraded performance on mental and physical tasks and mood changes, and minor digestive system upset.

## **Circadian Cycles**

15. Circadian rhythms are cyclical processes within the body such as sleepiness and wakefulness, secretion of digestive enzymes, hormone production and body temperature. All operate on a cycle of approximately twenty four hours. The cycles are controlled by the circadian body clock in the brain and determine when the body expects rest and activity. A key feature of our circadian clock is that it is very light sensitive and the light intensity is monitored through a network of cells in the retina of the eye. The sensitivity of the circadian body clock to light enables it to stay in step with the day/night cycle; therefore, those personnel that work nightshifts, or crews that are required to sleep outside of the normal day/night cycle may disrupt this process, and these personnel may be vulnerable to fatigue. The daily minimum core body temperature corresponds to the time in the circadian cycle when individuals generally feel most sleepy and least able to perform mental and physical tasks. This is sometimes referred as the Window of Circadian Low (WOCL). For most people the WOCL occurs in the early hours of the morning around 0300 to 0500 and the afternoon WOCL is said to occur around 1500 to 1700. During known periods of WOCL, there is a higher risk of fatigue related errors.

## **Air/Ground Crew Accommodation**

16. A fundamental aspect of combating fatigue is to ensure that personnel receive sufficient good quality sleep. Whilst deployed on Operations or Detachments, there are certain standards that should be met to ensure we give our personnel the best possible conditions to obtain sufficient good quality sleep. The basic requirement for accommodation for aircrew as decreed by ICAO is *"A well furnished bedroom which is subject to minimum noise, is well ventilated, and has the facility to control the levels of light and temperature"*<sup>4</sup>. This may be impossible to achieve in practice but it is a useful guide to conditions that allow optimal sleep.

## **Fatigue and Food**

17. The need for adequate feeding facilities and the ability to receive good quality nutrition is often overlooked when fatigue is considered. In certain susceptible individuals, low blood sugar levels caused by insufficient food at key times may contribute to a reduction in alertness, although most normal healthy people are able to maintain stable blood sugar levels even if a meal is missed. Furthermore, there is evidence that high sugar content drinks alone do not alleviate sleepiness caused by fatigue. As mentioned previously our bodies are usually adjusted to be active during the day and to sleep at night, and the digestive system is also controlled around this cycle such that it is far more efficient during the day and much less so at night. Digestive juices (stomach acids and enzymes) are mainly secreted during the day; therefore, food eaten at night will undergo slower digestion than during the day. Consumption of foods with a low glycaemic index (GI) is thought to release energy more slowly, which may be an advantage to individuals working on a night shift.

## **Feeding Facilities**

18. In order to ensure shift workers working non-regular hours are adequately fed during a twenty four hour period, DHs should ensure as far as is reasonably practicable that facilities are available to provide personnel with a choice of hot and cold food.

## **Stimulants**

19. Caffeine is the most widely recognised and used stimulant. Caffeine has the effect of perking you up by blocking adenosine reception in the brain. Adenosine can suppress nerve cell activity and may be involved in the sleep/wake cycle. Caffeine from drinks (e.g. coffee) is usually absorbed within 45 minutes of consumption and the affects can last for up to 6 hours. Therefore, caffeine consumption is not recommended close to periods of sleep. Doses of 100-600 mg are effective in people who do not normally use caffeine. However, caffeine should be used judiciously immediately before its effect is needed. Heavy caffeine users (4-5 cups of coffee or 8-12 ounce servings of caffeinated drinks) develop tolerance quickly; much larger doses are then needed to maintain consistent alerting effects. Sudden caffeine withdrawal can produce adverse effects on performance and mood, and often results in headache. Ingesting large amounts of caffeine regularly can render it ineffective in maintaining alertness. Frequently reported side effects include anxiety, tremor, frequent urination, and upset stomach. These same symptoms can be precipitated by withdrawal of caffeine after prolonged use. Caffeine should be used strategically and a number of strategies to ensure maximum benefit are detailed below:

- a. Personnel should avoid caffeinated drinks/food when they are not tired.
- b. Avoid caffeinated drinks/food in the morning, as the body is waking up naturally and will feel more awake as the morning progresses. Using caffeine to speed this process simply increases an individual's tolerance to it. However, the exception to this is when required to rise earlier than normal or when needing an extra boost.

---

<sup>4</sup> ICAO Definition.

- c. Avoid caffeinated drinks/food within 3 hours of bedtime.
- d. Awareness of how long caffeine takes to be absorbed and to take effect.
- e. Be aware how much caffeine you are consuming. Caffeine has a small diuretic effect in people who do not use it regularly, and you will need to increase your water intake to counteract this effect.

What?	How much caffeine?	Comments
Instant coffee	60-100 mg/cup	Caffeine content depends on how much you put in your cup.
Fresh coffee	80-350 mg/cup	Caffeine content depends on: - The type of beans ('Robusta' contains more caffeine than 'Arabica') - The way the coffee is made. - How strong the brew is.
Decaffeinated coffee	2-4 mg/cup	The amount of caffeine is usually marked on the package.
Tea	8-90 mg/cup	Caffeine depends on how strong the brew is.
Cola drinks	35 mg/250 ml	Often contains a lot of sugar.
Cocoa and chocolates	10-70 mg/cup	Caffeine content depends on how strong the brew is and other chemical content in the product.
Chocolate bars	20-60 mg/200g	Contains a lot of sugar

**Table 2. The amount of caffeine in common food products**

## Shift Work

20. Shift work is sometimes the only way to maximise capability in both aviation and engineering environments but the implementation of shift working should be approached with caution. Work-rest schedules should promote adequate sleep and when feasible, restrict night shift work, split-sleep patterns or counter-clockwise shift rotation. The length of the duty period and rest breaks in between should be considered. When planning work-rest cycles, the type and complexity of the task should be taken into consideration. Shifts should also have a definitive end of duty time, as the absence of a definitive end of duty time creates uncertainty which can act as a stressor within the body that may lead to mental fatigue. This is particularly key on some engineering night shifts where personnel commence duty at 1630 and have no definitive end of duty time. DHs should therefore ensure that for normal situations an end of duty time is defined. Furthermore, DHs should ensure that their Aircraft Document Sets, where fatigue is covered, include maximum permissible consecutive duties and details mandatory rest periods. These duties should clearly articulate the process for deviation away from the norm, where an increased consecutive period is required for operational reasons.

## Fatigue Risk Management Strategies

21. Whilst the aim of a FRMS is to reduce fatigue levels to as low as reasonably practicable (ALARP), achieving this goal involves management of time available to sleep and awareness of

the actual sleep obtained. It may not be possible to completely eliminate fatigue from all working environments and supervisors should understand that a certain amount of fatigue in the work place may be acceptable, provided the risks are identified and managed. Supervisors should make themselves familiar with 'circadian' lows, and should identify when these are likely to occur and manage their personnel. The tasks carried out during these periods of decreased alertness should be managed carefully. Latent errors are failures of organisation or design that may contribute to the occurrence of an incident. Supervisors can implement countermeasures as defences against latent errors. For example, once a shift plan is established, the accountable manager should target the areas of highest fatigue and apply fatigue management strategies to alleviate the opportunity for a fatigue-related incident to occur. The main strategies to counteract the risk of fatigue-related errors include:

- a. Ensuring that personnel are appropriately trained, understand their personal limitations and are aware of strategies to increase alertness.
- b. Ordering less complex or less safety critical tasks at times of higher fatigue risk:
  - i. Where possible ensure 'high-risk' tasks are conducted during the day.
  - ii. Avoid mundane tasks during times of higher fatigue.
  - iii. Avoid highly complex tasks at times of higher fatigue.
- c. Targeted checking to improve the likelihood of detecting errors:
  - i. Closer supervision on complex/demanding tasks.
  - ii. Working in pairs or teams dependent on the task.
  - iii. Task rotation.

### **Training/Education**

22. Training is an essential component of Fatigue Risk Management. On completion of initial training, personnel should:

- a. Understand the science behind fatigue.
- b. Understand fatigue management policies and procedures.
- c. Understand the individual's responsibilities in managing fatigue.
- d. Know how to identify and manage risks associated with fatigue at both a personal and organisational level.

23. Supervisors should:

- a. Understand their responsibility for decisions that influence sleep opportunities for personnel and the available appropriate fatigue-reduction strategies.
- b. Ensure teaching on the principles of fatigue is included in HF and Aeromedical initial and refresher training.

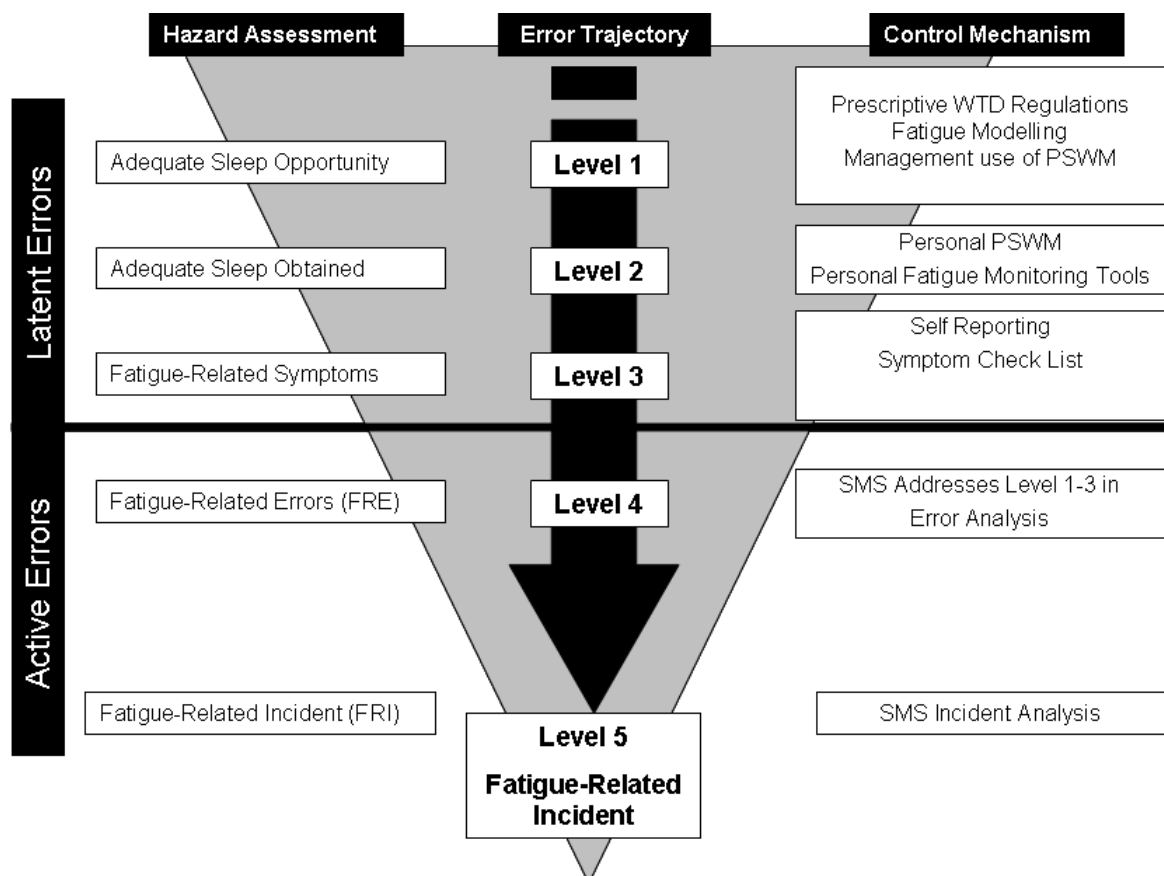
### **Other Training**

24. Post specific courses conducted by the MAA will cover fatigue as part of their syllabus and will be taught by RAF CAM<sup>5</sup>. These courses are as follows:

- a. Flying Supervisors Course.
- b. Flying Authoriser's Course (FLAC) – Fatigue training covered at CAM.
- c. Flight Safety Officers Course.
- d. MAA Flight Safety Course.

## CONTROLS AND TOOLS

25. Accountable managers should make themselves aware of some of the available tools to support the management of fatigue. The controls and tools listed in this document are not exhaustive, and managers should not be restricted to only those included herein. The tools listed here are designed to facilitate fatigue management. It is for the DH to decide what would work best for their AOR. Accountable managers are to ensure that they understand and apply the most appropriate action to combat fatigue in relation to the Fatigue Risk Trajectory described below and detailed at Fig 2.



**Fig 2. Fatigue Risk Trajectory.**

26. In order to manage and control fatigue, the Fatigue Risk Trajectory at Fig 2 is a methodology proposed by Dawson and McCulloch (2005). A fatigue-related incident (FRI) or accident is seen as only the final point of a longer causal chain of events of 'error trajectory'. The FRI is always preceded by a common sequence of event classifications that lead to the actual incident. Thus, an FRI is always preceded by a fatigue-related error (FRE). Each FRE, in turn, will

<sup>5</sup> RAF Centre of Aviation Medicine

be associated with an individual in a fatigued state, exhibiting fatigue-related symptoms or behaviours.

27. Each of the four levels in error trajectory for an FRI provides the opportunity to identify potential incidents and more importantly, the presence or absence of appropriate control mechanisms. In common with other types of error, there will be more potential, than actual incidents and that these could, if monitored, provide a significant opportunity to identify fatigue-related risk and to modify organisational processes prior to an actual FRI. Although the Fatigue Risk Trajectory focuses predominantly on sleep, the system will aid DHs to identify the root causes of many potential FRIs in a logical and consistent manner.

28. Controls are aimed at ensuring that work scheduling provides personnel with sufficient sleep opportunities. To achieve this, consideration should be given to length and timing of shifts and breaks, number of shifts worked consecutively and number of days off between shifts. This should enable an approximate estimate of how much sleep personnel will obtain. It is also important to access work schedules by examining specific aspects of the hours of work. Sleep opportunity alone should not determine appropriate schedules even though it is generally the most important factor. For example, although it is known that an early morning start will generally produce higher fatigue levels, in certain circumstances a 0500 morning start may be more appropriate than working under extremely hot and humid conditions in the afternoon.

29. This factors 'related' approach reflects the risk-based approach of an intelligent SMS. Below are some aspects of the level 1 of the Fatigue Risk Trajectory that should be used to assess sleep opportunity and potential fatigue levels:

- a. How many hours are worked per seven-day period? As total hours worked increases, sleep opportunity decreases.
- b. What is the maximum shift length? As the length of a given shift increases, the subsequent sleep opportunity decreases. Risk increases quickly beyond 12 hours on shift.
- c. How much time is provided for an adjustment to the shift pattern? Personnel should have a short break to permit circadian adjustment when moving from one shift pattern to another. A short break is defined as a single sleep opportunity between subsequent work periods - it is typically a period of less than 32 hours. As the break between shifts decreases, so does the sleep opportunity.
- d. How many hours are worked between 2100 and 0900? This relates to late finishes, early starts and night work. These will reduce night sleep opportunity and result in a significant reduction in total sleep opportunity.
- e. How often do personnel get a long break from work? A long break is defined as a period of two night sleeps with a non-working day in-between. Long breaks typically provide a significant opportunity to recover from sleep debt accumulated over a series of shifts.

30. Table 3 provides an example of how the questions above can be quantified into a rule system where fatigue scoring is used to identify potentially high fatigue-hazard areas.

<b>Fatigue Likelihood Scoring Matrix for Work Schedules</b>					
<b>Score</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>4</b>	<b>8</b>
a) Total hours per 7 days	< 36 hours	36.1 – 43.9	44 – 47.9	48 – 54.9	55+
b) Maximum shift duration	< 8 hours	8.1 – 9.9	10 – 11.9	12 – 13.9	14+
c) Minimum short break duration	> 16 hours	15.9 – 13	12.9 –	9.9 – 8	< 8

			10		
d) Maximum night work per 7 days	0 hours	0.1 – 8	8.1 – 16	16.1 – 24	> 24
e) Long break frequency	> 1 in 7 days	< 1 in 7 days	< 1 in 14 days	<1 in 21 days	< 1 in 28 days

**Table 3. Fatigue Likelihood Scoring Matrix for Work Schedules**

31. In Table 3, a 0900 hrs to 1700 hrs work week (5 days in a row) would produce a score of zero. On the other hand, a work schedule of seven 12-hour night shifts (2100-0900), followed by seven days off would produce a score of 21, which would be considered high<sup>6</sup>. Calculating a score for a schedule would allow DH to quantify what they deem to be acceptable or unacceptable. For example, a task may be given a lower score for highly complex or safety-critical work or for a high environmental stress working environment (e.g. high humidity) than for less critical work in an air conditioned environment. Initially, scores will be best estimates; however, as the understanding of fatigue hazards improves through the collection of data on ASIMS reports, scores that show signs of providing insufficient sleep opportunity should be reassessed. In order to assist in the matrix of fatigue scoring JHC Flight Safety has derived the following levels as an indicator to assess fatigue levels. This scale should be used as a guide to aid assessing potential fatigue risks.

- a. Low 0 – 6: Considered low risk related to the likelihood of a fatigue related error to occur. This region would be the optimal operating environment for all tasks.
- b. Medium 7 – 16: Considered a medium risk related to the likelihood of a fatigue related error to occur. This region requires fatigue management, awareness and mitigation strategies.
- c. High 17 – 26: Considered a high risk related to the likelihood of a fatigue related error to occur. This region should be short duration where there is no other means to achieve the task. Furthermore, increased awareness and management strategies need to be adopted to mitigate against a fatigue related error. Extensive periods of operation in this region are to be escalated up the chain of command to ensure ownership of the increased risks associated with fatigue.
- d. Extremely High 27 – 40: Considered an extremely high risk related to the likelihood of a fatigue related error to occur. This region should be avoided where possible. An extensive understanding of fatigue management is required to manage persons within this region. Escalation to the DH is recommended to ensure ownership and that a risk assessment against the task has been carried out necessitating the operation in this region.

### **Cumulative fatigue**

32. If the scoring over a rolling 28 day period is taken into account a rolling average can be determined, thereby establishing a score that would provide an indication on the possible effects of cumulative fatigue over a 28 day period. For example; a shift pattern working 12 hr shifts between 2100 hrs – 0900 hrs, 4 days on / 4 off, 4 nights on / 4 off and so on would produce the following scores: 1<sup>st</sup> Shift Score = 10, 2<sup>nd</sup> Shift Score = 18, 3<sup>rd</sup> Shift Score = 10 and 4<sup>th</sup> Shift Score = 18. Whilst being on nights the score produces a score of 18, which is considered high but the mitigation against this is that it is short lived and averaging over the 28 day period gives a score of 14 which is considered medium. This system allows DHs to understand where the increased levels of fatigue are likely to occur. The fatigue scoring matrix can produce scores averaging 14 over a 28 day period where persons are not actually receiving a full day off, but do receive a period of 24 hrs off between shifts. Therefore, the fatigue scoring system needs to be taken in context and the environment in which it is being used.

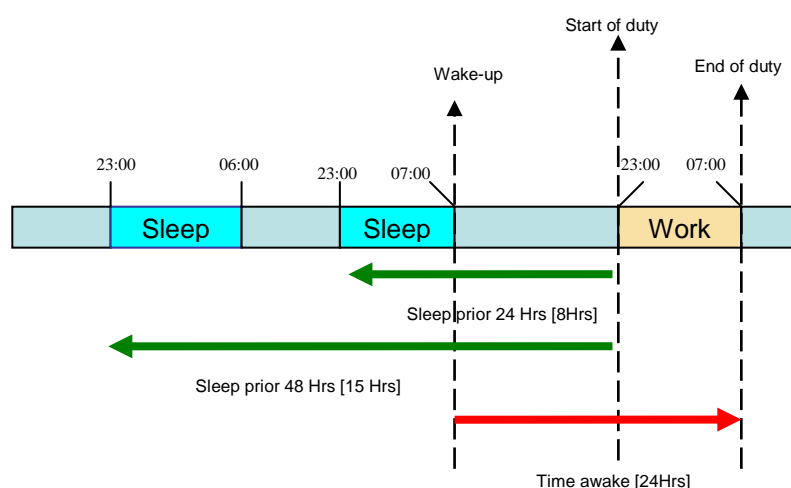
<sup>6</sup> Fatigue Risk Management System for the Canadian Aviation Industry – Fatigue Management Strategies for Employees – TP14573

## Prior Sleep and Wake Model (PSWM)

33. The PSWM is another tool to identify whether an individual is likely to be affected by fatigue based upon time awake and previous sleep patterns. There are 2 components:

- a. **Sufficient sleep:** should obtain 5 hrs sleep in the 24 hrs prior, and 12 hrs sleep in the 48 hrs prior to commencing a duty.
- b. **Excess time awake:** the period from wake-up to the end of a duty should not exceed the amount of sleep obtained in the 48 hrs prior to commencing the duty.

34. In order to determine if a person is likely to be fatigued and to assess the required degree of hazard control, a simple calculation can be performed on the amount of sleep and wake experienced in the 24 and 48 hours prior to commencing work. Fig 3 provides an example where the periods of sleep or wake do not meet the criteria and there is a significant increase in the likelihood of a fatigue-related error and the DH should implement an appropriate hazard control procedure for the individual. It should be noted that the thresholds could vary as a function of fatigue-related risk within a working area. For example, if a task has either a greater susceptibility of fatigue-related error or there are significantly greater consequences of a fatigue-related error, the threshold values may be adjusted to a more conservative level.



There is a significant increase in the likelihood of a fatigue-related error if time awake (24hrs) is more than cumulative sleep in preceding 48hrs (8hrs+7hrs)

**Fig 3. Example of the Prior Sleep and Wake Model (PSWM)**

## RISK ASSESSMENT, HAZARD MANAGEMENT AND SAFETY ASSURANCE

### Risk Assessments

35. As part of the JHC SMS, DHs are to ensure that they manage fatigue robustly i.a.w. this policy within their AOR. STARS teams are to conduct routine analysis of fatigue-hazards and report any significant trends at the ASSWG and to JHC Flight Safety. All fatigue-related errors/incidents are to be reported using ASIMS.

### Hazard Management

36. DHs are to ensure that, within their AOR, they develop, maintain and document the 3 predominant processes for fatigue hazard identification – predictive, proactive and reactive

processes (see below). All of these processes gather various types of data to enable continuous monitoring of fatigue risks covered within the FRMS.

## **Predictive**

37. In order to minimise potential future effects, predictive hazard identification focuses on establishing crew schedules and shift working conditions that consider factors known to affect sleep and fatigue:

- a. **Experience of managers and supervisors.** There will be a collective level of experience from managers, supervisors, schedulers and personnel who are all key sources of information for identifying aspects of a proposed roster that may cause increased fatigue levels.
- b. **Evidence based scheduling practices in accordance with fatigue reporting.** The value of experience can be enhanced when fatigue science is also applied in the building of schedules. This means considering factors such as the dynamics of sleep loss, recovery, the circadian biological clock and the impact of workload on fatigue, along with operational requirement. Since the effects of sleep loss and fatigue are cumulative, evidence based rosters need to address both flights/shifts and multiple duty periods. These principles can be used by schedulers, managers or supervisors in fatigue hazard identification.
  - i The perfect shift timing for the human body is daytime with unrestricted sleep at night. Any change to this status quo is a compromise.
  - ii The circadian clock does not adapt fully to altered rosters such as night shifts. However, it can adapt progressively to a new time zone, but full adaptation will depend on how many time zones are being crossed.
  - iii When a duty period overlaps a person's usual sleep time, it can be expected to restrict sleep. Examples are early duty start times, late duty end times and night shift.
  - iv Night shift also requires working through the time in the circadian body clock cycle when self-regulated fatigue and mood are lowest, and additional effort is required to maintain alertness and performance.
  - v Consecutive duties with restricted sleep will accumulate a sleep debt and fatigue-related impairment will increase.
  - vi In order to fully recover from acute sleep debt, personnel need a minimum of two full nights sleep consecutively. The frequency of rest periods should be related to the rate of accumulation of sleep debt.
- c. **Bio-mathematical modelling.** A range of bio-mathematical models are available commercially and are marketed as tools for predicting fatigue hazards relating to schedules, and some of these have been listed above. Used properly, these models can be a helpful tool as part of the FRMS because it is hard to visualise the dynamic interactions between sleep loss, and recovery and the circadian biological clock. To use models properly requires some understanding of what they can and cannot predict. These bio-mathematical tools should be validated against fatigue data from operations and schedules to ensure they are robust and fit for purpose. It should be noted that whilst bio-mathematical modelling offers some strong benefits, there are limitations.
  - i. Predict average individual and group fatigue levels.
  - ii. Do not take into account the impact of workload or personal and work-related stressors that may affect fatigue levels.

- iii. Cannot take into account the effects of personal or operational mitigation strategies that may or may not be used by individuals, such as stimulants, exercise and improved rest facilities.
- iv. Do not predict the safety risk that fatigued personnel represent in a particular operation or task.

38. The most effective and reliable method currently available to predict relative fatigue levels is to compare likely fatigue hazards against schedules. Furthermore, bio-mathematical modelling should be used in conjunction with current fatigue data to validate and confirm potential areas of fatigue hazards.

## Proactive

39. Proactive hazard identification processes focus on monitoring fatigue levels in an operation or task. Fatigue-related impairment affects many skills and has multiple causes, and there is no single measurement that gives a total picture of a person's current fatigue level. The success of proactive fatigue processes depends largely on personnel reporting fatigue through ASIMS. The willingness of personnel to continue to submit fatigue-related reports will reflect their confidence in the system and the ultimate goal which is to improve safety. ICAO Annex 6, Part 1, Appendix 8 identifies 5 possible methods of proactive fatigue hazard identification:

- a. **Reporting of fatigue risks.** Personnel reporting high fatigue levels or fatigue-related performance issues are key to provide data to the ASSWG about fatigue hazards in day-to-day operations.
- b. **Personnel fatigue surveys.** Personnel fatigue surveys can either be retrospective or prospective surveys. Both approaches have their own merits; however, care should be taken as to the periodicity of these surveys.
- c. **Cross referencing fatigue related reports with Fight Data Monitoring (FDM).** Within commercial aviation there is considerable interest in establishing ways to link crew member fatigue levels to FDM, particularly for approach and landings. The advantage of using this type of data is that it is routinely collected and is relevant to flight safety. However, there is difficulty in that a multitude of factors contribute to deviations from planned flight parameters, which makes interpretation difficult. In order to use FDM as an indicator of crew fatigue, it must be demonstrated that changes in FDM that are reliably linked to other indicators of personal fatigue, such as sleep loss in the preceding 24 hrs.
- d. **Cross referencing ASIMS with equivalent commercial Air Safety Reports (ASR) and scientific research.** There is a plethora of fatigue-related information available from external safety databases, such as the ASR and MOR maintained by the CAA and airlines<sup>7</sup>. Cross referencing some of the ASIMS data with these sources could be beneficial, especially for multi-engine fleets.
- e. **Analysis of planned versus actual hrs worked.** The planning of schedules and rosters based on fatigue as well as operational requirements permits predictive identification of fatigue hazards. However, numerous unforeseen circumstances can cause changes to planned schedules, i.e. weather, technical problems and personnel illness. Personnel fatigue should relate to what is actually flown or shifts completed, not what was planned.

40. Given the primary importance of sleep loss and recovery in the dynamics of personal fatigue, another valuable and commonly used method for proactive fatigue hazard identification is sleep monitoring. Sleep can be monitored in a variety of ways, the simplest and most cost effective method being where personnel complete a daily sleep diary before, during and after

<sup>7</sup> ASR – Air Safety Report, MOR – Mandatory Occurrence Reporting – Both civilian reporting.

trips/shifts. They are typically asked to record when they sleep and rate the quality of their sleep, as soon as possible after waking. There are more objective measurement of sleep/wake patterns which can be obtained by continuously monitoring movement whilst sleeping and applications to assess this can be purchased commercially.

## **Reactive**

41. The reactive processes are designed to identify the contribution of personnel fatigue to reports and events. The aim is to identify how the effects of fatigue could have been mitigated, and to reduce the likelihood of similar occurrences in the future. ICAO Annex 6, Part 1, Appendix 8 identifies 5 examples of triggers for a reactive process:

- a. Fatigue Reports.
- b. Confidential Reports.
- c. Audit Reports.
- d. Incidents.
- e. Flight Data Monitoring Analysis.

42. Depending on the severity of the event, fatigue analysis should be undertaken by the DH or a fatigue expert. Unfortunately, there is no simple test for fatigue-related impairment, therefore, to establish that fatigue was a contributing factor in an event, it has to be shown that: the person was probably in a fatigued state, the person took particular actions or decisions that were causal in what went wrong and that those actions or decisions were consistent with the type of behaviour expected of a fatigued person.

## **REPORTING, AUDIT AND REVIEW**

### **Reporting.**

43. All personnel reporting any fatigue related hazard/observation, incident or accident are to use ASIMS. Within ASIMS there are drop down menus to guide completion of all the relevant fields. Personnel should complete this report with due diligence, ensuring that all of the fields are complete before submitting. JHC Flight Safety will conduct analysis of fatigue related reports. However, DHs are to monitor ASIMS for fatigue related reports and conduct analysis within their AOR. Reports that are of significant risk to Air Safety will be discussed at the relevant ASSWG. Feedback on trends will be promulgated through RAF Flight Safety communications and other mediums where appropriate.

A TUCKER  
Col  
AD SA  
For Comd

### **Further reading**

JHC Flying Order Book J2345

JHC Pamphlet: [Commanders' Guide to Fatigue Management](#) – **read** version  
[Commanders' Guide to Fatigue Management](#) – **print** version